

Does Wage Bargaining Justify Environmental Policy Coordination?*

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Abstract

This paper analyzes the welfare consequences of coordinated tax reforms in an economy where a transboundary environmental externality and an international wage bargaining externality are operative at the same time. We assume that the wage in each country is decided upon in a bargain between trade-unions and firms, and the wage bargaining externality arises because the fall-back profit facing firms depends on the profit they can earn if moving production abroad. Using the noncooperative Nash equilibrium as a reference case, our results imply that the international wage bargaining externality may either reinforce or weaken the welfare gain of a coordinated increase in environmental taxation, depending on (among other things) how the reform affects the wage. For a special case, we also derive an exact condition under which a coordinated increase in the environmental tax leads to higher welfare.

Keywords: Environmental taxes, externalities, policy coordination, trade-unions

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1 Introduction

In today's world, both economists and policy makers generally agree that transboundary environmental problems require international policy coordination, since uncoordinated actions taken by national governments are unlikely to give rise to an efficient resource allocation from the perspective of society as a whole. This is so because country-specific objectives and constraints can be expected to govern the policies decided upon by national governments, meaning that (the transboundary) part of the externality will remain uninternalized. At the same time, a full cooperative equilibrium may be beyond reach for a variety of reasons. It is, therefore, relevant to analyze the welfare consequences of partial policy coordination, where the purpose is to improve the resource allocation by comparison to the initial (uncoordinated) equilibrium. This is the topic of the present paper, which focuses on the role of trade-union wage formation in this particular context.

The bulk of earlier literature that analyzes tax and expenditure coordination assumes that the labor market is competitive. However, since the 1970s, many European countries have suffered from high unemployment rates, and it seems unlikely that full employment will be restored in the near future. As trade-unions are important actors in the European labor markets, it has been argued¹ that the wage bargaining structure may create an additional international externality. The argument is that the threat of moving production abroad may be used by firms during wage bargaining as a tool to moderate wage claims. A key factor determining the credibility of the firms' threat is the size of the potential profit they can obtain by moving production abroad. The larger the potential outside profit, the stronger will be the firms' bargaining position vis-a-vis the trade-unions, and the lower will be the wage. As a consequence, if the policies undertaken by the national government influences the profits of domestic firms, it will also give rise to an international externality. The intuition is, of course, that a national government is unlikely to consider how its policies affect the outcome of wage bargaining in other countries.

The purpose of the present paper is to analyze the welfare consequences of coordinated tax reforms in an economy where a transboundary environmental externality and the international wage bargaining externality are operative at

¹See Aronsson and Sjögren (2004b).

the same time. This is an interesting extension of the literature on environmental policy reforms because if the wage bargaining externality is non-negligible, previous studies have omitted a potentially important mechanism when they evaluate the welfare effects of such reforms. Our study is based on a multi-country economy, in which production gives rise to environmental damage and capital is mobile across countries. Each national government can use both distortionary taxes and lump-sum taxes to raise tax revenue, meaning that distortionary taxation will be used solely for externality correction. The tax instruments available to each national government are an emission tax (i.e. a tax on a dirty production factor), a capital tax and lump-sum taxes.

We start the analysis by characterizing the emission and capital taxes in a noncooperative Nash equilibrium, where each national government treats the policies decided upon by the other countries as exogenous. An interesting result here is that the wage bargaining externality may (itself) give rise to an incentive for tax competition. Then, we derive and characterize the welfare effects of coordinated increases in the emission and capital tax, respectively. The central question is whether the appearance of the wage bargaining externality reinforces, or weakens, the arguments for policy coordination. Using the noncooperative Nash equilibrium as a reference case, our results imply that the international wage bargaining externality may either reinforce or weaken the welfare gain of a coordinated increase in the emission tax depending on (among other things) how this reform affects the wage. For a special case where the consumers have quasi-linear utility functions and the production function is of Cobb-Douglas type, we also derive an exact condition under which a coordinated increase in the emission tax leads to higher welfare.

There is a relatively large literature dealing with different aspects of environmental policy coordination. One body of literature focuses on the incentives underlying the establishment of coalitions.² Another deals explicitly with the implementation of such arrangements by applying theories of optimal taxation or theories of policy reforms in the context of multi-country economies with transboundary environmental damage.³ Over the last decade, a number of studies have also emerged where fiscal and labor market distortions operate si-

²See, e.g. Mäler (1989), Barrett (1994) and Carraro (2003).

³See, e.g. van der Ploeg and de Zeeuw (1992), Aronsson and Löfgren (2000), Aronsson and Blomquist (2003) and Aronsson et al (2006).

multaneously with environmental externalities.⁴ However, most earlier research on economic policy, where environmental damage and labor market distortions jointly affect the policy outcome, abstracts from international spillover effects of environmental damage.⁵

Although the present paper is not primarily concerned with tax competition, it is, nevertheless, related to the literature dealing with taxation of labor and capital in economies with international capital mobility. Most studies in this area are based on the assumption that the labor markets are competitive.⁶ One exception is Koskela and Schöb (2002), who analyze the optimal use of labor and capital taxes in an open economy with union-firm wage bargaining. They show that capital should generally be taxed at a higher rate than labor, because labor supply is locally infinitely elastic in an economy with equilibrium unemployment. Another exception is Fuest and Huber (1999), who show that coordinated increases in the labor and capital tax rates may actually lead to lower welfare, if the economies are characterized by unemployment.

However, none of these studies have addressed the above mentioned wage bargaining externality. The main contribution of the present study is that it examines how the wage bargaining externality influences the welfare effects of coordinated increases in the emission tax and capital tax. Therefore, since the welfare effects of policy coordination associated with the environmental externality and the wage bargaining externality, respectively, may either reinforce or counterbalance each other, we are able to analyze under what circumstances countries are likely to gain from (and take part of) such policy coordination. In addition, there are few earlier studies dealing with international environmental policy in economies with imperfectly competitive labor markets, meaning that our study also contributes more generally by focusing on the role of the wage formation system in the context of environmental policy coordination.

The outline of the study is as follows. In Section 2, we present the basic model. Section 3 concerns the tax and expenditure policy that each country

⁴See, for example, Bovenberg and de Mooij (1994), Bovenberg and Goulder (1996) and Bovenberg and van der Ploeg (1998).

⁵Exceptions are Hoel (1997) and Aronsson et al (2006).

