Consumers' Ecological Awareness, Environmental Regulation and MNCs' Choices in a Global Economy

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Abstract: Using a monopolistic competition model with mobile capital, in which firms may choose between "dirty" or "clean" technology, this paper investigates the relationship between the environment, trade liberalization, and the geographical and technical choices of multinational firms. Simulation results show that beyond environmental regulations, the ecological sensitivity of consumers can serve as a market mechanism that urges firms to self-regulate. In particular, local sensitivity to environmental issues amplifies the "pollution haven" phenomenon, as induced by an environmental tax, whereas a more comprehensive environmental awareness attenuates or cancels this phenomenon gradually as liberalization progresses.

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1. Introduction

By disrupting national economic boundaries, globalization often raises the question of the rationale of multinational corporations' (MNCs) location choices. On the other hand, by expanding the negative externalities of economic growth, especially to emerging countries, globalization also imposes increasing environmental constraint to MNCs which may determine their technological choices. This paper explores the links between economic openness, location, and environmental performance of MNCs by examining how the firms may internalize both environmental and economic constraints in their geographical and/or technological choices during a trade liberalization process.

Polluting activities generally occurring in imperfect competition settings with increasing returns to scale and high transport costs (Zeng and Zhao (2009)), we use a model derived from the *New international trade theory* (Dixit and Stiglitz (1977); Krugman (1991)) where MNCs may move internationally because of capital mobility (Baldwin, et al.(2003)). Some elements are then introduced in order to extend this traditional framework and adapt it to our problematic. Firstly, besides a location choice, MNCs may determine their environmental performance by choosing between a "clean" or a "dirty" technology. Secondly, in the spirit of the PHH, governments may implement environmental regulations which influence MNCs' choices. Thirdly, in the line of the

Corporate Self-regulation concept, some incentives for firms to self-regulate by reducing their environmental externalities and/or by moving abroad are introduced in the model. The main one leads on the demand side, where consumers are assumed to be concerned by environmental issues and may internalize themselves the pollution phenomenon in their consumption choices. Two forms of ecological sensitivity of consumers are tested: a limited one, where consumers are only sensitive to local environmental degradation, and a large scale one, where they are concerned about global environment issues.

Section 2 presents the main issues debated in economic literature centered on themes of trade, environment and MNCs' geographical and technological choices. Section 3 presents a Dixit-Stiglitz-Krugman Trade Model including some of these issues. Section 4 simulates several scenarios and discusses the different effects of environmental regulations and/or consumers' ecological sensitivity on firms' choices.

2. Literature Review

In economic literature, research primarily focus on the effects of public environmental policies on location choices of MNCs during a trade liberalization process. The pollution haven hypothesis (PHH) suggests therefore that environmental regulatory costs shift traditional comparative advantages among nations and incite polluters to relocate to less stringent countries, where marginal return on capital is higher (Walter (1982); Pearson (1987) Mani and Wheeler (1998)). From this theoretical perspective, weak environmental policies may become strategic attractive distinctions between nations (along with low taxation or labor costs), and economic openness may be harmful to the environment. However, if the PHH has generated great interest among academic researchers, many empirical studies have highlighted the difficulties associated with demonstrating it econometrically. They often indicate a small or partial pollution haven phenomenon (*e.g.*, List and Co (2000); Keller and Levinson (2002); Eskeland and Harrison (2003); Hanna (2004); Cole and Elliott (2005); Dean et al.(2009)) or else produce opposing results that suggest firms relocate to countries with more stringent regulations (*e.g.*, Kalt (1988); Grossman and Krueger (1993); Javorcik and Wie (2005); Raspiller and Riedinger (2008)). If these difficulties to "unmask" the pollution haven may have some technical explanations, mainly involving the limits of econometric tools used, (*e.g.*, Levinson (2000); Wagner and Timmings (2009)), they may also suggest that in presence of opposing forces, higher costs of environmental regulation may be insufficient to determine multinational firms' choices (*e.g.*, Copeland and Taylor (2004); Ederington et al.(2005)).

A second line of research within economic literature, namely the *Corporate Self-regulation* concept develops such arguments (Dasgupta et al.(2000); Christmann and Taylor (2001); Haufler (2001); Khanna (2001); Khanna and Anton (2002); O'Rourke (2003); Anton et al.(2004); Graham and Woods (2006); Mironiuc (2008)). Dedicated to explaining why private voluntary initiatives designed to improve environmental performance of MNCs are proliferating independent of any coercive regulations[1], this *Corporate Self-regulation* literature embraces the *Corporate Social Responsibility* concept (Freeman and Werhane (1999)). Companies are thus supposed to have multiple responsibilities toward stakeholders (including consumers, investors, business partners, employees, nongovernmental organizations, local communities, and public institutions), and therefore may have market-based incentives to voluntarily improve their environmental performance because it can lead to private benefits in the form of direct or indirect payoffs (see

[1] Examples include implementations of environmental management systems, acceptance of environmental codes of conduct (*e.g.*, OECD (2000)), pursuit of international environmental certifications (*e.g.*, ISO 14001 or ISO 26000), transfers of clean technology from MNCs to their foreign subsidiaries, or local sourcing based on minimum environmental standard criteria.

