The humble economist:
What economics can – and can't – tell us about climate change

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DRAFT: Comments welcome
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Introduction

"The weather," the nineteenth century New England essayist Charles Dudley Warner once observed, "is a matter about which a great deal is said and very little done."[1] Today we are doing something *to* the weather, however: we are destabilizing the climate by pumping greenhouse gases into the Earth's atmosphere. And a great deal is being said about this, if not much done.

Economists are very much a part of the climate change conversation. Most joined it later than the scientists, but this has not inhibited them from offering bold prescriptions as to what ought to be done, or as the economists themselves might put it, sharing their expertise.

Today I will offer some thoughts about what economics can tell us about climate change, and about what economics cannot tell us.

I will suggest that economists can bring important insights into the choices we face in climate policy. In particular, economics can shed light on the crucial role of carbon pricing for mitigation, how it should be instituted, and its distributional impacts.

I will also maintain, however, that there are important questions that economics cannot be expected and should not try to answer. In particular, economics cannot be relied upon to tell us what limit we should put on the quantity of carbon dioxide and other greenhouse gases that we add to the atmosphere. On this question, I will argue, economists ought to show some humility.

What economics can't tell us

Let me begin by discussing what economics cannot tell us – to clear the air, so to speak, for what it can.

Climate targets

A widespread consensus exists among climate scientists that we should do all we can to limit the increase in global mean temperature to 1.5 to 2 °C above pre-industrial levels. The 2015 Paris Agreement adopted this goal, giving it an official imprimatur as the way to define the broad UNFCCC commitment to prevent "dangerous anthropogenic interference with the climate system."[2] While there is no way to avoid arbitrariness in delineating what is "safe" from what is "dangerous," the 1.5-2° target is now firmly in place as "an easily understood, politically

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[1] A similar version of this remark is often attributed to Mark Twain, with whom Dudley co-authored the novel *The Gilded Age*: "Everybody talks about the weather, but nobody does anything about it." On the quote's origins, see https://quoteinvestigator.com/2010/04/23/everybody-talks-about-the-weather/.

[2] United Nations Framework Convention on Climate Change (UNFCCC), 1992. For a review of the history of this goal, see C.-F. Schleussner *et al.* (2016).

useful marker to communicate the urgency of the climate change problem and to drive action on a global scale."[3]

One might think that economists, as members in good standing of the international community, would simply adopt this target. They could then proceed to analyze the most cost-effective and equitable ways to attain it, including the desirable mix of private and public investment, a task on some economists have embarked.[4] But many influential climate economists have been unwilling to defer to the international scientific and policy norm. Instead they have advanced their own, quite different, climate policy targets.

The social cost of carbon

What is remarkable is not only that economists have second-guessed climate scientists and international negotiators alike, but also that this fact has largely escaped notice outside and even within the economics profession. One reason is that the climate goals advanced by economists have come in the guise of a price rather than a quantity. This price is called "the social cost of carbon," or SCC for short. The SCC is derived from integrated assessment models that combine climatology with economics, and seek to optimize social welfare as defined in conventional cost-benefit analysis. William Nordhaus, the Yale economist whose DICE (Dynamic Integrated model of Climate and the Economy) is perhaps the best-known model, calls the SCC "the most important single economic concept in the economics of climate change."[5]

The headline results from integrated assessment models are a prescribed time path of carbon prices, the SCC. Built into this path is also a prescribed emissions trajectory, tied to the SCC by assumed relationships between quantity and price. And if we look at the emissions counterpart of the SCC, we find that what these models recommend as "optimal" is a global mean temperature increase well beyond 1.5 to 2 °C.

In a recent study, Nordhaus contrasts the SCC prescribed by DICE to the carbon price that he estimates would be needed to limit mean temperature increase to 2.5 °C.[6] (He briskly dismisses a hard cap of 2 °C as "infeasible," an assertion that is disputed in recent studies that affirm that even a 1.5 °C target remains technically achievable.[7]) The divergent price paths between the SCC optimum recommended by Nordhaus and a trajectory consistent with the 2.5 ° target are shown in Figure 1.

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[3] Karmalkar and Bradley (2016).

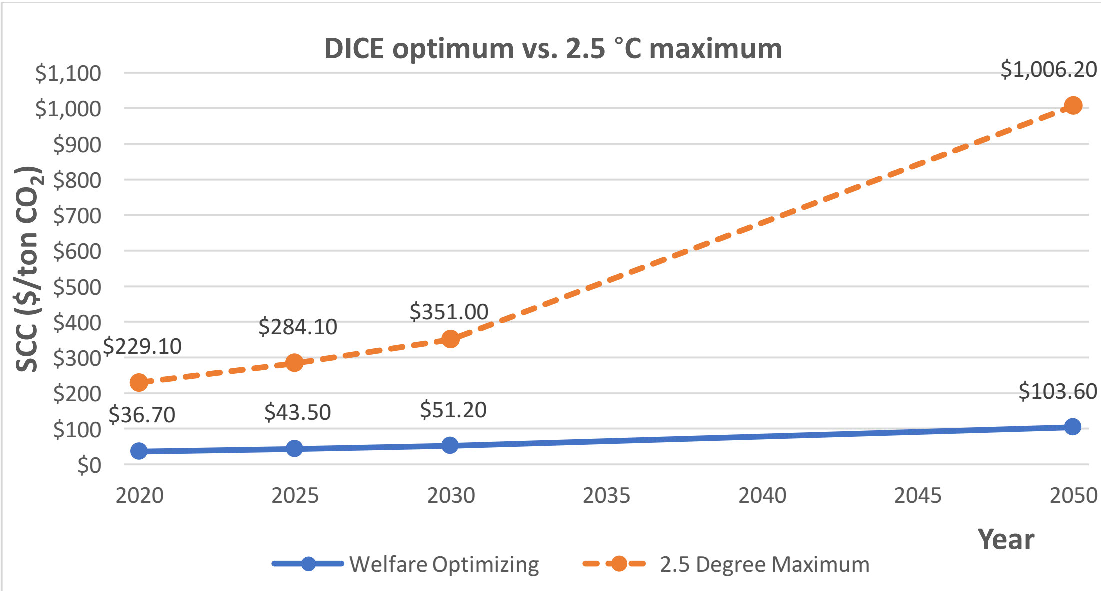
[4] For an analysis of the investments that would be needed to cut global emissions by 40% by the year 2030, see Pollin (2015).

