Abstract

Aid from environmentally conscious donors to developing recipients has long been thought of as a very promising way of preserving the global environment. However, aid is fungible and recipients cannot commit to using it for the purpose it was intended. We analyze competition for aid games in the presence of aid fungibility to gain insights on how to allocate environmental aid more efficiently. We set up a two stage game of two recipients receiving aid from a donor interested in minimizing pollution. Recipients cannot commit on the use of aid but they can commit on the infrastructure necessary to use aid for pollution abatement. We find that the success of competition for aid games depends on the degree of cross-border pollution, the amount of aid and on frictions in allocating aid.

Keywords: Competition for aid, aid fungibility, environmental policies

JEL Classification: F35, Q58, H21
1 Introduction

A number of environmentally conscious international organizations and rich countries offer aid to developing countries to persuade them to follow more environmentally friendly policies. A branch of the literature examines distributing aid by setting up competition for aid games. The lesson from that literature is that competition for aid between two countries can help protect the environment.

However, it is well established that in most cases aid is fungible, that is, it ends up being used for purposes other than its intended use. This is true even if aid is earmarked for specific purposes. In that case, recipients can substitute their own expenditures for that purpose with aid. The overall effect is that a fraction of the aid is allocated to other uses. This highlights the fact that aid can not be conditioned on its use. Putting it another way, aid recipients can not credibly commit to using aid in the way the donor wishes. This of course, is known by potential donors who are for this reason reluctant to give aid. The key goal of this paper is to provide insights on how to overcome this problem.

In some cases it might be possible to condition aid on the ability of the recipients to use aid in its intended use. Since the goal of the donor is to minimize pollution she would want all aid to be allocated to public pollution abatement. However, the donor can observe the institutional and legal framework as well as the public pollution abatement technology of each country. In other words the donor can observe the efficiency of each country in public pollution abatement. As a country becomes more efficient it will chose to allocate more aid to public pollution abatement since the marginal return to that use is high. Therefore, if the donor sets up a competition for aid game conditional on the recipients’ investments in public pollution abatement he might be able to increase the amount of pollution abated and thus minimize pollution.

We set up a two stage game with two recipient countries receiving aid from a donor. In the first stage recipients choose their investments in pollution abatement infrastructure and technology. In the second stage they decide on
pollution taxes and the fraction of aid they allocate to consumption and the donor decides on the distribution of aid between the two countries. Pollution is abated by the private sector in response to pollution taxes and by the public sector by the provision of a public pollution abatement good. Countries also suffer from cross-border pollution. We find that the success of such games depends critically on the degree of cross-border pollution, the amount of aid and frictions in distributing aid. We also find a couple of surprising results. The first is that competition for aid games might in some cases be counterproductive and lead to a decrease in investment in infrastructure. The donor would, of course, want to avoid such games. The other result is that depending on the procedures used in distributing aid, competition for aid games might be more productive if the competition is between countries that are far away from each other.

The plan of the paper is as follows. Section 2 sets up the model and section 3 solves the second stage of the game and analyzes the comparative statics of the solution. Section 4 provides the solution to the whole game while section 5 discusses the conclusions.

2 The model

We construct a two stage game theoretic model of two countries, Home and Foreign\(^1\), competing for foreign aid from a donor. The recipient countries can be thought of as developing countries and the donor can be interpreted either as a rich developed country or an international organization such as the UNEP, the OECD, the World Bank and Green Peace. Pollution is generated by production and is abated partly by the private sector in response to pollution taxes and partly by the public sector through the provision of a public good. Pollution generated in either country affects welfare negatively in both countries. In other words there is two-way cross-border pollution. The recipients use part of the aid, and pollution tax revenue to finance investment in technology and the provision of public pollution abatement. The

\(^{1}\)Foreign’s variables are denoted by asterisks.
rest of the aid is lump-sum distributed to households for consumption and from the point of view of the donor is wasted.

Our definition of public sector pollution abatement technology includes anything that is observable and affects the quantity of pollution abated per dollar spent on public pollution abatement. Therefore, in addition to the usual interpretation of technology it includes the institutional and legal framework (e.g. the Environmental Protection Agency in the US) required for the implementation of public pollution abatement.