Segerson and Li (1999); Lyon and Maxwell (1999)). Among these incentives, customer preferences for "green" products seems critical and needs to be explored (Christmann and Taylor (2001); Corbett and Kirsch (2001); Potoski and Prakash (2005)). But because environment is a public good, researchers face several difficulties to conciliate "green" consumerism with consumer theory. On the one hand, it supposes that "green" goods may be clearly distinguished and do not lead to adverse selection problems. To this effect, environmental attributes of products are often considered as vertical ones and ecolabel credible enough to ensure perfect information (*e.g.* Cremer and Thisse (1999)). On the other hand, it supposes that consumers may take some kind of private benefit from "green goods" and do not act with noncooperative behaviors (*e.g.* Andreoni (1990)). They are thus often supposed to have a willingness to pay a premium (WTP) for "green goods" motivated by *egoism* when green products are considered as impure public goods (Kotchen (2006)), or values driven when they act from a certain degree of *altruism* and obtain utility from the environmental attribute of goods (Bergstrom (1995); Andreoni (1990); Popp (2001)).

3. The Model

3.1 Main Hypotheses

Consider a world composed of two identical regions, 1 and 2, (both denoted h or f) with the same factor endowment ($\bar{L}$ and $\bar{K}$). Each region hosts an agricultural sector (A) that uses labor to produce a homogeneous good with constant returns to scale, as well as an industrial polluting sector (I) where firms use both labor and capital and operate in Chamberlin's monopolistic competition. Labor is internationally immobile but perfectly mobile between sectors. With the agricultural homogeneous good as the numeraire, we have:

$$\bar{L} = L_{Ah} + L_{Ih} \quad \forall\, h = 1, 2, \text{ with } w_A = w_I = 1 \tag{1}$$

where L_{Ah} and L_{Ih} are the labor used in agriculture and industry in Region h, and w_A and w_I are the remuneration of labor in those sectors in each region, respectively.

Hypothesis 1 - Location choices. Because of capital mobility, any industrial firm may locate in each region according to the remuneration of its capital. The interregional allocation of capital is then:

$$\bar{K} = K_{hh} + K_{hf} \quad \forall\, h = 1, 2 \quad f = 1, 2 \text{ and } h \neq f \tag{2}$$

where K_{hh} is the capital of Region h remaining in Region h and K_{hf} the capital of Region h relocating in Region f

Hypothesis 2 - Technological choices. Any industrial firm may choose to produce either a "dirty" good with high pollution flows, or a "clean" good, with an environmentally friendly technology.

Assuming a unitary capital cost, the total cost functions of dirty and clean firms in Region h therefore are, respectively,

$$C_{hi}^{d} = \alpha_h \pi_h^{d} + \varphi_h x_{hi}^{d} \qquad \forall\, h = 1, 2 \tag{3}$$

$$C_{hi}^{c} = \alpha_h \pi_h^{c} + \varphi_h x_{hi}^{c} + \Phi_h \qquad \forall\, h = 1, 2 \tag{4}$$

where φ_h and α_h are respectively the capital and labor units used to produce a variety i; x_{hi}^{d} (resp. x_{hi}^{c}) is the quantity of dirty (resp. clean) variety i produced in Region h; π_h^{d} (resp. π_h^{c}) is the nominal return to capital of dirty (clean) firms; and Φ_h is the access cost for clean technology. For simplicity, we choose units of capital such that $\alpha_h = 1$.

Hypothesis 3 - Technological spillover effect. R&D results determine the access cost for clean technology and are not captured exclusively by the firm which finances it, but may benefit others competitors. This *technological spillover effect* is geographically limited and depends on the number of clean firms located in region *h* and on the firm's ability to capture, internalize, and use external tacit knowledge from its competitors (Autant-Bernard (2001))[2] :

$$\Phi_h = v_h Q_h \left[1 - \left(\frac{n_h^c}{2\bar{K}} \theta_h Q_h \right)^k \right] \qquad \forall\, h = 1, 2 \tag{5}$$

where $v_h > 0$ is the cost of a unit of R&D; $0 < Q_h \leq 1$ is the firm's expenditure on R&D; $0 \leq \theta_h \leq 1$ is an indicator of knowledge permeability of firms; $0 \leq k \leq 1$ indicates the possible concave effects of congestion in innovation activity (Boschma (2005)).

Hypothesis 4 - Ecological sensitivity of consumers. Consumers may have an environmental quality preference.

