The Demands for Environmental Regulation and Trade[1]

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September 12, 2007

[1]©Louis Hotte and Stanley L. Winer. We thank Ruth Forsdyke, Bryan Paterson, and seminar participants at the University of Ottawa, the Université de Rouen, CERDI in Clermont-Ferrand, the Université Paris 1 Pantheon-Sorbonne, the Canadian Economics Association 2006 Annual Meeting at Concordia University; The 2006 Annual Meeting of the Canadian Resource and Environmental Economics Group at Acadia University; .

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Abstract

Using a framework in which environmental degradation may be both mitigated by *individual actions* and internalized by *environmental regulation,* we consider the following questions: How does trade affect individual demands for environmental regulation?; How does environmental regulation affect the demand for trade openness?; And, what does the analysis of these questions tell us about the study of the political economy of the environment - trade - welfare nexus?

Keywords: regulation, environment, pollution, private mitigation, trade, welfare, collective choice

JEL classification:

1 Introduction

When environmental inputs into trade are important, it is reasonable to expect that environmental regulation and trade patterns will be closely connected. In this paper, we analyze the relationship between environmental externalities, the demand for environmental regulation, and the demand for and consequences of trade for welfare when environmental degradation may be both mitigated by *individual actions* and internalized by *environmental regulation.* In particular, within the framework we develop we ask the following three questions:

1. How does trade affect individual demands for environmental regulation?

2. How does regulation affect the demand for trade openness? And,

3. What does the analysis of these questions tell us about the political economy of the environment-trade-welfare nexus?

Over the past two decades or so, integration of the world economy has led many to fear that dirtier industries would move to poorer countries in order to escape rich countries' more stringent environmental regulation (Grossman and Krueger, 1993; Anderson and Blackhurst, 1992; Low, 1992). This outcome, referred to as the *pollution haven hypothesis*, is often deemed undesirable for two reasons: one is that it would generate increases in global pollution levels; another is that pollution increases in poor countries and decreases in the rich.

The pollution haven hypothesis carries with it a sound theoretical underpinning. It is not surprising, then, that it raises fears. But when one looks at the wealth of accumulated research on the issue since the early 1990's, one finds much reason for hope. A first reaction is to look at what is meant by a "desirable" outcome. This question has been forcefully put forward by Larry Summers' famous note circulated within the IMF in 1991. Summers' point was that it may make sense for dirty industries to move South if one considers environmental quality to be a *normal good.* Simply put, it is not the same when one forgoes luxury goods in order to improve on environmental quality as it is to forgo basic shelter. Poorer individuals would thus opt for a dirtier environment if it meant a better housing and more food.

Of course, the mere fact that environmental quality is a normal good does not by itself imply that there is too little pollution in the South. We need a subtler theoretical framework to explain sub-optimal pollution levels. It is thus important to focus on welfare and not environmental degradation per se. Two seminal theoretical contributions published in 1994 attest to this need for a focus on welfare. On the one hand, Copeland and Taylor (1994) show that, if environmental quality is a normal good, then an integrated world leads pollution-intensive industries to locate in the South. The reason is that poor countries adopt looser environmental standards. In this setting, the *motive for trade* stems solely from differences in environmental regulation stringency, which are in turn due to income differences. This choice by the South is fully intentional and increases its people's welfare through gains from trade. Not only does this result support the pollution haven hypothesis, it also makes it desirable as trade remains welfare improving.

Chichilnisky (1994) approaches the issue from a different angle. She assumes that North and South have identical factor endowments, thus removing any *a priori* motive for trade. She then posits that regions differ only by their institutions: property rights over natural resources are well defined in the North and subject to open access in the South. This induces trade between the countries; the South exports natural resources because its open access regime generates a higher supply. Pethig (1976) and Copeland and Taylor (2003) apply a similar concept to the case of pollution by assuming an absence of environmental regulation in the South, thus providing another theoretical explanation for the pollution haven hypothesis.

Although Copeland and Taylor (1994) and Chichilnisky (1994) similarly explain trade patterns and the pollution haven hypothesis as resulting from lax environmental regulation, there is a crucial difference. The first assumes lax regulation in the South to be expressly chosen by poorer individuals who cannot afford the standards of the North, with the result that trade is always welfare improving. The second posits that due to institutional constraints, the South cannot achieve its preferred regulation level; hence, trade gains may not materialize. In short, Copeland and Taylor (1994) assume full internalization of pollution effects through government regulation, while Chichilnisky (1994) assumes no internalization at all.[1]

To be sure, full internalization cannot be taken for granted anywhere, and especially so in developing economies. But the assumption of a total absence of internalization is too strong. In the Coasian view (1960), incomplete internalization is due to the presence of transaction costs that prevent agents to achieve an efficient outcome. But transaction costs come in many forms and depend on many factors. In the case of natural resources, for instance, it has been shown that when enforcement of exclusion is costly, full internalization will not necessarily obtain, even though a private property regime is in place (Hotte 1997, 2005). This way of explaining the degree of internalization has been used in Hotte, Long and Tian (2000) to analyze the welfare consequences of trade for a small open economy.

In this previous work, country differences in the equilibrium degree of internalization result from decentralized decisions by agents, i.e. the government's role is passive. Of course government may be an active ingredient in determining the degree of internalization, depending on how individual interests are reflected in government decisions. A survey of the theoretical work on the political-economy of the environment indicates that authors have typically chosen to base citizen interests on factor endowments. (Aidt (1998), McAusland (2003), Fredriksson (1997), Schleich (1999) and Copeland and Taylor (2003)) . Such differences are no doubt relevant. Yet, individual variations in actual suffering from pollution

[1]In the case of renewable resources, Brander and Taylor (1997, 1998) also analyze the welfare effects of trade in the absence of internalization in the South.

have largely been ignored in this literature, despite their importance. Those variations are moreover typically linked to an individual's total income level, independently of its source.[2] This can be explained, in large part, by the individual's ability to be protected against the adverse effects of pollution, which we shall refer to as mitigating efforts.[3] An original feature of this paper is thus to base differences in interests among citizens on the fact that the rich may suffer less from pollution because of individual pollution-mitigating efforts that depend in the first instance on overall individual income and the costs and benefits of private actions.

