



EUROPEAN CENTRAL BANK

EUROSYSTEM

WORKING PAPER SERIES

NO 921 / JULY 2008

ECB EZB EKT EKP

**FOREIGN DIRECT
INVESTMENT AND
ENVIRONMENTAL TAXES**

by Roberto A. De Santis
and Frank Stähler





EUROPEAN CENTRAL BANK

EUROSYSTEM



WORKING PAPER SERIES

NO 921 / JULY 2008

**FOREIGN DIRECT INVESTMENT
AND ENVIRONMENTAL
TAXES¹**

by Roberto A. De Santis²
and Frank Stähler³



In 2008 all ECB publications feature a motif taken from the €10 banknote.

This paper can be downloaded without charge from <http://www.ecb.europa.eu> or from the Social Science Research Network electronic library at http://ssrn.com/abstract_id=1157777.

¹ We would like to thank Scott McCracken, two anonymous referees and participants at various conferences and seminars for helpful comments. The views expressed in this study are those of the authors and do not necessarily reflect those of the European Central Bank. All errors are authors' responsibility.

² European Central Bank, Kaiserstrasse 29, D-60311 Frankfurt am Main, Germany; e-mail: roberto.de_santis@ecb.europa.eu

³ Corresponding author: Department of Economics, University of Otago, PO Box 56, Dunedin, New Zealand; e-mail: fstaehler@business.otago.ac.nz



© European Central Bank, 2008

Address

Kaiserstrasse 29
60311 Frankfurt am Main, Germany

Postal address

Postfach 16 03 19
60066 Frankfurt am Main, Germany

Telephone

+49 69 1344 0

Website

<http://www.ecb.europa.eu>

Fax

+49 69 1344 6000

All rights reserved.

Any reproduction, publication and reprint in the form of a different publication, whether printed or produced electronically, in whole or in part, is permitted only with the explicit written authorisation of the ECB or the author(s).

The views expressed in this paper do not necessarily reflect those of the European Central Bank.

The statement of purpose for the ECB Working Paper Series is available from the ECB website, <http://www.ecb.europa.eu/pub/scientific/wps/date/html/index.en.html>

ISSN 1561-0810 (print)

ISSN 1725-2806 (online)

CONTENTS

Abstract	4
Executive summary	5
1 Introduction	7
2 The model	10
3 Environmental policy under trade	15
4 Environmental policy under trade and FDI	17
4.1 The bilateral FDI equilibrium	18
4.2 The unilateral FDI equilibrium	20
4.3 Equilibrium FDI	23
4.4 FDI and welfare	26
5 Concluding remarks	28
Appendices	30
References	35
European Central Bank Working Paper Series	40

Abstract

This paper studies the effect of foreign direct investment (FDI) on environmental policy stringency in a two-country model with trade costs, where FDI could be unilateral and bilateral and both governments address local pollution through environmental taxes. We show that FDI does not give rise to ecological dumping because the host country has an incentive to shift rents away from the source country towards the host country. Environmental policy strategies and welfare effects are studied under the assumption that parameter values support FDI to be profitable.

JEL-Classification: F12, F18, F23.

Keywords: Foreign direct investment, environmental taxes, multinational enterprises, plant location.

Executive summary

Over the last two decades the global economy has witnessed an unprecedented world-wide integration of commodity and factor markets. Foreign direct investment (FDI) contributes substantially to this process because it involves multinational firms setting up a plant in a foreign country rather than serving the foreign market via exports. The aggregate sales by affiliates of multinational firms have outnumbered aggregate world exports since the end of the 1980s, which implies that FDI is a key aspect of globalization, even more than trade. For example, the World Investment Report of the United Nations estimates sales of foreign affiliates at USD 22.2 trillion in 2005, whereas global exports of goods and non-factor services amounted to USD 12.6 trillion in the same year. In 1982, conversely, sales of foreign affiliates and global exports were of the same magnitude: less than USD 3 trillion. Moreover, the United Nation estimates that exports of foreign affiliates rose to USD 4.2 trillion in 2005 from USD 0.6 trillion in 1982. This also implies that FDI activity carried out to be closer to foreign markets as a substitute of trade (i.e. horizontal FDI) is very important.

Given this background, several papers have investigated the implication of environmental tax policies on firms' competition and location choice based on race to the bottom games, where governments set policies before firms choose location. Most of these papers conclude that governments set too low standards or taxes in equilibrium. However, the empirical evidence of no significant correlation between location of multinational enterprises and environmental standards in host countries challenges this race to the bottom argument, though environmental regulation seems to restrict industrial activity.

Market share games, where firms choose location before governments set policies, have been less used, although there could be situations in which governments' strategic environmental policies are influenced by firms' location choice. This assumption may well reflect the hold-up problem faced by multinational firms and the risks that their investment will be expropriated. Even if governments promise to levy low environmental taxes from the outset, taxes may be adjusted once the polluting multinational firm has set up a plant in the country and can no longer pull out without losing its original investment. Governments may be induced by citizens to change

environmental taxation policies once the size of potential pollution becomes public knowledge. Therefore, we consider the less investigated case that firms anticipate changes in the environmental taxes resulting from their FDI decision under the hypothesis that externalities do not spillover to other countries, as in the case of global environmental damages.

How environmental policy is affected by polluting FDI activity? The key important finding is that, when FDI is permitted (i.e. FDI liberalization), FDI does not lead to an insufficient internalization of externalities created by pollution (i.e. ecological dumping), because the host country has an incentive to shift rents away from the source country towards the host country by taxing the production of the multinational enterprise. This can be achieved only by means of an increase in the tax on polluting production activities in the host country. We show that the country hosting FDI would introduce a Pigouvian tax rate, which internalises the disutility from a polluted environment caused by the FDI activity.

If FDI is unilateral, the country attracting FDI loses in terms of welfare although its tax is at the Pigouvian rate, because FDI deteriorates the competitive position of the domestic firm. Conversely, the other country gains if FDI costs are not too large, despite insufficient internalization of the negative externality. In this case, each country would rather prefer its own firm to become a multinational firm. If FDI is bilateral, the welfare effects are identical for both countries, but they depend upon the size of FDI costs. In this case, the results support environmentally friendly policy strategies but FDI does not necessarily lead to welfare improvement, even though environmental policies react endogenously to firms' behaviour.

1 Introduction

Over the last two decades the global economy has witnessed an unprecedented world-wide integration of commodity and factor markets. Foreign direct investment (FDI) contributes substantially to this process because it involves multinational firms setting up a plant in a foreign country rather than serving the foreign market via exports. The aggregate sales by affiliates of multinational firms have outnumbered aggregate world exports since the end of the 1980s, which implies that FDI is a key aspect of globalization, even more than trade. For example, the World Investment Report of the United Nations estimates sales of foreign affiliates at USD 22.2 trillion in 2005, whereas global exports of goods and non-factor services amounted to USD 12.6 trillion in the same year. In 1982, conversely, sales of foreign affiliates and global exports were of the same magnitude, that is less than USD 3 trillion. Moreover, the United Nation estimates that exports of foreign affiliates rose to USD 4.2 trillion in 2005 from USD 0.6 trillion in 1982. This also implies that horizontal FDI, that is serving the foreign markets via FDI rather than trade, is very important.

