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The Spillover Effects of Good Governance: How to Export Bribes and Pollution

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Abstract. We investigate the impact of a political regime shift lowering the weight governments place on lobby contributions when countries engage in tax competition in capital and a polluting resource, where resource owners attempt to influence environmental policy. We derive the government's optimal policy rules and show that such a political reform will cause the resource tax rate and public spending to rise and extraction of the resource, damage to the environment, bribes, and the tax on capital to fall. This response can spill over to other countries if the resource price rises. We provide examples where such a price increase causes extraction of the resource, damage to the environment, and bribes in other countries to rise resulting in lower welfare. Finally, a general political reform across countries that reduces the weight on lobby contributions acts like a treaty where all countries raise their resource tax rate to increase public spending that benefits consumers.

Keywords: lobbying, environmental damage, tax competition, spillovers

JEL: H23, D73

1. Introduction

The recent global recession has contributed to a number of political regime changes such as the revolutions in certain Arab countries. The determining factors that set the stage for the Arab Spring are poor economic opportunities, the lack of democracy, and high levels of corruption (The Economist, 2011). Egypt, with the second largest economy in the region, is a good example of this phenomenon. Such a dramatic change in the political system can have a favorable impact in reducing the influence of lobbying on policy choices (Treisman 2000).

A shift away from the importance of bribes toward the welfare of the citizens in determining policy can have significant implications for the government's choice of the optimal tax, spending and environmental policy. A significant policy change in one country can also affect other countries when the economy is open to trade. For instance, a change in how governments deal with lobby groups may cause a change in trade patterns that can alter the distribution of pollution across countries.[1] As another example, countries may be engaged in tax competition with one another in taxing mobile capital.[2] A substantial shift in the political system in one country that causes a change in its tax on mobile capital may cause other countries to respond in kind.

The purpose of this paper is to study the impact of political lobbying on a government's choice of tax and spending policy when that government is engaged in tax competition with other governments and part of its mobile tax base is a resource that causes environmental damage when extracted. More specifically, we want to know how the government's general policy rules involving capital and resource taxes and public spending are affected when resource

[1] Antweiler, et. al. (2001) discuss the connection between trade and pollution and Karp (2011) provides a survey of the literature on trade and the environment.

[2] See Oates (1972), Wilson (1986), Zodrow and Mieszkowski (1986), and Wildasin (1988, 1989) for the early research on tax competition. Under horizontal tax competition two governments at the same level, e.g., federal, compete to tax the same mobile good, e.g., capital, which creates a policy externality. For several recent surveys of the literature see Wilson and Wildasin (2004), Fuest, et al. (2005) and Genschel and Schwarz (2011), who summarize the extensive evidence on the existence of the tax competition problem across countries. For a survey of empirical work on tax competition within countries see Brueckner (2003).

owners can make bribes to government officials to favorably alter the government's environmental policy. Second, we study how a political reform that shifts the weight governments place on consumer welfare and away from lobby contributions affects the government's policy choices. Finally, we are also interested in how that response to the political reform may spillover to other countries and cause them to respond in turn. We extend the classic model of tax competition, e.g., Zodrow and Mieszkowski (1986), to the case where there are two mobile inputs that are taxed, capital and a polluting resource, and owners of the resource try to influence the government's environmental policy as it affects the resource through bribes.

Our analysis is based on the connection between lobbying and policy decisions affecting environmental regulations and business tax rates. Many developing countries that have experienced political regime changes depend on natural resources, such as mineral or oil extraction, as a significant source of income (Larson and Nash, 2010). Environmental regulations that are used to protect the ecosystem and local population are significantly negatively affected by lobbying in the government (Cole 2007; Pellegrini and Gerlagh 2006). The location and investment decisions by firms are dependent not only on environmental regulations but also the prevailing business climate. Chirinko and Wilson (2010) find that campaign contributions significantly affect the level of tax policy where $1 of business contributions yields a $4 gain from lower corporate taxes. We contribute to the literature by modeling the impact of business taxes and environmental regulations in a firm's decision to invest in economies that are subject to political regime changes.

In our model there is one private good produced using labor, mobile capital, and a resource that causes pollution when extracted. The government imposes a source-based tax on capital and a tax on the resource and uses the proceeds to finance public spending that benefits consumers,

e.g., roads, schools, libraries, and health clinics. Resource owners can lobby the government to influence the tax on the resource in a manner similar to Grossman and Helpman (1994). We derive the government's optimal policy rules for its tax and spending policy and show there is a tradeoff between the government's weight on consumer welfare versus lobby contributions and environmental damage in the rule for the resource tax.

We also show that a shift in government's welfare away from lobbying contributions in a *reform country* toward the welfare of the consumers will cause the government to increase the tax on the resource, increase spending on public goods, decrease the capital tax rate, reduce extraction of the resource, and hence reduce damage to the environment and bribes. This change in policy will spillover to other countries if the resource price increases as a result of the reduction in extraction in the reform country. In that case, resource owners in *non-reform* countries will increase their extraction and this will increase damage to the environment and bribes to keep the resource tax low in those countries. We provide simulation examples that support these general equilibrium conclusions and show that welfare improves in the reform country but declines in the non-reform countries.

Finally, we study a system wide political regime change where all governments reduce weight on lobby contributions. We show that the impact on the economy of such a political harmonization is very similar to the impact of a tax treaty where all governments agree to raise their tax rate on resource extraction in order to increase public spending. To our knowledge this point has not been made in the literature.

Our work combines the different strands of the literature on lobbying, the environment, and tax competition across countries. Damania et al. (2003) links the effectiveness of environmental policy to trade liberalization and lobbying. Hultberg and Barbier (2004) consider when

harmonizing environmental policies across corrupt countries can improve welfare. Arikan (2004) studies the case where the government can use some of the source based capital tax revenue for its own purpose and shows that an increase in the number of governments can reduce the amount set aside. Cremer and Gahvari (2006) study the case where there are two private goods, a clean good and a dirty good that causes transboundary pollution, and the government imposes an emissions tax and a commodity tax on the dirty good. Their focus is on a comparison of the equilibria under various scenarios, e.g., both countries choose to impose the commodity tax under the origin principle versus both choosing the destination principle. Ogawa and Wildasin (2009) study pollution spillovers in a capital tax competition model with transboundary pollution and show how a decentralized choice of policy can lead to a Pareto optimal solution. Esteller-More, at al. (2012) combine imperfect competition, an excise tax on a good that causes a harmful consumption externality, political contributions to the government to influence tax policy, and government diversion of some of the tax revenue for its own purpose with an excise tax and vertical tax competition between a federal and a state government. They provide an example where lobbying can improve efficiency. Finally, Withagen and Halsema (2013) develop a two period model and show that emissions taxes are more stringent in the presence of tax competition of a mobile good than with a tax treaty.

