The Case Against a Carbon Tax

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EXECUTIVE SUMMARY

A vigorous campaign aimed at American policymakers and the general public has tried to create the perception that a federal carbon tax (or similar type of "carbon price") is a crucial element in the urgently needed response to climate change. Within conservative and libertarian circles, a small but vocal group of academics, analysts, and political officials are claiming that a revenue-neutral carbon tax swap could even deliver a "double dividend"—meaning that the conventional economy would be spurred in addition to any climate benefits. The present study details several serious problems with these claims.. The actual *economics* of climate change—as summarized in the peer-reviewed literature as well as the U.N. and Obama Administration reports—reveal that the case for a U.S. carbon tax is weaker than the public has been told.

In the policy debate over carbon taxes, a key concept is the "social cost of carbon," which is defined as the (present value of) future damages caused by emitting an additional ton of carbon dioxide. Estimates of the SCC are already being used to evaluate federal regulations, and will serve as the basis for any U.S. carbon tax. Yet the computer simulations used to generate SCC estimates are largely arbitrary, with plausible adjustments in parameters—such as the discount rate—causing the estimate to shift by at least an order of magnitude. Indeed, MIT economist Robert Pindyck considers the whole process so fraught with unwarranted precision that he has called such computer simulations "close to useless" for guiding policy.

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Future economic damages from carbon dioxide emissions can only be estimated in conjunction with forecasts of climate change. But recent history shows those forecasts are in flux, with an increasing number of forecasts of less warming appearing in the scientific literature in the last four years. Additionally, we show some rather stark evidence that the family of models used by the U.N.'s Intergovernmental Panel on Climate Change (IPCC) are experiencing a profound failure that greatly reduces their forecast utility.

Ironically, the latest U.N. Intergovernmental Panel on Climate Change (IPCC) report indicated that a popular climate target cannot be justified in cost/benefit terms. Specifically, in the middle-of-the-road scenarios, the economic compliance costs of limiting global warming to 2 degrees Celsius would likely be higher than the climate change damages that such a cap would avoid. In other words, the U.N.'s own report shows that aggressive emission cutbacks—even if achieved through an "efficient" carbon tax—would probably cause more harm than good.

If the case for emission cutbacks is weaker than the public has been led to believe, the claim of a "double dividend" is on even shakier ground. There really *is* a "consensus" in this literature, and it is that carbon taxes cause more economic damage than generic taxes on labor or capital, so that in general even a revenue-neutral carbon tax swap will probably reduce conventional GDP growth. (The driver of this result is that carbon taxes fall on narrower segments of the economy, and thus to raise a given amount of revenue require a higher tax rate.) Furthermore, in the real world at least *some* of the new carbon tax receipts would probably be devoted to higher spending (on "green investments") and lump-sum transfers to poorer citizens to help offset the impact of higher energy prices. Thus in practice the economic drag of a new carbon tax could be far worse than the idealized revenue-neutral simulations depict.

When moving from academic theory to historical experience, we see that carbon taxes have not lived up to the promises of their supporters. In Australia, the carbon tax was quickly removed after the public recoiled against electricity price hikes and a faltering economy. Even in British Columbia—touted as the world's finest example of a carbon tax—the experience has been underwhelming. After an initial (but temporary) drop, the B.C. carbon tax has not yielded significant reductions in gasoline purchases, and it has arguably reduced the B.C. economy's performance relative to the rest of Canada.

Both in theory and practice, economic analysis shows that the case for a U.S. carbon tax is weaker than its most vocal supporters have led the public to believe. At the same time, there is mounting evidence in the *physical* science of climate change to suggest that human emissions of carbon dioxide do not cause as much warming as is assumed in the current suite of official models. Policymakers and the general public must not confuse the confidence of carbon tax proponents with the actual strength of their case.

INTRODUCTION

Over the years, Americans have been subject to a growing drumbeat of the (ostensibly) urgent need for aggressive government action on climate change. After two failed attempts at a U.S. federal cap-and-trade program, those wishing to curb emissions have switched their focus to a *carbon tax*.

Although environmental regulation and taxes are traditionally associated with progressives Democrats, in recent years several vocal intellectuals and political officials from the right have begun pitching a carbon tax to libertarians and conservatives. They argue that climate science respects no ideology and that a carbon tax is a "market solution" far preferable to the top-down regulations that liberal Democrats will otherwise implement. In particular, advocates of a carbon tax

claim that if it is *revenue neutral* then a "tax swap" deal involving reductions in corporate and personal income tax rates might deliver stronger economic growth *and* reduce the harms from climate change, whatever they might be.

Although they often claim to be merely repeating the findings of "consensus science," advocates of aggressive government intervention stand on very shaky ground. Using standard results from the economics of climate change—as codified in the peer-reviewed literature and published reports from the U.N. and Obama Administration—we can show that the case for a carbon tax is weaker than the public has been led to believe. Furthermore, the real-world experiences of carbon taxes in Australia and British Columbia cast serious doubt on the promises of a "market-friendly" carbon tax in the United States.

The present study will summarize some of the key issues in the climate policy debate, showing that a U.S. carbon tax is a dubious proposal in both theory and practice.

THE "SOCIAL COST OF CARBON"

The "social cost of carbon" (often abbreviated SCC) is a key concept in the economics of climate change and related policy discussions of a carbon tax. The SCC is defined as the present-discounted value of the net future external damages from an additional unit of carbon dioxide emissions. In terms of economic theory, the SCC measures the "negative externalities" from emitting CO_2 (and other greenhouse gases expressed in CO_2-equivalents), and helps quantify the "market failure" where consumers and firms do not fully take into account the true costs of their carbon-intensive activities. To a first approximation, the "optimal" carbon tax would reflect the SCC (along the emission trajectory that would obtain with the carbon tax regime), and in practice the Obama Administration has issued estimates[1] of the SCC that are being used in the cost/benefit evaluation of federal regulations (such as

minimum energy efficiency standards) that aim to reduce emissions relative to the baseline.

It is important to note that the SCC reflects the estimated damages of climate change on *the entire world*. This means that if the SCC (calculated in this fashion) is used in federal cost/benefit analyses, the analyst is contrasting benefits accruing mostly to non-Americans with costs borne mostly by Americans. Whether the reader thinks this is valid or not, it is clearly an important issue that has not been made clear in the U.S. debate on climate change policy. In any event, the Office of Management and Budget (OMB), in its Circular A-4, clearly states that federal regulatory analyses should focus on domestic impacts:

> Your analysis should focus on benefits and costs that accrue to citizens and residents of the United States. Where you choose to evaluate a regulation that is likely to have effects beyond the borders of the United States, these effects should be reported separately.[2]

However, when the Obama Administration's Interagency Working Group calculated the SCC, it ignored this clear OMB guideline, and only reported a *global* value of the SCC. Thus, if a regulation (or carbon tax) is thought to reduce carbon dioxide emissions, then the estimated benefits (calculated with use of the SCC) will vastly overstate the benefits *to Americans*.

As an affluent nation, the U.S. economy is much less vulnerable to the vagaries of weather and climate. Using two different approaches, the Working Group in 2010 "determined that a range of values from 7 to 23 percent should be used to adjust the global SCC to calculate domestic effects. Reported domestic values should use this range" (p. 11). Therefore, following OMB's clear guideline on reporting the *domestic* impacts of proposed regulations, the SCC value would need to be reduced anywhere from 77 to 93 percent, in order to show the benefit *to Americans* from stipulated reductions in carbon dioxide emissions. To repeat, these figures all derive from the Obama Administration's own Working Group report.

In addition to such procedural problems with the use of the SCC in federal policy, there are deeper, conceptual problems. The average layperson may have the belief that the "social cost of carbon" is an empirical fact of nature that scientists in white lab coats measure with their equipment. However, in reality the SCC is a malleable concept that is entirely driven by the analyst's (largely arbitrary) initial assumptions. The estimated SCC can be quite large, modest, or even *negative*—this latter meaning that greenhouse gas emissions should arguably be subsidized to benefit humanity—depending on defensible adjustments of the inputs to the analysis.

The most popular current approach used by U.S. policymakers to estimate the SCC involves the use of computer-based Integrated Assessment Models (IAMs), which are complex simulations of the entire global economy and climate system for hundreds of years. Officially, the IAMs are supposed to rely on the latest results in the *physical* science of climate change, as well as *economic* analyses of the impacts of climate change on human welfare, where these impacts are measured in monetary units but include a wide range of non-market categories (such as flooding and loss of ecosystem services). With particular assumptions about the path of emissions, the physical sensitivity of the climate system to atmospheric CO_2 concentrations, and the impact on humans from changing climate conditions, the IAMs estimate the flow of *incremental* damages occurring centuries into the future as a result of an additional unit of CO_2 emissions in some particular year. Then this flow of additional dollar damages (over the centuries) can be turned into an equivalent present value expressed in the dollars at the date of the emission, using a discount rate chosen by the analyst, where this rate is typically *not* derived from observations of market rates of interest but is instead picked (quite openly) according to the analyst's ethical views on how future generations should be treated.

In May 2013, the Interagency Working Group produced an updated SCC value by incorporating revisions to the underlying three Integrated Assessment Models (IAMs) used by the IWG in its initial 2010 SCC determination. But, at that time, the IWG did *not* update the equilibrium climate sensitivity (ECS) employed in the IAMs. The ECS is a critical concept in the physical science of climate change. Loosely speaking, it refers to the long-run (after taking into account certain feedbacks) warming in response to a doubling of carbon dioxide concentrations. Thus, it is incredibly significant that the published estimates of the ECS were trending downward, and yet the Obama Administration Working Group did not adjust this key input into the Integrated Assessment computer models. Specifically, they made no downward adjustment in this key parameter in their May 2013 update despite there having been, since January 1, 2011, at least 15 new studies and 21 experiments (involving more than 45 researchers)[3] examining the ECS, each lowering the best estimate and tightening the error distribution about that estimate.