The paper is organized as follows. In section 2, we define the individual welfare function. In section 3, we introduce the production and pollution-mitigating technologies, while section 4 describes the effects of environmental regulation. We solve for the individual consumption and defensive efforts decisions in section 5, which we introduce into a general equilibrium framework in section 6 for both a closed and a small-open economy with trade. Section 7 pins down the effects of trade and environmental regulation on pollution. We then answer the key questions posed above in sections 8, 9 and 10

2 Pollution, consumption, and individual welfare

Individual welfare is negatively affected by pollution. However, in order to mitigate those effects, individuals can take *private* measures to defend themselves against pollution. Those measures typically include choice of house location, installation of household water filtration system, drinking bottled water or fetching water at a distance, air cleaning system, vacations, medicines, etc.[4] Given a decreasing marginal utility of income, richer individuals are expected to be better protected from the negative effects of pollution.[5] Pollution will, as a result, affect the poor more severely than the rich.

More formally, individual welfare depends positively on the consumption level of two (types of) goods, x_1 and x_2, and negatively on the economy-wide pollution level Q, though

[2]See, for instance, the empirical evidence in Ash and Fetter (2004), Pearce et al. (2006) and Brooks and Sethi (1997). Brunekreef and Holgate (2002) offer a review of recent work linking air pollution to health outcomes and mention the larger susceptibility of disadvantaged population groups.

[3]There are not very many theoretical analyses which explicitly account for private pollution-mitigating efforts. The only recent one that we found is that of McKitrick and Collinge (2002), who argue that we should not ignore them when considering environmental policy. (See also their references to previous theoretical work.) In their empirical analysis, Dasgupta et al. (2005:622) mentions the fact that the poor's suffering from pollution may be more important than the rich because they cannot afford partially compensating health care.

[4]Shibata and Winrich (1983) and McKitrich and Collinge (2002) analyze such cases. We did not find any model that considers the effects of income levels or integrate this into a general equilibrium setting. (Look for it. Oates?)

[5]Mention empirical studies that obtain negative relationships between household income level and individual environmental suffering. (Check those references: Kahn and Matsusaka, 1997; Brooks and Sethi, 1997; Maasoumi and Millimet, 2005; Look for stuff addressing specifically LDCs on WB website?)

the effect of pollution on one individual can be mitigated by his own environmental defensive effort d. The utility function for individual i is represented as follows:

$$V(i) = \ln(x_1(i)^a x_2(i)^{1-a}) - (\delta_0 - \delta_1 d(i))Q, \tag{1}$$

where $(\delta_0 - \delta_1 d(i))Q$ defines how economy-wide pollution affects one's welfare, given one's own defensive effort $d(i)$. Parameters δ_0 and δ_1 summarize the private pollution-mitigating technology.

Good 2 is the numéraire good. It is a dirty good in the sense that its production generates pollution. Good 1 sells at price p and is clean because its production does not generate any pollution. Indirect utility can be represented as follows:

$$V(i) = \ln(v(p)y(i)) - (\delta_0 - \delta_1 d(i))Q, \tag{2}$$

where $y(i)$ denotes expenditures on consumption goods net of pollution-mitigating expenditures. The assumed Cobb-Douglas form of consumption utility implies that $v(p) = 1/p^a$.

3 Production and private pollution-mitigating expenditures

Individuals differ with respect to their total factor endowments in *absolute* terms. However, each individual's set of production factors has identical *relative* proportions. This simplification allows us to concentrate on individuals' divergent interests based solely on total wealth differences and do away with differences in sources of income. Since individual pollution defensive efforts reduce the amounts left for expenditures on consumption goods $y(i)$, the trade-offs faced by individuals will differ between the rich and the poor.[6]

The economy is composed of a continuum of individuals indexed by $i \in [0, 1]$, distributed according to density function $f(i)$, with total population size normalized to one. Each individual can produce either of the two consumption goods. We assume that each uses the same individual *Ricardian* production technology. The *individual* production possibility frontier ($IPPF$) is given by

$$z_2(i) = \hat{z}_2(i) - bz_1(i), \tag{3}$$

where $z_2(i)$ and $z_1(i)$ respectively denote individual i's output of goods 2 and 1, parameter b is the (constant) opportunity cost of producing an extra unit of good 1 in terms of good 2, and $\hat{z}_2(i)$ is a *measure* of individual i's wealth.

Remark: We could *equivalently* assume that individual i receives a share $\alpha(i)$ of the total national income where the national PPF is given by

$$Z_2 = \hat{Z}_2 - bZ_1, \tag{4}$$

[6] McAusland (2003) and OTHERS analyze the effect of divergent interests due to differences in relative factor ownership, while at the same time assuming that pollution affects all individuals equally.

with $\hat{Z}_2 \equiv \int_0^1 \hat{z}_2(i) f(i) di$ and $\alpha(i) = \hat{z}_2(i)/\hat{Z}_2$.

