

Climate Policy and the Economics of Technical Advance: Drawing on Inventive Activity

I N T E R N E T E D I T I O N

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RFF Climate Issue Brief #8

RFF's Climate Issue Briefs are short reports produced as part of RFF's Climate Economics and Policy Program to provide topical, timely information and analysis to a broad nontechnical audience.

The preparation of these briefs is funded in part by
The G. Unger Vetlesen Foundation.

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INTRODUCTION

As the United States and other nations debate the pros and cons of “binding targets” for emissions of greenhouse gases (GHGs), support is growing for the idea that policies can and should seek to reduce GHG emissions at low cost through the use of advanced technology. Indeed recent U.S. government-sponsored analysis shows that the cost of GHG abatement drops dramatically assuming that technical progress can be enhanced. Using three models to track abatement costs, the May 1997 draft report of the Clinton Administration’s Interagency Analytic Team (IAT) states that a 40 percent increase in the pace of technical change giving rise to energy efficiency improvements would lead to a 65 percent drop in the cost of GHG abatement in the year 2020.

It goes without saying that it is politically expedient to support a policy that purports to reduce the economic cost of GHG abatement by an appeal to advanced technology. However, formulation of such a policy and its actual cost-reducing potential give rise to a number of questions. The bottom line is that, as with other uses of society’s scarce resources, there is no free lunch. Technical innovation focused on reducing GHG emissions likely will lower the cost of abatement below the minimum cost possible with today’s technologies. However, it may also have important effects on productivity growth elsewhere in the economy by crowding out other investments in technical improvement.

BACKGROUND: INNOVATION AND GHG REDUCTIONS

Technical advance that eventually leads to reductions in the cost of GHG policies proceeds through three stages: invention, innovation, and adoption. Invention is a creative process in which the end result is a new product, concept, process, or idea. Innovation is the adaptation (or evolution) of an invention into a usable, useful, and desired commercial product or process, while adoption is the process by which households and firms accept a new product or process into their economic activities.

Technical advance (or technical change or progress) means doing things better than before as a result of enhanced knowledge. Changes in information processing brought about by enhanced knowl-

edge of chip manufacture and CPU (central processing unit) design have resulted in computers that grow faster and more powerful each year and therefore represent technical advance. Similarly, growing knowledge of solar panel manufacture gained through repeated experience with the process has led to technical advance.

Technical advances can lower the cost of GHG abatement policies by directly affecting the products produced by the economy and the processes used to produce them. Within each of these categories, at least three effects of inventive activity can be identified.

1. Product innovation

- More energy-efficient existing products
- More energy-efficient new products
- Advances in exotic technologies like CO₂ scrubbing and advanced forms of carbon sequestration

2. Process innovation

- Improvements in the energy efficiency of any manufacturing process
- Cost reductions in the manufacture of low-emission energy conversion technologies (e.g., solar panels)
- Improvements in fossil energy conversion technologies that lead to lower GHG emissions

Technical advance is driven by two somewhat overlapping processes: learning—by doing (LBD), which means accumulating knowledge through routine experience with an activity like solar panel manufacture; and making conscious investments in research and product development (R&D), as exemplified by investments in new CPU design. Accumulation of technical knowledge leading to a fall in the cost of GHG abatement is facilitated by LBD; technical knowledge that results in an entirely new process, activity, or products is driven by R&D investments. R&D is naturally associated with inventive activity but LBD can, and often does, lead to invention in the form of new production processes and techniques.

The two paths leading to technical advance operate differently, and the differences between them influence the ways in which GHG abatement affects technical advance and the ways in which technical advance can affect the cost of GHG abatement. Technical knowledge gained through LBD resides with the persons (and firms) that acquire the knowledge, manifesting itself in changes in processes or activities that lead to cost reductions. On the other hand, knowledge gained through R&D investments finds its way beyond the confines of the firms where it originates and into the market as the new processes, activities, or products are sold. Thus, technical knowledge begins to take on the attributes of a public good.