Given this background, several papers have investigated the implication of environmental tax policies on firms' competition and location choice based on race to the bottom games, where governments set policies before firms choose location (*e.g.* Motta and Thisse, 1994, Ulph, 1994, Rauscher, 1995, Beladi, Chao and Frasca, 1999). Most of these paper conclude that governments set too low standards or taxes in equilibrium. However, the empirical evidence of no significant correlation between location of multinational enterprises and

environmental standards in host countries (Levinson (1996), Letchumanan and Kodoma, 2000, Smarzynska and Wei, 2001, and Eskeland and Harrison, 2003) challenges this race to the bottom argument, though environmental regulation seems to restrict industrial activity (Greenstone, 2002). Interestingly, Cole et al. (2006) find that FDI leads to a higher (lower) stringency of environmental policy when the degree of local government corruptibility is low (high), while Keller and Levinson (2002) find evidence that pollution abatement costs reduce manufacturing FDI only by a small amount.

Market share games, where firms choose location before governments set policies, have been less used, although there could be situations in which governments' strategic environmental policies are influenced by firms' location choice.¹ This assumption may well reflect the hold-up problem faced by multinational firms and the risks that their investment will be expropriated.² Even if governments promise to levy low environmental taxes from the outset, taxes may be adjusted once the polluting multinational firm has set up a plant in the country and can no longer pull out without losing its original investment. Governments may be induced by citizens to change environmental taxation policies once the size of potential pollution becomes public knowledge. Therefore, we consider the less investigated case that firms anticipate changes in the environmental taxes resulting from their FDI decision under the hypothesis that externalities do not spillover to other countries, as in the

¹Ulph and Valentini (2001) compare both models and conclude that ecological dumping can be larger in the market share game than in the race to the bottom game if damage costs are convex.

²The FDI literature has extensively discussed the hold-up problem of multinational firms when FDI is subject to expropriation risks. For the pioneering paper, see Thomas and Worrall (1994).

case of global environmental damages.

The existing studies considering the market share game ignore trade costs (see *e.g.* Hoel, 1997, and Ulph and Valentini, 2001). Therefore, they cannot study the case where FDI is a substitute for trade, as the existence of an equilibrium with horizontal FDI requires positive trade costs. Moreover, the optimal size of exports and FDI in models with horizontal FDI depends on the size of the trade costs as well as fixed costs. In a nutshell, the novelty of this paper consists of investigating how environmental policy that is optimal in a two-country setting with trade costs is affected by horizontal FDI (*i.e.*, FDI liberalization) in a market share game.

As pointed out by Markusen, Morey and Olewiler (1995) and De Santis and Stähler (2004), the analysis of FDI and trade under imperfect competition becomes complex because firms may change location and number of their plants, and hence the reaction curves are discontinuous. In this paper, we tackle these analytical problems and we solve for the subgame perfect Nash equilibrium of a three-stage game with positive trade costs, commodity trade and horizontal FDI, where two governments and different types of firms play Nash. Therefore, the exhaustive characterization of all possible equilibria is provided.

Under the hypothesis that parameter values are such that FDI is profitable, we show that under FDI liberalization two alternative Nash equilibria can occur depending upon the size of fixed costs to set up a plant: unilateral FDI, where one firm becomes a multinational firm and the other remains a national firm, but it cannot longer export; bilateral FDI where both firms become multinational firms.

With regard to the impact on environmental taxation and welfare, the first important finding is that FDI does not lead to ecological dumping because the host country has an incentive to shift rents away from the source country towards the host country. On the contrary, we show that the country hosting FDI would introduce a Pigouvian tax rate. This result holds for both types of Nash equilibria. However, if FDI is unilateral, the country attracting FDI loses in terms of welfare although its tax is at the Pigouvian rate. Conversely, the other country gains if FDI costs are not too large, despite insufficient internalization of the negative externality. In this case, each country would rather prefer its own firm to become a multinational firm. If FDI is bilateral, the welfare effects are identical for both countries, but they depend upon the size of FDI costs. In this case, the results support environmentally friendly policy strategies but FDI does not necessarily lead to welfare improvement, even though environmental policies react endogenously to firms' behavior.

The remaining sections of the paper are organized as follows. Section 2 introduces the model. Section 3 discusses strategic environmental policies under intra-industry trade. Section 4 explores the impact of FDI on strategic environmental policies, trade flows and welfare; and Section 5 summarizes the results. For convenience, we have relegated to the appendix all technical details on firms' output, profits, pollution and tax revenues.

2 The model

The theoretical model used in this paper is an extension of the model of Markusen, Morey and Olewiler (1995). We consider two countries, a domestic

country and a foreign country. All terms associated with the foreign country are denoted by a star. Both countries are identical with respect to preferences, endowment and size, and there is only one factor of production, denoted by L . In both countries, a homogeneous good, denoted by Z , is produced under perfect competition by using this production factor such that $L^Z = Z$, where the superscript denotes the sector in which the factor is used. Z is the numeraire of the model. There is no pollution associated with the production or consumption of Z , and exporting Z is assumed to raise no trade costs. In order to keep the structure of the model simple, the consumers' preferences in each country are given by the utility function $U(X, Z, D) = aX - bX^2/2 + Z - D$, where X denotes the consumption of the product produced by the oligopolistic industry and D the environmental damage, which is a public bad. We assume an international duopoly for the oligopolistic industry, where one firm is located in each country. By using the typical terminology of the trade literature, we will refer to a firm which serves the foreign market with exports as a *national firm*, and to a firm which does it with a plant set up abroad as a *multinational firm*.

Since the consumer structure is atomistic, consumers do not take into account the effects of their behavior on environmental damage. Each individual views pollution as exogenous, so that market failure occurs if the externality is not internalized. Given the aggregate resource constraint $L + \Pi + T = pX + Z$, where Π denotes the profits of the domestic firm, T the domestic tax revenues and p the price of X in terms of the numeraire, maximization of U subject to the resource constraint yields the following inverse income inelastic demand



function:

$$p = a - bX. \quad (1)$$

With regard to the equilibrium in the goods market, let $y(y^*)$ denote the production of the domestic (foreign) firm for the domestic (foreign) market, and $x(x^*)$ the production of the foreign (domestic) firm for the domestic (foreign) market.³ The equilibrium in the goods market is given by $X = x + y$ in the domestic country, and by $X^* = x^* + y^*$ in the foreign country. Note that $x(x^*)$ denotes exports of the foreign (domestic) firm, if it is a national firm, or sales via FDI of the foreign (domestic) firm, if it is a multinational firm.

Regarding the environmental damage, we assume that no international spillovers exist, and that pollution depends linearly on the level of aggregate production within the domestic country, Q : $D = \delta Q$, where $\delta > 0$ reflects the constant marginal disutility from pollution. It is important to emphasize that $Q = x^* + y$, if both firms are national firms; $Q = x + y$, if both firms are multinational firms; $Q = x + x^* + y$, if the domestic firm is a national firm and the foreign firm is a multinational firm; and $Q = y$, if the domestic firm is a multinational firm and the foreign firm is a national firm. Needless to say, the strategically optimal environmental policies will depend on the type of firms serving the market.