In stage 1 the recipient countries invest in pollution abatement technology. Such investment allows the government to clean up the environment more effectively through public pollution abatement. Technology is indexed by its effectiveness to abate pollution per dollar spent on abatement, \( p \). The cost of the investment is \( F(p) \). Since this investment takes place before aid is given it is observable to the donor and therefore aid can be conditioned upon it. In stage 2 the donor decides on the distribution of a fixed amount of aid, \( T \), between Home and Foreign at fractions \( \lambda \) and \( 1 - \lambda \) respectively. We assume that this distribution is chosen to minimize total pollution in this two country region. This might be motivated by concerns about preservation of the global environmental heritage (especially in the case of international organizations) or concerns about cross border pollution from the recipient region to the donor country. At the same time the two recipients choose pollution taxes \( (t, t^*) \) and the fraction of aid \( (\mu, \mu^*) \) distributed to consumers to maximize welfare. The timing of the game highlights the assumption that recipients can credibly commit on the level of investment in public pollution abatement technology but not on pollution taxes or the share of aid used for public pollution abatement.

In both countries, a number of goods, which are freely traded in international markets are produced. Factor endowments are inelastically supplied and factor markets are perfectly competitive. Pollution abatement is carried out by private producers in response to a pollution tax, \( t \), and by the public sector financed by emission tax revenue and by a fraction of the foreign aid. Home’s maximum value of production of private goods is denoted by the revenue function, \( R(q, v, t) \), defined as:
\[ R(q, v, t) = \max_{x, z} \{ q' x - tz : (x, z) \in \Omega(v) \}, \]  

(1)

where \( q \) is the vector of exogenously given world commodity prices, \( \Omega(v) \) is the country’s production technology set, \( v \) is the factor endowment vector, \( x \) is the vector of net outputs, and \( z \) is the amount of pollution emitted by the private sector, net of the amount abated by the private sector.\(^2\) Since \((v)\) and \((q)\) are invariant the revenue function is written as \( R(t) \). We assume that the \( R(t) \) function is strictly convex in \( t \) \( (R_t < 0 \text{ and } R_{tt} > 0) \). This assumption implies that a higher emission tax rate lowers the amount of pollution emissions by the private sector. By the envelop theorem the level of pollution, \( z \), generated by the private sector is given by\(^3\)

\[ z = -R_t(t). \]  

(2)

Accounting for both private and public sector pollution abatement, and for cross-border pollution the overall net pollution \( r \), affecting Home’s residents is:

\[ r = -R_t(t) - pg + \Theta(-R_t^*(t^*) - p^*g^*), \]  

(3)

where the parameter \( \Theta \in [0, 1] \) is the rate of cross-border pollution or the spillover parameter, \( g \) is the expenditure on public pollution abatement in Home, and \( z^* \) and \( g^* \) denote Foreign’s levels of pollution net of private abatement and the expenditure on public pollution abatement, respectively.\(^4\) Thus \( pg \) and \( p^*g^* \) denote the levels of public pollution abatement in Home and Foreign, respectively.

For Home’s government budget constraint we assume that the government incurs the cost \( F(p) \) of the investment in technology, and it imports

\(^2\)The technology set includes pollution abatement technologies in the various sectors. Also for simplicity we assume that only one type of pollutant \((z)\) is generated in one or more sectors.

\(^3\)\(^?\) and \(^?\), among others, define pollution in the same way.

\(^4\)This formulation of additive level of net pollution, \( r \), implies that the two countries emit the same pollutant. Generalizing the present specification to one where the two countries emit different types of pollutants only results to unwarranted algebraic complications without providing substantive analytical insight.
from the rest of the world, at a constant world price, a commodity used to provide public pollution abatement. This assumption implies that no resources other than government funds are used for public pollution abatement. The alternative is to assume that public pollution abatement is produced locally using the available factors of production. This complicates the analysis without changing the qualitative results.\(^5\) The total expenditure on the imported abatement good is denoted by \(g\). Total government expenditures are assumed to be financed through emissions tax revenue (i.e., \(tz = -tR(t)\)) and a fraction \(1 - \mu\) of foreign aid received \(\Phi(\lambda T)\). Thus, Home’s government budget constraint is written as:

\[
F(p) + g = (1 - \mu)\Phi(\lambda T) - tR(t),
\]

where the function \(\Phi(.)\) is an increasing and concave function i.e., \(\Phi > 0\) and \(\Phi' < 0\). This function represents the amount of resources that the recipients spend in lobbying for aid. The concavity ensures that in equilibrium both recipients receive some aid.