[5] Nordhaus (2017a), p. 1518.

[6] Nordhaus (2017a).

[7] Millar et al. (2017).

Figure 1: Carbon price paths



Note: Global CO2 price in 2010 US dollars.
Source: Data from Nordhaus (2017a), Table 1.

The DICE model recommends a carbon price that rises from $37/t CO2 in 2020 to about $100/t in 2050. To meet the 2.5 ° target, the price would start more than six times higher, at about $230/t in 2020, and rise to more than $1,000/t in 2050. The disconnect between the model's "optimal" SCC and the carbon price under the hard cap is striking. It would be wider still if we accepted the 1.5-2° target that was agreed upon in Paris.

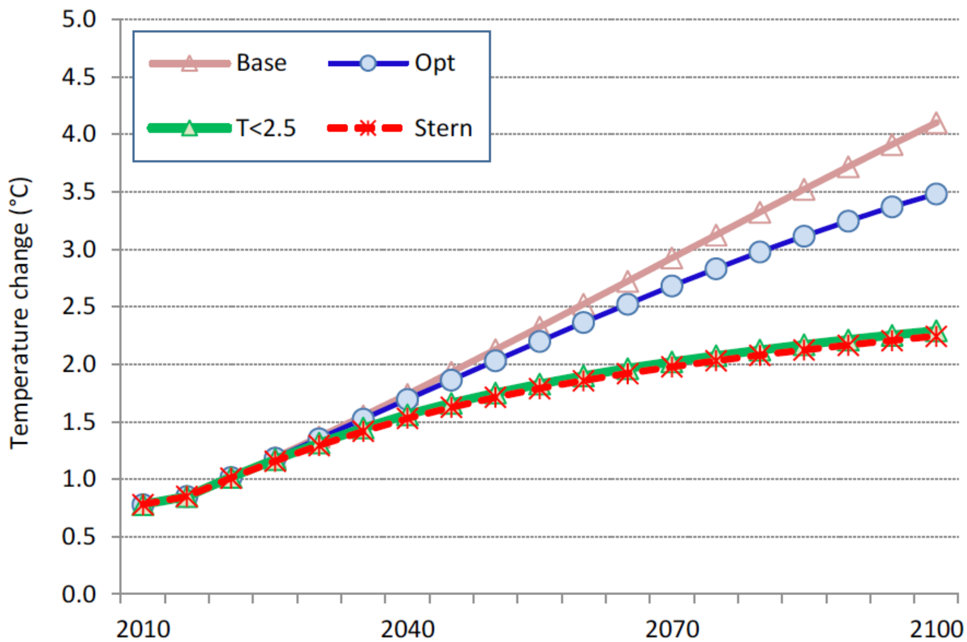
There is a handy way to translate CO2 prices into units more meaningful to non-experts. A one-dollar increment in the price of CO2 translates into a one-cent increment in the price of one gallon of gasoline (or 0.3 Euro cent per liter of petrol). The 2050 carbon price prescribed by DICE thus would raise gasoline prices in the U.S. by $1/gallon and petrol prices in Europe by 30 Euro cents/liter. These changes lie well within the range in which fuel prices have fluctuated in the past five years in the absence of a carbon price. The proposition that such a low SCC would produce an optimal emissions path will, I suspect, strike many non-economists as highly implausible. The 2.5° target, in contrast, translates into a 2050 gasoline price increase of $10/gallon (3 Euros/liter).

Climate change denial lite

What is the increase in global mean temperature that would accompany the "optimal" SCC in the Nordhaus model? By the year 2100, the predicted increase is 3.5 °C (6.3 °F) – and still rising thereafter. As Nordhaus forthrightly remarks, "the cost-benefit optimum with standard parameters has sharply rising temperatures."[8] To put the 3.5 °C number in perspective, the last time the Earth experienced temperatures that high was about 125,000 years ago, long before the advent of cave paintings (about 40,000 years ago), let alone agriculture (about 10,000 years ago), when global sea levels were about 6 meters higher than at present.

This "optimum" increase in temperature is dramatically higher than the 1.5-2 °C target, and only about 0.6 °C below the rise that Nordhaus reckons would occur in the absence of any climate policy. It is noteworthy that the integrated assessment model adopted by the 2007 Stern Review, which used a lower discount rate to convert future damages into present values, recommended an optimum path close to that implied by the 2.5 °C target (see Figure 2).

Figure 2: Temperature paths



Notes: Base = business-as-usual scenario (no climate policy); Opt = cost-benefit economic optimum from DICE model; T<2.5 = path that limited global mean temperature increase to 2.5 °C; Stern = policy with low discount rate recommended by Stern Review (2007).

Source: Nordhaus (2017b), Figure 4.

