The Demands for Environmental Regulation and for Trade in the Presence of Private Mitigation

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Abstract

We study the nature of individual demands for environmental regulation and for trade openness in the general equilibrium of a small open economy where the environment is an input to production. Differences in the ability of individuals to afford private mitigation of the adverse consequences of pollution is a central feature of the analysis. Private mitigation leads to an endogenous, unequal distribution of the health-related consequences of pollution across income groups in a manner consistent with epidemiologic studies, in contrast to much of the literature which assumes equal health effects for all. We show that when private mitigation is possible at a cost, trade polarizes the interests of rich and poor with respect to the stringency of regulation. Moreover, even though trade has the potential to benefit everyone, the poor may oppose trade openness because of a concern that laxer environmental regulation will then be imposed in the interest of the rich. We explain why heterogeneity in the *intensity* of preferences, and not just in their direction, is likely to play a role in the determination of collective choices with respect to the regulation of the environment and of trade. We conclude by drawing out the implications of the analysis for the study of the political economy of the environment-trade-welfare nexus.

JEL Code: D7, F18, Q56.

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

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1 Introduction

In this paper, we analyze the demands by individuals of varying incomes for environmental regulation and for trade openness. The setting is that of a small open economy in which the pattern of trade depends on the extent to which the environment is used up in production. The differential ability of individuals to privately mitigate the adverse consequences of pollution at a cost is a key characteristic of the analysis.

According to epidemiologic studies, the adverse health effects of pollution are not equally distributed across the population, as those with lower socioeconomic status tend to suffer a heavier health burden.[1] For this reason, we might expect that individual demands for environmental regulation will be more intense among lower income groups. Similarly, whenever a country's comparative advantage lies with the production of goods that are pollution-intensive, it is reasonable to expect that opposition to trade openness will be stronger among lower income citizens.

Simple application of economic theory, on the other hand, teaches us that poorer individuals will demand laxer environmental regulation if environmental quality is a normal good.[2] There is no reason to believe that environmental quality is not a normal good. But in the light of the epidemiologic studies, that this characteristic of the environment leads poorer individuals to always demand, in the end, less stringent environmental regulation does not seem like a sensible conclusion.[3] Indeed, a similarly straightforward application of the normal good argument could also lead one to infer that wealthier indi-

[1]See, for instance, the empirical evidence in Ash and Fetter (2004), Pearce et al. (2006), Brooks and Sethi (1997), Neidell (2004), Jayachandran (2008) and Evans and Smith (2005) and the reviews of Brunekreef and Holgate (2002) and O'neill et al. (2003).

[2]This is the reasoning behind Larry Summers' fateful 1991 memo at the IMF, which advanced that it may make sense for dirty industries to move South. In the theoretical literature, Copeland and Taylor (1994) have shown that, based on the normal-good argument, a representative individual in a poor country optimally chooses lower environmental standards and thus specializes in dirtier industries. The assumption here is that all externalities are somehow internalized. If that is not the case, and at the other end of this normative literature, is the analyses of Pethig (1976) and Chichilnisky (1994) who take as given that environment standards are lower in some countries for exogenous reasons. Hence, although these countries (also) attract dirtier industries, in their frameworks one cannot be sure that trade does not lower welfare; it depends on what drives the choice of standards.

[3]Kahn and Matsusaka (1997) provide convincing empirical evidence based on voting patterns in California.

viduals demand more restricted trade than the poor because it causes too much pollution.

In our view, the normal-good reasoning, though correct in principle, is missing two important elements that are required for a fuller understanding of the environment-trade-welfare nexus, which are addressed here. The missing elements are the multi-dimensionality of individual interests – in the regulation of the environment and of trade – and their heterogeneity both in terms of direction and intensity.

To introduce and study both elements, we incorporate the fact that the impact of pollution on health can be privately mitigated at a cost. This straightforward consideration has far-reaching implications. First of all, it yields an endogenous, unequal distribution of the health related consequences of pollution across income groups in a manner consistent with epidemiologic studies, in contrast to much of the literature which assumes equal health effects for all.[4] Secondly, it leads to a general equilibrium in the small open economy analyzed here in which the normal-good-based prediction about the relationship between income levels and the demand for regulation, of either the environment or of trade, does not always hold.[5]

Our approach includes another unusual feature, one not found in most of the existing frameworks used for the political-economic analysis of trade. We assume that, a priori, individuals differ only by the magnitude of their claims on national income. We thus take a different route than those who blend classical Heckscher-Ohlin theory with a median-voter or other model of public policy by identifying interests in the electorate primarily with capital-labor ratios.[6] The reason is that individual interests in our framework depend importantly on the ability to privately mitigate the effects of pollution, and this ability is a function of income whatever its source.

The analysis is conducted using a model of a small-open economy with Ricardian production technology in which private mitigation is embedded.

[4] Existing political-economic analyses of the relationship between the environment and trade typically assume equal health effects for all (see Fredriksson (1997), Aidt (1998), Schleich (1999), McAusland (2003) and Copeland and Taylor (2003)). And yet, news stories about how it is the poorest within the developing countries which are affected by pollution are legion (see, for instance, Bernard (2006), Bradsher and Barboza (2006), French (2005) or The Economist (2005)).

[5] For a theoretical perspective on optimal environmental regulation in the presence of private mitigation, see Coase (1960), Shibata and Winrich (1983) and McKitrick and Collinge (2002).

[6] See, for instance, Mayer (1984) and McAusland (2003).

For a given degree of environmental regulation, we show that even where trade openness leads to a more polluted environment compared to autarky, the demand for pollution regulation can be weaker for a range of high-income individuals. This is because the additional income that trade generates allows them to be much better insulated from pollution. But since the trade gain effect may be weaker for low-income individuals, more trade may also strengthen their demand for environmental regulation, and thus increase the polarization of interests.