The environment is here considered as a pure public good, whose stock is given but whose quality depends on the industrial pollution level. Consumers in Region *h* exhibit a Cobb-Douglas utility function for industrial and agricultural goods. Their consumption of industrial varieties is a CES function across four types of goods (clean, dirty, local, or imported).

$$U_h = \left[\zeta_{hh}^d \int_1^{n_h^d} c_{hhi}^{d\,\frac{\varepsilon-1}{\varepsilon}} + \zeta_{hh}^c \int_1^{n_h^c} c_{hhi}^{c\,\frac{\varepsilon-1}{\varepsilon}} + \zeta_{hf}^d \int_1^{n_f^d} c_{hfi}^{d\,\frac{\varepsilon-1}{\varepsilon}} + \zeta_{hf}^c \int_1^{n_f^c} c_{hfi}^{c\,\frac{\varepsilon-1}{\varepsilon}} \right]^{\beta \frac{\varepsilon}{\varepsilon-1}} C_{Ah}^{1-\beta}$$

$$\forall\, h = 1, 2 \;\; f = 1, 2 \text{ and } h \neq f \tag{6}$$

where $0 < \beta < 1$ is the share of expenditures spent on industrial goods; C_{Ah} is the total consumption of the agricultural good; c_{hhi}^d (resp. c_{hhi}^c) is the consumption of a dirty (resp. clean) variety *i* produced in region *h*; c_{hfi}^d (resp. c_{hfi}^c) is the consumption of a dirty (resp. clean) variety *i* in region *h* but produced in *f*; $n_h^d, n_h^c, n_f^d, n_f^c$ are the number of firms producing clean and dirty varieties in each region; and ε is the constant elasticity of substitution across the varieties ($\varepsilon > 1$). For simplicity, we assume all varieties have the same degree of substitution. ζ_{hh}^c (resp. ζ_{hh}^d) represents an inverse indicator of the ecological sensitivity of a consumer in Region *h* for a clean (resp. dirty) variety produced in *h* (*e.g.*, Beaumais and Schubert, 1999):

$$\zeta_{hh}^d = 1 - \Delta_h^{-1} \left(\mu_h e_h^d \int_1^{n_h^d} x_{hi}^d \right) \qquad \forall\, h = 1, 2 \tag{7}$$

$$\zeta_{hh}^c = 1 - \Delta_h^{-1} \left(\mu_h e_h^c \int_1^{n_h^c} x_{hi}^c \right) \qquad \forall\, h = 1, 2 \tag{8}$$

[2] We assume firms in each region exert the same environmental effort and that R&D always produces results. If probability of project failure is $1 - \gamma$, the probability that R&D at least leads to an innovation must be $1 - (1-\gamma)^n$, with $0 < \gamma < 1$. When firms' number is high – one of the characteristics of Chamberlin's monopolistic competition – this probability approaches 1.

$$\zeta_{hf}^{d} = 1 - \Delta_h^{-1}\left(\upsilon_h e_f^d \int_1^{n_f^d} x_{fi}^d\right) \qquad \forall\, h = 1, 2 \quad f = 1, 2 \text{ and } h \neq f \tag{9}$$

$$\zeta_{hf}^{c} = 1 - \Delta_h^{-1}\left(\upsilon_h e_f^c \int_1^{n_f^c} x_{fi}^c\right) \qquad \forall\, h = 1, 2 \quad f = 1, 2 \text{ and } h \neq f \tag{10}$$

This inverse indicator of sensitivity depends on the maximum level of tolerance to environmental degradation in the region in which the consumer (Δ_h) resides, as well as on the pollution flows generated by each type of variety (e_h^d and e_h^c per unit produced, with $e_h^d > e_h^c$). The parameters μ_h and υ_h indicate that perceptions of this pollution differ if it is emitted locally versus abroad. Therefore, when the pollution level equals the maximum tolerable threshold, consumer sensitivity is high, and they do not obtain any utility from consuming the relevant category of industrial goods. Conversely, if they are indifferent to pollution (μ_h and υ_h equal zero), their sensitivity is null and does not affect their choices[3].

Hypothesis 5 - Environmental regulation. Interregional trade costs may suffer a tax and differ according to the environmental performance of goods

If trade in agricultural goods is free, industrial goods face intra- and inter-regional trade costs. When a dirty (resp. clean) variety produced in Region *h* is consumed locally, its transport cost equals τ_h^d (resp. τ_h^c). The inter-regional trade costs instead are determined by trade policy but also may be environmental policy instruments if they differ for clean versus dirty goods of each variety. Then τ_{hf}^d (resp. τ_{hf}^c) represents the trade cost when Region *h* imports a dirty (resp. clean) variety produced in Region *f*. We assume these trade costs are greater than unity, and intra-regional costs should be lower than inter-regional costs.

3.2 Characterization of Equilibrium

Profit maximization gives the equilibrium price of each variety in each region[4]. For simplicity, we assume that the production processes are identical in both countries and choose $\varphi_h = \varphi_f = \dfrac{\varepsilon - 1}{\varepsilon}$ such that $p_h^d = p_h^c = 1$ $\forall\, h$ = 1, 2. Then in equilibrium, supply equals demand for each type of variety in each region:

$$x_h^d = \left(\frac{\tau_h^d}{G_h}\right)^{1-\sigma} \left(\zeta_{hh}^d\right)^{\sigma} \beta Y_h + \left(\frac{\tau_{fh}^d}{G_f}\right)^{1-\sigma} \left(\zeta_{fh}^d\right)^{\sigma} \beta Y_f \;\forall\, h = 1, 2\; f = 1, 2 \text{ and } h \neq f \tag{11}$$

[3] Because of Chamberlin's monopolistic competition, we assume environmental characteristics are horizontal attributes, measurable and known by consumers and clean and dirty varieties have the same price. Consumers' choices are independent of prices and only determined by the level of pollution each good generates. Consumers are therefore not willing to pay extra for clean products and "love of variety" insures that they use all the goods.