Level $d(i)$ of private pollution-mitigating effort is attained through a Cobb-Douglas production technology:

$$d(i) = d_1(i)^{\beta} d_2(i)^{1-\beta}, \tag{5}$$

where $d_1(i)$ and $d_2(i)$ respectively denote the amount of goods 1 and 2 being sacrificed. The total cost of the private defensive effort is thus $c(p)d(i)$, where $c(p) = \beta^{-\beta}(1-\beta)^{\beta-1}p^{\beta}$, which yields the budget constraint:

$$y(i) = pz_1(i) + z_2(i) - c(p)d(i). \tag{6}$$

4 Pollution and environmental regulation

Good 2 is a dirty good in the sense that its production increases pollution. Good 1 is clean and does not pollute at all. Let Z_2 be the aggregate amount of good 2 being produced. We assume that, in the absence of environmental regulation, the economy-wide pollution level Q is simply given by $Q = Z_2$, i.e. each unit of good 2 produces one unit of pollution.

Environmental regulation forces suppliers of good 2 to produce in a cleaner way. Some productive resources will thus have to be devoted to either cleaning up along the production process, or using more sophisticated, cleaner production techniques. Either way, in comparison with the no-intervention case, environmental regulation translates in the following two direct effects: (i) there is less pollution for any given production level $z_2(i)$; and (ii) it is more costly to produce a level $z_2(i)$, i.e. it requires additional inputs. Regulation thus results in a downward shift of the $IPPF$ as follows: For any given amount of z_1 produced, less of z_2 can be produced.

Let us define the stringency of environmental regulation as a continuous variable θ, with $\theta \in (0,1)$. $\theta = 0$ corresponds to no regulation and $\theta = 1$ corresponds to a pollution-free output of good 2. This is conveniently represented with the following modification of the $IPPF$:

$$z_2(i) = (1-\theta)(\hat{z}_2(i) - bz_1(i)). \tag{7}$$

From a producer's point of view, environmental regulation simply increases the opportunity cost of producing the dirty good from $1/b$ to $1/(1-\theta)b$ in terms of the clean goods. As would be expected, the maximum amount of the clean good that can be produced is not affected by environmental regulation. Figure 1 illustrates the effect of environmental regulation on the $IPPF$.

FIGURE 1 HERE

For any given aggregate production level of the dirty good, environmental regulation reduces its effect on the economy-wide pollution level. This is represented as follows:

$$Q = h(\theta)Z_2, \text{ with } h(0) = 1 \text{ and } h'(\theta) < 0. \tag{8}$$

5 The individual problem

In order to maximize his own welfare, individual i must choose a production bundle $(z_1(i), z_2(i))$, a consumption bundle $(x_1(i), x_2(i))$, and the level of his environmental defensive effort $d(i)$. He does so while taking as given $\hat{z}_2(i)$, p, θ, and Q. Making use of the indirect utility function in (2), individual i's maximization problem can be represented as follows:

$$\max_{\{z_1(i),z_2(i),y(i),d(i)\}} V(i) = \ln(v(p)y(i)) - (\delta_0 - \delta_1 d(i))Q \tag{9}$$

$$\text{s.t. } y(i) = pz_1(i) + z_2(i) - c(p)d(i) \tag{10}$$

$$\text{and } z_2(i) = (1-\theta)[\hat{z}_2(i) - bz_1(i)] \tag{11}$$

In autarky, with the assumption of a Ricardian production technology for each producer, the opportunity cost of good 1 is constant in terms of good 2. Moreover, regardless of the wealth level, this opportunity cost is the same across producers and equal to $(1-\theta)b$. As a result, $p = (1-\theta)b$. Inserting this price into individual income constraint (10) yields $y(i) = (1-\theta)\hat{z}_2(i) - c(p)d(i)$.

With trade, we consider the case of a small open economy. The world price of good 1 is fixed at p^T. There are two cases to consider.

One possibility is that $p^T \geq (1-\theta)b$, in which case only good 1 is produced. There is no pollution in equilibrium. Hence, $d(i)^* = 0$ and individual net income is equal to $y(i) = p^T(\hat{z}_2(i)/b)$. Individual welfare is thus measured with the indirect utility function and there is no further choice to make at the individual level. Note however that whether p^T is larger or smaller than $(1-\theta)b$ depends on the stringency of environmental regulation. We will need to reconsider this case later on when we analyze the choice of environmental policy.

The other possibility is that $p^T < (1-\theta)b$. In this case, only good 2 is produced and there is pollution in equilibrium. Individual i's net income is thus equal to $y(i) = (1-\theta)\hat{z}_2(i) - c(p)d(i)$.

In the cases of both trade with $p^T < (1-\theta)b$ and autarky, net income is expressed as a function of the level of environmental defensive effort only. The problem of an individual simply reduces to choosing $d(i)$ in order to maximize welfare, i.e.

$$\max_{d(i)} V(i) = \ln(v(p)y(i)) - (\delta_0 - \delta_1 d(i))Q, \tag{12}$$

$$\text{s.t. } y(i) = (1-\theta)\hat{z}_2(i) - c(p)d(i). \tag{13}$$

The first-order conditions for an interior solution are[7]

$$\frac{\partial V(i)}{\partial d(i)} = \frac{-c(p)}{y(i)^*} + \delta_1 Q = 0. \tag{14}$$

This condition simply indicates how much consumption expenditures an individual must optimally forgo at the margin if he wishes to reduce his pollution affliction. This yields

$$d(i)^* = \frac{1}{c(p)}\left[(1-\theta)\hat{z}_2(i) - \frac{c(p)}{\delta_1 Q}\right] \text{ and } y(i)^* = \frac{c(p)}{\delta_1 Q} \Leftrightarrow \frac{c(p)}{(1-\theta)\delta_1 Q} < \hat{z}_2(i) < \frac{c(p)}{1-\theta}\left[\frac{1}{\delta_1 Q} + \frac{\delta_0}{\delta_1}\right]. \tag{15}$$

As would be expected, the environmental defensive effort increases with the wealth endowment $\hat{z}_2(i)$, and pollution level Q, in the interior solution.