The dramatically lowered sensitivity in the recent literature is graphically shown in our Figure 1. The range used by the IWG is clearly outdated; it was calculated by Roe and Baker in 2007.[4]

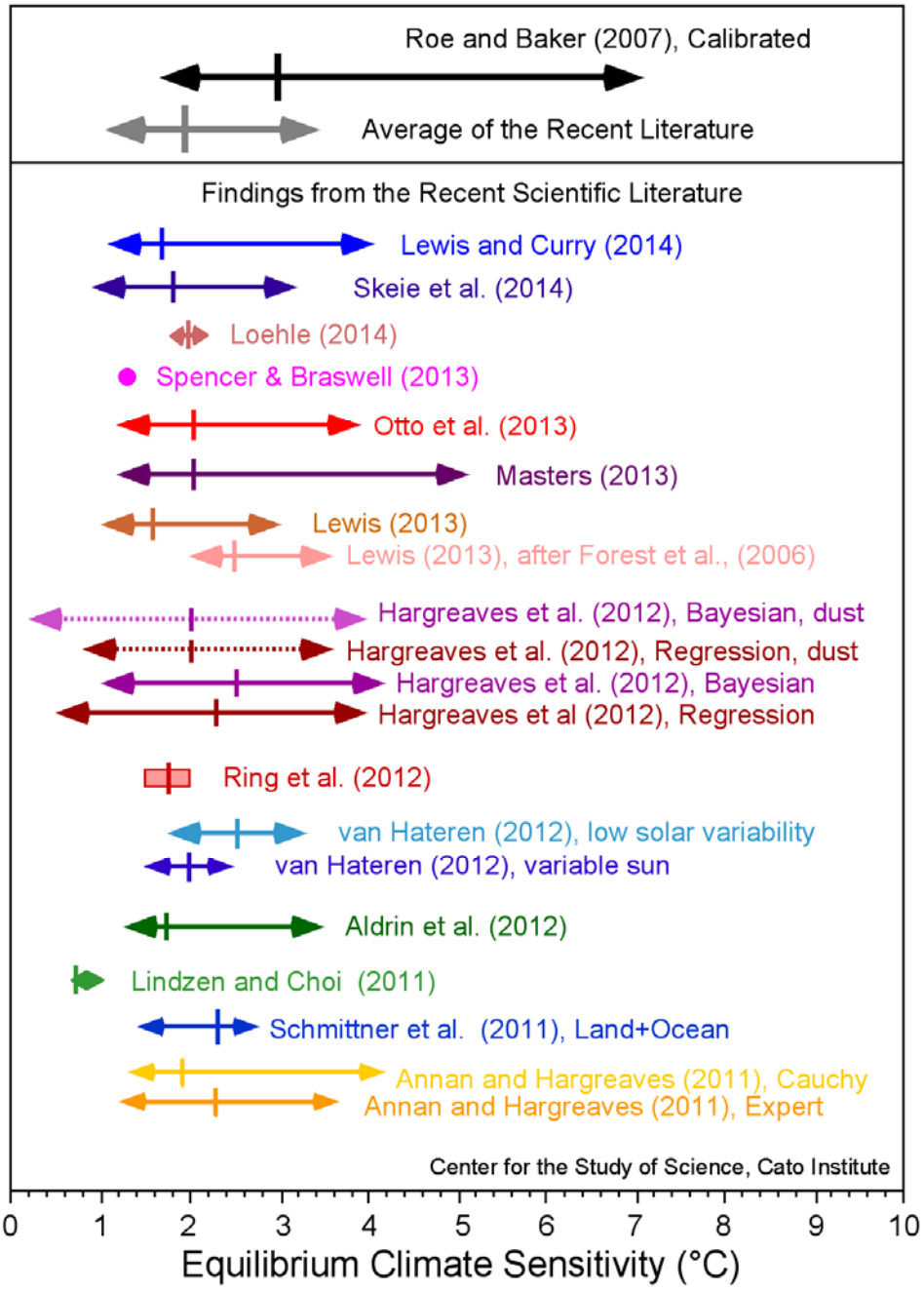

Figure 1. The median (indicated by the small vertical line) and 90% confidence range (indicated by the horizontal line with arrowheads) of the climate sensitivity estimate used by the Interagency Working Group on the Social Cost of Carbon Climate (Roe and Baker, 2007) is indicated by the top black arrowed line. The average of the similar values from 21 different determinations reported in the recent scientific literature is given by the grey arrowed line (second line from the top). The sensitivity estimates from the 21 individual determinations of the ECS as reported in new research published after January 1, 2011 are indicated by the colored arrowed lines. The arrows indicate the 5 to 95% confidence bounds for each estimate along with the best estimate (median of each probability density function; or the mean of multiple estimates; colored vertical line). Ring et al. (2012)[5] present four estimates of the climate sensitivity and the

red box encompasses those estimates. Spencer and Braswell (2013)[6] produce a single ECS value best-matched to ocean heat content observations and internal radiative forcing.

The abundance of literature supporting a lower climate sensitivity was at least partially reflected in the latest (2013) assessment of the Intergovernmental Panel on Climate Change (IPCC):

> Equilibrium climate sensitivity is *likely* in the range 1.5°C to 4.5°C (*high confidence*), *extremely unlikely* less than 1°C (*high confidence*), and *very unlikely* greater than 6°C (*medium confidence*). The lower temperature limit of the assessed *likely* range is thus less than the 2°C in the AR4 [Fourth Assessment Report]…

Clearly, the IWG's assessment of the low end of the probability density function that best describes the current level of scientific understanding of the climate sensitivity is indefensible.

The 2013 study of Otto et al., which was available at the time of the IWG's 2013 revision, is particularly noteworthy in that 15 of the paper's 17 authors were also lead authors of the 2013 IPCC report. Otto has a mean sensitivity of 2.0°C and a 5-95% confidence interval of 1.1 to 3.9°C. If the IPCC truly defined the consensus, that consensus has now changed. Instead of a 95th percentile value of 7.14°C, as used by the IWG, a survey of the recent scientific literature suggests a value of 3.5°C—more than 50% lower. This is very significant and important difference because the high end of the ECS distribution has a large impact on the SCC determination—a fact frequently commented on by the IWG.

Yet to repeat, the problem with the SCC as a tool in policy analysis goes beyond quibbles over the proper parameter values. At least the equilibrium climate sensitivity (ECS) is *an objectively defined* (in principle) feature of nature. In contrast, there are other parameters needed to calculate the SCC that by their very essence are subjective, such as the analyst's view on the proper weight to be given to the welfare of future generations. Needless to say, this approach to "measuring" the SCC

is hardly the way physicists estimate the mass of the moon or the charge on an electron. To quote MIT economist Robert Pindyck (who *favors* a U.S. carbon tax) in his scathing *Journal of Economic Literature* article:

> And here we see a major problem with IAM-based climate policy analysis: The modeler has a great deal of freedom in choosing functional forms, parameter values, and other inputs, and different choices can give wildly different estimates of the SCC and the optimal amount of abatement. You might think that some input choices are more reasonable or defensible than others, but no, "reasonable" is very much in the eye of the modeler. **Thus these models can be used to obtain almost any result one desires.** [Pindyck 2013, bold added.][7]

To see just how significant some of the apparently innocuous assumptions can be, consider the latest estimates of the SCC put out by the Obama Administration's Working Group. For an additional ton of emissions in the year 2015, using a 3% discount rate the SCC is $36. However, if we use a 2.5% discount rate, the SCC rises to $56/ton, while a 5% discount rate yields a SCC of only $11/ton.[8] Note that this huge swing in the estimated "social cost" of carbon relies on the same underlying models of climate change and economic growth; the only change is in adjustments of the discount rate which are quite plausible. Indeed, the Administration's Working Group came under harsh criticism because it ignored explicit OMB guidance to include a *7 percent* discount rate in all federal cost/benefit analyses, presumably because the SCC at such a discount rate would be close to $0/ton or even negative.[9]

The reason the Obama Administration estimates of the SCC are so heavily dependent on the discount rate is that the three underlying computer models all show relatively modest damages from climate change in the early decades. Indeed, one model (Richard Tol's FUND model) actually exhibits *net benefits* from global warming through about 3°C of warming relative to preindustrial temperatures. The higher the discount rate, the more weight is placed on earlier time periods (when global warming is not as destructive or is even beneficial) and the less important are the large damages that will not occur in the computer simulations until future

centuries. Economists do not agree on the appropriate discount rate to use in such settings, because the usual arguments in favor of market-based measures (which would yield a very low SCC) are not as compelling when we cannot bind future policymakers.[10] Such are the difficulties in making public policy on the basis of threats that will not fully manifest themselves for another two generations.

If the economic models were updated to more accurately reflect the latest developments from the physical and biological sciences, the estimated "social cost of carbon" would likewise decline between one-third and two thirds,[11] because lower temperature increases would translate into reduced climate-change damages. This is a sizeable and significant reduction.

Then there are problems with the climate models themselves. There is clearly a large and growing discrepancy between their predictions and what is being observed, as shown in Figure 2.

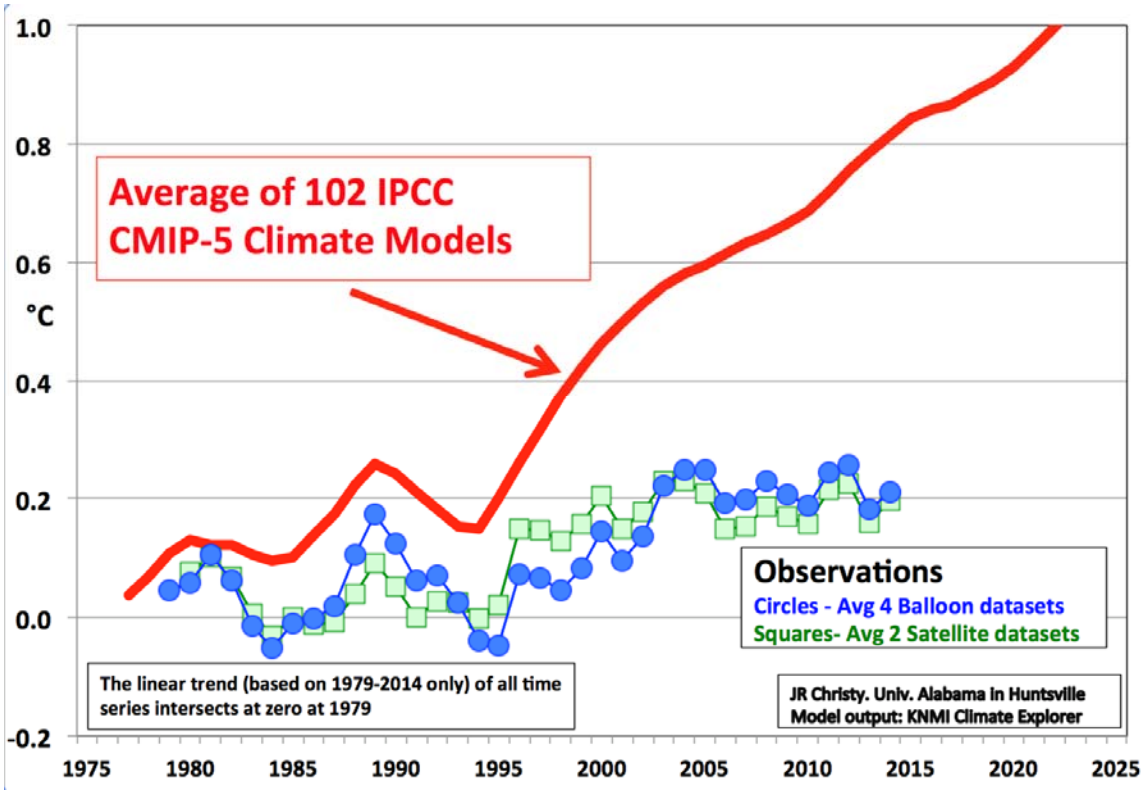

Figure 2. Five-year running means of the model projections in the 2013 IPCC report for the lower troposphere versus both weather balloon and satellite observations. While surface temperatures are compromised by a number of problems, such as urbanization and observational and instrumental changes, the satellite and weather balloon data—which clearly show the same temperatures—are less compromised.

