

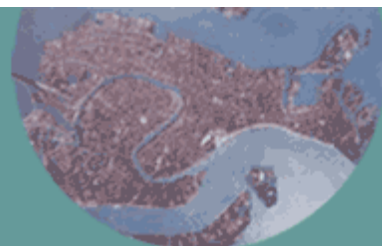
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## **Political economy of land use and logging in presence of externalities**

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# Political Economy of Land Use and Logging in Presence of Externalities

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## Abstract:

*This paper develops a political economy model with menu auctions between a government and lobbies to determine the environmental policy. Two of the (three) production sectors share a common sector-specific factor of production, namely land, which has two externalities connected to it: a positive one arising from forest amenities and a negative one arising from logging. The government has two policy instruments at its disposal: a land tax-cum-subsidy and a production tax-cum-subsidy. The interdependence between the two land using sectors is shown to impact the setting of respective land tax-cum-subsidy. Consequently, land use in logging will be subsidized and that in agriculture will be taxed. Production of logs will be taxed. Moreover, the paper also studies the effect of property rights. It is found that the worse the property rights regime, the lower the tax on agricultural land use and subsidy on logging will be. This leads to more land being allocated to agriculture than would be optimal were the property rights to (forest) land well defined. Further, the worse the property rights regime, the more the logging sector has at stake. This leads to a lower production tax imposed on logging and higher production of logs. Thus, the model can explain some factors that can lead to the disappearance of forests from countries with corruptible governments and poorly defined property rights to forests.*

# 1. Introduction

Determination of the optimal forest area has been the subject of several studies. Many of these have used optimal control (see, e.g., Simeon K. Ehui and Thomas W. Hertel, 1989, Simeon K. Ehui et al., 1990). The weakness of many models within natural resource economics is, however, that they only do a partial equilibrium analysis of the problem. Incorporating political economy considerations in this type of models is difficult. Although the present paper contributes to the solution this problem, it is not a substitute to studies made using optimal control since the model here is static. Therefore it is impossible to directly compare the present conclusions with ones drawn using optimal control techniques.

Deforestation is a very complicated issue. Today, it is mainly a problem in developing countries; indeed, forest cover in Europe has rather expanded over the past years. The typical story (gravely simplified) in a developing country seems to go like this: a logging company gets concessions to log in a certain area, often in virgin forest. In order to get access to the area, they have to build a road. Once they have logged the area, they leave, and leave the forest to regenerate, although they most often do not replant. Assuming there is pressure for more agricultural land, it is then easy for poor landless people to follow the roads built by logging companies and settle in the forests thus exposed. Oftentimes the government owns the forests and is either unable or unwilling to dispel settlers. In many countries, for instance in Brazil and in Indonesia, it has rather been a government policy to let people settle in “unused” forests.

The presence of diverse interest groups does not make the problem any simpler. In order to grasp at least some of the complexity, we model the problem by assuming the presence of two externalities. The first one arises from forests in the form of amenities (public goods), such as watershed protection, carbon sequestration and biodiversity conservation. It is included in order to address the issue of conversion of forestland to agriculture: we assume that land that is being farmed cannot be forested and therefore will not produce these amenities. The second externality arises from log production. The case for the externality from logging is less clear-cut than the one arising from amenities. However, it addresses the issue of the role of logging industry in, first, unsustainable logging and second, its role in the conversion of forestland to

agriculture. As the model is static, we have not been able to model the land conversion process directly but attempt to determine the equilibrium prices that lead to a socially or politically optimal allocation of land between the two sectors. Since the logging industry does have part of the blame in the disappearance of world's forests, we conclude that it would be wrong to only assume a negative externality arising from land use for agriculture.

A further question of interest is the property rights structure to forests and how strictly these property rights are enforced. If property rights are poorly defined, logging can be excessive. Examination of property rights also allows us to explain why the forest area has developed so differently in countries with different property rights regimes.

The question of optimal policy instruments to internalize these externalities then arises. Traditionally forests have been protected using quantitative restrictions on their use. In the present paper, however, a tax-cum-subsidy on land use as a factor of production is used to internalize the positive externality arising from the amenities, and a production tax cum subsidy is used to internalize the externality arising from logging. The use of pecuniary policy instruments rather than quantitative ones is justified by noting that governments do not set environmental regulations without taking their economic consequences into consideration. Taxes give us an indication of the costs and benefits associated with keeping a certain area under forests. The taxes used in the present paper aim at lowering agricultural land use but at the same time lowering log production without impacting on the forested area. Whether taxes of this type would be feasible, especially in a developing country and on the land use of subsistence farmers is a question beyond the scope of this paper.

We model the political economy by using a principle-agent model with menu-auctions, originally developed by Bernheim and Whinston (1986), and extended by Grossman and Helpman (1994). The principals, namely the lobbyists, give a menu of campaign contribution offers to the agent, namely the government, contingent on the chosen policy in order to influence the latter's policy decisions. The government observes the offered contributions and sets the level of taxes (or subsidies) that maximizes its welfare.

Grossman and Helpman's model has by now given rise to a large literature studying the effect of lobbying on political outcomes. Fredriksson (1997) shows that in the presence of both industry and environmental lobbies in a small open economy the pollution tax rate is increasing in the world market price, the tax is ambiguous in lobby group membership and that the deviation from optimal tax rate diminishes as the importance of lobbying activities is reduced. He also shows that a pollution abatement subsidy may lead to a fall in pollution tax rate. Aidt (1998) considers a production externality arising from the use of raw materials. The government is assumed to have both an output- and an input tax-cum-subsidy at its disposal. Aidt shows that the most efficient tax instrument will be used to internalize the externality. Further, he shows that although lobbying distorts taxation, the tax always also contains a Pigouvian element. Schleich (1999) analyses the case where, depending on the type of externality present, the government has either a production or a consumption tax, respectively, at its disposal. As compared to Fredriksson (1997) or Aidt (1998), Schleich explicitly allows for an endogenous trade policy. In the case of a production tax the conclusion is that whether the environmental quality in political optimum is higher or lower than socially optimal depends on the slope of the marginal political cost function in relation to the marginal benefits curve. In case of a consumption externality, the resulting environmental quality is socially optimal. Fredriksson (1997, 1999), only considers functionally specialized lobbies' impact on taxation whereas Schleich (1999) considers lobbies with multiple goals and Aidt (1998) considers both cases.

Fredriksson (1999) studies the effect of trade liberalization on total pollution in a small country where the externality arises from a production externality in a tariff-protected sector and where pollution abatement is possible. He shows how political pressure on pollution tax from the two lobbies falls as the tariff decreases and how political polarization decreases. Trade liberalization may however lead to an increase in total pollution because the equilibrium pollution tax is shown to fall in most cases. Fredriksson and Svensson (2003) and Fredriksson and Mani (2003) study the impact of economic integration on the determination of environmental policies in countries with corrupt and/or unstable political regimes. The latter paper also considers the effect of (exogenous) trade liberalization. Both papers find empirical support for the hypotheses developed.