The international duopoly is characterized by imperfect competition and Cournot behavior. Each firm faces a fixed set-up cost and produces one good, which is traded within the home market and may be exported or produced

³The superscript refers to the destination of the respective production.

abroad.⁴ Exports and FDI are assumed to be perfect substitutes, which implies that we focus our analysis upon *horizontal* FDI.⁵ Firms' production decisions depend on the fixed costs, the marginal cost c , environmental taxes t and t^* and the trade costs s . Governments are not allowed to discriminate against foreign firms and markets are segmented in the sense that each firm is able to regard each country as a separate market.

The profits of a firm depends upon the firm's type. The profits of the domestic national firm, Π_n , and of the foreign national firms, Π_n^* , are given by (2) and (3); whilst the profits of a domestic multinational firm, Π_m , and of a foreign multinational firm, Π_m^* , are given by (4) and (5), respectively:

$$\Pi_n = (p - c - t)y + (p^* - c - t - s)x^* - F - G, \quad (2)$$

$$\Pi_n^* = (p^* - c - t^*)y^* + (p - c - t^* - s)x - F - G, \quad (3)$$

$$\Pi_m = (p - c - t)y + (p^* - c - t^*)x^* - F - 2G, \quad (4)$$

$$\Pi_m^* = (p^* - c - t^*)y^* + (p - c - t)x - F - 2G, \quad (5)$$

where F denotes the firm-specific fixed costs for headquarters, and G the plant-specific fixed costs for setting up a production plant, *i.e.*, the FDI costs. A national firm has to carry trade costs s , which depend linearly on

⁴The benchmark of the model is the trade regime because the autarky case has already been examined in the literature (see, for example, Ulph, 1995) and we focus on the impact of FDI. Nevertheless, we will show that environmental policies under autarky coincide with environmental policies under unilateral FDI in the home country of the multinational firm (see subsection 4.2).

⁵The literature distinguishes between horizontal FDI, which replaces trade, and vertical FDI, which is complementary to trade. In the horizontal case, a firm sets up a production plant in the foreign country to serve the foreign market. In the vertical case, this plant serves the foreign market as well as the domestic market. In this paper, we assume that FDI is horizontal, a hypothesis which is also supported by recent empirical evidence (see Brainard, 1997, Blonigen, 2001, and Markusen and Maskus, 2002). An exhaustive review can be found in Markusen (2002) and Markusen and Maskus (2003).

exports. This variable collects all costs associated with cross-border activities. Conversely, the multinational firm saves the variable trade costs s , but has to carry the additional fixed costs G to set up a second plant in the other country. Since we assume that producing the oligopolistic good is profitable and that each firm has already sunk $F + G$, only the additional cost G to set up a second plant is relevant for welfare comparisons. Therefore, we will no longer take $F + G$ into account in subsequent sections.

Note that if the firm serves the foreign market by exporting goods, these exports will be subject to the domestic environmental tax t ; by contrast, if the firm serves the foreign market with FDI, the production in the foreign country will be subject to the foreign environmental tax t^* . Note also that we assume that governments apply the non-discrimination rule vis-à-vis foreign companies that is often established in international agreements and is enshrined in European Union laws.

Given the quasi-linear structure of the utility function, we can measure welfare by the sum of firms' profits, Π , consumer surplus, CS , tax revenues, the disutility of pollution, and labor income:

$$W = \Pi + CS + (t - \delta)Q + L. \quad (6)$$

Note that the profits of the multinational firm belong to the country where its headquarters are located. However, this firm can only transfer profits net of environmental taxes. These taxes are collected by local governments. Given the linear inverse demand function (1), consumer surplus is determined by $bX^2/2$. Expression (6) allows us to derive a simple measure for the internalization of the environmental damage. If the environmental tax rate is such

that $t = \delta$, then perfect internalization occurs, because the marginal damage is equal to the marginal tax rate. This case will be referred to as the Pigouvian tax rate. If, instead, the environmental tax rate is such that $t < \delta$, the tax rate falls short of its Pigouvian level and internalization is incomplete. It is important to emphasize that this comparison does not allow us to draw any conclusion concerning welfare, because imperfect competition implies market distortions, which also have to be taken into account.

3 Environmental policy under trade

For the time being, assume that FDI is banned and that intra-industry trade takes place between both countries. As shown in Appendix A.2, trade occurs if $2(a - c) - 2\delta - 3s \geq 0$. Under this hypothesis we set up a simple two stage non-cooperative game between firms and governments in this section: in the first stage, both governments decide simultaneously on environmental taxation; in the second stage, both firms compete á la Cournot. Appendix A.1 shows that differentiation of domestic welfare W_I with respect to t yields

$$\frac{\partial W_I}{\partial t}(t, t^*) = -\frac{2(2(a - c) - 6\delta - s) + 7t + t^*}{9b}. \quad (7)$$

The strategic tax rates can be determined by setting (7) equal to zero. Given the symmetry assumption of the intra-industry trade model, then

$$\tilde{t}_I = \tilde{t}_I^* = \underbrace{-\frac{a - c - \delta}{4}}_{(I), (-)} \underbrace{-\frac{a - c - s - \delta}{4}}_{(II), (-)} + \underbrace{\delta}_{(III), (+)}. \quad (8)$$

Expression (8) collects three incentives. Firstly, the government of each country wishes to correct the distortion existing in its own market, due to

the presence of the duopoly (see Barnett, 1980). This incentive alone implies a subsidy (see term (I) in (8), which corresponds to the classic *domestic correction* incentive). Secondly, the government can subsidize exports of its home firm in order to shift profits from the foreign country to the home country (see term (II) in (8), which corresponds to the *profit shifting* incentive) already analyzed by Brander and Spencer (1985). Thirdly, the government has to take into account the externality which is caused by its own firm in producing goods to be supplied internally and exported (see term (III) in (8), which we label as the *environmental protection* incentive). The first two incentives imply a negative tax, whereas the third incentive leads to a positive tax. Although the aggregate effect is ambiguous in sign, the strategic environmental tax rate is lower than the marginal damage.⁶ Lemma 1 summarizes and proves this result:

Lemma 1: *In the case of intra-industry trade, the strategic environmental tax rate is lower than the Pigouvian tax rate.*

Proof: See Appendix A.2.

We can now compute equilibrium welfare, denoted by a hat, *i.e.*,

$$\hat{W}_I = \hat{W}_I^* = \frac{(a - c - \delta)^2}{2b} - \frac{s(4(a - c - \delta) - 5s)}{8b} + L. \quad (9)$$

We observe that autarky would be an equilibrium if $s > 2(a - c - \delta)/3$. Ap-

⁶A similar result can be also found in Conrad (1996). Note also that the *profit shifting* incentive weakens as s increases. This is because high trade costs make profit shifting more costly, as the home firm finds itself at a substantial cost disadvantage in the foreign country.

pendix A.3 shows that welfare is convex in trade costs s , because equilibrium profits

$$\hat{\Pi}_I = \hat{\Pi}_I^* = \frac{(a - c - \delta)^2}{2b} - \frac{s(4(a - c - \delta) - 5s)}{8b}, \quad (10)$$

increase as trade costs become larger.⁷ In the subsequent section, we relax the assumption that FDI is banned and we take (9) as the benchmark of our welfare analysis.