Turning to the demand side of the economy, we assume that the country comprises of identical individuals. Utility is adversely affected by both local and foreign pollution transmitted across borders. Let \(E(u, r)\) denote the minimum expenditure required to achieve a level of utility, \(u\) and at the given level of net pollution \(r\).\(^6\) The partial derivative of the expenditure function with respect to \(u\), \(E_u\), denotes the reciprocal of the marginal utility of income. Since pollution adversely affects household utility, the partial derivative of the expenditure function with respect to \(r\), \(E_r\), is positive denoting the households’ marginal willingness to pay for a reduction in pollution (e.g. see ?).\(^7\) The expenditure function is assumed strictly convex in \(r\), \(E_{rr} > 0\), i.e., a higher level of net pollution raises the households’ marginal willingness to pay for pollution abatement. Home’s consumer budget constraint requires that private spending \(E(u, r)\) must equal factor income

\(^5\)The solution of the more complicated system is available upon request.
\(^6\)Since prices are constant they are omitted from the expenditure function.
\(^7\)In ?’s terminology, \(E_r\) is a measure of the marginal damage to consumers from pollution.
from the production of goods $R(t)$ plus the fraction $\mu$ of aid $\Phi(\lambda T)$ lump-sum distributed to domestic households. Thus, the income-expenditure identity for the home country is

$$E(u, r) = R(t) + \mu \Phi(\lambda T)$$

(5)

The corresponding conditions for Foreign are given as:

$$E^*(u^*, r^*) = R^*(t^*) + \mu^* \Phi((1 - \lambda)T),$$

(6)

$$F^* + g^* = (1 - \mu^*) \Phi((1 - \lambda)T) - t^* R^*_t(t^*),$$

(7)

$$r^* = -R^*_t(t^*) - p^* g^* + \Theta^*(R_t(t) - pg).$$

(8)

The system of equations describing the total derivatives of the equations of the second stage of the game is shown in a matrix form in the Appendix.

### 3 Pollution taxes and aid

Using the equations of the system in the Appendix the model is solved by backwards induction. First, we solve the second stage and derive the Nash emission tax rates $(t, t^*)$ and the fractions of aid $(\mu, \mu^*)$ allocated to consumption in each recipient country. For the donor we derive the fraction $\lambda$ of aid allocated to Home ($1 - \lambda$ for Foreign). Since $p$ is chosen in stage 1 it is treated as exogenous in stage 2. In section 4 we solve the first stage where the recipient countries’ governments invest in pollution abatement technology indexed by $p$.

Setting $(du/d\mu) = 0$ and $(du/dt) = 0$ from the Appendix, the emerging Nash equilibrium conditions for Home give:
Equation (9) indicates that the Nash equilibrium value of $\mu$ must satisfy the condition that households’ marginal willingness to pay for public pollution abatement must equal the marginal benefit of an additional dollar spent on pollution abatement $(1/p)$. From equation (10) note that the marginal tax on emissions is also equal to the marginal benefit of pollution abatement. Therefore, the marginal cost of the two types of pollution abatement (private and public) are equated to each other and to the marginal benefit of pollution abatement. The corresponding conditions for Foreign are $1 - p^*E_r^* = 0$ and $t^N = \frac{1}{p}$.

It is worth noting that the Nash equilibrium pollution taxes are inefficiently low if the proportion of aid allocated to consumption is also chosen non-cooperatively. If the proportion of aid is chosen cooperatively the Nash equilibrium pollution taxes are efficient in the sense that they maximize the combined utility in the two countries.

As previously noted, the donor chooses $\lambda$ to minimize aggregate pollution in the region, defined by

$$r + r^* = (1 + \Theta^*)(-R_t - pg) - (1 + \Theta)(R_t^* + p^*g^*).$$

That is, $\lambda$ is chosen to satisfy $\frac{dr}{d\lambda} + \frac{dr^*}{d\lambda} = 0$. This results in the following first order condition:

$$\frac{\Phi_\lambda(\lambda T)}{\Phi_\lambda((1-\lambda)T)} = \frac{p^*(1 - \mu^*)(1 + \Theta)}{p(1 - \mu)(1 + \Theta^*)}.$$  

Note that from equation (12) is that when countries are identical the right hand side is equal to 1 and therefore aid is divided equally between the two countries.
3.1 Comparative Statics

