Modelling the Impact of Environmental Regulations on Bilateral Trade Flows: OECD, 1990–1996*

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Abstract

Since the early seventies an increasing attention has been paid to the impact environmental policy has on foreign trade. One of the most important issues is whether countries with relatively strict environmental regulations tend to experience a deterioration of international competitiveness and thus a fall in the exports, and a rise in the imports, of the pollution-intensive commodities or, on the other hand, benefit from the improvement in environmental quality and are likely to develop new comparative advantages in the environmentally more sensitive industries. So far, most empirical studies have concluded that the proportion of environmental costs to the total production costs is still so marginal that environmental policies have hardly any effect on comparative advantage patterns and thus on foreign trade. One of the few exceptions is Van Beers and Van den Bergh (1997), who found that stricter regulations have some negative impact on bilateral trade flows between OECD countries. The aim of this paper is to show that this outcome is partly due to model mis-specification. The analysis is based on a triple indexed fixed-effects model and on its variants. It is found that, as soon as both the importing and exporting country specific effects are taken into consideration, the relationship between stricter regulations and foreign trade becomes statistically insignificant. This suggests that environmental costs do not have a real impact, neither negative nor positive, on foreign trade.

1 Introduction

Since the early seventies policy makers and academics alike, have been paying an increasing attention to the impact environmental policy might have on foreign trade. One of the main issues is whether countries with relatively strict environmental regulations tend to experience a deterioration of international competitiveness and a decline of both local and foreign investment, at least in the pollution-intensive industries. Among others, Anderson and Blackhurst (1992), Dean (1992), Jaffe, Peterson, Portney and Stavins (1995), Levinson (1995), Van Beers and Van den Bergh (1996) and Xing and Kolstad (1996) provide interesting reviews of this issue.

It is a commonly held belief that the pollution-intensive industries of a country which imposes more stringent environmental regulations than its trading partners are likely to suffer a significant increase in production costs. Consequently, these industries either become less competitive internationally and lose some of their market share or, in order to avoid this loss, they migrate to countries with lower environmental standards. In any case, exports of pollution-intensive commodities of a country with relatively strict environmental regulations decrease, while their imports are expected to increase.

On the other hand, following for example Porter and Van der Linde (1995), this static view can be challenged on the ground that a country with relatively stringent environmental regulations can benefit from the improvement in environmental quality and is likely to develop new comparative advantages in the environmentally more sensitive industries. These advantages, in the long run, might more than offset the short-term losses. Moreover, even in the short run, as Van Beers and Van den Bergh (1997) point out, the negative effect of stringent environmental regulations on export flows and its positive effect on import flows can be blurred by government interventions, such as subsidies to pollution-intensive industries, and import restrictions on foreign products which do not meet the higher than average domestic environmental standards. In addition to these environmental cost factors, industry location will also be driven by other economic fundamentals such as:

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access to resources and markets, the supply and quality of labour, and transportation costs, for example. Indeed, the effect of these economic fundamentals may outweigh that of environmental cost factors.

So far empirical studies have not provided strong support for the hypothesis that relatively high environmental standards lead to the loss of competitiveness, and to the consequent decrease of exports and increase of imports. In fact, apart from a few exceptions (Walter (1974) and Van Beers and Van den Bergh (1997)), most studies on different countries, industries and sample periods, conclude that environmental costs relative to total production costs are still marginal and have hardly any effect on comparative advantage patterns and therefore on foreign trade (see for example, Jaffe *et al.* (1995), Low (1992b), OECD [1985], Ratnayake (1998), Stevens (1993), Sorsa (1994), Tobey (1990) and Vallaru and Peterson (1997)).

The study which most strongly motivated this paper is that of Van Beers and Van den Bergh (1997). It analyses the impact of environmental regulations on bilateral trade flows for the cross section of 21 OECD countries in 1992. It is based on a gravity model, as developed by Tinbergen (1962) and Linnemann (1966), augmented by variables that measure the strictness of environmental regulations both in the importer and exporter countries. Two strictness measures of environmental regulations were used. The first one was based on the combination of seven output-oriented environmental indicators, whilst the second was calculated from only two. Both of these measures, but especially the narrower one, are consistent with the Polluter Pays Principle. The model was estimated over three kinds of bilateral trade flows: total trade; pollution-intensive (or 'dirty') trade; and pollution-intensive trade related to non-resource based (or 'footloose') sectors. The results, based on the narrow environmental regulations strictness measure, can be summarised as follows (Van Beers and Van den Bergh, 1997, pp.41-42):

i.   The analysis of total and 'footloose' trade supports "the hypothesis that a more stringent environmental policy exerts a negative influence on exports". However, environmental standards have no significant effect on 'dirty' exports in general. This

means that the presence of resources is a more important factor determining competitiveness of pollution-intensive resource based industries than environmental standards.

ii.   Relatively strict environmental regulations have negative impact on all three types of imports (total, 'dirty' and 'footloose'). This suggests that countries imposing more strict environmental regulations on their own producers, probably also erect non-tariff barriers to imports in order to protect domestic industries.

