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A paler shade of green: Environmental policy under induced technical change[☆]

Corrado Di Maria[a,*], Sjak Smulders[b,1]

[a] School of Economics, University of East Anglia, Norwich Research Park, Norwich, NR4 7TJ, United Kingdom
[b] Tilburg Sustainability Center, Department of Economics and CentER, Tilburg University, P.O. Box 90153, Tilburg 5000 LE, The Netherlands

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ABSTRACT

Conventional wisdom argues that environmental policy is less costly if it induces the development of cleaner technologies. In contrast to this argument, we show that once the second-best nature of actual economies is taken into account, the cost of environmental policy may well be larger with induced technical change (ITC) than without. Thus, ITC may lower both the emissions reductions and the welfare gains associated with environmental policy. In an endogenous policy framework, ITC may reduce the desired stringency of the policy.

1. Introduction

A widely held tenet among environmental economists and policy makers alike is that the development of new, cleaner technologies decreases the cost of pollution reductions. The natural consequence of this view is that policy-induced technical change lowers the costs of complying with environmental regulations and facilitates the implementation of ambitious environmental policies. This deep-rooted trust in the salvific power of technology, however, may appear unjustified in light of the historical record showing that over the course of the last two centuries a number of major technological developments ushered dramatic improvements in energy efficiency, while at the same time fostering large increases in energy use and

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* Corresponding author.
E-mail addresses: c.di-maria@uea.ac.uk (C. Di Maria), j.a.smulders@uvt.nl (S. Smulders).
[1] Smulders is also a CESifo Research Network Fellow.

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polluting emissions.[2] In other words, the process of technological change has in the past often proven to be pollution-using, rather than pollution-saving.

To explain this apparent paradox, it is useful to distinguish between the general notion that the adoption of new technologies responds to profit incentives, and the more specific notion whereby technological change responds to policies in so far as they affect profits - a distinction between endogenous innovation and policy-induced technical change. Within an endogenous innovation framework, firms implement innovations they expect to increase their profits, and the pollution-saving or pollution-using nature of the technology is immaterial. When environmental policy makes pollution more expensive, however, it also makes pollution-saving innovations relatively more profitable than pollution-using ones. For this reason in the dominant view (environmental) policy-induced technical change (ITC) is good for the environment: the policy aligns the innovative firm's profit motives with the policymaker's environmental goals and ITC makes the policy more effective and less costly.

In this paper, we show that this view may break down in the presence of externalities, distortions, or general equilibrium effects. We emphasize two main avenues behind this result. On the one hand, while environmental policy would become cheaper if firms adopted pollution-saving technology, they may actually find it optimal to respond to changes in policy by instead adopting pollution-using technology if the latter turns out to be more profitable from their point of view. This may happen in a second-best world in which price distortions introduce a wedge between the firms' profit incentives and society's policy aims. On the other hand, even if firms focus on pollution-saving innovations, their response may impose a large enough cost to society to end up crowding out valuable innovations.[3] The literature has so far widely neglected these possibilities, either by assuming that innovation can only be pollution-saving or by abstracting from second-best and general equilibrium issues.

The key mechanism by which ITC may increase the cost of environmental policy is thus by decoupling the private returns to investment in clean technologies from their social returns. To illustrate this mechanism, it is enough to consider the role of a simple production externality from pollution. As pollution falls, firms' production and profits benefit, but the firms themselves do not recognize this external effect when making decisions on their emission levels and technologies. In the presence of such an externality, firms might profitably respond to the bigger market size by increasing their production and emissions, and by investing in polluting-using capital. To make matters worse, investment incentives may also be distorted by suboptimal policies, such as subsidies to polluting inputs that trigger pollution-using investment and innovation.

Our results challenge the conventional wisdom and show that ITC may raise the opportunity cost of pollution abatement, reduce the willingness to pay for environmental quality, or both. The presence of ITC may thus make environmental policy targets more costly to achieve, or lead to situations where policies become optimally less ambitious, implying lower pollution reductions.[4] These results are at odds with most of the existing literature, which instead finds that ignoring ITC leads to overestimating the costs of environmental policy.[5,6]

In this paper, we use a stylized, static framework that lets us transparently identify the driving forces behind our results. These results are driven by a combination of elements that are empirically relevant but often neglected in other analyses of induced technical change. In particular, our conclusions emerge in a second-best world in which environmental quality affects productivity and thus interacts with investment decisions. We also find that they are more likely to arise when innovations lead to a significant increase in the demand for physical capital. Such complementarity between new technology and physical capital matches historical patterns of innovation and investment, with expansions in sectors where new products and improved technologies are introduced, and with displacements of older technologies by newer, more capital-intensive ones.[7]

[2] Examples of such technologies are steam powered pumps and looms in the nineteenth century, internal combustion engines at the turn of the twentieth century, petrochemical plastics and fertilizers after World War II, jet planes for intercontinental flights in the 1960's, and personal computer and other information and communication technologies from the 1980's.

[3] This mechanism is similar to the scale effect emphasized in Gans (2012).

[4] Note that, in the model presented below, environmental policy is both desirable, in the sense that it leads to welfare improvements, and effective, in the sense that it achieves pollution reductions. Our claim that ITC reduces the effectiveness or increases the cost of environmental policy refers to the comparison between an hypothetical world where technology is exogenously given, and the more realistic world in which technology and investment react to changes in the relative prices of production factors.

[5] In the context of climate change, the latest IPCC report discusses climate policy models with ITC and concludes that "*These models demonstrate that ignoring induced innovation overstates the costs of climate control*" (IPCC, 2014, p.257). Similar positions have been expressed in the well-known Stern Review (Stern, 2006) and by Goulder (2004). Modeling efforts that support this view are discussed at length in the context of the Innovation Modeling Comparison Project by Edenhofer et al. (2006). An extreme representation of this paradigm is offered by Acemoglu et al. (2012), who show that environmental policy only needs to be temporary to prevent environmental collapse by redirecting technological change.

[6] As discussed later in the paper, a number of authors have previously argued that technical change might lead to an increases in the marginal cost of pollution abatement (Amir et al., 2008; Baker et al., 2008; Bauman et al., 2008; Brechet and Meunier, 2014; Perino and Requate, 2012). We differ from these contribution in that their focus is on partial equilibrium models of technology adoption, whereas we provide a general equilibrium view of induced innovation in the presence of additional distortions. Gans (2012) finds that environmental policy may reduce innovation through a scale effect. Our results in the present paper generalize his findings since, rather than relying on specific functional forms, we derive our results in a general setting.

[7] Looking back to the list of innovations in footnote 2, one might think of the development of petrochemistry and plastics – whose versatility in production lead to a myriad novel uses – as well as jet engines used for transatlantic flights as examples of new products introduced with increased demand for capital as a result. The other technologies in that list fit better among the capital-intensive innovations. Large steam-powered iron pumps and mills replaced hand-operated wooden ones during the industrial revolution, automobiles replaced horses and carriages, etc.