Journal of Economic Dynamics & Control 41 (2014) 20–37

Contents lists available at ScienceDirect

Journal of Economic Dynamics & Control

journal homepage: www.elsevier.com/locate/jedc

Abatement R&D, market imperfections, and environmental policy in an endogenous growth model

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ARTICLE INFO

Article history:
Received 10 September 2012
Received in revised form
15 January 2014
Accepted 18 February 2014
Available online 2 March 2014

JEL classification:
H23
O32
Q56

Keywords:
Private abatement R&D
Market imperfections
Endogenous growth

ABSTRACT

We develop an endogenous growth model featuring environmental externalities, abatement R&D, and market imperfections. We compare the economic performances under three distinct regimes that encompass public abatement, private abatement without tax recycling, and private abatement with tax recycling. It is found that the benefit arising from private abatement will be larger if the degree of the firms' monopoly power is greater. With a reasonably high degree of monopoly power, a mixed abatement policy by which the government recycles environmental tax revenues to subsidize the private abatement R&D is a plausible way of reaching the highest growth rate and welfare.

1. Introduction

An important environmental problem policy-makers are facing concerns how to reconcile sustainable growth with limited pollution. On the one hand, endogenous growth theory requires that most economic factors grow unlimitedly. On the other hand, if pollution, an input or a by-product of output, were to grow to become infinitely large, any life or economic activities could hardly exist. To ensure sustainable growth, it is therefore essential for pollution to be abated within a survivable level in the long run. In the US, for example, the estimated total annual abatement expenditure represents between 1.5% and 2.5% of GDP (Berman and Bui, 2001).

Recent studies dealing with the relationship between pollution abatement and environmental growth, such as van Ewijk and van Wijnbergen (1995), Bovenberg and Smulders (1995, 1996) and Fullerton and Kim (2008), treat abatement as technology or knowledge that could be accumulated and developed in a separate sector (i.e., the environmental R&D sector).[1] Since knowledge is non-rival and has the characteristic of a public good, the costs associated with the use of abatement knowledge as an input are zero, while knowledge creation and accumulation, by contrast, require rival inputs

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[1] Alternatively, some studies treat abatement spending as a flow variable which cannot be accumulated. See Gradus and Smulders (1993), Ligthart and van der Ploeg (1994), Smulders and Gradus (1996), and Bovenberg and de Mooji (1997).

http://dx.doi.org/10.1016/j.jedc.2014.02.011
0165-1889

and are costly.[2] This implies that, as stressed in Bovenberg and Smulders (1995), in a perfectly competitive market abatement R&D could *not* be rewarded so that no innovation in abatement technologies would be undertaken without the government's intervention. Therefore, this strand of the literature essentially assumes that abatement R&D activities are publicly conducted by the government.[3]

In reality, however, we often observe that private and public abatement activities coexist. Moreover, it is usually observed that abatement technologies are developed and produced in a private upstream sector, which then sells abatement equipment (or blueprints) to downstream polluting industries (OECD, 2000; Greaker and Rosendahl, 2008). In the US, the private abatement investment is even greater than the public abatement investment (OECD, 2007, Table 3).[4] Based on these observations, it is quite fair to say that a satisfactory model should be able to consider both possibilities of public and private abatement R&D. This is what we aim to do in this paper. To be more precise, we build up a theoretical framework which enables us to compare economic performance under the private and public abatement investment regimes.

Another key feature of our model is that we introduce imperfect competition in the intermediate good market. As mentioned above, private abatement R&D requires incentives, which are not available in a perfect market because, if they were, the competitive firms would not be left with any quasi-rent for abatement R&D. Hence, we should resort to a different market structure, such as an imperfectly competitive market. In the 1980s, several studies (e.g., Hart, 1982; Mankiw, 1985; Blanchard and Kiyotaki, 1987) noted that market power in the private sector plays a crucial role in the performance of government policy. More recently, Judd (2002) has also argued that imperfect competition is a key feature of dynamic modern economies. The empirical evidence, on the other hand, suggests that polluting industries are often equipped with monopoly power (Beccarello, 1996; Considine, 2001). To reflect the observed facts, a considerable body of studies have developed environmental economic models which take market imperfections into account (e.g., Fullerton and Metcalf, 2002; Greaker and Rosendahl, 2008; Chang et al., 2009).