⁶The potential inefficiency associated with tax competition has been analyzed by e.g. Zodrow and Mieszkowski (1986) and Wildasin (1989), and it is argued that uncoordinated tax policies lead to inefficiently low tax rates (e.g. Bucovetsky and Wilson 1991). Therefore, tax policy coordination may be used to improve the resource allocation. For a survey of the welfare economics of tax coordination, see Keen (1993).

would implement in an uncoordinated equilibrium. In Section 4, we analyze the welfare effects of a coordinated increase in the emission tax and capital tax, respectively. The paper is summarized in Section 5.

2 The Model

In this section, we describe the behavior of consumers, firms and trade-unions as well as the equilibrium conditions characterizing the private sector. The public policy implemented by each national government in an uncoordinated equilibrium and the welfare effects of policy coordination are analyzed in Sections 3 and 4, respectively.

2.1 Consumers and Firms

Consider an economy comprising H identical countries. In each country, competitive firms produce a single output using three factors of production; labor, L , capital, K and energy, E . We assume that the use of energy has a detrimental effect on the environment in the sense of causing transboundary pollution. Since the production sector is competitive, each firm perceives that its actions do not influence the aggregate economy, meaning means that each firm treats prices and the environmental damage as exogenous. Given these characteristics, the number of firms in each country is, itself, not important and will be normalized to one.

The production function, $F(L, K, E)$, is increasing and strictly concave in each argument, and the inputs are complements in production in the sense that $F_{LK}, F_{LE}, F_{KE} > 0$. In addition, the production is characterized by decreasing returns to scale.⁷ Normalizing the price of output to one, the firm's profit is given by

$$\Pi = F(L, K, E) - wL - rK - tE \quad (1)$$

where w is the wage, r the interest rate and t an energy tax.⁸ The first order

⁷The reason for having decreasing returns to scale is that the labor market is dominated by trade unions. To be able to characterize the wage bargain between the unions and firms, the labor demand function must be well defined.

⁸We assume that the supply of energy is infinitely elastic. In addition, and without loss of generality, we normalize the marginal cost of producing energy to zero, meaning that the

conditions are $F_L(\cdot) = w$, $F_K(\cdot) = r$ and $F_E(\cdot) = t$, which implicitly define the factor demand functions

$$L = L(w, r, t), \quad K = K(w, r, t), \quad E = E(w, r, t) \quad (2)$$

and the profit function $\Pi(w, r, t)$.

Turning to the consumption side, there are three types of consumers; employed workers, unemployed workers and firm-owners. The consumers share a common utility function, which is written as

$$u(c) + v(Q) \quad (3)$$

where c is consumption and Q denotes environmental quality. The functions $u(\cdot)$ and $v(\cdot)$ are increasing and strictly concave in their respective argument. The total number of workers will be denoted by M , out of which $L \leq M$ are employed and $M - L$ unemployed. The number of firm-owners is normalized to one for notational convenience. Variables associated with consumer-types will be superindexed e (employed worker), u (unemployed worker) and f (firm-owner), respectively.

Each worker supplies one unit of labor inelastically. The reason for assuming fixed labor supply per worker is that the link between distortionary taxes, endogenous labor supply and wage formation in unionized economies has been analyzed thoroughly in earlier literature.⁹ Therefore, to be able to focus on the novel aspects of this paper in the simplest possible way, we disregard endogenous labor supply here.

Each (employed and unemployed) worker is endowed with a fixed and divisible capital asset, \bar{k} , which can be invested at home and/or abroad. Capital is taxed at source, meaning that the amount invested at home gives the net return $(1 - \theta)r$, while investments abroad generate the net return $(1 - \theta^*)r^*$, in which r is the interest rate and θ the capital income tax rate. Variables indexed by "*" are non-domestic.

Equilibrium in the global capital market implies equalization of net capital returns, i.e.

$$(1 - \theta)r = (1 - \theta^*)r^*. \quad (4)$$

energy price paid by the final goods producer equals the energy tax.

⁹See e.g. Aronsson and Sjögren (2004a,b).

By using equation (4), the capital income (net of taxation) can be written as $y = (1 - \theta^*)r^*\bar{k}$, and the budget constraint facing each employed and unemployed worker, respectively, becomes

$$c^e = w + y - T^e \quad (5)$$

$$c^u = b + y \quad (6)$$

in which T^e is the lump-sum tax¹⁰ per employed worker, and b an unemployment benefit.

Let us finally turn to the firm-owner. To simplify the analysis, we assume that the firm-owner does not work; instead, he/she receives profit income, Π , and pays a lump-sum tax, T^f . This means that the firm-owner's consumption is given by $c^f = \Pi - T^f$.

The environmental quality is given by

$$Q = \bar{Q} - \sum_{i=1}^H E_i \quad (7)$$

where \bar{Q} is an exogenous measure of the potential environmental quality that would prevail in the absence of pollution. Since there are H countries in the economy, and pollution is transboundary, the actual environmental quality facing the residents in any country is equal to \bar{Q} minus the total energy use (i.e. the sum of emissions across countries). Therefore, since there is a one-to-one correspondence between energy use and emissions here, the terms "energy tax", "emission tax" and "environmental tax" will be used synonymously in what follows.

2.2 The Labor Market

We assume that all workers are trade-union members, and that wage formation is decentralized in the sense that each trade-union (i) is firm specific and (ii) treats the policy instruments of the government as exogenous. Therefore, in accordance with the treatment of the production sector above, we normalize the number of trade-unions to one. Following Oswald (1993), the objective

¹⁰When the labor supply is fixed, a proportional labor income tax is equivalent to a lump-sum tax. This is why we use the latter tax instrument.

function of the trade-union is assumed to coincide with the objective function of the member with median seniority. This means that the trade-union members are ranked according to (exogenous) seniority, and that the member with median seniority is the decisive voter. As long as the median voter is not at an immediate risk of becoming unemployed, the trade-union will be indifferent to the level of employment. Within our framework, this means that the median voter's objective is to maximize $u(c^e) + v(Q)$ subject to the employment restriction $L(w, r, t) \geq M/2$.