Rather surprisingly, net income is independent of the wealth endowment. This is due to the fact that the marginal gain from private mitigating efforts, $\delta_1 Q$, is the same for all. This means that in the interior solution, all individuals choose to spend the same amount on consumption goods, though the wealthiest are still better off because their defensive effort is larger. But since we are also interested in studying the effects of changes in consumption levels, we explicitly consider corner solutions. The solution for $d(i)^*$ in (15) yields the following two corner solutions:

$$d(i)^* = 0 \text{ and } y(i)^* = (1-\theta)\hat{z}_2(i) \Leftrightarrow (1-\theta)\hat{z}_2(i) \leq \frac{c(p)}{\delta_1 Q}, \tag{16}$$

$$d(i)^* = \frac{\delta_0}{\delta_1} \text{ and } y(i)^* = (1-\theta)\hat{z}_2(i) - c(p)\frac{\delta_0}{\delta_1} \Leftrightarrow \frac{1}{c(p)}\left[(1-\theta)\hat{z}_2(i) - \frac{c(p)}{\delta_1 Q}\right] \geq \frac{\delta_0}{\delta_1}. \tag{17}$$

Solution (16) indicates that when a person is very poor, or when environmental degradation is relatively mild, an individual prefers not to be protected at all against pollution. Conversely, solution (17) implies that a rich enough individual, or a severe pollution problem, induces one to be completely insulated against the effects of pollution.

6 The general equilibrium

6.1 The autarkic economic general equilibrium

In autarky, the supply of each good must be equal to its demand. With the assumed Cobb-Douglas forms for both consumption utility and defensive efforts, individual i's demand for

[7] It is straightforward to verify that the second-order conditions for a maximum are satisfied.

good 2 is $x_2(i) = (1-a)y^*(i)+(1-\beta)c(p)d^*(i)$. Aggregating over all individuals, the demand for good 2 adds up to

$$Z_2 = \int_0^1 [(1-a)y^*(i) + (1-\beta)c(p)d^*(i)]f(i)di. \tag{18}$$

This expression brings forth the issue of the relative *pollution intensity* of the consumption bundle versus the defensive effort bundle. If $\beta > a$, defensive efforts are less pollution intensive than the mix of consumption goods, and conversely with $\beta < a$. Now there is *a priori* no reason to believe that pollution defensive measures are any more or any less pollution intensive than the mix of consumption goods on average. For this reason, we adopt the neutral position that $\beta = a$, which greatly simplifies the analysis and allows us to concentrate on the role of endowment inequality. Indeed, we now have

$$Z_2 = \int_0^1 (1-a)(1-\theta)\hat{z}_2(i)f(i)di. \tag{19}$$

Defining the total wealth index in the economy as $\hat{Z}_2 \equiv \int_0^1 \hat{z}_2(i)f(i)di$, we write

$$Z_2 = (1-a)(1-\theta)\hat{Z}_2. \tag{20}$$

In autarky, the economic general equilibrium for a given environmental regulation θ is fully described by the following set of equations:

$$p = (1-\theta)b \tag{21}$$

$$Z_2 = (1-a)(1-\theta)\hat{Z}_2 \tag{22}$$

$$Z_1 = \frac{a}{(1-a)p}Z_2 \tag{23}$$

$$Q = h(\theta)Z_2 \tag{24}$$

and $y^*(i)$ and $d(i)^*$ are defined according to either of conditions (15), (16), or (17). The system has 6 endogenous variables $\{p, Z_1, Z_2, Q, y^*(i), d^*(i)\}$ and contains 6 equations.

6.2 The economic general equilibrium with trade

With Ricardian production technologies, trade results in complete specialization for a small open economy:

Specialization in good 1 If $p^T \geq (1-\theta)b$, we have

$$Z_2 = 0 \tag{25}$$

$$Z_1 = \hat{Z}_1, \text{ with } \hat{Z}_1 \equiv \int_0^1 \hat{z}_1(i) f(i) di \tag{26}$$

$$y^*(i) = p^T \hat{z}_1(i), \tag{27}$$

$$d^*(i) = 0, \tag{28}$$

$$Q = 0 \tag{29}$$

Specialization in good 2 If $p^T < (1-\theta)b$, we have

$$Z_1 = 0 \tag{30}$$

$$Z_2 = (1-\theta)\hat{Z}_2 \tag{31}$$

$$Q = h(\theta) Z_2 \tag{32}$$

and $y^*(i)$ and $d^*(i)$ are defined according to either of conditions (15), (16), or (17). Since the price is now exogenous, the system has 5 endogenous variables $\{Z_1, Z_2, Q, y^*(i), d^*(i)\}$ and 5 equations as well.

7 The effects of trade and environmental regulation on pollution

Since specialization in the clean good eliminates pollution completely, let us consider only the cases where trade induces a specialization in the dirty good. Given a regulation level θ, equations (22) and (31) imply that

$$Q^A = (1-a) Q^T, \tag{33}$$

where superscripts A and T respectively represent the autarky and trade values. Compared to trade, pollution in autarky is lower by a factor of $1-a$.

To study the effects of regulation on pollution, it is convenient to rewrite equations (24) and (32) as

$$Q^A(\theta) = \Gamma(\theta)(1-a)\hat{Z}_2, \tag{34}$$

$$Q^T(\theta) = \Gamma(\theta)\hat{Z}_2, \tag{35}$$

where $\Gamma(\theta) = h(\theta)(1-\theta)$. Since $\Gamma'(\theta) < 0$, higher regulation lowers pollution in both trade and autarky, though the effect in autarky is smaller by a factor $1-a$.