THE COSTS OF TECHNICAL ADVANCES FOR GHG MITIGATION

While much attention has been paid to the direct costs of various policies designed to reduce greenhouse gas emissions, it is important to recognize the costs of making technical advances in response to a GHG-reduction policy. These costs reflect the value of economic resources that could have been allocated to some other use. This category of cost is not well accounted for by current climate policy models and usually overlooked by policy makers. The Administration's IAT report notes this

category of cost but leaves it unquantified, thereby implicitly setting it to zero. Ideally, the costs of making technical advances—along with the benefits—should be subsumed within any analysis of the net cost of climate policy, not simply ignored.

The cost of an advance depends in part on its nature. For example, as we build solar panels we gain knowledge about how to build them more cheaply. We gain the knowledge as a byproduct of the act of producing the panels, without the investment of additional resources. (To be sure, however, firms are cognizant of the LBD process, actively seek to learn from their activities, and therefore consciously put forth effort and incur costs to gain that knowledge.) On the other hand, technical advance through investments in R&D can involve large direct resource costs. Accelerating the pace of R&D-driven technical advance means accelerating the pace at which resources are expended on R&D. If a GHG abatement policy is intended to bring forth a noncarbon “backstop” technology, for example, a full analysis of the policy’s cost includes the additional resources devoted to the required R&D. A complete analysis also links the stimulus of the policy to the behavior of economic agents (most importantly firms) and accounts for the additional resources devoted to R&D as a result of the stimulus, as well as estimating the results of these resource expenditures.

The redirection of R&D activity to incentives created by GHG abatement policy can be expected to reduce the rate of technical advance in other activities and sectors. Such “crowding out” can occur within firms and across firms and is an important factor in accounting for the full cost of achieving technical innovation in response to GHG policy. A recent paper by Lawrence Goulder and Stephen Schneider of Stanford finds that ignoring the crowding out effect could seriously understate GHG abatement costs.

In practice, of course, foregone opportunities for advances elsewhere are hard to identify and evaluate, but this difficulty does not make the cost any less real. Assuming that private markets for R&D investment function reasonably well, on average the rates of return to R&D in one sector of the economy (or one area of a single firm) are likely to equal rates of return in other sectors. Under such an assumption the market value of the lost technical advance in the sector where R&D has been crowded out will be roughly offset by the gain derived from the improved energy efficiency. (This result will tend to be true for modest reallocations of R&D activity but might not hold for very large reallocations.)

Once again in practice, however, the net overall gains to society from the reallocation of R&D are more difficult to assess. Even with patent and other intellectual property right protections, a privately produced technical advance gives rise to benefits extending beyond the originating firm to the public at large. Indeed, recognition of these potentially substantial external benefits is what undergirds the economic argument for government-sponsored R&D. (This argument applies to R&D generally, not just to R&D for GHG reduction.) These external benefits will change in ways that are hard to evaluate when R&D is redirected. For example, society can be made better off, if the GHG abatement benefits from the redirection are large enough to offset the lost social benefits from diverted R&D resources invested in areas like information technology and health care, or if other substantial ancillary benefits accrue. However, the reverse also could be true.

Given the current state of knowledge, we are relatively ignorant about the size of these different tradeoffs. Nevertheless, to repeat the economist’s old adage, there is no free lunch. Moreover, policy modeling approaches that rely on exogenous characterizations of technical advance but do not properly account for the economic effort needed to improve energy efficiency are inherently inadequate and ultimately should be abandoned. The well-known autonomous energy efficiency index (AEEI) is but one example.

TECHNICAL ADVANCE AND POLICIES FOR GHG ABATEMENT

If we can make existing products and processes more energy-efficient and produce more efficient products to replace old products (at similar cost to purchasers), we increase our capacity to lower our consumption of energy and GHG emissions to desired levels without substantial adverse effects on economic growth. However, while we can identify the possible paths by which technical advance can lead to cost reductions, it is difficult to quantify the likely cost savings. Quantifying the savings is difficult because many factors influence the pace, scale, and direction of technical advance. Important factors include the timing of GHG abatement activities and policies that induce inventive activity, as well as the nature of the latter policies themselves.