4 Environmental policy under trade and FDI

If FDI is liberalized, the game presented in the previous section becomes more elaborated, because firms can decide on their long-run investment policies. Since investment is a long-run decision with a high degree of commitment by firms, we employ the following three stage game: in the first stage, firms decide simultaneously on their type; in the second stage, governments decide simultaneously on environmental taxation; and in the third stage, firms compete in the usual Cournot-Nash fashion. Three alternative market structure equilibria have to be distinguished in the last stage: intra-industry trade, where both the domestic and the foreign firm are national firms; bilateral FDI, where both firms are multinational firms; and unilateral FDI, where one firm is a multinational firm and the other firm is a national firm. Strategic environmental taxes, profits and welfare levels have already been computed for the intra-industry trade case in the previous section. These variables will be determined for both the bilateral and the unilateral FDI

⁷The behavior of welfare with trade costs will also be used for proofs in Section 4.

equilibria, respectively, in the next two sub-sections.

4.1 The bilateral FDI equilibrium

Assume that parameter values are such that bilateral FDI, denoted by the subscript B , is profitable. As shown in Appendix A.4, the welfare function (6) in the bilateral FDI case is equal to

$$W_B = \frac{(a - c - t)^2}{3b} + \frac{(a - c - t^*)^2}{9b} + (t - \delta) \frac{2(a - c - t)}{3b} - G + L. \quad (11)$$

At the second stage, the social planner has to compute the strategic environmental tax rate, which maximizes social welfare. The solution is summarized by Proposition 1.

Proposition 1: *In the case of bilateral FDI, the strategic environmental tax rate coincides with the Pigouvian tax rate in both countries.*

Proof: Maximization of (11) with respect to t leads to $\tilde{t}_B = \delta$. \square

Proposition 1 is a surprising result because strategic incentives are not absent in this setting. The government has the incentive to correct the market distortions with a subsidy (*domestic correction* incentive). But, at the same time, it wishes to tax production of the foreign multinational firm in the domestic country. Clearly, the *profit shifting* incentive is different from that discussed in the intra-industry trade case, because it is not domestic exports but foreign "imports" (which are produced in the domestic country) which are subject to environmental taxation. To a certain extent,

the *profit shifting* incentive is similar to the tariff argument of Brander and Spencer (1984). Proposition 1 shows that the *domestic correction* incentive and the *profit shifting incentive* offset each other, leaving effective only the *environmental protection* incentive.

Proposition 1 demonstrates that FDI does not lead to ecological dumping, as one might have believed in the first place. Given the symmetry of the bilateral FDI case, equilibrium profits and welfare turn out to be respectively equal to

$$\hat{\Pi}_B = \hat{\Pi}_B^* = \frac{2(a - c - \delta)^2}{9b} - G, \quad (12)$$

$$\hat{W}_B = \hat{W}_B^* = \frac{4(a - c - \delta)^2}{9b} - G + L. \quad (13)$$

The coincidence of the tax rate with the Pigouvian tax rate depends crucially on the assumption of linear demand. If the inverse demand function were convex (concave), the increase in demand induced by a reduction in the tax would be larger (smaller). Hence, convex (concave) demand would imply a stronger (weaker) incentive to raise domestic consumption, and the tax would be larger (lower) than the Pigouvian tax.⁸ It also depends on the hypothesis that domestic and foreign firms are symmetric. Indeed, if the foreign firm were relatively more efficient, higher foreign profits would amplify the rent shifting incentive by the domestic government, but reduce the domestic correction incentive as the foreign firm's output is already relatively larger. Hence, a difference in efficiency in favor of a foreign firm would lead to a domestic tax above the Pigouvian tax. Since we would like to focus on the environmental protection incentive, we will not explore the asymmetric cases any further.

⁸For the influence of consumer preferences on the sign of commodity tax rates, see Hauffer, Schjelderup and Stähler (2005).

4.2 The unilateral FDI equilibrium

Assume that parameter values are such that unilateral FDI, denoted by the subscript U , is profitable. For convenience, assume also that the foreign firm is the multinational firm and the domestic firm is the national firm. Under this scenario, Appendix A.5 can substantiate the following Lemma 2.

Lemma 2: *In the case of unilateral FDI, the national firm does not export to the home country of the multinational firm.*

Proof: See Appendix A.5.

The basic intuition behind Lemma 2 is that the domestic country's *profit shifting* incentive to tax the multinational firm harms the potential exports of the domestic firm. Furthermore, the *domestic correction* incentive in the foreign country deteriorates the competitive position of the domestic firm in the foreign market. Lemma 2 suggests that these effects are so strong that exports are not profitable.

Given Lemma 2, the national firm is producing only for the home market and faces competition by the multinational firm, whilst the foreign multinational firm is a monopolist in its home market. Appendix A.6 shows that domestic social welfare

$$\tilde{W}_U = \frac{(a - c - t)^2}{3b} + (t - \delta) \frac{2(a - c - t)}{3b} + L, \quad (14)$$

depends only on the domestic tax rate. Proposition 2 derives the strategically optimal environmental policy for the domestic country.

Proposition 2: *In the case of unilateral FDI, the country hosting the national firm introduces a strategic environmental tax rate, which coincides with the Pigouvian tax rate.*

Proof: Differentiating (14) with respect to t yields $\tilde{t}_U = \delta$. \square

Proposition 2 and Proposition 1 give the same solution for the domestic country, because the effects are similar. The *domestic correction* incentive and the *profit shifting* incentive compensate each other for the same reasons already discussed in the previous subsection, such that only the *environmental protection* incentive is left. As shown in Appendix A.6, aggregate welfare in the foreign country adds up to

$$W_U^* = \frac{3(a - c - t^*)^2}{8b} + \frac{(a - c - t)^2}{9b} + (t^* - \delta) \frac{a - c - t^*}{2b} - G + L. \quad (15)$$

Proposition 3 draws the environmental policy conclusion for the foreign country.

Proposition 3: *In the case of unilateral FDI, the country hosting the multinational firm introduces an environmental tax which falls short of the Pigouvian tax rate.*

Proof: Differentiation of (15) with respect to t^* yields $\tilde{t}_U^* = -(a - c - \delta) + \delta$. This tax rate is larger than δ if, and only if, $\delta > a - c$, which would imply negative exports (see Appendix A.6). \square

Since the domestic firm is not in the foreign country and the foreign activities of the foreign multinational firm are subject to domestic taxation, the foreign government balances only two incentives: on the one hand, it has to correct the market imperfections due to the monopoly power (*domestic correction* incentive); on the other hand, it has to internalize the environmental damage (*environmental protection* incentive). This is the reason why the strategic tax rate is lower than the Pigouvian level.⁹ Note that $\tilde{t}_U^* = -(a - c - \delta) + \delta$ is also the tax rate which we would observe under autarky. Since the foreign firm faces no competition in its home market, business conditions for the foreign firm in the home market do not differ between unilateral FDI and autarky. Note also that $\tilde{t}_U^* < \tilde{t}_I^*$.

The results of Propositions 2 and 3 allow to compute the equilibrium values of domestic and foreign profits and of domestic and foreign welfare, respectively:

$$\hat{\Pi}_U = \frac{(a - c - \delta)^2}{9b}, \quad (16)$$

$$\hat{\Pi}_U^* = \frac{10(a - c - \delta)^2}{9b} - G, \quad (17)$$

$$\hat{W}_U = \frac{(a - c - \delta)^2}{3b} + L, \quad \hat{W}_U^* = \frac{11(a - c - \delta)^2}{18b} - G + L. \quad (18)$$

⁹Note that Proposition 3 does not necessarily imply a subsidy. The tax rate is positive if $\delta < a - c < 2\delta$. Note also that the tax structure described by Proposition 2 and Proposition 3 is consistent with Lemma 2 since (A.15) in Appendix A.5 would be equal to $x_U^* = -2s/3b < 0$.

