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Do stringent environmental regulations really hurt competitiveness? A re-examination of recent evidence using structural gravity with high-dimensional fixed effects

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Abstract
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Keywords: Pollution haven hypothesis; Structural gravity model; Environmental policy; Sectoral bilateral trade; Intra-national trade

JEL: F18, F64, N54, N74, Q56

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Do stringent environmental regulations really hurt competitiveness? A re-examination of recent evidence using structural gravity with high-dimensional fixed effects.

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ABSTRACT

The empirical evidence for the so-called pollution haven hypothesis, which predicts that inter-country differences in environmental policy stringency will cause pollution-intensive production to relocate to countries with lax environmental standards, has traditionally been weak. However, in recent years, a large number of studies have reported results in support of the hypothesis. A major drawback of this recent literature is that none of the studies use a theoretically consistent gravity model of trade. The main objective of this paper is to see whether their results hold after having corrected for this shortcoming. In the paper, I analyze sectoral bilateral trade flows for a panel of 31 countries between 1990 and 2006, using a new composite index developed by the OECD to proxy environmental policy stringency. I find that stringent environmental policy does indeed reduce exports of pollution-intensive goods, but that the effect is limited to a smaller subset of manufacturing sectors.

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INTRODUCTION

The aim of this paper is to analyse the relationship between inter-country differences in environmental policy stringency and bilateral trade flows. The notion that stringent environmental policies may hurt the competitiveness of pollution-intensive export industries has been propagated by numerous researchers, as well as economic and political analysts ever since modern environmental legislation first appeared in high-income countries during the 1970's. According to the so-called pollution haven hypothesis, countries that institute more stringent environmental policies than their trading partners will erode their comparative advantage in pollution-intensive exports. Due to the costs of complying with the regulations, pollution-intensive industries in such countries are expected to shrink in size, either due to a general loss in competitiveness or/and because of business migration to countries with less stringent regulations. Either way, the expected result is a reorientation of pollution-intensive export flows from high-regulation to low-regulation countries. Up until quite recently, the empirical evidence supporting this proposition has, however, been quite limited. But over the past few years, a large number of articles have appeared, which have reported significant and economically meaningful negative effects of environmental policy stringency on export performance. However, none of these studies use a theoretically consistent gravity model of trade. The main objective of this paper is to see whether their results hold after having corrected for this shortcoming. In the paper, I analyse sectoral bilateral trade flows for a panel of 31 countries between 1990 and 2006, using a new composite index developed by the OECD to proxy environmental policy stringency. I find that stringent environmental policy does indeed reduce exports of pollution-intensive goods, but that the effect is limited to a smaller subset of manufacturing sectors.

GRAVITY MODELLING OF TRADE FLOWS

It has been known for quite some time that the volume of trade between two countries tends to be roughly proportional to their respective economic size and proximity (Tinbergen, 1962). This "gravity equation" has been widely used to assess the impact of trade agreements, customs unions, exchange rate arrangements and a host of other institutions, by modelling bilateral trade as a positive function of the total output of the exporter and total expenditure of the importer (proxied by their GDP's) and as an inverse function of the geographical distance that separates them (Anderson, 1979; Bergstrand, 1985). The basic gravity equation thus takes the form:

$$x_{ij} = G\frac{y_i y_j}{\emptyset_{ij}} \tag{1}$$

where x_{ij} is the volume of exports from country *i* to country *j*, y_i and y_j are the nominal incomes of *i* and *j* respectively, while $\emptyset_{ij}$ is a vector of bilateral trade costs and *G* is a constant. Apart from geographical distance, $\emptyset_{ij}$ normally includes a host of other variables that affect the trade between countries, such as whether two countries share a common border, have a common language, whether one or both are members of a regional trade agreement, have a past colonial relationship and so forth.