The foregoing does not imply that the poor necessarily lose from trade. To see why, we begin with a case in which interests over regulation stringency in autarky are similar across all income groups. We then show that by fixing regulation at the overall autarky-preferred level, trade has the potential to improve welfare for people at all income levels. The problem is that environmental regulation can be changed and, in our example, interests over regulation do diverge with trade. The newly preferred regulation level for high-income individuals, if chosen, decreases welfare for low-income individuals when compared to the autarkic equilibrium. As a result, if the high-income group has its way over pollution regulation, trade then makes low-income individuals worse off. The poor may thus attempt to block freer trade even though it has the potential to improve aggregate welfare.[7]

The paper is organized as follows. In section 2, we define individual welfare and introduce the production and pollution-mitigating technologies. We solve for individual consumption and defensive effort decisions in section 3, allowing for corner solutions where no private defense, or a complete defense may occur. These elements are introduced into a general equilibrium framework in sections 4 and 5 for both a closed and a small-open economy. In section 6, we consider the effects on individual welfare of changes in the stringency of environmental regulation, and in 7 we study the role of trade regimes in determining the demand for environmental regulation. Using simulation, in section 8 we analyze the relationship between environmental regulation, the demand for trade openness and welfare. We conclude by drawing out the general implications of the analysis for the study of the political economy of the relationship between the environment and trade.

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[7] It is of interest to note that this result is consistent with the shift of emphasis from anti- to alter-*mondialisation* among some French globalization protest movements. They do not oppose trade *per se*, but rather the type of trade that they observe.

2 The model

2.1 Individual welfare

In its bare form, individual welfare depends positively on the health condition and the consumption of goods and services, though at a decreasing rate for the latter. Let $U(i)$ denote the welfare level of individual i, $x(i)$ his consumption level and $h(i)$ his health condition. We have

$$U(i) = U(x(i), h(i)), \text{ with } U_x > 0, U_{xx} < 0, U_h > 0. \tag{1}$$

Pollution has adverse consequences on health, but this can be *privately* mitigated at a cost.[8] With a decreasing marginal utility of consumption, environmental quality is a normal good. Let Q denotes the economy-wide pollution level and $d(i)$ the pollution mitigation effort for i. We have

$$h(i) = h(d(i), Q), \text{ with } h_Q \leq 0 \text{ and } h_d \geq 0. \tag{2}$$

For the general-equilibrium analysis, we shall adopt a logarithmic form for consumption utility and a linear form for private mitigation; that is,

$$U(i) = \ln(x(i)) - (\delta_0 - \delta_1 d(i))Q. \tag{3}$$

Parameters δ_0 and δ_1 summarize the private-mitigation technology. In the absence of pollution ($Q = 0$), or with maximum private mitigation ($d(i) = \delta_0/\delta_1$), i's health condition attains its maximum. With $Q > 0$, the extent to which i's health is affected by pollution decreases with his own pollution-mitigation effort $d(i)$.

2.2 The production technology

We assume an economy with two types of goods, denoted 1 and 2. Good 2 is a dirty good in the sense that its production increases pollution while good 1 is clean and does not pollute at all. Production uses a *ricardian* technology as represented by the following national production possibility frontier (PPF):

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

[8] Examples of pollution mitigation measures include choice of house location, installation of household water filtration system, drinking bottled water, fetching water at a distance, chlorine pills, air cleaning system, weekends at the mountain, asthma medicines, etc. See, for instance, Neidell (2004), Hanna (2007) and Rosado (2006).

where Z_2 and Z_1 respectively denote the aggregate outputs 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 $\hat{Z}_2$ measures the height of the PPF (an index of the country's total production capacity). With good 2 as the numéraire good and good 1 selling at price p, the national income is

$$Y = pZ_1 + Z_2. \tag{5}$$

2.3 Individual income

The economy is composed of a continuum of individual types indexed by $i \in [0, 1]$ and distributed according to density function $f(i)$. The total population size normalized to one. *A priori*, individuals differ solely by their *claim* on the national income, which is expressed as the exogenous share $\alpha(i)$. Individual income is thus

$$y(i) = \alpha(i)Y. \tag{6}$$

Individuals are ranked so that $\alpha(i)$ is non-decreasing in i. Note that this representation of heterogeneity allows us to concentrate on individuals' divergent interests based solely on wealth differences and do away with differences in the sources of income, such as the capital-labor ratios.

Remark: We could equivalently assume that each individual can produce either of the two goods using the same ricardian production technology. The *individual* production possibility frontier is then given by

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

where $z_2(i)$ and $z_1(i)$ respectively denote individual i's output of goods 2 and 1, while $\hat{z}_2(i)$ is a *measure* of individual i's wealth. We then have $\hat{Z}_2 \equiv \int_0^1 \hat{z}_2(i)f(i)di$ and $\alpha(i) = \hat{z}_2(i)/\hat{Z}_2$. Both formulations are equivalent under price-taking behavior.

2.4 Individual expenditures

Let goods 1 and 2 be imperfect substitutes as consumption goods. We represent this by using the following Cobb-Douglas form: $x(i) = x_1(i)^a x_2(i)^{1-a}$, where $x_1(i)$ and $x_2(i)$ respectively denote the quantities of goods 1 and 2 being used for consumption. Consumption expenditures are thus given by

$e(i) = c(p)x(i)$, where $c(p) = a^{-a}(1-a)^{a-1}p_A$. We shall also make use of the fact that $x(i) = v(p)e(i)$, where $v(p) = 1/c(p)$.

In a similar fashion, goods 1 and 2 are used as imperfect substitutes in order to attain a level $d(i)$ of private pollution-mitigation effort. This is represented by the following Cobb-Douglas technology: $d(i) = d_1(i)^{\beta} d_2(i)^{1-\beta}$, where $d_1(i)$ and $d_2(i)$ respectively denote the quantities of goods 1 and 2 being used for pollution mitigation. To simplify, we shall assume that $a = \beta$.[9] Private mitigation expenditures are thus equal to $c(p)d(i)$. This yields the following individual budget constraint:

$$e(i) \leq \alpha(i)Y - c(p)d(i). \tag{8}$$

2.5 Pollution and its regulation

In the absence of environmental regulation, the economy-wide pollution level Q is simply given by $Q = Z_2$; that is, each unit of good 2 produces one unit of pollution. Environmental regulation requires the suppliers of good 2 to produce in a cleaner way. Some productive resources must be devoted to either cleaning up along the production process or using more sophisticated, cleaner production techniques. Either way, in comparison to the no-intervention case, environmental regulation has two direct effects:

i) A benefit in the form of less pollution for any production level Z_2;

ii) A cost in the form of more inputs necessary to achieve any output level Z_2.