Helpfully, Nordhaus also reports the magnitude of economic damages that his model reckons would result from 6 °C warming. The estimate is 8.5% of global income. This may seem like a rather small effect from returning the planet to temperatures that last prevailed some 15 million years ago, long before humans walked the Earth. The damages look even less worrying when we note that integrated assessment models predict that average global income will rise

[8] Nordhaus (2017b), p. 30.

"four to over ten-fold over the century without mitigation," a rosy forecast that makes an 8.5% haircut look like a rounding error.[9]

How do economists arrive at such modest estimates of climate damages? The DICE *User's Manual* notes that the studies on which the model's "highly simplified" damage function is based "generally omit several important factors (the economic value of losses from biodiversity, ocean acidification, and political reactions), extreme events (sea-level rise, changes in ocean circulation, and accelerated climate change), impacts that are inherently difficult to model (catastrophic events and very long-term warming), and uncertainty." To adjust for these omissions, the model adds 25 percent to monetized damages. "While consistent with the estimates from other studies," the authors write, "it is recognized that this is largely a judgmental adjustment."[10]

The Intergovernmental Panel on Climate Change (IPCC) offers this assessment of economic assessments of climate change risks: "These impact estimates are incomplete and depend on a large number of assumptions, many of which are disputable." Furthermore, the IPCC adds, "very little is known about the economic cost of warming above 3 °C relative to the current temperature level."[11]

The damage functions in integrated assessment models typically extrapolate by assuming a smooth relationship between economic impacts and increasing temperatures.[12] In a recent survey of damage estimates, Nordhaus acknowledges the possibility that impacts may rise more sharply beyond some threshold, but he concludes that "there is no indication from the damage estimates of a sharp discontinuity or high convexity."[13] But this does not mean that such threshold effects do not exist, only that the damage functions used by economists do not include them. A recent meta-analysis concluded that a revised damage function that corrects for omitted variables and other biases and incorporates risks of catastrophic impacts would yield a SCC four- to five-fold greater than that prescribed by the DICE model, and would limit the global temperature increase to 2.1 °C or lower.[14]

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[9] Clarke *et al.* (2014) p. 490. 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."

[10] Nordhaus and Sztorc (2013), p. 11.

[11] IPCC (2014), p. 79.

[12] Nordhaus (2017b, p. 7), for example, uses a quadratic function in which doubling the temperature increase leads to four times the damages. An estimated impact of 2.1% of global income at 3 °C warming thus implies 8.5% of income at 6 °C.

[13] Nordhaus and Moffat (2017), p. 3.

[14] Howard and Sterner (2017). On the treatment of catastrophic risks, see also Weitzman (2007) and Ackerman (2018).

In computing the SCC, integrated assessment models further deflate the magnitude of future damages by converting them into present values by means of a discount rate. This practice assumes that the logic used by individual mortals in thinking about their own futures applies equally well to how the present generation ought to think about future generations. At 4¼ percent, the discount rate preferred by Nordhaus, one million dollars of damages (in real terms) a century from now has a present value of only $15,000, and two centuries from now of only $250. Much as ice sheets will melt with climate change, future damages melt away with discounting.[15]

Non-economists may be tempted to regard these computations as quaint eccentricities on the part of economists. But the SCCs recommended by economists are taken quite seriously by policy makers. In the United States, for example, the federal government's Interagency Working Group on the Social Cost of Carbon has used DICE along with two other integrated assessment models to derive the SCC that is used by policy makers to assess the efficiency of proposed regulations and the appropriate level for proposed carbon taxes. The SCC "reflects the official position of the U.S. government," writes Cass Sunstein, who directed the Office of Information and Regulatory Affairs, the agency that oversees cost-benefit analysis of major regulations, in the Obama administration, adding that "until it is changed through an appropriate process, it is binding."[16]

One need not subscribe to the physicist Stephen Hawking's dire prediction that humankind has only 100 years to find a new planet to be skeptical about the claim that global temperature increases to levels unprecedented in human history will merely shave a few percentage points from the rise in future global income.[17] Between the extremes of apocalyptic end times and outright climate change denial, there is a wide middle ground where the possibilities include terrible suffering for our grandchildren and the generations who follow them.

Those economists who prescribe a very modest SCC accept the reality of climate change, but they low-ball its costs. On the spectrum of concern, their rather relaxed position could be called "climate change denial lite."

Neoclassical efficiency versus safety

The difference between the SCC prescribed by neoclassical economists and the carbon price required to meet the 1.5-2 degree target reflects two distinct normative approaches to choosing policy objectives. The SCC is based on the "efficiency" criterion in neoclassical

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[15] For a discussion of discounting, see National Academies of Sciences, Engineering, and Medicine (2017), ch. 6.

[16] Sunstein (2014), p. 61. In March 2017, President Trump issued an executive order that disbanded the Interagency Working Group, but does not jettison the SCC altogether (Hess, 2017). In an October 2017 regulatory impact analysis for a proposed repeal of the Clean Power Plan, the EPA recalculated the SCC to be $1-6/t in 2020, using higher discount rates and eliminating the non-U.S. benefits of mitigation (Mooney, 2017).

[17] Holley (2017).

economics, where the objective is taken to be maximization of net present value. The 1.5-2 degree limit is based on a "safety" criterion, where the policy objective is protection from harm and risk. In the former case, economists arrogate unto themselves the power to set the goals of climate policy; in the latter, economists fulfill the humbler but nevertheless important role of recommending means to achieve the ends chosen by others.