The article is organized in the following way. Section two describes our model. The theoretical results are discussed in section three. The general equilibrium model is simulated in section four. Section five concludes the article.

2. Theoretical model

One purpose of the article is to examine the spillover effects of a reform that takes place in one country. We refer to a reform country as one where such a reform occurs, and refer to a

country where no such change occurs as a non-reform country. Also, we look at general reforms that occur under the auspices of a treaty where all countries agree to coordinate the choice of a variable such as a tax rate.

2.1 General features of the model

There are *J* identical countries and two private industries in each country. The first industry produces a private consumption good using capital, labor, and a resource, while the second industry extracts and supplies the resource using only sector specific labor. Extraction of the resource produces pollution as a byproduct, which reduces the welfare of consumers within the country. For simplicity, we only consider local pollutants and not transboundary pollutants.[3] Capital and the resource once extracted are perfectly mobile, while labor is perfectly immobile. Consumers supply labor and capital inelastically to the consumption goods sector, consume the private consumption good and the publicly provided good, and incur damage from pollution.

There is one government in each country that imposes a tax on resource extraction and a source based tax on capital, and uses the proceeds to finance spending on the publicly provided good. This good confers a consumption benefit within the country only such that there are no spillover effects of public spending. Environmental damage from resource extraction sets up the classic Pigouvian tax problem, while taxation of the mobile resource and capital sets up the classic tax competition problem.

2.2 Consumption good industry

Firms producing the consumption good are identical, the industry is competitive, and normalized to be of measure one. The technology is represented by a constant returns to scale production function, $F(K, N, L)$, where K is capital, N is the resource used, and L is labor.[4] Each

[3] See Ogawa and Wildasin (2009) for a discussion of the case of transboundary spillovers.
[4] We omitted country specific superscripts for brevity.

country is endowed with only one unit of labor that is used to produce the consumption good so we can represent the technology in intensive form, $f(k,n)$, where *k* is capital per worker and *n* is the demand for the resource per worker. We assume the production function is concave, twice continuously differentiable, increasing in both inputs, and the resource is essential in production, $f(k,0)=0$. The representative consumption firm's profit is given by $f(k,n)-qn-(r+\tau)k-w$, where *q* is the price of the resource, *r* is the real interest rate, τ is the source based tax on capital, and *w* is the wage. The consumption good is numeraire with a price of one.

Firms producing the consumption good maximize profit, so that the marginal products of the inputs are equal to the input prices, $f_n = q$ and $f_k = r+\tau$.[5] We can solve this system to obtain the demand for capital and the resource as a function of prices, $K(r+\tau,q)$ and $N(r+\tau,q)$, respectively. It is straightforward to show that the responses of the demand functions are the following, $\frac{dk}{d(r+\tau)} = K_r < 0, \frac{dn}{d(q-\theta)} = N_q < 0$, and $K_q = N_r = \frac{dn}{d(r+\tau)} < (>)0$ if $f_{kn} > (<)0$. Note that $\frac{dk}{d\tau} = K_r$ in this notation, and so on. Competition in the consumption goods sector drives profit to zero such that wage is given by $W(r+\tau,q) = f(K,N)-(r+\tau)K-qN$, with $\frac{dw}{dr+\tau} = W_r = -k$ and $\frac{dw}{dq} = W_q = -n$, by the envelope theorem.

2.3 Resource extraction industry

Resource production firms are identical and there is a measure of one of resource firms. The representative resource owner of such a firm is endowed with sector specific labor that is used to extract the resource. We assume the cost of extracting the resource is differentiable and increasing at an increasing rate. It takes the following quadratic form for simplicity,

(i) $$C(m) = \frac{dm^2}{2},$$

[5] Subscripts denote derivatives, $\frac{dF}{dx} = F_x$ and $\frac{d^2F}{dx^2} = F_{xx}$.

where m is the amount extracted, which is equal to the labor used to extract the resource, and $d > 0$ is a constant. One interpretation of this cost is that it represents the disutility of the resource owner's labor, or the effort undertaken in extracting the resource. Profit for the representative resource firm is $(q-\theta)m - C(m) - b$, where b is a payment schedule chosen by the lobby representing the resource firms and paid to the government in order to influence its choice of the resource tax rate, θ. Profit maximization along with the cost function given in assumption (i) gives a supply function for the resource of the form, $m = \frac{q-\theta}{d}$. For more general, well-behaved, cost functions, we can write the supply function of the resource as $M(q-\theta)$, with $M_q > 0$ and $M_\theta = -M_q < 0$.

2.4 Consumers

We normalize on the group of consumers by assuming there is a measure of size one of identical consumers in each country. The representative consumer's preferences are given by $U(c, g, D)$ where c is consumption of the private consumption good, g is public spending, and D is environmental damage caused by extraction of the resource. The utility function is concave, twice continuously differentiable, increasing in consumption and public spending, and additively separable. We also assume that utility is decreasing and linear in damage to the environment such that

(ii) $U_D = -1.$

Damage is a function of the amount of resource extraction and is assumed to be quadratic,

(iii) $D(m) = \frac{\delta m^2}{2}.$

where $\delta > 0$ is a parameter.

The consumer is endowed with one unit of labor, which is supplied to the labor market in a perfectly inelastic manner, in exchange for the wage. They are also endowed with s units of

capital, which is also supplied to the capital market in an inelastic manner. So consumption is given by, $c = w + rs$. We define indirect utility as a function of the government's policy as,

$$V(\theta, \tau, g) = U\Big(W(r+\tau, q) + rs, g, D\big(M(q-\theta)\big)\Big),$$

with the derivatives, $V_\theta = \big(m - \theta M_q\big)U_g - U_D D_m M_q$, $V_\tau = -kU_c + (k + \tau K_r)U_g$, and $V_g = U_g$, where we have suppressed the factor prices for convenience.

The willingness to pay for public spending is the marginal rate of substitution between the private good and public spending, $\frac{U_g}{U_c}$. We will assume $\lim_{g/c \to 0} \frac{U_g}{U_c} = \infty$, which ensures that there is spending on the publicly provided good in equilibrium, which requires at least one tax rate to be positive. The willingness to pay for a less damaged environment at the margin is $-\frac{U_D}{U_c}$. Since utility is additively separable, the marginal willingness to pay for public spending is decreasing in public spending.

