Carbon Taxes: Accelerating Innovation While Cutting Emissions

By Jonathan Marshall, Economics Policy Network contributor

Summary

- Carbon taxes greatly enhance innovation in clean technology, a benefit that is often overlooked in discussions of climate policy.
- Many economic models underestimate this effect, thus exaggerating the cost of reducing emissions.
- Policies that support innovation directly, such as R&D subsidies, are a useful complement to carbon pricing.
- Innovation policies alone, however, will not achieve adequate, timely, or cost-effective emissions reductions.

Introduction

Economists overwhelmingly agree that "carbon taxes"—levies on the sale of fossil fuels such as oil, natural gas, and coal—offer "the most cost-effective lever to reduce carbon emissions at the scale and speed that is necessary" to address the global climate emergency.[1] The logic of harnessing market incentives is simple: individuals and enterprises, acting out of self-interest, will shift toward lower-carbon alternatives as prices rise for fossil fuels and the products and services that embed them. Real-world evidence supports that logic; for example, a modest carbon tax in Great Britain slashed the use of coal in electricity generation from more than 40 percent in 2013 to a mere 3 percent in just six years.[2]

Sometimes overlooked in discussions of carbon taxes is the similarly strong consensus among economists that "a consistently rising carbon price" will also "encourage technological innovation" to favor less reliance on fossil fuels.[3] New technology offers the welcome promise of weaning the world off of dirty fuels much faster, and at lower cost, than many scenarios assume. By *inducing* the development of such new technology, as well as favoring currently available low-carbon options, carbon taxes provide two paths toward climate mitigation: reducing both emissions *and* the cost of cleaner energy.

Why Innovation Matters

Modern civilization is built on fossil fuels, which provide most of the energy to run our factories, power our cars, and heat our homes. Eliminating them over the next thirty years will require more than regulations or taxes. It will necessitate rapid discovery of lower-cost forms of clean energy and their speedy deployment throughout industry, agriculture, transportation, power generation, and buildings.

The findings of government research laboratories hold out hope that future technology can help mitigate the impending climate crisis. A 2006 study by Pacific Northwest National Laboratory concluded that "accelerated technology development offers the potential to dramatically reduce the costs of [climate] stabilization . . . over the century, compared to the Baseline Cases, by 50% or more, leading to economic benefits of hundreds of billions to trillions of dollars globally."[4]

Progress in the clean energy sector since then has been dramatic. Over the past 10 years, the unsubsidized cost of wind energy has fallen 70 percent, and the cost of utility-scale solar has plummeted 89 percent.[5] Global emissions of CO2, however, have continued to increase in the absence of strong tax or regulatory policies to promote the development and adoption of clean energy as a substitute for fossil fuels.[6]

A report by the Department of Energy in 2017 nonetheless concluded that aggressive "stretch" national technology policies could, with some luck, reduce CO2 emissions by nearly 30 percent between 2017 and 2040, enough at least to slow current warming trends. By comparison, DOE concluded that a very modest carbon tax of $20 per ton, increasing 5 percent annually, would cut emissions about 20 percent. Together, they could slash emissions as much as 45 percent by 2040.[7]

How Carbon Taxes Induce and Accelerate Innovation

Many critics of strong tax or regulatory policies to address the climate emergency claim that innovation alone will continue driving down the cost of clean energy with minimal government involvement, lowering emissions without raising costs to consumers. That's not how leading economists see it. As Glenn Hubbard, former chairman of the Council of Economic Advisors in the George W. Bush administration, observed, "business people don't innovate because it feels good; they innovate because there's a return to that innovation. If you want a return to that innovation, . . . you will need to put a price on carbon."[8]

Carbon taxes are also vital to accelerating the *adoption and diffusion* of cleaner new inventions. Incumbent fossil fuel companies, and entrenched industries built around using their products, will resist change if oil, gas, and coal remain artificially cheap. Former Commerce Department chief economist Joe Kennedy observes, "When new technology comes at a higher cost, companies may not adopt it even if it significantly reduces emissions. A carbon tax partially addresses this by increasing the cost of dirty energy and, in the process, raising the private benefits of research on energy efficiency and low-carbon energy."[9]

The discovery of knowledge is highly creative, widely dispersed, and hard to predict. Nonetheless, most economists believe, as a matter of both logic and empirical study, that innovators respond to profitable market opportunities for technology invention and adoption. Carbon taxes shift those opportunities from fossil fuels to clean energy. As former Federal Reserve Vice Chairman Alan Blinder wrote, "Once America's entrepreneurs and corporate executives see lucrative opportunities from carbon-saving devices and technologies, they will start investing right away — and in ways that make the most economic sense. . . . I can hardly wait to witness the outpouring of ideas [a carbon tax] would unleash."[10] In the same spirit, Paul Romer, former chief economist of the World Bank and a Nobel laureate famed for his theoretical work linking technology to economic growth, observed,

> The main reason to put a tax on greenhouse gases is not the one from the textbook. This is a tax that we want to people to avoid. We want innovators to discover all kinds of clever new ways to let people have the things that they want without paying this tax. . . The lesson . . . is that small incentives can generate lots of innovation.[11]

Many entrepreneurs agree. Two major clean energy investors, one a Republican and one a Democrat, wrote in *Politico*, "Putting a market price on carbon would provide clear price signals to investors like us.