Most environmental law is based on the safety criterion rather than neoclassical efficiency. The U.S. Clean Air Act, for example, mandates the EPA to set air quality standards "to protect the public health," not to weigh the value of human health against the costs of cleaning the air.[18]

In choosing between scientists and economists to define the goals of climate policy, and between safety and neoclassical efficiency as normative criteria on which to base these goals, my money is on scientists and safety. Of course, the choice of normative criteria is a matter of ethics, not a true-or-false proposition, and I'm sure some of my fellow economists will stick to their neoclassical guns. But if so, their policy recommendations should be seen for what they are – normative prescriptions rooted in assumptions that some may find idiosyncratic or even bizarre – rather than statements of fact based on what economics can "tell us."

What economics can tell us

If we accept the goals agreed upon by climate scientists and by the negotiators at Paris, rather than coming up with an alternative that is ostensibly more "efficient," this does not mean that economists no longer have anything useful to contribute to climate policy.

On the contrary, by focusing on what economics *can* tell us, we may enhance both the usefulness and credibility of climate economics. I want to focus, in particular, on carbon pricing as a policy instrument, that is, as a means to achieve (as opposed to decide upon) climate goals. Economics has three important things to tell us about carbon pricing:

- First, it is a valuable tool in the climate policy mix.

- Second, the long-run relationship between the carbon price and the quantity of emissions is uncertain, a fact with important implications for policy design.

- And third, the distributional impacts of carbon pricing are uneven across the population, again with important implications for policy design.

Why price carbon?

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[18] 42 U.S. Code § 7409 - National primary and secondary ambient air quality standards, section (b)(1).

It would be unfortunate if the shortcomings of the SCC were to blind us to the value of carbon pricing as a policy tool. Regardless of how the emissions targets are chosen – whether on the basis of a safety standard as recommended by climate science or an efficiency standard as recommended by neoclassical economics – putting a price on carbon is a crucial means to meet this goal. We should not toss out the carbon pricing baby with the SCC bathwater.

Possibly the most compelling reason to include carbon pricing in the policy mix is to set a hard outer limit on the quantity of carbon emissions. This can be done either by setting an emissions cap and letting the price adjust to meet this constraint, or by instituting a carbon tax with an adjustable rate that is keyed to emission targets.

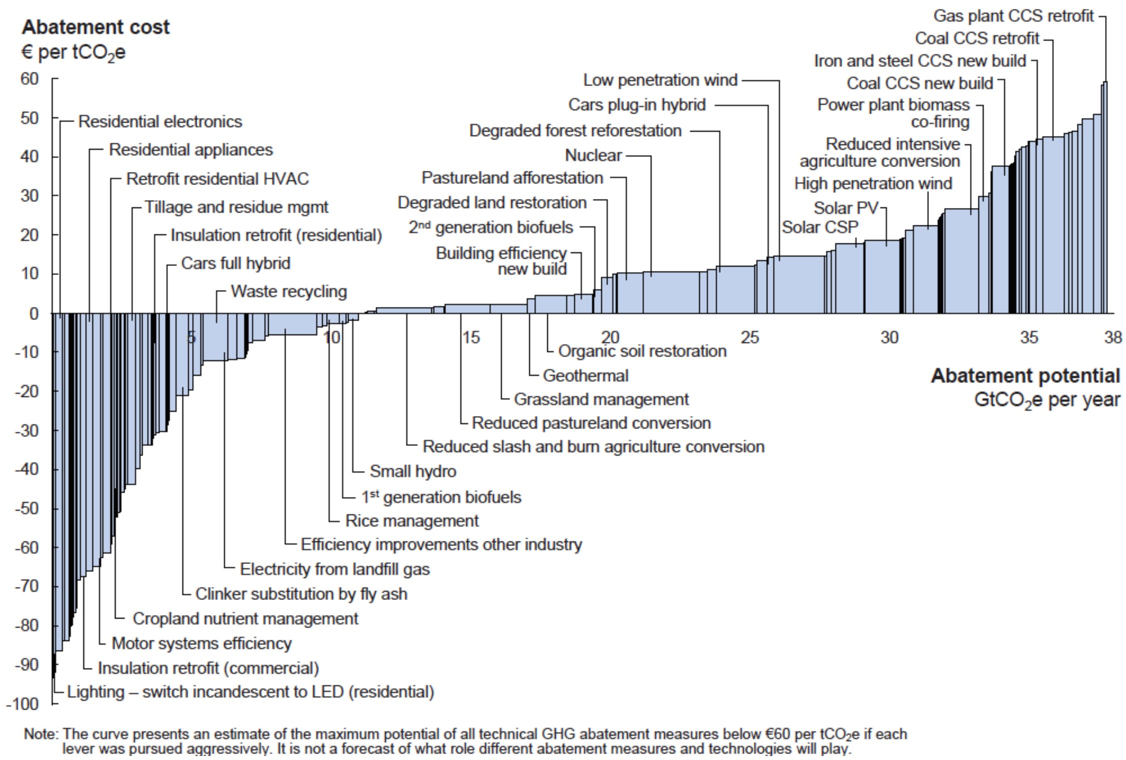
Carbon pricing can be combined with other policy instruments, such as renewable portfolio standards for electric power and fuel economy standards for automobiles. Indeed, this is how emission pricing is usually implemented in practice. When the sulfur dioxide cap-and-trade program for power plants was established in the U.S. by the 1990 Clean Air Act amendments, it complemented existing regulations rather than supplanting them. When California created a carbon cap-and-trade system under its 2006 Global Warming Solutions Act, it was coupled with other regulatory measures that together were expected to meet about 85% of the state's emission reduction targets. In practice, hybrid policies that mix prices with other instruments are the rule, not the exception.