This basic formulation of the gravity model has proven extremely successful in explaining bilateral trade flows and has been instrumental for our understanding of many trade related matters. Hence, it is commonly used in empirical research, in its traditional form, even to this day. However, over the past two decades, gravity analyses of trade flows have undergone substantial modifications and improvements, which are many times overlooked in recent empirical applications. Most notably, Anderson and van Wincoop (2003) criticized the singular focus on bilateral trade costs in traditional gravity analyses. Trade between two countries, they argued, is not solely determined by the absolute level of bilateral trade costs, but rather on the trade costs between these two countries *relative* to their respective trade costs with all other countries. Accounting for this fact requires that the gravity equation is augmented by price indices –which Anderson and van Wincoop called "multilateral resistance" terms – which capture the importer's and exporter's ease of access to alternative markets (Anderson & van Wincoop, 2003). This yields the following structural gravity equation:

$$x_{ij} = \frac{y_i y_j}{y^w}\left(\frac{t_{ij}}{P_i P_j}\right)^{1-\sigma} \qquad (2)$$

where y^w is world nominal income, t_{ij} is the bilateral trade costs facing exporters from *i* in market *j*, while P_i and P_j are country *i*'s outward and country *j*'s inward multilateral trade resistance (MTR) terms. In this model, the level of trade between *i* and *j* is determined, on the one hand, by the product of their respective shares of world income and, on the other hand, by the level of their bilateral trade costs relative to the product of their MTR terms. As is evident from equation (2), a rise (reduction) in P_i and/or P_j will raise (lower) the level of exports from *i* to *j*, irrespective of any change in bilateral trade costs. Consequently, a failure to control for multilateral resistance may introduce substantial bias in many empirical settings. P_i and P_j in equation (2) are, of course, not directly observable. A number of different methods for approximating P_i and P_j have been suggested in the literature, but there is currently more or less universal agreement that the only way to properly account for the MTR terms is by using importer and exporter fixed effects. Since multilateral resistance varies over time, the fixed effects should also be time-varying (importer-year and exporter-year effects) when panel data is employed.

When using panel data, Baier and Bergstrand (2007) and others have furthermore suggested that t_{ij} should be controlled for by the inclusion of country-pair fixed effects, rather than by including a set of observable trade cost variables (Baier & Bergstrand, 2007; Agnosteva, 2014; Egger & Nigai, 2015). The pair fixed effects corrects for possible endogeneity of included trade policy variables, and also obviates the need to identify a proper set of trade cost variables, as their inclusion automatically eliminates all omitted variable bias stemming from unobservable (or, observable but missing) time-invariant country-pair specific factors (Egger & Pfaffermayr, 2003; Baldwin & Taglioni, 2006; Fally, 2015).

Due to the multiplicative nature of the theoretical gravity equation, it has been standard practice to take the natural log of all variables in order to make the equation additive, as it can then be estimated by OLS. However, Santos Silva and Tenreyro (2006) and others have shown that OLS estimation of gravity equations will invariably produce biased estimates if the assumption of homoskedasticity in the data is violated. They therefore recommend estimating gravity equations in their multiplicative form using the Poisson Pseudo-Maximum Likelihood (PPML) estimator. This also solves another longstanding issue in the gravity model literature, the question of how to handle zero trade flows. As countries typically do not engage in trade with all other countries, most trade datasets will contain a significant number of trade flows with value zero. But as the log of zero is not defined, such observations have traditionally either been left out of the analysis or have been manipulated (typically assigned some small value) in order to allow for logarithmization. The PPML estimator on the other hand, handles zero trade flows well and is robust in the presence of heteroskedasticity, which is why it has become the standard in gravity estimation (Santos Silva & Tenreyro, 2006).

Following these recommendations, the structural gravity equation can be rewritten as:

$$x_{ij,t} = \exp\left[\pi_{i,t} + \chi_{j,t} + \mu_{ij} + \beta \mathrm{BTC}_{ij,t}\right] * \varepsilon_{ij,t} \tag{3}$$

where $\pi_{i,t}$ and $\chi_{j,t}$ are the exporter-year and importer-year fixed effects, μ_{ij} are the country-pair fixed effects, while the term $\mathrm{BTC}_{ij,t}$ is a vector of bilateral time-varying covariates. As all time-varying exporter- and importer-specific determinants of trade are controlled for by $\pi_{i,t}$ and $\chi_{j,t}$, $y_{i(t)}$ and $y_{j(t)}$ drop out of the model. Similarly, because all time-invariant bilateral determinants of trade are controlled for by μ_{ij}, bilateral distance and other time-invariant covariates that are normally included in t_{ij} are also dropped, due to perfect collinearity with μ_{ij}. This structural gravity model thus makes it possible to estimate $\beta \mathrm{BTC}_{ij,t}$ while at the same time controlling for confounding factors in three other dimensions. The same model may be used with sectoral data, but the country-year fixed effects then become country-sector-year fixed effects and the country-pair fixed effects similarly become country-pair-sector fixed effects.