Then, the U.S. innovation engine — our most valuable asset — would be turned loose, and capital and U.S. jobs would follow."[12] Their judgment was confirmed by a survey of 35 large U.S. companies, which found that "among the nine policy tools listed in the survey, putting a price on carbon was by far the most important action that respondents think the U.S. government could take to advance low-carbon innovation."[13] Former Microsoft CEO Bill Gates, founder of the Breakthrough Energy Coalition, said, "Without a carbon tax, there's no incentive for innovators or plant buyers to switch" to clean energy.[14]

History also supports the view that prices strongly influence the pace of technology development and adoption. In the 1960s, when energy prices were falling, the efficiency of air conditioners actually declined. That trend reversed sharply after the oil price shocks of the 1970s, with energy prices accounting for up to half the subsequent efficiency gains in these home appliances.[15] In the transportation sector, a recent study based on data from 80 countries estimates that a 10 percent increase in tax-inclusive gasoline prices would stimulate a 37 percent increase in the number of green vehicle technology patents over the succeeding five years.[16] A study of the European Union's carbon pricing system finds that even its low pricing levels have increased low-carbon innovation among affected firms by as much as 10 percent.[17]

Despite such evidence, few economists have undertaken the complex task of fully accounting for technology improvements in their forecasts of the effect of carbon taxes on greenhouse gas emissions. As one detailed assessment of state-of-the-art models cautioned, "these models generally do not represent induced research and development spending and the associated spillovers" and thus "may understate the environmental effectiveness of the policies."[18] One recent estimates that carbon taxes could induce energy efficiency innovations sufficient to cut energy usage 30 percent more than traditional models assume over the course of a century.[19]

How to Promote Innovation

Carbon taxes can and should be structured to maximize their potential to promote innovation. As Paul Romer has observed,

> We want innovators to know that the tax is coming and to take steps now to make sure that when it bites, it will be little more than a nuisance. Eventually, we want the tax to be so high that no one ever pays it, yet no one cares because it is irrelevant.
>
> One way to achieve this would be to start with a very low tax on greenhouse gases right away and commit that the tax (in dollars per unit of greenhouse gas emitted) will increase gradually but inexorably. Innovators will start investing now in ways to for people to get what they want without paying the tax. They will stop investing in ways to extract more fossil fuels that will be subject to the tax.[20]

The good news is that the leading carbon tax bill now pending in Congress, the Energy Innovation and Carbon Dividend Act, adopts just such an approach. It starts with a carbon tax of $15 per ton, rising at a rate of $10 annually. Such a tax structure would do little to disrupt consumers in the near term, while exerting a powerful influence on business investment and R&D spending based on future cost projections.[21]

Taxing pollution isn't the only way to promote innovation in non-polluting technologies, of course. Regulations, such as building efficiency standards, can also promote innovation, though economists generally believe that taxes provide broader and thus more effective incentives for innovation.[22] Direct government subsidies and tax incentives for research and development also promote new technology. Indeed, virtually every introductory economics textbook makes the case for such subsidies.[23] The logic is that private firms, left to their own devices, underinvest in R&D from a *social* perspective, because they do not capture the full benefits that "spill over" to other firms, and consumers, from the broader adoption of their innovations. In addition, aversion to risk and uncertainty leads most firms to underinvest in the sorts of basic research that produce fundamental technological breakthroughs (atomic energy, the Internet, etc.), which can revolutionize entire industries.[24] All that said, studies repeatedly find that *public support for R&D, while highly desirable, is no substitute for carbon taxes when it comes to curbing greenhouse gas emissions*, or even promoting faster technological progress.[25] The two approaches are, in fact, highly complementary.[26]

Conclusion

Transitioning to a low-carbon world will not be painless, but new technology can significantly ease the way if given an economy-wide boost. As economist Paul Krugman notes, "Even modest incentives for expanded use of renewable energy led to a spectacular fall in prices over the past decade."[27] The key, of course, is getting the right incentives to unlock the full creative potential of humanity. Rising carbon taxes are "the most cost-effective lever to reduce carbon emissions at the scale and speed that is necessary," not least because they will powerfully promote new innovations and accelerate their adoption.