Our illustration, taken from John Christy of University of Alabama-Huntsville,[12] dramatically shows the climate modelling problem in a nutshell. It shows model-predicted and observed temperatures, not at the surface, but in the lower troposphere, roughly from 5,000 to 30,000 feet. These are less compromised by earth's complicated surface and man's role in altering it. More important, though, is that it is the vertical profile of temperature that determines atmospheric stability. When the "lapse rate", or the difference between the lowest layers and higher levels is large, the atmosphere is unstable. Instability is the principal source for global precipitation. While models can be (and are) "tuned" to mimic surface temperatures, the same can't be done as easily in the vertical.

As the figure indicates, the air above the surface is warming far more slowly than had been predicted, so that the difference between the surface and the upper air has changed very little. This means that observed global precipitation should be the same as it was. The forecast warming of the upper layers (in red) would reduce the surface-to-upper air temperature difference, which would tend to reduce precipitation.

That means that the models themselves are making systematic errors in their precipitation projections. This has a dramatic effect on the resultant climate. When the surface is wet, which is what occurs after it rains, the sun's energy is directed towards the evaporation of that moisture rather than the direct heating of the surface. In other words, much of what we call "sensible weather" (the kind of weather you can sense) is determined by the vertical distribution of temperature. If

the popular climate models get that wrong (which is what's happening) then all the subsidiary weather caused by it is also incorrectly specified.

Therefore there are problems and arbitrariness not just with the economic assumptions, but with the physical models that are used as input to the SCC calculations. The situation is even worse than described above by Pindyck.

So, even though the modelled sensitivities are dropping, there are still indications that the models themselves are too hot. None of the current batch of "official" SCC calculations accounts for this.

Besides the arbitrariness and/or dubious choices for the major input parameters, another problem with use of the SCC as a guide to setting carbon taxes is the problem of *leakage*. Strictly speaking, it would make sense (even in textbook theory) to calibrate only a *worldwide and uniformly enforced* carbon tax to the SCC. If a carbon tax is applied only to certain jurisdictions, then emission cutbacks in the affected region are partially offset by increased emissions (relative to the baseline) in the non-regulated regions. Depending on the specifics, leakage can greatly increase the economic costs of achieving a desired climate goal, and thus the "optimal" carbon tax is lower if applied unilaterally in limited jurisdictions.

To get a sense of the magnitude of the problems of leakage, consider the results from William Nordhaus, a pioneer in the economics of climate change, and creator of the DICE model (one of the three used by the Obama Administration).[13] After studying his 2007 model runs, Nordhaus reported that relative to the case of the entire globe enforcing the carbon tax, to achieve a given environmental objective (such as a temperature ceiling or atmospheric concentration) with only 50 percent of planetary emissions covered would involve an economic abatement cost penalty of *250 percent*. Even if the top 15 countries (by emissions) participated in the carbon tax program, covering three-quarters of the globe's emissions, Nordhaus still

estimated that compliance costs for a given objective would be 70 percent higher than for the full-coverage baseline case.[14]

To see the tremendous problem of limited participation from a different perspective, one can use the same model that EPA uses to calculate the effect of various policy proposals. The Model for the Assessment of Greenhouse-Gas Induced Climate Change (MAGICC) is available and easy-to-use on the Cato Institute website. MAGICC shows that even if the U.S. linearly reduced its emissions to *zero* by the year 2050, the average global temperature in the year 2100 would be 0.1°C—that's one-tenth of a degree—lower than would otherwise be the case.[15] Note that this calculation does not even take into account "leakage," the fact that complete cessation of U.S. emissions would induce other nations to increase their economic activities and hence emissions. Our point in using these results from the MAGICC modeling is not to christen them as confident projections, but rather to show that *even on their own terms, using an EPA-endorsed model,* American policymakers have much less control over global climate change than they often imply.

U.N. REPORTS CAN'T JUSTIFY POPULAR CLIMATE GOAL

Although the goal's selection was never formally explained, advocates of government intervention to mitigate climate change have broadly settled on a *minimum* goal of limiting global warming (relative to preindustrial times) to 2°C, with many pushing for much more stringent objectives (such as limiting atmospheric greenhouse gas concentrations to 350ppm of CO_2). Given the confidence with which carbon tax advocates refer to the "consensus" among scientists on the key issues in the climate change debate, the innocent American public would surely conclude that the periodic reports from the United Nations Intergovernmental Panel on Climate Change (IPCC) would *easily* justify implementation of government policies to hit the 2°C target.

Ironically, this is not the case. According to 2013 IPCC report [often referred to as "AR5" for "Fifth Assessment Report"], to "likely" limit global warming to 2°C would require stabilizing atmospheric concentrations between 430 - 480ppm by the year 2100.[16] The same AR5 report shows that achieving this climate goal would entail reductions in consumption in the year 2100 of 4.8 percent (which is the central estimate, and relative to the baseline).[17] These are the *costs* of achieving the popular 2°C goal, according to the latest U.N. report.

In contrast, to compute the *benefits* of the 2°C goal we would need to know the *reduction* in climate change damages that would result under business-as-usual versus the mitigation scenario (with the temperature ceiling). Even under the most pessimistic emission scenario with no government controls (RCP8.5), by 2100 the AR5's central estimate of global warming is about 4.5°C, and a more realistic business-as-usual scenario (between RPC6 and RPC8.5) would involve warming by 2100 of less than 4°C.[18] Therefore the *gross* benefits of the stipulated mitigation policy are the climate change damages from 4°C warming minus the climate change damages from 2°C warming.

Unfortunately, the AR5 report does not allow us to compute such figures, because just about all of the comprehensive analyses of the impacts of global warming consider ranges of 2.5°C - 3°C. The AR5 *does* contain a table[19] summarizing some of the estimates in the literature, out of which the most promising (for our task) are two results from Roson and van der Mensbrugghe's 2012 study.[20] They estimated that 2.3°C warming would reduce GDP by 1.8 percent, while 4.9°C warming would reduce GDP by 4.6 percent. (Note that this particular estimate was the *only* one in the AR5 table that estimated the impact of warming higher than 3.2°C.)

Therefore, using ballpark figures, one could conclude from the AR5 summary of impacts that limiting climate change to 2°C rather than an unrestricted 4°C of warming, would mean that the Earth in the year 2100 would be spared about (4.6-1.8) = 2.8 percent of GDP loss in climate change damages. In contrast, the same IPCC

AR5 report told us that the *economic compliance* costs of the mitigation goal would be 4.8 percent of consumption in the year 2100.

As this demonstration has shown, even if we take the IPCC's numbers at face value, and even assuming away the practical problems that would prevent mitigation policies from reaching the theoretical ideal, the popular climate goal of limiting global warming to 2°C would most likely entail greater economic damages than it would deliver in benefits (in the form of reduced climate change damages). The pursuit of more aggressive goals, and/or the use of imperfectly designed policy tools to achieve them, would, of course, only make the mismatch between costs and benefits even worse.

"Fat Tails" and Carbon Tax as Insurance?

As a postscript to these observations, we note that the leaders in the pro-carbon tax camp are abandoning traditional cost/benefit analysis as (allegedly) inappropriate in the context of climate change. For example, Harvard economist Martin Weitzman has warned that climate scenarios involve "fat tails" that (mathematically) make the conventionally-calculated social cost of carbon tend to infinity. Weitzman and others have moved away from treating a carbon tax as a policy response to a given (and known) negative externality, and instead liken it to a form of insurance pertaining to a catastrophe that *might* happen but with unknown likelihood. But the utility of such "insurance" is being compromised, given the strong emerging evidence very large warming is unlikely.

This approach, which is growing in popularity among the advocates of aggressive government intervention, has several problems. In the first place, the whole *purpose* of the periodic IPCC reports was to produce a compilation of the "consensus" research in order to guide policymakers. But when the models and methods contained in the IPCC reports do not yield aggressive enough action, critics such as Weitzman point out their (admitted) shortcomings and propose that policymakers

take actions based on what we *don't* know.[21] Yet as economist David R. Henderson points out, broad-based uncertainty cuts *both* ways in the climate change policy debate. For example, it is *possible* that the Earth is headed into a period of prolonged cooling, in which case offsetting anthropogenic warming would be beneficial—meaning that a carbon tax would be undesirable.[22]

Another problem with Weitzman's approach—as Nordhaus, among other critics, has pointed out[23]—is that it could be used to justify aggressive actions against *several* catastrophic risks, including asteroids, rogue artificial intelligence developments, and bio-weapons. After all, we can't *rule out* humanity's destruction from a genetically engineered virus in the year 2100, and what's worse we are not even sure how to construct the probability distribution on such events. Does that mean we should be willing to forfeit 5 percent of global consumption to merely reduce the likelihood of this catastrophe?

This question leads into the final problem with the insurance analogy: With actual insurance, the risks are well-known and quantifiable, and competition among insurers provides rates that are reasonable for the damages involved. Furthermore, for all practical purposes buying the insurance policy *eliminates* the (financial) risk. Yet to be analogous to the type of "insurance" that Weitzman et al. are advocating, a homeowner would be told that there was a roving gang of arsonists who might, decades from now, set his home on fire, that a fire policy would cost 5 percent of income every year until then, and that even if the house were struck by the arsonists, the company would indemnify the owner for only *some* of the damages. Who would buy such an "insurance" policy?

