Do Environmental Regulations Influence Trade Patterns? Testing Old and New Trade Theories

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The authors would like to thank Marius Brulhart, Simon Peters, Nick Horsewood, Toby Kendall and John Bates for their helpful comments and suggestions on an earlier draft, but retain responsibility for all remaining errors.

1. INTRODUCTION

The relationship between trade liberalisation and the environment has received a great deal of attention in recent years, amongst both academics and policy makers. The last thirty years have been characterised by both a steady decrease in global trade barriers and a steady increase in environmental regulation, particularly in the developed world. During this time, a large literature examining different aspects of the trade-environment relationship has developed (see e.g. Siebert et al. 1980, Anderson and Blackhurst 1992, Chichilnisky 1994, Copeland and Taylor 1994, 1995, Antweiler et al. 2001, Cole and Elliott 2003). One particular focus of attention has been on the possible influence of environmental regulations on global trade patterns.

It has been claimed, for example, that trade between two countries with different levels of environmental regulations will lead to the low regulation country specialising in pollution intensive production (Baumol and Oates 1988). In the developed world the cost of complying with environmental regulations appears to be steadily increasing over time and, for the USA alone, was estimated to be $184 billion in 2000, equivalent to 2.6% of US GNP.[1] Since the stringency of environmental regulations increases with income (Dasgupta et al. 1995), this line of reasoning suggests that developing countries possess a comparative advantage in pollution-intensive production. If so, then we may see dirty industries relocating from the North to the South (foreign direct investment), or simply dirty industries from the developed world becoming displaced from the world market by similar industries in

[1] US Environmental Protection Agency (1990) estimated in 1992 US dollars. This is an estimate of private sector compliance costs and therefore omits personal consumption abatement, government abatement and government regulation and monitoring.

developing countries. This phenomenon, known commonly as the pollution haven hypothesis, has been cited as one explanation for the inverted-U relationship often estimated between per capita income and emissions of local air pollution (e.g. Grossman and Krueger 1995, Cole et al. (1997). Theoretical models of pollution havens include Pethig (1976), McGuire (1982) and Baumol and Oates (1988) who conclude that those countries that do not control pollution emissions, whilst others do, will 'voluntarily become the repository of the world's dirtiest industries' (Baumol and Oates 1988 p. 265).

A number of authors have empirically tested whether environmental regulations affect trade patterns, although results have been inconclusive. Lucas et al. (1992) and Birdsall and Wheeler (1992) find that the growth in pollution intensity in developing countries was highest in periods when OECD environmental regulations were strengthened. Mani and Wheeler (1998) examine the import-export ratio for dirty industries and find evidence consistent with the pollution haven hypothesis, although they claim that such havens appear to have been temporary. Similarly, Antweiler *et al* (2001) examine the impact of trade liberalisation on city-level sulphur dioxide concentrations and also claim to find some evidence of pollution haven pressures. Van Beers and Van den Bergh (1997) find some evidence to suggest that regulations are influencing trade patterns, although Harris et al. (2002) claim that no such influence is found if fixed effects are included in the model. In a notable change of direction, recent papers by Levinson and Taylor (2001) and Ederington and Minier (2001) claim that environmental regulations should be treated as a secondary trade barrier i.e. a means of protecting domestic industry. If this is the case, then the stringency of regulations may be a function of trade as well as trade being a function of regulations. When treated as an endogenous variable, both Levinson and Taylor (2001) and Ederington and Minier (2001) find that US environmental regulations do influence US trade patterns.

In contrast, Tobey (1990) and Janicke et al. (1997) find no evidence to suggest that the stringency of a country's environmental regulations is a determinant of its net exports of dirty products. Similarly, Xu and Song (2000) find that environmental regulations do not appear to influence trade in embodied environmental factor services. The OECD (1997), in a review of the literature on FDI and the environment, state that "fears of a 'race to the bottom' in environmental standards, based on the idea of 'pollution havens', may be generally unfounded" (OECD 1997, p. 13). Also in a review of the literature, Jaffe et al. (1995) conclude that there is little evidence to suggest that stringent environmental regulations have a significant effect on industrial competitiveness in developed countries. Finally, in an overview of the recent empirical literature, Ferrantino and Linkins (1999) conclude that the effects of trade liberalisation on the level of global pollution are ambiguous.

One approach to examining the impact of environmental regulations on trade patterns is via the standard Heckscher-Ohlin-Samuelson (HOS) framework where comparative advantage is determined by factor endowment differentials. In this approach, net exports are expressed as a function of factor endowments, including environmental regulations. An often-cited study by Tobey (1990) uses this methodology. However, the empirical observation that much of the post-war expansion of trade was between countries of similar size and relative factor endowments has raised questions regarding the HOS framework's ability to explain actual trade patterns. A preliminary investigation of the trade patterns of 'dirty' industries also reveals a significant level of two-way trade in products from the same product grouping, commonly known as intra-industry trade (IIT). The existence of IIT led to the development of 'new' trade theories that were able to explain the co-existence of inter- *and* intra-industry trade (see e.g. Lancaster 1980, Dixit and Norman 1980, Krugman 1980, 1981, Helpman 1981, Falvey 1981 and Helpman and Krugman 1985). These models usually rely on differentiated products and an element of imperfect competition with increasing returns to scale.

The aim of this paper is to examine the impact of environmental regulations on trade patterns within the traditional comparative advantage based model and within the 'new' trade theoretic framework. In the former we will test whether the stringency of a country's environmental regulations influences its net exports of pollution intensive output. In the 'new' trade model we are asking a slightly different question. Since this approach is concerned with bilateral trade and the share of intra and inter-industry trade within total trade, we are testing whether environmental regulations, like other factor endowments, influence the composition of trade i.e. the extent to which countries trade within the same, or different, industries.[2]

With regard to the HOS framework, we extend Tobey's (1990) analysis in a number of ways; (i) we use a larger and more up to date dataset that allows us to assess whether the impact of regulations on trade patterns has changed since the mid 1970s;

[2] Environmental regulations may be interpreted as a measure of a country's 'environmental' endowment.

(ii) we test two alternative measures of environmental regulations; (iii) where possible, we include industry dummies to control for unobserved industry characteristics that may affect the relationship between regulations and net exports; (iv) we control for the potential endogeneity of environmental regulations.

Turning to the 'new' trade model, we are unaware of any previous study that tests the effect of environmental regulations within a framework of this type. More specifically, we include environmental regulation differentials alongside other factor endowment differentials as a possible explanation of the share of inter-industry trade within total trade, with determinants of the share of intra-industry trade also included. We, again, control for possible endogeneity thereby providing the first *cross-country* trade analysis to incorporate the possible endogeneity of environmental regulations.[3]

The remainder of the paper is organised as follows: Section 2 provides the econometric analysis based on a model of comparative advantage, Section 3 estimates the 'new' trade model and Section 4 provides an interpretation of the results. Section 5 summarises and concludes.