Let us define the stringency of environmental regulation as a continuous variable $\theta \in (0, 1)$. $\theta = 0$ imposes no restriction on emissions, while $\theta = 1$ is an obligation to abate all emissions. The benefits and costs of regulation are represented as follows:

$$\text{Benefit: } Q = h(\theta)Z_2, \text{ with } h'(\theta) < 0, \ h(0) = 1 \text{ and } h(1) = 0; \tag{9}$$

$$\text{Cost: } Z_2 = (1-\theta)(\hat{Z}_2 - bZ_1). \tag{10}$$

[9] This assumption raises the issue of the relative *pollution intensity* of the consumption bundle versus the pollution mitigation effort bundle. If $\beta > a$, then mitigation efforts are less pollution intensive than the mix of consumption goods, and conversely for $\beta < a$. But 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 also simplifies the analysis.

One may note, from (10), that regulation results in a downward shift of the PPF: for any given amount of Z_1 produced, less of Z_2 is produced. Moreover, a pollution-free output of good 2 is prohibitively costly. 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. The maximum amount of the clean good that can be produced is not affected by environmental regulation. We shall refer to equation (10) as the *regulated* production possibility frontier ($RPPF$). Figure 1 illustrates the effect of environmental regulation on the $RPPF$.

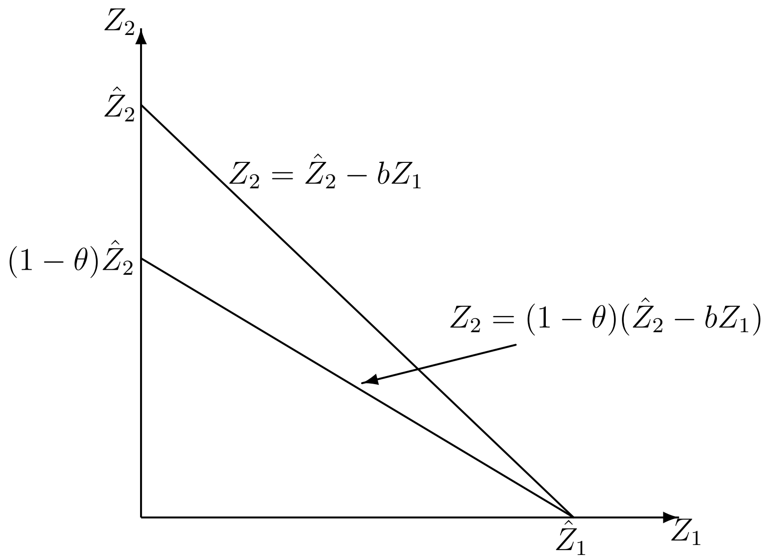

Figure 1: The regulated production possibility frontier

3 Output and consumption decisions

We assume price-taking behavior throughout.

3.1 The production decisions

3.1.1 Autarky

Under the assumption of a ricardian technology, the opportunity cost of good 1 is constant in terms of good 2 and equal to $(1-\theta)b$. Therefore, if both goods are produced, we have $p_A = (1-\theta)b$. The autarky national income is $Y_A = (1-\theta)bZ_1 + Z_2$. Substituting the $RPPF$ in (10), we obtain

$$Y_A = (1-\theta)\hat{Z}_2, \tag{11}$$

where subscript A refers to autarky.

3.1.2 Trade

We consider the case of a small open economy. The world price of good 1 is fixed at p_T. There are two polar cases to consider.

Specialization in the clean good If $p_T \geq (1-\theta)b$, only good 1 is produced and there is no pollution in equilibrium. The national income is given by

$$Y_T = p_T \frac{\hat{Z}_2}{b}, \tag{12}$$

where subscript T refers to trade.

Specialization in the dirty good If $p_T < (1-\theta)b$, only the dirty good is produced and there is pollution in equilibrium. The national income is given by

$$Y_T = (1-\theta)\hat{Z}_2. \tag{13}$$

Note that whether p_T is larger or smaller than $(1-\theta)b$ depends on the stringency of environmental regulation.

3.2 The consumption decisions

With the assumed Cobb-Douglas forms for both $x(i)$ and $d(i)$, the quantities demanded for goods 1 and 2 are, respectively, $a\alpha(i)Y/p$ and $(1-a)\alpha(i)Y$.

We now have to solve for the distribution of expenditures between consumption and pollution mitigation. Substituting for $x(i) = v(p)e(i)$ into the utility function, the individual problem can be expressed as

$$\max_{\{e(i),d(i)\}} V(i) = \ln(v(p)e(i)) - (\delta_0 - \delta_1 d(i))Q \tag{14}$$

$$\text{s.t. } e(i) = \alpha(i)Y - c(p)d(i). \tag{15}$$

The individual takes prices, pollution, environmental regulation and national income as given. Substituting $e(i)$ for the budget constraint, the problem of an individual reduces to choosing $d(i)$. The first-order condition for an interior solution is[10]

$$\frac{\partial V(i)}{\partial d(i)} = -\frac{c(p)}{e^*(i)} + \delta_1 Q = 0. \tag{16}$$

This condition simply equates the marginal welfare loss from a lower consumption level to the health gain from an increase in the pollution mitigation effort. Given that we must have $0 \leq d(i) \leq \delta_0/\delta_1$, we obtain the following interior and corner solutions:

$$d^*(i) = 0; \qquad e^*(i) = \alpha(i)Y \qquad \text{iff } \alpha(i) \leq \underline{\alpha}, \tag{17}$$

$$d^*(i) = \frac{\delta_0}{\delta_1}; \quad e^*(i) = \alpha(i)Y - c(p)\tfrac{\delta_0}{\delta_1} \quad \text{iff } \alpha(i) \geq \bar{\alpha}, \tag{18}$$

$$d^*(i) = \frac{\alpha(i)Y}{c(p)} - \frac{1}{\delta_1 Q}; \qquad e^*(i) = \tfrac{c(p)}{\delta_1 Q} \qquad \text{otherwise}, \tag{19}$$

where

$$\underline{\alpha} = \frac{c(p)}{Y}\frac{1}{\delta_1 Q}, \tag{20}$$

$$\bar{\alpha} = \frac{c(p)}{Y}\left[\frac{1}{\delta_1 Q} + \frac{\delta_0}{\delta_1}\right]. \tag{21}$$