2.5 Government

The representative government imposes a tax on resource extraction and a source-based tax on capital, and uses the proceeds to spend on the publicly provided good. A unit of the private good can be converted to one unit of public spending. The government is willing to alter the resource tax rate at the margin in exchange for a payment from the resource extraction lobby. Capital owners are mobile and can move their capital to the most advantageous country. As a result, they do not have to influence local officials. Resource owners, on the other hand, have to mine the resource at the site where they find it inside the country and cannot relocate their entire operation including the source of extraction to another country. Instead, they can have their association lobby the government to reduce their tax rate. The lobby's payment acts like mobility in reducing the tax rate.

Following Grossman and Helpman (1994) and the subsequent literature, the government's objective function is given by,

(1) $$\Lambda = \alpha V(\theta, \tau, g) + (1-\alpha)b,$$

where $\alpha \in (0,1]$ is the weight given to the importance of consumer welfare in the government's decisions and $1-\alpha$ is the weight given to the influence of the lobby. The budget constraint for public spending is

(2) $$g \leq \theta M(q-\theta) + \tau K(r+\tau, q).$$

Equation (2) will hold with equality in equilibrium as long as consumers matter to the government, $\alpha > 0$, since utility is increasing in public spending. Also notice that the payment from the lobby does not enter this constraint since the government has appropriated it entirely for its own purpose.

The government chooses tax rates and public spending, (θ, τ, g) to maximize (1) subject to its budget constraint equation (2) with equality, the behavior of the private sector in extracting resources and investing capital, and the lobby's payment schedule, taking as given aggregate variables like the world price of the resource, and the policies of the other governments. Let $\pi^{*j} = (\theta^{*j}, \tau^{*j}, g^{*j})$ denote the optimal policy for country j that solves this decision problem. The optimal policy is a function of the parameters including α^j and aggregate variables like the resource price and interest rate, $\Pi^j(q, r; \alpha^j, d, \delta)$.

Finally, the lobby chooses a payment schedule to maximize the aggregate profit of the resource industry subject to the following participation constraint,

(3) $$\alpha V(\theta, \tau, g) + (1-\alpha)b \geq \alpha V^+,$$

where $V^+ = U\big(W(r+\tau^+, q) + rs, \theta^+ m + \tau^+ K(r+\tau^+, q), D(M(q-\theta^+)\big)$ is indirect utility when the government imposes the optimal policy π^+ in the absence of the lobby's payment to

the government. Since there is a measure of unity for the resource industry, aggregate profit of the industry is given by $(q-\theta)m-c(m)-b$. If the lobby wants to have an impact on resource tax policy it must offer the government a payment schedule that satisfies the condition in (3) so the government will participate in the exchange of the lobby's payment for a lower resource tax rate. We show in the Appendix that when the payment schedule is chosen optimally it will satisfy the local truthfulness condition (Grossman and Helpman 1994),

(4) $\frac{\partial b}{\partial \theta}=-m.$

The interpretation of this condition is that if the government lowers the resource tax rate by one unit, it will lose *m* in revenue at the margin. The condition informs us that the lobby will compensate for this loss in tax revenue by increasing it's payment by *m.*[6]

2.6 *Sequence of action*

In the first stage of the policy game in the representative country, the lobby representing the resource firms confronts the local government with a payment schedule or function. In the second stage governments simultaneously choose their policies π, which are announced publicly and implemented. Next, owners of capital decide where to locate their capital after observing the policy rules of the governments. Finally, production and consumption occur, payments are paid, taxes are collected, and public spending takes place. The local truthfulness condition links the choice of the payment function at the margin in equilibrium to the first order conditions of the government's subsequent decision problem.

2.7 *Equilibrium*

The resource market must clear,

(5) $\sum_j^J\left(M^j\left(q-\theta^j\right)-N^j(r+\tau^j,q)\right)=0,$

[6] For this type of interpretation in a more abstract setting see Dixit, et al. (1997).

and the capital market must clear,

(6) $$\sum_j^J [K^j\left(r+\tau^j, q\right) - s^j] = 0.$$

Since there are no economic profits in the consumption goods sector, the local wage is determined by

(7) $$W(r+\tau^j, q) = f(K^j\left(r+\tau^j, q\right), N^j\left(r+\tau^j, q\right)) - \left(r+\tau^j\right)K^j(r+\tau^j, q) - qN^j(r+\tau^j, q).$$

We can now define the equilibrium. A *decentralized policy equilibrium* is a vector of prices $(q^*, r^*, w^{1*}, \ldots, w^{J*})$, a vector of policies, $(\pi^{*1}, \ldots, \pi^{*J})$, an allocation of inputs $(n^{*1}, k^{*1}, m^{*1}, \ldots, n^{*J}, k^{*J}, m^{*J})$, and a vector of payment schedules $(b^{*1}, \ldots, b^{*J})$ such that:

i) (n^{*j}, k^{*j}) solves the consumption good firm's decision problem of maximizing profit, taking prices and tax rates as given for all j;

ii) (m^{*j}) solves the resource firm's decision problem of maximizing profit taking prices and tax rates as given, and for all j;

iii) The lobby's payment (b^{*j}) solves the lobby's decision problem and also satisfies the truthfulness condition, equation (4), for all j;

iv) (π^{*j}) solves the government's decision problem for all j;

v) World markets clear so equations (5) and (6) hold and the local wage is determined by equation (7) for all j;

We assume the equilibrium is unique and stable when it exists. Ultimately, the equilibrium resource price and interest rate will be a function of the distribution of tax rates from equations (5) and (6). To solve for the equilibrium we work backwards starting with the policy the government chooses taking into account the behavioral response of the demand for capital and the supply of the resource in the last stage of the game. Working backwards to the first stage,

the lobby chooses its optimal payment to maximize the profit of the resource industry subject to the government's participation constraint, using the results of Grossman and Helpman (1994) and Dixit, et al. (1997). The resulting equilibrium is subgame perfect.

3. Theoretical results

3.1 *Government's policy rules*

There is a tradeoff between environmental damage and political influence by the lobby in the choice of the resource tax rate and there are two cases to consider depending on whether environmental damage dominates the lobby, or vice versa, in determining tax policy. If we rule out the Laffer phenomenon in the resource tax rate, then environmental damage will be dominated by the lobby's effort to influence policy when choosing the optimal resource tax rate. The following lemma accomplishes this.