Before proceeding to examine the first stage of the game it is useful to examine the comparative statics of the second stage for two reasons. First, all these results are necessary to derive the solution of the first stage and second these results provide interesting insights on the behavior of the recipient countries and the donor. From the system in the appendix we get that

\[
\frac{dg}{d\mu} = -\Phi(\lambda T), \\
\frac{dg^*}{d\mu^*} = -\Phi((1-\lambda)T),
\]

and that the expenditure of each country on public pollution abatement is unaffected by changes in the other country’s fraction of aid allocated to consumption (i.e. \( \frac{dg}{d\mu^*} = \frac{dg^*}{d\mu} = 0 \)). The intuition here is straightforward since an increase in the fraction of aid allocated to consumption reduces the funds available for public pollution abatement. Equations (3), (8), (13) and (14) give the impact on net pollution from increasing the amount of aid allocated to consumption as follows:

\[
\frac{dr}{d\mu} = p\Phi(\lambda T), \\
\frac{dr}{d\mu^*} = \Theta p^\star \Phi((1-\lambda)T), \\
\frac{dr^*}{d\mu^*} = p^\star \Phi((1-\lambda)T), \\
\frac{dr^*}{d\mu} = \Theta^\star p\Phi(\lambda T).
\]

Notice that equations (15)-(18) show that an increase in the fraction of aid allocated to consumption in either country increases net pollution in both countries. This is hardly surprising since allocating more aid to consumption reduces expenditure on public abatement and therefore increases net pollution in the country itself and through cross-border pollution in the other country, as well. From the donor’s point of view allocating aid to consump-
tion is wasteful. The donor’s problem is that aid can not be conditioned on the fraction of it allocated to consumption. If that was possible the donor would force the two countries to spend all of the aid on pollution abatement technology and public pollution abatement achieving the first best result as far as minimizing pollution is concerned.

The impact of changes in the pollution taxes on public pollution abatement and pollution are similarly derived as follows:

\[
\frac{dg}{dt} = -(R_t + tR_{tt}) \tag{19}
\]
\[
\frac{dr}{dt} = (pR_t - R_{tt}(1 - pt)) \tag{20}
\]
\[
\frac{dr}{dt^*} = \Theta (p^* R_t^* - R_{tt}^*(1 - p^* t^*)) \tag{21}
\]

An increase in the pollution tax in Home has two effects on public pollution abatement in that country. The first is that it increases tax revenues and thus public pollution abatement (direct effect) and the second is that it decreases pollution generated at Home and thus pollution tax revenues (indirect effect). The former is positive while the latter is negative leading to an overall ambiguous impact of pollution taxes on public pollution abatement. As it is clear the direction of the overall effect depends on the pollution tax elasticity of pollution generated at Home. The overall impact of an increase in Home’s pollution tax on net pollution in that country depends on its impact on public pollution abatement \((-\frac{dg}{dt})\) and its impact on private pollution abatement \((-R_{tt})\). Since the first is ambiguous while the second is negative the overall effect is ambiguous. However, if it is evaluated at the Nash equilibrium rates an increase in the pollution tax decreases net pollution in the same country. Equation (21) highlights the fact that the impact of an increase in the pollution tax in Foreign affects net pollution in Home only through cross border pollution and is therefore, proportional to its effect on Foreign’s net pollution (i.e. \(\frac{dr}{dt} = \Theta \frac{dr^*}{dt^*}\)). Finally, it is also worth pointing out that, as expected, public pollution abatement in one
country is unaffected by changes in the pollution tax in the other country (i.e. $\frac{dg}{dt} = \frac{dg^*}{dt} = 0$) since tax revenues in the former are unaffected.

We proceed by examining how the technology choice in stage 1 affects the choices of the recipient countries in the second stage. We assume that the marginal willingness to pay for pollution in both countries is independent of income (i.e. $E_{ru} = E_{r^*u^*} = 0$). This is an unrealistic assumption since pollution is regarded by most researchers to be a normal good (i.e. $E_{ru} > 0$). We agree with the conventional wisdom on this point but we assume income effects away in an effort to isolate and highlight the other effects in this set up which we find less obvious. Totally differentiating all the Nash equilibrium conditions (9), (10), (12) and the corresponding equations for the choice of pollution tax and proportion of aid allocated to consumption in Foreign we get the system in Appendix B. We summarize the results in the following proposition:

**Proposition 1** Evaluated at the Nash equilibrium values an increase in $p$ has the following effects:

1. $\frac{du}{dp} < 0$
2. $\frac{du^*}{dp} = 0$
3. $\frac{du}{dp} < 0$ if $F + pF_p - \Phi(\lambda T)(1 - \mu) > 0$ and large
4. $\frac{du^*}{dp} > 0$ if $\Phi_{\lambda\lambda}(\lambda T)$ is large in absolute value
5. $\frac{d\lambda}{dp} > 0$ if $F + pF_p - \Phi(\lambda T)(1 - \mu) > 0$

All the expressions in proposition 1 appear in Appendix B. From these expressions one can quantify how large $F + pF_p - \Phi(\lambda T)(1 - \mu)$ and how small $\Phi_{\lambda\lambda}(\lambda T)$ have to be. The latter condition puts a lower limit on the concavity of $\Phi$ and the former states that the cost of the investment in public pollution abatement technology must be large relative to the amount of aid that is used for public pollution abatement.
The first result of proposition 1 states that as \( p \) increases the Nash pollution tax decreases. The intuition is straightforward. Optimizing behavior requires the marginal benefit from the two types of pollution abatement (public and private) to be equated. An increase in \( p \) increases the marginal benefit of public pollution abatement so to increase the marginal benefit of public pollution abatement governments reduce pollution taxes. Since the increase in \( p \) leaves the marginal benefits of both public and private pollution abatement in the other country unaffected it has no impact on the pollution tax in Foreign as result 2 of the proposition states.

The third result states that the amount of aid allocated to consumption (or wasted from the point of view of the donor) decreases as long as the cost of the investment is large relative to the amount of aid. The intuition is similar in this case too. Optimizing behavior requires the government to allocate aid in a way that equalizes the marginal benefit of consumption to that of public pollution abatement. The increase in \( p \) increases the marginal benefit of public pollution abatement so the government restores equality by increasing the amount of aid allocated to public pollution abatement.

The reverse is true in Foreign as result four shows. In this case, the increase in the marginal benefit of public pollution abatement in Home reduces cross border pollution into Foreign reducing the marginal willingness of consumers in Foreign to pay for public pollution abatement in their own country. Therefore, they optimally allocate more aid to consumption.

Last, but not least, the increase in \( p \) increases the share of aid the donor allocates to Home if the cost of the investment is large relative to the aid allocated to public pollution abatement. The donor equalizes the marginal benefit of aid allocated to Home to that allocated to Foreign. An increase in \( p \) increases the marginal benefit from aid allocated to Home and the donor allocates more aid to her and less to Foreign.
4 Public pollution abatement technology

In this section we analyze the investment decision of the two countries in public pollution abatement technology. This entails solving the first stage of the game anticipating the behavior described in section (3). Each country chooses the level of investment in technology that maximizes its welfare. The effect of technology on welfare in Home is given by

\[
E_u \frac{du}{dp} = E_r g - F_p + \frac{\Phi(\lambda T)}{(1 + \Theta)} (\Theta \mu - \Theta \Theta^* + \Theta \mu \Theta^* + 1) \frac{d\lambda}{dp} - \Theta E_r p^* \Phi((1 - \lambda)T) \frac{d\mu^*}{dp}.
\]

Equation (22) highlights the fact that the choice of technology depends on three effects, the direct effect and the indirect effect through the share of aid allocated to Home and the share of aid Foreign allocates to consumption. The indirect effects through the variables that are optimally chosen by Home (pollution taxes and share of aid allocated to consumption) do not affect welfare. This is, of course, an application of the Envelope Theorem. The direct effect is the comparison of the cost, \( F_p \), to the benefit, \( E_r g \), of investing in technology. In the absence of aid this effect alone would determine the amount of investment in technology. The second effect is the change in distribution of aid that investment in technology might induce (represented by the term multiplied by \( \frac{d\lambda}{dp} \)). An increase in the share of aid allocated to Home will affect welfare in two ways. First it will increase public pollution abatement in Home but at the same time it will decrease public pollution abatement in Foreign since the aid allocated to Foreign decreases. The former increases welfare while the latter due to cross-border pollution decreases welfare. Under the right conditions an increase in technology in Home will increase the share of aid that Home receives (see proposition 1). Finally, the third effect is the change in the share of aid allocated to consumption in Foreign (represented by the term multiplied by \( \frac{d\mu^*}{dp} \)). An increase in the amount of aid wasted by Foreign will increase cross-border pollution into Home and thus reduce welfare. Under the right conditions an increase in technology in Home increases the amount of aid allocated to consumption in Foreign (see proposition 1).
The key question we are interested in is whether the donor succeeds in reducing pollution in this area by allocating aid in the manner described above. To answer that we need to assess whether investment in technology and therefore the efficiency of public pollution abatement increased and whether more resources are devoted to public pollution abatement. Substituting equations \( d\mu/dp \) and \( d\lambda/dp \) in (22) and setting it equal to zero one can get the reduced form of the reaction function for the choice of \( p \) and therefore solve explicitly for it.