Result 1 *Compared to autarky and given the regulation level, trade with specialization in the dirty good induces individuals to (weakly) increase their pollution-mitigating effort.*

Proof: Given θ, trade causes both an increase in pollution Q and a decrease in the unit cost of pollution-mitigating efforts $c(p)$. From (15), this results in a higher interior $d(i)^*$. As for corner solution (16), it can be readily verified that trade's higher Q and lower $c(p)$ reduces the range of the poorest individual who do not engage in pollution-mitigating efforts. And from corner solution (17), we see that trade increases the range of individuals who completely insulate themselves from pollution.♠

8 Trade regimes and the demand for environmental regulation

We now wish to analyze how increased stringency of environmental regulation affects individuals in our general-equilibrium setting. Making use of the envelop condition, we have

$$\frac{\partial V^*(i)}{\partial \theta} = \frac{1}{v(p)y^*(i)}\left(v'(p)p'(\theta)y^*(i) + v(p)\frac{\partial y^*(i)}{\partial \theta}\right) - (\delta_0 - \delta_1 d^*(i))Q'(\theta), \tag{36}$$

$$\text{where } \frac{\partial y^*(i)}{\partial \theta} = -\hat{z}_2(i) - d^*(i)c'(p)p'(\theta). \tag{37}$$

A change in regulation generally affects individual welfare through its effect on relative prices, production possibilities, and the global pollution level. Note that the price effect $p'(\theta)$ appears in two instances as it affects both consumption and defensive expenditures; this price effect vanishes in the case of a small open economy.

Appendix A reports the expressions for $\partial V^*(i)/\partial\theta$ in both autarky and trade, while taking into account corner solutions regarding the pollution-mitigating efforts. Figure 2 illustrates those results with respect to individual wealth, where $\dot{z}_2^k$ denotes the wealthiest individual whose pollution-mitigating effort is nil, and $\ddot{z}_2^k$ denotes the poorest individual who completely insulates himself from pollution, for $k \in \{A, T\}$. Note also that $Q^{A'}(\theta) = (1-a)Q^{T'}(\theta)$ and $Q^{T'}(\theta) = \Gamma'(\theta)\hat{Z}_2$ as per (34) and (35).

FIGURE 2 HERE

In figure 2, regulation level θ has been chosen such that $1/(1-\theta) < -\delta_0 Q^{T'}(\theta)$. As a result, a range of lowest wealth individuals will demand more stringent regulation in both trade an autarky here.

Result 2 *The marginal pollution effect is (weakly) monotonously decreasing with wealth, in both trade and autarky.*

Proof: The marginal pollution effect is equal to $-(\delta_0 - \delta_1 d^{k*}(i))Q^{k'}(\theta)$, for $k \in \{A, T\}$. The result follows from the fact that $d^{k*}(i)$ is (weakly) increasing in $\hat{z}_2(i)$ as per conditions (15), (16) and (17). ♠

Result 3 *The marginal pollution effect is strictly higher with trade than autarky for low wealth individuals, while it is (weakly) lower for the rest.*

Proof: Note that the marginal pollution effect is strictly higher with trade for a range of lowest wealth individuals, while $\ddot{z}_2^A > \ddot{z}_2^T$ implies that it is (weakly) lower for higher wealth individuals. It can be verified, with a little bit of algebra, that for strictly positive values of the marginal pollution effect, the trade and autarky values can only be equal for a unique wealth level. The proof is complete by the continuity of the marginal pollution effects. ♠

Proposition 4 *The proportion of individuals that demand more environmental regulation is (weakly) lower with trade than autarky.*

Proof: In a situation where there are some individuals who prefer strictly more environmental regulation, it can be verified, through graphical inspection, that the individual who is marginally indifferent between more or less regulation is in an interior solution with respect to his pollution-mitigating expenditures. From both (40) and (43), this indifferent individual is defined by

$$\tilde{z}^k = -\frac{(\delta_0 - \delta_1 d^{k*}(\tilde{z}^k))\Gamma'(\theta)}{\delta_1 \Gamma(\theta)} \text{ for } k \in \{A, T\}. \quad (38)$$

Now for interior values of d^*, we have $d^{T*}(\hat{z}_2(i)) > d^{A*}(\hat{z}_2(i))$. Hence, $\tilde{z}^A > \tilde{z}^T$. ♠

This proposition is rather counter intuitive. Even though trade results in a more polluted environment, some individuals who preferred more stringent regulation in autarky now prefer less. But higher pollution constitutes only one of three channels through which trade affects the demand for regulation; the other two going through income and the pollution-mitigating effort. The first two effects are of opposite sign and happen to increase by the same proportion as trade opens. Hence, taken together, they do not affect the *sign* of the individual demand for regulation in a move from autarky to trade.[8] This leaves only the pollution-mitigating effort which, because it (weakly) increases with trade, reduces the sensitivity to pollution. As a result, a range of individuals who preferred strictly more regulation in autarky will prefer strictly less with trade.

Result 5 *For a range of the poorest individuals, the* intensity *of the demand for additional regulation increases with trade.*

Proof: For all those whose pollution mitigating-effort is nil with trade, the distance between marginal pollution effect and the marginal income effect increases by a factor of $1/1 - a$. Among those who protect themselves partially, the distance is zero at $\tilde{z}_2^T$. Hence, by continuity of the two curves, there must be an individual who partially protects himself and whose wealth is comprise strictly between $\dot{z}_2^T$ and $\tilde{z}_2^T$, for which the intensity of the demand for regulation is equal in autarky and trade.♠

[8] This is not to say that the *intensity* of the demand for regulation is unaffected.

Result 6 *The intensity of the demand for less regulation increases with trade for a range of the wealthiest individuals.*

Proof: This can be verified by inspection of Figure 2. (Note that there is a possible exception to this, which occurs when the price with trade is sufficiently lower than the autarky price. It that case, one can show that for a range of individuals whose wealth is located around $\ddot{z}_2^A$, the marginal income effect with trade may fall below that in autarky. We will not consider this special case further as it does not appear to be very interesting.)♠

Proposition 4, along with results 5 and 6 imply that while trade reduces the absolute number of people demanding more regulation, it increases the intensity of the demand for more stringent regulation stemming from the poorest individuals, but simultaneously increasing the intensity of the demand for less stringent regulation stemming from the richest individuals.