2. THE HECKSCHER-OHLIN-VANEK (HOV) APPROACH

In this section we provide a detailed cross-sectional analysis of the role-played by factor endowments and environmental regulations in determining trade patterns.

[3] The previous studies to have incorporated endogeneity (Levinson and Taylor 2001 and Ederington and Minier 2001) focus purely on US trade.

The Heckscher-Ohlin-Samuelson (HOS) framework originates from the notion that different commodities use factors in different proportions and that countries are endowed with factors of production in different proportions. The Heckscher-Ohlin-Vanek (HOV) model is the "factor content" version of the HOS model and allows us to consider the *N*-good *S*-factor case (*N*>2 and *S*>2), since it avoids the problem of defining factor intensities in the presence of more than two factors.[4]

To empirically investigate the impact of environmental regulations on trade flows within the HOV model, we estimate equation (1) which expresses a country's net exports as a function of its factor endowments. This equation is derived from the outline of the HOV model provided in Appendix A.

$$W_{ij} = \sum_{k=1}^{S} b_{ik} V_{kj} \qquad i = 1,...,N \qquad j = 1,...,T \tag{1}$$

where, W_{ij} are net exports from sector i by country j, V_{kj} are endowments of resource k in country j, and b_{ik} are the coefficients to be estimated. Equation (1) is estimated using 14 factor endowments together with 2 alternative measures of the stringency of environmental regulations. The data cover 60 developed and developing countries for 1995. The dependent variable is each country's net exports in one of four dirty sectors. The sectors are Iron and Steel, Chemicals, Pulp and Paper, and Non-Ferrous Metals. The explanatory variables, which cover a wide range of factor endowments are as follows; the capital stock, three measures of labour endowment (professional

[4] Previous empirical tests of the HOV include Leamer (1980) and Bowen *et a.l* (1987). Trefler (1993, 1995) emphasises the HOV's reliance on the factor price equalisation theorem and internationally identical technologies. He includes a variable of productivity differences that is found to significantly improve empirical results.

and technical workers, literate non-professional workers and illiterate workers), two measures of environmental regulations (discussed below), mineral endowments (lead, zinc, iron and copper), oil, gas and coal endowments, tropical forest area, non-tropical forest area and area of cropland. Appendix B defines these variables, provides details on the data sources and lists the countries included in our sample.

We include two measures of the stringency of environmental regulations, *ENVREG* and *ENVPOL*. The former is provided by Eliste and Fredriksson (2001) who built on the work of Dasgupta et al. (1995). Dagupta et al gathered information from individual country reports compiled under United Nations Conference on Environment and Development (UNCED) guidelines. Each report is based on identical survey questions and provides detailed information on the state of environmental policies, legislation and enforcement within each country. Using this information, Dasgupta et al. (1995) developed an index of the stringency of environmental regulations for 31 countries. Eliste and Fredriksson (2001) then used the same methodology to extend the index to 60 countries. *ENVPOL* is a proxy for the stringency of environmental regulations based on each country's *change* in energy intensity (energy use/GDP) over the period 1980-95, together with the *level* of energy intensity in 1980. Van Beers and Van den Bergh (1997) use a similar measure of environmental regulations. For the 60 countries in our sample, *ENVREG* and *ENVPOL* have a correlation coefficient of 0.77. Appendix B provides more information on the calculation of *ENVPOL*.

Tobey (1990) incorporates a measure of environmental regulations in a HOV estimation from the mid-1970s and uses a sample of 23 countries (and 12 degrees of freedom). He does not find a statistically significant relationship between environmental regulations and net exports, although given the number of degrees of freedom this is not entirely surprising. We extend Tobey's estimations in a number of ways; (i) we have 60 countries in our sample rather than 23; (ii) we use data for 1995 rather than the mid 1970s allowing us to test the possibility that the increased stringency of environmental regulations during the intervening period will have changed the relationship between regulations and net exports; (iii) we test two alternative measures of environmental regulations; (iv) whilst we undertake industry specific estimations, we also pool all dirty industries and include industry dummies. This allows us to control for unobserved industry characteristics that may affect the relationship between regulations and net exports; (v) related to point (iv) is the issue of endogeneity. If environmental regulations are themselves a function of trade flows, rather than the other way around as has been assumed, then the estimated results will be spurious. We therefore estimate the impact of regulations on trade flows assuming firstly that such regulations are exogenous, but then allow for the fact that they may be endogenous.

Table 1 provides the results estimated individually for each sector, together with those from a 'panel' estimation in which all four sectors are included together.[5] These estimations stem from equation (1) and hence environmental regulations are here taken to be exogenous.

[5] In all cases a Breusch-Pagan test did not reject the null of homoscedastic variances.

Table 1. HOV Estimation Results (dependent variable: net exports in 1995 US$).

Variable	Panel[a]	Non-ferrous metals	Paper and pulp	Iron and steel	Chemicals
LAB1	-10.6	73.4	-119.8	-109.8	113.6
LAB2	-21.1**	-23.8***	-23.0**	-20.4*	-17.4***
LAB3	40.07**	21.0	55.8**	57.1**	26.2***
CAPITAL	1.5*	-3.0***	0.45	7.4***	1.27***
ENVREG	34.4	-8.7	102.3	38.3	57.7
LEAD	4.1	-17.8**	37.2***	-4.1	1.5
ZINC	-2.5	5.8**	-17.4***	4.7	-0.017
IRON	0.52	1.2**	0.55	0.87	-0.52
COPPER	0.16	0.57***	0.10	-0.05	0.038
OIL	3.5	9.02***	-2.3	6.6	0.70
GAS	-20.9**	-16.9***	-37.8***	-31.0***	2.2
COAL	10.2	11.7	7.5	12.0	9.5*
TROPFOR	8.5	-6.79	22.09*	8.28	10.5**
NONTROP	28.1***	6.1	97.8***	8.65	-0.22
CROPLAND	-36.7**	-31.8***	-30.3	-54.2**	-30.5***
R^2	0.801	0.893	0.852	0.782	0.643
n	240	60	60	60	60

Notes: For reasons of space, t-statistics have not been reported. Instead, *, ** and *** denote significance at 90%, 95% and 99%, respectively.
[a] Where 'panel' refers to the inclusion of all four sectors in the same regression. This estimation includes industry dummies, but for reasons of space these are not reported.