Jonathan Marshall is former Economics Editor of the San Francisco Chronicle *and is a member of Citizens' Climate Lobby's Economics Policy Network. The views expressed here do not necessarily represent those of Citizens' Climate Lobby.*

---

[1] Climate Leadership Council, "Economists' Statement on Carbon Dividends: The Largest Public Statement of Economists in History ."

[2] University College London, "British carbon tax leads to 93% drop in coal-fired electricity," January 27, 2020. For other international evidence, see Jonathan Marshall, "Carbon Taxes Can Do the Job," April 2019.

[3] "Economists' Statement on Carbon Dividends." A team of economists associated with Resources for the Future expressed the profession's consensus that "Establishing a price on CO2 emissions is the single most important policy for encouraging the innovation that might bring about advanced technology development." Joseph E. Aldy et al., "Designing Climate Mitigation Policy," *Journal of Economic Literature*, 48:4 (2010), 903-934. For another bullish assessment, see Andrea Baranzini, et al., "Carbon pricing in climate policy: seven reasons, complementary instruments, and political economy considerations," *Climate Change* 8 *(*March 2017).

[4] Leon Clarke, et al., *Climate Change Mitigation: An Analysis of Advanced Technology Scenarios* (Richland, Wash.: Pacific Northwest National Laboratory, 2006).

[5] Lazard, "Levelized Cost of Energy and Levelized Cost of Storage 2019," November 7, 2019.

[6] Hannah Ritchie and Max Roser, "CO2 and Greenhouse Gas Emissions," December 2019. Emissions from richer nations have fallen slightly over the past decade, "thanks to the expanding role of renewable sources (mainly wind and solar PV), fuel switching from coal to natural gas, and higher nuclear power output," but not nearly fast enough to slow the pace of warming in a meaningful way. International Energy Agency, "Global CO2 Emissions in 2019," February 11, 2020.

[7] U. S. Department of Energy, "Energy CO2 Emissions: Impacts of Clean Energy Technology Innovation and Policy," January 2017.
[8] "Hubbard Argues for a Carbon Tax," *Wall Street Journal Environmental Capital blog*, June 28, 2007.
[9] Joe Kennedy, "How Induced Innovation Lowers the Cost of a Carbon Tax," Information Technology & Innovation Foundation, June 2018.
[10] Alan S. Blinder, "The Carbon Tax Miracle Cure," *Wall Street Journal*, January 31, 2011.
[11] Paul Romer, "Conditional Optimism," October 8, 2018.
[12] Martin Lagod and Jason Scott, "Put a Price on Carbon," *Politico*, July 26, 2010.
[13] Pew Center on Global Climate Change, "A Survey of Company Perspectives on Low Carbon Business Innovation 3," (2011).
[14] Quoted in James Bennet, "We Need an Energy Miracle," *Atlantic*, November 2015.
[15] Richard Newell, et al., "The Induced Innovation Hypothesis and Energy-Saving Technological Change," *Quarterly Journal of Economics* 114 (1990:3), 941-975. Government efficiency standards and unexplained factors accounted for the rest of the observed efficiency gains.
[16] Philippe Aghion, et. al. "Carbon Taxes, Path Dependency, and Directed Technical Change: Evidence from the Auto Industry," *Journal of Political Economy* 124 (2016:1), 1–52.
[17] Raphael Calel and Antoine Dechezleprêtre, "Environmental Policy and Directed Technological Change: Evidence from the European Carbon Market," *Review of Economics and Statistics* 98 (March 2016), 173-191. Other case studies of price-induced innovation may be found in OECD, *Taxation, Innovation and the Environment* (2010).
[18] Alexander Barron, et al., "Policy Insights from the EMF 32 Study on U.S. Carbon Tax Scenarios," *Climate Change Economics* 9 (2018:1). On the complexities of modeling induced technological change, see also David Popp, et al., "Energy, the Environment, and Technological Change" (2009), NBER working paper 14832; reprinted in Bronwyn Hall, ed., *Handbook of Economics of Innovation* (2010), 873-937.
[19] Rong Wang et al., "Induced Energy-Saving Efficiency Improvements Amplify Effectiveness of Climate Change Mitigation," *Joule* (2019). A sophisticated estimate of how much clean innovation would be induced by a carbon tax is offered by a study published in 2018, based on evidence from the oil price shocks of the 1970s. Assuming only normal technological change, the study estimates that a $30 carbon tax would cut greenhouse gas emissions by a baseline 30 percent over 20 years. Taking into account the big boost to green innovation at the expense of R&D spending on fossil fuels would bring the total reduction in emissions to about 35 percent. S. Fried, "Climate Policy and Innovation: A Quantitative Macroeconomic Analysis," *American Economic Journal: Macroeconomics*, 10 (2018:1), 90–118. A Rhodium Group model estimates that a $50 carbon tax would cut CO2 emissions by 39 percent relative to 2005 by 2030—but by 46 percent if the rate of innovation accelerates. Noah Kaufman and Kate Gordon, "The Energy, Economic, and Emissions Impacts of a Federal US Carbon Tax," July 2018.
[20] Romer, "Conditional Optimism." The case for an increasing carbon tax is supported by the observation that "what matters to the firm is not the effective price of carbon emissions today. Rather, it is the expected price of carbon emissions a decade or more in the future." David Popp, et al., "Energy, the Environment, and Technological Change," op. cit.
[21] Note that competing proposals to price carbon through cap-and-trade schemes offer no clear price path for enterprise planning, and a further counterproductive effect: "if a cap-and-trade program is successful in encouraging innovation in greenhouse gas-reducing technologies, the ironic effect is that this innovation will reduce the price of emissions permits and thereby reduce the price incentive to innovate. A carbon tax, by contrast, represents a continuing price signal to find lower-carbon alternatives." Shi-Ling Hsu, *The Case for a Carbon Tax: Getting Past Our Hang-ups to Effective Climate Policy* (Island Press, 2011).
[22] Thus a 2010 OECD study observed, "Putting a price on pollution creates opportunities for a wide range of types of innovation. This gives taxation an advantage over more prescriptive environmental policy instruments which tend to encourage a focus on end-of-pipe innovations (i.e. innovations that reduce the emission of pollution but not the creation of it). . . . Such innovations are important, but are often less efficient than measures which reduce the creation of pollution in the first place. The wide range of actions that can be induced by taxation encourages a more balanced mix between innovations that result in a cleaner production process and end-of-pipe abatement measures." OECD, *Taxation, Innovation and the Environment* (2010). For contrary evidence that some regulations may be more effective than taxes at promoting radical innovation, see René Kemp and Serena Pontoglio, "The