Apart from setting the envelope on total emissions, carbon pricing can be highly cost-effective, an argument often, and quite rightly, voiced by economists of all stripes. The costs of carbon mitigation vary widely among alternative techniques. This was illustrated in a well-known study by McKinsey & Company that reported very low (indeed, negative) marginal abatement costs for some options, such as the installation of LED lighting and insulation retrofits, and high abatement costs for others, like carbon capture and sequestration (see Figure 3). In responding to a carbon price, economic agents may be expected to choose the least-cost options for reducing emissions.

Before celebrating this insight too effusively, however, it would be prudent to consider the meaning of the *negative* cost options identified in the study. These are ways to cut carbon emissions that would actually save money for the firm or household or government implementing them. The fact that such options are not fully exploited implies that the real-world behavior of economic agents often departs from textbook assumptions. Rather than perfect information and perfectly rational behavior, for example, we can find plenty of ignorance, inertia and myopia. These are one justification for including additional tools in the policy mix, rather than relying upon prices to do the job alone.

A third attraction of carbon prices is that they provide incentives for research and development of new technologies for emissions reduction. Experience from other pollution-pricing initiatives indicates that these dynamic effects can be large; the marginal cost of abatement in the first decade of the SO2 allowance trading program in the U.S., for example, fell to less than half of what most analysts had expected.[19] As we know, however, returns to R&D are not fully appropriable by those who undertake it, leading to underinvestment by the private sector. Public policies and investments in R&D are needed to redress these externalities, a further rationale for a hybrid policy mix rather than relying on prices alone. Similarly, public investment is needed for infrastructural transformations, such as development of mass transit and smart electric grids, that cannot be brought about by individual responses to price signals.

Figure 3: Marginal Costs of Emission Reduction Options



Source: McKinsey & Company (2009).

Fossil fuel combustion generates numerous co-pollutants apart from CO2, including sulfur dioxide, nitrogen oxides and particulate matter, whose hazards are more localized. Co-pollutant intensity per ton of CO2 varies across pollution sources and locations. The impacts of co-pollutants on public health, using conventional techniques for valuation of a statistical life, often exceed conventional measures of the SCC.[20] Moreover, these impacts often fall disproportionately upon socio-economically vulnerable populations.[21] For reasons of both efficiency and equity, therefore, it makes sense to design climate policy so as to achieve greater reductions in emissions where co-pollutant impacts are greater, and to guard against the

[19] Burtraw (2000). See also Baranzini *et al.* (2017).

[20] For discussion, see Boyce (2018).

[21] Boyce and Pastor (2013).

creation or exacerbation of co-pollutant hotspots. This again is an argument for nesting carbon pricing within a broader policy mix, rather than treating it as a one-price-fits-all magic bullet.

A final reason why carbon pricing is important is that it offers an opportunity to address the unresolved question of ownership of environmental sinks – in this case, the limited capacity of the biosphere to safely absorb CO2 emissions. In the absence of pricing, the free use of these sinks leads to overuse and abuse, an example of the so-called "tragedy of the commons" (more accurately termed the tragedy of open access).[22] Carbon pricing turns this open-access resource into a form of property. Depending, crucially, on how this novel property is allocated, it can help to advance a more egalitarian distribution of wealth and income, an issue to which I return below.

In short, carbon pricing is a key instrument in the climate policy toolkit. It can set a secure envelope within which emissions reductions are achieved by a variety of means. It incentivizes both cost-effective abatement in the short run and cost-reducing technological change in the longer run. And it can redress the open-access problem in a manner that not only recognizes the limited carbon-absorptive capacity of the biosphere to be a valuable asset, but also allocates ownership of this asset, and income from its use, so as to advance other goals such as greater distributional equity. These are things that economics can tell us.

Relationship between carbon price and emissions quantity

At the same time, it is important to review what economists know and do not know about the relationship between carbon prices and the quantity of emissions. We know that an increase in the price of fossil fuels will decrease the quantity consumed. But we don't know by exactly how much, especially over time frames that are long enough to allow for technological and institutional change.

A recent meta-analysis on the price elasticity of energy demand found an average short-run elasticity of -0.21 and an average long-run elasticity of -0.61.[23] In other words, a 10% increase in energy prices results in a 2.1% decline in the quantity consumed in the short run, and a 6.1% decline in the long run. In response to an increase in the price of gasoline, for example, people tend to drive their existing vehicles a bit less in the short run, and in the longer run they may buy more fuel-efficient vehicles. Even in the long run, however, the percentage decline in quantity is less than the percentage increase in price. This inelasticity reflects the fact that energy generally is a necessity, not a luxury. The elasticities today are somewhat closer to zero than those found in earlier studies, and the authors speculate that this may reflect a depletion of easier abatement options in the wake of past energy crises.

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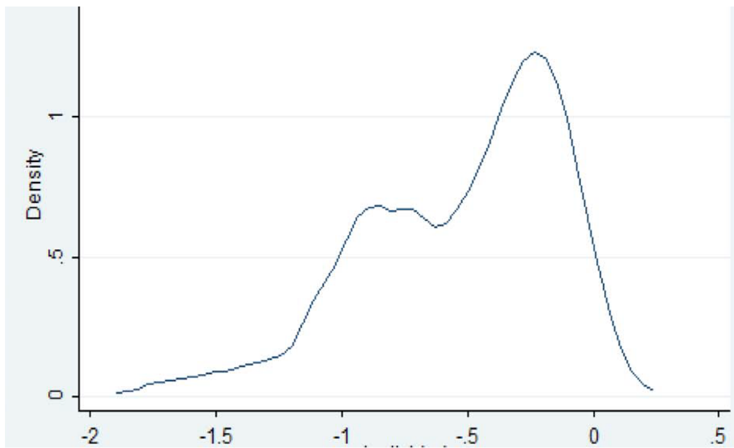
[22] On the difference between common property and open access, see Cole (2002).