Note that in all estimations, environmental regulations are not significantly correlated with net exports from dirty sectors. When we replaced *ENVREG* with *ENVPOL* in equation (1) the results were almost identical with *ENVPOL* remaining non-significant across estimations albeit with varying signs. The evidence in Table 1 seems to confirm Tobey's (1990) findings.

Turning to the other results, many variables are statistically significant and the R^2s are suggestive of a generally good fit to the model. For example, for two sectors, iron and steel and chemicals, we find capital stock to be positively and significantly related to net exports of dirty products. In addition, we find zinc, iron and copper endowments to be highly correlated with net exports of non-ferrous metals; forests (particularly non-tropical) to be positively and significantly related to net exports of paper and pulp; and that countries with large endowments of fertile land (cropland) do not tend to specialise in these four heavy industrial sectors. The dependence of these sectors on capital and natural resource endowments may explain why empirical evidence for any pollution haven effect to date is generally weak.

We do, however, find one or two slightly puzzling results. For instance, the capital stock is estimated as being *negatively* (and significantly) related to net exports of non-ferrous metals. Turning to the labour endowments, we find *lab1* (professional and technical workers) to be a non-significant determinant of net exports. In contrast, lab2 (literate non-professional workers) is negatively and significantly related to net exports, with lab3 (illiterate workers) being positively related to net exports. The lab3 finding at least would seem to suggest that these are low skill sectors, yet we know that this is not entirely true. Finally, we find gas extraction to be negatively, and highly significantly, related to net exports in four out of the five estimations. Again, this result is difficult to explain.

However, it is questionable whether environmental regulations should be considered to be exogenous, as has been the case so far. If trade considerations play a role in the setting of environmental regulations, as is assumed by second-best trade models, (see e.g. Trefler 1993a), then regulations should clearly be treated as endogenous. It is feasible, for instance, that if net exports were declining in pollution intensive industries, the reaction of government may be to reduce the stringency of regulations to boost the competitiveness of these industries. Such a positive relationship could therefore offset any negative impact of regulations on net exports, and therefore must be controlled for. In such a situation it is necessary to estimate simultaneous equations whereby the impact of regulations on net exports is estimated in a manner that controls for simultaneity between these two variables.

In addition to equation (1), which expresses net exports as a function of factor endowments, including environmental regulations, it is necessary to introduce a second equation that identifies the determinants of environmental regulations. We believe the key determinant of the stringency of a nation's environmental regulations is per capita income and therefore include this, along with net exports, in equation (2). Since we are estimating the relationship between net exports *in a single dirty industry* against *national* environmental regulations, it could be argued that endogeneity is unlikely to be found. Nevertheless, it is still possible that simultaneity exists, particularly when we combine four industries into a single panel.

$$ENVREG_j = a + ß_1 Y_j + ß_2 W_{ij} + e_i \qquad (2)$$

where W_{ij} refers to net exports in dirty industry *i*, country *j* and Y_j denotes per capita income in country *j*. Equations (1) and (2) are estimated simultaneously using two stage least squares, with $ENVREG_j$ and W_{ij} treated as endogenous variables. All other variables are treated as exogenous, instrumental variables.

Our results are provided in Appendix C. The sign and significance of the determinants of net exports can be seen to be almost identical to those provided in Table 1, in which regulations were treated as exogenous. The *ENVREG* variable is not a statistically significant determinant of net exports in any of the estimations. Furthermore, in only one instance (iron and steel) are net exports a significant determinant of environmental regulations.

In sum, whether environmental regulations are treated as exogenous or endogenous and whether they are measured as *ENVREG* or *ENVPOL*, they are not statistically significant determinant of dirty net exports, within an HOV framework. What these HOV results do suggest, however, is that Iron and Steel and Chemicals are both highly capital intensive, whilst non-ferrous metals and paper and pulp are both natural resource intensive. The HOV model does however appear to explain trade patterns with some, if not total, success.

3. THE IMPERFECT COMPETITION APPROACH

A shortcoming of the HOV model, as defined, is that it is unable to explain trade between two countries within the same industry, that is, it cannot explain the phenomenon of intra-industry trade. However, an empirical feature of international trade is the co-existence of inter- and intra-industry trade. Appendix A provides an overview of a model of monopolistic competition with differentiated products (see Helpman 1987). Within this model, inter-industry trade will be motivated by relative factor abundance (and perhaps environmental regulations), whilst intra-industry trade will be motivated by the exchange of varieties of differentiated products.

The Grubel and Lloyd (GL) index measures the share of trade that is intra-industry in nature and was first presented in Grubel and Lloyd (1975). The GL index provides a common measure of IIT between countries *j* and *k*, over all industries.[6]

$$IIT_{jk} = \frac{2\Sigma_i \min(X_{ijk}, X_{ikj})}{\Sigma_i (X_{ijk} + X_{ikj})} \tag{3}$$

where X_{ijk} are exports of industry *i* from country *j* to country *k*. Following Hummels and Levinsohn (1995), equation (3) can be thought of in the following way;

$$IIT_{jk} = \frac{INTRA}{INTRA + INTER} \tag{4}$$

It can therefore be seen that, controlling for the size of the countries, if both countries have identical capital-labour ratios, no trade will be motivated by relative factor endowments and hence inter-industry trade (*INTER*) will be zero and the share of trade that is intra-industry (IIT_{jk}) will equal 1. Conversely, if there are differences between capital-labour ratios then *INTER* will increase and *INTRA* will decrease. By allowing relative factor endowments to affect trade patterns, this approach still draws

[6] IIT within a specific industry can also be measured by equation (3) if the 'aggregation over all industries' (Σ_i) terms are removed.

heavily on the HOV model, and therefore allows us to test for factor endowment (and environmental regulation) effects. In any trade-pair, the greater the difference between two countries' capital-labour ratios, the greater will be the share of inter-industry trade and the lesser will be the share of intra-industry trade. Similarly, the greater the difference in environmental regulations between two countries, the greater will be their share of inter-industry trade and, again, the lesser will be their share of intra-industry trade.

Drawing on Helpman (1987) and Hummels and Levinsohn (1995) we would like to estimate equation (5);

$$
\begin{aligned}
IIT_{jki} &= b_0 + b_1 \ln\left|\frac{K^j}{L^j} - \frac{K^k}{L^k}\right| + b_2 \ln\left|\frac{T^j}{L^j} - \frac{T^k}{L^k}\right| + b_3 \ln\left|ENV^j - ENV^k\right| \\
&+ b_4 \ln\left|PcY^j - PcY^k\right| + b_5 \min(\ln GDP^j, \ln GDP^k) + \qquad (5) \\
&b_6 \max(\ln GDP^j, \ln GDP^k) + b_7 BORDER + e_{jk}
\end{aligned}
$$

where, IIT_{jki} is the GL index measuring the share of IIT between countries j and k in dirty sector i. K denotes the country's capital stock, L the labour force, and T the endowment of fertile land. *ENV* represents the stringency of environmental regulations (we test both *ENVREG* and *ENVPOL*), whilst *PcY* denotes per capita income. *MINGDP* and *MAXGDP* are included to control for relative size effects and *BORDER* is a common border dummy. Note that in our North-South estimations the common border dummy is replaced by a dummy for trade-pairs with colonial links, given the fact that very few developed countries share borders with developing countries.