Aidt (2000) develops a model to study the effect of environmental and industry lobbying on the pollution tax when environmentalists not only care about the environment in their own country but also in the other (identical) country. His analysis and results resemble those by Conconi (2003), who develops a large-country model to determine the optimal levels of trade and pollution taxes in the presence of functionally specialized environmental and industry lobbies. She further introduces transboundary pollution. The result is that green lobbying, even in the case where green lobbies in different countries co-operate, might lead to a decrease in the pollution tax if trade is totally liberated. Finally, Eerola (2003) studies the determination of optimal forest area protection in presence of interest groups and a monopoly in the forestry sector. The conclusion is that an exporting monopoly will face a stricter conservation policy than a monopoly, whose production is destined for the domestic market, and that industrial lobbying most often leads to a conservation policy insufficient as compared to the social optimum.

The main difference between the present model and the previous ones is the attempt to change the character of the so called sector specific factor input, which in the above models is assumed to be fixed and specific to each sector. Here two sectors use the same input factor, namely land, which can be reallocated between the sectors. Further, the present model includes two externalities that both arise from the production of goods. One of them is related to the use of factor inputs, as in Aidt (1998) and the other to production of output, as in, e.g., Fredriksson (1997) and Schleich (1999). Finally, the paper at hand considers the effect of property rights to forestland on land use and production.

What follows next is a description of the production side of the economy and the externalities present. After this we define the consumer's maximization problem and describe the political process. In section 3 we calculate the optimum tariffs (or subsidies) for two cases: one where the lobbies are functionally specialized and one where they have multiple goals. Section 4 studies the effect of property rights on tax rates. Finally, section 5 concludes.

## 2. The Model

### 2.1. Production

Consider a small open economy with three competitive sectors of production: the numéraire sector, agriculture ( $A$ ) and logging ( $L$ ) (also called the “industry”). Both the consumer and producer price of the numéraire good equals one and the consumer price of the non-numéraire goods equals their international price,  $p_i^*$ . The numéraire sector uses only labour as a factor of production whereas agriculture and logging use land and labour. Production in all sectors exhibits constant returns to scale and the production functions are assumed to be continuous, strictly increasing, strictly quasi concave,  $y^i(0, \mathbf{z}) = 0$  and they are homogeneous of degree 1. Due to profit maximization and mobility of labour across sectors the wage rate of the economy can be set to  $w = 1$ . Labour supply  $M$  is assumed to be large enough so that a positive amount of the numéraire good is produced.

Total arable land area is denoted by  $l$ , and is divided into two uses: land under forests  $f$  and land use in agriculture ( $l - f$ ). We can normalize  $l = 1$  without loss of generality; land use (demand) in agriculture is then denoted by  $K^A \equiv (1 - f)$  and land under forests by  $f$ . Further, logging uses a fraction  $\delta$  of the total forest area for production of logs,  $0 \leq \delta \leq 1$ , so that land demand for logging is  $K^L \equiv \delta f$ .

Land is not traded internationally but its price is determined by domestic demand and production technologies. In equilibrium, the relative land price is equal to the ratio of the value of marginal product of land in the two sectors:  $z_i/z_j = (p_i y_K^i)/(p_j y_K^j)$ ,  $i, j = A, L$ ,  $i \neq j$ . The price of land in each sector  $i$  equal  $z_i = z + t_i$ .  $t_i$  is tax or subsidies on land use in sector  $i$  (negative  $t_i$  denoting a subsidy) and  $z \equiv z(\mathbf{t})$  is the variable common part of the land price to both sectors.  $p_i = p_i^* - \tau_i$  is the producer price of good  $i = A, L$ , which is equal to the world market price minus the tax (subsidy if negative) on production,  $\tau_i$ , and  $y_K^i$  is the marginal productivity of land. The input and output prices are assumed to be independent of each other. Imposing a land tax on either sector, holding the tax-cum-subsidy on the other sector constant,

changes the relative price of land; besides, both sectors have market power on the price of land. Therefore,  $0 < \partial z_i / \partial t_i = \partial z / \partial t_i + 1 < 1$ , where  $-1 < \partial z(\mathbf{t}) / \partial t_i < 0$  and  $\partial z_j / \partial t_i = \partial z / \partial t_i$ . We assume that a rise in tax on sector  $i$  lower land demand in that sector and increase demand of land in sector  $j$ , i.e., land-demand curves are downward sloping in price. We further assume that the changes in land demand are of equal size. This means that  $\partial K^L / \partial z_A = -\partial K^A / \partial z_A$  and that  $\partial K^A / \partial z_L = -(\partial K^L / \partial z_L) / \delta$ .

Each firm is a price taker and supplies its output to a competitive market. Profit maximization lead to the restricted profit functions  $\pi^i(p_i, \mathbf{z})$ .  $\pi^i$  is strictly convex and from Hotelling's lemma we have  $\partial \pi^i / \partial p_i = y^i(p_i, \mathbf{z})$  and  $\partial \pi^i / \partial z_i = -K^i(p_i, \mathbf{z})$ .  $y^i$  is firm  $i = A, L$ 's supply function. Further, since the two sectors are connected, their profits also depend on land prices in the other sector. Therefore, we have  $\partial \pi^j / \partial p_i = 0$  and  $\partial \pi^j / \partial z_i = -K^j(\partial z_j / \partial z_i)$ .<sup>1</sup>

## 2.2. Externalities

Benefits from land arise from two sources. It enters into the production functions of agricultural goods and logs, and besides, if forested, land also produces amenities. The latter have a public good character. As land that is used for agricultural purposes cannot be forested, it is assumed that agricultural land use lowers the production of amenities from forests. Logging sector is assumed to have no effect on amenities as land that is logged has to be forested.

<sup>1</sup> We have further used a number of second order conditions of the profit function. These have been defined as follows:  $\frac{\partial^2 \pi^i}{\partial p_i^2} = \frac{\partial y^i}{\partial p_i} > 0$ ,  $\frac{\partial^2 \pi^i}{\partial z_i^2} = -\frac{\partial K^i}{\partial z_i} > 0$ ,  $\frac{\partial^2 \pi^i}{\partial p_i \partial z_i} = \frac{\partial^2 \pi^i}{\partial z_i \partial p_i} = \frac{\partial y^i}{\partial z_i} = -\frac{\partial K^i}{\partial p_i} < 0$

but "small",  $\frac{\partial^2 \pi^j}{\partial p_i^2} = 0$ ,  $\frac{\partial^2 \pi^j}{\partial z_i^2} = -\frac{\partial K^j}{\partial z_i} \frac{\partial z_j}{\partial z_i} > 0$ ,  $\frac{\partial^2 \pi^j}{\partial p_i \partial z_i} = \frac{\partial^2 \pi^j}{\partial z_i \partial p_i} = 0$ ,

$\frac{\partial^2 \pi^j}{\partial p_j \partial p_i} = \frac{\partial^2 \pi^j}{\partial p_i \partial p_j} = 0$ ,  $\frac{\partial^2 \pi^j}{\partial p_j \partial z_i} = \frac{\partial^2 \pi^j}{\partial z_i \partial p_j} = \frac{\partial y^j}{\partial z_i} = -\frac{\partial K^j}{\partial p_j} \frac{\partial z_j}{\partial z_i} > 0$ ,

$\frac{\partial^2 \pi^j}{\partial z_i \partial z_j} = \frac{\partial^2 \pi^j}{\partial z_j \partial z_i} = -\frac{\partial K^j}{\partial z_j} \frac{\partial z_j}{\partial z_i} = -\frac{\partial K^j}{\partial z_i} > 0$ , and finally,  $\frac{\partial^2 \pi^j}{\partial p_i \partial z_j} = \frac{\partial^2 \pi^j}{\partial z_j \partial p_i} = 0$ . For

consistency the last effect should exist and be negative. As we have assumed the own price effect on land use to be "small" and the effect of a price change in sector  $i$  on profits on sector  $j$  to be nil, it is deemed safe to set the second difference equal to zero.

