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Analysis

Tradable pollution permits in dynamic general equilibrium: Can optimality and acceptability be reconciled?

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ABSTRACT

In this paper we study the dynamic general equilibrium path of an economy and the associated optimal growth path in a two-sector overlapping generation model with a stock pollutant. A sector (power generation) is polluting, and the other (final good) is not. Pollution is regulated by tradable emission permits. The issue is to see whether the optimal growth path can be replicated in equilibrium with pollution permits, given that some permits must be issued free of charge for the sake of political acceptability. We first analyze the many adverse impacts of free allowances, and then we propose a policy rule that allows optimality and acceptability to be reconciled.

1. Introduction

Since Montgomery (1972) it is well established both in the economic literature and in the policy debate that the way pollution permits are issued does not affect efficiency. This finding has been widely used in the policy debates about the carbon markets created under the Kyoto protocol, and the EU Emission Trading Scheme that came into force in 2005 (see IEA, 2005, or Ellerman et al., 2010). While it is well known that this result only holds in a static setting and in partial equilibrium, only a few studies have scrutinized the properties of a market of tradable permits in a dynamic general equilibrium. The exception is the stream of research led by Bovenberg, Goulder and Parry on the double dividend issue (e.g. Bovenberg and De Mooij, 1994; Goulder, 2002; Parry et al., 1999). In an overlapping generation framework (OLG),[1] Jouvet et al. (2005) showed that decentralization of the optimal path can be obtained with lump-sum transfers only if tradable permits are not given to the polluting firms for free. This result contrasts with the standard OLG model (Allais, 1947; Diamond, 1965) without environmental constraints where the optimal policy can be decentralized with lump-sum transfers without any other conditions (on these issues, see De La Croix and Michel, 2002). With an environmental externality, free permits act as a subsidy that increases the return to the owners of the firm's capital, which leads to a major distortion in the economy.

Despite the fact that the research mentioned above, by using general equilibrium models, suggests that auctioned permits or emission fees dominate the market in tradable permits with free endowment in terms of welfare, free allocation (via grandfathering) remains the main policy option in practice. This is true for the US SO_2 market, the EU-ETS market, and also under the Kyoto protocol.[2]

Stavins (1998) explored the motives that lead policy makers to favor free allocation rather than auction, which we will call *acceptability*. We follow Stavins (1998) and Goulder (2002) by defining acceptability as the property that environmental regulation does not reduce a firm's profit. Clearly, if such a policy is possible, both the polluters (the firms) and the polluted (the consumer) will agree on the proposed policy. As explained by Stavins, existing firms favor freely

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[1] Solow (1986) points out that intergenerational issues must be analyzed within an overlapping generation model which takes into account intra- and inter-generation relations.

[2] However, it must be noticed that political discussions on the third phase of the EU-ETS market led to an increase in the proportion of auctioning.

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allocated tradable permits because they convey rents (known in the literature as *windfall profits*) to them. These windfall profits create a distortion in capital allocation among firms by increasing the total capital return, since extra profits are given to the shareholders. Furthermore, emission permits also create entry barriers since newcomers have to purchase permits from the existing firms (Koutstaal, 1997). The economic literature shows that optimality cannot be reached because it will be rejected by the polluters (here, the firms) if all the permits are auctioned. *Acceptability* suggests giving pollution permits for free, but *optimality* requires them to be fully auctioned, or an emission tax to be levied. Thus, optimality and acceptability appear as conflicting issues. Can the two policy options be reconciled?

In this paper we question this result. We extend Jouvet et al. (2005) by developing a two-sector two-good overlapping generation model.[3] This new framework will allow us to scrutinize the redistributive effects of various allocation rules of pollution permits in the economy and among the productive sectors. Dynamic issues related to the environment have long been the subject of economic analysis, especially in the framework of optimal growth models. In this framework, firm shareholders are well identified and capital accumulation can be fully studied. This is particularly important since we are interested in the effect of permit allocation on the optimal growth conditions. We show that the optimal path can be decentralized while satisfying the acceptability condition that firms' profits are not reduced. We provide the policy rule for that. Our main contribution is the annulment of windfall profits through this policy rule, based on implicit lump-sum transfers, that tolerates grandfathering or the actual policy in place. Furthermore we show the necessity for combining both quantity and price-based regulations to reach that result.

