Journal of Environmental Economics and Management 56 (2008) 141 – 154

Contents lists available at ScienceDirect

Journal of Environmental Economics and Management

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

Environmental investment and policy with distortionary taxes, and endogenous growth

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ARTICLE INFO

Article history:
Received 11 December 2006
Available online 18 June 2008

JEL Classification:
O41
Q20
H41
H23

Keywords:
Pollution tax
Environmental policy
Growth rate
Income tax
Abatement knowledge

ABSTRACT

Recent studies consider public R&D spending that affects abatement knowledge and endogenous growth, distortionary taxes that affect capital formation, pollution taxes that affect environmental degradation, and regeneration that restores natural capital. Our model combines all those elements. The combination affects prior results, focusing on two parameters: the need for distorting taxes, and productivity of abatement knowledge relative to pollution. First, these two extensions can reverse prior findings that pollution tax revenue is always enough to pay for public R&D. Second, tax distortions and externalities alter prior findings that the ratio of public to private capital depends only on output elasticities. Third, dynamics affect prior static findings about other public spending "crowding out" environmental public goods. Fourth, a greater need for public spending can lead to greater increases in distorting taxes or pollution taxes. Fifth, greater environmental regulation can mean growth is higher or lower, even if welfare is higher.

To ensure that economic growth and environmental preservation are compatible and socially optimal, it is crucial to understand the simultaneous dynamic interactions among public spending needs, distortionary taxes, pollution taxes, abatement R&D, technological progress, pollution externalities, ecological regeneration, private economic activities, welfare, and growth. How can environmental investment and tax policies contribute to the productivity of private factors of production and to sustainable economic growth? So far, existing research has used a number of different models to address different questions that each focus on a particular interaction among only some of the policies and outcomes just listed.

Existing endogenous growth models have physical capital, human capital, and fixed inputs such as raw labor, but environmental models add other inputs supplied by nature. Bovenberg and Smulders [5,6] extend the model of Lucas [22] by incorporating two stocks that are "public" inputs to production: the environment and abatement knowledge.[1] They consider a pollution tax, but not other distorting taxes.

Three papers consider both a pollution tax and a distorting income tax, but not those two "public" capital stocks. Bovenberg and de Mooij [4] and Greiner [14] include public infrastructure, and Hettich [16] has human capital, but none of these papers considers the dynamics of investment in abatement or environmental quality. Yet these papers can ask what

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[1] Other models with nature as an input include Tahvonen and Kuuluvainen [32], Gradus and Smulders [13], van Ewijk and van Wijnbergen [33], Smulders and Gradus [31], Elbasha and Roe [8], Mohtadi [25], Xepapadeas [34], and Bovenverg and de Mooij [4].

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doi:10.1016/j.jeem.2008.02.001

is the optimal tax mix, where the pollution tax affects externalities on production and the income tax affects private capital formation.[2] They also ask whether a tightening of pollution standards can boost long-run growth.

In this paper, we combine various elements from prior models to construct a single endogenous growth model that we then use to answer more of their questions in a way that is more complete and comparable than in prior papers. We show how the added features of our model change and in some cases reverse previous answers. We focus on five questions, first noting how prior papers address them.

As in Bovenberg and Smulders [5,6] our model has three assets: private capital, accumulated either from physical investment or human capital formation; abatement knowledge, accumulated from public R&D spending; and environmental quality, modeled as a stock of a renewable resource that is depleted by pollution but augmented by ecological regeneration. This natural capital stock provides a nonrival public input to production and nonrival benefits in utility, so pollution has negative external effects on both. Firms choose inputs of private capital and "effective pollution", which is the product of actual pollution and public abatement knowledge. Thus, while some pollution is essential to production, it can be reduced either by public spending on abatement or by public policies to control emissions.