The aim of this paper is to find out how much these outcomes depend on the specification of traditional gravity models, such as the one used by Van Beers and Van den Bergh (1997). For this reason, instead of the traditional double indexed cross-sectional approach, a three-dimensional panel data framework is employed, which allows for both importing and exporting country effects, as well as for time (or Business cycle) effects. Even if these additional specific effects are insignificant, the panel data set used is expected to be more reliable and enlightening than a simple cross-sectional data set, since bilateral trade, especially on the lower, two- and three-digit Standard International Trade Classification (SITC) levels, is often prone to strong annual fluctuations. As our analysis shows, as soon as these specific effects are taken into consideration, the relationship between stricter regulations and foreign trade becomes statistically insignificant. This suggests that environmental costs do not have a real impact, neither negative nor positive, on foreign trade.

The paper is structured as follows. The model is briefly described in Section 2. Section 3 discusses the measurements and sources of the data used, with special regard to the strictness of environmental regulations. The empirical findings are summarised in Section 4. Finally, the concluding remarks can be found in Section 5.

2 The Model

The basic model, hereafter referred to as *Model B*, is a triple indexed generalisation of the model used by Van Beers and Van den Bergh (1997). It has the following form.

$$\ln IMP_{ijt} = \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln POP_{it} + \beta_4 \ln POP_{jt}$$
$$+ \beta_5 \ln DIST_{ij} + \beta_6 ADJ_{ij} + \beta_7 EEC_{ijt} + \beta_8 EFTA_{ijt} + \beta_9 NAFTA_{ijt} \quad (1)$$
$$+ \beta_{10} \ln LAND_i + \beta_{11} \ln LAND_j + \beta_{12} \ln SC_{it} + \beta_{13} \ln SC_{jt} + u_{ijt} \quad ,$$

where: ln denotes natural logarithm;

IMP_{ijt}, the imports of country i from country j in year t;

GDP_{it}, GDP_{jt}, the GDPs of countries i and j, respectively, in year t;

POP_{it}, POP_{jt}, the populations of countries i and j, respectively, in year t;

$DIST_{ij}$, the distance between countries i and j;

ADJ_{ij}, a dummy variable, equal to 1 if countries i and j are adjacent, *i.e.* share a common land border, and zero otherwise;

EEC_{ijt}, a dummy variable, equal to 1 if countries i and j are both members of the EEC in year t and zero otherwise;

$EFTA_{ijt}$, a dummy variable, equal to 1 if countries i and j are both members of the EFTA in year t and zero otherwise;

$NAFTA_{ijt}$, a dummy variable, equal to 1 if countries i and j are both members of the NAFTA in year t and zero otherwise;

$LAND_i$, $LAND_j$, the land areas of countries i and j, respectively;

SC_{it}, SC_{jt}, scores measuring the relative strictness of environmental regulations in countries i and j, respectively, in year t;

u_{ijt}, white noise disturbance term; and

$i = 1,..., N$, $j = 1,..., i - 1, i + 1,..., N$, $t = 1,..., T$.

In this model, GDP_i measures the potential demand of the importing country, while GDP_j represents the potential supply of the exporting country. Therefore, the corresponding

slope parameters, β_1 and β_2, are expected to be positive. POP_i and POP_j are used to capture the effects of economies of scale in the importing and exporting countries, respectively. Since countries with large populations tend to be more self-reliant, one might expect β_3 and β_4 to be negative. However, the expansion of the scale of productive capacity causes long-run average costs to fall, giving more populous countries a competitive edge in exporting, so that β_4 could also be positive.

$DIST_{ij}$ is a proxy for resistance to trade, thus it is anticipated that β_5 will be negative. The ADJ_{ij}, EEC_{ij}, $EFTA_{ij}$ and $NAFTA_{ij}$ dummy variables indicate whether the trading partners have a relatively stronger bond, so that β_6 ,..., β_9 are expected to be positive. $LAND_i$ and $LAND_j$ are the sheer sizes of the importing and exporting countries, respectively. Their slope parameters, β_{10} and β_{11}, are probably negative since larger countries are more diverse and potentially richer in natural resources. One might also argue, however, that β_{11} is positive since larger countries tend to possess more natural resources and a bigger exporting capacity.

Finally, SC_i and SC_j, measure how strict the environmental regulations are in the importer and exporter countries. In line with the assumption that strict environmental standards lead to relatively lower exports but higher imports, one might expect β_{12} to be positive and β_{13} to be negative. However, as mentioned earlier, β_{12} could be negative, either due to subsidization of local production suffering from the higher than average domestic environmental standards, or as a result of trade barriers imposed to imports from countries with lower environmental standards. Similarly, β_{13} could be positive for countries which have a comparative advantage in the environmentally more sensitive industries. In summary, it is hypothesized that the β_1, β_2, β_6, β_7, β_8, β_9 slope parameters are positive, β_3, β_5, β_{10} are negative, while the signs of β_4, β_{11}, β_{12} and β_{13} are ambiguous.