However, the question of whether allocating aid in this way increases investment in technology can be answered by analyzing equation (22). Recall that in the absence of aid Home equates the marginal benefit of investment to its marginal cost or \( E_{r,g} = F_p \). Evaluating (22) at this point we can deduce whether aid increases or decreases investment in public pollution abatement technology.

From the equation in the Appendix note that at this point \( d\lambda/dp > 0 \). The sign of \( d\lambda/dp \) remains ambiguous. From proposition (1) \( d\lambda/dp > 0 \) if \( \Phi_{\lambda\lambda}(\lambda T) \) is large in absolute value. The opposite is true if it is small. The sign of (22) at this point depends on the relative magnitudes of these two effects since the former has a positive impact on \( du/dp \) and the latter a negative impact. The degree of cross-border pollution is the key parameter determining these relative magnitudes. If there is no cross-border pollution from Foreign to Home the effect on \( du/dp \) does not affect welfare in Home and therefore \( du/dp > 0 \). That means that investment in technology will be higher with aid than without aid. As the degree of cross-border pollution from Foreign to Home increases the effect on the fraction of aid allocated to consumption in Foreign becomes more important and it is possible that the overall effect on welfare is negative. In that case aid decreases investment in technology. Therefore, it is possible that both countries increase their investment in technology, or both countries decrease their investment in technology or one country increases its investment while the other decreases it. In any case, if \( \Phi_{\lambda\lambda}(\lambda T) \) is large in absolute value the effect through \( \mu^* \) reduces the motives for investment in technology. In other words if there was no cross-border pollution then aid would lead to even more investment in technology. If this is the case then
the donor would be better off designing competition for aid games between
countries far away from each other and thus eliminating this negative effect
of cross-border pollution.

Now consider the case that \( \Phi_{\lambda\lambda}(\lambda T) \) is small. In that case \( \frac{d\mu^*}{dp} < 0 \) and
both effects push in the same direction. Cross-border pollution in that case
reinforces the effect through \( \lambda \) and countries invest even more in technology.
Therefore, it is obvious that the existence of cross-border pollution makes the
concavity of \( \Phi \) an important consideration in designing competition for aid
games. Recall, that this represents the amount of aid that actually reaches
the recipient countries and that the usual interpretation is that it is funds
wasted in lobbying for aid. To some degree this function is controlled by
the donor too since in reality it represents frictions in the procedures used
by the donor in distributing aid.

Finally, as mentioned above the possibility of a reduction in investments
in technology in both countries can not be ruled out. If \( \Phi_{\lambda\lambda} \) and cross-border
pollution are large in both countries then it is possible that both countries
reduce their investments in technology. From the point of view of the donor
aid would be counterproductive in this case.

The second question is a lot more difficult to answer. Closer examina-
tion of equation (4) shows that expenditure on public pollution abatement
depends on three factors. The first is the amount of aid allocated to this
goal \( (1 - \mu)\Phi(\lambda T) \). This effect is clearly positive meaning the existence
of aid increases expenditure through this effect. The second effect is the
investment in pollution abatement technology \( F \). If allocating aid in this
manner increases (decreases) investment in technology then balancing the
budget means that expenditure on public pollution abatement decreases (in-
creases). Finally, aid through its effect on technology affects pollution tax
revenue \( -tR_t \). From equation (10) note that an increase (decrease) in
technology decreases (increases) pollution taxes. The effect on pollution tax
revenue depends on the elasticity of pollution tax revenue since a decrease in
the pollution tax decreases revenues directly but also increases the tax base
to which the tax is applied. The overall effect of aid on public pollution
expenditure is therefore ambiguous. However, there is a way for the donor
to ensure that expenditure on public pollution abatement increases by in-
creasing the amount of aid, $T$. If $T$ is large enough the first effect outweighs
the other two effects. The only question there is whether the extra cost for
the donor is worth the reduction in pollution achieved.