Our dependent variable however is bounded between 0 and 1. This means that a linear or log linear estimation of equation (5) may generate predicted values for IIT_{jki} that are outside the range 0 to 1. A logistic function does not have this particular problem but its logit transformation is unable to cope with exact values of 0 or 1. In this study we do not have any observations where IIT_{jki} = 1, but we do have a significant number where IIT_{jki} = 0. Therefore, following Balassa and Bauwens (1987) we use non-linear least squares of the logistic function;

$$IIT_{jki} = \frac{1}{1+\exp(-b'x_{jk})} + e_{jk} \quad (6)$$

where *ß* is the vector of regression coefficients, *x* is the vector of explanatory variables (as defined in equation 5) and e_{jk} is the random disturbance term. Provided that the disturbances of the regression are normally distributed, non-linear least squares are maximum likelihood estimators and are therefore consistent and asymptotically efficient.

Referring back to the explanatory variables identified in equation (5), expected signs are $ß_1<0$, $ß_2<0$, $ß_3<0$, $ß_4<0$, reflecting the fact that the smaller the difference in capital, land, environmental regulations and per capita income between countries, the greater will be the share of intra-industry trade between those countries. It is also predicted that two countries will have a higher share of IIT the closer their levels of GDP. Thus, the greater the minimum level of GDP and the smaller the maximum level of GDP, within a trade-pair, the greater will be the IIT share. Thus we expect $ß_5>0$ and $ß_6<0$. Finally, having a common-border is expected to increase the IIT share and hence we expect $ß_7>0$. As with our HOV model, estimations are made for individual dirty sectors and for a 'panel' of all four dirty sectors. In the latter estimation, industry specific dummies are included to control for industry specific effects. We also initially assume environmental regulations to be exogenous and then allow for possible endogeneity. Other factor endowment differentials were also initially included in equation (6) (e.g. minerals, forest cover) but, in contrast to the HOV model, were not found to be robust across all specifications. We therefore focus on the variables listed in equation (5).

Note that per capita income differentials (*PcYdiff*)[7] are included to capture demand-side influences on IIT, namely the effect of preferences. In line with the assumption of identical homothetic preferences from Appendix A, our initial runs of equation (6) did not include *PcYdiff*. However, our results suggested that the estimated coefficient on the capital-labour differential was picking up the effects of per capita income (see discussion of results below). Following Linder (1961) and Bergstrand (1990), we therefore allow for the possibility that a divergence of per capita incomes will represent a divergence of tastes, thereby reducing the share of trade that is intra-industry in nature. Since *PcYdiff*, in principle, will capture both demand and supply side influences we have controlled for the latter by including capital-labour differentials. In contrast, Helpman (1981, 1987) assumes that tastes are homothetic, and includes per capita income differentials simply as a proxy for factor endowment

[7] For simplicity, we now denote differences in capital/labour ratios, land per head, environmental regulations and per capita income as *K/Ldiff*, *T/Ldiff*, *ENVREGdiff* and *PcYdiff*, respectively.

differentials. However, it appears likely that Helpman's estimated coefficients on *PcYdiff* also capture demand side influences. In order to explore these relationships, we estimate equation (6) with both capital-labour differentials and per capita income differentials, and then omit each of these variables individually. All results are discussed below.

Equation (6) is estimated for two samples of trade-pairs, for 1995. The first sample contains 630 trade-pairs and includes both developed and developing economies. However, to examine whether the impact of environmental regulations on trade flows is stronger between North-South countries than between the countries within the full sample, the second sample contains only North-South trade-pairs (i.e. trade between developed and developing countries), with 406 trade-pairs considered in total. Although the assumption of product differentiation and identical homothetic preferences within many of the trade-pairs, particularly in the North-South sample, may be questionable, the North-South IIT indices are not as low as may have been expected.[8] We therefore believe that the estimation of cross-section variations in IIT is appropriate within both the full sample and the North-South sample.[9]

We believe this model structure provides a more appropriate framework to estimate trade flows, since it allows us to separate the potential determinants of intra-industry trade (country size and preferences) from the potential determinants of inter-industry trade (factor endowments and environmental regulations). However, a drawback is

[8] IIT data information: Full panel sample; mean IIT = 0.21, % of zeros = 26%, n = 2520. North-South panel sample; mean IIT = 0.14, % of zeros = 33%, n = 1620.
[9] We also estimated a North-North sample with results almost identical to those from the full sample.

that by identifying only the shares of intra and inter-industry trade, this approach does not allow us to identify the *direction* of any change in inter-industry trade (net trade). Thus, we can identify whether the difference between two countries' environmental regulations increases the share of net trade, but we cannot say whether this represents an increase in the share of net exports or net imports. This issue is returned to in Section IV. We believe nevertheless, that this approach is a useful way of assessing whether environmental regulations, like other factor endowments, influence trade patterns and specifically the proportions of total trade that are intra and inter-industry in nature. Estimation results are provided in Tables 2 and 3.

Table 2. IIT Estimation Results Using the Full Sample (1995).

Variable	Panel (basic)	Panel	Non-ferr. Metals	Paper and Pulp	Iron and Steel	Chemicals
K/Ldiff	0.095***	0.68***	0.78***	0.61***	0.74***	0.62***
T/Ldiff	0.0906***	0.023	-0.037	0.066	-0.0023	0.048
PcYdiff	-	-0.42***	-0.45***	-0.40***	-0.44***	-0.41***
ENVREGdiff	-	-0.10***	-0.11***	-0.10***	-0.086***	-0.11***
MinGDP	0.14***	0.22***	0.23***	0.22***	0.22***	0.22***
MaxGDP	-0.14***	-0.032	-0.048	-0.027	-0.041	-0.015
Border	-	1.67***	1.79***	1.60***	1.97***	1.40***
R^2	0.40	0.52	0.48	0.49	0.50	0.65
n	2520	2520	630	630	630	630
IIT Estimation Results Using the North-South Sample (1995).						
K/Ldiff	0.28***	0.81***	0.92***	0.50***	1.16***	0.78***
T/Ldiff	0.10***	0.101***	0.0028	0.13**	0.15**	0.11**
PcYdiff	-	-0.46***	-0.51***	-0.33***	-0.58***	-0.49***
ENVREGdiff	-	-0.023	-0.022	-0.0045	-0.058	-0.036
MinGDP	0.12***	0.22***	0.18**	0.18**	0.28***	0.27***
MaxGDP	-0.12***	-0.0021	-0.012	-0.025	-0.024	-0.023
COLONY	-	0.46**	0.30*	0.19	1.02***	0.66**
R^2	0.32	0.35	0.28	0.34	0.32	0.50
n	1624	1624	406	406	406	406

Notes: Where *, ** and *** indicate significance at 90%, 95% and 99% respectively.
The panel estimations include industry dummies, but for reasons of space these are not reported.