The cross sectional specification used by Van Beers and Van den Bergh (1997) is a special case of (1), with $T = 1$. It is denoted as *Model A*.[1] Apart from *Models A* and *B*,

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[1] In this model $\beta_9 = 0$ because NAFTA became effective only in 1994.

which do not take any specific effects into consideration, three further generalisations of (1) are also considered. The first one, *Model C*, allows for importer country effects by including α_i, into *Model B*. This extra term represents all the factors that might have some influence on imports, but are not explicitly taken into consideration in (1), and it permits average propensities to import to differ across countries. The second one, *Model D*, additionally allows for exporter country effects. Therefore, it has two extra terms, α_i for the importer country effect and γ_j for the exporter country effect. Finally, the third one, *Model E*, has three extra terms, α_i, γ_j and λ_t, with the last one serving to capture any time (business cycle) effects on bilateral trade flows.

In matrix form the most general specification (*Model E*) can be written as

$$y = D_N \alpha + D_J \gamma + D_T \lambda + Z \beta + u \ , \tag{2}$$

where: y is the vector of observations of the dependent variable,

$$y = [y_{121}, y_{122}, ..., y_{12T}, y_{131}, ..., y_{13T}, ..., y_{N11}, ..., y_{N1T}, ..., y_{N(N-1)1}, ..., y_{N(N-1)T}] \ ;$$

Z is the matrix of observations of the explanatory variables in (1), including the constant term, organised in a similar way to y; $\alpha = [\alpha_1, \alpha_2, ..., \alpha_N]'$, $\gamma = [\gamma_1, \gamma_2, ..., \gamma_N]'$, $\lambda = [\lambda_1, \lambda_2, ..., \lambda_T]'$, and $\beta = [\beta_0, \beta_1, ..., \beta_K]'$ are parameter or disturbance vectors; K is the number of explanatory variables; and u is the vector of disturbances. D_N, D_T and D_J are dummy variable matrices defined as $D_N = I_N \otimes l_{NT}$ and $D_T = l_{N^2} \otimes I_T$, where l is a vector of ones with its size in the index. The structure of the D_J $((N^2 \times T) \times N)$ matrix is a bit more complex such that

$$D_J = \begin{pmatrix} \widetilde{I}^{(1)} \\ \vdots \\ \widetilde{I}^{(N)} \end{pmatrix} \qquad \text{where}$$

$$I^{(1)} = (0 \quad I_N) \qquad \text{and} \qquad \widetilde{I}^{(1)} = I^{(1)} \otimes l_T$$

$$I^{(2)} = \begin{pmatrix} 1 & \\ & 0 \quad I_{N-1} \end{pmatrix} \qquad \text{and} \qquad \widetilde{I}^{(2)} = I^{(2)} \otimes l_T$$

$$\vdots$$

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$$I^{(N)} = \begin{pmatrix} I_{N-1} & 0 \\ & 1 \end{pmatrix} \quad \text{and} \quad \tilde{I}^{(N)} = I^{(N)} \otimes l_T$$

Imposing the $\lambda_t = 0 \; \forall_t$ restrictions on (2) yields *Model D*. *Model C* requires $\gamma_j = \lambda_t = 0 \; \forall_{j,t}$, while in *Model B* all three vectors are assumed to be null vectors.

In *Models C-E*, the α_i, γ_j and λ_t specific effects can be treated in two different ways, either as random variables (an error components approach) or fixed parameters (a fixed effects approach). Given that a specific aim is to analyse these effects, they are treated as fixed unknown parameters. Note, however, that similarly to these fixed specific effects, some of the independent variables are one dimensional, that is they vary across countries, but not over time. As a result, *Models C-E* cannot be estimated without appropriate restrictions. In *Model C LAND$_i$* would be perfectly collinear with α_i, so it has to be dropped from the specification. Similarly, *Models D* and *E* have to be estimated without *LAND$_i$* and *LAND$_j$*. The other independent variables change in at least two dimensions, so they do not cause perfect multicollinearity. The *ij*-indexed *DIST* and *ADJ* variables, for example, would be perfectly multicollinear with $\alpha_i \times \gamma_j$, but not with $\alpha_i + \gamma_j$. Note also that all of the models have a constant term. Therefore, again in order to avoid perfect multicollinearity, at least one dummy variable has to be dropped from each set, *i.e.* there cannot be more than *N*-1 importer country dummies, *N*-1 exporter country dummies and *T*-1 year dummies.

3   The Data

The data utilised in this study is comprised of annual measures for seven years, 1990-1996, on 24 OECD countries (Australia, Austria, Belgium-Luxemburg[2], Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Mexico, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom

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[2] In international trade statistics Belgium and Luxemburg are usually treated as a single country.

and the USA).[3] Similarly to Van Beers and Van den Bergh (1997), all five models were estimated over three different kinds of bilateral trade flows. The precise definitions of the quantitative variables[4] and data sources are:

$TIMP_{ijt}$, total imports of country i from country j in year t in terms of thousands of 1990 US dollars. The import data in thousands of US dollars are from the *United Nations Commodity Trade Statistics, Statistical Papers, Series D (1990, 1991, 1992, 1993, 1994, 1995 and 1996).*[5] These current dollar import figures were deflated by deflators for imports of goods and services obtained from the *World Bank World Tables.*

$DIMP_{ijt}$, similar to *TIMP*, but instead of total imports it measures only the imports of pollution-intensive sectors. On the basis of SITC (version 3) the following industries are classified as 'dirty'[6]: 251 (Pulp and Waste Paper); 334 (Petroleum Products); 335 (Residual Petroleum Products); 51 (Organic Chemicals); 52 (Inorganic Chemicals); 562 (Fertilizers); 59 (Chemical Materials); 634 (Veneers, Plywood); 635 (Wood Manufactures); 64 (Paper, Paperboard); 661 (Lime, Cement, Construction Materials); 67 (Iron and Steel); 68 (Non-Ferrous Metals); and 69 (Metals Manufactures).