CARBON TAX REFORM "WIN-WINS"? THE ELUSIVE "DOUBLE DIVIDEND"

Some proponents of a carbon tax have tried to decouple it entirely from the climate change debate. They argue that if the receipts from a carbon tax were devoted to reductions in taxes on labor or capital, then the economic cost of the carbon tax

would be reduced and might even be *negative*. In other words, they claim that by "taxing bads, not goods," the U.S. might experience a "double dividend" in which we tackle climate change *and* boost conventional economic growth.

Such claims of a double dividend are emphasized in appeals to libertarians and conservatives to embrace a carbon "tax swap" deal. For example, in a 2008 *NYT* op ed calling for a revenue-neutral carbon tax swap, Arthur Laffer and Bob Inglis wrote, "Conservatives do not have to agree that humans are causing climate change to recognize a sensible energy solution."[24] For another example, in his 2015 study titled, "The Conservative Case for a Carbon Tax," Niskanen Center president Jerry Taylor writes, "Even if conservative narratives[25] about climate change science and public policy are to some extent correct, conservatives should say 'yes' to a revenue-neutral carbon tax."[26]

The idea of revenue-neutral "pro-growth" carbon tax reform for the U.S. is arguably a red herring, as it is very unlikely that any national politically feasible deal will respect revenue neutrality. On lower jurisdictions, note that Governor Jerry Brown wanted to use California's cap-and-trade revenue for high-speed rail,[27] while the website for the Regional Greenhouse Gas Initiative (RGGI)—which is the cap-and-trade program for power plants in participating Northeast and Mid-Atlantic states—proudly explains how its revenues have been spent on renewables, energy efficiency projects, and other "green" investments.[28] And far from insisting on revenue neutrality, Washington State Governor Jay Inslee wants to install a new state-level cap-and-trade levy on carbon emissions to fund his $12.2 billion transportation plan.[29]

Ironically enough, even Taylor *in his very study appealing to conservatives* touts a *non*-revenue-neutral carbon tax (which would impose a net tax hike of at least $695 billion in its first 20 years[30]). It is possible that this was a mere oversight (i.e. that in his study Taylor genuinely believed he was pushing a revenue neutral plan but was simply ignorant of its details), but all doubts were removed a month later in a

Niskanen Center post in which Taylor wrote: "But what if a tax-for-regulation swap were to come up in an attempt to address budget deficits and the looming fiscal imbalance?....But even were those fears realized, conservatives should take heart: using carbon tax revenues to reduce the deficit makes good economic sense."[31]

With progressives enumerating the various "green" investments that could be funded by a carbon tax, and with even one of the leaders in the conservative pro-carbon tax camp laying the intellectual foundation for a net tax hike, it should be clear that a revenue-neutral deal at the federal level is very unlikely. However, in order to drive home just *how* baseless are the claims that a carbon tax could somehow deliver a "win-win," we should review the results from the academic economists publishing in the field.

For example, a 2013 Resources for the Future (RFF) study[32] considered the different impacts on GDP from various methods of implementing a revenue-neutral carbon tax of varying levels. Figure 3 below reproduces their findings for the case of a $30/ton tax on CO_2 (in 2012 dollars) which is *completely* revenue neutral, with the funds being returned to citizens through one of four ways: (1) reductions in the corporate income tax rate and personal income tax rate on dividends, interest, and capital gains (blue line), (2) reductions in the payroll tax rate and personal income tax rate on labor income (red line), (3) reductions in state sales tax rates (green line), or (4) a lump-sum payment made to each adult citizen (purple line). The carbon tax is imposed in 2015 and revenue neutrality is maintained throughout the scenario.

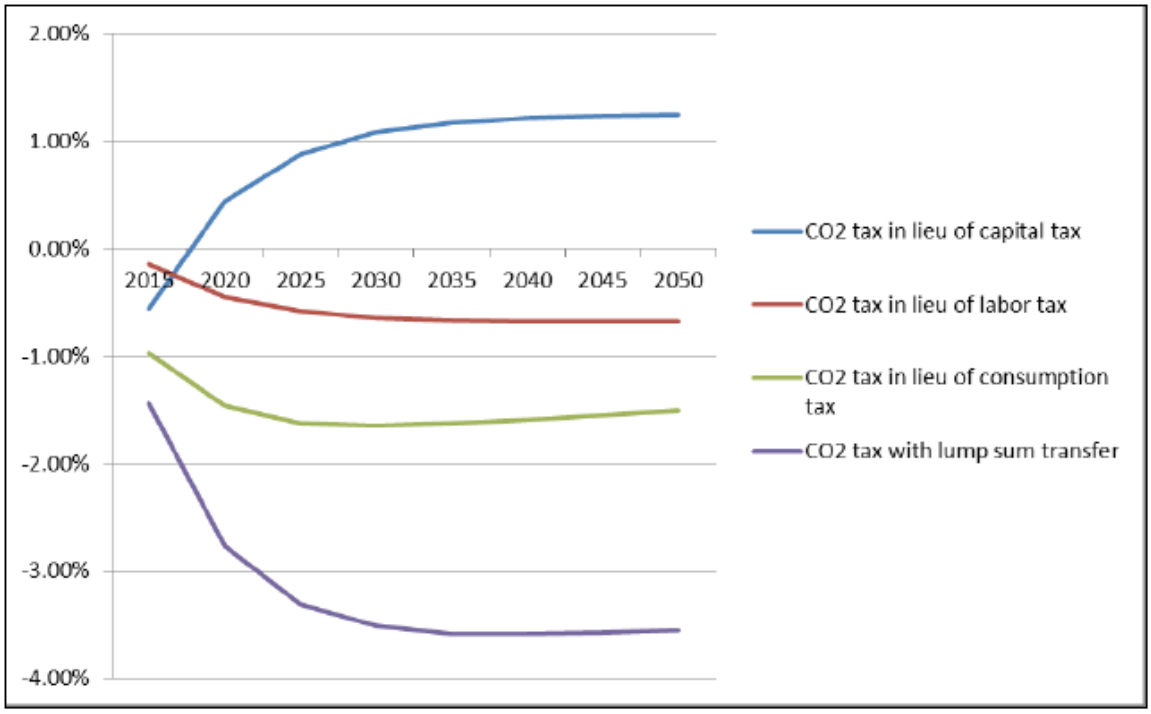

Figure 3 Difference in GDP Relative to Baseline from Revenue-Neutral $30/ton Carbon Dioxide Tax. SOURCE: 2013 Resources for the Future study, Figure 1

The results from the RFF modeling may surprise readers who are familiar with the "pro-growth" claims about a carbon tax swap deal. As Figure 3 reveals, *all* of the tax swaps reduced GDP relative to the baseline in the beginning. The only way to *eventually* see a "double dividend"—where the economy was stimulated in addition to any environmental benefits from the new carbon tax—was to refund all of the revenues *exclusively* through offsetting tax cuts on capital. Supposing instead that a completely revenue neutral deal used the carbon tax receipts to fund payroll tax reductions, Figure 3 shows (red line) that the economy would actually suffer a *permanent* reduction of about half a percentage point of GDP. To reiterate, this result may be very surprising to those familiar with the mantra, "tax bads, not goods." To the extent that a U.S. carbon tax were *not* fully revenue neutral, the reality would be much worse than is depicted in the theoretical ideal of Figure 3.

It should be stressed that RFF is a respected organization in this arena and it's fair to say that most of its scholars would *endorse* a (suitably designed) U.S. carbon tax; their team's modeling results are quite consistent with the academic literature.

Indeed, in a 2013 review article in *Energy Economics*, Stanford economist Lawrence Goulder—one of the pioneers in the analysis of environmental tax analysis—surveyed the literature and concluded:

> **If, prior to introducing the environmental tax, capital is highly overtaxed (in efficiency terms) relative to labor, and if the revenue-neutral green tax reform shifts the burden of the overall tax system from capital to labor (a phenomenon that can be enhanced by using the green tax revenues exclusively to reduce capital income taxes),** then the reform can improve (in efficiency terms) the relative taxation of these factors. If this beneficial impact is strong enough, it can overcome the inherent efficiency handicap that (narrow) environmental taxes have relative to income taxes as a source of revenue.
>
> …
>
> The presence or absence of the double dividend thus depends on the nature of the prior tax system and on how environmental tax revenues are recycled. Empirical conditions are important. **This does not mean that the double dividend is as likely to occur as not, however. The narrow base of green taxes constitutes an inherent efficiency handicap…**Although results vary, **the bulk of existing research tends to indicate that even when revenues are recycled in ways conducive to a double dividend, the beneficial efficiency impact is not large enough to overcome the inherent handicap, and the double dividend does not arise.** [Goulder 2013, bold added.][33]

In short, Goulder is saying that the bulk of research finds that even a theoretically ideal revenue-neutral carbon tax would probably *not* promote conventional economic growth (in addition to curbing emissions). The only way such a result is even theoretically possible is if the original tax code is particularly distorted in a certain dimension (such as taxing capital much more than labor), *and* if the carbon tax revenues are then devoted to reducing that distortion.

It is important for libertarian and conservative readers—concerned about the economic impacts of a new carbon tax—to understand what Goulder means when he explains that the "narrow base of green taxes constitutes an inherent efficiency handicap." If we put aside for the moment concern about climate change, then

generally speaking it would be foolish (on standard tax efficiency grounds) to raise revenue by taxing carbon dioxide emissions rather than taxing labor or capital more broadly. The tax on CO_2 would have a much narrower base, meaning that it would take a higher *rate* of taxation to yield a given dollar amount of revenue. Since standard analyses suggest that the economic harms of taxes (the "deadweight losses") are proportional to the *square* of the tax rate, these considerations mean that even a dollar-for-dollar tax swap, in which a new carbon tax raised $*x* which was then used to fund rate reductions in labor or capital taxes, would nonetheless *increase* the economic drag of the overall tax code.[34]

The technical phenomenon in the literature driving these results is the "tax interaction effect," in which a new "green" tax (such as a carbon tax) interacts with the pre-existing, distortionary taxes on labor and capital and makes them *more* damaging. Note that the carbon tax raises consumer prices and effectively reduces the after-tax earnings of labor and capital, acting as its own (implicit) tax on labor and capital, but with the difference that it is concentrated in particular areas, rather than spread uniformly over *all* labor and capital. This is the intuition behind the results found in the literature: as a general rule, even a dollar-for-dollar carbon tax swap deal will hurt the conventional economy.