[23] Labandeira *et al.* (2017).

A wide range of elasticity estimates were found in the 428 studies, all published between 1990 and 2016, that the authors analyzed (see Figure 4). These reflect, among other things, differences across energy products, countries, time, and estimation methodologies. They may also reflect differences in public policies; investment in mass transit systems, for example, makes it easier for consumers to reduce fuel use in response to increases in the price of gasoline. For these reasons, there is a degree of uncertainty as to elasticities, particularly over the long run. Moreover, past experience does not necessarily provide a reliable guide to future price responsiveness, particularly when considering price increases of the magnitude and duration that would be needed to meet the 1.5-2 degree warming target.

Figure 4: Frequency distribution of estimated long-run price elasticities of demand for energy



Note: Distribution of 959 estimated long-run price elasticities of demand obtained from multiple studies.

Source: Labandeira *et al*. (2017), Fig. 1.

This inevitable uncertainty, coupled with the centrality of emissions reduction targets as the policy goal, is a strong argument for setting an emissions quantity trajectory and letting prices adjust, as opposed to setting a price trajectory, letting quantities adjust, and hoping for the best. A quantity trajectory that guarantees the desired emissions reduction can be established in two ways.

One is simply to set a cap on total emissions, a task most easily accomplished “upstream,” at the pipeline terminals, ports and mine heads where fossil carbon first enters the economy. Permits are issued up to the limit set by the cap; it would be illegal bring unpermitted fossil fuel into the economy. Assuming that the permits are initially auctioned, or tradeable, or both, the carbon price can vary over time. If energy-saving technological or institutional changes proceed quickly, for example, the carbon price will be less than if such changes prove to be slow. Regardless, we will hit the quantity target.

Since there has been some confusion on this point, it is worth pointing out that prices would also increase if the quantity of fossil fuels entering the economy were restricted without issuing permits to create a carbon price. When OPEC restricts oil exports, for example, prices rise. The difference is that in the absence of marketable permits, the money that consumers pay in higher prices ends up in the pockets of energy suppliers, whereas with marketable permits there are other options for distribution of the money, as discussed below.

The second way to set the emissions trajectory is to establish an adjustable carbon tax with the rate keyed to quantity targets. This is what Switzerland has done, for example, in its CO2 levy on power plants. Adjustable tax rates are akin to adjustable-rate loans in which the interest rate is indexed to a benchmark. Carbon taxes can be indexed to quantity targets, so that the rate rises automatically when the target is not met (and falls if emission reduction goals are exceeded).[24]

In short, economics tells us that if the policy objective is a certain path of emission reductions, we should set the quantity and let the carbon price adjust rather than vice versa. Indeed, unless the price is determined by quantitative targets, there can be no assurance that carbon pricing will result in the desired level of emission reductions. Again, this is something economics tells us.

Distributional impacts of carbon pricing

The sums of money generated by carbon pricing will be substantial, particularly if the price is high enough to attain the emission reductions to keep the rise global temperatures within 1.5-2 °C. A simple calculation will illustrate the order of magnitude. U.S. CO2 emissions from fossil fuel combustion currently amount to about 5.2 billion tons/yr, or about 16 tons per capita.[25] At the $230/ton carbon price in the year 2020 in Nordhaus's 2.5 °C trajectory, this price would yield roughly $1 trillion/yr after taking into account the resulting reduction in demand. This is equivalent to roughly $3,000 per person, or about 6% of average U.S. personal income (currently about $50,000/yr). The amount will rise in subsequent years as the cap tightens, as long as demand for fossil fuel remains price-inelastic (since the percentage decrease in quantity will be smaller than the percentage increase in price).

This money – I'll term it "carbon rent" – is a transfer from consumers of fossil fuels (and of goods and services produced or distributed by using them) to whomever receives it. Not everyone will pay $3,000/yr. Some will pay more, some less, depending on the size of their carbon footprints. In general, the biggest consumers of carbon are the biggest consumers,

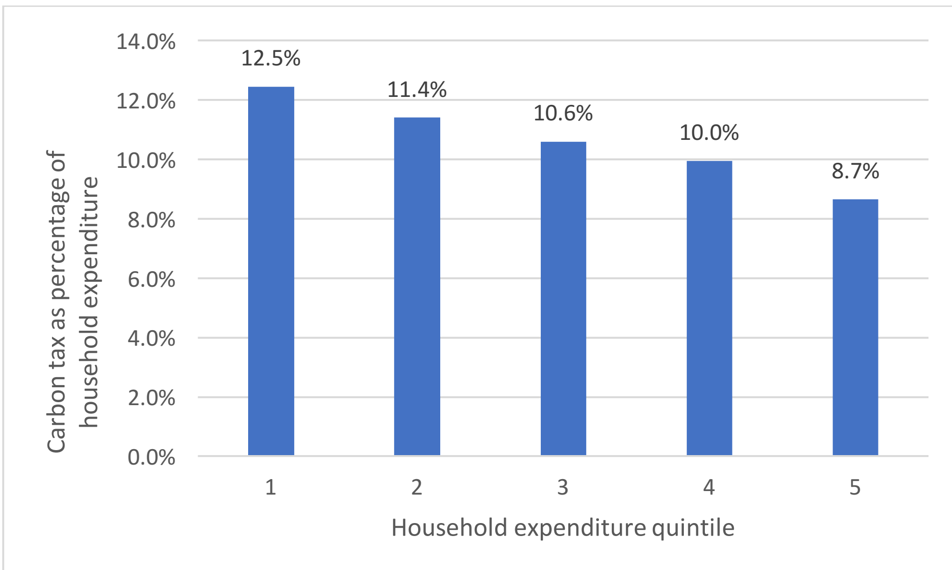
[24] For discussion, see also Acworth *et al.* (2017).