Seeing as bilateral time-varying determinants of trade flows, such as free trade agreements, bilateral tariffs, currency unions etc., will most often not have an instantaneous impact on trade, but rather reaches their full impact only after some adjustment period has elapsed, it is commonly argued that gravity models ought not be estimated with data pooled over consecutive years (Trefler, 2004; Cheng & Wall, 2005; Anderson & Yotov, 2016). Olivero and Yotov (2012) have shown that models with data in 3- to 5-year intervals produce very similar estimates of standard gravity variables, and recommend researchers to experiment with different intervals in order to ensure the robustness of their results (Olivero & Yotov, 2012).

Finally, Bergstrand et al. (2015), Yotov et al. (2016) and others have argued that in addition to bilateral trade flows, gravity models should also be supplemented with data on intra-national (or internal) trade, i.e. a country's trade with itself, or gross production minus exports. This is warranted both for theoretical and applied reasons. In the structural gravity model of Anderson and van Wincoop (2003) consumers choose between foreign and domestic varieties, and internal and external sales sum up to total output/expenditure for each exporter/importer. Fally (2015) has demonstrated that absent the inclusion of intra-national trade flows, the equivalence between the theoretical gravity model (equation 2) and the recommended fixed effects model (equation 3) no longer holds (Fally, 2015). Furthermore, the inclusion of intra-national trade flows also enables the researcher to construct controls for the impact of globalization, through variables that account for average (across all country-pairs) declines in the cost of international relative to intra-national trade (Bergstrand et al., 2015).

PREVIOUS RESEARCH

Research into the relationship between environmental quality and trade in general, and into the veracity of the pollution haven hypothesis in particular, took off from the early 1990's, and produced what is now a quite voluminous literature. The literature on the pollution haven hypothesis comprises both single-country and multi-country- cross-sectional and panel- studies, which have used a wide variety of trade-, investment-, employment- and other data, as well as various different proxies for environmental policy stringency. Most studies in this literature have tended to conclude that pollution-haven type effects are either statistically or economically insignificant, and that environmental costs are normally dwarfed by other determinants of trade and investment, such as transportation and relocation costs, availability of markets, labour and raw materials, agglomeration economies and so on. As late as 2014, a major review concluded that "[t]he effect of current environmental regulations on where trade and investment takes place has been shown to be negligible compared to other factors" (Dechezlepretre & Sato, 2014).[1]

More recently, a number of studies have however reported statistically significant and economically meaningful negative effects of environmental policy stringency on export performance. Kozluk and Timiliotis (2016) analyse whether differences in environmental policy stringency affect sectoral bilateral trade flows for a sample of 29 countries over the period 1990-2009. They use a new composite index developed by the OECD to measure environmental policy stringency (which is the same measure that I will use in this paper), and interact bilateral differences in stringency with an index of manufacturing sector pollution intensity to derive their focus variable. They find that stringent environmental policy reduces exports of pollution-intensive goods, both when measured in gross terms and in terms of domestic value added in exports. Martinez-Zarzoso et al. (2017) similarly analyse sectoral bilateral trade flows for a panel of 21 countries between 1999-2013, using environmental tax revenues as a proxy for environmental policy stringency, but find no significant effects on the aggregate level. They do, however, find large negative effects for select manufacturing sectors. Bagayev and Lochard (2017) finally, use sectoral bilateral trade data for a sample of

[1] See, for instance, Jaffe et al. (1995), Van Beers and Van den Bergh (1997), Harris et al. (2002), Grether and De Melo (2003).