According to corner solution (17), relatively poor individuals whose income share falls below $\underline{\alpha}$ choose not to spend on pollution mitigation because of their high marginal utility of consumption. Conversely, solution (18) denotes relatively wealthy individuals with income shares above $\bar{\alpha}$ who choose to be completely insulated from the effects of pollution. Interior solution (19) represents middle-income individuals who opt for a partial protection against pollution. Note how the pollution level also tends to increase the pollution-mitigation effort. The welfare maximization solution allows us to assert the following:

Proposition 1 *The environmental defensive effort (weakly) increases with pollution and individual income, while the converse holds for consumption expenditures.*

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

We obtain the following indirect utility function:

$$\begin{aligned} &= \ln(v(p)\alpha(i)Y) - \delta_0 Q \text{ iff } \alpha(i) \leq \underline{\alpha}, \\ V^*(p, y(i), Q) &= \ln\left(v(p)\alpha(i)Y - \frac{\delta_0}{\delta_1}\right) \text{ iff } \alpha(i) \geq \bar{\alpha}, \\ &= \ln\left(\frac{1}{\delta_1 Q}\right) - \left[\delta_0 - \delta_1\left(\frac{\alpha(i)Y}{c(p)} - \frac{1}{\delta_1 Q}\right)\right] Q \text{ otherwise.} \end{aligned} \tag{22}$$

4 The general equilibrium

4.1 The general equilibrium in autarky

In autarky, the supply of each good must be equal to its aggregate demand. We thus have

$$Z_{2A} = \int_0^1 (1-a) Y_A \alpha(i) f(i) di, \tag{23}$$

$$= (1-a)(1-\theta)\hat{Z}_2, \tag{24}$$

where (24) is obtained using expression (11) for the national income. In autarky, given θ, the economic general equilibrium is fully described by the following set of equations:

$$p^A = (1-\theta)b, \tag{25}$$

$$Z_{2A} = (1-a)Y_A, \tag{26}$$

$$Z_{1A} = \frac{aY_A}{p}, \tag{27}$$

$$Q_A = h(\theta) Z_{2A}, \tag{28}$$

$$Y_A = (1-\theta)\hat{Z}_2 \tag{29}$$

and $e^*(i)$ and $d^*(i)$ are defined according to either of conditions (19), (17), or (18). The system has 7 endogenous variables $\{p_A, Y_A, Z_{1A}, Z_{2A}, Q_A, e^*(i), d^*(i)\}$ and contains 7 equations.

4.2 The general equilibrium with trade

4.2.1 Specialization in the clean good

As shown in section 3.1.2, we have $p_T \geq (1-\theta)b$. In the absence of pollution, we have $d^*(i) = 0$ and individual consumption spending is $e(i) = \alpha(i)Y_T =$

$p_T(\alpha(i)\hat{Z}_2/b)$ (see (12)). In this case, consumers do not have any decision to make; they just spend all their income on consumption goods. Note that this is consistent with corner solution (17) when $Q \to 0$. Note further that whether p_T is larger or smaller than $(1-\theta)b$ depends on the stringency of environmental regulation; as a consequence, whether this outcome obtains or not hinges on the choice of θ, which can only be explained by the addition of a political equilibrium concept; we shall discuss this point in a later section. For now, the general equilibrium with trade and specialization in the clean good is summarized by the following system:

$$Z_{2T} = 0, \tag{30}$$

$$Z_{1T} = \frac{\hat{Z}_2}{b}, \tag{31}$$

$$e^*(i) = \alpha(i)Y_T, \tag{32}$$

$$d^*(i) = 0, \tag{33}$$

$$Q_T = 0, \tag{34}$$

$$Y_T = \frac{p_T}{b}\hat{Z}_2 \tag{35}$$

4.2.2 Specialization in the dirty good

We now have $p_T < (1-\theta)b$ and the country produces only good 2. There is pollution in this trade equilibrium, which is summarized by the following system:

$$Z_{1T} = 0, \tag{36}$$

$$Z_{2T} = (1-\theta)\hat{Z}_2, \tag{37}$$

$$Q_T = h(\theta)Z_{2T}, \tag{38}$$

$$Y_T = (1-\theta)\hat{Z}_2 \tag{39}$$

with $e^*(i)$ and $d^*(i)$ being determined according to either of conditions (19), (17), or (18). Since the price is now exogenous, the system now has 6 endogenous variables $\{Y_T, Z_{1T}, Z_{2T}, Q_T, e^*(i), d^*(i)\}$ and 6 equations as well.

5 Trade regimes and the effect of environmental regulation on pollution

Since specialization in the clean good eliminates pollution completely, we concentrate on the more interesting case where trade induces a specialization in the dirty good. For a given regulation level θ, equations (26) and (37) imply that

$$Q_A(\theta) = (1 - a)\Gamma(\theta)\hat{Z}_2, \tag{40}$$

$$Q_T(\theta) = \Gamma(\theta)\hat{Z}_2, \tag{41}$$

where $\Gamma(\theta) \equiv h(\theta)(1-\theta)$. As should be expected, regulation affects pollution through two channels: the cleaner technology effect and the higher production cost effect. Since both tend to reduce pollution, we have $\Gamma'(\theta) < 0$. Pollution in autarky is a fraction $1 - a$ of the trade level. This difference is due to the fact that in autarky, the supply for each good must match its demand, thus determining the relative output proportions between the clean and dirty goods. With trade, however, demand and supply are disjoint. In the case of a ricardian production technology, full specialization in the production of good 2 results in a jump in pollution equal to a fraction a of its output, precisely the share of the demand corresponding to good 1. This leads us to assert the following:

Proposition 2 *The pollution-reducing effect of an increase in regulation stringency is smaller in autarky by a fraction* $1 - a$ *of the effect with trade and specialization in the dirty good.*

Proof: It derives directly from equations (40) and (41).■

Proposition 3 *Compared to autarky and for a fixed regulation level, trade with specialization in the dirty good induces individuals to (weakly) increase their pollution-mitigation effort.*

Proof: First, note that with specialization in the dirty good, we have $Y_T = Y_A$. Given θ, trade causes both an increase in pollution Q and a decrease in the unit cost $c(p)$ of the pollution-mitigating effort. From (19), this results in a higher interior $d^*(i)$. As for corner solutions (17) and (18), it can be readily verified from (20) and (21) that trade's higher Q and lower $c(p)$ reduces $\underline{\alpha}$ and increases $\bar{\alpha}$.■