Lemma: If (a) $1 + \tau\frac{K_r}{k} = 1 - \mathrm{T}\varepsilon > 0$ and (b) $1 - \frac{\theta M_q}{m} = 1 - \Theta\xi > 0$, then an increase in either tax rate raises more revenue, given factor prices, where $\mathrm{T} = \frac{\tau}{r+\tau}$ is the ad valorum capital tax rate, $\Theta \equiv \frac{\theta}{q-\theta}$ is the ad valorem resource tax rate, $\varepsilon \equiv -\frac{(\mathrm{r}+\tau)K_r}{k} > 0$ is the own price elasticity of capital, and $\xi = \frac{(\mathrm{q}-\theta)M_q}{m}$ is the own price elasticity of the resource.

Proof: See Appendix A.1.

Proposition 1 summarizes the representative government's optimal policy rules. There are a number of effects to consider, the distortion of the capital location decision, the distortion of the

resource extraction decision, the impact of the policy on damage to the environment, and, finally, the impact of the lobby's payments on the optimal policy rules.

Proposition 1: The rules governing the representative government's policy when both tax rates are chosen optimally are

(8) $$\frac{U_g}{U_c} = \frac{1}{1-\mathrm{T}\varepsilon},$$

(9) $$\frac{U_g}{U_c} = \left[\frac{1}{1-\Theta\xi}\right]\left[\frac{U_D}{U_c}\,\frac{mD_m}{D}\,\frac{D}{\theta m}\Theta\xi + \frac{(1-\alpha)}{\alpha U_c}\right].$$

Proof: See Appendix A.1.

Corollary 1: Combining equations (8) and (9), the relative tax rates must satisfy the following,

(10) $$1-\Theta\xi = (1-\mathrm{T}\varepsilon)\left[\frac{U_D}{U_c}\,\frac{mD_m}{D}\,\frac{D}{\theta m}\Theta\xi + \frac{(1-\alpha)}{\alpha U_c}\right].$$

It is noteworthy that the capital tax policy rule in equation (8) is not directly affected by lobbying in Proposition 1, i.e., α does not enter the first rule. It does, however, have an important impact on the rule governing the resource tax rate in equation (9). As a result of this, lobbying will affect the optimal mix of tax rates. Equation (8) governs the choice of the optimal capital tax rate and is a standard result in the tax competition literature.[7] The marginal willingness to pay for public spending is set equal to the social marginal cost of raising revenue through the source-based capital tax. The willingness to pay for public spending is positive for an interior solution. It

[7] For example, see equation (7) in Zodrow and Mieszkowski (1986).

follows that the social marginal cost of raising revenue on the right hand side of (8) must also be positive, which occurs if we assume condition (a) of the lemma. If capital is perfectly immobile, then this cost is equal to unity, and the result mimics the first best rule. More generally, the more elastic the capital tax base, the larger the social marginal cost of taxing capital, and the greater the downward pressure on public spending.[8]

Equation (9) governs the optimal resource tax rate. The first term in (9), $\frac{1}{1-\Theta\xi}$, is the social marginal cost of public spending in the absence of any externalities and lobbying relative to the resource tax. It captures the distortion of the resource supply decision to the local market caused by the resource tax. Recall that the resource is also mobile across countries once it has been extracted. The second term, $\frac{U_D}{U_c}\frac{mD_m}{D}\frac{D}{\theta m}\Theta\xi < 0$, captures the impact of the tax on damage to the environment and hence utility when the tax causes a change in extraction. This is the Pigouvian element to the tax and serves to lower the social marginal cost of public spending. The term $\Theta\xi$ is the responsiveness of the supply of the resource to the tax, $\frac{D}{\theta m}$ is the ratio of the damage to the resource tax revenue, $\frac{mD_m}{D}$ is the elasticity of damage to the supply, and the term - $\frac{U_D}{U_c}$ captures the willingness to pay for a marginally cleaner environment. The last term in equation (9), $\frac{(1-\alpha)}{\alpha U_c} > 0$, captures the impact of the lobby on the government's policy choice. Lobbying raises the social marginal cost of financing public spending via a resource tax. The greater the influence of the lobby, the larger this last term will be.

Consider the special case where the lobby cannot influence the government's policy, $\alpha = 1$. If the resource tax is used to raise revenue for public spending, the resource tax rate must be

[8] If the social marginal cost of funds depicted on the right hand side of equation (8) is larger because the capital base is more elastic, then the willingness to pay for public spending is larger at the margin and this will reduce public spending since the willingness to pay for public spending is decreasing in public spending.

quite high, $\Theta > 1/\xi$, since damage to the environment reduces welfare, which is captured by the second bracketed expression in (9).

More generally when $\alpha \in (0, 1)$, the marginal willingness to pay for public spending will be greater than one in magnitude if the capital tax rate is positive and chosen optimally from (8) under condition (a) of the lemma. If the resource tax rate is also chosen optimally, the right hand side of (9) must be greater than one in magnitude since the left hand side is greater than one. However, this is not enough to sign the two bracketed expressions in equation (9). There are two cases to consider, and they illustrate the tradeoff between the lobby's influence and environmental damage,

$$\left[\frac{1}{1-\Theta\xi}\right] > 0 \text{ and } \left[\frac{U_D}{U_c}\,\frac{mD_m}{D}\,\frac{D}{\theta m}\Theta\xi + \frac{(1-\alpha)}{\alpha U_c}\right] > 0,$$

$$\left[\frac{1}{1-\Theta\xi}\right] < 0 \text{ and } \left[\frac{U_D}{U_c}\,\frac{mD_m}{D}\,\frac{D}{\theta m}\Theta\xi + \frac{(1-\alpha)}{\alpha U_c}\right] < 0.$$

In the first case, $1 > \Theta\xi$, and it follows that $-\frac{U_D}{U_c}\,\frac{mD_m}{D}\,\frac{D}{\theta m}\Theta\xi < \frac{(1-\alpha)}{\alpha U_c}$. This is the case where the resource tax rate is low because the influence of the lobby dominates the environmental damage done by extraction in the government's choice of policy. In the second case, it is the reverse; the resource tax rate is high, $1 < \Theta\xi$, and the value of the damage done to the environment dominates the lobby's activity, $-\frac{U_D}{U_c}\,\frac{mD_m}{D}\,\frac{D}{\theta m}\Theta\xi > \frac{(1-\alpha)}{\alpha U_c}$. Of course, the lemma rules out this second case.