Nevertheless, logging, too, causes a negative externality. As was noted above, a fraction of  $\delta$  of the total forest area is logged. A fraction  $\alpha^E$  of citizens experience a negative externality from logging. This can be thought of, for instance, as the loss of recreational value of a forest due to logging. Alternatively, it may be that logging is not on an entirely sustainable basis and the environmentalists are concerned about this. Although we, in a static model, are unable to model the conversion of logged forestland to other purposes because of the low productivity of once logged land, this is also a possible explanation for a negative externality arising from logging.

We further use the parameter  $\delta$  as a measure of the property rights regime present in the country. The greater  $\delta$ , the worse the property rights regime. The property rights structure may be an explaining factor to why logging may be unsustainable. This is a very simple way of modelling property rights but deemed sufficient for present purposes. The idea is based loosely on Chichilnisky (1994).

In order to internalize the two externalities the government has two policy instruments at its disposal, namely a tax on output produced ( $\tau_i$ ) and a tax on land use ( $t_i$ ).

### 2.3. Consumption

The economy consists of  $N$  identical consumers; we normalize  $N=1$  without loss of generality. Each consumer derives utility from consumption of all the three goods and from the amenities produced by forests. Utility is quasi-linear and additively separable, and for all other individuals except for the environmentalists it can be expressed as  $U^h = x_0 + u_A(x_A) + u_L(x_L) + \phi(f)$ .  $x_0$  is the consumption of the numéraire good. The sub-utility functions  $u_i(x_i)$  give the utility derived from the consumption of good  $i = A, L$ ,  $u' > 0$  and  $u'' < 0$ . We denote benefits from the forest amenity by  $\phi(f)$  and assume that  $\phi'(f) > 0$  and  $\phi''(f) < 0$ , i.e., benefits from standing forests are increasing but at a decreasing rate. Since forest amenities are a public good, all individuals consume it in the same proportion.

Environmentalists for their part also receive disutility from logging. This disutility is assumed to be proportional to the area logged, which in its turn is proportional to

output produced, by an exogenously given damage coefficient  $\gamma > 0$ . Environmentalists' utility can then be expressed as  $U^e = x_0 + u_A(x_A) + u_L(x_L) + \phi(f) - \gamma y^L(p_L, \mathbf{z})$ .

Each consumer receives income from two sources. First, she supplies, inelastically, her endowment of labour,  $n_h$ , to the competitive labour market and receives the wage income  $n_h$ . Second, each consumer receives an equal share of any government revenue,  $R(\mathbf{t}, \boldsymbol{\tau})$ , as a lump sum transfer. Furthermore, agriculturalists and loggers own a share  $\alpha_h^i$  of land in sector  $i = A, L$  and get the rent from land use. To simplify the model each individual holds land claims only in one of the two sectors, i.e., for each  $i = A, L$ , the share  $\alpha_h^i$  is positive for one  $i$  only and zero for the other. Environmentalists are assumed not to own any land. From utility maximization subject to income  $I$ , and domestic consumer prices  $\mathbf{p}^*$  we derive demand  $d_i(p_i^*) = x_i$  for the non-numéraire goods, where  $d_i(p_i^*)$  is the inverse of  $u_i'(x_i) = p_i^*$ . We can then write the indirect utility of consumer  $h$  as:

$$V^h = n_h + \sum_{i=A,L} \alpha_h^i \pi_i(p_i, \mathbf{z}) + \frac{1}{N} [R(\mathbf{t}, \boldsymbol{\tau}) + S(\mathbf{p}^*)] + \phi(f) \quad (1)$$

$S(\mathbf{p}^*) = \sum_{i=A,L} u_i[d_i(p_i^*)] - \sum_{i=A,L} p_i^* d_i(p_i^*)$  is the consumer surplus for goods  $A$  and  $L$ . As there is no tariff in place the consumer price equals the world market price. The indirect utility of an environmentalist  $e$  is:

$$V^e = n_e + \frac{1}{N} [R(\mathbf{t}, \boldsymbol{\tau}) + S(\mathbf{p}^*)] + \phi(f) - \gamma y^L(p_L, \mathbf{z}) \quad (2)$$

Adding the indirect utilities up over all individuals gives the following social welfare function:

$$W(\mathbf{t}, \boldsymbol{\tau}) = n + \sum_{i=A,L} \pi^i(p_i, \mathbf{z}) + R(\mathbf{t}, \boldsymbol{\tau}) + S(\mathbf{p}^*) + \phi(f) - \alpha^E \gamma y^L(p_L, \mathbf{z}) \quad (3)$$

## 2.4. The Political Process

The incumbent government chooses environmental policy. To this end it has two environmental policy instruments at its disposal: a tax-cum-subsidy on the use of land

as a factor of production and a production tax-cum-subsidy. The net revenue from taxation and subsidies is given by:

$$R(\mathbf{t}, \boldsymbol{\tau}) = \sum_{i=A,L} (z_i - z)K^i(p_i, \mathbf{z}) + \sum_{i=A,L} (p_i^* - p_i)y^i(p_i, \mathbf{z}) \quad (4)$$

The government is assumed to pursue its own goals and to care about a mixture of political contributions and social welfare. We assume that the government either collects political contributions to be used in future elections that are not modelled or collects bribes to be used for personal consumption of the politicians. Whichever interpretation we choose does not impact on the results. The objective function of the government is given as  $G(\mathbf{t}, \boldsymbol{\tau}) = \sum_{i=A,L,E} C^i(\mathbf{t}, \boldsymbol{\tau}) + aW(\mathbf{t}, \boldsymbol{\tau})$ , where  $C^i$  are the contributions made by respective lobby, contingent on the chosen policies.

The formation of lobby groups is not modelled here; the reader is referred to Olson (1965). We assume that at most three groups overcome the free riding problem inherent to interest group organization and organize, following Aidt (1998), functionally specialized lobby groups that offer a menu of campaign contributions to the government dependent on the environmental policy. In section 3.2 we also study the case where the lobbies have multiple goals. The three lobbies are the agriculturalists with a share  $\alpha^A$  of the total population, loggers with a share  $\alpha^L$ ; these two groups only care about land rent; and the environmentalists with a share  $\alpha^E$ , who only care about the two environmental externalities. Further, there is a group of workers that constitute  $\alpha^W = \left(1 - \sum_{b \in B} \alpha^b\right)$  of the population, which do not organize politically.  $B$  is the subset of organized lobby groups. The population groups are mutually exclusive. From equations (1) and (2) we can derive the gross (of contributions) welfare function of lobby group  $j = A, L$ :

$$W^j(\mathbf{t}, \boldsymbol{\tau}) = n^j + \pi^j(\mathbf{p}, \mathbf{z}) + \alpha^j (R(\mathbf{t}, \boldsymbol{\tau}) + S(\mathbf{p}^*)) + \phi(f) \quad (5)$$

The environmentalists' gross welfare function is

$$W^E(\mathbf{t}, \boldsymbol{\tau}) = n^E + \alpha^E (R(\mathbf{t}, \boldsymbol{\tau}) + S(\mathbf{p}^*) - \gamma y^L(p_L, \mathbf{z})) + \phi(f) \quad (6)$$