5 Conclusion

The competition for aid literature formalized the idea that international or-
ganizations or other donors might be able to persuade developing countries
to follow more environmentally friendly policies. In this paper we analyze
competition for aid in the presence of aid fungibility. There is ample evi-
dence that recipients do not use aid in the way the donor intended even if
receiving aid is conditioned on its use. This is because recipient countries,
are unable to commit on how they are going to use the aid.

To examine that we set up a two-stage game model of two countries
receiving aid from a donor. The donor distributes aid to minimize total
pollution in the two countries. These countries can use the aid either for the
 provision of public pollution abatement or consumption. In both countries
the private sector also abates pollution in response to pollution taxes. The
donor wants the aid to be used for pollution abatement but recipients can not
commit to that. However, the donor observes the infrastructure available
for pollution abatement and can condition aid on that. Therefore, aid is
conditioned on the amount of pollution that can be abated per dollar of aid
received. That increases the motives of recipient countries to invest in such
infrastructure.

If countries invest more in public pollution abatement infrastructure to
attract more aid then it is optimal to waste less of the aid by diverting it to
consumption since the marginal benefit of using aid for pollution abatement
increases. On the other hand, it also makes it optimal to lower pollution
taxes since public pollution abatement is now a more efficient way of abating
pollution. From the point of view of the donor the former is welcome but
the latter is not.
We find that whether countries will increase their investments in infrastructure depends on the degree of cross-border pollution and how much of the aid actually reaches the recipients since they have to spend resources in persuading the donor to actually offer aid. In the best possible scenario both countries increase their investment and in the presence of cross-border that increase is even higher. It is also possible for the countries to increase overall investment but the presence of cross-border pollution mitigates that increase. In that case the donor would be better off by setting up competition for aid games between countries that are far away from each other and do not suffer from cross-border pollution between them. Finally, it is also possible for these games to lead to situations where the two countries decrease their investments. In that case donors would not want to set up such games. The success of these games also depends on the amount of resources devoted to public pollution abatement as well as investments in technology. We find that if the amount of aid is large enough aid leads to more resources being devoted to public pollution abatement.

These results provide some new insights on the parameters that affect the success of competition for aid games. These are the degree of cross-border pollution, the amount of aid and frictions in the procedures set up for distributing aid. Donors can increase the effectiveness of aid by paying close attention to these parameters.

Appendix A
The determinant of the matrix of the coefficients of the unknowns is
\[ \Delta = E_u E_{u^*} > 0. \]

**Appendix B**

Stage 2 comparative statics

\[
\begin{align*}
\begin{bmatrix}
E_u & -E_r p & -\Theta E_r p^* \\
0 & -\Theta^* E_r^* p & -E_r^* p^* \\
0 & 0 & 0 \\
0 & 0 & 0
\end{bmatrix}
\begin{bmatrix}
du \\
du^* \\
dg \\
dg^*
\end{bmatrix}
&=
\begin{bmatrix}
R_t + E_r R_{tt} \\
\Theta^* E_r^* R_{tt} \\
-(R_t + t R_{tt}) \\
0
\end{bmatrix}
dt
\begin{align*}
&+ \begin{bmatrix}
\Theta E_r R_{t^* t^*} \\
R_t^* + E_r^* R_{t^* t^*} \\
0 \\
-(R_t^* + t^* R_{t^* t^*})
\end{bmatrix}
dt^* + \begin{bmatrix}
\Phi(\lambda T) \\
0 \\
-\Phi(\lambda T) \\
0
\end{bmatrix}
d\mu \\
&+ \begin{bmatrix}
0 \\
\Phi((1 - \lambda) T) \\
0 \\
-\Phi((1 - \lambda) T)
\end{bmatrix}
d\mu^* + \begin{bmatrix}
\Phi(\lambda T) \\
0 \\
-\Phi(\lambda T) \\
0
\end{bmatrix}
d\lambda
\end{align*}
\]