[4] In this monopolistic competition framework, price equals marginal cost plus a mark-up. This mark-up is not here affected by the subjectivity ζ introduced in the utility function.

$$x_h^c = \left(\frac{\tau_h^c}{G_h}\right)^{1-\sigma} \left(\zeta_{hh}^c\right)^{\sigma} \beta Y_h + \left(\frac{\tau_{fh}^c}{G_f}\right)^{1-\sigma} \left(\zeta_{fh}^c\right)^{\sigma} \beta Y_f \ \forall\, h = 1, 2\ f = 1, 2 \text{ and } h \neq f \quad (12)$$

Demand quantities can be obtained by aggregating individual demand functions, as determined by the constrained maximization of utility. Demand value is composed of local and foreign demand, and depends on consumers' ecological sensitivities, transport costs, and price indices for each region (G_h and G_f). These prices indices measure the purchase cost of the good manufactured in each region, and are defined by:[5]

$$G_h = \left[n_h^d \left(\zeta_{hh}^d\right)^{\sigma} \left(\tau_h^d\right)^{1-\sigma} + n_h^c \left(\zeta_{hh}^c\right)^{\sigma} \left(\tau_h^c\right)^{1-\sigma} + n_f^d \left(\zeta_{hf}^d\right)^{\sigma} \left(\tau_{hf}^d\right)^{1-\sigma} + n_f^c \left(\zeta_{hf}^c\right)^{\sigma} \left(\tau_{hf}^c\right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

$$\forall h = 1, 2 \quad f = 1, 2 \text{ and } h \neq f \qquad (13)$$

Demand value also depends on consumers' income (Y_h and Y_f) in each region, defined by:

$$Y_h = \bar{L} + \pi_h K_{hh} + \pi_f K_{hf} \quad \forall\, h = 1, 2 \quad f = 1, 2 \text{ and } h \neq f \qquad (14)$$

where π_h is the nominal return of capital in region h. Because capital is restricted to fixed costs, this short-term nominal return is the Ricardian surplus of a firm, that is, the operating profit related to the production of a variety. For each type of firm, it equals:

$$\pi_h^d = \frac{x_h^d}{\sigma} \quad \forall\, h = 1, 2 \qquad (15)$$

$$\pi_h^c = \frac{x_h^c}{\sigma} - \psi_h \quad \forall\, h = 1, 2 \qquad (16)$$

The location and technology choices of industrial firms are thus determined endogenously and simultaneously in the model. The geographical distribution of firms is based on the capital profitability differential between regions. The technological distribution is based on the profit differential between non-polluting and polluting firms. Thereby, equalization of capital returns determines the distribution of the four types of firms in the world. Assuming that fixed capital cost per firm is unitary, the number of clean and dirty firms in each region is limited by the capital endowment:

$$n_h^d + n_h^c = K_{hh} + K_{fh} \qquad \forall\, h = 1, 2 \quad f = 1, 2 \text{ and } h \neq f \qquad (17)$$

Moreover, assuming full employment in each region, the number of workers employed in the industrial sector is

$$L_{Ih} = \frac{\varepsilon - 1}{\varepsilon}\left(n_h^d x_h^d + n_h^c x_h^c\right) \ \forall\, h = 1, 2 \qquad (18)$$

The perfect mobility of capital allows for intersectoral and international equalization of capital returns. In the long-run equilibrium, we therefore assume

$$\pi_h^d = \pi_h^c = \pi_h = \tilde{\pi} \qquad \forall\, h = 1, 2 \qquad (19)$$

Combining these equations reveals the long-run capital return value (Reiber and Tran, 2008):

[5] This price index is partly subjective. *Ceteris paribus*, when perceptions of pollution (ζ) tend toward unity, G_h decreases, and the standard of living increases qualitatively.

$$\tilde{\pi} = \frac{\beta Y}{2\varepsilon \bar{K}} - \Theta \qquad (20)$$

where βY is the share of world income devoted to the acquisition of the industrial good and Θ the average cost of the environmental efforts of firms. Θ and Y are defined by:

$$\Theta = \Phi_1 \frac{n_1^c}{2\bar{K}} + \Phi_2 \frac{n_2^c}{2\bar{K}} \qquad (21)$$

$$Y = 2\bar{L} + 2\tilde{\pi}\bar{K} \qquad (22)$$

Finally, combining Equations (20) and (22) reveals the value of long-run capital returns[6]:

$$\tilde{\pi} = \frac{\varepsilon \bar{K}\Theta - \beta \bar{L}}{(\beta - \varepsilon)\bar{K}} \qquad (23)$$

4. Simulations

We now address interactions between the intensity of trade liberalization (*i.e.*, level of the exogenous variables of interregional transports costs, τ_{hf}^c and τ_{hf}^d) and strategic choices of firms in terms of location and technology (*i.e.*, endogenous variables n_1^d, n_1^c, n_2^d, and n_2^c). The nonlinearity of the model prevents any analytical resolution. Thus we simulate numerically the equilibrium reached after a change of an exogenous variable. To obtain the initial reference equilibrium, we calibrate key model parameters[7]. It is perfectly symmetrical between regions, with the same number of clean or dirty firms, though the latter are assumed to be the majority worldwide (65%).