6 The welfare effects of environmental regulation

We now wish to analyze how increased stringency of environmental regulation affects individual welfare in the general-equilibrium setting, assuming no shift in production specialization for the case of trade. We generally have

$$\frac{d}{d\theta}V^*(p,y(i),Q) = \underbrace{\left[\frac{\partial V^*(i)}{\partial p}p'(\theta) + \frac{\partial V^*(i)}{\partial y}\alpha(i)Y'(\theta)\right]}_{\text{price-income effect}} + \underbrace{\left[\frac{\partial V^*(i)}{\partial Q}Q'(\theta)\right]}_{\text{health effect}} \tag{42}$$

The impact of regulation on individual welfare reveals itself through prices, income and pollution. To gain insight, we analyze the *price-income* effect, given by the first term between square brackets, separately from the *health effect*, given by the second term between square brackets.[11] In the general equilibrium, we have

$$p'_A(\theta) = -b \text{ and } p'_T(\theta) = 0 \text{ for a small open economy,} \tag{43}$$
$$Y'_A(\theta) = Y'_T(\theta) = -\hat{Z}_2, \tag{44}$$
$$Q'_A(\theta) = (1-a)\Gamma'(\theta)\hat{Z}_2 \text{ and } Q'_T(\theta) = \Gamma'(\theta)\hat{Z}_2. \tag{45}$$

In autarky and for trade with specialization in the dirty good, this yields

$$\begin{aligned} &= -\nu_k\left\{\left[\frac{1}{1-\theta}\right] + \left[\delta_0\Gamma'(\theta)\hat{Z}_2\right]\right\} \text{ iff } \alpha(i) \leq \underline{\alpha}_k, \\ \frac{d}{d\theta}V_k^*(i) &= -\nu_k\left[\frac{\alpha(i)\hat{Z}_2}{e_k^*(i)}\right] \text{ iff } \alpha(i) \geq \bar{\alpha}_k, \\ &= -\nu_k\left\{\left[\frac{\alpha(i)\hat{Z}_2}{e_k^*(i)}\right] + \left[(\delta_0 - \delta_1 d_k^*(i))\Gamma'(\theta)\hat{Z}_2\right]\right\} \text{ otherwise,} \end{aligned} \tag{46}$$

where $k \in \{A, T\}$, $\nu_A = 1-a$ and $\nu_T = 1$. In each case, the first term between square brackets denotes the price-income effect while the second one is the health effect. Note that for $\alpha(i) \geq \bar{\alpha}_k$, the pollution effect is nil since those individuals are completely insulated from pollution. We begin by analyzing the health effects.

6.1 The health welfare effects of regulation

We have the following:

[11] This approach should also be useful for the conduct of empirical work.

Proposition 4 *In both trade and autarky, the marginal health welfare gains from a more stringent pollution regulation (weakly) decrease with individual income share $\alpha(i)$.*

Proof: In the case of corner solutions, the marginal pollution effect is constant in $\alpha(i)$. In the interior solution, the marginal pollution effect is equal to $-(\delta_0 - \delta_1 d_k^*(i))Q_k'(\theta)$. The result follows from the fact that $d_k^*(i)$ is increasing in $\alpha(i), \forall k \in \{A, T\}$. ■

We now wish to compare the importance of the health welfare effects of regulation when moving from autarky to trade. In this respect, two effects oppose each other. One the one hand, there is a higher pollution reduction effect with trade than autarky (proposition 2). On the other hand, individuals tend to (weakly) increase their private-mitigation effort with trade (proposition 3). After somewhat tedious but straightforward algebra, it can be verified that there exists a unique wealth level, denoted $\dot{\alpha}$, for which the marginal health effect is non-zero and equal in both trade and autarky. Hence the following:

Proposition 5 *The health welfare effect of regulation is strictly more important with trade than autarky for individuals whose income share is below some unique value $\dot{\alpha}$, while it is (weakly) less important for all the other, wealthier individuals.*

Proof: Note that the marginal health effect is strictly higher with trade for all $\alpha(i) \leq \underline{\alpha}_T$; that is, for those who cannot afford any protection. Conversely, $\bar{\alpha}_A > \bar{\alpha}_T$ implies that it is (weakly) lower with trade for higher wealth individuals. And for a strictly positive value of the marginal health effect, the trade and autarky values are equal only at $\dot{\alpha}$. The proof is complete by the continuity of the marginal pollution effects. ■

Figure 2 summarizes proposition 5. It can be readily seen that when trade leads to a specialization in the dirty good, poorer individuals tend to receive higher health benefits from a more stringent regulation while richer ones receive lower benefits. But in order to have a complete picture of the welfare effects of regulation, we must also consider its price-income effects.

6.2 The price-income welfare effects of regulation

We begin with the following two propositions:

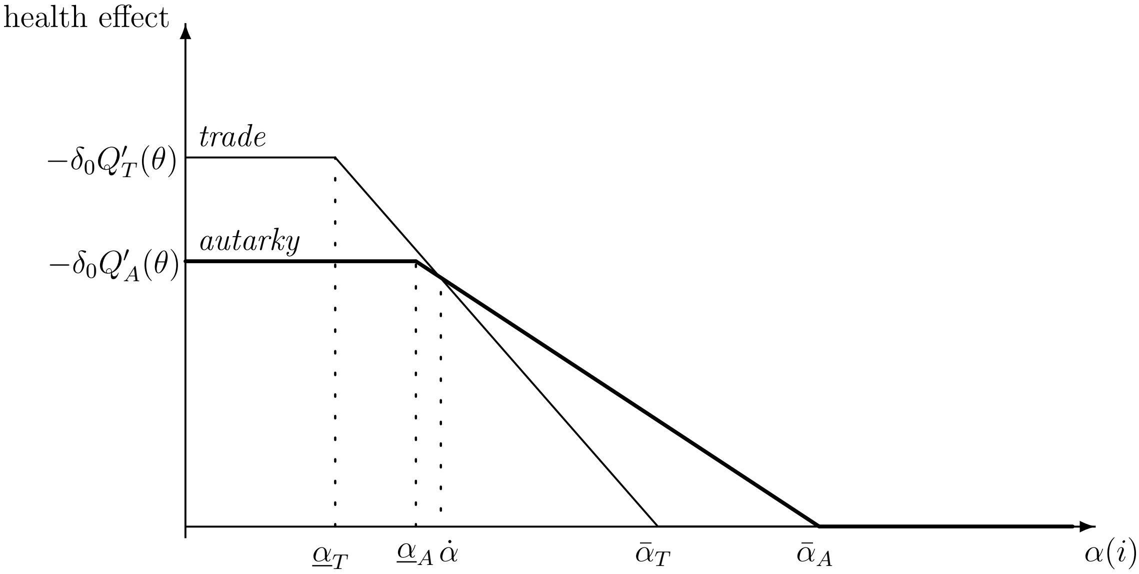

Figure 2: Marginal health welfare effect versus income share in autarky and trade