Derivation of the equilibrium in differentiable strategies follows Grossman and Helpman (1994), Dixit (1996) and Fredriksson (1997) closely and is left out. Instead, following Aidt (1998) and Conconi (2003) we note that we model policy making under lobby influence as a two-stage common agency game. In the first stage, lobbies confront politicians with their contribution schedules, which are assumed to be globally truthful, continuous, and differentiable at least in the neighbourhood of an equilibrium. In the second stage, policy makers unilaterally or co-operatively set environmental policies and receive the corresponding political contributions. The assumption of global truthfulness implies that the (politically) optimal policy vector can be characterized by the following equation:

$$\sum_{i=A,L,E} \nabla W_i(\mathbf{t}^0, \boldsymbol{\tau}^0) + a \nabla W(\mathbf{t}^0, \boldsymbol{\tau}^0) = 0 \quad (7)$$

### 3. Politically Optimal Equilibrium Taxes

#### 3.1. Functionally Specialized Lobbies

Differentiating the lobbies' objective functions (5) and (6), and the government's objective function (3) with respect to  $t_i$  and  $\tau_i$  and entering them into equation (7) gives us following first order conditions for the two prices:

$$z_i : -I^i K^k \frac{\partial z_i}{\partial t_i} - I^j K^j \frac{\partial z_j}{\partial t_i} + (I^E + a) \phi'(f) \left[ \frac{\partial f}{\partial z_i} - \alpha^E \gamma \frac{\partial y^L}{\partial z_i} \right] \frac{\partial z_i}{\partial t_i} - a (K^i + K^j) \frac{\partial z}{\partial t_i} \\ + a \left[ (z_i - z) \frac{\partial K^i}{\partial z_i} + (z_j - z) \frac{\partial K^j}{\partial z_i} + (p_i^* - p_i) \frac{\partial y^i}{\partial z_i} + (p_j^* - p_j) \frac{\partial y^j}{\partial z_i} \right] \frac{\partial z_i}{\partial t_i} = 0$$

$$p_i : I^i y^i + (I^E + a) \left[ \phi'(f) \frac{\partial f}{\partial p_i} - \alpha^E \gamma \frac{\partial y^L}{\partial p_i} \right] + a \left[ (z_i - z) \frac{\partial K^i}{\partial p_i} + (p_i^* - p_i) \frac{\partial y^i}{\partial p_i} \right] = 0$$

$I^k$ ,  $k = A, L, E$ , is an indicator variable taking value one if the sector is politically organized and zero otherwise and  $\partial f / \partial z_i$  and  $\partial f / \partial p_i$  are the change in forest area given a change in the price of land respectively output price in sector  $i = A, L$ . The effect of a change in either price is assumed to have following effect on the forest area:  $\partial f / \partial z_A = -\partial K^A / \partial z_A > 0$ ,  $\partial f / \partial z_L = (\partial K^L / \partial z_L) / \delta < 0$ ,  $\partial f / \partial p_A = -\partial K^A / \partial p_A < 0$  and  $\partial f / \partial p_L = (\partial K^L / \partial p_L) / \delta > 0$ .

We express the results in terms of the equilibrium ad valorem taxes and subsidies, which are defined by  $t_i^0 \equiv (z_i^0 - z)/z$  (land-tax) and  $\tau_i^0 \equiv (p_i^* - p_i^0)/p_i^*$  (production tax). We solve the first order condition for each sector separately, since some of the terms cancel differently. In order to do this we denote by  $\varepsilon_i^K = -\frac{z_i^0}{K_i} \frac{\partial K_i}{\partial z_i}$  the (land) price elasticity of land demand and by  $e_i^K = \frac{p_i}{K^i} \frac{\partial K^i}{\partial p_i}$  the output price elasticity of land demand, which is assumed to be “small”. Moreover,  $\varepsilon_i^y = \frac{p_i^0}{y^i} \frac{\partial y^i}{\partial p_i}$  is the (output) price elasticity of output, and  $e_i^y = -\frac{z_i}{y^i} \frac{\partial y^i}{\partial z_i}$  is the land price elasticity of output, which, too, is “small”. Further, we use the properties of profit functions given in footnote 1.  $r_i = K_j/K_i$  is the ratio of land demand in the two sectors, and  $\Delta_i = \frac{\partial z/\partial t_i}{\partial z/\partial t_i + 1} < 0$  is the ratio of price change in sector  $j$  to the price change in sector  $i$  due to a change in  $t_i$ . This yields the following taxes and subsidies on land use:

$$\begin{aligned} \frac{t_A^0}{1+t_A^0} = & \underbrace{\frac{I^E + a \phi'(f)}{a}}_{+} \underbrace{\frac{z_A^0}{z_A^0}}_{-} + \underbrace{\frac{t_L^0}{1+t_L^0} \delta}_{-} \underbrace{-\frac{I^A}{a} \frac{1}{\varepsilon_A^K}}_{-} \underbrace{-\frac{I^L}{a} \frac{r_A \Delta_A}{\varepsilon_A^K}}_{+} \\ & - \underbrace{\frac{\tau_A}{1-\tau_A} \frac{e_A^K}{\varepsilon_A^K}}_{+} + \underbrace{\left[ \frac{I^E + a \alpha^E \gamma}{a} \frac{1}{p_L} - \frac{\tau_L}{1-\tau_L} \right] \frac{r_A e_L^K}{\varepsilon_A^K} \frac{\partial z_L}{\partial z_A}}_{+} - (1+r_A) \frac{\Delta_A}{\varepsilon_A^K} \end{aligned} \quad (8a)$$

$$\begin{aligned} \frac{t_L^0}{1+t_L^0} = & \underbrace{-\frac{I^E + a \phi'(f)}{a}}_{-} \underbrace{\frac{\delta z_L^0}{\delta z_L^0}}_{-} + \underbrace{\frac{t_A^0}{1+t_A^0} \delta}_{-} \underbrace{-\frac{I^L}{a} \frac{1}{\varepsilon_L^K}}_{-} \underbrace{-\frac{I^A}{a} \frac{r_L \Delta_L}{\varepsilon_L^K}}_{+} \\ & + \underbrace{\left( \frac{I^E + a \alpha^E \gamma}{a} \frac{1}{p_L} - \frac{\tau_L}{1-\tau_L} \right) \frac{e_L^K}{\varepsilon_L^K}}_{+} - \underbrace{\frac{\tau_A}{1-\tau_A} \frac{r_L e_A^K}{\varepsilon_L^K} \frac{\partial z_A}{\partial z_L}}_{+} - (1+r_L) \frac{\Delta_L}{\varepsilon_L^K} \end{aligned} \quad (8b)$$

The land tax is dependent on the production taxes. In order to proceed, we solve for these:

$$\frac{\tau_A^0}{1-\tau_A^0} = \underbrace{\left[ \frac{I^E + a \phi'(f)}{a} \frac{1}{z_A} - \frac{t_A^0}{1+t_A^0} \right]}_{-/+} \underbrace{\frac{e_A^y}{\varepsilon_A^y}}_{-} \underbrace{\frac{I^A}{a} \frac{1}{\varepsilon_A^y}}_{-} \quad (9a)$$

$$\frac{\tau_L^0}{1-\tau_L^0} = \underbrace{\frac{I^E + a \alpha^E \gamma}{a} \frac{1}{p_L}}_{+} \underbrace{\left[ \frac{I^E + a \phi'(f)}{a} \frac{1}{\delta z_L} + \frac{t_L^0}{1+t_L^0} \right]}_{-/+} \underbrace{\frac{e_L^y}{\varepsilon_L^y}}_{-} \underbrace{\frac{I^L}{a} \frac{1}{\varepsilon_L^y}}_{-} \quad (9b)$$