We also have the following corollary, which makes it easier to see the relationship between the lobby's influence and environmental damage. It specializes the optimal rules to our assumptions involving environmental damage.

Corollary 2: Under assumptions (i) – (iii), the policy rule governing the representative government's optimal resource tax policy specializes to the following:

$$(11) \quad U_g = \left[\frac{1}{1-\Theta}\right]\left[\frac{(1-\alpha)}{\alpha} - \frac{\delta}{d}\right],$$

and taxes must satisfy,

$$(12) \quad 1 - \Theta = (1 - \mathrm{T}\varepsilon)\frac{1}{U_c}\left(\frac{1-\alpha}{\alpha} - \frac{\delta}{d}\right).$$

Proof: See Appendix A.1.

Clearly, $1 > (<) \frac{\theta}{q-\theta}$ as $\frac{1-\alpha}{\alpha} > (<) \frac{\delta}{d}$, from (11), since the marginal utility of public spending is positive in equilibrium. This emphasizes that the resource tax rate is low when the lobby dominates the political decision making and is high when the damage externality dominates. Notice that $\frac{\partial g}{\partial \theta} = m\left(1 - \frac{\theta}{\mathrm{q}-\theta}\right)$, so total revenue is increasing in the low resource tax case and decreasing in the high resource tax case. As before, condition (b) of the lemma rules out the case where the environment damage dominates.

3.2 *Policy responses to a shift toward consumer welfare*

A shift toward consumer welfare by the government will have a direct effect on the reform country's choice of policy, and indirect spillover effects on non-reform countries that work through world prices. If a reform causes the resource price to increase, for example, resource firms in the reform country will reduce their extraction and resource firms in other countries will extract more, and this will shift pollution to those countries. It will also have implications for government policy in those countries. Since the government's response in both the reform

country and the non-reform countries follows their policy rules in our model, their policy response is optimal.

3.2.1 Direct effects in the reform country

More emphasis towards consumer welfare in the reform country shifts the government's policy towards those that benefit the consumer and away from those that are influenced by the lobby. This causes the government in the reform country to increase the resource tax rate and to increase public spending, which, in turn, allows the government to reduce the tax rate on capital. We can see the influence of this shift most clearly in equation (12). An increase in α reduces the right hand side of (12). A decrease in the capital tax rate and an increase in the resource tax rate are consistent with this response since the former raises the right hand side of (12), while the latter reduces the left hand side of the formula.

A shift toward consumer welfare also affects the level of the lobby's payment to the government, extraction of the resource, and environmental damages. The increase in the resource tax rate will reduce the effectiveness of payments by the lobby, leading to a fall in those payments. In addition, the higher resource tax rate reduces the net price for the resource and this will lead to a decrease in the production of the resource in the reform country, which, in turn reduces environmental damages. The following proposition summarizes these results.

> **Proposition 2**: If the lemma holds, then an increase in the weight attached to consumers in one country will unambiguously increase the resource tax rate, increase public spending, and reduce the capital tax rate, i.e. $\frac{\partial \theta}{\partial \alpha} > 0$, $\frac{\partial g}{\partial \alpha} > 0$, and $\frac{\partial \tau}{\partial \alpha} < 0$, In addition, the lobby's payments, production of the resource, and environmental damage will fall, i.e., $\frac{\partial b}{\partial \alpha} = -M_q \frac{\partial \theta}{\partial \alpha} < 0$, $\frac{\partial M}{\partial \alpha} = -M_q \frac{\partial \theta}{\partial \alpha} < 0$, and $\frac{\partial D}{\partial \alpha} = -D_M M_q \frac{\partial \theta}{\partial \alpha} < 0$.

Proof: See Appendix A.2.

3.2.2 Indirect spillover effects on non-reform countries

There will be upward pressure on the resource price when the resource firms cut back extraction in the reform country. This will increase the return to extraction in non-reform countries and increase extraction as a result with a concomitant increase in damage as well. Non-reform governments can reduce the impact of this by raising their resource tax rate, which lowers the return to extracting the resource in that country. However, extraction will increase in non-reform countries due to the higher net resource price leading to greater environmental damage.

In addition, this will also increase the resource tax base in non-reform countries when resource extraction is taxed. A windfall gain is generated in the form of an increase in public spending in those countries and this lowers the marginal willingness to pay for public spending, $\frac{U_g}{U_c}$. From equation (8), this leads to a decrease in the capital tax rate. Public spending in the non-reform country may decrease or increase given an increase in the resource tax rate and a decrease in the capital tax rate. This is consistent with an increase in the resource price q in equation (12) for non-reform countries. We will provide simulation examples in the next section that support these conjectures.

3.2.3 *A general shift toward consumers and away from lobbyists*

When all of the countries that are competing with one another in these markets sign a treaty to reform their political systems to shift toward the welfare of consumers, each country will experience the same direct impact as discussed in Proposition 2, and generate the same spillover effects for other countries. The spillover effects will perfectly cancel under the assumption that

all countries are identical. However, if there are small differences in countries, for example, in terms of their weight placed on consumers before the reform, then there will be small spillover effects. We simulate the model in the next section to provide examples where the direct effects of the reform outweigh the spillover effects.

Focusing on the direct effects of the reform, a general shift toward consumer welfare will increase the resource tax rate, increase public spending, reduce the capital tax rate, and reduce extraction of the resource in all of the countries involved in the reform. This will, in turn, cause a reduction in environmental damage and also lobbying payments.

4. Simulation results

4.1 Functional Forms and Parameters

We simulate the model to provide some guidance on the general equilibrium responses and provide an example illustrating the predictions of the model. We consider two regions under tax competition: the USA and the rest of the Organization for Economic Co-operation and Development (OECD). The production technology, cost functions, bribe functions and utility functions are assumed to take the same form across the two regions.

The technology for the consumption good is Cobb – Douglas and constant returns to scale, $Y = AK^a N^b L^{1-a-b}$. We can write this in per capita units as $y = Ak^a n^b$. The cost function for the resource sector is given by $dm^2/2$ so profit is $(q - \theta)m - dm^2/2$. Profit maximization implies that the supply of the resource is given by $m = (q - \theta)/d$. Finally, the utility function of the representative consumer is $u = \ln(1 + c) + \gamma \ln(1 + g) - \delta m^2/2$, where the damage function is $\delta m^2/2$.