Thus we see that the typical "pro-growth" case for the carbon tax gets things exactly *backwards*: Generally speaking, to the extent that the U.S. tax code is already filled with distortions, the case for implementing a carbon tax of a particular magnitude is actually *weaker*, not stronger, even if we are assuming full revenue-recycling by reduction of those pre-existing, distortionary taxes.

In order to illustrate these nuances, as well as to convey the magnitude of their importance, in Table 1 below we reproduce the estimates from a numerical simulation in a pioneering 1996 paper in the *American Economic Review* by Bovenberg and Goulder.[35]

Assumed Marginal Environmental Damages From Carbon Emissions ($/ton)	Textbook Pigovian Carbon Tax (Ignoring Other Taxes)	Optimal Carbon Tax from Numerical Model, In Light of Pre-Existing Taxes, when carbon tax receipts…	
		…distributed lump-sum to citizens	…used to reduce rates on personal income tax
$25	$25	$0	$7
$50	$50	$0	$27
$75	$75	$13	$48
$100	$100	$31	$68

Table 1. Textbook Carbon Tax vs. "Optimal" Carbon Tax, With Presence of Prior U.S. Federal Tax Code Distortions (Adapted from 1994 simulation by Bovenberg and Goulder.)

Much of the contemporary U.S. policy debate on climate change restricts its attention to the first two columns in Table 1 above. That is, many analysts assume that if the "social cost of carbon" is, say, $25/ton, then the federal government should *at least* put a "price on carbon" (such as a carbon tax) at a level of $25/ton, in order to reflect the "negative externality."

Then, to the extent that consideration is given to pre-existing taxes which are themselves distortionary, most analysts—particularly those urging libertarian or conservative readers to embrace a carbon tax—think it is self-evident that full revenue recycling can only *enhance* the case for a carbon tax, indeed perhaps making it sensible even if one neglects the environmental externality. Yet the third and fourth columns in Table 1 show that such common reasoning is backwards,[36] at least in typical models in this literature: Generally speaking, the presence of distortionary taxes *reduces* the case for a new carbon tax, meaning that (considering all economic and environmental aspects) the "optimal" carbon tax will end up being *lower* than the social cost of carbon.[37]

The impact of the "tax interaction effect" on policy design can be enormous: For example, as Table 1 indicates, in the case of a $50 social cost of carbon, if the carbon tax receipts are to be returned in lump-sum fashion, then the optimal carbon tax—with all feedback effects on the tax system taken into account—is *zero*. This outcome reflects the fact that introducing even a very modest carbon tax (such as a mere $1/ton) would exacerbate the deadweight losses of the pre-existing taxes so much that the marginal economic costs swamp the stipulated $50/ton environmental benefits of the carbon tax, meaning that it would be better—all things considered—to not levy even the modest carbon tax in the first place. The policy wonks pushing a carbon tax on libertarians and conservatives almost never include this type of possibility in their discussions, even though (at least qualitatively) this is the consensus view in the literature.

It is true that *given* a carbon tax, it is better to use the receipts to reduce tax rates, rather than spending the money or returning it lump-sum to citizens. That is why Table 1 shows that in the case of a $50 social cost of carbon, the optimal carbon tax with personal income tax rate reduction is $27. Thus, putting the U.S. policy debate in terms of our Table 1 the analysts pitching a carbon tax to libertarians and conservatives have been focusing on the fact that $27 > $0 (i.e. it's better to use carbon tax receipts to fund tax rate reductions rather than other uses). But they almost universally ignore the fact that $27 < $50, meaning that carbon taxes make sense only if there are *high* environmental damages from emissions, and even in that case—and even with a fully revenue-neutral tax rate swap—we would still implement only a carbon tax much lower than the assumed social cost of carbon.

ARE CARBON TAXES A "MARKET SOLUTION"?

Advocates will often refer to a carbon tax (and also a cap-and-trade program) as a "market solution" to the problem of human-caused climate change, in contrast to the command-and-control mandates that would directly regulate greenhouse gas

emissions. Indeed, such a tax-for-regulation swap is a central plank in Jerry Taylor's pitch for a carbon tax to libertarians and conservatives. According to textbook theory, it is cheaper for society to achieve a desired emission reduction through putting a "price on carbon" and letting individuals in the market determine the *specific areas* of cutbacks, rather than political officials mandating fuel economy standards, power plant rules, building insulation standards, and so on.

There are several flaws with such a pitch. In the first place, even on its own terms, a carbon tax is hardly a genuine "market solution" analogous to other introductions of property rights. The classic "tragedy of the commons" involved animals overgrazing on English pastureland, and this problem was solved by establishing private property in real estate (enforced at low costs via barbed wire fencing). But if we were to implement a "market solution" in the spirit of a carbon tax, the English government would have fined only *English* ranchers and shepherds a certain number of guineas for every acre-year of grazing by their animals, with that fine periodically adjusted based on the whims of Parliament, and where any *non-English* rancher or farmer could let his animals graze on English pastureland without paying anything to the government. (No fences would be allowed to restrict foreign ranchers, who fell outside the jurisdiction of the English government, from coming into England and grazing on the land that the English were trying to preserve for the future.) Would this be a "market solution" to the original tragedy of the commons?

Another problem with the idea of a carbon-tax-for-regulation swap is that progressive environmentalists would be, on their own terms, foolish to go along with such a bargain. David Roberts, in a Vox interview with Jerry Taylor, gets the Niskanen Center president to estimate that the true social cost of carbon dioxide emissions (including the "fat tails" catastrophic risks described by Weitzman and others that are increasingly inappropriate) ranges "anywhere from, say, $70 to $80 a ton to a couple hundred dollars a ton," and Taylor further agrees with Roberts that any politically feasible U.S. carbon tax will be "almost certainly well south" of $70/ton.[38] Why then would any progressive give up direct regulatory tools, if a U.S.

carbon tax—especially in the beginning, when much of the world continues to emit without constraint—will be nowhere near the level needed to achieve the (stipulated) emission cutbacks for a 2°C goal, let alone a more aggressive goal such as 350ppm? In the interview, Taylor answers that even a modest carbon tax will achieve more emission cutbacks than particular regulatory interventions, but how would that satisfy someone worried about catastrophic risks to future generations? It would simply underscore the need to pursue *further* command-and-control regulations in conjunction with the (inadequate) carbon tax.

The idea that progressive environmentalists would want a carbon tax to *supplement* direct mandates is clear as day: it is what they are announcing to the world. For just one example, the group Clean Energy Canada in early 2015 published a pamphlet, "How to Adopt a Winning Carbon Price: Top Ten Takeaways from Interviews with the Architects of British Columbia's Carbon Tax."[39] Here is takeaway #8: "A carbon tax can't do everything; it needs to be just one component of a full suite of climate policies." (A post on the U.S. progressive website *grist.com* favorably covered the release of the pamphlet, where the author—the same David Roberts—commented, "I certainly hope [carbon] tax advocates take heed of No. 8!"[40]) We will return to the celebrated case of B.C.'s carbon later in this study, but for now it serves to make the point that the proposal to *replace* top-down regulations with a carbon tax is a fantasy. Progressives aren't even agreeing to that *in principle*. How, then, can we expect them to go along with such a deal in practice?

Finally, to link the discussion in the preceding section with this one, we note that a 2010 RFF analysis concluded that the tax interaction effect could be so powerful as to dominate the textbook advantages of a market-based approach. In their words:

> The increase in energy prices caused by market-based climate policies causes higher production costs throughout the economy, which in turn leads to a slight contraction in the overall level of economic activity, employment, and investment. As a result, **distortions in labor and capital markets due to preexisting taxes**

> **are increased, producing an economic cost. This cost is larger for market-based instruments because they tend to have a much greater impact on energy prices than emissions standards,** for envisioned CO_2 reductions over the medium term. [RFF 2010, bold added.][41]

To be sure, this 2010 RFF analysis still favored a carbon tax *with full revenue recycling through other tax rate reductions* as the best policy. But if forced to choose between a direct kilowatt-hour emission mandate on the power sector, versus a politically realistic cap-and-trade program containing substantial amounts of "free" allowances to ease the burdens on certain groups, the RFF study actually rejected the cap-and-trade "market solution" as having economic costs 200 percent higher than the command-and-control mandates. Such an outcome doesn't occur in a simplistic textbook analysis that disregards the existing tax code, but in the real world *all* "market solutions"—whether cap-and-trade or a carbon tax—raise energy prices and thus render pre-existing taxes much more destructive.

CASE STUDIES: CARBON TAXES IN ACTION

As of November, 2014, there were at least 39 distinct programs around the world to "price" some portion of their carbon dioxide emissions, consisting of a tax, a cap-and-trade program, or a hybrid of the two approaches. In terms of time, this count ranges from Finland's carbon price which became effective as of 1990, to Chile's plan which will begin in 2017, and in terms of prices this count includes effective carbon prices ranging from $1 per ton up to $168/ton (in Sweden, but with major exemptions and rebates for certain businesses).[42] In the interest of brevity, this study will explore the history of two prominent examples of real-world carbon taxes, in Australia and British Columbia.

Australia

On July 1, 2012, the Australian government instituted a carbon tax of $23 (Australian dollars) per ton of CO_2-equivalent, and raised it to $24.15/ton a year later. The tax proved so unpopular that in the September 2013 elections, Leader of the Opposition Tony Abbott won on a campaign which he explicitly billed as a referendum on the carbon tax. (The carbon pricing scheme was formally ended in July 2014.[43]) Dr. Alex Robson, an economics professor from Griffith University in Brisbane, Australia who has published peer-reviewed papers on the interaction of fiscal and environmental policies,[44] authored a 2013 study critical of the Australian carbon tax.[45]

Robson's study shows that the introduction of the Australian carbon tax went hand in hand with a spike in household electricity prices (the "highest quarterly increase on record," p. 39) and unemployment, while many Australian business owners anecdotally reported that the carbon tax was a key factor in their decision to lay off workers or shut down entirely. Yet beyond these drawbacks—which help to explain the voters' embrace of Tony Abbott in 2013—Robson's study reveals that *none* of the pillars in the "conservative case" for a U.S. carbon tax swap came true in the case of Australia.

For example, contrary to the promise that a U.S. carbon tax could be used to provide "pro-growth" tax reform, in Australia the carbon tax was accompanied by so many give-aways (to mitigate the negative impact on various groups) that the Australian government actually *raised* effective marginal income tax rates on 2.2 million taxpayers, compared to income tax reductions for only 560,000 taxpayers.