4.3 Equilibrium FDI

In the two previous subsections, we have only considered the effects of bilateral and unilateral FDI on environmental taxation. But we have not yet shown whether and under which conditions FDI is a Nash equilibrium. To determine the Nash equilibrium, we have to examine the best responses of firms to various strategy choices. Table 1 shows the payoff matrix of profits in the first stage where profits refer to (10), (12), (16) and (17).¹⁰ The left (right) box on the upper (lower) line gives the profits in case of intra-industry trade (bilateral FDI) whereas the other boxes give the unilateral FDI cases.

Table 1: Payoff matrix

		Foreign firm	
		Trade	FDI
Domestic firm	Trade	$(\hat{\Pi}_I, \hat{\Pi}_I^*)$	$(\hat{\Pi}_U, \hat{\Pi}_U^*)$
	FDI	$(\hat{\Pi}_U^*, \hat{\Pi}_U)$	$(\hat{\Pi}_B, \hat{\Pi}_B^*)$

Suppose that the foreign firm wishes to make an investment, *i.e.*, it considers to move from the left to the right on the upper line of Table 1. Then, it would have an incentive to do so if, and only if, its profits under intra-industry trade are not larger than its profits under unilateral FDI, taking into account that it will then face a Pigouvian tax in the domestic country and a tax according to Proposition 3 at home. Namely, a firm has an incentive to become a multinational firm if expression (10) is not larger than expression (17). Both terms are equal if G is equal to:

¹⁰Payoffs are denoted by (domestic profit, foreign profit). Due to symmetry, (un-)starred terms may also give domestic (foreign) profits.

$$G_1 = \frac{11(a - c - \delta)^2}{18b} + s \frac{4(a - c - \delta) - 5s}{8b}, \quad (19)$$

such that if G is lower than G_1 , then at least one firm becomes a multinational firm. However, $G \leq G_1$ does not describe a complete equilibrium behavior, because the other firm may do the same. Define

$$G_3 = \frac{(a - c - \delta)^2}{9b}, \quad (20)$$

in order to demonstrate that the other firm may not follow in equilibrium.¹¹

Proposition 4: *The Nash equilibrium of the first-stage game is as follows:*

- i *if $G < G_3$, then it is a dominant strategy of each firm to set up a plant in the other country;*
- ii *if $G > G_1$, then it is a dominant strategy for each firm not to set up a plant in the other country;*
- iii *if $G_3 < G < G_1$, then there are two asymmetric Nash equilibria in which one firm sets up a plant in the other country and the other firm does not.*

Proof: The proof can be given by checking the one-shot deviation property of an asymmetric equilibrium. Suppose that G is not larger than G_1 , so that the foreign firm is better off by investing abroad, given that the other domestic firm is a national firm. Then, the domestic firm has also an incentive to

¹¹ G_2 and G_4 will be introduced when discussing welfare effects.

become a multinational firm if (16) is not larger than (12), that is, it then prefers to move from top to down in the second column of Table 1. Note that the domestic firm takes into account that Pigouvian taxation will be introduced in both countries in this case. The equality between (16) and (12) gives a critical level of fixed costs which is equal to G_3 : if G is larger (less) than G_3 , then the domestic firm will refrain from (go for) an FDI policy. Hence, the proof for the existence of an asymmetric equilibrium is complete if $G_1 > G_3$. The latter inequality means that a non-empty range for G exists so that one firm becomes a multinational firm and the other firm remains a national firm. The difference between G_1 and G_3 proves that this is in fact true:

$$G_1 - G_3 = \frac{4(a - c - \delta)^2 + s(4(a - c - \delta) - 5s)}{8b} > 0. \quad \square \quad (21)$$

Although countries are symmetric, a Nash equilibrium with an asymmetric industry structure and asymmetric environmental tax rates may exist. Proposition 4 is by no means a trivial conclusion, especially as an asymmetric equilibrium can never exist, if tax rates are exogenously fixed and symmetric because symmetric tax rates imply symmetric behavior of both firms.¹² However, if firms can anticipate the effects of FDI on tax rates, different profitability conditions imply the possibility of an asymmetric equilibrium. In summary, if $G \leq G_3$, the unique Nash equilibrium is given by bilateral FDI. However, if $G_3 < G \leq G_1$, the Nash equilibrium is represented by unilateral FDI. Note that either the domestic firm or the foreign firm be-

¹²The proof is available upon request.

comes multinational. Therefore, two asymmetric Nash equilibria characterize the unilateral FDI case.

4.4 FDI and welfare

With regard to welfare in the unilateral FDI case, an asymmetric equilibrium can be expected to imply asymmetric welfare effects. Define

$$G_2 = \frac{(a - c - \delta)^2}{9b} + s \frac{4(a - c - \delta) - 5s}{8b}, \quad (22)$$

for which $G_3 < G_2 < G_1$, in order to demonstrate the welfare effects of FDI.

Proposition 5: *If unilateral FDI replaces the trade regime, the welfare of the country hosting the national firm deteriorates. If $G \in [G_2, G_1]$, the welfare of the country hosting the headquarters of the multinational firm declines, if $G \in [G_3, G_2]$, the welfare of the country hosting the headquarters of the multinational firm improves.*

Proof: Compare (18) with (9). The switch from intra-industry trade to unilateral FDI is welfare improving for the country hosting the national firm if, and only if, \hat{W}_U in (18) is larger than \hat{W}_I in (9), which implies that

$$s \frac{4(a - c - \delta) - 5s}{8b} - \frac{(a - c - \delta)^2}{6b} > 0. \quad (23)$$

Appendix A.3 shows that $s[4(a - c - \delta) - 5s]/8b$ is smaller than or equal to $(a - c - \delta)^2/10b$ (see (A.9) and (A.10)), which is in contradiction with (23). The country hosting the multinational firm is worse (better) off if \hat{W}^* in (18)

is less (larger) than \hat{W}^* in (9), which implies that

$$G > (<) \frac{(a - c - \delta)^2}{9b} + s \frac{4(a - c - \delta) - 5s}{8b} = G_2. \quad \square \quad (24)$$

We observe from Proposition 5 that one country may gain, whereas the other country definitely loses if unilateral FDI is the Nash equilibrium. This is because the profits of the domestic firm decline due to the lack of exports, whereas the profits of the foreign firm increase because it no longer faces competition at home. In addition, the dumping effect of trade costs for the foreign consumer is annulled, whereas the domestic consumer has to carry an additional plant-specific fixed cost. Note that the country which imposes the Pigouvian environmental taxation internalizes the environmental damage, but is worse off in terms of social welfare. Conversely, the other country chooses a lower tax rate, but can be better off if the fixed costs of FDI are not too large. In this case, each country would rather prefer its own firm to become a multinational firm, even at the cost of insufficient environmental regulation.

For the case of bilateral FDI, define

$$G_4 = s \frac{4(a - c - \delta) - 5s}{8b} - \frac{(a - c - \delta)^2}{18b}. \quad (25)$$

Note that $G_4 < G_3$ (see (20)) and that the sign of G_4 depends on parameter values.¹³ Proposition 6 summarizes the welfare results if FDI is bilateral.