The wage formation part of the model is governed by the right-to-manage framework¹¹, meaning that the wage rate is determined in a bargain between the union and the firm. If no contract is signed, the median union member becomes unemployed, so that his/her fall-back utility is given by $u(c^u) + v(Q)$. The firm, on the other hand, has the option to move production abroad, in which case its fall-back profit is given by $\Pi(w^*, r^*, t^*) - q$, where q is a fixed moving cost. By using the short notations $u^e = u(c^e) + v(Q)$, $u^u = u(c^u) + v(Q)$, $\Pi = \Pi(w, r, t)$ and $\Pi^* = \Pi(w^*, r^*, t^*)$, and then defining $u^e - u^u$ and $\Pi - (\Pi^* - q)$ to be the union's and the firm's respective rents from bargaining, the outcome of the bargain will be the wage that maximizes the Nash product

$$\Omega = [u(w + y - T^e) - u(b + y)]^a [\Pi(w, r, t) - \Pi(w^*, r^*, t^*) + q]^{1-a} \quad (8)$$

where $a \in (0, 1)$ is the trade union's bargaining power vis-a-vis the firm. If $a = 0$, the firm unilaterally determines the wage, which is then pushed down to the market clearing level where $L(w, r, t) = M$. On the other hand, if $a = 1$ the union has monopoly power and pushes up the wage so that the employment restriction $L(w, r, t) = M/2$ will bind.

The first order condition for an interior solution with respect to the wage can be written as

$$\Omega_w = au_c^e (\Pi - \Pi^* + q) - (1 - a) L(u^e - u^u) = 0 \quad (9)$$

where the second-order condition, $\Omega_{ww} < 0$, is assumed to be satisfied. Equation (9) implicitly defines the bargained wage as

$$w = w(T^e, b, y, r, t, \Pi^* - q). \quad (10)$$

¹¹See Oswald (1985).

For the analysis below, we observe that the bargained wage rate satisfies the following comparative static properties

$$\frac{\partial w}{\partial T^e} = \frac{au_{cc}^e (\Pi - \Pi^* + q) - (1 - a) Lu_c^e}{\Omega_{ww}} > 0 \quad (11)$$

$$\frac{\partial w}{\partial b} = -\frac{(1 - a) Lu_c^u}{\Omega_{ww}} > 0 \quad (12)$$

$$\frac{\partial w}{\partial y} = -\frac{au_{cc}^e (\Pi - \Pi^* + q) - (1 - a) L(u_c^e - u_c^u)}{\Omega_{ww}} \quad (13)$$

$$\frac{\partial w}{\partial \Pi^*} = \frac{au_c^e}{\Omega_{ww}} < 0. \quad (14)$$

Equations (11) and (12) are standard. Equation (13) shows that the wage response to an increase in the nonlabor income comprises two counteracting effects. First, the employed workers now have a higher total income, meaning that the union can reduce its wage claims. Second, as an increase in y also increases the income of the unemployed, the union can be more aggressive in its wage demands. The net effect of these two forces is ambiguous. Finally, equation (14) shows that an increase in the fall-back profit contributes to reduce the bargained wage; a property which will be important below.

3 Noncooperative Nash Equilibrium

We assume that the national government faces a utilitarian welfare function, which is given by

$$W = L[u(c^e) + v(Q)] + (M - L)[u(c^u) + v(Q)] + [u(c^f) + v(Q)]. \quad (15)$$

The government raises revenue via the lump-sum taxes paid by the employed workers and the firm-owner, respectively, the capital income tax and the emission tax. The revenue is used to finance an unemployment benefit. Therefore, the policy instruments are T^e , T^f , t , θ and b , and the government's budget constraint is written as

$$tE + \theta rK + LT^e + T^f - b(M - L) = 0. \quad (16)$$

Each national government also recognizes that the environmental quality is determined by equation (7). In addition, as the national governments are Nash competitors to one another, each national government treats the policies decided upon by the other countries (i.e. T^{*e} , T^{*f} , t^* , θ^* and b^*) as exogenous.

The Lagrangian corresponding to the government's decision-problem can be written as

$$\mathcal{L} = W + \gamma [tE + \theta rK + T^f + LT^e - b(M - L)] \quad (17)$$

where γ is the Lagrange multiplier associated with the budget constraint. The first order conditions are presented in the Appendix. Here, we concentrate on the implications of these conditions for optimal taxation.

To begin with, let us define the welfare gain of increased employment, i.e. marginal value that the national government attaches to an increase in the number of employed persons. By differentiating the Lagrangean in equation (17) with respect to L , using the private first order conditions and rearranging, we obtain

$$\Phi = (u^e - u^u) + \gamma(T^e + b). \quad (18)$$

Equation (18) decomposes the welfare effect of increased employment into two parts. First, each worker who becomes employed experiences a direct utility gain equal to $u^e - u^u > 0$. Second, the net effect on tax revenue if one additional worker goes from unemployment to employment is given by $T^e + b$. If the government aims to redistribute from the employed to the unemployed, meaning that $T^e + b > 0$, we have $\Phi > 0$.

We show in the Appendix that each national government implements the following emission and capital taxes in the noncooperative Nash equilibrium;

$$t = (M + 1) \frac{v_Q}{\gamma} - \frac{\Phi (\alpha^0 - \alpha^1 \beta^1 r)}{\gamma (1 - \alpha^1 \beta^0 r)} \quad (19)$$

$$\theta = \frac{\Phi (\alpha^0 \beta^0 - \beta^1)}{\gamma (1 - \alpha^1 \beta^0 r)} \quad (20)$$

where

$$\alpha^0 = \frac{(L_t + \mu L_w \frac{\partial w}{\partial t})}{(E_t + \mu E_w \frac{\partial w}{\partial t})}, \quad \alpha^1 = \frac{(K_t + \mu K_w \frac{\partial w}{\partial t})}{(E_t + \mu E_w \frac{\partial w}{\partial t})}$$

$$\beta^0 = \frac{(E_r + \mu E_w \frac{\partial w}{\partial r})}{r (K_r + \mu K_w \frac{\partial w}{\partial r})}, \quad \beta^1 = \frac{(L_r + \mu L_w \frac{\partial w}{\partial r})}{r (K_r + \mu K_w \frac{\partial w}{\partial r})}$$

and $\mu = 1/(1 - \partial w/\partial T^e)$.

The variable μ is interpretable in terms of wage compensation for increased taxation; if $\partial w/\partial T^e > 1$ (< 1), workers are "overcompensated" ("undercompensated") in terms of the wage response. Therefore, $1/\mu = 1 - \partial w/\partial T^e$ is the degree of undercompensation and, as a consequence, μ the inverse of the degree of undercompensation.