In the same vein, rather than allowing for a reduction in top-down environmental policy as is promised in the U.S., the Australian carbon tax was *not* accompanied by any reform of their inefficient wind and solar subsidies, or Renewable Energy Target (RET) mandates. On the contrary, Australia's carbon tax was instituted along with a "Clean Energy Finance Corporation."

Finally, advocates claim that a U.S. carbon tax will establish a predictable "price" for carbon that firms can incorporate into their long-term investment plans. Yet in Australia, the carbon tax was a comedy of errors. Originally the government promised during the 2010 campaign that it would not implement a carbon tax in the next 3-year cycle. This promise was abandoned, as the carbon tax was in fact introduced in July 2012, with a planned transition to a cap and trade scheme in 2015. Later the government proposed to move to the cap and trade scheme a year ahead of time, but this was never formalized, leaving the business community uncertain. And of course, with the September 2013 election of Abbott, the policy was upended again, with Australia's carbon tax being abolished in July 2014. The real-world case of Australia shows that achieving a carbon tax most certainly does *not* provide "policy certainty" to allow businesses to confidently make long-term decisions.

British Columbia

The Canadian province established a C$10/ton carbon tax in 2008, which was ramped up gradually until maxing out at C$30/ton (or US$24/ton using current exchange rates) in July 2012.[46] This works out to about 6.7 CDN cents per liter[47] of gasoline, or about 21 US¢ per gallon. The tax is quite broad, with the B.C. government claiming that its "carbon tax applies to virtually all emissions from burning fuels, which accounts for an estimated 70 per cent of total emissions in British Columbia."[48] Of special interest to the U.S. policy debate among conservatives and libertarians is that the B.C. carbon tax was explicitly designed to be revenue neutral, with the government periodically reporting on how the carbon tax receipts have been returned to B.C. residents via other tax cuts.[49]

Many proponents of a U.S. carbon tax point to the example of British Columbia as a model, which (they claim) shows that a properly designed carbon tax has significantly reduced B.C. emissions while apparently leaving the B.C. economy unscathed. For example, Yoram Bauman (of "standup economist" fame) is a PhD

author of a cartoon book explaining the economics of climate change,[50] while Shi-Ling Hsu is a PhD economist and the expert on carbon tax swaps for the Niskanen Center.[51] Thus it is fair to say that these two men are experts who have been pushing a carbon tax, one coming from the progressive left and the other from the conservative right. In a 2012 op ed in the *New York Times*, here is how they described the relevance of the B.C. carbon tax to the U.S. policy debate:

> On Sunday, **the best climate policy in the world got even better: British Columbia's carbon tax** — a tax on the carbon content of all fossil fuels burned in the province — increased from $25 to $30 per metric ton of carbon dioxide, making it more expensive to pollute.
>
> …
>
> A carbon tax makes sense whether you are a Republican or a Democrat, a climate change skeptic or a believer, a conservative or a conservationist (or both). **We can move past the partisan fireworks over global warming by turning British Columbia's carbon tax into a made-in-America solution.** [Bauman and Hsu, bold added.][52]

Other examples could be cited to show that B.C. is one of the prime exhibits (allegedly) showing that a revenue-neutral carbon tax can reduce emissions without impairing economic growth.[53] In this section, we challenge both claims.

One popular 2012 econometric analysis of the B.C. episode concluded that its carbon tax reduced emissions from gasoline about *five times as much* as would be expected from comparable, market-induced increases in gasoline prices.[54] The authors hypothesize that this result is due to B.C. residents being willing to cut back on driving in the effort to mitigate climate change, *so long as* their fellow B.C. residents can't free ride off their sacrifices. The problem with this theory, however, is that it would indicate very poor reasoning on the part of B.C. residents: the rest of the world, not subject to B.C.'s carbon tax, can still free ride off of any B.C. cutbacks.

A much more plausible explanation for the econometric results is that B.C. residents are (at least partially) buying gasoline in other jurisdictions. Note that a *market-induced* rise in pump prices in B.C. would not lead to this effect, because presumably gas prices in neighboring Alberta (on B.C.'s eastern border) or Washington State (to the south) would be affected too by a change in the world supply and demand. However, when B.C. residents see their gas prices rise *because of the B.C. carbon tax*, then (other things equal) we would expect gasoline in other jurisdictions to become relatively more attractive.

Although pro-carbon tax writers have tried to downplay the significance of the results, the data *do* indicate a sharp increase in cross-border traffic between British Columbia and Washington State, as the B.C. carbon tax was implemented. Figure 4 shows various trends in cross-border vehicle traffic expressed as an index relative to year 2007 levels.

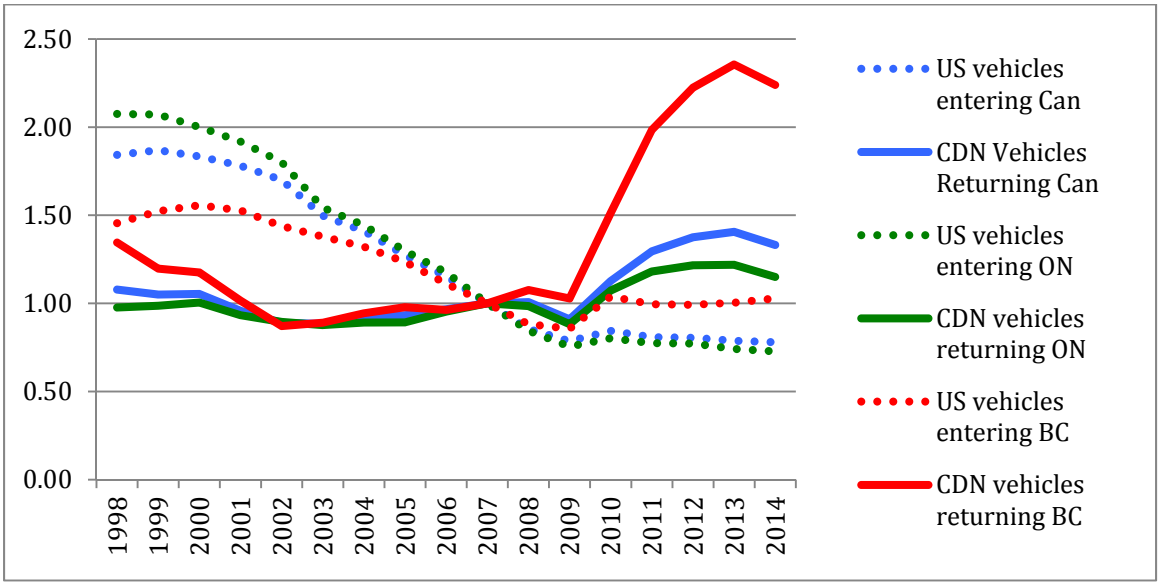

Figure 4. Select US/Canadian Vehicle Border Crossings, Annual, 1998-2014, Index 2007=100.

As Figure 4 indicates, there was a pronounced increase in *Canadian* vehicle crossings of the B.C./Washington State border after the B.C. carbon tax was

introduced (in July 2008). This surge cannot be due to, say, changes in the CDN/USD exchange rate, because we don't see nearly the same rise in Canadian vehicles returning to either Canada as a whole, or Ontario in particular. (Vehicles returning to B.C. were up *136 percent* in 2013 relative to 2007 levels, while in Ontario they were up only 22 percent. The actual number of returning B.C. vehicles was 3.2 million in 2007 and 7.6 million in 2013, compared to a total British Columbia population of about 4.6 million in 2013.[55]) Furthermore, the surge can't be due (as some have suggested) to changes in border flexibility, because we don't see nearly as much of a relative surge in U.S. traffic at the B.C. border relative to other checkpoints.

Another significant point is that even if not a statistical artifact, the apparently large reduction in B.C. emissions was only temporary. The studies trumpeting the potency of B.C.'s carbon tax went only up through 2012 data. However, officially reported B.C. gasoline sales increased sharply in 2013 and 2014, such that as of 2014, annual per capita B.C. gasoline sales were down only 2 percent compared to 2007, which was only a percentage point lower than the rest of Canada.[56] (See Figure 5.) On this criterion it seems B.C.'s carbon tax had a very weak long-term impact on gasoline consumption, even if we ignore the significant "leakage" problem.

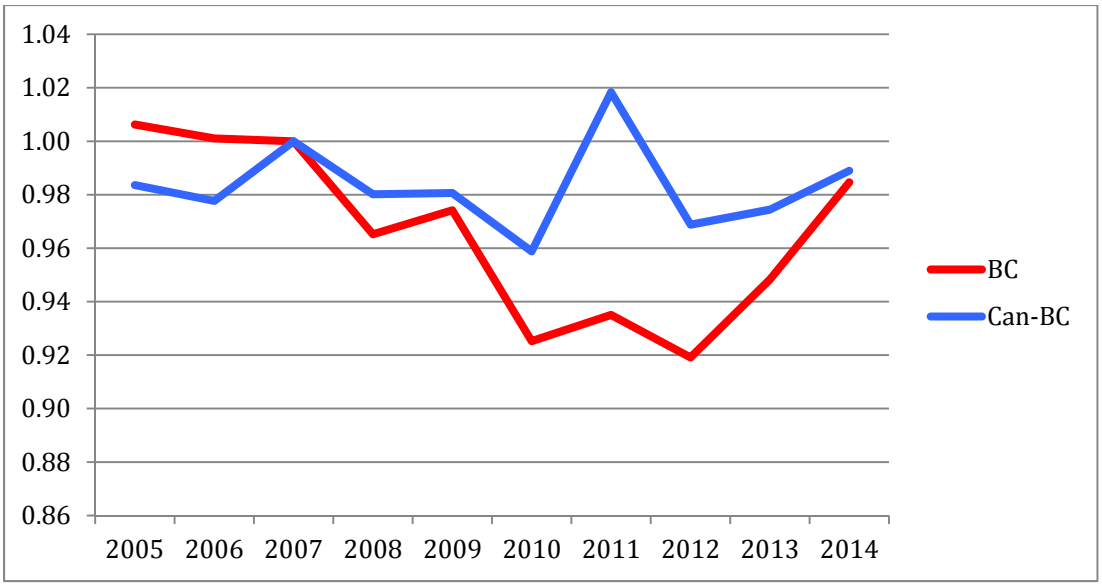

Figure 5. Per Capital Official Gasoline Sales in B.C. vs. Rest of Canada, Annual, 2005-2014, Index 2007=100.