9 Environmental regulation, welfare and the demand for trade

In the previous section, we analyzed the effects of *local* variations of environmental regulation on individual welfare. It allowed us to decompose the welfare effects of regulation into its various sub-components. This procedure yielded a clearer picture of the *sources* of interest divergences that may exist between individuals of differing wealth when it comes to their demands for environmental regulation and the interactions with trade openness. Such local analysis, however, does not permit us to make predictions concerning people's preferred regulation level and trade regime. It is for this reason that we now turn to a *global* welfare analysis.

In order to conduct a global welfare analysis, we have performed simulations using specific functional forms that respect the model's assumptions. *A priori*, individuals differ only by their individual endowment indexed by the height $\hat{z}_2(i)$ of their respective $IPPF$. In equilibrium, of course, individual welfare differs by the individual choices of consumption and pollution mitigation effort.

FIGURE 4 HERE

Depending on parameter values, many case scenarios are possible. We have chosen to present one which we found especially illuminating. Figure 4 reports the equilibrium welfare levels V_i for three types of individuals in the economy for all regulation levels $\theta \in (0, 1)$ and for both autarky and trade. It should be noted that with the assumed international price of good 1, the regulation level with trade does not go above $\theta = 0.9$. This is because at that point, there is a shift of specialization from the dirty good to the clean good. With trade, welfare at $\theta = 0.9$ therefore represents the welfare level when only the clean good is produced in the small open economy and there is no pollution. Here are some observations that can be drawn from the represented economy:

Result 7 *i) Individuals with* average to high *wealth prefer trade over autarky, for any given stringency of pollution regulation.*

ii) If pollution regulation is sufficiently stringent, low-wealth *individuals also prefer trade over autarky. But they prefer autarky over trade if regulation is too lax.*

iii) Individuals with average to low *wealth globally prefer a regulation level equal to* $\theta = 0.59$ *for* both *autarky and trade.*

iv) With autarky, high-wealth *individuals also globally prefer a regulation level set at* $\theta = 0.59$*. But with trade, they globally prefer no environmental regulation at all.*

v) Individuals with average to low *wealth prefer autarky with regulation level around* $\theta = 0.59$ *over trade with very lax regulation.*

This set of observations leads us to conclude that even though both the rich and the poor may prefer trade over autarky, *they may not see trade with the same eyes.* The poor see trade as beneficial so long as pollution controls are still in place. But though the rich prefer trade over autarky regardless of pollution regulation levels, they may push for removing the regulation once with trade, thus making the poor worse off than with autarky.

Hence, not only do all groups' globally preferred regulation level coincide in autarky, but at that regulation level, all would demand trade liberalization. One may thus be tempted to conclude that interests converge between the rich and the poor when it comes to trade and regulation issues. The problem is that once the trade regime is in place, interests over regulation may become polarized. Of course, this effect can be anticipated by the less wealthy, so that they may try to block trade opening unless they obtain a guarantee over the regulation levels that will prevail with trade. Whether this is the case or not remains to be seen. But one can clearly see that for a country where the less wealthy have little say over regulation, opposition to trade will mount even though trade has the potential to improve everyone's welfare. It is important to realize that it is not trade that is being opposed, but rather the trade-cum-regulation package.[9] In the mean time, the poor may sadly be missing an opportunity to improve their lot with the potential gains from trade. The foregoing discussion leads us to assert the following:

Proposition 8 *The two issues of trade openness and environmental regulation cannot be dealt with separately.*

[9]The distinction is similar to the one made between the anti-globalization and alter-globalization movements.

10 Implications for the study of the political economy of the environment-trade-welfare-nexus

The previous two sections carry with them significant implications for the study of the political economy of the environment-trade-welfare nexus.

First, from section 8 one can see that the conception of, or approach to, the operation of collective choice - i.e., whether voting is strictly deterministic on a one person-one vote basis, or depends on uncertainty by the parties involved about how people will behave at the polls - will play an important role in determining whether the demand for environmental regulation increases with trade. Given a deterministic view of pure majority rule, as for example is implied by the use of a median voter model, we have seen that trade leads to reduced demands for regulation as a result of the predominance of the pollution mitigating effect: trade increases incomes, and there are more people who want the higher welfare that comes from trade with reduced environmental regulation provided that this is accompanied by more intensive private pollution mitigation.

But if this idealized view of collective choice, where intensity of preference does not matter, is replaced with a more sophisticated view, such as a probabilistic spatial voting model (see for example Coughlin and Nitzan 1981, Hinich and Munger 1994, Hettich and Winer 1999 or Adams, Merrill and grofman 2005) then it could go the other way. It is well known that in a spatial voting model, uncertainty by the parties about how people will vote opens the door for *intensity* of preference to play a role in determining the collective choice outcome. This follows as long as we reasonably assume that citizens will be more likely to vote for a party's platform the higher the individual welfare that (the party thinks) results from this platform, given that of the opposition. We may make this approach even more realistic by allowing for the fact that some groups of voters are more influential than others as a result of the problems of organizing collective action of various kinds.[10]

Then, as results 5 and 6 show, the effect of trade on demands for environmental regulation are more difficult to predict. Now the interests of the rich and the poor diverge - the rich want more trade with less regulation (and will protect themselves), while the poor want more trade and associated higher incomes, but prefer internalization of environmental externalities via government action. Moreover, the rich want less regulation more intensely with trade, while the opposite is the case for the poor. *So modeling the outcome requires that we specify how the political system effectively weights these different groups.*

The second implication follows from the observation in section 9 that one cannot predict demands for trade without also knowing what environmental regulation is to accompany trade openness. Heterogeneity of interests is also crucial here: the poor want more trade

[10] For an exploration of the importance of the difference between economic interests and political influence, see Hotte and Winer (2001).

and the extra income that goes with it, but only if there is sufficient regulation to deal with environmental externalities. Richer votes want more trade too, but without regulation. This means that for an understanding of the demand for trade, it is necessary to understand the choice of at least two policy instruments: regulation of environmental externalities, and regulation of the degree of trade openness (as, for example, through a tariff or nontariff barrier). Furthermore, since these instruments are not linked by a government budget or other constraint, it is necessary to cope with a multi-dimensional issue space of the sort that a median voter model cannot deal with.