27 EU importers and 11 Eastern European exporters and find that more stringent air pollution regulations in EU countries increases the propensity to import pollution-intensive goods from Eastern Europe. As already stated, none of these studies do however employ a theoretically consistent gravity model of trade. Kozluk and Timiliotis (2016) use the PPML estimator and a model with time-invariant importer, exporter, sector and year fixed effects. Martinez-Zarzoso et al. (2017) use a log-linear model with sector-year and country-pair fixed effects. Bagayev and Lochard (2017) include the appropriate importer-sector-year and exporter-sector-year fixed effects to control for inward and outward multilateral resistance, but uses a log-linear model and no country-pair fixed effects. In separate robustness tests Bagayev and Lochard (2017) experiments with including country-pair fixed effects and with using a PPML estimator, but never in the same model and never along with country-sector-year fixed effects. Furthermore, all of these studies use trade data for consecutive years and none of the studies include data on intra-national trade.

METHOD AND DATA

My estimates are based on a high-dimensional fixed effects (or "structural") gravity model, in which all importer-sector- and exporter-sector specific time-varying factors that may affect bilateral trade flows are captured by importer-sector-year and exporter-sector-year fixed effects, while all country-pair-sector specific time-invariant factors are captured by (directed) country-pair-sector fixed effects. This allows me to estimate the impact of inter-country differences in environmental policy stringency –which is a time-varying country-pair specific variable – while controlling for confounding factors in all other dimensions. I use the new EPS index developed by the OECD (Botta & Kozluk, 2014) as a proxy for environmental policy stringency and estimate the following equation[2] with sector-level (bilateral and intra-national) trade data in four-year intervals:

$$x_{ij,t}^{k} = \exp\left[\pi_{i,t}^{k} + \chi_{j,t}^{k} + \mu_{ij}^{k} + \beta \mathrm{EPSr}_{ij,t} + \beta \mathrm{PTA}_{ij,t} + \beta \mathrm{FTA}_{ij,t} + \beta \mathrm{EU}_{ij,t} + \sum_{T-1994}^{2006} \beta INTL\_BRD\_(T)_{ij,t}\right] * \varepsilon_{ij,t} \qquad (4)$$

where $X_{ij,t}^{k}$ is exports from country *i* to country *j* in sector *k* at time *t*, $\pi_{i,t}^{k}$, $\chi_{j,t}^{k}$ and μ_{ij}^{k} are the different sector-level fixed effects, $\mathrm{EPSr}_{ij,t}$ is the ratio between the level of environmental policy stringency in *i* and *j* at time *t*, expressed in percentage terms, and $\mathrm{PTA}_{ij,t}$, $\mathrm{FTA}_{ij,t}$ and $\mathrm{EU}_{ij,t}$ are controls for different types of economic integration agreements that were in effect, or were signed between the countries in the sample between 1990 and 2006.[3] The expression $\sum_{T-1994}^{2006} \beta INTL\_BRD\_(T)_{ij,t}$, finally, denotes a set of dummy variables that takes the value of one for trade flows that crossed international borders in each year T, and zero otherwise. These dummies measure changes in the level of international relative to intra-national trade across all country-pairs in different years, and hence control for possible average declines in unobservable bilateral export costs (decreasing the costs of international relative to intra-national trade).[4] Narrowly defined, $\sum_{T-1994}^{2006} \beta INTL\_BRD\_(T)_{ij,t}$ can, in other words, be thought of as controlling for the impact of economic globalization. Due to perfect collinearity

[2] All estimations have been performed in Stata, using a user-written command (ppml_panel_sg) that was developed by Tom Zylkin. See Larch et al. (2019).

[3] PTA = one- or two-way preferential trade agreements, FTA = free-trade agreements or customs unions, EU = common market agreements or economic unions.

[4] See Bergstrand et al. (2015) for an extended discussion.

with the other fixed effects, it is not possible to estimate these dummies for all years. I have therefore dropped the dummy for 1990, and the remaining dummies should thus be interpreted relative to this year.