$FLIMP_{ijt}$, similar to *DIMP*, but only for the non-resource based pollution-intensive ('footloose') sectors, *i.e.* for 59, 661, 67 and 69.

GDP_{it}, GDP_{jt}, GDPs of countries i and j in year t in terms of billions of 1990 US dollars. Two different series were experimented with, based on purchasing-power parities (*GDP1*) and on exchange rates (*GDP2*), respectively. Both series are from *Energy*

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[3] At the moment the OECD has 29 members. However, we have considered only those which joined the organisation before 1995, so we have disregarded the Czech Republic, Hungary, Korea and Poland.

[4] The exact descriptions of the ADJ_{ij}, EEC_{ijt}, $EFTA_{ijt}$ and $NAFTA_{ijt}$ dummy variables can be found in Section 2.

[5] Unfortunately, this data source proved to be a bottleneck in this project. At the time of data collection (the second half of 1999) detailed trade data were still not available for after 1996.

[6] This definition of 'dirty' SITC categories is from Low (1992a).

Balances of OECD Countries, 1996-1997, International Energy Agency, 1999.

POP_{it}, POP_{jt}, populations of countries i and j in year t (Source: *Energy Balances of OECD Countries, 1996-1997, International Energy Agency, 1999*).

$DIST_{ij}$, average distance between the major economic areas of countries i and j in nautical miles. It has been calculated following Linnemann (1966). The distances between major ports are extracted from *http://www.ports.com*, the average distances between the ports and the most important economic areas are from Linnemann (1966, pp.222-226).

$LAND_i$, $LAND_j$, land areas of country i and j in 1,000 ha, obtained from the *Human Development Report, 1996, United Nations Development Programme.*

SC_{it}, SC_{jt}, measure of the relative strictness of domestic environmental regulations in countries i and j in year t.

Since *SC* is the most crucial variable in the analysis, it warrants further discussion. As already mentioned, Van Beers and Van den Bergh (1997) constructed two environmental regulations strictness measures for 1992. The first one was based on seven output-oriented societal indicators which, in different ways, try to assess the overall effect of the environmental regulations and the corresponding compensating subsidies, if there are any.[7] Since most of these indicators are published only irregularly, it is not possible to develop this first type of strictness measures for each year 1990-1996. The second, narrower measure, was composed from only two indicators - from the level of energy intensity in 1980 and from the change of energy intensity from 1980 to 1991 - by a ranking procedure.[8] This second approach was followed.

Six strictness measures were experimented with. Each one of these was based on one of the following two indicators published in the *Energy Balances of OECD Countries,*

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[7] These indicators are the following (Van Beers and Van den Bergh, 1997, p. 34): protected areas as a percentage of national territory in 1990; market share of unleaded petrol in 1990; recycling rate of paper in 1990; recycling rate of glass in 1990; percentage of population connected to sewage treatment plant in 1991; level of energy intensity in 1980; and change of energy intensity 1980-1991.

[8] See Van Beers and Van den Bergh (1997), p. 35.

1993-1994 and *1996-1997, International Energy Agency, 1996* and *1999*:

EC_{it}, total final consumption of energy (Mtoe) in country *i* in year *t*; and

ES_{it}, total primary energy supply (Mtoe) in country *i* in year *t*.

These absolute indicators were compared to *GDP1*, to *GDP2* and to *POP*, respectively, and from the resulting relative measures, index numbers were calculated for 1990-1996 (1980=100). Then, for each year, the countries were ranked (from the worst to the best), both upon the static and dynamic measures. For each country the two ranks were summed and upon this compound measure the countries were ranked again. In this way six sets of ranks were obtained for 1990-1996. Finally, these ranks were divided by the number of countries in order to derive six sets of strictness measures ranging between 0 (no environmental regulations) and 1 (strict environmental regulations).

The rankings for 1992 are shown in Table 1, along with the one developed by Van Beers and Van den Bergh (1997). These rankings are similar, but not identical, especially not so for Australia, France, Japan, Mexico, the Netherlands, Norway, Spain, Sweden, Switzerland and Turkey. Measuring the strength of association between these rank orders by Kendall's τ_b and Spearman's ρ coefficients, it was found that neither $R_{EC, GDP2}$ nor $R_{ES, GDP2}$ is significantly correlated with $R_{EC, POP}$ and $R_{ES, POP}$, not even at the 10% level.[9] This suggests that the estimation results of (2), or any of its variants, might strongly depend on the choice of the strictness measure. The comparison of these rankings to the one created by Van Beers and Van den Bergh (1997), R_{BB}, also revealed that $R_{ES, GDP2}$ is the most similar to R_{BB}, followed by $R_{ES, GDP1}$ and $R_{EC, GDP2}$.