We start the analysis of these equations by defining as  $s_A$  and  $s_L$  the parts of (8a) and (8b) that are not dependent on the land tax-cum-subsidy itself:

$$s_A(\delta) = \frac{I^E + a \phi'(f)}{a} \frac{1}{z_A} - \frac{I^A}{a} \frac{1}{\varepsilon_A^K} - \frac{I^L}{a} \frac{r_A(\delta) \Delta_A}{\varepsilon_A^K} - \frac{\tau_A}{1-\tau_A} \frac{e_A^K}{\varepsilon_A^K} + \left[ \frac{I^E + a \alpha^E \gamma}{a} \frac{1}{p_L} - \frac{\tau_L}{1-\tau_L} \right] \frac{r_A(\delta) e_L^K}{\varepsilon_A^K} \frac{\partial z_L}{\partial z_A} - [1+r_A(\delta)] \frac{\Delta_A}{\varepsilon_A^K} > 0 \quad (10a)$$

$$s_L(\delta) = -\frac{I^E + a \phi'(f)}{a} \frac{1}{\delta z_L} - \frac{I^L}{a} \frac{1}{\varepsilon_L^K} - \frac{I^A}{a} \frac{r_L(\delta) \Delta_L}{\varepsilon_L^K} + \left( \frac{I^E + a \alpha^E \gamma}{a} \frac{1}{p_L} - \frac{\tau_L}{1-\tau_L} \right) \frac{e_L^K}{\varepsilon_L^K} - \frac{\tau_A}{1-\tau_A} \frac{r_L(\delta) e_A^K}{\varepsilon_L^K} \frac{\partial z_A}{\partial z_L} - [1+r_L(\delta)] \frac{\Delta_L}{\varepsilon_L^K} < 0 \quad (10b)$$

$s_A$  and  $s_L$  have been defined as functions of  $\delta$  for future use. Examining their properties gives us the following two propositions:

*Proposition 1:* Given that  $s_A < -\frac{s_L}{1-s_L}$ , the land-tax will be positive for the

agricultural sector and given that  $\frac{s_A}{1-s_A} > -\delta s_L$  it will be negative (a subsidy) for the

logging sector.

*Proof:* We start by solving equations (9a) and (9b) as functions of equations (10a) and (10b), which give us the following:

$$t_A^0 = -\frac{s_A(1-s_L) + \delta s_L}{(s_A + s_L - s_A s_L)} \quad (11a)$$

$$t_L^0 = \frac{s_A - \delta(s_A - 1)s_L}{\delta(s_A + s_L - s_A s_L)} \quad (11b)$$

The proof involves several steps. We start by noting that we assume that the marginal benefits from forests –term (the first term in equations (10a) and (10b)) is greater than the rest of the terms in case these are of the opposite sign. This ensures us that  $s_A(\delta) > 0$  and that  $s_L(\delta) < 0$ .

The next step is to examine the sign of  $s_A + s_L - s_A s_L$  (the “denominator”). We start by examining the case where the denominator is negative. Then, either (a)  $-1 < s_L < 0$ , and  $s_A < -s_L/(1-s_L)$  or (b)  $s_L < -1$  and  $s_A > -s_L/(1-s_L)$ . Substituting in the values of  $s_A$  and  $s_L$  from (10a) and (10b), and simplifying, we find that the inequality reduces to  $s_L \gg [s_A(s_L - 1)]/a$ . Both sides are negative but the RHS approaches 0 as  $a \rightarrow \infty$ . Even though we want our results to hold even outside the social optimum we take this as a sign of the RHS being greater (less negative) than the LHS. Thus, we have proven that  $s_A < -s_L/(1-s_L)$ . This has the consequences of

- (i) Imposing  $-1 < s_L < 0$ , and
- (ii) (i) together with  $s_A < -s_L/(1-s_L)$  means that  $0 < s_A < 0.5$ .<sup>2</sup>

Continuing with the case where the denominator is positive, this is possible if (c)  $-1 < s_L < 0$ , and  $s_A > -s_L/(1-s_L)$  or if (d)  $s_L < -1$  and  $s_A < -s_L/(1-s_L)$ . However, in case (d) the LHS is positive and the RHS negative, so it is ruled out. As for case (c), we know from above that  $s_A < -s_L/(1-s_L)$ . This rules out case (c). Consequently, the denominator is negative.

Now that we know the sign of the denominator we can easily examine the tax equations. Rewriting  $t_A = -1 - [(\delta - 1)s_L]/[s_A + s_L - s_A s_L]$ , simple manipulations

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<sup>2</sup> The result is obtained from simulations in Excel.

show that this will be positive if  $-\delta s_L/(1-s_L) < s_A$ . We know that  $0 < \delta < 1$ . Then, assuming that  $s_A \rightarrow -s_L/(1-s_L)$ , we know that the inequality holds.<sup>3</sup> Then,

(iii)  $t_A > 0$  and

(iv) We can delimit further  $-\delta s_L/(1-s_L) < s_A < -s_L/(1-s_L)$ .

Rewriting  $t_L = 1 + [(1-\delta)s_A]/[\delta(s_A + s_L - s_A s_L)]$ , simple manipulations show that  $t_L < 0$  if  $s_A/(1-s_A) > -\delta s_L$ . Simulations in Excel show that as long as  $s_A < -s_L/(1-s_L)$ ,  $s_A/(1-s_A) < -s_L$ . As  $s_A \rightarrow -s_L/(1-s_L)$ , the closer  $s_A/(1-s_A)$  is to  $s_L$ . Then, for most reasonable values of  $\delta$  (from Excel,  $0 < \delta \approx 0.9$ ),

(v)  $-\delta s_L < s_A/(1-s_A) < -s_L$ . Then we deem it safe to make our final conclusion:

(vi)  $t_L < 0$ . Q.E.D.

Proposition 1 shows the importance of considering the connection between the two sectors. For instance,  $t_A$  would be unambiguously positive if it were not for the effect of  $\delta s_L$  that drags it down. Similarly,  $t_L$  would be unambiguously negative if  $s_A$  did not tend to “pull it up”. When the input market is thus interconnected, it would be wrong not to consider the effect of the changes in the price of the common input.

We turn next to the size of the respective tax and formulate following proposition:

*Proposition 2:*  $t_A > 1$  and  $-1 < t_L < 0$ . The former implies  $z_A^0 > 2z(\mathbf{t})$  and the latter  $0 < z_L^0 < z(\mathbf{t})$ .

*Proof:* From proposition 1 we know that  $t_A > 0$ . We prove proposition 2 by proving that the opposite  $t_A = -1 - [(\delta-1)s_L]/[s_A + s_L - s_A s_L] < 1$  is ruled out. Simple manipulation yields  $-(\delta+1)s_L/(1-s_L) = -\delta s_L/(1-s_L) - s_L/(1-s_L) > 2s_A$ . From finding (iv) in Proposition 1 we know that this is no true. Thereby,  $t_A > 1$ .

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<sup>3</sup> Simulations made in Excel support the assumption.