To interpret the tax policy summarized by equations (19) and (20), consider first the special case where the labor market is competitive. In a competitive labor market (where $L \equiv M$), one can show that the emission tax equals the marginal value that the (national) government attaches to reduced environmental damage, i.e. $t = (M + 1) v_Q/\gamma$, whereas the capital tax is equal to zero. The intuition is that the government can use lump-sum taxes to raise revenue, and it is able to equalize the marginal utility of consumption among consumers (meaning full implementation of the distributional objective implicit in the utilitarian welfare function). As a consequence, there will be no tax competition for mobile capital. In other words, the only corrective role of taxation that remains is correction for the environmental externality, which is accomplished by using the emission tax. In summary, this means that the emission tax is positive (and equal to the marginal value that the national government attaches to reduced environmental damage), and the capital tax is zero.

However, this basic intuition does not carry over to an economy with equilibrium unemployment, which is seen from equations (19) and (20). The reason is that the emission and capital taxes will, in this case, also serve as indirect instruments for influencing the employment. This is seen by the "extra term" in each tax formula, which is proportional to Φ . Therefore, these extra terms reflect an employment-motive for taxation, as a change in either the emission tax or capital tax affects the number of employed persons. Although this employment-motive can lead to either higher or lower taxes in general, one would expect the extra term in each tax formula to be negative, i.e. that the government tries to

boost employment by implementing a lower emission tax than would be motivated by pure domestic externality-correction and subsidizing capital. Note that this argument also implies that the appearance of equilibrium unemployment provides an incentive for at the government to compete for mobile capital (as an increase in the domestic capital stock contributes to increased domestic employment).

4 Policy Coordination

The uncoordinated equilibrium is globally inefficient for two reasons. The first inefficiency arises because each country implements emission tax policies solely on the basis of its own domestic objectives, i.e. it does not incorporate into its decision-problem that the domestic emissions (use of energy) causes environmental damage abroad. The second is due to the international wage bargaining externality. To see this more clearly, note from equation (10) that the profit abroad, Π^* , directly affects the domestic wage. The larger the outside profit, the stronger is the firm's bargaining position vis-a-vis the trade union, ceteris paribus, and the lower will be the wage, i.e. $\partial w/\partial \Pi^* < 0$. However, when each national government decides upon tax and expenditure policies, it does not take into account that the domestic profit also affects the fall-back profit for firms in other countries.

We consider policy coordination with respect to the energy and capital tax, respectively, which are the two corrective tax instruments that each national government has at its disposal. Since the countries are identical, the point of departure is a symmetric equilibrium where all countries have chosen the same tax and expenditure policies. This means that the resource allocation is the same in all countries; in particular, the capital stock used in the production in each country is fixed at $K = \bar{K} = M\bar{k}$ and the profits are equalized, so $\Pi = \Pi^*$. By using the first order conditions for the firm and the first order condition for the wage, where we normalize a to 0.5 for notational convenience¹², we obtain the following equation system

¹²This simplification shortens the relevant mathematical expressions. It is not important for the qualitative results.

$$0 = F_L(L, \bar{K}, E) - w \quad (21)$$

$$0 = F_E(L, \bar{K}, E) - t \quad (22)$$

$$0 = F_K(L, \bar{K}, E) - r \quad (23)$$

$$0 = u_c^e(w + y - T^e)q - L[u^e(w + y - T^e) - u^u(b + y)]. \quad (24)$$

Equations (21)-(24) imply a symmetric equilibrium in the sense that $L = L^*$, $E = E^*$, $w = w^*$ and $r = r^*$ become functions of $b = b^*$, $T^e = T^{e*}$, $t = t^*$ and $\theta = \theta^*$ (the latter via $y = y^*$).

Since the domestic policy has been optimally chosen conditional on the policies implemented by other countries, a coordinated infinitesimal increase in either the emission tax or the capital tax affects welfare only because a policy change in each country influences the welfare in other countries (via the two uninternalized international externalities). Throughout the paper, we assume that each national governments adjusts the income tax paid by the firm-owner, T^f , to maintain budget balance.

Consider first the welfare effect of a coordinated increase in the emission tax accompanied by an adjustment of the income tax paid by the firm-owner. With the other policy instruments held constant, we may then write T^f as a function of the domestic and foreign emission taxes, i.e. $T^f = T(t, t^*)$. Differentiating the Lagrangian in equation (17) w.r.t. t and t^* , and using that $t = t^*$ in the symmetric equilibrium, we obtain

$$dW = \frac{\partial \mathcal{L}}{\partial t} dt + \frac{\partial \mathcal{L}}{\partial T^f} \left(\frac{\partial T^f}{\partial t} dt + \frac{\partial T^f}{\partial t^*} dt^* \right) + \frac{\partial \mathcal{L}}{\partial t^*} dt^* = \frac{\partial \mathcal{L}}{\partial t^*} dt^* \quad (25)$$

Note that the first order effects on domestic welfare following small changes in t and T^f are zero (i.e. $\partial \mathcal{L} / \partial t = \partial \mathcal{L} / \partial T^f = 0$). As a consequence, the only welfare effect that remains is due to increased emission taxation abroad, which is seen from the expression after the second equality. By using a similar argument, the cost benefit rule for a coordinated increase in the capital tax can be written as $dW = (\partial \mathcal{L} / \partial \theta^*) d\theta^*$.