The paper is organized as follows. In Section 2 the setting is presented. The optimal growth problem is laid out in Section 3, where we explicitly identify the conditions for optimal growth. In Section 4, we define a dynamic general equilibrium with pollution permits and show why giving free permits to the polluters cannot lead to optimal growth. In Section 5 we explore alternative policy solutions and suggest a way in which optimal growth and acceptability can be reconciled. In Section 6, we study the long run effects of such policies. The last section is the conclusion.

2. The Model

We model a two-sector economy. The first sector produces a good (energy, for instance) by using capital and labor and by emitting a global pollutant (carbon dioxide). The second sector produces a final good by using capital, labor, and an intermediate good, energy. Although the final good sector uses the energy supplied by the power sector, it does not directly emit polluting emissions. It still has an indirect effect on pollution through its energy demand to the power sector. The power sector is indexed by e and the final good sector by g. Households consume the final good and energy, and their utility level is impacted by the quality of the environment.

2.1. Power and Final Good Sector Technologies

The output Y_t^g of the final good sector occurs in each period according to a production function $F^g(.)$ of capital, K_t^g, labor, L_t^g and power Z_t,

$$Y_t^g = F^g\left(K_t^g, L_t^g, Z_t\right). \tag{1}$$

Let us stress that Z_t is the intermediate consumption of energy in the final good sector. It is produced by the power sector. The output of the power sector is denoted by Y_t^e and given by the production function $F^e(.)$ by using capital, K_t^e, labor, L_t^e and emissions E_t,

$$Y_t^e = F^e\left(K_t^e, L_t^e, E_t\right). \tag{2}$$

Both production functions are homogeneous of degree one and differentiable. The power supply Y_t^e will be used both as an intermediary input for the final-good sector and as a final good for consumers.

2.2. Pollution Dynamics

Let us consider a stock pollutant whose dynamics at time t, P_t, are given by

$$P_t = (1-h)P_{t-1} + m(E_t), \tag{3}$$

where h is the natural level of pollution absorption, $0 \leq h \leq 1$, E_t is the flow of pollutant resulting from economic activity and $m(.)$ is the contribution of this flow to the stock. The transition from E_t to $m(E_t)$ represents the fact that only a fraction of E_t may contribute to the flow. For example, only 95 p.c. of the flow of greenhouse gases stays in the atmosphere. With the function $m(.)$ we accept that this proportion is not necessarily linearly related to the flow. Naturally we assume that $m_E \geq 0$.[4] Even if specification (3) is widely used in economics, we acknowledge that assuming a constant natural level of pollution absorption can be seen as unsatisfactory. In fact, current observations suggest that carbon sequestration rate is likely to decrease as pollution accumulates.[5] Nevertheless, one can see that a more complex dynamics would actually not qualitatively affect our results. Whatever these dynamics, we shall assume that the pollution level is optimally managed by the regulator (the amount of pollution is fixed by the amount of permits at each time period, which coincides with the socially optimal one by assumption). The problem we are interested in is the analysis of the general equilibrium effects of this regulation when permits are issued for free, not the environmental dynamics itself. Although the dynamics of the pollution does shape the economic path, this is not our main concern in this paper.

2.3. Households Preferences

We consider an overlapping generation model with two consumption goods (the final good and power) and a by-product, pollution. Individuals live for two periods. The number of agents born at date t, N_t, is exogenous. Each agent young in period t, supplies inelastically one unit of labor in period t. He or she derives utility from the consumption of the two goods during the two periods — i.e. c_t^g and c_t^e in period t and d_{t+1}^g and d_{t+1}^e when old. The pollution stock negatively affects utility during the two periods of life — i.e. P_t and P_{t+1}. Household preferences are thus represented by a general utility function of the form:

$$U_t = U\left(c_t^g, c_t^e, P_t, d_{t+1}^g, d_{t+1}^e, P_{t+1}\right). \tag{4}$$

The function $U(.)$ is strictly concave, increasing with respect to the two consumption goods, and decreasing with respect to pollution, twice continuously differentiable and it satisfies the Inada conditions.

[3] Originally introduced by Galor (1992).

[4] An extension of this specification would be to consider abatement as an argument in the function $m(.)$. In such a case, the flow of emissions, net of abatement, that goes into the polluting stock would be $m(E, X)$, with $m_X < 0$. Such a specification would not change the properties of our model. It would just introduce some more flexibility, for example if X were a policy instrument.

[5] We are grateful to an anonymous referee for having raised that issue.