4.1 Simulation 1: Trade Liberalization in the Presence of an Environmental Tax in One Region

The effect of public environmental policies on location choices of MNCs is the critical point of the Pollution Haven Hypothesis that may lead some less developed States to experiment low level of regulatory environmental costs in order to attract industries. For example, emerging countries or Eastern European countries have been suspected to adopt this kind of strategy (see Oxelheim and Ghauri (2004)).

In order to test the PHH, we first consider a trade liberalization process when one region (arbitrarily, Region 1) imposes a unilateral tax t^* (*e.g.*, carbon tax) on the intra and international transport of polluting goods produced in this region[8]. This tax causes a reduction in the short-term profitability of capital employed in the dirty industry in Region 1. It alters the initial technological distribution of firms, by inducing polluters to adopt clean technology (Table 1). This effect is proportional to the level of tax (low $t^* = 5\%$; high $t^* = 20\%$). However, for high transport costs, the relocation effects are negligible.

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[6] Capital returns cannot be negative or zero, so we ensure the values of the parameters and exogenous variables satisfy the following condition: $\Psi < \left(\bar{L}\beta\right)/\left(\varepsilon\bar{K}\right)$

[7] $\forall h = 1, 2$: $\beta = 0.8$; $\varepsilon = 3$; $\bar{K} = 1$; $\bar{L} = 100$; $\Delta_h = 40$; $e^d = 0.8$; $e^c = 0.4$; $\mu_h = \nu_h = 0.1$; $Q_h = Q_f = 1$ and $\theta_h = \theta_f = 0.5$.

[8] In this partial equilibrium framework, the redistribution effects of tax revenue are ignored.

Table 1 Effects on initial equilibrium of introducing an environmental tax in Region 1

Change compare with initial equilibrium (percentage)	n_1^c	n_1^d	n_2^c	n_2^d
t^* = 5%	+29.1	-17.5	-0.6	+2.2
t^* = 20%	+116.9	-69.1	-0.3	+6.3

Whatever the tax level, trade liberalization causes a partial polarization of firms in Region 2 and a declining share of polluting firms in the world (see Figures 1a and 1b). These movements are consistent with the traditional results from monopolistic competition models with capital mobility, where the presence of asymmetry between regions is sufficient to cause endogenous dynamics of firm agglomeration. In this case, polluting firms are incited to move where the transport is not taxed. This movement reflects a change in the comparative advantages induced by the tax. When dirty firms choose to locate where environmental constraints are less strict, Region 2 tends to specialize in the production of dirty varieties, and Region 1 produces more clean varieties. The simulation shows that this effect is proportional to the tax level, and there is a critical threshold level of transport costs (τ_{hf}^d and τ_{hf}^c = 2) below which it accelerates. Moreover, the slight increase of clean firms in Region 2 (after the threshold level of transport costs) shows that some dirty firms of Region 1, under pressure to change their technology, prefer to relocate in Region 2, which implies a "home market effect" in this latter region. That is, the polarization of dirty firms in one region increases that region's asymmetry with the other region, beyond the simple effect of the tax. By adopting a progressively larger share of global production activities, Region 2 increases its domestic market and thus its relative attractiveness. When transport costs are sufficiently low to overcome the inertia of the labor factor, firms, including clean ones, prefer to locate in the larger market. When the level of the tax is high, after the liberalization process has finished, Region 2 contains about 65% of firms, 43% of which are clean.

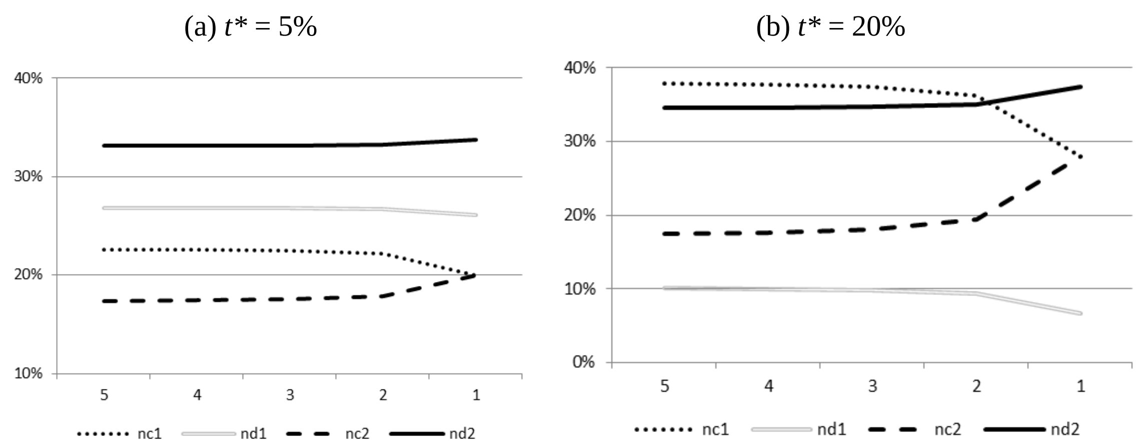


Figure 1 Effects of trade liberalization on the distribution of firms in the presence of an environmental tax in Region 1