Data on sector-level (in ISIC Rev. 2) bilateral and intra-national trade have been collected from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) database TradeProd (de Sousa et al., 2012) for a panel of 31 countries between 1990-2006.[5] The panel is more or less balanced, apart from a few missing years for Eastern European countries in the beginning of the period, and missing data for Canada and the United Kingdom in 2004-2006 and 2006 respectively. Data on economic integration agreements have been collected from the NSF-Kellog institute's EIA database (Baier et al., 2014). Data on environmental policy stringency has, as already stated, been collected from the OECD's EPS database (Botta & Kozluk, 2014). The OECD's Environmental Policy Stringency Index is a composite index which ranks countries' environmental policy on a scale from 0 to 6 (0 being lax and 6 being stringent) on 15 market-based and non-market-based policy instruments. Table 1 shows some descriptive statistics for the EPS index for the countries in the OECD and for the six BRIICS countries (Brazil, Russia, India, Indonesia, China and South Africa). As seen in the table, the median level of environmental policy stringency increased between 1990 and 2006, both within the OECD and for the BRIICS countries, but markedly faster for the former. The coefficient of variation (COV) of the EPS index within the OECD more than halved between

[5] The countries included are: Australia, Austria, Brazil, Canada, China, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, India, Indonesia, Ireland, Italy, Japan, South Korea, Netherlands, Norway, Poland, Portugal, Russia, Slovak republic, South Africa, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

1990 and 2006, as countries with relatively lenient environmental policies (such as Australia, Canada or Hungary) started to catch up with the more stringent countries. There is, however, no sign of any convergence between the environmental policies of the BRIICS countries and those of the countries within the OECD, rather, the gap in environmental policy stringency between the OECD and the BRIICS seem only to have been further accentuated during the period. This makes it reasonable to expect that possible pollution haven-type effects should show up in an examination of this data, despite the relatively short time-period examined, especially since the stringency of the OECD countries with the highest value of the EPS index in 2006 was still more than twice that of the OECD countries with the lowest values in that year.

Table 1. Descriptive statistics for the EPS index, 1990-2006.

Year	1990	1994	1998	2002	2006
OECD					
Max	2,00	2,23	2,56	2,58	3,28
Min	0,35	0,46	0,50	0,69	1,50
Median	0,71	1,00	1,21	1,58	2,59
COV	47,39	45,73	43,38	31,72	20,55
BRIICS					
Max	0,44	0,52	0,52	0,65	0,77
Min	0,25	0,33	0,42	0,44	0,42
Median	0,39	0,40	0,49	0,56	0,58
COV	19,17	16,39	9,05	15,67	20,23

Source: Botta and Kozluk, (2014)

RESULTS

The results of the gravity model analysis can be seen in table 2 below. The coefficients of the EPSr variable have been transformed[6] and can be interpreted as elasticities, while the remaining coefficients are semi-elasticities. In column 1 of table 2 I have estimated a model using all available bilateral trade flows, but have excluded intra-national trade flows and the dummies for economic integration agreements. As seen in the table, the coefficient of the EPSr variable is insignificant, indicating that differences in environmental policy stringency do not affect overall export competitiveness. In column 2 I have estimated the same model, but only for trade flows in a subset of very pollution-intensive sectors.[7] The coefficient of the EPSr variable now turns significant, showing that differences in stringency do affect trade in pollution-intensive sectors. The value of the coefficient (-0.05) indicates that a 10 percent increase in the stringency of an exporter relative to that of an importer reduces export flows by 0.5 percent. This may not seem like a large effect size, but is definitively an economically meaningful effect given the large variation in environmental policy stringency in the researched sample. In column 3 I have included the controls for economic integration agreements (in the following EIA's). This does not affect the coefficient of the EPSr variable, but as can be seen, none of the coefficients of the controls are significant and two even have a negative sign, which may seem puzzling. In the trade policy literature it has been shown that the direct effects of EIA's are twofold: 1) diverting trade from outsiders to member countries and 2) diverting trade from domestic to international sales (i.e. making countries more open),

[6] By taking (exp(β)-1)*100.