Turning to the claim that B.C.'s carbon tax did not harm its conventional economy (because B.C. has matched overall Canadian growth since 2008), there is one awkward problem: the B.C. economy was *outperforming* the rest of Canada prior to the carbon tax. Specifically, from 2003 – 2008, B.C. real output grew by a cumulative 18.6%, whereas Canadian real GDP grew by only 12.7%. In contrast, from 2008 – 2013 (the latest annual figure available), B.C. output grew by 8.0%, while Canada grew by 7.7%.[57]

We see a similar pattern in the labor market. In the five years before introduction of the B.C. carbon tax, the average unemployment rate in B.C. was 5.6%, compared to a Canadian average of 6.6%. But in the five years *after* the B.C. carbon tax began, the average unemployment rate in B.C. was 7.1% compared to 7.6% in Canada overall.[58] Thus the labor market advantage of B.C. versus Canada was cut in half if we look at the five-year periods before and after introduction of the B.C. carbon tax, which we have illustrated in Figure 6.[59]

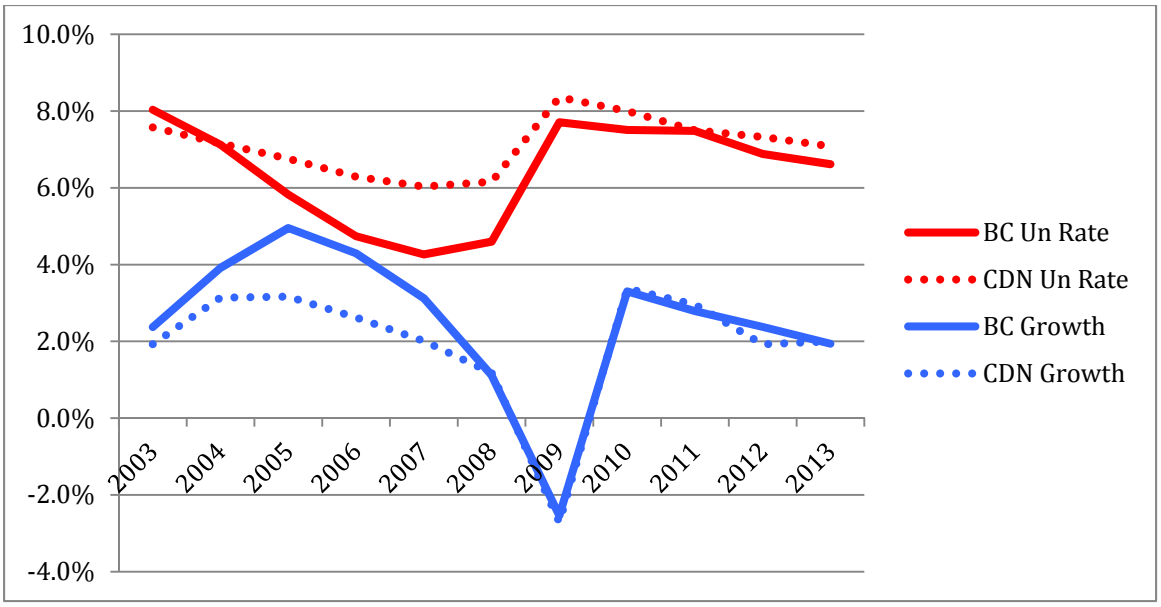

Figure 6. Unemployment and Real Growth Rates, Annual Averages, B.C. vs. Canada, 2003 – 2013.

As a final twist, we note that the B.C. authorities report that they actually provided *net tax cuts* in conjunction with the "revenue neutral" carbon tax, presumably because they did not anticipate the sharp fall in gasoline sales in the region.[60] (In other words, they gave too generous tax cuts, because they assumed the carbon tax receipts would be higher than turned out to be the case.) Furthermore, the B.C. tax cuts are a mixture of rate reductions and lump-sum payments (the latter directed to low-income groups who would be harmed by rising energy prices). Indeed, although proponents claim that the B.C. carbon tax swap has yielded the lowest personal income tax rates in Canada, such claims refer to the *average* effective rates. In terms of marginal brackets—what really matters as far as supply-side economic analysis of incentives—in 2014 British Columbia had *six* income tax brackets, ranging up to 16.8%, while neighboring Alberta had a flat income tax of 10%.[61] The notion that B.C. is now a supply-side powerhouse because of its carbon tax is far from reality.

In summary, when we look at British Columbia—the hands-down best real-world example of a carbon tax swap, according to proponents—we find that even the official figures show B.C. has had only a modest reduction in gasoline consumption

relative to the rest of Canada, and that these official figures are plagued by significant "leakage" into other jurisdictions, which may have led authorities to provide larger tax cuts than they had intended. Furthermore, B.C.'s offsetting tax cuts were *not* designed from a supply-side perspective, as they included lump-sum transfers to low-income groups. Indeed, in practice the evidence suggests that even with the associated net tax cuts, B.C. unemployment and real economic growth rates suffered after the carbon tax was enacted. Inasmuch as any U.S. carbon tax will *not* be revenue neutral—let alone be phased in with net tax cuts—the B.C. example leads us to expect modest changes in gas consumption in exchange for a weaker economy.

CONCLUSION

A growing drumbeat of media reports on the dangers of human-caused climate change, in conjunction with the rejection of "science deniers" from polite company, has led some Americans to believe that aggressive U.S. government action to slow carbon dioxide emissions is a self-evidently justified policy. Furthermore, a handful of vocal intellectuals and political officials have begun warming libertarians and conservatives up to the possibility of a "win-win" tax swap deal, which would give them desired reductions in other taxes and regulations in exchange for conceding to a carbon tax.

This study has shown just how dubious this popular narrative is. Indeed, many proponents of a carbon tax are "denying" a growing body of low-sensitivity findings, as well as a large and growing discrepancy between climate model predictions and temperature observations in the lower atmosphere. Furthermore, relying on standard results in the economics of climate change literature, we have shown that there are serious problems in the estimation of the "social cost of carbon," and that even if we *knew* it, other considerations would imply that an "optimal" carbon tax should be significantly lower than the estimated "social cost of carbon."

Of particular relevance to libertarians and conservatives, we further showed that the "tax interaction effect" suggests that there most likely would *not* be a double-dividend boost to conventional economic growth, even if a carbon tax were fully refunded through payroll tax cuts or lump-sum payments. In the more realistic scenario in which a carbon tax would only *partially* be refunded, the results aren't even close: such a tax would clearly hurt the conventional economy, meaning that it could *only* be justified on environmental grounds.

Finally, we critically analyzed the real-world carbon tax experiences in Australia and British Columbia. We found that the promises of a "market-friendly" U.S. carbon tax were violated in both cases. Even in the case of British Columbia—hailed by carbon tax advocates as the best example to date—after an initial drop, the tax has not yielded significant reductions in gasoline purchases, while it has apparently reduced the B.C. economy's performance relative to Canada.

Libertarians and conservatives in particular should not simply trust the assurances from the advocates of a carbon tax, but should instead read the relevant literature themselves. In both theory and practice, a U.S. carbon tax remains a very dubious policy proposal.

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[1] The original social cost of carbon (SCC) estimates from the Obama Administration Interagency Working Group (IWG) were published in, "Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis – Under Executive Order 12866," Interagency Working Group on Social Cost of Carbon, U.S. government, February 2010, available at: http://www.epa.gov/oms/climate/regulations/scc-tsd.pdf. A major update to the estimates was issued in May 2013, available at: https://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf. As of this writing, the latest estimates were released on July 2015, available at: https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf.

[2] OMB Circular A-4 (September 17, 2003) regarding Regulatory Analysis.

[3] There were 10 studies with 21 experiments, from 42 authors available to the IWG for its 2013 update.

[4] Roe, G., and M. Baker, 2007. Why is climate sensitivity so unpredictable? *Science* **318**, 629-632.
[5] Ring, M.J., et al., 2012. Causes of the global warming observed since the 19th century. *Atmospheric and Climate Sciences,* **2**, 401-415, doi: 10.4236/acs.2012.24035.
[6] Spencer, R. W., and W. D. Braswell, 2013. The role of ENSO in global ocean temperature changes during 1955-2011 simulated with a 1D climate model. *Asia-Pacific Journal of Atmospheric Science*, doi:10.1007/s13143-014-0011-z.
[7] Robert Pindyck, "Climate Change Policy: What Do the Models Tell Us?" *Journal of Economic Literature*, September 2013, p. 5, NBER version available at: http://web.mit.edu/rpindyck/www/Papers/Climate-Change-Policy-What-Do-the-Models-Tell-Us.pdf.
[8] The White House Technical Support Document on the Social Cost of Carbon, after its July 2015 revision, is available at: https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf.
[9] For a comprehensive discussion of the SCC and discount rates, see the Institute for Energy Research's Comment on the Technical Support Document, submitted to the Office of Management and Budget in February 2014, available at: http://instituteforenergyresearch.org/wp-content/uploads/2014/02/IER-Comment-on-SCC.pdf.
[10] Some standard references showcasing various perspectives in the discounting literature are Robert C. Lind (ed.), *Discounting for Time and Risk in Energy Policy.* (Washington, D.C.: Resources for the Future), 1982; and Paul R. Portney and John P. Weyant (eds.), *Discounting and Intergenerational Equity* (USA: Resources for the Future), 1999.
[11] Waldhoff, S., Anthoff, D., Rose, S., and R.S.J. Tol, 2011. The marginal damage costs of different greenhouse gases: An application of FUND. Economics, *The Open-Access E-Journal*, No. 2011-43, http://www.economics-ejournal.org/economics/discussionpapers/2011-43
[12] Testimony of John Christy to the Committee on Natural Resources, U.S. House of Representatives, May 15, 2015.
[13] It is true that in the text to this point, we have seriously questioned the accuracy of IAMs such as Nordhaus' DICE model. However, we are merely illustrating the quantitative significance of "leakage" in terms of the standard models themselves, to show that even on its own merits, the case for a U.S. carbon tax is weaker than the public has been led to believe.
[14] William Nordhaus, *A Question of Balance: Weighing the Options on Global Warming Policies* (New Haven, CT: Yale University Press), 2008, p. 19.
[15] The calculator is available at: http://www.cato.org/blog/current-wisdom-we-calculate-you-decide-handy-dandy-carbon-tax-temperature-savings-calculator. The estimate relies on a 3°C climate sensitivity assumption.
[16] See IPCC AR5 Working Group III, Technical Summary, p. 25, available at: http://report.mitigation2014.org/drafts/final-draft-postplenary/ipcc_wg3_ar5_final-draft_postplenary_technical-summary.pdf.