To assess these welfare effects, consider the following Proposition;

Proposition 1. (i) *In the uncoordinated symmetric equilibrium, the welfare*

effect of a coordinated increase in the emission tax, accompanied by an adjustment of the income tax paid by the firm-owner to maintain budget balance for the government in each country, is given by

$$\frac{\partial W}{\partial t^*} = -(H-1)(M+1) \frac{dv}{dQ} \frac{dE^*}{dt^*} + \frac{\partial \mathcal{L}}{\partial w} \frac{\partial w}{\partial \Pi^*} \frac{d\Pi^*}{dt^*} \quad (26)$$

where

$$\frac{d\Pi^*}{dt^*} = \frac{\partial \Pi^*}{\partial w^*} \frac{\partial w^*}{\partial t^*} + \frac{\partial \Pi^*}{\partial r^*} \frac{\partial r^*}{\partial t^*} + \frac{\partial \Pi^*}{\partial t^*} \quad (27)$$

$$\frac{dE^*}{dt^*} = \frac{\partial E^*}{\partial w^*} \frac{\partial w^*}{\partial t^*} + \frac{\partial E^*}{\partial r^*} \frac{\partial r^*}{\partial t^*} + \frac{\partial E^*}{\partial t^*}. \quad (28)$$

(ii) The analogous cost benefit rule for the capital tax becomes

$$\frac{\partial W}{\partial \theta^*} = -(H-1)(M+1) \frac{dv}{dQ} \frac{dE^*}{d\theta^*} + \frac{\partial \mathcal{L}}{\partial w} \frac{\partial w}{\partial \Pi^*} \frac{d\Pi^*}{d\theta^*} \quad (29)$$

where

$$\frac{d\Pi^*}{d\theta^*} = \frac{\partial \Pi^*}{\partial w^*} \frac{\partial w^*}{\partial \theta^*} + \frac{\partial \Pi^*}{\partial r^*} \frac{\partial r^*}{\partial \theta^*} \quad (30)$$

$$\frac{dE^*}{d\theta^*} = \frac{\partial E^*}{\partial w^*} \frac{\partial w^*}{\partial \theta^*} + \frac{\partial E^*}{\partial r^*} \frac{\partial r^*}{\partial \theta^*} \quad (31)$$

Proof: See the Appendix.

Each cost benefit rule contains two parts, which correspond to the respective externality discussed above. Consider first the cost benefit rule for the emission tax. The first part of equation (26) shows that a coordinated infinitesimal increase in the emission tax changes the use of energy in each foreign country by dE^*/dt^* . There are $(H-1)$ foreign countries, implying that the total change in environmental quality due to increased energy taxation abroad is given by $-(H-1)dE^*/dt^*$. Therefore, since there are $(M+1)$ domestic consumers, each of whom experiences a utility change equal to dv/dQ , the total welfare change arising via this mechanism becomes $-(H-1)(M+1)(dv/dQ)(dE^*/dt^*)$. The intuition behind the first part of the cost benefit rule for the capital tax is analogous.

The second part of each cost benefit rule is due to the international wage bargaining externality. Note first that if the labor market were competitive, then this component would vanish (as a small change in the wage would have a zero first order welfare effect). However, in the presence of equilibrium unemployment, an additional (nonzero) welfare effect arises as a coordinated increase in the emission tax or capital tax influences the foreign profit, Π^* , and, therefore, the fall-back profit facing the domestic firm during the wage bargain. Since Π^* constitutes the fall-back profit for the domestic firms, the change in Π^* will influence the domestic wage, captured by $\partial w/\partial \Pi^*$.

The domestic welfare effect following a change in the wage, i.e. $\partial \mathcal{L}/\partial w$ in each cost benefit rule in the proposition, can be written as

$$\frac{\partial \mathcal{L}}{\partial w} = \frac{\Phi}{\gamma} \mu L_w + \left[t - (M + 1) \frac{v_Q}{\gamma} \right] \mu E_w + \theta \mu r K_w. \quad (32)$$

The first part of equation (32) is standard: it reflects the direct welfare cost of a higher wage in terms of lost employment. The second and third parts arise because $t \neq (M + 1) v_Q/\gamma$ and $\theta \neq 0$, since imperfect competition in the labor market means that the emission and capital tax policies governing the uncoordinated equilibrium typically deviate from the policies that would be implemented if the labor markets were competitive.¹³ As we argued above, although these components can be either positive or negative in general, intuition suggests that the tax policy in the uncoordinated equilibrium satisfies $t < (M + 1) v_Q/\gamma$ and $\theta < 0$, in which case the second and third terms in equation (32) tend to reduce the welfare cost of an increase in the wage. In other words, even if we were to base our interpretations on the assumption that $\partial \mathcal{L}/\partial w < 0$ (which appears to be reasonable in an economy with unemployment), the preexisting emission tax and capital tax policies may, nevertheless, offset part of the welfare gain that would otherwise arise from a decrease in the wage and, therefore, also reduce the absolute value of the second part of each cost benefit rule in the proposition.

Although the uncoordinated equilibrium is suboptimal from the perspective

¹³With competitive labor markets, where $L \equiv M$ in each country, the uncoordinated equilibrium would support a "national first best policy" in the sense that

$$t = (M + 1) v_Q/\gamma \text{ and } \theta = 0$$

in which case the second and third terms on the right hand side of equation (32) would be equal to zero.

of society as a whole, we cannot sign the cost benefit rules in Proposition 1 without further assumptions. However, what we can say is that if dE^*/dt^* and $d\Pi^*/dt^*$ have opposite signs - and if $\partial\mathcal{L}/\partial w < 0$ - then $\partial W/\partial t^*$ is signed, in which case it is possible to make a coordinated change of the emission tax such that welfare increases in all countries. If, on the other hand, dE^*/dt^* and $d\Pi^*/dt^*$ have the same sign, then $\partial W/\partial t^*$ is not signed. The condition under which the cost benefit rule for the capital tax can be signed is analogous.

4.1 A More Specific Model

To go further, we consider the special case of the model, where the utility function is quasi-linear and the production function is of Cobb-Douglas type. The utility facing an employed and unemployed worker, respectively, then becomes

$$u^e = w + y - T^e + v(Q) \quad (33)$$

$$u^u = b + y + v(Q). \quad (34)$$

The production function is given by

$$F(L, K, E) = L^{\rho_1} K^{\rho_2} E^{\rho_3} \quad (35)$$

where $0 < \rho_1, \rho_2, \rho_3$ and $\rho_1 + \rho_2 + \rho_3 < 1$. We begin by analyzing a coordinated increase in the emission tax and then continue with a coordinated increase in the capital tax. Throughout this section, our discussion is based on the assumption that $\partial\mathcal{L}/\partial w < 0$.

4.1.1 A Coordinated Change in the Emission Tax

Before using the utility and production functions in equations (33)-(35) to evaluate the cost benefit rule for the emission tax, we start by examining how a change in the emission tax abroad affects the environmental damage and profit abroad, i.e. the derivatives dE^*/dt^* and $d\Pi^*/dt^*$. It turns out that the signs of these derivatives depend on the component $(T^e + b)/w$, which we will refer to as the "net tax revenue-wage ratio". Consider Lemma 1.