For this reason, although each model was estimated using all six rankings, attention is focussed on the results based on total primary energy supply and GDP deflated by exchange rates. The corresponding ranks, $R_{ES, GDP2}$, for each year, are illustrated in Figure 1. Clearly, the relative strictness of environmental regulations changed significantly during the sample period, most notably in Finland, France, Ireland, Japan, Norway, Spain, Sweden

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[9] The complete set of strictness measures and the bivariate rank correlation coefficients for 1992 can be obtained from the authors on request.

Table 1

Rankings Representing Environmental Regulations Strictness, 1992

Country	Ranks (from worst to best)[#]						
	R_{BB}	$R_{EC, GDP1}$	$R_{EC, GDP2}$	$R_{EC, POP}$	$R_{ES, GDP1}$	$R_{ES, GDP2}$	$R_{ES, POP}$
Australia	2	7	8	17	6	7	15
Austria	17	17	18	14	23	22	21
Belg.-Lux.	17	11	13	8	9	9	5
Canada	7	5	9	8	7	8	13
Denmark	19	24	24	22	24	24	21
Finland	4	3	5	2	3	10	5
France	12	15	17	20	10	14	5
Germany	21	22	23	23	20	23	21
Greece	6	4	7	11	5	4	12
Iceland	-	1	3	1	1	3	1
Ireland	13	20	20	12	19	19	13
Italy	13	19	15	17	20	19	20
Japan	19	23	22	8	22	21	8
Mexico	-	5	1	24	8	2	24
Netherlands	16	7	10	12	17	16	17
New Zealand	1	2	1	2	2	1	2
Norway	9	11	21	4	11	18	3
Portugal	2	11	4	6	13	5	9
Spain	8	17	12	6	11	10	9
Sweden	4	7	18	14	4	12	4
Switzerland	13	11	16	4	15	16	15
Turkey	-	21	5	20	18	6	17
UK	11	10	10	17	16	15	17
USA	9	15	14	14	13	12	11

[#] : The subscripts refer to the variables used to construct the given ranking. The first ranking (*BB*), for 21 countries, is from to Van Beers and Van den Bergh (1997, Table 1, p.36).

Figure 1: Ranks Based on ES and GDP2

(from worst to best)
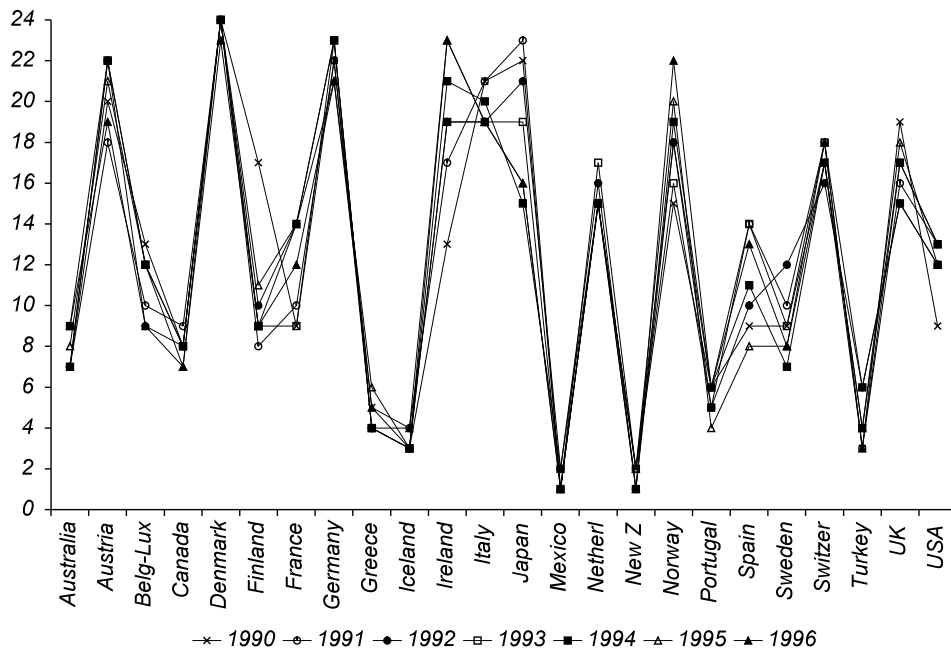
and the UK. This fact further highlights the potential advantage of a panel-data analysis over a purely cross-sectional one, which is based on a single snapshot in time and thus lacks dynamics.

4   Estimation Results

Before reviewing the most important outcomes of the analysis, there are two remarks to be made. Firstly, since heteroscedasticity is very likely, the usual t-statistics were computed from heteroscedasticity-consistent standard errors. Secondly, some of the bilateral trade flows are zero, for which the dependent variable, lnIMP, is not defined. In order to circumvent this problem, all import figures were inflated by unity.[10] In spite of this, due to the fact that ln(IMP+1) might be zero, the OLS estimators are still potentially biased, so

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[10] Given the magnitudes of *TIMP*, *DIMP* and *FLIMP*, this manipulation assures that the logarithms exist without having any statistical effect on the estimates.