[7] I use the ranking in Mani and Wheeler (1998) to identify the five most pollution-intensive sectors which, according to this ranking, are 1) Iron and Steel, 2) Non-Ferrous Metals, 3) Industrial Chemicals, 4) Non-Metallic Mineral Products and 5) Pulp and Paper.

with the latter effect being significantly stronger. The reason for the insignificant coefficients is thus, most likely, 1) that the sample does not contain many of the countries that within-sample EIA’s diverted trade away from, and 2) the failure to include data on intra-national trade flows. In column 4 I have included data on intra-national trade flows, and in column five I have estimated the same model but with data in four-year intervals, rather than with data for consecutive years. In both these models EIA’s are shown to have a large positive impact on trade flows, but the inclusion of intra-national trade flows also renders the EPSr variable insignificant. In column 6 finally, I have estimated the full model indicated by equation (4) and thus have also included the time-varying international border dummies that control for the effects of economic globalization. This renders the EPSr variable significant once more and more than doubles the implied effect size. According to this estimate, which I deem to be the most reliable, a 10 percent increase in the environmental policy stringency of an exporter relative to that of an importer reduces export flows of pollution-intensive goods by 1.1 percent. This effect size is almost twice as large as that reported by Kozluk and Timiliotis (2016), whose methodological setup most closely resembles the method that has been used in this paper. My estimate indicates that if two countries with equal stringency would start to diverge, so that the exporter increases its relative stringency by 68 percent (which corresponds to a move from the median to the 75th percentile of the distribution in EPSr) its exports of pollution-intensive goods to said importer would decrease by 7.5 percent.[8]

[8] This is the same comparison that Kozluk and Timiliotis (2016) used in their paper. Their corresponding estimate was -4 percent.

Table 2. Impact of environmental policy stringency on export performance

	(1)	(2)	(3)	(4)	(5)	(6)
PTA			0.03	0.33***	0.45***	0.32***
			(0.05)	(0.06)	(0.09)	(0.07)
FTA			-0.09	0.42***	0.51**	0.23**
			(0.08)	(0.09)	(0.11)	(0.11)
EU			-0.08	0.61***	0.80***	0.22*
			(0.09)	(0.10)	(0.12)	(0.12)
EPSratio	-0.02	-0.05**	-0.05***	-0.02	-0.06	-0.11***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.05)	(0.03)
INTL_BRDR1994						0.18***
						(0.03)
INTL-BRDR1998						0.34***
						(0.04)
INTL_BRDR2002						0.29***
						(0.05)
INTL_BRDR2006						0.68***
						(0.05)
Internal trade	No	No	No	Yes	Yes	Yes
N	367320	71273	71273	73463	20576	20576
Pseudo-R^2	0.99	0.98	0.98	0.99	0.99	0.99

Note: All estimates are obtained with importer-sector-year, exporter-sector-year and countrypair-sector fixed effects. Robust standard errors (clustered by countrypair) are reported in parentheses.

*>0.1, **<0.05, ***<0.01

In the literature on the pollution haven hypothesis a lot of attention has been devoted to identifying the most pollution-intensive manufacturing sectors, as pollution-haven type effects is only expected to arise within industries which are characterized by high environmental adaptation costs. In the previous analysis I identified the five most pollution-intensive manufacturing sectors on the basis of the ranking in Mani and Wheleer (1998), as this ranking has been widely used in the pollution haven literature. However, other researchers have proposed other rankings, and it is hence not at all self-evident that the one I have used is the "correct" one. For this reason, I have also estimated separate regressions for trade flows in nine individual manufacturing sectors; the five sectors identified by Mani and Wheeler (1998) and an additional four sectors that have also ranked high in terms of pollution-intensity in the literature.[9] The structural sectoral gravity equation (see equation 5) has the property of separability, meaning that it may equally well be estimated separately for each sector as with data pooled across sectors. The only difference is that the high-dimensional fixed effects reverts back to importer/exporter-year and country-pair fixed effects (Yotov et al., 2016).

$$x_{ij,t}^{k} = \frac{y_{i,t}^{k} y_{j,t}^{k}}{y_{w,t}^{k}} \left(\frac{t_{ij,t}^{k}}{P_{i,t}^{k} P_{j,t}^{k}} \right)^{1-\sigma_k} \qquad (5)$$