Following in the footsteps of these studies, this paper develops an environmental endogenous-growth model that features market imperfections. More specifically, the market structure we consider is characterized by three vertically integrated sectors. Abatement technologies are developed in an upstream sector, which sells the abatement knowledge (ideas) to the intermediate sector. The intermediate sector, which generates pollution, can generate a positive profit by exhibiting monopoly power, but it has to pay fees to the upstream sector for the right to use the abatement knowledge. The perfectly competitive downstream sector produces a single final output by employing intermediate inputs. Under such a setting, we are able to deal with various regimes including public abatement (hereafter, GA), private abatement without tax recycling (PA), and private abatement with tax recycling (PAR) regimes. Moreover, we compare the relative superiority in terms of economic growth and social welfare among various regimes. In particular, we highlight whether market imperfections play an important role in determining the relative superiority.

An interesting issue in this paper is whether the private provision of abatement knowledge leads to a higher growth rate than public abatement. Our analysis shows that the answer crucially depends on two factors, namely the monopoly power of the polluting firms and the type of government spending. We find that the greater the degree of the firms' monopoly power, the larger will be the benefit arising from the private implementation of abatement. The reason for this result is that the incentive for the upstream sector to engage in R&D is precisely determined by the intermediate firms' profit. It is also found that growth will be enhanced if the government distributes its tax revenues to boost (or directly engage in) abatement R&D. This finding implies that if environmental tax revenues are used to provide public goods or other private services, a subsidy on private R&D abatement will possibly be a good choice to achieve higher economic growth and social welfare.

The analysis of this paper is also related to recent studies on the effect of environmental taxation on economic growth. The conventional wisdom in the literature (e.g., Huang and Cai, 1994; Ligthart and van der Ploeg, 1994; Grimaud, 1999) is often that there is an unavoidable conflict between the economic growth and the conservation of the environment in the economy. However, in recent years a growing body of literature that proposes a positive growth effect of environmental taxation has accumulated. For example, in their frequently cited article, Bovenberg and Smulders (1995) find that environmental taxation has an ambiguous effect on economic growth by assuming that environmental quality is beneficial to input productivity.[5] In departing from this strand of the literature, our analysis assumes that the polluting inputs are purchased from abroad at a non-bargaining price. Accordingly, a higher environmental tax will reduce the pollution by way of an accumulation of abatement R&D, but the polluting inputs will remain unchanged. Since an environmental tax does not decrease the level of polluting inputs (and thereby the marginal productivities of other inputs), it undoubtedly spurs economic growth through the positive environmental productivity effect.

[2] See Smulders (1995) for a detailed discussion.

[3] One exception is van Ewijk and van Wijnbergen (1995), in which the accumulation of abatement capital is costless (a by-product of the accumulation of human capital); thus private abatement takes place even without policy intervention. As is evident, our model's structure is completely different from theirs. Furthermore, van Ewijk and van Wijnbergen (1995) do not deal with public abatement investment.

[4] See Hatzipanayotou et al. (2005) for more detailed discussions on private and public abatement in the US and the UK.

[5] Other justifications contributing to a positive (ambiguous) environmental tax effect on economic growth include a positive externality of abatement activities (Smulders and Gradus, 1996), an elastic labor supply (Hettich, 1998; Chen et al., 2003), the international accumulation of environmental assets (Ono, 2003), tax revenues recycled to subsidize intermediate goods R&D (van Zon and Yetkiner, 2003; Nakada, 2004), and the existence of an indeterminate equilibrium path (Itaya, 2008).