Note: Abscissa $\tau_{hf}^{c,d}$ – Ordinate $n_h^{c,d}$ (% of global firms)

4.2 Simulation 2: Trade Liberalization in the Presence of Selfish Ecological Consumers in One Region

The growing liking for environmentally friendly products is a rising movement in high living standard countries (see Boström and Klintman (2008)). Associated with the multiplication of environmental conduct codes, international certifications (as ISO 14001 or ISO 14031) or institutional rules of environmental reporting, it may be a powerful driving force for firms' behaviors. These have then the choice between relocating their heavily polluting production in laxer countries[9] and preserving the environment by actively participating in the ecological effort[10].

In order to assess the impact of this green consumerism on the firms' choices, this second simulation tests a scenario of trade liberalization when consumers of one region (arbitrarily, Region 1) have a "Not In My Back Yard" behavior. More specifically, they are sensitive to local environmental issues only. In the model, the parameters μ_h and υ_h reflect the importance that consumers attach to local pollution and to foreign pollution (Equations 6 to 10). When $\mu_h \neq 0$ and $\upsilon_h = 0$, consumers in region h appear thus selfish, concerned only with the quality of their local environment (which affects them directly) and indifferent to any degradation of the environment in the other region.

Table 2 Effects on initial equilibrium of introducing a local environmental sensitivity in Region 1

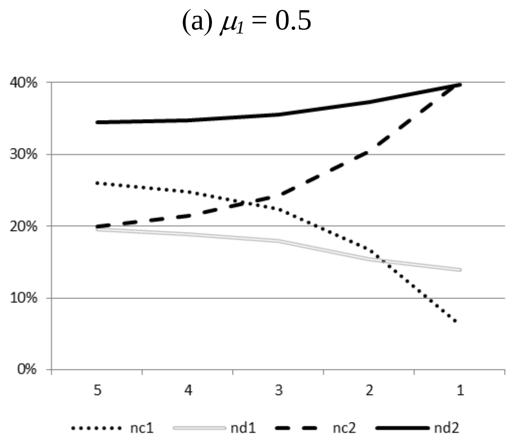
Change compared with initial equilibrium (percentage)	n_1^c	n_1^d	n_2^c	n_2^d
$\mu_1 = 0.5$	+48.9	-39.8	+14.3	+6.0
$\mu_1 = 1$	+16.3	-55.7	+62.0	+13.5

We consider two levels of local environmental sensitivity (medium $\mu_1 = 0.5$ and maximum $\mu_1 = 1$), and ν_1, μ_2, and ν_2 all remain low. This local sensitivity alters the initial technological and geographical distribution of firms by encouraging polluting enterprises of Region 1 to modify their technology (Table 2). When strong enough, this effect pushes all firms to leave Region 1, because consumers in that region have developed an aversion to local pollution generated by both clean and dirty firms.

Reduced transport costs determine a new technological and geographical distribution of firms (Figures 2a and 2b). As trade liberalization makes the imported industrial varieties gradually less expensive, both dirty and clean firms leave Region 1 because of consumers' aversion to local pollution. These movements are proportional to the level of environmental sensitivity. At the end of the process, firms mainly locate in Region 2 (90% of them when sensitivity is at the maximum level, and 80% for medium sensitivity). Because incentives to invest in clean technology affect both the demand side (through consumers' sensitivity) and the supply side (through technological spillovers), 53% (resp. 50%) of the firms are clean at the end of the liberalization process for $\mu_1 = 1$ (resp. 0.5).

[9] It's for example the case of Volkswagen which has, further to the Kyoto Protocol, relocated a part of its energy-intensive activities in the Emirate of Abu Dhabi. A similar manifestation can be found in China where dirty activities are relocated from richest provinces (more sensitive to the quality of the environment) to the poorer (northern Jiangsu and Anhui province).

[10] This is the way chosen by companies such as Daimler-Benz, Glaxo Wellcome, Valeo, *etc*. See Attarça and Jacquot (2005) for example.



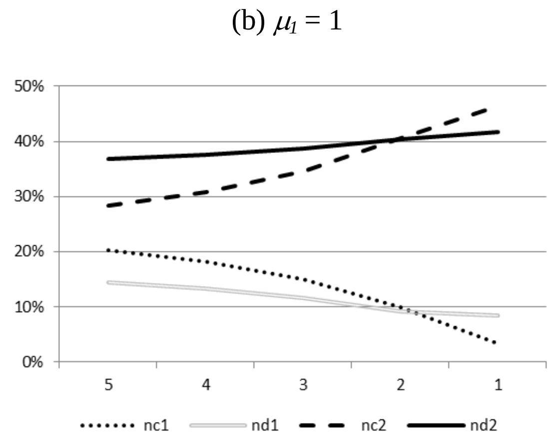


Figure 2 Effects of trade liberalization on the distribution of firms in the presence of a local environmental sensitivity in Region 1

Note: Abscissa $\tau_{hf}^{c,d}$ – Ordinate $n_h^{c,d}$ (% of global firms)