The primary concern of this study is the role played by environmental regulations in determining trade patterns. In both halves of Tables 2 we find our environmental regulation differential variable to be a negative determinant of the share of IIT across all sectors. This indicates that the greater the differences in environmental regulations between two countries, the smaller will be their share of intra-industry trade within total trade and the greater will be their share of inter-industry trade in these pollution-intensive sectors. It is notable, however, that in the North-South sample, *ENVREG* is not statistically significant as a determinant of IIT, in contrast to the full sample. We also estimate the above regressions using *ENVPOL*, our alternative measure of environmental regulations which stems from changes in energy intensity. The estimated coefficients for the variables are almost identical to those in Tables 2 and hence Table 3 simply reports the estimated coefficients for *ENVPOL*. Again in all cases *ENVPOL* is negative although it is less significant than *ENVREG*, particularly in the North-South sample. The generally lower significance of *ENVPOL* may reflect the fact that it is only a proxy for the stringency of environmental regulations.

Table 3. Estimated Coefficients for ENVPOL

Sample	Variable	Panel	Non-ferr. Metals	Paper and Pulp	Iron and Steel	Chemicals
Full	*ENVPOL*	-0.064***	-0.059*	-0.064*	-0.073**	-0.055**
North-South	*ENVPOL*	-0.420	-0.057	-0.140	-0.154*	-0.300

Notes: Where *, ** and *** indicate significance at 90%, 95% and 99% respectively.

The panel (basic) estimation from Table 2 checks for consistency with the results of previous studies (e.g. Hummels and Levinsohn, 1995) by examining whether basic factor differentials, together with GDP size, are significant determinants of the share of IIT. Our variables are all highly significant and have signs as predicted by theory, with the exception of the capital-labour and, for some estimations, the land-labour differentials (*K/Ldiff* and *T/Ldiff*) which we estimate to be *positive* determinants of IIT. For *K/Ldiff*, in particular, this finding is robust across all of our estimations, both panel and sector-specific. Our results therefore suggest that the greater the capital-labour (and perhaps land-labour) differentials between two countries, the *lower* their inter-industry trade share and hence the greater their intra-industry trade share. This clearly does not support the theory developed in Appendix A. Hummels and Levinsohn also test capital-labour and land-labour differentials as determinants of IIT, for a smaller sample of 91 OECD trade-pairs for individual years covering the period 1962-1983. They find the land-labour differential to be negative throughout, although, interestingly, whilst *K/Ldiff* is negative and significant for the early years in their sample, for the later years it becomes positive and significant. Furthermore, Greenaway et al. (1999), in a study of UK IIT with the EU, also find capital-labour differentials to be a positive, significant determinant of IIT. Our result is therefore consistent with the notion that capital-labour (and perhaps land-labour) differences are no longer positive determinants of net trade.[10]

Whilst *K/Ldiff* is a positive determinant of IIT, we find *PcY* to be a statistically significant negative determinant, suggesting that our separation of demand and supply influences is appropriate. Note that we also estimate equation (6) in the absence of

[10] Hummels and Levinsohn (1995) undertake a comprehensive sensitivity analysis to investigate how robust their results are to alternative specifications. One point they raise is that the relationship between IIT and *K/Ldiff* may be nonlinear so they include a quadratic term for *K/Ldiff.* They find the OLS coefficient on the linear (quadratic) term to be negative (positive). Fixed effects estimates, however, show that both terms are statistically insignificant. The removal of the quadratic term (again in a fixed effects framework) leads to a positive, significant coefficient on the linear *Kldiff* term. Hummels and Levinsohn offer a number of explanations for this positive result including a lack of time series variation in *K/Ldiff*, the problem of categorical aggregation and the role of geography (via cross border trade). However they still end up end up with a series of "inconclusions". See Hummels and Levinsohn (1995) for further details.

PcY and, alternatively, in the absence of *K/Ldiff*, although for reasons of space we have not reported these results. In these estimations, there is strong evidence that the included variable is picking up the effects of the omitted variable. For instance, when we include *K/Ldiff* but omit *PcY*, the coefficients on *K/Ldiff* and *ENVREG* are smaller than those in Table 2, suggesting that they are partially capturing the (negative) effects of per capita income. Since both *K/Ldiff* and *ENVREG* are highly correlated with *PcY* this is not surprising. The inclusion of both *K/Ldiff* and *PcY* therefore appears appropriate in order to capture both the demand and supply influences on IIT, a conclusion also reached by Bergstrand (1990). Furthermore, including *PcY* also reduces the possibility of *ENVREG* picking up demand effects.

Turning to the other results in Table 2, in line with Helpman (1987) and Hummels and Levinsohn (1995) we find GDP differentials (which they call ‘size’) to be a negative and partially significant determinant of the share of IIT. In addition, we find that two countries that share borders will typically have a greater share of IIT than two countries that do not. Finally, in the North-South sample we also find that two countries with colonial links (e.g. UK and India) will generally have a higher share of IIT than two countries without such historical links.

As discussed previously, however, it may not be appropriate to treat environmental regulations and trade flows (IIT) as exogenous variables. In common with the HOV section, we therefore again estimate a simultaneous equations model with our first equation estimating IIT as a function of factor endowment differentials (equation 6) and our second equation estimating environmental regulations as a function of per capita income differentials and IIT. Tables 4a and 4b report the results for the full sample and the North-South samples, respectively.

Table 4a. Simultaneous Equations Results Using the Full Sample (1995).

Variable	Panel	Non-ferr. Metals	Paper and Pulp	Iron and Steel	Chemicals
Dependent Variable: *IIT (GL index)*					
K/Ldiff	0.77***	0.83***	0.65***	0.76***	0.69***
T/Ldiff	-0.0093	-0.085*	0.051	-0.020	0.033
PcYdiff	-0.30***	-0.28***	-0.27***	-0.36***	-0.29***
ENVREGdiff	-0.17***	-0.23***	-0.17***	-0.11***	-0.16***
MinGDP	0.22***	0.21***	0.19***	0.21***	0.20***
MaxGDP	-0.053**	-0.072	-0.034	-0.047	-0.029
Border	1.66***	1.81***	1.52***	1.88***	1.45***
R^2	0.53	0.52	0.49	0.50	0.66
Dependent Variable: *ENVREGdiff*					
PcYdiff	0.20***	0.20***	0.20***	0.20***	0.20***
IIT	-41.6***	-43.7***	-42.5***	-38.6***	-38.8***
R^2	0.47	0.47	0.47	0.47	0.47
n	2520	2520	630	630	630

Table 4b. Simultaneous Equations Results Using the North-South Sample (1995).