In his interesting survey of work on trade integration, Verdier (2004) argues that trade openness affects a government's ability to redistribute, so that it is not possible to discuss the politics of globalization without also considering those of internal redistribution. Our analysis is analogous while being more specific: the demands for regulation of the environment and for regulation of trade are intimately connected and so must be considered together.

11 Conclusions

In the analytical framework we have proposed, the heterogeneous demands for regulation of environmental externalities among citizens of different incomes depend importantly on the cost of private mitigation. To better isolate this key role of private mitigation, we have broken the link between factor endowments and citizen interests employed in much of the existing literature on trade and the environment. This is because private mitigation depends solely on total individual income, regardless of its source.

We have shown that trade with specialisation in the dirty good may polarize interests between the wealthy and the poor when it comes to environmental regulation. This is because even though trade increases pollution, the possibility of using some of the extra income for private pollution mitigation may allow the wealthiest to actually be less affected by pollution. Poorer individuals may not be in a position to afford such protection against pollution even after benefitting from trade gains.

It follows from this analysis of the demands for regulation that the demands for trade openness are also heterogeneous. For it matters what kind of trade - with what degree of internalization via regulation - one is considering when analyzing who is in favor and who is against more openness. For instance, we have shown that even when all could simultaneously benefit from trade openness, lower income individuals may try to block trade if they anticipate that wealthy individuals will push for lax environmental regulation with trade.

The heterogeneity of demands among the population, both in direction and with respect to intensity of preference, poses interesting challenges for the study of the political economy of the environment and trade. Heterogeneity of demands cannot be dealt with by using a median voter model if one thinks that collective action does take intensity of preference into account. Nor can a complete model be content with the analysis of just one policy instrument - both regulation of the environment and of trade openness are clearly connected.

In this paper, the multi-dimensionality of the policy issue space is finessed by focusing on the demands for regulation, and for trade openness given regulation, without specifying a full political equilibrium. We think that the careful analysis has helped to reveal the directions in which it will be fruitful to move in characterizing a full, multi-dimensional political analysis of the environment-trade-welfare nexus.

12 Acknowledgements

APPENDIX

A Effect of regulation on individual welfare

With trade and specialization in the dirty good, we have

$$\frac{\partial V^{T*}(i)}{\partial \theta} \begin{cases} = -\dfrac{1}{1-\theta} - \delta_0 \Gamma'(\theta)\hat{Z}_2 \text{ when } \hat{z}_2(i) \leq \dot{z}_2^T, & (39) \\ = -\hat{z}_2(i)\delta_1\Gamma(\theta)\hat{Z}_2 - (\delta_0 - \delta_1 d^*(i))\Gamma'(\theta)\hat{Z}_2 \text{ when } \dot{z}_2^T < \hat{z}_2(i) < \ddot{z}_2^T, & (40) \\ = -\dfrac{\hat{z}_2(i)}{(1-\theta)\hat{z}_2(i) - c(p^T)\frac{\delta_0}{\delta_1}} < 0 \text{ when } \hat{z}_2(i) \geq \ddot{z}_2^T, & (41) \end{cases}$$

where $\dot{z}_2^T \equiv \frac{c(p^T)}{(1-\theta)\delta_1 Q^T(\theta)}$ and $\ddot{z}_2^T \equiv \frac{c(p^T)}{1-\theta}\frac{\delta_0}{\delta_1} + \dot{z}_2^T$.

In autarky, we have

$$\frac{\partial V^{A*}(i)}{\partial \theta} \begin{cases} = -\dfrac{1-a}{1-\theta} - \delta_0 \Gamma'(\theta)(1-a)\hat{Z}_2 \text{ when } \hat{z}_2(i) \leq \dot{z}_2^A, & (42) \\ = -\hat{z}_2(i)\delta_1\Gamma(\theta)(1-a)\hat{Z}_2 - (\delta_0 - \delta_1 d^*(i))(1-a)\Gamma'(\theta)\hat{Z}_2 \text{ when } \dot{z}_2^A < \hat{z}_2(i) < \ddot{z}_2^A, & (43) \\ = -\dfrac{(1-a)\hat{z}_2(i)}{(1-\theta)\hat{z}_2(i) - c(p^A)\frac{\delta_0}{\delta_1}} < 0 \text{ when } \hat{z}_2(i) \geq \ddot{z}_2^A, & (44) \end{cases}$$

where $\dot{z}_2^A \equiv \frac{c(p^A)}{(1-\theta)\delta_1 Q^A(\theta)}$ and $\ddot{z}_2^A \equiv \frac{c(p^A)}{1-\theta}\frac{\delta_0}{\delta_1} + \dot{z}_2^A$.

Note that since $Q^T > Q^A$ and $c(p^T) < c(p^A)$, we have $\dot{z}_2^A > \dot{z}_2^T$ and $\ddot{z}_2^A > \ddot{z}_2^T$. This is consistent with the fact that because there is more pollution with trade, people will tend to spend (weakly) more on defensive efforts than with autarky.

