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Technical change and the marginal cost of abatement

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ABSTRACT

We address one aspect of the treatment of technical change in the environmental economics literature: how technical change impacts the marginal cost of abatement. We review a selection of papers that employ a variety of representations of technical change, and show that these representations have quite different, and sometimes surprising, effects on the marginal costs of pollution reductions. We argue that these varied representations in fact correspond to a variety of different technology options. We then present results indicating that this representation matters — the impacts of technical change on the marginal cost of abatement can crucially impact policy analysis.
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1. Introduction

Economic researchers have long been interested in the relationship between environmental policy and technical change. This interest has taken on a renewed vigor in recent years in response to increasing concerns about climate change. The ability of pollution reduction policies to induce technical change influences their dynamic efficiency and, in the climate context, has potentially important ramifications for the appropriate stringency of near-term emissions reductions. Moreover, a broader suite of policies to foster technical change (e.g., publicly-funded R&D) are becoming increasingly accepted as integral to a comprehensive approach to climate change.

Appropriate environmental policy depends not just on whether and how much technology responds to policy, it also depends on which technologies respond. Improvements in solar cells, for example, may have different impacts on carbon dioxide emissions reduction possibilities than improvements in the efficiency of fossil fuel power plants. An incremental improvement in solar cells may have a small impact on climate change if the carbon price is low (since solar is not widely economically competitive under such a scenario), but a larger impact if carbon prices are high. On the other hand, an improvement in the efficiency of fossil fuel power

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plants will have a large impact on climate change if carbon prices are low, but less impact if carbon prices are high causing society to substitute away from fossil fuels altogether. While not explicitly acknowledging this fact, researchers using theoretical models as well as applied aggregate-level (or "top-down") integrated assessment models have employed a variety of simplified representations of technical change. These different representations lead to different impacts on the marginal costs of emissions reductions and, in turn, to different policy implications. For example, Baker, Clarke, and Weyant (2006) have shown that different representations of technical change have very different effects on the optimal societal investment in climate change technology R&D in the face of uncertainty. They find that the socially optimal investment in technologies that pivot the cost curve down increases with some Mean-Preserving-Spreads (MPS); while the socially optimal investment in technologies that pivot the cost curve to the right tend to decrease in MPS. Yet the empirical basis for this aspect of technical change–how it affects marginal abatement costs–has been largely ignored in the construction of these models.

This paper addresses the treatment of technical change in theoretical and aggregate-level models. The paper has three distinct, but related purposes. The first is to demonstrate that theoretical and aggregate-level applied models have, indeed, used a number of different formulations for technical change and, furthermore, that these different formulations can lead to very different impacts on the marginal costs of pollution reductions. In Section 2, we review a variety of approaches from the literature, and show that these representations have quite different, and sometimes surprising, effects on the marginal costs of pollution reductions. In particular, we highlight the interesting case of formulations in which technical change increases marginal abatement costs at higher levels of abatement.

The second purpose of this paper is to provide examples demonstrating that this particular phenomenon–technical change increasing marginal costs–is not an error or an anomalous special case. In Section 3 we show that the MAC is likely to be increased for improvements in technologies that might be employed at low or intermediate levels of abatement, but that would be substituted away from at higher levels of abatement. Efficiency improvements in fossil fuel power plants serve as one example in the context of climate change. Efficiency improvements provide valuable benefits at lower levels of abatement, but society may substitute away from fossil fuel electricity at higher levels of abatement if carbon capture and storage technologies do not prove viable. Internal combustion engines are another example. Improvements to fuel economy are valuable at lower levels of abatement, and are in fact potentially a cornerstone of near-term U.S. climate policy, but electric vehicles or hydrogen fuel cell vehicles may be the most appropriate choice at higher levels of abatement. Examples can also be found in a number of other contexts, including SO_2 and particulate matter reduction, water pollution, and fish preservation. We focus on this phenomenon because it seems to be the most surprising.

The third purpose of this paper is to demonstrate that the differences in the representation of technical change matter; that is, that implied policy prescriptions can be different with different representations. In Section 4 we first review previous results in the literature; we then re-work the seminal paper on Firm Incentives to Promote Technical Change in Pollution Control by Milliman and Prince (1989) and show, for example, that different policy instruments may provide incentives for different types of technical change. Section 5 concludes the paper.

Taken together these three elements make a case for care in the representation of environmental technical change in theoretical and applied environmental models. There is no single, general effect of environmental technical change on the costs of abatement; in fact, it is possible that technical change can increase the marginal costs of abatement; and this phenomenon may change our conceptions of the most appropriate policy actions to spur environmental technical change. Although the case of increasing marginal costs is only one of many possibilities, the plausibility of its occurrence and the striking implications for Pigouvian taxes and policy more generally, provide a reminder that the devil is indeed in the details. Researchers and consumers of research alike should maintain a healthy skepticism in ascribing generality to the results of analyses positing a single, general representation of technical change.

2. Representation of technical change in models

In this section we discuss a number of approaches that have been used to model technical change in top-down and theoretical models.[1] This section has two purposes. One purpose is general — to demonstrate

[1] See Clarke et al. (2006, 2008), Clarke and Weyant (2002), Gillingham, Newell, and Pizer (2007), Grubb, et al. (2002), Loschel (2004), and Sue Wing (2006), for surveys focusing on how technical change is made endogenous in formal models of energy and the environment.

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