[25] U.S. Energy Information Administration, "Short-term Energy Outlook." Release date 12 September 2017: https://www.eia.gov/outlooks/steo/report/renew_co2.cfm?src=Environment-b1, accessed 22 September 2017.

period – people at the upper end of the income distribution. In absolute dollars, they'll pay more than others.[26]

Relative to annual incomes, however, upper-income households often will pay a lower percentage than lower-income households, at least in countries where fossil fuels are a necessity rather than a luxury.[27] Figure 5 shows the impact of a $200/ton CO2 tax in the U.S. by household expenditure quintile. In the lowest quintile, this carbon price would claim more than 12% of household expenditure. In the top quintile, it would claim less than 9%. In short, the impact of carbon pricing at this level would be (a) big and (b) regressive.

Figure 5: Incidence of $200/t CO2 tax in U.S.



Note: Based on consumer expenditure survey data for 2012-2014. Quintiles based on equivalent household expenditures using the square root scale, where equivalent household expenditures = household expenditures/(household size^1/2).

Source: Calculated from data presented in Fremstad and Paul (2017), Table 10.

Regardless of the degree to which carbon pricing itself is regressive, there is no question that increases in energy prices commensurate with what is needed to meet the 1.5-2 degree target will have highly perceptible impacts on the pocketbooks of low- and middle-income

[26] Governments consume carbon, too. In the U.S., for example, federal, state and local government account for roughly one-fourth of total fossil fuel use. An important issue in carbon pricing is whether, and if so, how, some of the carbon rent will be recycled to "keep government whole" (Boyce and Riddle, 2008).

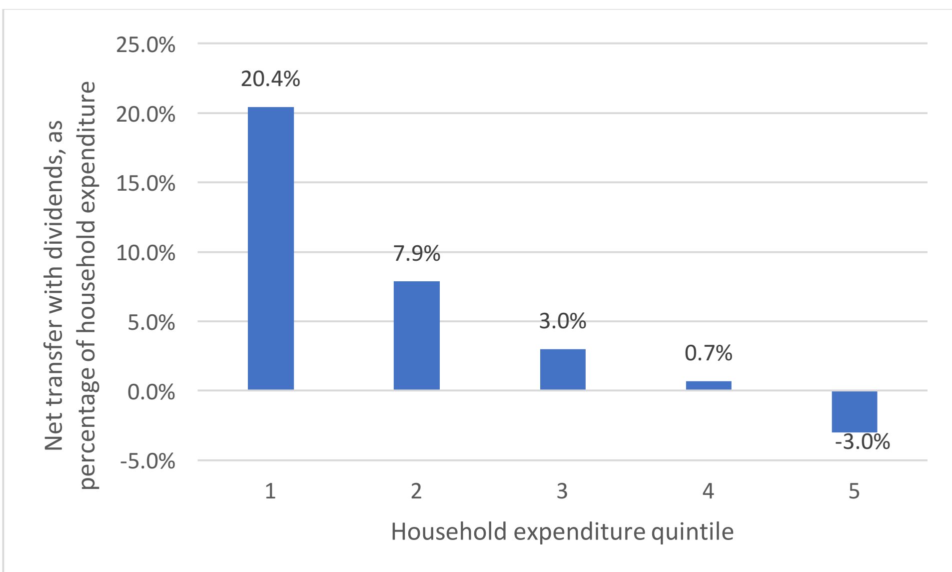
[27] The extent of measured regressivity depends, among other things, on whether household income or expenditure is taken as the base for calculations (Hassett *et al*., 2009). It also may depend on whether inflation-indexed changes in government transfer payments are taken into account (Cronin *et al.,* 2017). In some settings, possibly including many low-income countries, the incidence of carbon pricing is progressive; see, for example, Brenner *et al.* (2007), who found this to be true for China using 1995 consumption data.

households, and little doubt that the political repercussions could jeopardize the political sustainability of the carbon pricing policy. But the money that consumers pay as a result of carbon pricing does not disappear from the economy: it is a transfer, not a resource cost. If a substantial share of this money is rebated to the public as dividends (what economists call "lump-sum transfers"), the policy's net impact would be markedly and quite visibly progressive.

This is illustrated in Figure 6, which shows the impact of the \$200/t CO2 tax when coupled with disbursement of the revenue as equal per capita dividends. The lowest quintile would receive a positive transfer, net of the impact of the carbon price, equivalent to roughly 20% of household expenditure, while the top quintile would see a negative net transfer equivalent to 3% of theirs.

Carbon dividends are an example of a "feebate" system, in which people pay in proportion to their use of a resource they own in common, and receive equal rebates per person based on the principle of common ownership. The incentive for households to reduce their carbon footprints is not diminished by the dividends, since their own use of carbon affects what they pay but not what they receive.

Figure 6: Net incidence of \$200/t CO2 tax coupled with dividends in U.S.