4.3 Simulation 3: Trade Liberalization in the Presence of Consumers Concerned by Global Environmental Issues in One Region

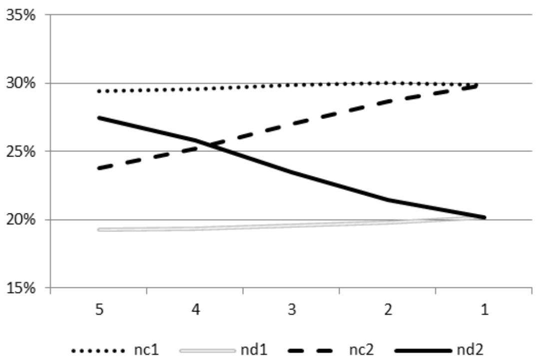
With economic globalization, environmental externalities issues are more globally considered by consumers. In order to test the impact of a rising global green consumerism, our third simulation extends Simulation 2 by assuming consumers in Region 1 are concerned about both their local environment and the environment of Region 2. Their local environmental sensitivity is here assumed maximal (μ_1 = 1), and their perception of the pollution emitted in the other region can be either medium (ν_1 = 0.5) or high (ν_1 = 1) levels. The new initial equilibrium shows that a global environmental sensitivity encourages polluting firms in Region 1 to change their technology and become environmentally responsible (Table 3). Compared with the previous simulation, this effect also extends to dirty firms in Region 2. When global environmental sensitivity is medium, it encourages a reallocation of firms to Region 2, though this phenomenon lessens when sensitivity is stronger.

Table 3 Effects on initial equilibrium of introducing a global environmental sensitivity in Region 1

Change compared with initial equilibrium (percentage)	n_1^c	n_1^d	n_2^c	n_2^d
$\nu_1 = 0.5$	+47.1	-46.6	+62.6	-12.3
$\nu_1 = 1$	+68.3	-40.8	+36.0	-15.5

The decreased transport costs enhance the intensity of these phenomena (Figures 3a and 3b). For a medium level of global sensitivity, firms tend to polarize in Region 2 (67% of firms, 60% of them clean). We recognize some mechanisms at work from the previous simulation. Even if they are concerned about environmental issues in Region 2, consumers of Region 1 maintain a relatively greater vigilance over their local environment, so firms are still encouraged to move to Region 2 (with relatively lower environmental pressures) but also to accelerate their technological innovation. When consumers' sensitivity is maximal, we find a rising number of clean firms in Region 2. But spurred by demand effects (environmental sensitivity) and supply effects (technological spillovers), this movement comes now to the detriment of dirty firms in Region 2. Firms gradually return to Region 1 when transport costs decrease. Thus, the combination of lower transport costs and a global environmental sensitivity in Region 1 generates an integrated space, in which location choices are less important. At the end of the liberalization process, the geographical and intersectoral distributions of firms tend to equilibrate, such that 50% of firms (60% of them clean) are located in each region.

(a) $\mu_1 = 1$ and $\nu_1 = 0.5$



(b) $\mu_1 = 1$ and $\nu_1 = 1$

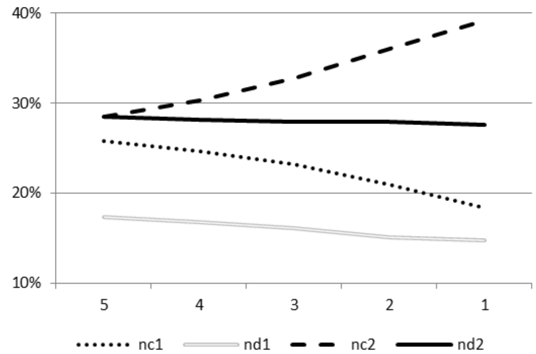


Figure 3 Effects of trade liberalization on the distribution of firms in the presence of a global environmental sensitivity in Region 1

Note: Abscissa $\tau_{hf}^{c,d}$ – Ordinate $n_h^{c,d}$ (% of global firms)

4.4 Simulation 4: Trade Liberalization, Environmental Regulation and Self-regulation of Firms

Compared to Simulation 1, pressure from consumers on their local environment intensifies the pollution haven phenomenon generated by the tax (Figure 4) with a greater polarization of dirty firms in Region 2 at the end of trade liberalization (94% versus 85% when only the tax is taken into account). Similar to Simulation 2, this polarization affects equally clean firms for the first steps of trade liberalization.

These last two simulations combine all the effects obtained separately in the previous simulations. In the first, an environmental tax is implemented in Region 1 in the presence of consumers with high local ecological sensitivity. In the second, the same tax is kept, but consumers in Region 1 are assumed to be highly concerned by global environmental issues.