Proposition 6: *If bilateral FDI replaces the trade regime and $G_4 > 0$, FDI*

¹³ $G_4 > (<)0$ if $s > (<)2(a - c - \delta)/15$.

is welfare enhancing if $G < G_4$ but welfare reducing if $G \in [G_4, G_3]$. If $G_4 < 0$, FDI is welfare reducing.

Proof: Bilateral FDI compared to intra-industry trade does not lead to welfare losses, if expression (13) is larger than or equal to expression (9). This is the case if

$$G \leq s \frac{4(a - c - \delta) - 5s}{8b} - \frac{(a - c - \delta)^2}{18b} = G_4 \quad \square.$$

Under bilateral FDI, the strategic tax rates are always positive. Due to these high rates, firms produce less and make less profits affecting social welfare negatively, despite the fact that the detrimental reciprocal dumping effect would not materialize. However, if the plant-specific fixed costs are sufficiently small and $G_4 > 0$, then FDI liberalization would result in mutual welfare gains because the lack of the reciprocal dumping effect would dominate the negative aggregate fixed costs effect.

5 Concluding remarks

This paper has discussed strategic environmental taxation policies in a non-cooperative model of potential intra-industry trade and FDI with positive trade costs, where pollution cannot spill-over to other countries, the location of plants is endogenous and decisions on FDI are prior to environmental regulation. This assumption may reflect the hold-up problem of polluting multinational firms, which anticipate that environmental taxes can be changed once they have entered the country. Environmental policies are no longer taken as given by firms, since firms' behavior can affect policy decisions.

We have taken the case of intra-industry trade as the point of departure of our analysis. Due to imperfect competition, intra-industry trade implies taxes which fall short of the Pigouvian level, because governments have the incentive to correct domestic distortion and to promote exports with lower taxes. If FDI is liberalized, the model shows that FDI does not lead to ecological dumping. On the contrary, governments are tempted to levy higher taxes against polluting foreign multinationals in order to shift rents away from the source country towards the host country.

We find that two types of equilibria are possible in the presence of FDI, depending on the size of plant-specific fixed costs: (i) one with unilateral FDI, where one firm is a multinational firm, and the other is a national, not-exporting firm; (ii) and one with bilateral FDI, where both firms are multinational. If FDI is unilateral, the impact on welfare is negative for the home country of the national firm and positive for the home country of the multinational firm only if plant-specific fixed costs are not too large. This is because the profits of the domestic firm decline as a result of a lack of exports, whereas the profits of the foreign firm increase because it no longer faces competition at home. If, on the other hand, FDI is bilateral, the impact on welfare for both countries will depend on the size of plant-specific fixed costs. In this case, larger aggregate fixed costs have to be borne by firms even though the dumping effect of trade costs is annulled.

Furthermore, we show that the country attracting FDI introduces a Pigouvian environmental tax, whereas the country served by the local firm only, regardless of whether it is a national firm or a multinational firm, levies a lower tax rate. Ecological dumping is therefore more likely to occur in the

absence of FDI because in that case the traditional strategic profit-shifting incentive would become dominant. Conversely, in the presence of FDI, the strategic profit-shifting incentive implies higher taxes in order to shift profits from the foreign multinational firm to the domestic country.

In summary, the impact of FDI on strategic environmental policies - when pollution cannot spillover to other countries - seems to imply a tendency to higher rather than to lower environmental taxes, challenging therefore the known results of the race to the bottom game.

Appendix

A.1 Trade without FDI

By using (1), (2) and (3), the f.o.c.'s describing firms' behavior imply the following equilibrium output levels in the intra-industry trade equilibrium, denoted by the subscript I :

$$y_I = \frac{a - c - 2t + t^* + s}{3b}, x_I = \frac{a - c - 2t^* + t - 2s}{3b}, \quad (\text{A.1})$$

$$x_I^* = \frac{a - c - 2t + t^* - 2s}{3b},$$

which can then be used to compute equilibrium consumer surplus and equilibrium profits of the domestic firm and its change with t as follows:

$$\widetilde{CS}_I = \frac{(2(a - c) - s - t - t^*)^2}{18b}, \quad (\text{A.2})$$

$$\frac{\partial \widetilde{CS}_I}{\partial t} = -\frac{2(a - c) - s - t - t^*}{9b}, \quad (\text{A.3})$$

$$\widetilde{\Pi}_I = \frac{(a - c - 2t + t^* + s)^2 + (a - c - 2t + t^* - 2s)^2}{9b}. \quad (\text{A.4})$$

$$\frac{\partial \widetilde{\Pi}_I}{\partial t} = -\frac{4(2(a - c - 2t + t^*) - s)}{9b}. \quad (\text{A.5})$$

Similarly, the equilibrium output levels can be used to determine the tax revenues corrected by the environmental damage and its change with t as follows:

$$\tilde{T}_I - \tilde{D}_I = (t - \delta) \frac{2(a - c) - s - 4t + 2t^*}{3b}, \quad (\text{A.6})$$

$$\frac{\partial(\tilde{T}_I - \tilde{D}_I)}{\partial t} = \frac{2(a - c - 4t + t^* + 2\delta) - s}{3b}. \quad (\text{A.7})$$

Social welfare (6) in the intra-industry trade equilibrium, W_I , is then the sum of (A.2), (A.4) and (A.6), and adding up (A.3), (A.5) and (A.7) leads to (7).

A.2 Proof of Lemma 1

The proof of Lemma 1 can be given by contradiction. By inserting (8) into (A.1), we can determine the necessary condition for exports, x_I^* , to be positive. This is the case if

$$2(a - c) - 2\delta - 3s \geq 0. \quad (\text{A.8})$$

If $\tilde{t}_I = \tilde{t}_I^* \geq \delta$, by using (8), $2(a - c) - 2\delta - 3s \leq -2s < 0$, which given (A.8) would imply $x_I^* < 0$. \square

A.3 Welfare under intra-industry trade with trade costs

Welfare is convex in trade costs s and decreases (increases) with s , if s is lower (larger) than $2(a - c - \delta)/5$. Since only the second term in (9) depends on s , we may concentrate our analysis on its behavior:

$$\Sigma(s) := \frac{s(4(a - c - 4\delta) - 5s)}{8b}, \Sigma' = \frac{4(a - c) - 4\delta - 10s}{8b}, \Sigma'' < 0. \quad (\text{A.9})$$

Σ has a maximum at $\bar{s} = 2(a - c - \delta)/5$. Since exports are profitable only if $s \leq 2(a - c - \delta)/3$, then \bar{s} is within the relevant range. The maximum of the

function Σ is given by

$$\Sigma(\bar{s}) = \frac{(a - c - \delta)^2}{10b}. \quad (\text{A.10})$$

This implies that the value of the function $\hat{W}_I(\bar{s}) = \hat{W}_I^*(\bar{s})$ is a minimum. The potential welfare losses of intra-industry trade with a fixed market structure have already been demonstrated by Brander and Krugman (1983) in a model without any policy intervention.