Tobit estimators were also experimented with and all non-positive dependent variable values were censored. However, as the proportion of censored observations is small, the OLS and Tobit results are very similar, so only the most important OLS results are discussed in this paper.[11]

Five models, *Models A-E*, for three types of bilateral trade flows, using six different environmental regulations strictness measures were estimated.[12] The OLS results based on *GDP2* and $R_{ES, GDP2}$ are summarised in Tables 2-4. Table 2 contains the findings for *TIMP*, Table 3 for *DIMP* and Table 4 for *FLIMP*. In each table the first set of results is from a cross-sectional analysis for 1992, similar to the one performed by Van Beers and Van den Bergh (1997), and the other four sets are the estimation results of (2) and its generalisations over the whole sample period. The outcomes of various *F*-tests for the joint significance of the additional dummy variables are also presented in these tables.[13]

Total Imports

In *Models A* and *B*, which do not allow for any specific effects, all slope estimates but two are significant in the expected direction. In particular, both importing and exporting country GDPs, adjacency and EEC or NAFTA membership seem to be positively related to total bilateral import flows. On the other hand, importing and exporting country populations and land sizes, as well as the distance between these countries, exert negative impacts on total imports. The EFTA dummy is insignificant in *Model A*, but it is weakly significant in the unexpected, *i.e.* negative, direction in *Model B*. Most importantly, the relative strictness of environmental regulations in the importing country has a strongly significant negative effect

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[11] There are only 2 censored *TIMP* observations, 81 censored *DIMP* observations and 127 *FLIMP* observations, while the sample size is 3864.

[12] For brevity, not all details are reported in this paper, but are available on request.

[13] Note that these *F*-tests are strictly evaluating the *net* effect of the additional set of dummies and that of the left out perfectly collinear variable(s).

Table 2

OLS Estimation Results for TIMP

($GDP2$ and $R_{ES,\,GDP2}$)

Variable	Specification				
	Model A	Model B	Model C	Model D	Model E
Constant	22.069***	23.848***	174.002***	147.202***	171.673***
ln GDP_{it}	1.459***	1.677***	2.265***	2.174***	1.796***
ln GDP_{jt}	1.491***	1.431***	1.481***	1.063***	0.685*
ln POP_{it}	-0.535***	-0.760***	-9.902***	-10.300***	-10.900***
ln POP_{jt}	-0.580***	-0.541***	-0.572***	1.684	1.077
ln $DIST_{ij}$	-0.689***	-0.627***	-0.736***	-0.948***	-0.949***
ADJ$_{ij}$	0.488***	0.588***	0.500***	0.351***	0.350***
EEC_{ijt}	0.401***	0.387***	0.123***	0.104***	0.097***
EFTA$_{ijt}$	0.004	-0.122* (?)	0.082	0.123**	0.131**
$NAFTA_{ijt}$	na	0.751***	1.034***	0.798***	0.793***
ln $LAND_i$	-0.069**	-0.082***	na	na	na
ln $LAND_j$	-0.097***	-0.097***	-0.091***	na	na
ln SC_{it}	-0.246***	-0.252***	0.068	0.067	0.092
ln SC_{jt}	-0.029	0.012	-0.049	-0.026	-0.001
D_i	na	na	-	-	-
D_j	na	na	na	2,5,6,9,10, 13,18,21	2-24
D_t	na	na	na	na	2-5
Observations	552	3864	3864	3864	3864
RSS		2867.783	2285.79	1748.068	1744.098
adj. R^2	0.859	0.855	0.884	0.911	0.911

F-tests^d	df1	df2	*F*-statistic		
C vs *B*	22	3828	44.299***		
D vs *B*	44	3806	55.405***		
D vs *C*	22	3806	53.216***		
E vs *B*	50	3800	48.963***		
E vs *C*	28	3800	42.151***		
E vs *D*	6	3800	1.442		

Note: (see next page)

on total bilateral import flows, while the regulations in the exporting country seem to be uninfluential. This is in sharp contrast with the findings of Van Beers and Van den Bergh (1997) who detected significant negative relationships between total bilateral imports and the strictness of environmental regulations in both the importing and exporting countries.[14]

Considering the other three specifications, three notable important differences in the results are apparent. Firstly, as both the importing and exporting country effects are taken into consideration, the exporting country population loses its significance. Secondly, the EFTA dummy becomes significant in the expected direction. Thirdly, both stringency measures turn out to be insignificant, suggesting that they have no real impact on bilateral trade. It is also clear from the general *F*-tests that both the importing country dummy variables and the exporting country dummy variables are jointly significant. These results suggest that *Models A* and *B* are incorrectly specified. In those models the omitted specific effects might be assumed by the other independent variables, most notably by $\ln POP_{jt}$ and $\ln SC_{it}$, making them appear significant.[15]

Judging the quality of these models by the adjusted coefficient of determination, all

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[14] However, as our analysis with the different stringency measures shows, the apparent effect of environmental regulations in the exporting country strongly depends on the measure used. If, for example, instead of $R_{ES,GDP2}$ we use $R_{EC,GDP1}$, then $\ln SC_{jt}$ seems to exert a significant positive effect on $\ln TIMP_{ijt}$, while using $R_{ES,POP}$ or $R_{EC,POP}$ the effect is insignificant in *Model A*, but significantly negative in *Model B*.