[17] See IPCC AR5 Working Group III Summary for Policymakers, Table SPM.2, p. 16, available at: http://report.mitigation2014.org/spm/ipcc_wg3_ar5_summary-for-policymakers_approved.pdf.
[18] See Figure 12-40, IPCC AR5 Working Group I.
[19] See Table 10.B.1 from AR5 Working Group II, p. 82.
[20] Roberto Roson and Dominique van der Mensbrugghe, "Climate Change and Economic Growth: Impacts and Interactions," *International Journal of Sustainable Economy* 4(3): 2012, pp. 270–85.
[21] Martin L. Weitzman, "On Modeling and Interpreting the Economics of Catastrophic Climate Change," *The Review of Economics and Statistics*, February 2009, 91(1), pp. 1-19, available at: http://www.mitpressjournals.org/doi/pdf/10.1162/rest.91.1.1.
[22] David R. Henderson, "Uncertainty Can Go Both Ways," *Regulation*, Energy and Environment, Cato Institute, Summer 2013, pp. 50-51, available at: http://object.cato.org/sites/cato.org/files/serials/files/regulation/2013/6/regulation-v36n2-1-5.pdf.
[23] William Nordhaus, "An Analysis of the Dismal Theorem," Cowles Foundation Discussion Paper No. 1686, January 20, 2009.
[24] Bob Inglis and Arthur Laffer, "An Emissions Plan Conservatives Could Warm To," *New York Times*, December 28, 2008, available at: http://www.nytimes.com/2008/12/28/opinion/28inglis.html.
[25] It is unclear what Taylor means here.
[26] Jerry Taylor, "The Conservative Case for a Carbon Tax," Niskanen Center, March 23, 2015, p. 2, available at: http://niskanencenter.org/wp-content/uploads/2015/03/The-Conservative-Case-for-a-Carbon-Tax1.pdf.
[27] See: http://blogs.sacbee.com/capitolalertlatest/2014/01/jerry-brown-eyes-cap-and-trade-money-for-high-speed-rail.html.
[28] See: http://www.rggi.org/rggi_benefits.
[29] See: http://crosscut.com/2014/12/inslee-carbon-tax-fund-transportation-john-stang/.
[30] The details of Taylor's $695 billion oversight are explained at: http://instituteforenergyresearch.org/analysis/jerry-taylor-strikes-out-again-on-carbon-tax/.
[31] See: https://niskanencenter.org/blog/should-carbon-tax-revenue-be-used-to-retire-debt/.
[32] Jared C. Carbone, Richard D. Morgenstern, Roberton C. Williams III, and Dallas Burtraw, "Deficit Reduction and Carbon Taxes: Budgetary, Economic, and Distributional Impacts," Resources for the Future, August 2013, available at: http://www.rff.org/RFF/Documents/RFF-Rpt-Carbone.etal.CarbonTaxes.pdf.
[33] Lawrence H. Goulder, "Climate Change Policy's Interactions with the Tax System," *Energy Economics* 40 (2013): S3-S11, available at: http://web.stanford.edu/~goulder/Papers/Published%20Papers/Climate%20Change%20Policy's%20Interactions%20with%20the%20Tax%20System.pdf.
[34] A commenter on an early draft pointed out that the impact of higher tax rates is somewhat mitigated if the object of the new tax has a demand that is more inelastic

than for the original scenario. The intuition is that deadweight loss occurs when consumers and producers no longer exploit gains from trade on as many units as before. Nonetheless, because the base is smaller on carbon-intensive activities, we are still comparing a higher tax rate on the relatively inelastic activities to a lower tax rate on the relatively elastic ones. In any event, the consensus of the general equilibrium simulations is that carbon taxes do in fact hinder conventional growth more than other common taxes.

[35] A. Lans Bovenberg and Lawrence H. Goulder, "Optimal Environmental Taxation in the Presence of Other Taxes: General Equilibrium Analyses," *American Economic Review* 86 (1996): 985-1000. The table in the text is adapted from Table 2 (in the appendix) from their 1994 NBER Working Paper No. 4897 version of the article, available at: http://www.nber.org/papers/w4897. Note that our table uses their "realistic benchmark" PIT rate reduction and lump-sum scenarios.

[36] A commenter pointed out that the table excludes the analysis of recycling the carbon tax receipts through tax rate reductions on capital. This is true, but the point we are making with the table is that the intuition of some pro-carbon-tax writers is simply wrong.

[37] Bovenberg and Goulder explicitly model changes in the deadweight losses from the pre-existing tax code, to see the effect on optimal carbon taxes. In the case of a stipulated $75/ton social cost of carbon, our table in the text shows the result that a revenue-neutral PIT tax swap implies an optimal $48/ton carbon tax. This result (we recall) was calibrated to the PIT and other tax rates circa the early 1990s. But Bovenberg and Goulder show in Table 3 of their NBER working paper that if marginal PIT rates had in fact been 50 percent higher, then the new optimal carbon tax—with full PIT revenue recycling—would drop from $48 to $34/ton. To repeat, this shows that the reasoning of many pro-carbon tax analysts is *backwards*: the more distortionary the U.S. tax code is originally, the *less* net benefits that flow from introducing a revenue-neutral carbon tax.

[38] David Roberts, "A libertarian makes the case for a carbon tax," *Vox*, May 13, 2015, available at: http://www.vox.com/2015/5/13/8594727/conservative-carbon-tax.

[39] Available at: http://cleanenergycanada.org/wp-content/uploads/2015/02/Clean-Energy-Canada-How-to-Adopt-a-Winning-Carbon-Price-2015.pdf.

[40] David Roberts, "What we can learn from British Columbia's carbon tax," grist, February 23, 2015, available at: http://grist.org/climate-energy/what-we-can-learn-from-british-columbias-carbon-tax/.

[41] Ian Parry and Roberton C. Williams III, "Is a Carbon Tax the Only Good Climate Policy? Options to Cut CO_2 Emissions," Resources for the Future, *Resources* 176, Fall 2010, available at: http://www.rff.org/Publications/Resources/Pages/Is-a-Carbon-Tax-the-Only-Good-Climate-Policy-176.aspx.

[42] Information on worldwide carbon pricing programs taken from Kristin Eberhard, "All the World's Carbon Pricing Systems in One Animated Map," Sightline Daily, November 17, 2014, available at: http://daily.sightline.org/2014/11/17/all-the-worlds-carbon-pricing-systems-in-one-animated-map/.

[43] Rob Taylor and Rhiannon Hoyle, "Australia Becomes First Developed Nation to Repeal Carbon Tax," *Wall Street Journal*, July 17, 2014, available at: http://www.wsj.com/articles/australia-repeals-carbon-tax-1405560964.
[44] Alex Robson's publications are listed at: http://www.griffith.edu.au/business-government/griffith-business-school/departments/department-accounting-finance-economics/staff/dr-alex-robson.
[45] Alex Robson, "Australia's Carbon Tax: An Economic Evaluation," September 2013, Institute for Energy Research. Available at: http://instituteforenergyresearch.org/wp-content/uploads/2013/09/IER_AustraliaCarbonTaxStudy.pdf.
[46] See: http://www.fin.gov.bc.ca/tbs/tp/climate/carbon_tax.htm.
[47] See: http://www.sbr.gov.bc.ca/documents_library/bulletins/mft-ct_005.pdf.
[48] See: http://www.fin.gov.bc.ca/tbs/tp/climate/A6.htm.
[49] For example, the latest British Columbia Budget and Fiscal Plan (2015/16 – 2017/18) shows on Table 1 (page 60) its "Revenue Neutral Carbon Tax Report" for the 2013/14 - 2014/15 fiscal years, detailing the revenues collected and the offsetting tax cuts provided. See: http://bcbudget.gov.bc.ca/2015/bfp/2015_Budget_and_Fiscal_Plan.pdf.
[50] For a critical discussion of Bauman's (with Grady Klein) *The Cartoon Introduction to Climate Change*, see Bryan Caplan's May 2014 EconLog post at: http://econlog.econlib.org/archives/2014/05/the_cartoon_int.html.
[51] For an example of Shi-Ling Hsu's articles on carbon tax swaps see: https://niskanencenter.org/blog/a-carbon-for-corporate-tax-swap/.
[52] Yoram Bauman and Shi-Ling Hsu, "The Most Sensible Tax of All," *New York Times*, July 4, 2012, available at: http://www.nytimes.com/2012/07/05/opinion/a-carbon-tax-sensible-for-all.html.
[53] For example, see "British Columbia's Carbon Tax Shift: The First Four Years," Sustainable Prosperity, June 2012, available at: http://www.sustainableprosperity.ca/sites/default/files/publications/files/British%20Columbia's%20Carbon%20Tax%20Shift.pdf, and "British Columbia's Carbon Tax: The Evidence Mounts," *The Economist* blog post, July 31, 2014, available at: http://www.economist.com/blogs/americasview/2014/07/british-columbias-carbon-tax.
[54] Nicholas Rivers and Brandon Schaufele, "Salience of Carbon Taxes in the Gasoline Market," October 22, 2014, SSRN Working Paper, available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2131468.
[55] Some have argued that the cross-border statistics do not affect the general lessons of the B.C. carbon tax episode. See for example: http://critical-angle.net/2013/08/18/the-effect-of-cross-border-shopping-on-bc-fuel-consumption-estimates/.
[56] Calculations of B.C. and rest-of-Canada gasoline sales based on Statistics Canada Table 134-0004, "Retail sales of motor gasoline." Population figures from Table 051-0001.
[57] Percentages based on chained 2007 CDN dollars as reported by Statistics Canada.

[58] Unemployment data from Statistics Canada, Table 282-0087. The averages are based on the monthly data, i.e. July 2003 through July 2008, and July 2008 through July 2013.

[59] To be sure, if one adjusts the period of comparison, this conclusion can change. For example, if one looks at the *seven* years prior and following the July 2008 introduction of the B.C. carbon tax, then the difference between average unemployment rates in B.C. versus Canada only differs by a tenth of a percentage point (and in the other direction).

[60] See the Sustainable Prosperity (June 2012) study for their claim that (to date) the B.C. authorities had provided at least $300 million in excess tax cuts compared to the new revenues collected from the carbon tax.

[61] For provincial income tax rates see: http://www.taxtips.ca/marginaltaxrates.htm.