Table 1 summarizes the parameters used in the simulations. The two regions differ in two ways: the ratio of public spending to GDP and the weight given to lobbying contribution. We

calibrate scaling parameters so that we achieve public spending composition matching the available data. Public spending on final consumption is 16% of GDP for the USA and 19% of GDP for the OECD (OECD, 2013). In addition, resource taxes typically do not finance a large portion of government budgets, and capital taxes, especially corporate taxes, are lower now than thirty years ago in many countries and thus only finance a small portion of government spending.

We use data from the International Country Risk Guide (ICRG) called corruption control as a proxy for the weight governments place on consumer welfare versus lobby contributions, α. It is noteworthy that the data indicates α is higher for the USA which affects our initial equilibrium results. Next, the data also indicates that there is greater public spending in the OECD than in the USA (World Bank, 2013). This requires the preference parameter for the public good γ to be larger for the OECD than the USA.

We compare the equilibrium with and without lobbying and then consider a decrease in the weight on lobby contributions in one country and several reforms under a treaty involving all countries. These include a general decrease in the weight placed on lobby contributions, a general increase in the capital tax rate, and a general increase in the resource tax rate. We should point out that the spending and tax rates satisfy the policy rules studied in the last section and hence are chosen optimally throughout. Therefore, when there is an exogenous change in a parameter, e.g., α in one country, the response of both governments is optimal.

4.2 The Effect of Lobbying

We depict the effect of lobbying and changes in the weight placed by the government on lobby contributions by the USA in Table 2. Without lobbying, the resource tax rate in the initial equilibrium is higher in the USA. As a consequence of this, the supply of the resource will be lower in the USA than in the OECD. Furthermore, the slightly lower resource tax rate in the

OECD along with greater preference for public goods leads to a higher capital tax rate in the OECD to finance the higher level of public spending.

When lobbying occurs within a region, resource tax rates are lower compared to the no lobbying case. Also, capital tax rates tend to be higher to compensate for lower tax revenues from the resource sector. Overall public spending is lower. Production in the resource sector is higher leading to more environmental damages. Lower public spending and higher environmental damages lead to a decline in welfare relative to the case where no lobbying occurs.

If the US government institutes policies that reduce the weight on political contributions, the resource tax rate increases. In addition, the increase in the resource tax rate reduces production of the resource in the USA, which reduces bribes in the resource sector and pollution damages. Capital tax rates also decline resulting in a slight net inflow of capital to the USA. Overall public spending increases even with a decline in capital tax rates since it is compensated by increased revenue from the resource sector. Welfare improves in the USA due to increased public spending and a reduction in pollution along with an influx of capital, which outweighs the fall in the wage rate.

A shift in government's welfare weight away from lobby contributions in the USA induces a spillover effect on the OECD by causing an increase in the world resource price. A higher resource price increases supply of the resource produced in the OECD leading to greater environmental damage. As the supply of the resource increases in the OECD, the resource tax base increases and this leads to an increase in public spending and a reduction in the capital tax

rate. The resource tax rate increases and bribes also increase. Welfare in the OECD declines because of higher environmental damages and lower public spending.[9]

4.3 Tax Harmonization Versus Governance Harmonization

If both countries agree to a grand bargain where both increase their quality of governance by instituting similar policies that reduce the weight on lobby contributions, the pattern of response is the same as when one country reduces its own weight on lobby contribution except for the negative spillover effects. As shown in Table 3, when both countries reduce their weight on lobbying contributions by the same percentage, both regions experience an increase in the resource tax rate, an increase in public spending, a decline in the capital tax rate, a fall in the resource supply and environmental damage, and a decline in the wage. Welfare improves in both regions.

Another possibility is a tax treaty across countries that simultaneously raises either the capital tax rate, or the resource tax rate. A general 5% increase in the resource tax rate causes a response identical to a general reform by the government in placing less weight on lobby contributions, as depicted in Table 3. Here, public spending increases, the capital tax rate falls, supply of the resource falls, the wage falls, environmental damage falls, and the net impact on welfare is an improvement as a result.

A general reform of the capital tax rate, where all countries agree to raise their capital tax rate by 5%, has a different effect on the economy. First, such a tax treaty will cause public spending to rise and the resource tax rate to fall. There is a slight capital inflow to the USA from the OECD. As a result, the wage rises in the USA and falls in the OECD. In addition, the supply of the resource increases slightly in both countries, which causes a slight increase in environmental damage and bribes. The demand for the resource increases in the USA and in the OECD. There

[9] These general results were not sensitive to small changes in the basic parameters, e.g. a, b, d, δ and γ.

is a general improvement in welfare that is an order of magnitude larger than the experiment involving a general increase in the resource tax rate.

Thus, we find two important points that have not been made in the literature to our knowledge. First, we show that harmonizing governance quality across countries by increasing the weight placed on consumer welfare and away from lobby contributions has a positive impact on public spending, environmental quality, and welfare that is the same as a tax harmonization in the resource sector designed to overcome tax competition across different governments. Second, the welfare effects of a tax treaty involving the capital tax are larger than a tax treaty in the resource sector because the tax base of capital is larger than the resource.

5. Conclusion

We present a comprehensive theoretical investigation of the effects of improved governance in one country and the impact this may have on other countries. A general equilibrium model is developed where resource extraction causes damage to the environment, governments impose a tax on extraction and capital to fund public spending, and both the resource and capital are mobile across countries. If one country undertakes a political reform that emphasizes consumers at the expense of special interest groups this will lead to an increase in the tax rate on resource extraction, a reduction in environmental damage, a reduction in bribes, increased government spending on goods that benefit consumers, and will cause an improvement in welfare.

This may also spillover to other non-reform countries through the resource market. A higher resource tax rate in the reform country will raise the price of the resource because of reduced supply and this will cause resource extraction to increase in non-reform countries. We show that this will increase environmental damage and bribes in those countries, but may result in greater government spending when those countries tax resource extraction. Welfare in the non-reform

countries may decrease because of lower government spending and higher environmental damage. We verify these results using simulation examples.

Finally, we find that harmonizing political reform that reduces the weight of lobbying contributions has an impact that is very similar to a tax treaty that raises taxes on the mobile resource. When less weight is placed on lobbying contributions by all countries, there is an increase in public spending and the tax rate on resource extraction, decline in environmental damage and bribes, and improvement in welfare. The effects are similar when a tax treaty that raises tax rates on mobile resources in order to alleviate the tax competition problem exists. However, the welfare effects of a tax treaty involving the capital tax are much larger in magnitude. These results have important implications for the choice of tax treaties and harmonizing policies related to governance across trading partners and trading blocs.