[15] There is only one type of stringency measures which leads to a different outcome: using $R_{EC,GDP2}$ strictness in the importing country has a significant negative effect on total bilateral trade in all five specifications. Apart from this important difference, the estimation results are very similar.

five specifications have reasonable explanatory power. *Model D* is the best accounting for about 91% of the total variation in the logarithm of $TIMP_{ijt}$. Although the most general specification, *Model E*, does not perform better, it still provides an interesting new piece of information. The year dummy variables are jointly insignificant, but the only individually significant one causes all exporting country effects to become negligible. This implies that, as regards individual effects, total bilateral trade flows are influenced mainly by importing country effects.[16]

'Dirty' Imports

The results for 'dirty' trade are summarised in Table 3. They suggest that not allowing for specific effects, *i.e. Models A* and *B*, importing and exporting country GDPs have positive effects, while populations, land sizes and distance all exert negative impacts on 'dirty' imports. As for the relative stringency of environmental regulations, strictness in the importing country has a strongly significant negative influence on 'dirty' trade, while strictness in the exporting country seems to be positively related to it. Note, that in this respect there is an important difference between the total and 'dirty' trade flows. In these models total imports seemed to be unaffected by environmental regulations in the exporting country, but 'dirty' imports are positively related to them. It also indicates that importing countries prefer to purchase from countries with high environmental standards. This again contradicts Van Beers and Van den Bergh (1997) who found no significant relationship between 'dirty' imports and the strictness of environmental regulations in the exporting countries.[17]

In *Model A* adjacency, EEC and EFTA memberships are insignificant, whilst in

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[16] By and large this outcome is not sensitive to the choice of the strictness measure.

[17] However, as our results suggest, this might be due to the cross-sectional nature of their analysis. In *Model A*, using $R_{ES,POP}$ or $R_{EC,POP}$ no significant relationship between $\ln DIMP_{ijt}$ and $\ln SC_{it}$ or $\ln SC_{jt}$ can be detected, but in *Model B* the first relationship is significantly negative and the second is significantly positive.

Table 3

OLS Estimation Results for *DIMP*

(*GDP2* and $R_{ES, GDP2}$)

Variable	Specification				
	Model A	Model B	Model C	Model D	Model E
Constant	18.357***	21.561***	154.599***	90.542**	81.025
ln GDP_{it}	1.632***	1.925***	2.703***	2.259***	1.075
ln GDP_{jt}	1.479***	1.431***	1.524***	0.922	-0.259
ln POP_{it}	-0.371***	-0.760***	-8.846***	-10.503***	-9.779***
ln POP_{jt}	-0.486***	-0.417***	-0.486***	5.224**	5.902***
ln $DIST_{ij}$	-1.056***	-0.990***	-1.238***	-1.155***	-1.157***
ADJ_{ij}	0.231	0.334***	0.110	0.212***	0.212***
EEC_{ijt}	0.136	0.182***	-0.026	-0.042	-0.061
$EFTA_{ijt}$	0.359	0.0370	0.388***	0.303**	0.327**
$NAFTA_{ijt}$	na	0.2870	0.533***	0.371**	0.290*
ln $LAND_i$	-0.134**	-0.105***	na	na	na
ln $LAND_j$	-0.086*	-0.097***	-0.062***	na	na
ln SC_{it}	-0.575***	-0.512***	0.059	0.073	0.174
ln SC_{jt}	0.408***	0.341***	0.214***	0.042	0.145
D_i	na	na	-	-	-
D_j	na	na	na	4	4, 7-9, 13, 18,23
D_t	na	na	na	na	2,3,5-7
Observations	552	3864	3864	3864	3864
RSS		7961.467	7064.248	5339.597	5301.542
adj. R^2	0.781	0.762	0.788	0.839	0.839

F-tests	df1	df2	*F*-statistic		
C vs *B*	22	3828	22.099***		
D vs *B*	44	3806	42.474***		
D vs *C*	22	3806	55.878***		
E vs *B*	50	3800	38.131***		
E vs *C*	28	3800	45.124***		
E vs *D*	6	3800	4.546***		

Note: see Table 2.

Models C-E they are all significant in the expected (*i.e.* positive) direction. In *Model C* there is still a significant positive relationship between ln$DIMP_{ijt}$ and lnSC_{jt}, but lnSC_{it} becomes insignificant. In *Models D* and *E*, however, both strictness measures seem to be unimportant.[18] Therefore, the conclusion is that the unobserved exporter heterogeneity and time effects have a more important role in 'dirty' trade than environmental regulations, thus *Models A* and *B* are mis-specified. Another important feature of *Models D* and *E* is that lnGDP_{jt} is insignificant, but the slope of lnPOP_{jt} is significantly positive and quite large. This means that, after having accounted for both the importing and exporting country effects, the potential supply of the exporting country becomes unimportant, but its population exerts a strong positive effect on 'dirty' imports. Finally, this time all general *F*-tests reject the null hypothesis of jointly insignificant dummy variables. Therefore, though *Models D* and *E* have the same (adjusted) explanatory power, 84% approximately, the least restricted specification is statistically the most preferred one.