Timing of Abatement

The size of the cost reduction depends on when we abate. Since technical advance takes time, the longer we wait to abate while accumulating technical knowledge and experience, the larger will be the store of cost-reducing technical advance to be drawn upon when abatement is undertaken. This assertion does not imply that the best approach is simply to defer abatement until technological possibilities have improved. The appropriate policy might be a mix of options that includes abatement and pursuit of technical advance (as well as adaptation and continued assessment of the risks of climate change).

We cannot gain technical knowledge from LBD of course unless we are engaged in abatement activities. Moreover, if an abatement policy is the sole incentive for R&D investments, then no technical advance will occur otherwise. Conceivably, however, policies might induce R&D expenditures without necessarily undertaking abatement activity. Such policies might include R&D-related tax incentives, or announcements of carbon taxes to be levied at a specific future date—as long as such announcements are credible in the private sector.

A longer time horizon for abatement conveys other cost-reducing possibilities, such as greater opportunities for avoiding premature turnover of highly productive capital; but it also raises political questions about the credibility of commitments to reduce emissions. These issues go well beyond the scope of this paper. Here I simply note that we can attempt to accelerate the pace at which we accumulate knowledge through the use of strong policy-induced incentives. Generally speaking, it will be costlier to abate and acquire knowledge sooner rather than later.

Inducing Inventive Activity

Some who believe that technical advance will lower the cost of GHG abatement to acceptable levels apparently are nonetheless skeptical about the extent to which technical advances are likely to come about naturally from appropriately corrected market signals. These advocates argue that, to attain the necessary technical advances, firms will have to be induced more directly to put additional R&D resources into activities like energy efficiency research, and the use of technologies will have to be mandated to stimulate cost-reducing LBD (for example, with renewable energy technologies).

However, if the inventive process responds to economic signals, as I believe it does, then creating appropriate incentives through GHG control policies will be the most effective way to encourage invention. Such policies include both carbon taxes and tradable permit systems that put a price on carbon emissions. Mandates and subsidies inherently direct inventive activity to specified technologies that may not be the most cost-effective opportunities for GHG reduction. For example, an automobile fuel economy standard does not include incentives for reducing distances traveled, which will go up

once fuel economy is increased. And subsidies to, or mandates for, renewable energy use by utilities may bypass lower-cost GHG opportunities through upgrades of existing generation capacity. Technology mandates also limit the choice of products available in terms of cost, convenience, reliability, familiarity, and other attributes. Limiting choice carries with it subtle but real costs in terms of consumer well-being.

Beyond policies to expand inventive activity are policies to increase demand for new products and technologies with lower GHG emissions. Consumer demonstration programs, or low-cost financing for new energy-using capital, are examples. Given the scope of this paper, I do not address the adoption stage of technical advance, as opposed to invention. However, similar controversies about the capacity to change behavior with economic signals arise in this context as well.

CONCLUDING REMARKS

If GHG policy costs are to be reduced to politically acceptable levels, some inducement to undertake more inventive activity seems to be required and this requirement will no doubt lead to all sorts of novel approaches. In the face of such novelty, it is important to proceed with care. Economic growth—with appropriate correction for environmental spillovers where needed—is the major source of improved material and social conditions worldwide, and technical advance is the force that ultimately drives increases in per-capita living standards. Therefore, any tinkering with the economic processes that bring forth technical advance risks disturbing this all-important source of growth. The importance of technical advance to economic growth suggests caution when governments consider GHG policies with the goal of redirecting the forces of technical advance. The need for caution is further underscored by our primitive understanding of the economic processes underlying technical advance and the law of unintended consequences that so often exerts itself when policies are formulated in haste and on the basis of less than adequate understanding.

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FURTHER READING (relatively technical material):

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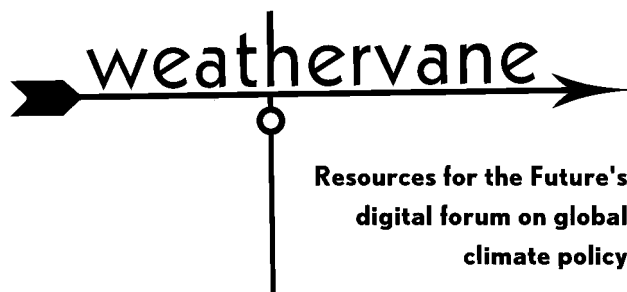
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