Lemma 1.

(i) If the net tax revenue-wage ratio satisfies $(T^e + b)/w < \rho_1$, then $dE^*/dt^* < 0$ and $d\Pi^*/dt^* > 0$.

(ii) If the net tax revenue-wage ratio satisfies $\rho_1 < (T^e + b)/w < \rho_1/(1 - \rho_3)$, then $dE^*/dt^* > 0$ and $d\Pi^*/dt^* > 0$.

(iii) If the net tax revenue-wage ratio satisfies $\rho_1/(1 - \rho_3) < (T^e + b)/w$, then $dE^*/dt^* < 0$ and $d\Pi^*/dt^* < 0$.

Proof: See the Appendix.

To interpret Lemma 1, we first need to evaluate how the wage rate responds to a coordinated increase in the emission tax. Differentiating equation system (21) - (24) w.r.t. $t = t^*$, we obtain

$$\frac{\partial w^*}{\partial t^*} = \frac{(w - T^e - b) F_{LE}}{\Psi} \quad (36)$$

where

$$\Psi = [(T^e + b)(1 - \rho_3) - \rho_1 w] \rho_3 L^{\rho_1} K^{\rho_2} E^{\rho_3 - 2}.$$

Equation (36) implies that the wage response is negative if $(T^e + b)/w < \rho_1/(1 - \rho_3)$. In this case, therefore, a coordinated increase in the emission tax leads to a lower wage. This means that the firms have the opportunity to substitute energy for labor in the production. Since relatively more labor will now be used in the production (at a lower cost than before the policy reform), there is room for an increase in the profit, which is what happens with a Cobb-Douglas production function. This explains part (i) of the lemma. Part (ii) is basically an extension of the argument underlying part (i) in the sense that, if the wage decreases in response to increased emission taxation, this wage reduction may be so large that the demand for energy actually increases. This happens if the net tax revenue-wage ratio satisfies $\rho_1 \leq (T^e + b)/w < \rho_1/(1 - \rho_3)$. Finally, part (iii) corresponds to the case where the wage response is positive, which happens when $\rho_1/(1 - \rho_3) < (T^e + b)/w$. As a consequence, both the use of energy in production and the profit will decrease.

Let us then turn to the implications in terms of the cost benefit rule for the emission tax. We have derived the following result;

Proposition 2. *Suppose that the economy has reached the uncoordinated symmetric equilibrium, that the consumers have a quasi-linear utility function, and that the production function is of Cobb-Douglas type. Consider the cost benefit rule for a coordinated increase in the emission tax in Proposition 1.*

(i) *If the net tax revenue-wage ratio satisfies $(T^e + b)/w < \rho_1$, a coordinated increase in the emission alleviates the preexisting environmental externality and the preexisting international wage bargaining externality. This leads to higher welfare.*

(ii) *If the net tax revenue-wage ratio satisfies $\rho_1 < (T^e + b)/w < \rho_1/(1 - \rho_3)$, a coordinated increase in the emission reinforces the preexisting environmental externality and alleviates the preexisting international wage bargaining externality. This renders the welfare effect ambiguous in sign.*

(iii) *If the net tax revenue-wage ratio satisfies $\rho_1/(1 - \rho_3) < (T^e + b)/w$, a coordinated increase in the emission tax alleviates the preexisting environmental externality and reinforces the preexisting international wage bargaining externality. This renders the welfare effect ambiguous in sign.*

Proposition 2 shows that the international wage bargaining externality may significantly influence the welfare effects of a coordinated increase in the emission tax. Part (i) of the proposition means that the welfare effect is unambiguously positive if the net tax revenue, $T^e + b$, is relatively small by comparison with the gross wage, w . In this case, therefore, the results are interpretable in terms of a "double dividend" of a coordinated increase in the emission tax, as such a reform alleviates both the environmental externality and the wage bargaining externality. Part (ii) implies that the higher emission tax induces the union to make large concessions in the wage bargain. In fact, the wage will be reduced so much that it causes an increase in the use of energy (as labor and energy are complements in terms of the production function). This means that the preexisting environmental externality is actually reinforced, although the reform contributes to alleviate the wage bargaining externality. Finally, part (iii) shows that if the net tax revenue is large enough relative to the gross wage, both the use of energy and the profit will decrease. The intuition is that a coordinated increase in the emission tax leads to a higher wage. Therefore, although the

reform contributes to alleviate the preexisting environmental externality, the preexisting wage bargaining externality becomes reinforced, which renders the welfare effect ambiguous.

In most real world economies, the net tax revenue-wage ratio is likely to satisfy the inequality in part (iii) of Proposition 2. The argument above then implies that the welfare effect of a coordinated environmental policy reform may not be so large (and it may even be negative).

4.1.2 A Coordinated Change of the Capital Income Tax

Let us now use the quasi-linear utility function and Cobb-Douglas production function to evaluate the cost benefit rule for the capital tax in Proposition 1. Consider the following result;

Proposition 3. *Suppose that the economy has reached the uncoordinated symmetric equilibrium, that the consumers have a quasi-linear utility function, and that the production function is of Cobb-Douglas type. It follows that a coordinated increase in the capital tax, while the income tax paid by the firm-owner is adjusted to maintain budget balance for the government in each country, leaves welfare unaffected (as a first order approximation).*

This result appears because the consumers have a quasi-linear utility function, in which case θ drops out from the first order condition for the wage. A coordinated change in θ will in this case neither affect the wage nor the allocation of capital between countries. As a consequence, the use of energy and the profit also remain unaffected, meaning that both parts of equation (29) are zero.

5 Summary

This paper analyzes the welfare effects of policy reforms designed to introduce coordination among countries. An uncoordinated equilibrium, where each country implements tax policy based solely on its own objectives and constraints, constitutes the reference case. We assume that the set of tax instruments facing the government in each country consists of an emission tax and a capital tax. The environmental damage is transboundary. In addition, firms and trade-unions bargain over the wage, which creates an inefficient labor market outcome

in the sense of equilibrium unemployment. The countries interact both via the transboundary externality and via the wage formation system. The latter interaction arises because the fall-back profit facing domestic firms during the wage bargain is the profit they can obtain if they move production abroad minus the cost associated with such a move. This creates an international wage bargaining externality.