We extend Bovenberg and Smulders in two important ways, summarized by two additional parameters. First, we assume that lump sum taxes are not available to pay for government spending that is a fixed fraction φ of private income, and so we add a distortionary income tax that must be used to help pay for it.[3] Second, we suppose that "effective pollution" is the product of abatement knowledge and actual pollution taken to the exponent ε, a parameter that allows for differential productivity of actual pollution relative to abatement knowledge.[4] We show how either of these two generalizations can reverse their conclusions.

We use all of these model features together to derive some results analytically, and then to show seven nonlinear equations for seven important endogenous variables. These equations cannot be used to find closed form solutions, and so we show some other important results using numerical analysis.

We are now in a position to describe the five major questions we address, the findings of prior models, and how our extensions affect the answers:

(1) Are pollution tax revenues always enough to pay for optimal public spending on abatement R&D? Bovenberg and Smulders [5] say "yes," using their model described above with private capital, abatement knowledge, and natural capital. Here, we show analytically that this conclusion can be reversed if effective pollution is augmented more by abatement than by actual pollution (where pollution has exponent $\varepsilon<1$). This reversal is more likely when a distorting income tax is needed for other government spending ($\varphi>0$). With these generalizations, pollution tax revenue may fall short of optimal abatement spending, which then requires a higher distorting tax.[5]

(2) What is the optimal public capital relative to private capital? Barro [1] and Barro and Sala-i-Martin [2,3] consider public "infrastructure" and find the answer is based on the ratio of output elasticities. This ratio is about 0.3 using our parameters (where public capital is abatement knowledge instead of infrastructure). Relative to their model we add tax distortions and pollution externalities, and we find that the optimal ratio almost doubles. Thus, the ratio of public capital to private capital depends not just on production, but on tax rates and preferences.

(3) Is government's provision of the environmental public good "crowded out" by the need to provide non-environmental public goods? Metcalf [23] and Gaube [10] ask this question in static models where a labor tax distorts labor supply, and they show conditions under which increased non-environmental spending will raise environmental quality. Relative to their models, we add the dynamics of endogenous growth and a tax on capital income. In our numerical model, all increases in required government spending necessitate increases to both the income tax and pollution tax, both of which reduce output and pollution. The result is more natural capital.

(4) Does greater need for public revenue mean larger increases in the income tax or pollution tax? This is not the well-researched "double dividend hypothesis", which is about tax reform. With endogenous growth, for example, Bovenberg and de Mooij [4] and Hettich [16] show effects of a revenue-neutral reform to raise the pollution tax and reduce the distorting tax. They look at non-optimal paths (since we already know effects on welfare of a change from the optimum!). Here, we look not at tax reforms but only at optimal growth paths. For all increases in required public spending, we find that both tax rates rise. The income tax rises relatively more than the pollution tax for initial increases in public spending, but subsequent spending hikes lead to greater relative increases in the pollution tax.

(5) When does a higher environmental tax mean higher economic growth, or welfare, or both? Environmental policy normally has costs in models with exogenous growth, but Bovenberg and Smulders [5,6] and Hettich [16] show how it can boost

[2] An income tax distorts intertemporal choices. It leads in neoclassical growth models to a lower long-run level of income and in endogenous growth models to a lower long-run growth rate. See Rebelo [28], Rebelo and Stokey [29], Jones et al. [18], and Jones and Manuelli [17]. Taxes on capital income or total income reduce the rate of saving and growth, while taxes on labor income or consumption have only level effects, not growth effects.

[3] Bovenberg and de Mooij [4] and Hettich [16] consider both distorting tax and pollution tax with endogenous growth. Relative to their models, we add two dynamic considerations: abatement knowledge accumulates from R&D spending, while natural capital is depleted by pollution and augmented by natural regeneration. We also address additional questions.

[4] Bovenberg and de Mooij [4] consider effective pollution as current abatement spending times pollution to an exponent. We employ their idea but use the stock of abatement knowledge.

[5] In a model where pollution/output is fixed (no ε parameter), and where government can spend on current abatement rather than on abatement capital, Greiner [14] also finds that pollution tax revenues are less than optimal abatement spending.