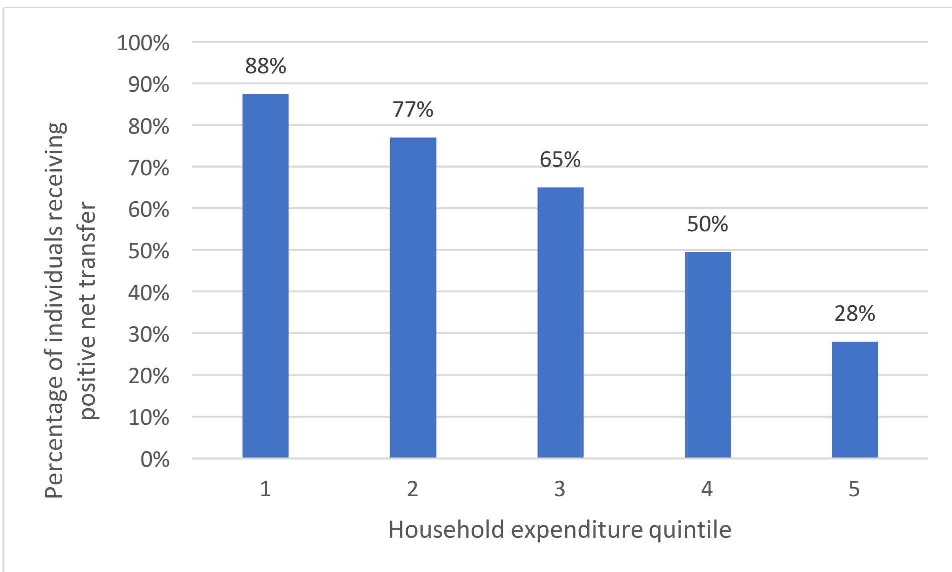
Source: Calculated from data presented in Fremstad and Paul (2017), Table 10.

Although a carbon fee-and-dividend system would be highly progressive in its net impact on the vertical distribution of income, there may be substantial horizontal variations within any given household income or expenditure stratum. Figure 7 shows the percentage of households in each quintile that would receive positive net transfers. In the poorest quintile, seven out of eight households come out ahead, receiving more in dividends than they pay as the result of carbon pricing; in the top quintile, 72% pay more than they receive.

The reasons for these horizontal variations include circumstances that are largely beyond the control of households, such as rural-urban differences in vehicle miles traveled and regional differences in needs for air conditioning in summer or heating in winter. On grounds of equity or political acceptability, policy makers may wish to take such variations into account in the allocation of part of the carbon rent.[28]

Underpinning the allocation of carbon rent is an implicit assignment of property rights to the limited carbon absorptive capacity of the biosphere. Given the amounts of money that will be on the table if and when serious carbon pricing is instituted, this assignment is a question of momentous import, both distributional and political.

Figure 7: Percentage of individuals receiving positive net transfers from $200/t CO2 tax coupled with dividends in U.S.



Source: Calculated from data presented in Fremstad and Paul (2017), Table 10.

Historically, the closest analogy to the allocation of carbon rent may be the allocation of land in frontier societies in earlier eras. One economist has remarked: "The initial allocation of these rights [to land] may have been coercive and unfair, but that ancient act is lost in the mists of history and no one really cares now, even though a significant portion of everyone's lifetime income is devoted to acquiring the right to call a small piece of the earth home."[29] Whether land ownership is truly a settled issue worldwide is an open question. Struggles over land rights were central in some of the most profound social and political upheavals of the 20th century, such as the Chinese revolution. In any case, the strife that historically often attended the

[28] For discussion, see Boyce and Riddle (2011) and Cronin et al. (2017).

[29] Ellerman (2005), p. 130.

establishment of land rights should give pause to anyone inclined to regard the allocation of carbon rights as a trivial matter.

The fact that serious carbon pricing will entail large-scale income transfers, based on the implicit underlying assignment of rights to the environmental sink asset, is another thing that economics can tell us.

Conclusions

To recap, economics cannot tell us the right answer to the most fundamental question in climate policy: how far we should allow CO2 levels and mean global temperature to rise above pre-industrial levels. This is a normative issue that the "efficiency" criterion of neoclassical economics is ill-equipped to address. In deriving a "social cost of carbon" that defies the prevailing consensus in the scientific and climate policy communities, founded on the normative criterion of safety, economists not only discount the future costs but also the credibility of the important things that economics usefully can tell us about climate change.

A central insight of economics is that carbon pricing is a key tool for climate change mitigation. It can set an envelope on total emissions, motivate both cost-effective emission reductions and cost-reducing technological change, and resolve the tragedy of open access to the biosphere's limited capacity to absorb carbon safely. Carbon pricing does not preclude other regulations and public policies; indeed, there are good reasons to deploy hybrid policy mixes. Just because emissions are legal – allowed by the regulatory framework – does not mean they should be free.

Owing to uncertainty as to the precise relationship between carbon prices and emission quantities, particularly over multi-year time frames, the only way to ensure that carbon pricing policies will meet emission reduction targets is to bind them together, by setting a quantity cap and letting permit prices adjust, or by indexing a carbon tax to quantitative emission reduction goals.

The distributional impacts of carbon pricing depend crucially on where the money goes. Rather than transferring money from consumers to energy suppliers (as would happen in a "cap-and-trade" system with free permit allocations to the firms) or to the government (as would happen if revenues from a tax or auctioned permits go into the treasury), part or all of the money can be returned to the public via equal per capita dividends. This option is not only attractive on equity grounds, but also may help to maintain broad public support for the carbon pricing policy as fossil fuel prices rise.

In sum, economics cannot tell us the right carbon price, but it *can* tell us a great deal about the right way to put a price on carbon. A healthy modicum of humility might help economists to get this message across.

Note

This paper draws on the author's forthcoming book, *The Case for Carbon Dividends* (Polity Press, 2018).

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