Innovation Effects of Environmental Policy Instruments — A Typical Case of the Blind Men and the Elephant?" *Ecological Economics* 72 (2011), 28-36.

[23] See, for example, Steven A. Greenlaw and David Shapiro, *Principles of Economics 2e* (OpenStax, 2017), 303, 308-309. The literature on these market failures is also discussed extensively in David Popp, et al., "Energy, the Environment, and Technological Change," op. cit. Such examples refute claims by some pundits that "innovation is not part of neoclassical economists' lexicon" and that economists are thus naïve to put their faith in carbon taxes. See, for example, Matthew Stepp and Alex Trembath, "Innovation Before Carbon Pricing" (2013); Matt Hourihan and Robert Atkinson, "Inducing Innovation: What a Carbon Price Can and Can't Do," Information Technology & Innovation Foundation, March 2011.

[24] For a survey of empirical studies in this area, see David Popp, "Environmental Policy and Innovation: A Decade of Research," CESifo Working Paper No. 7544, March 2019.

[25] Stephen H. Schneider and Lawrence H. Goulder, "Achieving Low-cost Emissions Targets," *Nature*, 389 (September 4, 1997), 13-14; A. Jaffe, et al., "Environmental Policy and Technological Change," *Environmental and Resource Economics* 22 (2002), 41–69; Matthew Clancy and GianCarlo Moschini, "Pushing and Pulling Environmental Innovation: R&D Subsidies and Carbon Taxes," selected paper presented at the Agricultural & Applied Economics Association annual meeting, Boston, MA, July 31-August 2, 2016: "Our numerical simulations agree with much of the earlier literature. R&D subsidies on their own achieve only a fraction of the welfare gains attained by a carbon tax on its own, and adding R&D subsidies to a carbon tax leads to minor additional welfare gains." One widely cited study found that "combining both policies yields the largest welfare gain. However, a policy using only the carbon tax achieves 95% of the welfare gains of the combined policy, while a policy using only the optimal R&D subsidy attains just 11% of the welfare gains of the combined policy in his model." A major reason is that "While technology policy can help facilitate the creation of new environmentally-friendly technologies, it provides little incentive to adopt these technologies." David Popp, et al., "Energy, the Environment, and Technological Change" op. cit.

[26] An OECD report concluded, "the optimal approach is to have a strong environmental policy that combines taxes levied directly on environmentally harmful activities (and set at levels that reflect the costs of that environmental damage) with broad innovation policies that address the undersupply of innovation (including for the environment)." *Taxation, Innovation, and the Environment* (2010). See also Daron Acemoglu, et al., "The Environment and Directed Technical Change," *American Economic Review* 102 (2012:1), 131–166; and Her Majesty's Treasury of the UK Government, *The Economics of Climate Change: The Stern Review* (2006).

[27] Paul Krugman, "Greta Versus the Greedy Grifters," *New York Times*, February 27, 2020.