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The impact of environmental policy instruments on the timing of adoption of energy-saving technologies

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Abstract

One of the main considerations in designing environmental policy is the impact of policy instruments on the *timing* of firms' investment decisions with respect to energy-saving technologies. This paper analyzes the impact of environmental taxes and quotas on the timing of adoption when (i) the rate at which new, improved energy-efficient technologies become available, is uncertain, and (ii) the investment decision is (at least partially) irreversible. We find that neither policy instrument is unambiguously preferred to the other when it comes to stimulating early adoption of new technologies.

JEL classification: D81; O14; O33; Q48

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1. Introduction

Much attention has been paid to the potential of public policies to reduce environmental pollution, such as emissions of carbon dioxide. Conventional wisdom is that, from an efficiency perspective, market-based instruments are preferred over command-and-control instruments. Taxes are an example of such market-based instruments, and their alleged

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superiority is based on the notion that they equalize marginal abatement costs across firms and hence yield statically efficient outcomes (Baumol and Oates, 1988). In addition, taxes are believed to be more effective in inducing technological change than command-and-control instruments as they offer a permanent incentive to use less of the environmental commodity and thus save on tax expenditures (Downing and White, 1986; Newell et al., 1999). Kneese and Schulze (1975) have argued that ''over the long haul, perhaps the most important single criterion on which to judge environmental policies is the extent to which they spur new technology toward the efficient conservation of environmental quality''. The case for taxes thus appears strong, both from a static and a dynamic efficiency viewpoint.

Whereas to date the literature has focused on calculating the willingness to pay for one particular new technology under different policy regimes (e.g., Milliman and Prince, 1989; Jung et al., 1996; Requate and Unold, 2003), we analyze the impact of the choice of policy instruments on the *timing* of the investment. We assume that new generations of energy-saving technologies become available at unknown future dates, and define the ''adoption lag'' as the expected number of periods that elapses until a firm purchases a new technology. We analyze whether taxes or command-and-control instruments (specifically, non-tradable quotas) are more conducive to early adoption by comparing the length of the adoption lag under the two policy regimes.

Governments may care about *early* adoption for at least two reasons. First, governments may be bound by international agreements (think of the Kyoto protocol) that have specific time horizons for compliance, and therefore be interested in immediate reductions in the energy intensity of production. Second, governments may have a short planning horizon, as predicted by political economy models (Mueller, 1993).

Our model is simple in many respects. We assume that the rate of invention (the arrival of new technologies) is exogenous.[1] Technologies produce output, using two variable factors of production, labor and energy. New technologies are of the energy-augmenting type but, upon equating total use of energy to total emissions, we can also say that technical progress reduces the pollution intensity of production. Firms may decide to invest and apply the new technology henceforth, or they may decide to forego the option to invest and await better technologies expected to become available in the future. Due to the fixed costs associated with purchasing and installing new machinery, irreversibility plays an important role in the investment decision as the firm will regret having adopted a specific new technology if an even better technology arrives shortly after adopting (Dixit and Pindyck, 1994). We take an extreme view on irreversibility by assuming that firms can purchase an energy-efficient technology only once, but the qualitative results of the model spill over to other cases where investments are at best partially reversible (for example when there are scrap markets for obsolete technologies) or when firms can invest more than once.

This paper aims to fill a gap in the environmental economics literature by focusing on the impact of instrument choice on the adoption of new technologies, if technological progress is expected to be ongoing. The effectiveness of policy instruments in inducing adoption have been addressed before, but always with respect to a single, specific new technology (e.g., Milliman and Prince, 1989; Jung et al., 1996; Malueg, 1989; Requate,

[1] For analyses of the impact of the choice of policy instruments on innovation, see for example Laffont and Tirole (1994, 1996b), Magat (1978), Milliman and Prince (1989), Jung et al. (1996) and Requate (1998).