ENVIRONMENTAL STANDARDS IN A LARGE OPEN ECONOMY

JEFFREY PETCHEY
Curtin University

Abstract

The small-country price-taking assumption of Oates and Schwab is relaxed to consider a large open economy that can influence its net capital return. This creates an incentive for the country to distort its policies. The key question asked is whether this induces inefficient outcomes. The result is that if the country has a dedicated tax on capital and uses this tax optimally, the Oates and Schwab first-best result still holds. However, efficiency in a large open economy requires that the tax on capital be nonzero, unlike Oates and Schwab where the capital tax must be zero for first-best efficiency.

1. Introduction

The 1988 paper by Oates and Schwab develops a model of a region with a large number of small open-economy jurisdictions.[1] The region has a given stock of capital that migrates between jurisdictions without restriction. Due to the large number assumption, jurisdictions are price-takers with respect to the net return they pay for mobile capital. Each jurisdiction has two policy variables, a dedicated tax on mobile capital and the choice of environmental standards. The main result, which has endured in the recent economics literature, is that each jurisdiction chooses a first-best efficient policy mix where

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[1] See also Oates (2002) and Cumberland (1979, 1981).

environmental standards are provided such that the social marginal benefit is equal to social marginal cost, and the tax on mobile capital is zero.

This paper extends the Oates and Schwab model by relaxing the assumption that jurisdictions are small price-takers. As a consequence, jurisdictions have an incentive to distort their policies to manipulate the net capital return. Despite this, the main Oates and Schwab result is shown to hold if jurisdictions have access to a dedicated capital tax and choose this tax optimally. With these conditions satisfied, environmental standards, or any public good for that matter, are still provided consistent with the first-best efficiency criterion. First-best efficiency is also shown to require the tax to be nonzero.

These results can be derived for a single economy or a multi-economy setup with strategic behavior. Hence, if a single jurisdiction that is not a price-taker with respect to its net capital return chooses an efficient policy mix, so too will a nonprice-taking jurisdiction acting strategically as part of a federation, or regional union. The result also holds whether a jurisdiction maximizes household utility or household income. Since the idea is presented most clearly for the single jurisdiction case with household income maximization, this is the option employed.[2]

The outline is as follows. Section 2 develops the model of a large open economy. Section 3 presents the results. Conclusions are found in Section 4.

2. Model

This section develops a model of an open economy where the government has two policy instruments—environmental standards and a tax on mobile capital. The model is analogous to the model of Oates and Schwab (1988). A point of departure is that here the economy's policies influence its net capital return. The economy is not a price-taker and can set the net return (price) it pays for mobile capital.

Suppose the economy has a given supply H of immobile households. Without loss of generality, assume that $H = 1$ from now on. An industry sector produces output y using two inputs; mobile capital k and unpriced pollutant emissions g (a pure public bad). Emissions are the inverse of environmental standards that are assumed to be a choice variable. In choosing environmental standards, the government also selects its pollutant emissions and the two instruments are perfectly interchangeable policy choices. Output is defined by the production function

$$y = f(k, g). \tag{1}$$

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[2] Results for a multistate utility-maximizing context with strategic behavior are available from the author.

Marginal products are nonnegative

$$\frac{\partial f}{\partial k} = f_k \geq 0, \quad \frac{\partial f}{\partial g} = f_g \geq 0. \tag{2}$$

For mathematical convenience, the price of output is assumed to be one so that expression (1) also defines the value of output. Assuming a competitive capital market within the economy, the gross return to capital is equal to the marginal product of capital f_k defined at (2). The following also applies:

$$\frac{\partial f_k}{\partial k} = f_{kk} < 0, \quad \frac{\partial f_g}{\partial g} = f_{gg} < 0, \quad \frac{\partial f_k}{\partial g} = f_{kg} > 0, \quad \frac{\partial f_g}{\partial k} = f_{gk} > 0. \tag{3}$$

The government has a second policy variable; a per-unit tax on capital.[3] Denoting the tax as t, the economy's net (after tax) return to capital is

$$r = f_k - t. \tag{4}$$

The model of Oates and Schwab supposes that there is a large number n of small jurisdictions. As a consequence, each jurisdiction is a price-taker with respect to the net capital return and r is an exogenously given parameter (refer to Equation (2) on page 337 in Oates and Schwab 1988). The policies chosen by a jurisdiction must be consistent with the net return being equal to some given region-wide return to capital.