Variable	Panel	Non-ferr. Metals	Paper and Pulp	Iron and Steel	Chemicals
Dependent Variable: *IIT (GL index)*					
K/Ldiff	1.12***	1.25***	0.74***	1.53***	1.10***
T/Ldiff	0.010	-0.082	-0.029	-0.0015	0.17***
PcYdiff	-0.44***	-0.48***	-0.29**	-0.57***	-0.49***
ENVREGdiff	-0.18***	-0.18**	-0.16**	-0.21**	-0.18***
MinGDP	0.19***	0.22**	0.15**	0.26***	0.19***
MaxGDP	0.047	0.074	0.014	0.070	0.022
COLONY	0.45**	0.29*	0.20	1.01***	0.64**
R^2	0.42	0.33	0.35	0.33	0.51
Dependent Variable: *ENVREGdiff*					
PcYdiff	0.19***	0.20***	0.19***	0.19***	0.18***
IIT	-34.7***	-54.9**	-60.4**	-28.34	7.4
R^2	0.50	0.50	0.50	0.50	0.50
n	1624	1624	406	406	406

Notes: Estimated using 2SLS. Where *, ** and *** indicate significance at 90%, 95% and 99% respectively. Note that almost identical results were estimated when *ENVREG* was replaced with *ENVPOL*. These latter results are available upon request.
The panel estimations include industry dummies, but for reasons of space these are not reported.

The results in Tables 4a and 4b are fully supportive of those in Table 2, with virtually all variables statistically significant, again, with the exception of land differentials (*T/Ldiff*). We now estimate the environmental regulation variables play an even greater role in determining IIT. All *ENVREG* coefficients are larger than those estimated in Table 2 and it is notable that these coefficients are now statistically significant for the North-South sample, whereas they were not when treated as exogenous variables. We also find the share of IIT to be a negative, statistically significant determinant of environmental regulations in virtually all estimations. This suggests that falling net, or inter-industry, trade (i.e. rising IIT) lowers environmental regulation differences.

In sum, we have found evidence to suggest that environmental regulations are statistically significant determinants of the share of inter-industry trade. Furthermore, we also find evidence to suggest that both environmental regulations and IIT should be treated as endogenous variables.

4. INTERPRETATION OF THE ECONOMETRIC RESULTS

At face value, our results from the 'new' trade model may appear to contradict those from the HOV model by finding a significant relationship between environmental regulations and trade patterns. However, it is important to be clear how these two models differ. The HOV model found no statistically significant relationship between an individual country's environmental regulations and that country's *volume* of net exports in a pollution intensive industry. In contrast, the 'new' trade model concentrates on *bilateral* trade and the *shares* of intra and inter-industry trade in total trade.

Equation (3), which defined the GL index and which formed our dependent variable in the 'new' trade model, can also be defined in the following way;

$$GL_i = 1 - \frac{|X_{ijk} - M_{ijk}|}{(X_{ijk} + M_{ijk})} \qquad (7)$$

Where $|X_{ijk} - M_{ijk}|$ denotes the absolute value of net trade.[11] Thus, our results indicate that the smaller the differential between two countries' environmental regulations the smaller will be the share of the absolute value of their net trade, in total trade. To put it another way, the larger the differential between two countries' environmental regulations the larger the share of net trade in total trade. Since the GL index incorporates the *absolute* value of net trade, we are saying nothing here about the *direction* of any change in net trade (i.e. whether it represents an increase in net exports or net imports). Furthermore, since the absolute value of net trade is expressed as a share of total trade, we are also saying nothing about the level, or volume, of net trade. When considered in this way, there is no reason to expect the same relationship between environmental regulations and the dependent variable within the two trade models.

Thus, whilst our HOV results provide no evidence to suggest that environmental regulations are reducing net exports of dirty output, our 'new' trade results do suggest

[11] Total trade is equal to the sum of intra-industry trade plus the absolute value of net trade i.e. *Total trade*$_{ijk}$ $= 2min(X_{ijk}, X_{ikj}) + |X_{ijk} - M_{ijk}|$.

that environmental regulation differentials are influencing trade patterns. This influence is more subtle than that tested for in the HOV model and suggests that differences in the stringency of regulations between two countries influence the composition of trade between those countries i.e. whether two countries trade within the same, or different, industries. Furthermore, this finding is made whether we use a full sample, a North-South sample or a North-North sample.

In terms of the pollution haven hypothesis, whilst the ‘new’ trade model cannot provide definitive results, a rising share of net trade in total trade, associated with bilateral regulation differentials, is consistent with the existence of pollution haven effects. It suggests that countries with relatively lax environmental regulations may possess a comparative advantage in pollution intensive output. Although the HOV model provided no direct evidence of this, the ‘new’ trade model does focus on *bilateral* trade and does control for the determinants of intra-industry trade. As such, it may be a more appropriate model in which to model issues such as this.

5. SUMMARY AND CONCLUSIONS

The complex interrelationships between trade, environmental regulations and the composition of the global economy have become a focal point for international policy makers. With this in mind, this paper has examined trade patterns, in the context of two trade models, to ascertain whether the influence of environmental regulations is discernible.

Within the HOV model, we found no evidence to suggest that either of our two measures of environmental regulations were statistically significant determinants of 'dirty' net exports. However, we did find that net exports from iron and steel and chemical industries were highest in capital abundant countries, whilst net exports of non-ferrous metals and paper and pulp were highest in countries endowed with minerals and forests, respectively. Both of these findings may explain why environmental regulations are not influencing trade patterns by a greater amount. In the case of capital, since it is the developed world that is capital abundant, this may explain why Northern iron and steel and chemical industries are not relocating to the developing world, even in the face of stringent environmental regulations. Similarly, in the case of other natural resource endowments, the reliance of non-ferrous metals and paper industries on such locally sourced resources may again explain why they are not relocating to take advantage of lower regulations. The estimation of a simultaneous equations HOV model, which allowed for the possible endogeneity of environmental regulations and net exports, did not change any of these findings.