We begin by characterizing the emission tax and capital tax policies in a noncooperative Nash equilibrium. Although the effects on the tax structure of imperfect competition in the labor market is ambiguous in general, we argue that each country is likely to implement lower taxes on emissions and capital than they would have done had the labor market been competitive.

Two policy reforms are then designed. First, a coordinated increase in the emission tax and, second, a coordinated increase in the capital tax. In both cases, a nondistortionary profit tax is adjusted to maintain budget balance for the government. Having characterized the cost benefit rule for each such reform, we consider a special case with a quasi-linear utility function and a Cobb-Douglas production function and show that the first reform is welfare improving if the ratio of the net tax revenue and the wage is smaller than the output elasticity of labor. If, on the other hand, the ratio of the net tax revenue and the wage is larger than the output elasticity of labor, the welfare effect is ambiguous. Therefore, even if a coordinated increase in the emission tax (most likely) alleviates the environmental externality, it may reinforce the international wage bargaining externality. We also show that, if the consumers have a quasi-linear utility function and the production function is of Cobb-Douglas type, the welfare effect of a coordinated increase in the capital tax is zero.

6 Appendix

The government's first order conditions are

$$\frac{\partial \mathcal{L}}{\partial b} = (M - L)(u_c^u - \gamma) + \frac{\partial \mathcal{L}}{\partial w} \frac{\partial w}{\partial b} = 0 \quad (\text{A.1})$$

$$\frac{\partial \mathcal{L}}{\partial T^f} = \gamma - u_c^f = 0 \quad (\text{A.2})$$

$$\frac{\partial \mathcal{L}}{\partial T^e} = (\gamma - u_c^e) L + \frac{\partial \mathcal{L}}{\partial w} \frac{\partial w}{\partial T^e} = 0 \quad (\text{A.3})$$

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial t} = 0 = & -(M + 1)v_Q E_t + (u^e - u^u) L_t + \frac{\partial \mathcal{L}}{\partial w} \frac{\partial w}{\partial t} \\ & + \gamma [tE_t + \theta r K_t + (T^e + b) L_t] \end{aligned} \quad (\text{A.4})$$

$$\frac{\partial \mathcal{L}}{\partial \theta} = \gamma r K + \frac{d\mathcal{L}}{dr} \frac{\partial r}{\partial \theta} + \frac{d\mathcal{L}}{dw} \frac{\partial w}{\partial r} \frac{\partial r}{\partial \theta} = 0 \quad (\text{A.5})$$

where

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial w} = & -(M + 1)v_Q E_w + (u^e - u^u) L_w + L(u_c^e - \gamma) \\ & + \gamma [tE_w + \theta r K_w + (T^e + b) L_w] \end{aligned} \quad (\text{A.6})$$

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial r} = & -(M + 1)v_Q E_r + (u^e - u^u) L_r - K\gamma \\ & + \gamma [tE_r + \theta K + \theta r K_r + (T^e + b) L_r]. \end{aligned} \quad (\text{A.7})$$

Equation (4) implies

$$r(\theta, \theta^*, r^*) = \frac{1 - \theta^*}{1 - \theta} r^* \quad (\text{A.8})$$

which, in turn, gives

$$\frac{\partial r}{\partial \theta} = \frac{r}{(1 - \theta)}. \quad (\text{A.9})$$

Combining (A.3), (A.4) and (A.6) and solving for t gives

$$t = (M + 1) \frac{v_Q}{\gamma} - \Phi \frac{\alpha^0}{\gamma} - \theta r \alpha^1. \quad (\text{A.10})$$

Similarly, combining equations (A.3), (A.5), (A.7) and (A.9), and solving for θ implies

$$\theta = \left[(M+1) \frac{v_Q}{\gamma} - t \right] \beta^0 - \Phi \frac{\beta^1}{\gamma}. \quad (\text{A.11})$$

Finally, combining equations (A.10) and (A.11), we obtain the tax formulas given by equations (19) and (20).

Proof of Proposition 1

Differentiating the Lagrangian w.r.t. t^* produces

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial t^*} = & -(H-1)(M+1) \frac{dv}{dQ} \frac{dE^*}{dt^*} + [Lu_c^e + (M-L)u_c^u] (1-\theta^*) \bar{k} \frac{\partial r^*}{\partial t^*} + \frac{\partial \mathcal{L}}{\partial r} \frac{\partial r^*}{\partial t^*} \\ & + \frac{\partial \mathcal{L}}{\partial w} \left[\frac{\partial w}{\partial y} (1-\theta^*) \bar{k} \frac{\partial r^*}{\partial t^*} + \frac{\partial w}{\partial r} \frac{\partial r^*}{\partial t^*} + \frac{\partial w}{\partial \Pi^*} \left(\frac{\partial \Pi^*}{\partial w^*} \frac{\partial w^*}{\partial t^*} + \frac{\partial \Pi^*}{\partial r^*} \frac{\partial r^*}{\partial t^*} + \frac{\partial \Pi^*}{\partial t^*} \right) \right]. \end{aligned} \quad (\text{A.12})$$

By combining equation (A.12) with equations (A.1), (A.3), (A.5) and (A.9), and using that $K = M\bar{k} = L\bar{k} + (M-L)\bar{k}$ in the symmetric equilibrium, we can write the resulting expression as

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial t^*} = & -(H-1)(M+1) \frac{dv}{dQ} \frac{dE^*}{dt^*} + \frac{\partial \mathcal{L}}{\partial w} \frac{\partial w}{\partial \Pi^*} \left(\frac{\partial \Pi^*}{\partial w^*} \frac{\partial w^*}{\partial t^*} + \frac{\partial \Pi^*}{\partial r^*} \frac{\partial r^*}{\partial t^*} + \frac{\partial \Pi^*}{\partial t^*} \right) \\ & + \frac{\partial \mathcal{L}}{\partial w} \left(\frac{\partial w}{\partial T^e} - \frac{\partial w}{\partial b} + \frac{\partial w}{\partial y} \right) (1-\theta^*) \bar{k} \frac{\partial r^*}{\partial t^*}. \end{aligned} \quad (\text{A.13})$$

If we use the comparative statics derivatives in equations (11) - (13), one can see that the sum of the partial derivatives of the bargained wage inside the first parenthesis in the second row of equation (A.13) sum to zero, in which case we obtain equation (26). The derivation of equation (29) is analogous.