\[
\begin{align*}
1 & 0 & 0 & 0 & 0 & 0 & dt \\
A_1 & A_2 & p E_{rr}^* \Phi(\lambda T) & \Theta E_{rr}^* p^* \Phi((1 - \lambda) T) & 0 & 0 & dt^* \\
0 & 1 & 0 & 0 & 0 & 0 & d\mu \\
A_3 & A_4 & \Theta^* E_{r^* r^*}^* p^* \Phi(\lambda T) & p^* E_{r^* r^*}^* \Phi_F & 0 & 0 & d\mu^* \\
0 & 0 & (1 + \Theta^*) p^* \Phi_\lambda((1 - \lambda) T) & -(1 + \Theta) p^* \Phi_\lambda((1 - \lambda) T) & -\Psi & d\lambda
\end{align*}
\]

\[
\begin{align*}
\frac{-1}{p^2} & \\
(-E_{rr} (p F_p^* - g) - \frac{1}{p^2}) & 0 \\
0 & dp + \frac{-1}{p^2} \\
0 & (1 + \Theta^*) (1 - \mu) \Phi(\lambda T) \\
0 & (1 + \Theta)(1 - \mu^*) \Phi((1 - \lambda) T)
\end{align*}
\]
where \( A_1 = -E_{rr}(R_t - p(R_t + tR_{tt})) \), \( A_2 = -E_{rr}(\Theta R_{tt} - \Theta p((R_t + tR_{tt}))) \), \( A_3 = -E_{r^*}^* (\Theta R_t - \Theta^* p((R_t + tR_{tt}))) \), \( A_4 = -E_{r^*}^* (R_{tt} - p^* (R_t + tR_{tt}))) \), and

\[
\Psi = (1 + \Theta^*)(1 - \mu) p \Phi_{\lambda\lambda}(\lambda T) + (1 + \Theta)(1 - \mu^*) p^* \Phi_{\lambda\lambda}(1 - \lambda T) > 0.
\]

Reduced forms

\[
\frac{dt}{dp} = -p^{-2}
\]
\[
\frac{dt^*}{dp} = 0
\]
\[
\Omega \frac{d\mu}{dp} = p^{-2} (E_{r^*}^*) T p^* \Phi^* \Psi
\]
\[
* (pE_{rr} (\Theta \Theta^* - 1) p (F - \Phi + \Phi^* p + pF_p) - 1)
\]
\[
+ \frac{p (E_{rr}) (\Theta \Theta^* - 1) (\Theta^* + 1) (\mu - 1)^2 (E_{r^*}^*) T \Phi^2}{(\mu^* - 1)(\Theta + 1)}
\]
\[
* ((\Theta^* + 1) p (F - \Phi + \Phi^* + pF_p) + (\mu^* - 1)(\Theta + 1) p^* \Phi^* + 1)
\]

\[
\Omega \frac{d\mu^*}{dp} = p^{-1} (E_{r^*}^*) T \Phi \Theta^* \Psi
\]
\[
+ (\Theta + 1)^{-1} (\Theta \Theta^* - 1) (\Theta^* + 1) (\mu - 1)(E_{r^*}^*) T \Phi^2
\]
\[
* (p^2 (E_{rr}) (\Theta^* + 1) (F + pF_p) + 1)
\]

\[
\Omega \frac{d\lambda}{dp} = \frac{(\Theta^* + \Phi^* p p (E_{rr}) (\mu^* - 1)(\Theta \Theta^* - 1)(\mu - 1)(E_{r^*}^*) (\Theta^* + 1) \Phi_{\lambda})(1 - \mu^*)}{p^{-1} p^* \Phi^* (E_{r^*}^*) (\Theta^* + 1) \Phi_{\lambda}}
\]
\[
* ((F - \Phi + \Phi^* + pF_p) (\Theta \Theta^* - 1)(E_{rr}) p^2 - 1)
\]
where $\Phi = \Phi(\lambda T)$, $\Phi^* = \Phi((1 - \lambda) T)$ and

$$
\Omega = (1 - \Theta \Theta^*) (E_{rr}^*) (E_{r^*_r^*})^T p \Phi \Phi^* \Phi^* \Psi \\
+ \frac{(\Theta \Theta^* - 1) (\Theta^* + 1) (\mu - 1) (E_{rr}) (E_{r^*_r^*})^T p^2 \Phi^2}{(1 - \mu^*) (\Theta + 1) \\
* ((\Theta^* + 1) (\mu - 1) p \Phi + \Phi^* p^* (\Theta + 1) (\mu^* - 1)).
$$

Note that $\Omega < 0$.