Manipulation of  $t_L = 1 + (1 - \delta)s_A / \delta(s_A + s_L - s_A s_L) < -1$  yields the condition  $(1 + \delta)s_A / (1 - s_A) > -2\delta s_L$  for  $t_L < 0$ . From finding (v) in Proposition 1 and because  $\delta s_A / (1 - s_A) < -\delta s_L$  this can be rejected. Therefore, we conclude that  $-1 < t_L < 0$ .

The latter part of the proposition is obvious from a manipulation of the definition of the (ad valorem) tax. Q.E.D.

Examining the government's decision in the setting of tax-cum-subsidies, we formulate the following proposition that supports the findings of Aidt (1998):

*Proposition 3:* The (main) instrument to internalize the externality arising from forest amenities is a land tax-cum-subsidy and the (main) instrument to internalize the production externality in the logging sector is a production tax on that sector.

*Proof:* Proposition 3 cannot be proved directly but an examination of the tax equations (8a), (8b), (9a) and (9b) supports it. The production externality enters the equations (8a) and (8b) only in a “stabilizing” fashion, i.e., the externality arising from production is subtracted from the production tax. The terms are further multiplied by the output price elasticity of land demand, which is assumed to be small. These terms are thus bound to be close to zero and the land tax-cum-subsidy equations are dominated by the marginal benefits from forests –term.

Similarly, in the case of the production taxes (9a) and (9b), the externality arising from land use is subtracted from the land-tax and multiplied by the land price elasticity of output that is assumed to be small. Therefore, the first term in (9a) and the second term in (9b) are bound to be close to zero and (9a) is approximately zero and (9b) dominated by the first term measuring the disutility from logging.

The presence of lobbies does not change these findings, they just lead to a downward pressure on the taxes from sector  $i$  and upward pressure from sector  $j$  and the environmentalists. Q.E.D.

The government imposes the land tax-cum-subsidy because of three reasons: first, in order to internalize the externality from land use, second, to raise tax revenue and third, to stabilize the effect of production taxation. The production tax is imposed, first, in order to internalize the production externality in the logging sector and second, to stabilize the effect of land taxation, but not in order to raise tax revenue. In absence of lobbying the government would use a production tax on the agricultural sector only to adjust for the deviation from the Pigouvian land-tax rate. Finally, similarly to Aidt (1998), all taxes, although not set to their Pigouvian levels, contain a Pigouvian element.

Turning finally to the effect of lobbying, we formulate the following proposition:

*Proposition 4:* Environmentalists lobby for higher-than-Pigouvian environmental taxes (or land use subsidy for logging) whereas the industrial sectors lobby for lower own taxes but higher land-tax on the other sector. The overall impact of lobbying is ambiguous.

*Proof:* This can be seen by examining the signs of the terms including the lobbying parameter  $I^k$ ,  $k = A, L, E$ . The Pigouvian land tax-cum-subsidy would equal the marginal benefits from forests  $((\phi'(f)/z_i)(\partial f/\partial z_i/\partial K^i/\partial z_i))$ . The environmentalists give more weight to the first term in both equations (8a) and (8b), thus leading to higher-than-Pigouvian land tax-cum-subsidy in absence of other effects. The Pigouvian production tax on sector  $A$  is zero and on sector  $L$  equal to  $\alpha^E \gamma / p_L$ . The presence of environmentalists rises the first term in equation (9b) thus leading to a higher production tax on logging.

Similarly, the third term in equations (8a) and (8b) is negative due to industry lobbying by the sector being taxed, given that the sector organizes a lobby, and the fourth term in these equations is positive, thus rising the tax. The fourth term arises from industry  $j$ 's interest to lobby for higher land-price for sector  $i$  because this benefits sector  $j$  by allocating more land to that sector via the price mechanism. Each sector's political clout depends on sector  $i$ 's (land price) elasticity of land use, and for sector  $j$  on its share of land use ( $r_i$ ). The higher the elasticity of land use, the less

sector  $i$ 's lobbying weighs in; the higher share of land in sector  $j$ , the higher that sector's influence.

Finally, both industrial lobbies lobby for a lower production tax on their own sector and do not concern themselves with the production tax on the other sector. Given that the first term in (9a) is small, this leads to agricultural production being subsidized. The overall effect of lobbying, with both environmental and industrial lobbies present is however ambiguous, except in the case of equation (9a) where the environmental lobby does not enter. Q.E.D.

### 3.2. Multi-purpose Lobbying and the Political Equilibrium

In this section we study how the equilibrium tax rates change if the lobbies have multiple goals instead of a single one. The multiple goals consist not only of maximizing each sector's profits or the level of environmental taxation but of also maximizing the tax-remittances coming from the government and, for the industrial lobbies, to lobby for a greater provision of forests because of the amenities these produce.

We do not give the explicit tax forms here since they are very similar to equations (8a), (8b), (9a) and (9b). The difference arises from the weights that the different terms get. It is noteworthy that because of the way we have specified our model, multipurpose lobbying increases the weight given to the forest amenities to

$\left(a + \sum_{b \in B} I^b\right) / \left(a + \sum_{b \in B} \alpha^b\right)$ , where  $\sum_{b \in B} I^b$  equals 3 if all lobbies organize. Thus, when  $a$

is finite and the government takes both contributions and the social welfare into consideration in its decision-making, the provision of forests increases, i.e., the land tax on agriculture and the subsidy on land use in logging will both be higher, and the forest area is more bound to exceed the socially optimal level than in the previous section where only the environmentalists lobbied for its provision. The production tax equation does not change in a significant manner, however.

## 4. Effect of Property Rights on Levels of Taxes

As noted in the introduction, the property rights regime may have a profound effect on forest cover. In this section we examine how a change in the “property rights parameter”  $\delta$  impacts the taxes solved for in section 3. We start with some intuition on the effect of property rights. We noted above that the land price equals the ratio of the value of marginal product of land:  $z_i/z_j = (p_i y_K^i)/(p_j y_K^j)$ . It is a well-known postulate of welfare economics that when property rights to a resource are poorly defined, the producers produce at a point where the value of average product equals price. Further, for a given  $K^L$ ,  $p_L y^L / K^L > p_L y_K^L$ , i.e., average product of land is higher than its marginal product.

In this section we assume that the land price  $z(\mathbf{t})$  is fixed. Then, as we examine changes in the property rights parameter  $\delta$ , which will be higher if the property rights to forests are poorly defined and has the consequence of increasing production:  $\partial y^L(\delta, p_L, \mathbf{z}(\mathbf{t})) / \partial \delta > 0$ , only the changes that arise through changes in tax policies are considered. The reason for this assumption is that for  $p_L y^L / K^L = p_L y_K^L = z_L$  to hold, the  $K^L$  in the average product function has to be greater than the last unit of land entering into the marginal product function for the value of production to be the same. I.e., of the given area  $f$ , under poorly defined property rights to forests a greater area will be logged. In order not to mix the effects we then exclude the possibility of property rights impacting on  $z(\mathbf{t})$ .<sup>4</sup>

It is important to note that we do not define the level of  $\delta$  at which property rights are “well defined” (i.e., private property rights apply and are enforced) and when they are “poorly defined” (i.e., open access to forests). This could naturally be solved for, but

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<sup>4</sup> If we wanted to make the model more realistic we should allow the land-price,  $z(\mathbf{t})$ , to be a function of property rights, too. This would mean that the worse the property rights to forests, the higher the land price for both sectors. This would have an effect of “allocating away” land from forests to agriculture as we “worsened” the property rights. As long as the price adjustment was not equal to the change in the property rights, the adjustment would not be full. As this complication does not give more insight to the effect of property rights it is left away and we assume constant prices. A further motivation for leaving it unconsidered is that no land just shifts its “property rights parameter” in the described fashion.

since we do not attempt to do this, the analysis merely shows is how the levels of taxes and thus the society's perception of the value of forests change with  $\delta$ .