Proposition 6 *The marginal price-income effect of regulation varies non-monotonously with income shares. In absolute terms, it is (weakly) increasing at low income shares (below $\bar{\alpha}$) and decreasing at high income shares (above $\bar{\alpha}$).*

Proof: The marginal price-income effects of regulation are given by the first terms between square brackets in (46) for all income shares. Taking the derivatives with respect to $\alpha(i)$ yields the results.■

Proposition 7 *In absolute terms, the marginal price-income effect of regulation is more important with trade than autarky for all income shares below or equal to $\bar{\alpha}_T$, as well as for arbitrarily large income shares.*

Proof: The marginal price-income effects of regulation are given by the first terms between square brackets in (46) for all income shares. For $\alpha(i) \in [0, \bar{\alpha}_T]$, the result is obtained by substituting for $\nu_A = 1 - a$ and $\nu_T = 1$, and for $e_A^*(i)$ and $e_A^*(i)$ in (17) and (19). For $\alpha(i) > \bar{\alpha}_A$, one can verify that $\lim_{\alpha(i)\to\infty} dV_k^*(i)/d\theta = -\nu_k/(1-\theta)$, $\forall k \in \{A, T\}$. The result follows from the fact that $\nu_T > \nu_A$.■

Note that for intermediate income shares directly above $\bar{\alpha}_T$, we cannot say anything definite concerning the price-income effect of trade. Figure 3 summarizes propositions 6 and 7.

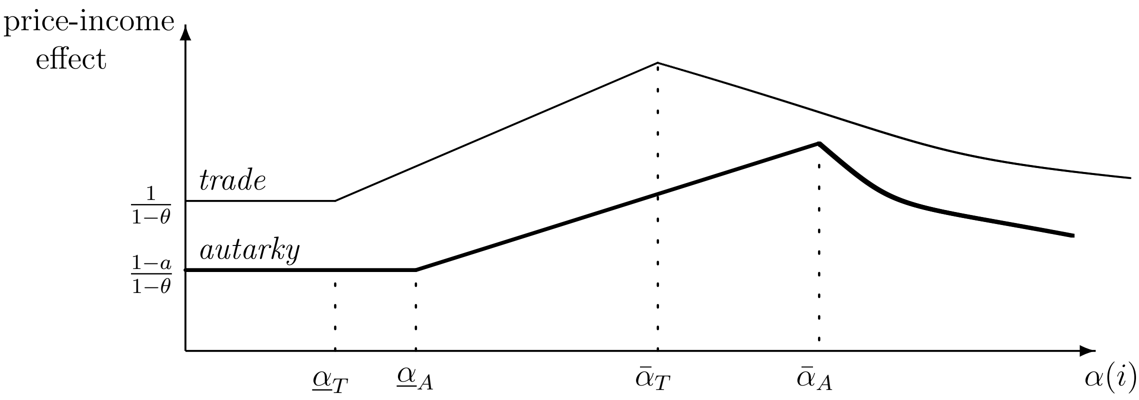

Figure 3: Marginal price-income welfare effect versus income share in autarky and trade

7 Trade regimes and the demand for environmental regulation

We would now like to analyze how trade openness affects the aggregate demand for environmental regulation. In this section, we consider the *local* effects of regulation on welfare; that is, we take the regulation level as given and compare the net marginal effect of regulation on welfare when moving from autarky to trade. In a later section, we shall consider global effects.

Note that in our analysis of the aggregate demand for regulation, we adopt a broader view than the sole change in the *number* of individuals who demand stricter or laxer regulation. Indeed, we shall consider explicitly variations in the *intensity* – or depth – of individual demands. To this end, we consider how a shift from autarky to trade affects the *relative* magnitudes of the price-income and the health effects of regulation for all income shares. We first have the following result:

Proposition 8 *The proportion of individuals that demand more environmental regulation is lower with trade than autarky.*

Proof: Let $\tilde{\alpha}_k$ denote the wealth level of an individual who is marginally indifferent between more or less regulation, given θ. From (46), it can be verified that $\tilde{\alpha}_k$, if it exists, is unique and must be in an interior solution with respect to the pollution-mitigation effort. Moreover, $\tilde{\alpha}_k$ necessarily exists if there are some individuals who would prefer strictly more environmental regulation. $\tilde{\alpha}_k$ must be such that the price-income and health effects are equal; that is,

$$\frac{\tilde{\alpha}\hat{Z}_2}{e_k^*(i)} = (\delta_0 - \delta_1 d_k^*(i))\Gamma'(\theta)\hat{Z}_2. \tag{47}$$

From (19), we have that $e_A^*(i) > e_T^*(i)$ and $d_A^*(i) < d_T^*(i)$. Hence, the LHS of (47) is higher with trade than autarky while the converse holds for the RHS. An indifferent individual in autarky will see his price-income effect of regulation strictly exceed the health effect with trade and specialization in the dirty good. The proof is made complete by the fact that the price-income effect increases with $\alpha(i)$ while the opposite holds for the health effect.■

This proposition may appear counter-intuitive. Even though trade results in a more polluted environment, some individuals who preferred more stringent regulation in autarky now prefer less. But recall that higher pollution constitutes only one channel through which trade affects the demand for regulation. One must also consider the price-income effect and the change in the pollution-mitigation effort. Under the assumptions of our model, the shift of expenditures from consumption to private mitigation induced by trade's higher pollution and income gains makes individuals in the interior solution for $d_A^*(i)$ more sensitive to the price-income losses from regulation in comparison to the health gains. Given θ, the indifferent individual in autarky thus becomes strictly negatively affected by a marginal increase in regulation with trade. One may thus be tempted to infer that trade leads to less stringent regulation. But this assumes that regulation choices be driven by numbers only. We believe that a more complete view should account for changes in *intensity* of preferences. In this respect, we have the following two propositions:

Proposition 9 *For lower income 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 gap between the marginal pollution effect and the marginal price-income effect is higher by a factor $1/(1-a)$ when opening up to trade; their demand for additional regulation is thus more intense with trade. Among those who protect themselves partially, we have determined that income share $\tilde{\alpha}_T$ denotes the marginally indifferent individuals with trade and that the same individuals demanded strictly more regulation in autarky; the intensity of their demand for additional regulation has decreased with trade. By continuity of both marginal effect curves, an income share must exist which is comprised strictly between $\underline{\alpha}_T$ and $\dot{\alpha}_T$ and for which the intensity of the demand for additional regulation is equal in both autarky and trade.■

Proposition 10 *The* intensity *of the demand for less regulation increases with trade for the highest income individuals and for a range of intermediate income levels.*

Proof: Concerning the wealthiest individuals, we have seen that for arbitrarily large income shares, the health effect is nil while the price-income effect increases with trade (proposition 7). Concerning intermediate income shares, it can be verified that although the price-income effect of regulation peaks at $\bar{\alpha}_k$ in both trade and autarky, its magnitudes is higher with trade than autarky. Hence, by continuity of the curves, individuals with income shares located next to $\bar{\alpha}_k$ on both sides are more severely and negatively affected by regulation with trade than autarky.■

On the one hand, we obtain that trade reduces the number of people demanding more regulation (proposition 8). On the other hand, trade increases the intensity of the demand for *more* stringent regulation stemming from the poorest individuals (propositions 9), while simultaneously increasing the intensity of the demand for *less* stringent regulation stemming from the richest individuals, as well as for some intermediate income levels (proposition 10). Now, if one sees regulation choices as the outcome a political bargaining process between different income groups, then merely looking at changes at the number of individuals who demand more regulation may not suffice; one must also account for individual sensitivities to regulation. In this respect, we are left with an indeterminacy concerning the impact of trade on the stringency of environmental regulation to be adopted by policy makers. The outcome will depend on how political bargaining weighs in the variations in sensitivities, as well as on the number of individuals. In this respect, the following result shall prove relevant for our understanding of the impact of trade on the adoption of environmental regulation.

Proposition 11 *Trade exacerbates the divergence of interests over environmental regulation between low and high income individuals.*

Proof: It derives directly from propositions 9 and 10.■

The essence of those results are illustrated in figure 4, where it is assumed that the following inequality holds: $1/(1-\theta) < -\delta_0 Q'_T(\theta)$, which implies that low income individuals demand more stringent regulation in autarky.

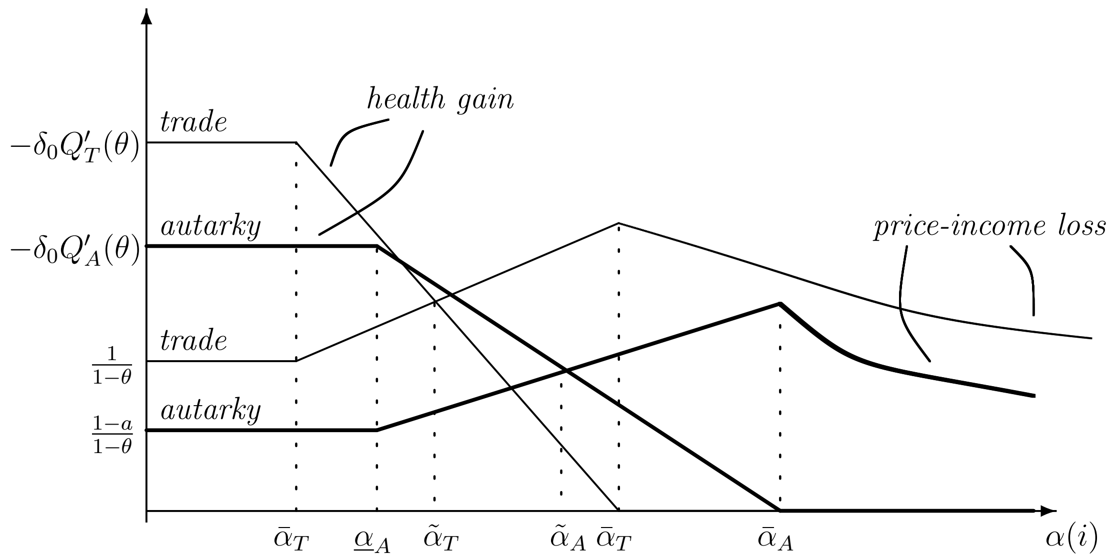

Figure 4: Health and price-income effects versus income shares and trade regime

In this section, we analyzed the effects of *marginal* variations of environmental regulation on individual welfare. It allowed us to decompose the welfare effects of regulation into its various sub-components. This procedure yields a clearer picture of the sources of interest divergence that may exist between individuals of differing income levels when it comes to their demands for environmental regulation and the interactions with trade openness. Marginal analysis, however, does not permit us to capture people's *global* preferences over regulation levels and trade regimes combined. The following section addresses this question.

8 Environmental regulation, welfare and the demand for trade

In order to conduct a global welfare analysis, we have performed simulations assuming that regulation affects pollution levels as per the following specific form:

$$h(\theta) = 1 - \theta. \tag{48}$$

Furthermore, depending on parameter values, many case scenarios are possible. We have chosen to discuss one which we found especially illuminating with the following list of parameter values:

$b = 1 :$ a production technology parameter;

$\hat{Z}_2 = 3 :$ a measure of total factor endowment;

$a = 0.5 :$ a preference parameter;

$\delta_0 = 1$ and $\delta_1 = 0.2 :$ private pollution-mitigation technology parameters;

$p_T = 0.1 :$ the world price of good 1.