A.4 Bilateral FDI

At the third stage, given the inverse demand function (1), the maximization of (4) and (5) yield the following equilibrium output levels in the domestic country

$$y_B = x_B = \frac{a - c - t}{3b}, \quad (\text{A.11})$$

consumer surplus

$$\widetilde{CS}_B = \frac{(2(a - c - t))^2}{9b}, \quad (\text{A.12})$$

the difference between tax revenues and damage

$$\tilde{T}_B - \tilde{D}_B = (t - \delta)(y_B + x_B) = (t - \delta) \frac{2(a - c - t)}{3b}, \quad (\text{A.13})$$

and, given the symmetry assumption, the domestic profits

$$\tilde{\Pi}_B = \frac{(a - c - t)^2 + (a - c - t^*)^2}{9b} - G. \quad (\text{A.14})$$

Adding (A.12), (A.13) and (A.14) yields (11).

A.5 Proof of Lemma 2

Contrary to Lemma 2, suppose that exports of the national firm are positive. In this case, given the f.o.c.'s, the production which takes place in the

domestic country is given by

$$y_U = x_U = \frac{a - c - t}{3b}, x_U^* = \frac{a - c - 2t + t^* - 2s}{3b}, \quad (\text{A.15})$$

leading to

$$P_U = \frac{3(a - c) - 4t + t^* - 2s}{3b}. \quad (\text{A.16})$$

Welfare can then be easily computed as

$$\begin{aligned} \tilde{W}_U = & \frac{2(a - c - t)^2}{9b} + \frac{(a - c - t)^2 + (a - c - 2t + t^* - 2s)^2}{9b} \\ & + (t - \delta) \frac{3(a - c) - 4t + t^* - 2s}{3b} + L, \end{aligned} \quad (\text{A.17})$$

where the first term represents the consumer surplus, the second term collects the profits of the national firm, and the third term gives the difference between tax revenues and environmental damage. With regard to the foreign country, the f.o.c. yields

$$y_U^* = P_U^* = \frac{a - c - 2t^* + t + s}{3b}. \quad (\text{A.18})$$

Given (A.15) and (A.18), the sum of consumer surplus, profits, tax revenues, the disutility of pollution and labor income is equal to

$$\begin{aligned} \tilde{W}_U^* = & \frac{(2(a - c) - s - t - t^*)^2}{18b} \\ & + \frac{(a - c - t)^2 + (a - c - 2t^* + t + s)^2}{9b} - G \\ & + (t^* - \delta) \frac{a - c - 2t^* + t + s}{3b} + L. \end{aligned} \quad (\text{A.19})$$

Differentiation of (A.19) with respect to t^* yields

$$\tilde{t}_U^* = -(a - c) + 2\delta. \quad (\text{A.20})$$

Given (A.20), $t \leq \delta - s$ must hold for $x_U^* \geq 0$. Maximization of (A.17) *s.t.* $t \leq \delta - s$ yields the corner solution

$$\tilde{t}_U = \delta - s, \quad (\text{A.21})$$

and proves that a domestic policy which implies $x_U^* = 0$ is optimal. \square

A.6 Unilateral FDI

The profit maximizing f.o.c.'s allow us to determine the following production, consumption and pollution levels in the domestic market:

$$x_U = y_U = \frac{a - c - t}{3b}, P_U = X_U = \frac{2(a - c - t)}{3b}, \quad (\text{A.22})$$

which can be used to determine the profits of the domestic national firm

$$\tilde{\Pi}_U = \frac{(a - c - t)^2}{9b}, \quad (\text{A.23})$$

Consumer surplus is equal to

$$CS = \frac{2(a - c - t)^2}{9b}, \quad (\text{A.24})$$

and the difference between tax revenues and damages amounts to

$$T - D = (t - \delta) \frac{2(a - c - t)}{3b}. \quad (\text{A.25})$$

Adding up (A.23), (A.24) and (A.25) yields domestic welfare (14). Since the foreign multinational firm does not face any competition from the national firm, the equilibrium output of the foreign firm for the foreign market is given by the monopoly output

$$y_U^* = P_U^* = \frac{a - c - t^*}{2b}. \quad (\text{A.26})$$

By using (A.22) and (A.26), the profits of the foreign multinational firm are equal to

$$\tilde{\Pi}_U^* = \frac{(a - c - t)^2}{9b} + \frac{(a - c - t^*)^2}{4b} - G. \quad (\text{A.27})$$

Note that the first term gives the profits realized in the domestic country and the second term gives the monopoly profits realized in the foreign country. Finally, collecting profits, consumer surplus

$$CS^* = \frac{(a - c - t^*)^2}{8b}, \quad (\text{A.28})$$

and the difference between tax revenues and environmental damage

$$T^* - D^* = (t^* - \delta) \frac{a - c - t^*}{2b}, \quad (\text{A.29})$$

yields foreign welfare (15).

References

- Beladi, H., Chao, C. and R. Frasca (1999), 'Foreign Investment and Environmental Regulations in LDCs', *Resource and Energy Economics* 21, 191-199.
- Barnett, A. H. (1980), 'The Pigouvian Tax Rule under Monopoly', *American Economic Review* 70, 1037-1041.
- Blonigen, B. A. (2001), 'In search of substitution between foreign production and exports', *Journal of International Economics* 53, 81-104.
- Brainard, S. L. (1997), 'An empirical assessment of the proximity-concentration trade-off between multinational sales and trade', *American Economic Review* 87, 520-540.

- Brander, J. A. and P.R. Krugman (1983), 'A "Reciprocal Dumping" Model of International Trade', *Journal of International Economics* 15, 313-323.
- Brander, J. A. and B. Spencer (1984), 'Tariff Protection and Imperfect Competition'in: H. Kierzkowski (ed.), *Monopolistic competition and International Trade*, Oxford University Press, Oxford.
- Brander, J. A. and B. Spencer (1985), 'Export Subsidies and International Market Share Rivalry', *Journal of International Economics* 18, 83-100.
- Cole, M., Elliott, R. J. R. and P. G. Fredriksson (2006), 'Endogenous Pollution Havens: Does FDI Influence Environmental Regulations?', *Scandinavian Journal of Economics* 108, 157-178.
- Conrad, K. (1996), 'Optimal Environmental Policies for Oligopolistic Industries under Intra-Industry Trade'in: C. Carraro, Y. Katsoulacos and A. Xepapadeas (eds.), *Environmental Policy and Market Structure*, Kluwer Academic Publishers, Norwell.
- De Santis, R. A. and F. Stähler (2004), 'Endogenous Market Structures and the Gains from Foreign Direct Investment', *Journal of International Economics* 64, 545-565.
- Eskeland, G. and A. Harrison (2003), 'Moving to Greener Pastures? Multinationals and the Pollution-Haven Hypothesis', *Journal of Development Economics* 70, 1-23.
- Haufler, A., Schjelderup, G. and F. Stähler (2005), 'Barriers to Trade and

Imperfect Competition: The Choice of Commodity Tax Base', *International Tax and Public Finance* 12, 281-300.

Greenstone, M. (2002), 'The Impacts of Environmental Regulations on Industrial Activity: Evidence from the 1970 and 1977 Clean Air Act Amendments and the Census of Manufactures', *Journal of Political Economy* 110, 1175-1219.

Hoel, M. (1997), 'Environmental Policy with Endogenous Plant Location', *Scandinavian Journal of Economics* 99, 241-259.

Keller, W. and A. Levinson (2002), 'Pollution Abatement Costs and Foreign Direct Investment Inflows to U.S. States', *The Review of Economics and Statistics* 84, 691-703.