4.4.1 Local ecological sensitivity and environmental tax in Region 1

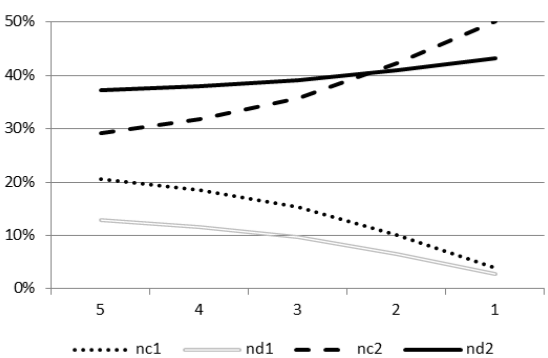


Figure 4 Effects of trade liberalization on firm distribution and environment quality in the presence of an environmental tax and a local ecological sensitivity in Region 1 (μ_1 = 1, t^* = 20%)

Note: Abscissa $\tau_{hf}^{c,d}$ – Ordinate $n_h^{c,d}$ (% of global firms)

4.4.2 Global ecological sensitivity and environmental tax in Region 1

This simulation reveals the distinction made by Copeland and Taylor (2004) between the *Pollution Haven Effect* (PHE) and the *Pollution Haven Hypothesis* (PHH) (Figure 5). Compared to Simulation 1, the PHH is not verified here due to the opposite force caused by the incentive to self-regulate, as induced by consumers' behavior. When this incentive is maximal, it overtakes the PHE generated by the tax. The results are similar to those of Simulation 3. At the end of the liberalization process, 61% of firms are clean, and 51% are located in Region 2. Region 1 contains 49% of firms, 62% of which are clean.

$\mu_1 = \nu_1 = 1$, $t^* = 20\%$

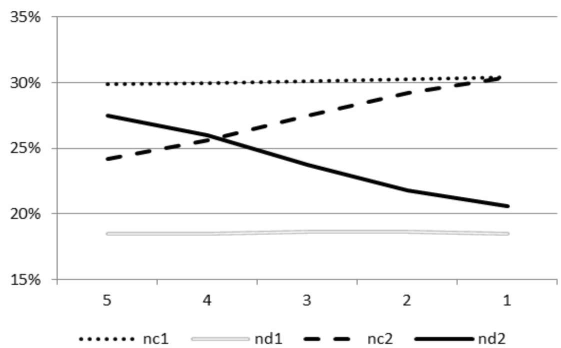


Figure 5 Effects of trade liberalization on firm distribution and environment quality in the presence of an environmental tax and a global ecological sensitivity in Region 1

Note: Abscissa $\tau_{hf}^{c,d}$ – Ordinate $n_h^{c,d}$ (% of global firms)

Sensitivity test results show that for a completed trade liberalization process, the PHH is verified up to a threshold level of ecological sensitivity, where μ_1 = 0.6 (Figure 6). Beyond that level, self-regulation incentives overtake the constraints of regulation, and technological choices prevail over geographical ones. In other words, the PHE generated by the tax is not sufficient to validate the PHH.

$\mu_1 = 1$, $\tau_{hf}^{c,d} = 1$ and $t^* = 20\%$

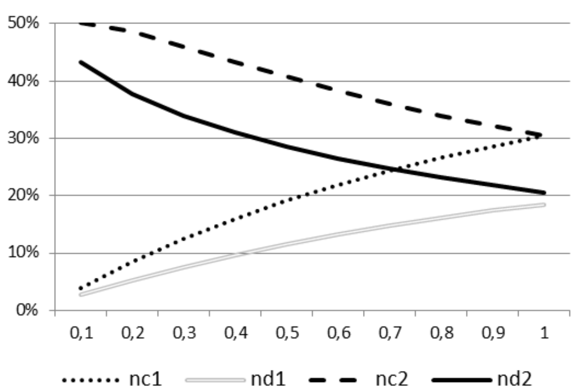


Figure 6 Sensitivity test results of firms' distribution to different levels of global ecological sensitivity in Region 1 in the presence of an environmental tax and low transports costs

Note: Abscissa ν_1 – Ordinate $n_h^{c,d}$ (% of global firms)

5. Conclusion

Starting from the point of view that geographical and technological choices by MNCs are determined by both regulation constraints and self-regulation incentives, we have introduced elements of this dimension in a model of monopolistic competition.

In this framework, our first simulations show that trade liberalization in the presence of a unilateral environmental regulation may generate, *ceteris paribus*, a pollution haven phenomenon.

Our following simulations show that corporate environmental behaviors may also be induced by market mechanisms such as the presence of an ecological sensitivity among consumers. With a local environmental sensitivity in one region, trade liberalization generates an agglomeration process in the other region, as well as a global incentive to adopt cleaner technology. As this sensitivity expands from the local to the global level, only technological choices remain important for firms which become mostly environmentally responsible and locate equally across the two regions as trade liberalization progresses. Our final simulations show how these different incentives either reinforce each other or cancel each other out when are they combined. If local ecological sensitivity amplifies the pollution haven phenomenon induced by an environmental tax during a trade liberalization process, a global ecological sensitivity instead reduces or overtakes the pollution haven effect up to a certain threshold level. This result thus indicates why it may be so difficult to identify the PHH econometrically.

However, our study is based upon the hypothesis that consumer pressure for self-regulation may only be effective if they are able to discern clearly the environmental responsibility characteristics of MNCs. Such hypothesis thus highlights the importance of providing reliable information about the environmental attributes of products and the environmental performance of firms and argues for support of any measure that strengthens the environmental reporting of companies or the ecological education of consumers.

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