In this paper, the economy is not constrained by a price-taking constraint and r is allowed to vary with the government's policy choices. Moreover, the supply of capital to the economy from the international capital market is defined by the function $S = S(r/\omega)$ where r is the economy's net return denoted above and ω is some given rate of return determined in the world capital market. Capital supply S to the economy is assumed to be a non-decreasing function of r relative to the world return. In Oates and Schwab (1988), r is equal to the world return, whereas here r can diverge from it. For mathematical convenience, it is assumed that $\omega = 1$ so that the economy's capital supply function becomes $S = S(r)$ and capital supply is a non-decreasing function of the economy's (endogenous) net return. Using (4), the supply of capital to the economy can be defined as

$$S = S(f_k - t). \tag{5}$$

Since the government's policies influence the net capital return, and because the supply of capital to the economy is a function of the net return, the choice of tax and standards affect the economy's capital supply. The capital supply response to a change in the tax is found from (5) to be

$$\frac{\partial k}{\partial t} = -\frac{S'}{[1 - S' f_{kk}]} \leq 0. \tag{6}$$

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[3] The result also applies with an *ad valorem* capital tax. This is available on request.

In this expression, $S' \geq 0$ is the capital supply response to a change in the economy's net capital return. This is greater than or equal to zero because the supply of capital to the economy is assumed to be nondecreasing in the net capital return. The term f_{kk} previously defined at (2) is negative. Hence, (6) is less than or equal to zero and an increase in the capital tax shrinks the economy's capital supply or leaves it unchanged.

The capital supply response to a change in emissions is

$$\frac{\partial k}{\partial g} = f_{kg}\frac{S'}{[1 - S' f_{kk}]} \geq 0. \tag{7}$$

From (2), f_{kg} is positive. Together with the signs of the other terms, this implies that (7) is greater than or equal to zero. Higher emissions never reduce the capital supply.

The income of the economy's single household is denoted as X and since the household is a residual claimant this becomes[4]

$$X = f(k, g) - r k. \tag{8}$$

The government is assumed to be benevolent and represents the interests of the household. This simplification allows a focus on whether relaxing the small price-taking assumption per se has implications for efficiency without the complexity of distortions arising from nonbenevolence. It is also assumed that the government chooses its policies to maximize household income. If the government were instead to maximize household utility, one would specify a utility function $u(x, -g)$ where x is private consumption with $u_x > 0$ and $u_g < 0$. The government would then choose its policies to maximize utility. The results hold for both forms of optimization but are more transparent with income maximization—hence, this assumption is adopted. The government therefore chooses t and g to maximize X while taking account of the effect of its choices on the net capital return and hence the economy's capital base through (6) and (7).

The net return and capital supply affect household income giving the government an incentive to distort its policies to manipulate these variables. Such an incentive arises because the economy is not a price-taker. The question answered below is whether this translates into a divergence from the Oates and Schwab efficiency result.

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[4] Hence, the jurisdiction is a net importer of foreign-owned capital. Equation (8) implies that revenue from the tax on the foreign-owned capital is returned lump-sum to the household. The results also hold if one allows the household to own some portion of the capital stock.

3. Results

This section presents the results of the paper. Equation (8) yields

$$\frac{\partial X}{\partial t} = t\frac{\partial k}{\partial t} - k\frac{\partial r}{\partial t}, \tag{9}$$

$$\frac{\partial X}{\partial g} = f_g + t\frac{\partial k}{\partial g} - k\frac{\partial r}{\partial g}. \tag{10}$$

From the definition of r,

$$\frac{\partial r}{\partial t} = f_{kk}\frac{\partial k}{\partial t} - 1, \tag{11}$$

$$\frac{\partial r}{\partial g} = f_{kk}\frac{\partial k}{\partial g} + f_{kg}. \tag{12}$$