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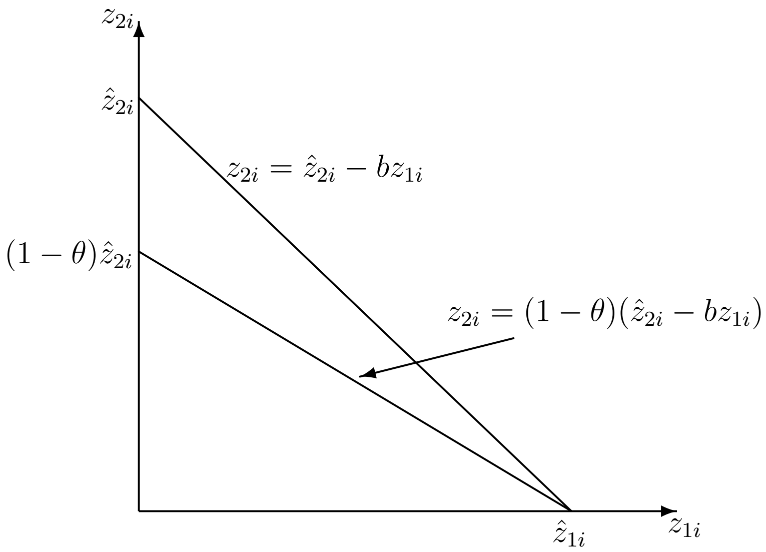

Figure 1: Environmental regulation and the individual production possibility frontier

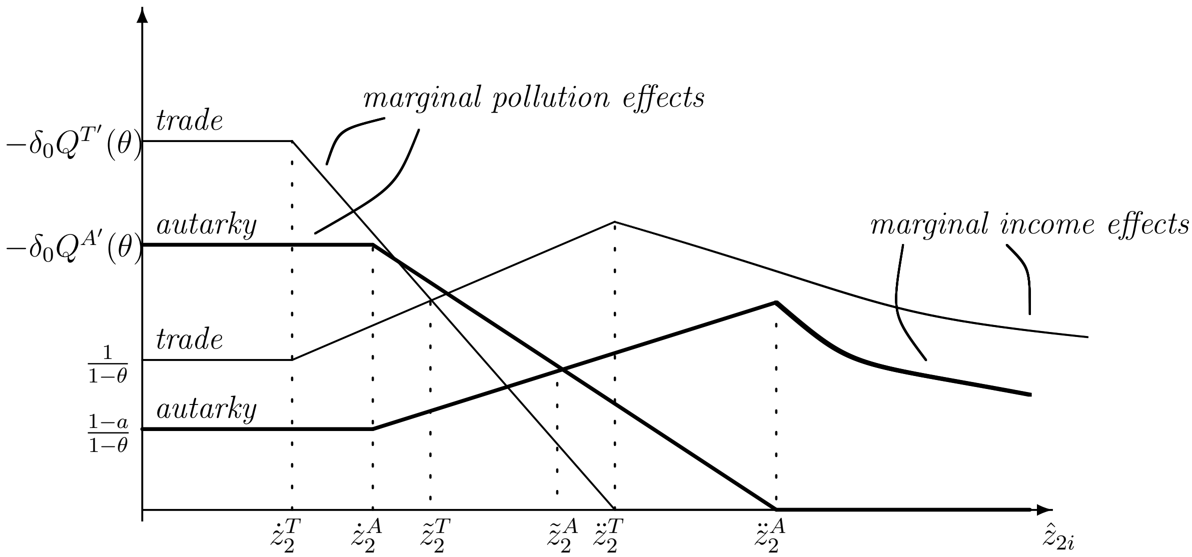

Figure 2: Demand for pollution regulation and individual wealth in autarky and trade

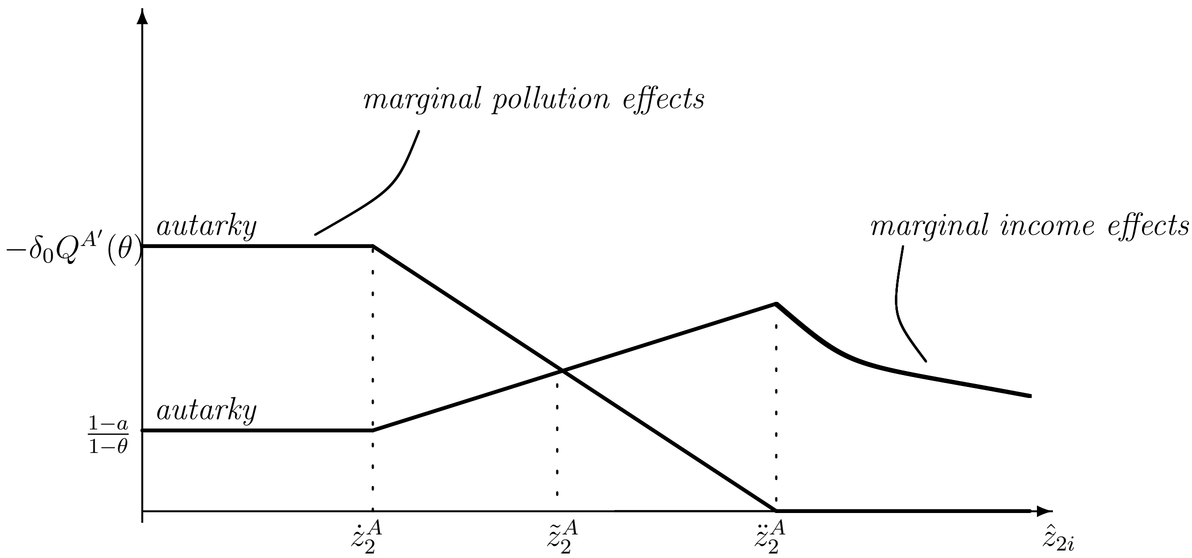

Figure 3: Demand for pollution regulation and individual wealth in autarky