'Footloose' Imports

If environmental regulations have a real impact on international trade flows, their impact should be the strongest on pollution-intensive non-resource based industries, as these can be relocated with relative ease. Nevertheless, as the results in Tables 4 show, there are only two minor differences between the results for 'dirty' and 'footloose' imports. Firstly, the land size of the importing country has a significant negative effect on 'dirty' imports, but it seems to be insignificant in relation to 'footloose' imports. This might be due to the fact that natural resources play a much more important role in the competitiveness of the 'dirty' sectors in general than in the competitiveness of the 'footloose' industries.[19]

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[18] There is only one exception: using $R_{ES,GDP1}$ at the 10% level we can detect a positive relationship between ln$DIMP_{ijt}$ and lnSC_{it} in *Model E*.

[19] Nevertheless, not much importance can be assigned to this outcome since according to the results based on *Model B* and on $R_{EC,GDP1}$, $R_{EC,GDP2}$, $R_{ES,POP}$ or $R_{EC,POP}$ the relationship between ln$FLIMP_{ijt}$ and ln$LAND_i$ is, in fact, significantly positive.

Table 4

OLS Estimation Results for *FLIMP*

(GDP2 and $R_{ES,\,GDP2}$)

Variable	Specification				
	Model A	Model B	Model C	Model D	Model E
Constant	19.115***	22.894***	114.392***	-28.100	-108.376
$\ln GDP_{it}$	1.672***	1.929***	2.880***	1.895***	1.197*
$\ln GDP_{jt}$	1.648***	1.705***	1.777***	0.458	-0.235
$\ln POP_{it}$	-0.554***	-0.859***	-6.447***	-10.687***	-8.007***
$\ln POP_{jt}$	-0.420***	-0.499***	-0.553***	12.782***	15.411***
$\ln DIST_{ij}$	-1.131***	-1.049***	-1.261***	-1.238***	-1.240***
ADJ_{ij}	0.256	0.381***	0.216***	0.261***	0.262***
EEC_{ijt}	0.139	0.251***	0.068	0.027	0.017
$EFTA_{ijt}$	0.236	0.091	0.395***	0.362***	0.379***
$NAFTA_{ijt}$	na	0.380	0.423**	0.459**	0.354*
$\ln LAND_i$	0.010	0.024	na	na	na
$\ln LAND_j$	-0.280***	-0.293***	-0.261***	na	na
$\ln SC_{it}$	-0.457***	-0.469***	0.092	0.132	0.205
$\ln SC_{jt}$	0.285**	0.152***	0.046	-0.047	0.026
D_i	na	na	4,7,12	-	-
D_j	na	na	na	-	-
D_t	na	na	na	na	2,3,5-7
Observations	552	3864	3864	3864	3864
RSS		7746.053	6993.362	6084.913	6042.477
adj. R^2	0.792	0.783	0.803	0.827	0.828

F-tests	df1	df2	*F*-statistic		
C vs *B*	22	3828	18.728***		
D vs *B*	44	3806	23.614***		
D vs *C*	22	3806	25.828***		
E vs *B*	50	3800	21.427***		
E vs *C*	28	3800	21.357***		
E vs *D*	6	3800	4.448***		

Note: See Table 2.

As regards environmental standards, in *Models A* and *B* the regulations in the importing country seem to have a significantly negative, while the regulations in the exporting country a significantly positive, effect on the 'footloose' bilateral trade flows. This is again in contradiction to Van Beers and Van den Bergh (1997), who found both relationships to be significantly negative. The really important point, however, is that in *Models D* and *E* the specific effects again make the stringency measures look unimportant.[20]

5 Conclusions

This paper studied the possible impact of environmental policy on bilateral foreign trade flows. The analysis was based on a three-way fixed-effects model which allows for importing country, exporting country and also for time specific effects. This model, and its variants, was estimated for a panel of 24 OECD countries over a sample period of 1990-1996. The stringency of environmental regulations was measured by six different indicators, all of which were based on either the relative energy consumption or on relative energy supply.

Although the application of the different measures led to somewhat different estimation results, it is clear from this study that the impact of environmental policy on foreign trade cannot be assessed properly without the importing and exporting country effects. Without these specific effects there seems to be a relationship between stricter regulations and foreign trade, but its significance fades as soon as both the importing and exporting country specific effects are taken into consideration. Moreover, *F*-tests suggest that these effects are jointly significant, that is they are important explanatory variables. This implies that a simple cross-sectional or naive panel-data model is mis-specified and the stringency measures, and probably also the other quantitative explanatory variables, absorb the influence of the missing specific effects.

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[20] Using $R_{ES,GDP1}$, though, both effects are significantly positive at the 10% level in *Model E*.

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