In contrast to the HOV model, the 'new' trade model does not estimate net exports but rather the share of total trade that is intra and inter-industry. Thus, whilst it still explains inter-industry trade (i.e. net trade) it now does so in a manner that simultaneously explains intra-industry trade. As has been noted, this approach does not allow us to identify the *direction* of any change in net trade resulting from a change in regulations. Thus, we are essentially asking a different question to that asked within the HOV section. We are asking whether environmental regulations, like other factor endowments, influence the composition of trade i.e. the extent to which two countries trade within the same, or different, industries. Our results suggest that the shares of trade that are intra and inter-industry are indeed influenced by environmental regulation differentials between two countries. If regulations are treated as exogenous variables, we find them to be negative and statistically significant determinants of IIT shares within the full sample, and negative and non-significant determinants in the North-South sample. In common with the IIT literature (e.g. Hummels and Levinsohn 1995) we also find country size, preferences and a common border dummy to be significant determinants of IIT shares. Contrary to expectations, we find capital-labour differentials to be a *positive* determinant of IIT shares. Once environmental regulations and IIT shares are treated as endogenous variables we find the coefficients on the *ENVREG* variable increase in size and significance and also find this variable to be now significant within the North-South sample. Whilst we are not directly modelling the direction of net trade, we have noted that an increased share of net trade in total trade, resulting from an increase in bilateral environmental regulations differentials, is *consistent* with the pollution haven hypothesis. Finally, IIT shares are also found to be a negative determinant of environmental regulation differentials, suggesting that falling inter-industry trade shares (e.g. a falling share of net exports) are associated with falling environmental regulation differentials.

We should finish on a note of caution. Although the analysis draws on a reasonably large number of cross-sections (60 countries in the HOV model, 630 trade-pairs in the IIT model), we have data for only one year (1995). This reflects the fact that our preferred environmental regulations variable (*ENVREG*) is only available for 1995.

Appendix A. Theoretical background

<u>The Heckscher-Ohlin-Vanek Model</u>

This section follows Murrell (1990) and is constructed to derive equation (1) in Section II. We do not include all of the intermediate steps but simply those that are pertinent to the derivation of our equation (1).

The standard HOV model assumes (1) many goods ($i=1 \ldots N$), many endowments ($k=1 \ldots S$) and many countries ($j=1 \ldots T$) where $S=N$[12], (2) identical linearly homogeneous production functions for homogeneous products with given technology, (3) identical homothetic preferences, (4) immobile factors of production between countries but mobile within a country, (5) no transport costs or trade barriers. To derive equation (1) we also assume sufficient factor endowment similarities so all countries are within the same “cone of diversification” and that perfect competition in factor and product markets and constant returns to scale results in factor price equalisation.

Let Q_{ij} be the amount of good i produced by country j where $\boldsymbol{Q_j}$ is the vector of N outputs and V_{kj} be the jth country’s endowment of factor k where $\boldsymbol{V_j}$ is the vector of S factor endowments. The input-output coefficients make up the factor intensity matrix A with elements a_{ki} representing the quantities of factor k used in producing a unit of output of good i. Let p_i be the price of good i, γ_k be the price of factor k and G_j be the national income (GDP) of country j.

If A is invertible,

$$\boldsymbol{Q_j} = A^{-1}\boldsymbol{V_j} \qquad \text{(A1)}$$

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12 In the general case $N \geq S$. See Leamer (1984, pp. 16-18) for ways in which models with $N>S$ can be converted into models where $N=S$.

Exports, W_{ij} are then defined as the difference between production and consumption: $\boldsymbol{W_j} = \boldsymbol{Q_j} - \boldsymbol{C_j}$, where $\boldsymbol{C_j}$ is the vector of consumption for country j and in addition, c_i represents the proportion of income spent on good i and **c** is the vector of expenditure shares across all goods. From assumption (3) consumption of any good, at given prices, is an equal proportion of national income in all countries. We can therefore describe the cross-country pattern of consumption as;

$$\boldsymbol{C_j} = \boldsymbol{c} G_{\boldsymbol{j}} \qquad \text{(A2)}$$

Denoting world values with a w subscript (because world production must equal consumption),

$$\boldsymbol{c} = \frac{A^{-1}\boldsymbol{V_w}}{G_w} \qquad \text{(A3)}$$

therefore, from (A1), (A2) and (A3),

$$\boldsymbol{W_j} = A^{-1}V_j - A^{-1}V_w\left(G_j / G_w\right) \qquad \text{(A4)}$$

Denoting the elements of A^{-1} by $\overline{a}_{ij}$ we can arrive at,

$$W_{ij} = \sum_{k=1}^{S}\left[\overline{a}_{ik} - \frac{g_k}{G_w}\left(\sum_{s=1}^{S}\overline{a}_{is}V_{sw}\right)\right]V_{kj} \qquad \text{(A6)}$$

where the term in the squared brackets is independent of j and therefore constant across countries, our final equation system is simply;

$$W_{ij} = \sum_{k=1}^{S} b_{ik} V_{kj} \qquad i = 1,...,N \qquad j = 1,...,T \tag{A6}$$

where b_{ik} represents the term in the squared brackets in equation (A5). This means we are able to predict a country's net exports of each of N traded goods in the world economy from data on its resource endowments in conjunction with parameters that are constant across countries.

<u>A Monopolistic Competition Model of Trade</u>

Consider an economy with 2 countries (Home and Foreign where * indicates the foreign country), two factors (K and L) and two sectors. Given assumptions (2)-(6) of the HOV model, now assume X is a differentiated product subject to increasing returns to scale and Y is a homogeneous product subject to constant returns to scale. Assuming free entry and monopolistic competition, equilibrium is characterised by a large number of firms each producing a unique variety of X and making zero profits. Assume X is the capital-intensive product, the home country is capital abundant and the number of firms is given by $n=X/x$, where x is also the number of varieties.

With zero transport costs and a utility function that rewards variety, all varieties of X will be demanded in both countries. Moreover, each country will consume an amount of each variety in proportion to its world share of GDP, $\overline{G}$ where;

$$s = G / \overline{G} \qquad and \qquad s^* = (1 - s) \tag{A7}$$

and $G+G^*=\overline{G}$. With balanced trade, the Home country consumes spn^*x^* (-spX^*) of the Foreign X good, and the Foreign country consumes s^*pnx (=s^*pX) of the Home country's X, and p is the price of all varieties of good X (where the price of Y is normalised to 1).

The standard result is that there will be two-way trade and that the Home country will be a net exporter of *X* and a net importer of *Y*. The total volume of trade is given by;

$$VT = s^* pX + spX^* + s\overline{Y} - Y \qquad \text{(A8)}$$

and the share of trade that is intra industry is given by;

$$IIT = \frac{2\min\left(s^* pX, spX^*\right)}{s^* pX + spX^* + (s\overline{Y} - Y)} \qquad \text{(A9)}$$

where *X* and *X** denote the production of *X* in the Home and Foreign country respectively and $\overline{Y}$ is the total production of *Y*.