THEOREM: *A large open economy that is not a price-taker chooses first-best efficient environmental standards if it can tax mobile capital and chooses this tax optimally.*

Proof. From (6) and (7),

$$\frac{\partial k}{\partial g} = -f_{kg}\frac{\partial k}{\partial t}.$$

As a result, (9) to (12) imply

$$\frac{\partial X}{\partial g} = f_g - f_{kg}\frac{\partial X}{\partial t}.$$

If the capital tax is set to maximize income, then

$$\frac{\partial X}{\partial t} = 0.$$

This implies that

$$\frac{\partial X}{\partial g} = f_g.$$

Therefore, if (and only if) the capital tax is set to maximize income, the government will choose its emissions standards consistent with the first-best efficiency criterion and the theorem is proved.[5]

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[5] If the government maximizes utility, the expressions in the proof are more complex but the logic, including the last expression for efficient provision of standards, remains exactly the same. The efficiency condition simplifies to equality between f_g and the cost of more emissions in terms of utility foregone.

Thus, while the ability to influence the net capital return provides an incentive for a large open economy to distort policies, an equilibrium is still first-best efficient if the government has a dedicated tax on capital and sets the capital tax optimally. Relaxing the price-taking small-country assumption does not lead to an inefficient outcome and the Oates and Schwab result still holds. Some other points are noteworthy.

The theorem depends on the government having access to a tax on capital and using this tax optimally. If, instead, it has only one instrument—for example—the choice of environmental standards, then any equilibrium is fully described by the first-order necessary condition based on (10) and is in general not first-best. Thus, inefficiency arises only if one restricts the policy vector to exclude access to the capital tax.

First-best efficiency requires the tax on mobile capital to be nonzero. This is in contrast to Oates and Schwab where the capital tax must be zero for efficiency. To see why this is so use (6) and (11) in (9) and rearrange to obtain the optimal tax

$$t^* = \frac{k}{S'}. \tag{13}$$

Define $S' = \varepsilon(k/r)$ where $0 \leq \varepsilon \leq \infty$ is the elasticity of capital supply.[6] The optimal tax becomes

$$t^* = \frac{f_k}{(1+\varepsilon)}. \tag{14}$$

When $\varepsilon = 0$ (closed economy), the optimal tax is $t^* = f_k$ with the net capital return $r = f_k - t$ equal to zero. The government sets the tax equal to the marginal product of capital and fully appropriates capital income on behalf of the household. If $0 < \varepsilon < \infty$ (the economy is partially open), the optimal tax is positive and the net return is less than the gross return (marginal product). The tax appropriates some but not all the marginal product of capital. As $\varepsilon \to \infty$ (fully open), the supply of capital becomes infinitely elastic and $t^* \to 0$ from (14). Since $r = f_k - t$, the economy's net return approaches its marginal product ($r \to f_k$) and the government appropriates nothing from capital. It can also be shown that the only feasible equilibrium is one in which the economy's net return approaches the given world return ($r \to \omega$). This is the case of Oates and Schwab where the optimal tax is zero and the net return is equal to the given world return. Thus, any divergence from price-taking behavior requires the tax to be nonzero to preserve first-best efficiency. Only when $\varepsilon \to \infty$ is the tax zero as in Oates and Schwab.

Finally, the model here has used a public bad—emissions—but the theorem holds for a public good. A government that is not a price-taker will

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[6] This is analogous to the standard supply elasticity for any commodity. Epsilon is a parameter.

undertake efficient provision of a public good if it has a dedicated capital tax. As for emissions, the tax will, in general, be nonzero.

4. Conclusion

This paper relaxes the small-country price-taking assumption of the Oates and Schwab model to allow a government to use its policies to manipulate the net return to capital. This is shown to create an incentive to distort policies. The question answered is whether this is sufficient to induce deviation from a first-best efficient outcome. The finding is that even when an economy is not a price-taker with respect to the net capital price, the Oates and Schwab efficiency result still holds. However, this depends on the government having a dedicated capital tax. First-best efficiency is also shown to require the capital tax to be nonzero. Hence, the contribution of the paper is to show the main Oates and Schwab efficiency result extends to an economy that is not a small open price-taker.

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