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Table 1

Variables and Parameters Used in Simulations

Variables	Parameter Values
Production Function	
Output elasticity for capital (a)	0.504
Output elasticity for the resource (b)	0.055
Scaling parameter (A)	10
Initial capital endowment	1
Resource Sector	
Scaling parameter for marginal cost (d)	0.559
Initial resource endowment	1
Government Sector	
Utility elasticity of government provided public goods (γ)	0.866 1.803
Scaling parameter of marginal damages from pollution (δ)	0.002
Weight on consumer welfare (α)	USA = 0.7815 Other OECD = 0.6269

Note: The weight on consumer welfare parameter α was normalized to a value between 0 and 1 to match the data from the International Country Risk Guide. The production function parameter a is chosen so the capital income share is 35% in both countries. The parameter b is chosen so the value added of resource production in GDP for the USA and OECD is 5% of GDP. The resource is initially normalized to one, m = 1, and the damage to resource ratio is 0.001. The capital endowment in each country was also normalized to unity, s = 1. The pattern in results was not sensitive to these choices.

Table 2

Simulation Results of an Impact of Lobbying and Lobbying Contribution Reform

	Equilibrium capital	Supply of resource	Demand of Wage resource		Public spending	Resource tax rate	Capital tax rate	Bribe	Welfare	Environmental Damages
No Lobbying Equilibrium										
USA	1.125	0.690	0.738	4.606	1.825	0.391	1.382		3.087	0.0005
OECD	0.875	0.692	0.645	4.028	1.989	0.390	1.965		4.093	0.0005
Lobbying Equilibrium										
USA	1.121	0.910	1.000	4.676	1.695	0.073	1.453	0.098	3.053	0.0009
OECD	0.879	0.968	0.878	4.105	1.820	0.041	2.027	0.135	3.997	0.0010
Lobbying Equilibrium after Lobbying Contribution Reform in USA (an increase in α in USA)										
USA	1.127	0.739	0.942	4.672	1.758	0.204	1.426	0.027	3.073	0.0006
OECD	0.873	1.024	0.822	4.077	1.814	0.044	2.026	0.148	3.990	0.0011

Table 3

Tax Harmonization Versus Harmonization of Lobbying Contribution Weight

	Equilibrium Capital	Supply of resource	Demand of resource	Wage	Public spending	Resource tax rate	Capital tax rate	Bribe	Welfare	Environmental Damages
Lobbying Equilibrium										
US	1.121	0.910	1.000	4.676	1.695	0.073	1.453	0.098	3.053	0.0009
OECD	0.879	0.968	0.878	4.105	1.820	0.041	2.027	0.135	3.997	0.0010
General decrease in the lobbying contribution weight										
US	1.124	0.776	0.894	4.653	1.763	0.214	1.420	0.030	3.072	0.0007
OECD	0.876	0.900	0.783	4.072	1.886	0.144	2.005	0.072	4.035	0.0009
Capital taxes increase										
US	1.127	0.921	1.014	4.691	1.775	0.060	1.525	0.033	3.071	0.0009
OECD	0.873	0.977	0.885	4.093	1.886	0.029	2.129	0.084	4.028	0.0010
Resource taxes increase										
US	1.122	0.906	0.997	4.675	1.697	0.076	1.452	0.096	3.054	0.0009
OECD	0.878	0.967	0.876	4.104	1.822	0.043	2.027	0.133	3.998	0.0010

APPENDIX A: PROOF OF PROPOSITIONS

A.1 Proposition 1: Optimal policy rules

A.1.1 *Policy rules*

We can define the representative government's objective function in the following manner,

$$\Lambda = \alpha V(\theta, \tau, g) + (1-\alpha)b,$$

where $V(\theta, \tau, g) = U(W(r+\tau, q) + rs,\ \tau K(r+\tau, q) + \theta M(q-\theta), D(M(q-\theta)))$ is the indirect utility. The following lemma rules out the Laffer curve phenomenon in both tax rates.

Lemma: If (a) $1 - \frac{\theta M_q}{m} > 0$ and (b) $1 + \tau\frac{K_r}{k} > 0$, then an increase in either tax rate raises more revenue, given factor prices.

Proof: Differentiate the government's budget constraint to obtain, $\frac{\partial g}{\partial \theta} = m - \theta M_q = m(1 - \frac{\theta M_q}{m})$ and $\frac{\partial g}{\partial \tau} = k + \tau K_r = k(1 + \frac{\tau K_r}{k})$. Government spending is increasing in each tax rate if the conditions of the lemma hold.

The lobby maximizes its member firms' profit through its choice of a contribution function given to the government to influence policy. This function must also satisfy the participation constraint, which compares the payoff for the government if it decides to participate in the lobbying arrangement with the payoff if it does not, $\alpha V + (1-\alpha)b \geq \alpha V^+$, where V^+ is utility in the equilibrium where there is no lobbying. The inequality will hold with equality in equilibrium and allows us to calculate the contribution function

accordingly, $b = \frac{\alpha(V^{+}-V)}{1-\alpha}$, following Grossman and Helpman (1994). The first order condition with respect to the resource tax rate is $-m - \frac{\partial b}{\partial \theta} + \eta\Lambda_{\theta} = 0$, where η is a Lagrange multiplier and $\frac{\partial \Lambda}{\partial X} = \Lambda_X$ is a derivative. When the government optimizes on the resource tax rate, $\Lambda_{\theta} = 0$. These two conditions imply that $\frac{\partial b}{\partial \theta} = -m$, which is the truthfulness condition.

To obtain the policy rules, differentiate the government's objective function and use the truthfulness condition to obtain the first order necessary conditions,

(A1) $$\Lambda_{\theta} = \alpha(\big(m - \theta M_q\big)U_g - U_D D_M M_q) - (1-\alpha)m = 0,$$

(A2) $$\Lambda_{\tau} = (k + \tau K_r)U_g - kU_c = 0.$$

Manipulate equation (A1) to obtain the policy rule of equation (9),

(A3) $$\frac{U_g}{U_c} = (1 - \frac{\theta}{q-\theta}\frac{(q-\theta)M_q}{m})^{-1}\,(\frac{U_D}{U_c}\frac{mD_M}{D}\frac{D}{\theta m}\frac{\theta}{q-\theta}\frac{(q-\theta)M_q}{m} + \frac{1}{U_c}\frac{1-\alpha}{\alpha}).$$

If we assume $U_D = -1$ and $D = \delta m^2/2$, and $M_q = 1/d$, then the rule (A3) becomes