In this sectoral analysis I use the same methodological setup as in column 6 of table 2. That is, I estimate (for each manufacturing sector) a model with bilateral and intra-national trade data in four-year intervals and with a full set of time-varying international border dummies. The results of this analysis can be seen in table 3. The coefficients of three out of the nine manufacturing sectors are negative and significant at the one-percent level. Two of these (Iron and Steel and Industrial Chemicals) belong to the top five pollution-intensive sectors as ranked by Mani and Wheeler (1998), while the third (Other Chemicals) does not.[10] Another

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[9] These four sectors are: Rubber Products, Leather Products, Metal Products and Other Chemicals.

[10] The sector Other Chemicals does however rank nr 6 on Mani and Wheelers extended list.

three sectors have coefficients that are negative and significant at the ten-percent level. However, considering the relatively large number of observations and the correspondingly large statistical power of the analysis, one should probably not attach too much weight to the p-values of these coefficients. Moreover, since the analysis consists of running nine identical regressions on different data sets a case could be made for adjusting the p-values for multiple testing. If the standard Bonferroni method of adjustment is used, the coefficients for Non-Ferrous Metals, Non-Metallic Mineral Products, Pulp and Paper and Metal Products ceases to be significant, while the coefficients for Iron and Steel and Industrial- and Other Chemicals remain significant at the five-percent level. A cautious interpretation of the results would thus be that inter-country differences in environmental policy stringency does indeed affect export competitiveness, but only in three manufacturing sectors. The average effect of environmental policy stringency in these sectors (-0.14) is, on the other hand, markedly stronger than the estimated effect on the aggregate level. It is also interesting to note that these three sectors have all been characterized as "footloose" in previous research – in the sense that they are less dependent on the local availability of factors of production – and hence as particularly sensitive to rising (abatement) costs.[11] The analysis thus also lends some support to another

[11] Harris et al. (2002) and Martinez-Zarzoso et al. (2017) classify SITC Rev.3 categories 59 (Chemical materials) and 67 (Iron and steel) as "footloose", while my data is in ISIC Rev.2, where Iron and steel, Industrial- and Other chemicals correspond to industry categories 371, 351 and 352. According to the OECD's correspondence tables, ISIC Rev. 2 categories 351 and 352 roughly corresponds to SITC Rev. 3 category 59, but do not include categories 59.3 (Explosives and pyrotechnic products) and 59.7 (Prepared additives for mineral oils etc.). ISIC Rev. 2 category 371 similarly corresponds to SITC Rev. 3 category 67, but do not include category 67.7 (Rails or railway track construction material).

Table 3. Sectoral estimates of the impact of environmental policy stringency on export performance

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Iron and steel	-0.12**								
	(0.04)								
Non-ferrous metals		-0.13^{+}							
		(0.07)							
Industrial hemicals			-0.15**						
			(0.05)						
Non-metallic min prd.				0.10^{+}					
				(0.06)					
Pulp and paper					-0.08^{+}				
					(0.04)				
Other chemicals						-0.16**			
						(0.06)			
Rubber products							-0.03		
							(0.07)		
Leather products								0.05	
								(0.10)	
Metal products									-0.10^{+}
									(0.05)
PTA	0.22**	0.52**	0.33**	0.64**	-0.20	-0.22*	0.27*	0.33*	0.36*
	(0.08)	(0.17)	(0.08)	(0.18)	(0.16)	(0.11)	(0.13)	(0.16)	(0.14)
FTA	0.47**	-0.08	0.19	0.43**	0.46**	-0.00	0.74**	-0.10	0.95**
	(0.10)	(0.16)	(0.18)	(0.13)	(0.15)	(0.12)	(0.13)	(0.23)	(0.18)
EU	0.47**	-0.13	0.26	0.07	0.50**	0.05	0.80**	-0.25	0.71**
	(0.13)	(0.22)	(0.20)	(0.16)	(0.17)	(0.14)	(0.17)	(0.29)	(0.25)
INTL_BRDR1994	0.08*	0.26^{+}	0.24**	0.09	0.07	0.20**	0.12*	0.07	0.11
	(0.04)	(0.14)	(0.05)	(0.06)	(0.05)	(0.05)	(0.05)	(0.13)	(0.08)
INTL-BRDR1998	0.10^{+}	0.85**	0.30**	0.38**	0.36**	1.12**	0.52**	0.10	0.71**
	(0.05)	(0.18)	(0.05)	(0.08)	(0.05)	(0.08)	(0.06)	(0.15)	(0.15)
INTL_BRDR2002	0.18**	0.85**	0.13	0.32**	0.46**	1.43**	0.69**	0.30*	0.68**
	(0.06)	(0.16)	(0.08)	(0.09)	(0.04)	(0.08)	(0.09)	(0.14)	(0.15)
INTL_BRDR2006	0.44**	1.26**	0.76**	0.27**	0.59**	1.83**	0.82**	0.86**	0.63**
	(0.07)	(0.16)	(0.08)	(0.10)	(0.05)	(0.12)	(0.10)	(0.24)	(0.14)
N	4124	4062	4164	4109	4117	4144	4122	4084	4167
Pseudo-R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99