In order to proceed with the formal examination of the effect of property rights we differentiate equations (10a) and (10b) with respect to  $\delta$ . We have disregarded of the effect arising through the cross-term of production taxation in the land tax equations, thus  $\tau_A$  and  $\tau_L$  are not differentiated with respect to  $\delta$  (the land-tax equations in equations (9a) and (9b) are considered, however). The only variable in equations (8a) and (8b) that is a function of  $\delta$  is  $r_i$ . We further note that  $\partial r_A / \partial \delta = f / (1-f) > 0$  and that  $\partial r_L / \partial \delta = -(1-f) / \delta^2 f < 0$ . Then we write:

$$\frac{\partial s_A}{\partial \delta} \equiv s'_A = \underbrace{\frac{1}{\epsilon_A^K}}_+ \underbrace{\frac{f}{(1-f)}}_+ \left[ \underbrace{\left( \frac{I^E + a \alpha^E \gamma}{a} - \frac{\tau_L}{p_L (1-\tau_L)} \right)}_{+/-, \text{"small"}} e_L^K \frac{\partial z_L}{\partial z_A} - \underbrace{\Delta_A \left( \frac{I^L}{a} + 1 \right)}_+ \right] > 0$$

$$\frac{\partial s_L}{\partial \delta} \equiv s'_L = \underbrace{\frac{1}{\epsilon_L^K}}_+ \underbrace{\frac{(1-f)}{\delta^2 f}}_+ \left[ \underbrace{\frac{\tau_A}{1-\tau_A} e_A^K \frac{\partial z_A}{\partial z_L}}_{+/-, \text{"small"}} + \underbrace{\Delta_L \left( \frac{I^A}{a} + 1 \right)}_- \right] < 0$$

We formulate the following proposition:

*Proposition 5:* Both the land tax on agriculture and the land subsidy on logging fall with  $\delta$  ( $\partial t_A / \partial \delta < 0$ ,  $\partial t_L / \partial \delta > 0$ ).

*Proof:* Differentiating the tax equations (11a) and (11b) with respect to  $\delta$  yields following first order conditions:

$$\frac{\partial t_A}{\partial \delta} = \frac{(\delta-1) [s'_A s_L (1-s_L) - s'_L s_A] + s_L (s_L s_A - s_A - s_L)}{(s_A + s_L - s_A s_L)^2} \quad (15a)$$

$$\frac{\partial t_L}{\partial \delta} = \frac{-(\delta-1) \delta [s'_A s_L + s_A s'_L (s_A - 1)] + s_A (s_A s_L - s_A - s_L)}{(s_A + s_L - s_A s_L)^2} \quad (12b)$$

The denominator in both equations is positive. The first term in the nominator in both is indeterminate at first sight, the latter term being negative in (12a) and positive in (12b). The sign of the first term in (12a) is determined by the respective sizes of the two terms in brackets. Thus, we need to determine whether  $s'_A/s'_L >< s_A/[s_L(1-s_L)]$ . Both sides of this are negative. We start with the RHS. Taking into consideration the limitations on the values of  $s_A$  and  $s_L$  found in proposition 1, from a simulation in Excel we find that  $-0.25 < s_A/[s_L(1-s_L)] < 0$ . The direction of the inequality then depends on whether the LHS is greater or smaller than  $-0.25$ . For this purpose we solve:

$$\frac{s'_A}{s'_L} = -r_A^2 \frac{\left(\frac{I^L}{a} + 1\right) \Delta_A \mathcal{E}_L^K}{\left(\frac{I^A}{a} + 1\right) \Delta_L \mathcal{E}_A^K} \approx -r_A^2 \quad (13)$$

We know that  $0 < r_A < \infty$ , although it takes the extreme values only when land in either use approaches zero. Simplifying  $-r_A^2 < -0.25$  yields  $f > 0.5/(\delta + 0.5)$ . Entering the most extreme values of  $\delta$  into this we obtain the grid of forest area values where we can be confident of the RHS exceeding the LHS:  $1/3 \leq f < 1$ . As long as this holds, the nominator of  $\partial t_A / \partial \delta$  is unambiguously negative and  $\partial t_A / \partial \delta < 0$ . At smaller values, however, it is possible (although not necessary) that  $s'_A/s'_L > s_A/[s_L(1-s_L)]$  which would make the first term negative and thus the sign of the whole first order condition indeterminate. Without presenting any proof for this to be the case we deem it safe to say that  $\partial t_A / \partial \delta < 0$  holds even in this region.

The proof of the sign of (12b) is similar to that above. The first order condition  $\partial t_L / \partial \delta$  is unambiguously positive in the same region of values of  $f$  as above ( $1/3 \leq f < 1$ ); then we know that  $s'_A/s'_L < [s_A(1-s_A)]/s_L$ . The indeterminacy again arises in a similar situation as the one described above but we deem it safe to claim that  $\partial t_L / \partial \delta > 0$ . Q.E.D.

Again, the cross-effect between the two land tax-cum-subsidy schemes for the two sectors causes indeterminacy: it makes the f.o.c of  $t_A$  higher than would otherwise be the case and lowers the f.o.c. of  $t_L$ .

What is the intuition behind these first order conditions? With less-well defined property rights to forests the government lowers both the subsidy to land use in logging and the tax on land use in agriculture. The signs arise from the fact that the government, instead of subsidizing *forests*, subsidizes *land use for logging*. A higher  $\delta$  leads to a perception of more land being forested and thus lowers the need for subsidizing land use in logging. In reality, in order not to make matters worse the land tax-cum-subsidy scheme should remain constant. As it is, the changes in the tax and subsidy lead to more land being allocated to agriculture and less to forests.

In order to determine whether the incentives to change the production tax are as perverted as the ones above, we formulate and prove the next proposition:

*Proposition 6:* The production tax on agriculture will increase marginally with the property rights parameter. The production tax on logging will fall with a higher  $\delta$ . If, however, the damage parameter is a function of  $\delta$ :  $\gamma \equiv \gamma(\delta)$  with  $\partial\gamma/\partial\delta > 0$ , the effect is indeterminate and depends on the relative strength of the environmental lobby vs. the logging lobby.

*Proof:* Differentiating equation (9a) with respect to  $\delta$  yields  $\partial(\tau_A/1-\tau_A)/\partial\delta = -\underbrace{(e_A^y t_A')}_- / \underbrace{[\varepsilon_A^y (1+t_A)^2]}_+ > 0$ . It is small, however, since we assume  $e_A^y$  to be small.