(A4) $$U_g = \left(1 - \frac{\theta}{q-\theta}\right)^{-1}(\frac{1-\alpha}{\alpha} - \frac{\delta}{d}),$$

where $1 - \frac{\theta M_q}{m} = 1 - \frac{\theta}{q-\theta} > 0$ is positive if the lemma holds. Next, manipulate (A2) to get equation (8),

(A5) $$\frac{U_g}{U_c} = (1 + \frac{\tau}{r+\tau}\frac{(r+\tau)K_r}{k})^{-1},$$

where $1 + \frac{\tau}{r+\tau}\frac{(r+\tau)K_r}{k} > 0$ under the lemma. We obtain the following result by combining (A3) and (A5), equation (10),

$$\left(1 - \frac{\theta}{q-\theta}\frac{(q-\theta)M_q}{m}\right) = (1 + \frac{\tau}{r+\tau}\frac{(r+\tau)K_r}{k})\,(U_D\frac{mD_M}{D}\frac{D}{\theta m}\frac{\theta}{q-\theta}\frac{(q-\theta)M_q}{m} + \frac{1-\alpha}{\alpha}),$$

which simplifies to equation (12),

$$(1-\frac{\theta}{q-\theta}) = (1-\frac{\tau}{r+\tau}\varepsilon)(\frac{1-\alpha}{\alpha}-\frac{\delta}{d}),$$

since $\frac{(q-\theta)M_q}{m}=1$, and where $\varepsilon=-\frac{(r+\tau)K_r}{k}>0$ is the own price elasticity for the demand for capital. Under the lemma the left hand side of this last equation is positive, and since $1-\frac{\tau}{r+\tau}\varepsilon>0$ under the lemma, it follows that $\frac{1-\alpha}{\alpha}>\frac{\delta}{d}$ must hold. However, if we do not rule out the Laffer curve phenomenon in the case of the resource tax rate, then this gives us the two cases mentioned in the text. Notice that $\frac{\partial g}{\partial \theta}=m\left(1-\frac{\theta}{q-\theta}\right)$. It follows in the first (second) case that tax revenue is increasing (decreasing) in the resource tax rate. Assuming the lemma is true rules out the second case and requires $\frac{1-\alpha}{\alpha}>\frac{\delta}{d}$ in equilibrium.

We also require the second order conditions hold, $\Lambda_{\theta\theta}\leq 0$, $\Lambda_{\tau\tau}\leq 0$, and $\Lambda_{\theta\theta}\Lambda_{\tau\tau}-\Lambda_{\theta\tau}\Lambda_{\tau\theta}\geq 0$, where these second derivatives are given by,

$$\Lambda_{\theta\theta} = \alpha(m-\theta M_q)^2U_{gg}-\frac{\left(1+\frac{\theta}{q-\theta}\right)\alpha U_g}{d}<0,$$

$$\Lambda_{\tau\tau} = (k+\tau K_r)^2U_{gg}+k^2U_{cc}+K_r(1-\tau K_r/k)U_g<0,$$

$$\Lambda_{\tau\theta} = (k+\tau K_r)m\left(1-\frac{\theta}{q-\theta}\right)U_{gg},$$

where $\Lambda_{\tau\theta}<0$ if the lemma holds, where we have used the policy rules to simplify.[10]

A.2 Proposition 2: Policy responses

A.2.1 *Policy responses to a shift toward consumer welfare*

[10] We are ignoring a term in K_{rr}, namely $\tau K_{rr}U_g$. If $f_{kkk}\geq 0$, then it is straightforward to show that $\tau K_{rr}U_g\leq 0$ and $\Lambda_{\tau\tau}<0$.

Recall that the representative government takes prices and the policies of other governments as given. To obtain the response of the representative government to an increase in the parameter α totally differentiate equations (A1) and (A2), holding prices constant,

$$\Lambda_{\theta\theta} d\theta + \Lambda_{\theta\tau} d\tau = -\Lambda_{\theta\alpha} d\alpha,$$

$$\Lambda_{\tau\theta} d\theta + \Lambda_{\tau\tau} d\tau = 0,$$

and solve,

(A6) $$\frac{\partial\theta}{\partial\alpha} = -\frac{\Lambda_{\theta\alpha}\Lambda_{\tau\tau}}{\Delta} > 0,$$

(A7) $$\frac{\partial\tau}{\partial\alpha} = \frac{\Lambda_{\theta\alpha}\Lambda_{\tau\theta}}{\Delta} < 0,$$

under the lemma, where $\Lambda_{\theta\alpha} = \frac{m}{\alpha} > 0$. The response of government spending is,

$$\frac{\partial g}{\partial\alpha} = m\left(1 - \frac{\theta M_q}{m}\right)\left(\frac{\partial\theta}{\partial\alpha}\right) + k(1 + \frac{\tau K_r}{k})(\frac{\partial\tau}{\partial\alpha}).$$

Use (A6) and (A7),

$$\frac{\partial g}{\partial\alpha} = -\frac{m^2}{\alpha}\frac{\left(1-\frac{\theta}{q-\theta}\xi\right)\left(k^2 U_{cc} + \left(1+\frac{\tau}{r+\tau}\varepsilon\right)U_g K_r\right)}{\Delta},$$

where $\xi = \frac{(q-\theta)M_q}{m} = 1$ is the own price elasticity of demand for the resource. Since $\Delta \geq 0$ and $k^2 U_{cc} + \left(1 + \frac{\tau}{r+\tau}\varepsilon\right) U_g K_r < 0$, government spending is increasing in the parameter α when the resource tax rate satisfies (b) of the lemma.

A.2.2 Response of prices to an increase in the resource tax rate in one country.

Suppose the resource tax rate increases in country i in response to an increase in α in that country. And suppose that the tax rates in non-reform countries are fixed, but

government spending responds to changes in the tax base in those countries. Differentiate the equilibrium conditions and solve to obtain,

$$\frac{\partial q}{\partial \theta^i} = M_q^i \sum_j \frac{K_r^j}{H} > 0,$$

$$\frac{\partial r}{\partial \theta^i} = M_q^i \sum_j \frac{K_q^j}{H},$$

where $H = \sum_j (M_q^j - N_q^j) \sum_j K_r^j - \sum_j N_r^j \sum_j K_q^j < 0$. This is essentially the response of prices to α in country i. An increase in α in country i that raises the resource tax rate in that country will cause the resource price to increase and this will spillover to other countries. If $f_{kn} > (<)0$, and hence $K_q^j < (>)0$, then the real interest rate decreases (increases) with the resource tax rate in the reform country.