When factor endowments are identical, all trade is intra-industry and no trade is motivated by relative factor abundance. If a reallocation of factors widens the capital labour ratio and the relative size of the country remains unchanged, then IIT will decrease and inter-industry trade will increase.

Appendix B. Data Information

Net exports	United Nations (1996), International Trade Statistics Yearbook
IIT	National Asia Pacific Economic and Scientific Database (NAPES)
LAB	Economically active population, from World Bank (1999) World Development Indicators 1999 CDROM
LAB1	Professional and technical workers (thousands). International Labour Office (various years) Yearbook of Labour Statistics
LAB2	Literate non-professional workers (thousands). Calculated as LAB-LAB1-LAB3
LAB3	Illiterate workers. Calculated as LAB*illiteracy rate. The latter is from World Bank (1999) World Development Indicators 1999 CDROM
CAPITAL	Physical capital stock. The sum of annual Gross Domestic Investment assuming an average life of 15 years. GDI data from World Bank (1999). World Development Indicators 1999
ENVREGS	Eliste and Fredriksson (2001) (based on Dasgupta et al. (1995))
ENVPOL	Calculated using the change in energy intensity between 1980 and 1995 and the level of energy intensity in 1980. The former was calculated using the averages of years 1980 and 1981 and 1994 and 1995, to reduce the effect of the end-years. The two variables were ranked, these ranks were summed and then ranked again. These values were then divided by 60 (the number of countries in the sample). Subtracting the result from 1 then provides a measure between 0 and 1, with 1 = high regulations and 0 = low regulations. Energy intensity is defined as total energy use divided by GDP. From World Bank (1999) World Development Indicators 1999 CDROM.
LEAD, ZINC, IRON, COPPER	Value of extraction (thousand 1995 US$). US Geological Survey (1997 and 1998). Minerals Information 1997 and 1998
OIL	Value of oil extraction (millions of 1995 US$). International Energy Agency (1996). Oil and Gas Information 1996
GAS	Value of gas extraction (millions of 1995 US$). International Energy Agency (1997). Natural Gas Information 1997
COAL	Value of coal extraction (millions of 1995 US$). International Energy Agency (1997). Coal Information 1997
TROPFOR	Thousand hectares of tropical forest. World Resources Institute (1998). World Resources 1998/99
NONTROP	Thousand hectares of non-tropical forest. World Resources Institute (1998). World Resources 1998/99
CROPLAND	Thousand hectares of cropland. World Resources Institute (1998). World Resources 1998/99
GDP	World Bank (1999) World Development Indicators 1999 CDROM

Countries included in the HOV sample:

1. Argentina	13. Denmark	25. Ireland	37. N. Zealand	49. Sweden
2. Australia	14. Dom. Rep.	26. Italy	38. Nigeria	50. Switzerland
3. Austria	15. Ecuador	27. Jamaica	39. Norway	51. Tanzania
4. Bangladesh	16. Egypt	28. Japan	40. Pakistan	52. Thailand
5. Belgium	17. Ethiopia	29. Jordan	41. P.N.Guinea	53. Trin.&Tob.
6. Brazil	18. Finland	30. Kenya	42. Paraguay	54. Tunisia
7. Bulgaria	19. France	31. Korea Rep.	43. Philippines	55. Turkey
8. Canada	20. Germany	32. Malawi	44. Poland	56. UK
9. Chile	21. Greece	33. Mexico	45. Portugal	57. USA
10. China	22. Hungary	34. Morocco	46. Senegal	58. Venezuela
11. Colombia	23. Iceland	35. Mozambique	47. S. Africa	59. Zambia
12. Czech Rep.	24. India	36. Netherlands	48. Spain	60. Zimbabwe

The IIT sample used a subset of 36 of these countries (to produce 630 trade-pairs), since the NAPES dataset does not report data for all 60 countries. They are;

1. Australia	11. France	21. Mexico	31. Sweden
2. Austria	12. Germany	22. Netherlands	32. Switzerland
3. Bangladesh	13. Greece	23. New Zealand	33. Thailand
4. Belgium	14. Hungary	24. Norway	34. Turkey
5. Canada	15. Iceland	25. Pakistan	35. UK
6. Chile	16. India	26. P.N.Guinea	36. USA
7. China	17. Ireland	27. Philippines	
8. Czech Rep.	18. Italy	28. Poland	
9. Denmark	19. Japan	29. Portugal	
10. Finland	20. Korea, Rep.	30. Spain	

Appendix C. HOV Estimations With Environmental Regulations and Net Exports Treated as Endogenous Variables

Variable	Panel[a]	Non-ferrous metals	Paper and pulp	Iron and steel	Chemicals
Dependent Variable: Net exports					
LAB1	-13.7	62.2	-126.4	-87.6	96.7
LAB2	-21.1**	-23.6***	-22.9**	-20.8*	-17.1***
LAB3	40.25**	21.7*	56.2***	55.7**	27.2***
CAPITAL	1.5*	-3.0***	4.5	7.4***	1.2***
ENVREG	38.5	5.9	11.1	9.2	2.7
LEAD	4.2	-17.5**	37.4***	-4.7	2.0
ZINC	-2.5	5.7**	-17.4***	1.4	-0.04
IRON	0.50	1.1**	0.51	1.0	-0.6*
COPPER	0.17	0.58***	0.11	-0.06	0.04
OIL	3.4	9.0***	-2.3	6.6	0.6
GAS	-21.0***	-17.2***	-38.1***	-30.3***	1.6
COAL	10.3	12.1*	7.7	11.1	10.1*
TROPFOR	8.8	-5.7	22.7*	6.1	12.1**
NONTROP	28.0***	6.0	97.8***	8.8	-0.38
CROPLAND	-36.5**	-31.0***	-29.8	-55.7***	-29.4***
R^2	0.79	0.89	0.85	0.78	0.63
Dependent Variable: Environmental Regulations					
Per Capita Y	2.9***	3.0***	2.9***	3.0***	2.9***
Net Exports	7.0	1.9	1.4	-2.9**	1.8
R^2	0.77	0.77	0.78	0.77	0.77
n	240	60	60	60	60

Notes: Estimated using 2SLS. For reasons of space, t-statistics have not been reported. Instead, *, ** and *** denote significance at 90%, 95% and 99%, respectively. Note that almost identical results were estimated when *ENVREG* was replaced with *ENVPOL*. These latter results are available upon request.

[a] Where 'panel' refers to the inclusion of all four sectors in the same regression. This estimation includes industry dummies, but for reasons of space these are not reported.

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