Note: All estimates are obtained with importer-year, exporter-year and countrypair fixed effects. Robust standard errors (clustered by countrypair) are reported in parentheses.

* <0.1, ** <0.05, *** <0.01

influential proposition within the pollution haven literature; that inter-country differences in environmental policy stringency will mainly impact highly mobile industries, while many other industries will be more or less insensitive to rising abatement costs, due to high plant fixed costs, agglomeration economies or dependence on locally available raw materials, which makes relocating production a non-viable option (Ederington et al., 2005). All in all, the combined results of the pooled and sector-specific analyses paints a very clear picture, which is also consistent with the main theoretical predictions in the literature, as 1) pollution haven effects are not visible when running the analysis on all manufacturing sectors, 2) they do show up when only pollution-intensive sectors are analysed, and 3) within the group of pollution-intensive sectors, pollution haven effects are only visible for the highly mobile, or "footloose", sectors.

CONCLUSIONS

In this paper I have estimated the impact of inter-country differences in environmental policy stringency on bilateral trade flows. According to the so-called pollution haven hypothesis, countries that institute more stringent environmental policies than their trading partners will erode their comparative advantage in pollution-intensive exports, and inter-country differences in environmental policy stringency is therefore expected to lead to a reorientation of pollution-intensive export flows from high-regulation to low-regulation countries. In the paper, I analyse sectoral bilateral trade flows for a panel of 31 countries between 1990 and 2006, using a new composite index developed by the OECD to proxy environmental policy stringency. I find that stringent environmental policy does indeed reduce exports of pollution-intensive goods, but that the effect is limited to a smaller subset of highly mobile, or "footloose", manufacturing sectors.

The main value added of this paper lies in the econometric specification, by employing the state-of-the-art recommendations on gravity modelling in testing for pollution haven effects. The fact that this analysis largely corroborates the findings of recent research, which have used alternative specifications, could plausibly be taken to suggest that pollution haven phenomena have simply become more prevalent over time. The multitude of studies in review articles by Jaffe et al. (1995), Grether and De Melo (2003) and others, which reported statistically and/or economically insignificant pollution haven effects, overwhelmingly studied pre-1990 periods, while recent research which has reached opposite conclusions has studied the 1990's and 2000's. That more and more articles are now reporting results that support the pollution haven hypothesis may thus have less to do with recent econometric advances and more to do with that pollution haven effects are now there to be found, whereas before, they were not. This would not be unreasonable in light of the unprecedented globalization of the post-1990 world economy. Just in the sample that was used in this paper, international trade increased almost 100 percent faster than intra-national trade between 1990 and 2006, indicating a formidable rise in multilateral trade integration. Indeed, recent theoretical contributions in the pollution haven literature have emphasized the pivotal role of market access, in that "no relocation [can be expected] until a critical threshold of trade integration is reached" (Candau & Dienesch, 2017). When researchers and policy analysts started warning about pollution havens during the early 1970's they may, in other words, have been right, just some 30 to 40 years ahead of their time.

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