Differentiating equation (9b) with respect to  $\delta$ , including the effect of  $\partial\gamma/\partial\delta > 0$ , yields:

$$\begin{aligned}
\frac{\partial \left( \frac{\tau_L}{1-\tau_L} \right)}{\partial \delta} &= \underbrace{\frac{I^E + a \alpha^E \gamma'(\delta)}{a p_L}}_+ + \underbrace{\frac{I^L}{a}}_{-} \frac{\partial \varepsilon_L^y}{\partial \delta} \\
&+ \underbrace{\left[ \frac{I^E + a \phi'(f)}{a} \frac{1}{\delta z_L} + \frac{t_L}{1+t_L} \right] \left[ e_L^y \frac{\partial \varepsilon_L^y}{\partial \delta} - \varepsilon_L^y \frac{\partial e_L^y}{\partial \delta} \right] + \left[ \frac{I^E + a \phi'(f)}{a} \frac{1}{\delta z_L} - \frac{t'_L}{1+t_L} \left( 1 - \frac{t_L}{1+t_L} \right) \right] e_L^y \varepsilon_L^y}_{\substack{+/-, \text{"small"} \\ (\varepsilon_L^y)^2}} \\
&\quad (14)
\end{aligned}$$

We examine two scenarios. In the first one we set  $\partial \gamma / \partial \delta = 0$ , which, considering that the third term in the first order condition is “small”, makes the first order condition negative. In this case lobbying by the logging sector leads to a greater fall in the production tax the worse the property rights are.

In the second scenario we again set  $\partial \gamma / \partial \delta > 0$ . This means that the environmentalists’ perception of the damage caused by logging increases in the property rights parameter.<sup>5</sup> Now the sign of the first order condition is dependent on the relative strengths of the environmental and logging lobbies. For instance, if the environmental but not the logging lobby organizes, the first order condition is automatically positive; in the opposite case it is negative. Further, as  $\alpha^E$  increases, the weight given to the externality increases and thereby the environmentalists clout in setting the tax. Q.E.D.

The intuition behind proposition 6 is that in countries with poorly defined property rights to forests, the logging industry’s production is higher and therefore the industry has more at stake and lobbies even more intensively for a low production tax on logging than in countries with well-defined property rights to forests. The reason why we examined both the case where  $\partial \gamma / \partial \delta > 0$  and where it is constant is that we question the ability of the environmentalists to determine the nature of property rights to forests. Therefore, we deem the case where the environmentalists do not vary their lobbying depending on  $\delta$  the more plausible.

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<sup>5</sup> How the environmentalists are able to observe such variations in  $\delta$  across countries is beyond the scope of the paper.

The results obtained so far shed light to the possibilities of forest conservation in countries with open access to forests. Thus, they explain why a government in a country with less-well defined property rights to forests allocates less land to agriculture and more to forests than would be socially optimal, and might even allow for more agricultural land conversion (the effect from  $\partial t_A/\partial \delta < 0$  and  $\partial t_L/\partial \delta > 0$ ).<sup>6</sup> The effect of production taxation only aggravates the situation as the logging sector intensifies its lobbying for lower production taxation thereby increasing the area logged even more ( $p_L$  increases as production taxation falls thereby increasing production).

Considering finally the effect of lobbying/bribes on the situation we formulate our final proposition:

*Proposition 7:* When property rights to forests are poorly defined the stake of the logging industry is greater than when they are well defined. This intensifies lobbying by the logging lobby, which leads to a higher production of logs than in absence of logging. If both industry lobbies organize, they do not affect the land-tax.

*Proof:* Starting from the latter statement, from proposition 4 we know that the effect of lobbying on tax rates is ambiguous. An examination of the  $\partial s_i/\partial \delta$ 's,  $i = A, L$  shows that an organized sector  $j$  lobbies for a higher tax on sector  $i$ . However, the first order conditions  $\partial s_i/\partial \delta$  do not enter the first order conditions of the tax equations  $\partial t_i/\partial \delta$  as such but in the ratio  $s'_A/s'_L$  (equation (13)). If both industries organize a lobby, their effects cancel out thus leaving  $\partial t_i/\partial \delta$  intact. If, however, either industry does not organize into a lobby, then the other sector has an impact on  $\partial t_i/\partial \delta$ . If the sector that organizes is the logging sector, this has the impact of making the first order conditions less steep. This would mean that more land was allocated to forests than when both sectors organize, given the property rights. If the sector that organizes is

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<sup>6</sup> The socially optimal land allocation is naturally the one where property rights to forests are well defined and when the government puts all weight on social welfare and disregards of lobbying.

the agriculture, then the term serves to make the slope of the first order conditions  $\partial t_i / \partial \delta$  even steeper, thus allocating more land to agriculture and less to forests.

In the case of the production tax the agricultural sector does not change its lobbying strategy with the property rights parameter. As already noted in the proof of proposition 6, the logging sector, however, has more at stake and intensifies its lobbying for a lower production tax, which is measured by the second term in equation (14). In presence of a logging lobby, then, the production tax on logging will be the lower the higher  $\delta$  and consequently log production will be higher. Q.E.D.

To summarize, we consider the implications of our analysis to countries that manage to enhance their property rights regimes and establish better-defined property rights to forests. From the land tax-cum-subsidy side of the analysis this would mean increasing the land tax on agriculture and allocating more land to forestry. This would increase the logging industry's stake. At the same time, if the industry would start logging at the marginal product of land instead of the average product, this would lower its production, decrease lobbying for production tax and increase the production tax on logging thus contracting its production further. If the government also managed to tackle corruption at the same time, this would lead to an even greater increase in the production tax to logging.

## 5. Conclusions

This paper has shown how two production-related but separate externalities impact on the allocation of land to forestry and agriculture. It has shown that if two sectors use a common factor of production that is in short supply, then taxation of one sector not only has an impact on that sector but also on the other. Further, it has been shown that given that the government has two different tax instruments at its disposal, it can and does use one tax instrument to compensate for inefficiencies in the use of another, albeit these terms tend to be small, possibly even negligible.

In presence of such interdependency between the two sectors the effect of functionally specialized lobbying on the land tax-cum-subsidy rates has been shown to be

ambiguous. The sector being taxed lobbies for a lower tax on its land use but the other sector lobbies for a higher tax. Which of these effects takes overhand is impossible to determine, especially as a third “force”, the environmentalists, also lobby for higher taxes (or subsidies). However, in the case of a production tax, since the production of the two goods is not related in any way, each industry lobby lobbies for lower production tax (or a subsidy) for itself and ignores the other sector.

Lobbies with multiple goals have the effect of increasing the provision of forests for amenities. They also lobby for tax revenue besides their own profit motivation. The inclusion of lobbies with multiple goals does not change the conclusions of the rest of the paper.

Finally, we studied the effect of property rights on forests. We were able to show that the property rights regime influences government’s perception of the forest area at least under the present specification. Thus, our findings concerning the size of the land-tax show that we have been able to find at least one variable that explains the disappearance of forests from countries with poorly defined property rights to forests. Governments in countries with bad property rights regimes will tend to perceive the forest area, and thereby the provision of amenities by forests as greater than it actually is, consequently lowering the subsidy to forestry; subsidy that is needed in order to internalize an otherwise under priced externality. Further, corruptible governments tend to impose lower production taxation on logging sector, which, besides is logging at the average product of land rather than marginal product, thus aggravating the problem further.

As mentioned, we suspect that our analysis is dependent on the specification of the model, however. Whether we would obtain similar results also in the case where the government were to subsidize forest owners for their ownership of forests instead of loggers for land use has not been studied. On the other hand, it is possible, for instance, that it is impossible to subsidize forest owners if the government itself is the owner of all forestland. Then policies that follow the ones delineated in this paper may be the only ones available.

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