Proof of Lemma 1

To begin with, we need to evaluate dE^*/dt^* . Differentiating equation system (21) - (24) w.r.t. $t = t^*$, we obtain

$$\frac{dE^*}{dt^*} = - \frac{(T^e + b) - \rho_1 w}{\Psi} \quad (\text{A.14})$$

where

$$\Psi = [(T^e + b)(1 - \rho_3) - \rho_1 w] \rho_3 L^{\rho_1} K^{\rho_2} E^{\rho_3 - 2}. \quad (\text{A.15})$$

By inspection, it follows that $dE^*/dt^* < 0$ when $(T^e + b)/w < \rho_1$, $dE^*/dt^* > 0$ when $\rho_1 \leq (T^e + b)/w < \rho_1/(1 - \rho_3)$ and $dE^*/dt^* < 0$ when $\rho_1/(1 - \rho_3) < (T^e + b)/w$.

To evaluate $d\Pi^*/dt^*$, we first need to evaluate dw^*/dt^* and dr^*/dt^* . Differentiating equation system (21) - (24) w.r.t. $t = t^*$, we obtain

$$\frac{\partial w^*}{\partial t^*} = \frac{(w - T^e - b) F_{LE}}{\Psi} \quad (\text{A.16})$$

$$\frac{\partial r^*}{\partial t^*} = -\frac{(T^e + b) F_{KE}}{\Psi}. \quad (\text{A.17})$$

Substituting equations (A.16) and (A.17) into equation (27), using $\partial\Pi^*/\partial t^* = -E^*$ and that the production function is given by (35), we have

$$\frac{d\Pi^*}{dt^*} = -\frac{(1 - \rho_1 - \rho_2 - \rho_3) \rho_3}{\Psi} L^{\rho_1} K^{\rho_2} E^{\rho_3 - 1} (T + b) \quad (\text{A.18})$$

By inspection, it follows that $\partial\Pi^*/\partial t^* > 0$ when $(T^e + b)/w < \rho_1/(1 - \rho_3)$ and $\partial\Pi^*/\partial t^* < 0$ when $(T^e + b)/w > \rho_1/(1 - \rho_3)$.

References

- [1] Aronsson, T. and Blomquist, S. (2003), "Optimal Taxation, Global Externalities and Labor Mobility" *Journal of Public Economics* **87**, 2749-2764.
- [2] Aronsson, T., Jonsson, T and Sjögren, T. (2006), "International Environmental Policy Reforms, Tax Distortions, and the Labor Market" *FinanzArchiv* **62**, 199-217.
- [3] Aronsson, T. and Löfgren, K.-G.. (2000), Green Accounting and Green Taxes in the Global Economy in: Folmer, H., Gabel, L. and Rose, A. (Eds) *Frontiers of Environmental Economics*, Edward Elgar Publishing Limited, Cheltenham.
- [4] Aronsson, T. and Sjögren, T. (2004a), "Is the Optimal Labor Income Tax Progressive in a Unionized Economy?" *Scandinavian Journal of Economics* **106 (4)**, 661-675.
- [5] Aronsson, T. and Sjögren, T. (2004b), "Efficient Taxation, Wage Bargaining and Policy Coordination" *Journal of Public Economics* **88**, 2711-2725.
- [6] Barrett, S. (1994), "Self-Enforcing International Environmental Agreements" *Oxford Economic Papers* **46**, 878-894.
- [7] Bovenberg, L. and de Mooij, R. (1994), "Environmental Levies and Distortionary Taxation" *American Economic Review* **84**, 1085-1089.
- [8] Bovenberg, L. and Goulder, L. (1996), "Optimal Environmental Taxation in the Presence of Other Taxes: General Equilibrium Analyses" *American Economic Review* **86**, 985-1000.
- [9] Bovenberg, L. and van der Ploeg, F. (1998), Tax Reform, Structural Unemployment and the Environment, *Scandinavian Journal of Economics* **100**, 593-610.
- [10] Bucovetsky, S. and Wilson, J. D. (1991), "Tax Competition with Two Tax Instruments" *Regional Science and Urban Economics* **21**, 333-350.
- [11] Carraro, C. (Ed) (2003), *The Endogenous Formation of Economic Coalitions*, Edward Elgar, Cheltenham.

- [12] Fuest, C. (1995), "Interjurisdictional Competition and Fiscal Expenditure: Is Tax Coordination Counterproductive?" *FinanzArchiv* **52**, 478-496.
- [13] Fuest, C. and Huber, B. (1999), "Tax Coordination and Unemployment" *International Tax and Public Finance* **6**, 7-26.
- [14] Hoel, M. (1997), "Coordination of Environmental Policy for Transboundary Environmental problems" *Journal of Public Economics* **66**, 199-224.
- [15] Kaufman, B. (2002), "Models of Union Wage Determination: What Have We Learned Since Dunlop and Ross?" *Industrial Relations* **41**, 110-158.
- [16] Koskela, E. and Scgöb, R. (2002), "Optimal Factor Income Taxation in the Presence of Unemployment" *Journal of Public Economic Theory* **4** (3), 387-404.
- [17] Mäler, K.-G. (1989), The Acid Rain Game in: Folmer, H. and van Ierland, E. (Eds), *Valuation Methods and Policy Making in Environmental Economics*, Elsevier, Amsterdam, 231-252.
- [18] Oswald, A., J. (1985), "The Economic Theory of Trade Unions: An Introductory Survey" *Scandinavian Journal of Economics* **87**, 160-193.
- [19] Oswald, A., J. (1993), "Efficient Contracts Are on the Labor Demand Curve: Theory and Facts" *Labour Economics* **1**, 85-113.
- [20] van der Ploeg, F. and de Zeeuw, A. J. (1992), "International Aspects of Pollution Control" *Environmental and Resource Economics* **2**, 117-139.
- [21] Wildasin, D. E. (1989), "Interjurisdictional Capital Mobility: Fiscal Externality and Corrective Subsidy", *Journal of Urban Economics* **25**, 193-212.
- [22] Wilson, J. D. (1999), "Theories of Tax Competition", *National Tax Journal* **52**, 269-304.
- [23] Zodrow, G. R. and Mieszkowski, P. (1986), "Pigou, Tiebout, Property Taxation and the Underprovision of Local Public Goods", *Journal of Urban Economics* **19**, 356-370.