Letchumanan, R. and F. Kodoma (2000), 'Reconciling the Conflict between the 'Pollution-Haven' Hypothesis and an Emerging Trajectory of International Technology Transfer', *Research Policy* 29, 59-79.

Levinson, A. (1996), 'Environmental Regulation and Manufactures' Location Choices: Evidence from the Census of Manufactures', *Journal of Public Economics* 65, 5-29.

Markusen, J. R. (1984), 'Multinationals, Multi-Plant Economies, and the Gains from Trade', *Journal of International Economics* 16, 205-226.

Markusen, J. R. (2002), *Multinational Firms and the Theory of International Trade*, The MIT Press, Cambridge.

- Markusen, J.R. and Maskus, K.E. (2002), 'Discriminating among Alternative Theories of the Multinational Enterprise', *Review of International Economics* 10, 694-707.
- Markusen, J. R. and K. E. Maskus (2003), 'General-Equilibrium Approaches to the Multinational Firm: A Review of Theory and Evidence'in: Harrigan J. and K. Choi (eds.), *Handbook of International Trade*, Basil Blackwell, Oxford.
- Markusen, J. R., Morey, E. R. and N. D. Olewiler (1995), 'Competition in Regional Environmental Policies when Plant Locations are Endogenous', *Journal of Public Economics* 56, 55-77.
- Motta, M. and J. F. Thisse (1994), 'Does Environmental Dumping Lead to Delocation?', *European Economic Review* 38, 563-576.
- Rauscher, M. (1995), 'Environmental Regulation and the Location of Polluting Industries', *International Tax and Public Finance* 2, 229-244.
- Smarzynska, B. K. and S. J. Wei (2001), 'Pollution Havens and Foreign Direct Investment: Dirty Secret or Popular Myth?', *NBER Working Paper*, n. 8465.
- Thomas, J. and T. Worrall (1994), 'Foreign Direct Investment and the Risk of Expropriation', *The Review of Economic Studies* 61, 81-108.
- Ulph, A. (1994), 'Environmental Policy, Plant Location and Government Protection'in: C. Carraro (ed.), *Trade, Innovation, Environment*, Kluwer Academic Publishers, Norwell.

Ulph, A. and L. Valentini (1997), 'Plant Location and Strategic Environmental Policy with Inter-Sectoral Linkages', *Resource and Energy Economics* 19, 363-383.

Ulph, A. and L. Valentini (2001), 'Is Environmental Dumping Greater when Firms are Footloose?', *Scandinavian Journal of Economics* 103, 673-688.

European Central Bank Working Paper Series

For a complete list of Working Papers published by the ECB, please visit the ECB's website (<http://www.ecb.europa.eu>).

- 888 "House prices, money, credit and the macroeconomy" by C. Goodhart and B. Hofmann, April 2008.
- 889 "Credit and the natural rate of interest" by F. De Fiore and O. Tristani, April 2008.
- 890 "Globalisation, domestic inflation and global output gaps: evidence from the euro area" by A. Calza, April 2008.
- 891 "House prices and the stance of monetary policy" by M. Jarociński and F. Smets, April 2008.
- 892 "Identification of New Keynesian Phillips Curves from a global perspective" by S. Déés, M. H. Pesaran, L. V. Smith and R. P. Smith, April 2008.
- 893 "Sticky wages: evidence from quarterly microeconomic data" by T. Heckel, H. Le Bihan and M. Montornès, May 2008.
- 894 "The role of country-specific trade and survey data in forecasting euro area manufacturing production: perspective from large panel factor models" by M. Darracq Pariès and L. Maurin, May 2008.
- 895 "On the empirical evidence of the intertemporal current account model for the euro area countries" by M. Ca'Zorzi and M. Rubaszek, May 2008.
- 896 "The Maastricht convergence criteria and optimal monetary policy for the EMU accession countries" by A. Lipińska, May 2008.
- 897 "DSGE-modelling when agents are imperfectly informed" by P. De Grauwe, May 2008.
- 898 "Central bank communication and monetary policy: a survey of theory and evidence" by A. S. Blinder, M. Ehrmann, M. Fratzscher, J. De Haan and D.-J. Jansen, May 2008.
- 899 "Robust monetary rules under unstructured and structured model uncertainty" by P. Levine and J. Pearlman, May 2008.
- 900 "Forecasting inflation and tracking monetary policy in the euro area: does national information help?" by R. Cristadoro, F. Venditti and G. Saporito, May 2008.
- 901 "The usefulness of infra-annual government cash budgetary data for fiscal forecasting in the euro area" by L. Onorante, D. J. Pedregal, J. J. Pérez and S. Signorini, May 2008.
- 902 "Fiscal consolidation in the euro area: long-run benefits and short-run costs" by G. Coenen, M. Mohr and R. Straub, May 2008.
- 903 "A robust criterion for determining the number of static factors in approximate factor models" by L. Alessi, M. Barigozzi and M. Capasso, May 2008.
- 904 "Does money matter in the IS curve? The case of the UK" by B. E. Jones and L. Stracca, June 2008.
- 905 "A persistence-weighted measure of core inflation in the euro area" by L. Bilke and L. Stracca, June 2008.
- 906 "The impact of the euro on equity markets: a country and sector decomposition" by L. Cappiello, A. Kadareja and S. Manganelli, June 2008.

- 907 “Globalisation and the euro area: simulation based analysis using the New Area Wide Model” by P. Jacquinot and R. Straub, June 2008.
- 908 “3-step analysis of public finances sustainability: the case of the European Union” by A. Afonso and C. Rault, June 2008.
- 909 “Repo markets, counterparty risk and the 2007/2008 liquidity crisis” by C. Ewerhart and J. Tapking, June 2008.
- 910 “How has CDO market pricing changed during the turmoil? Evidence from CDS index tranches” by M. Scheicher, June 2008.
- 911 “Global liquidity glut or global savings glut? A structural VAR approach” by T. Bracke and M. Fidora, June 2008.
- 912 “Labour cost and employment across euro area countries and sectors” by B. Pierluigi and M. Roma, June 2008.
- 913 “Country and industry equity risk premia in the euro area: an intertemporal approach” by L. Cappiello, M. Lo Duca and A. Maddaloni, June 2008.
- 914 “Evolution and sources of manufacturing productivity growth: evidence from a panel of European countries” by S. Giannangeli and R. Gómez-Salvador, June 2008.
- 915 “Medium run redux: technical change, factor shares and frictions in the euro area” by P. McAdam and A. Willman, June 2008.
- 916 “Optimal reserve composition in the presence of sudden stops: the euro and the dollar as safe haven currencies” by R. Beck and E. Rahbari, July 2008.
- 917 “Modelling and forecasting the yield curve under model uncertainty” by P. Donati and F. Donati, July 2008.
- 918 “Imports and profitability in the euro area manufacturing sector: the role of emerging market economies” by T. A. Peltonen, M. Skala, A. Santos Rivera and G. Pula, July 2008.
- 919 “Fiscal policy in real time” by J. Cimadomo, July 2008.
- 920 “An investigation on the effect of real exchange rate movements on OECD bilateral exports” by A. Berthou, July 2008.
- 921 “Foreign direct investment and environmental taxes” by R. A. De Santis and F. Stähler, July 2008.

ISSN 1561-0810



9 771561 081005