Recall that *a priori*, individuals differ only by their relative income shares $\alpha(i)$. Ultimately, individual welfare differs by choices over consumption and pollution mitigation. Figure 4 reports the equilibrium welfare levels attained by three types of individuals, referred to as low-, average-, and high-income, for all regulation levels and for both autarky and trade. Average and high incomes are respectively 1.5 and 3.5 times higher than the low income. The world price of good 1 being set at 0.1, it follows that when the regulation level reaches $\theta = 0.9$, production shifts specialization from the dirty to the clean good. With trade, welfare at $\theta = 0.9$ corresponds the level when only the clean good is produced in the small open economy and there is no pollution as a result. Welfare levels are thus constant for all $\theta \in (0.9, 1)$. Here is a list of observations that can be drawn from this economy:

FIGURE 4 HERE

a) Individuals with average to high income prefer trade over autarky *at any* given stringency of pollution regulation.

b) If pollution regulation is sufficiently stringent, low-income individuals also prefer trade over autarky. But they prefer autarky over trade when regulation is too lax.

c) Individuals with average to low income globally prefer a regulation level equal to $\theta = 0.59$; that is, for *both* autarky and trade.

d) In autarky, high-income individuals also prefer a regulation level at $\theta = 0.59$. But with trade, they prefer no regulation at all.

e) Individuals with average to low income prefer autarky with a regulation level around $\theta = 0.59$, over trade with very lax regulation.

We therefore note that even though both the rich and the poor prefer trade over autarky, *they do not see trade with the same eyes*. While the rich prefer trade over autarky at any regulation levels, the poor see trade as beneficial only when sufficient pollution controls are put in place. But more importantly, the rich prefer a lax regulation level with trade which makes the poor worse off than in autarky. Hence, not only do all groups' globally preferred regulation level coincide in autarky, but at that regulation level, all demand trade openness. One may thus be tempted to conclude that interests converge when it comes to trade and regulation issues. The problem is that once the trade regime is in place, interests over regulation may diverge. In anticipation of this, lower-income groups may try to block trade liberalization unless they can obtain a guarantee that pollution controls will remain in place with trade. Whether and how this can be achieved remains an open question. Indeed, for a country where the disadvantaged have little say over regulation, opposition to trade will mount even though trade has the potential to improve everyone's welfare. It is not trade *per se* which is being opposed, but rather the *trade-cum-regulation* package. As a result, the disadvantaged may sadly be missing an opportunity to improve their lot with the potential gains from trade.

9 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 7 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 health 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.[12]

Then, as propositions 9 and 10 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

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

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 8 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 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.

10 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 analysis has helped to reveal directions in which it will be fruitful to move the analysis of the environment-trade-welfare nexus.

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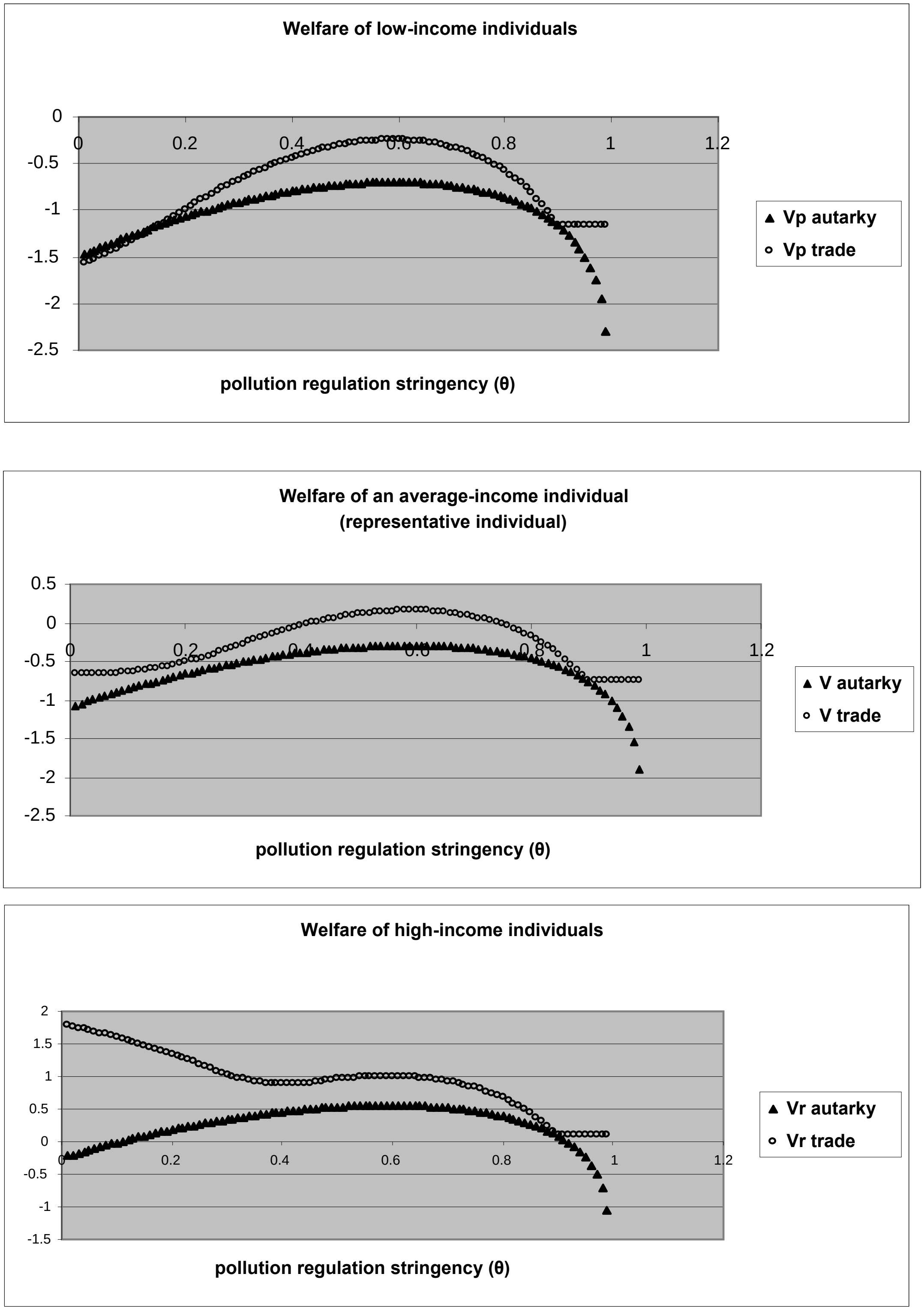

Figure 4 : Income level, trade regime and regulation stringency

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