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METHODS

Environmental policy in the European Union: Fostering the development of pollution havens?

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A pollution haven occurs when dirty industries from developed nations relocate to developing nations in order to avoid strict environmental standards or developed nations imports of dirty industries expand replacing domestic production. The purpose of this study is to determine whether the European Union (EU) has increased its imports of "dirty" goods from poorer, less democratic countries during a period of more stringent environmental standards. Previous empirical studies such as those by Levinson and Taylor [Levinson, A., and Taylor, M.S., in press. Unmasking the Pollution Haven Effect. International Economic Review.], Ederington, Levinson and Minier [Ederington, J., Levinson, A., and Minier, J., 2005. Footloose and Pollution-Free. Review of Economics and Statistics., 87: 92–99.], Kahn and Yoshino (2004), and Ederington and Minier [Ederington, J., and Minier. J., 2003. Is Environmental Policy a Secondary Trade Barrier? An Empirical Analysis. Canadian Journal of Economics., 36: 137–54.] find evidence that United States imports are responsive to changes in environmental stringency, but the effects of EU policy have not been examined as thoroughly. Our study follows Kahn [Kahn, M.E., 2003. The Geography of Us Pollution Intensive Trade: Evidence from 1958 to 1994. Regional Science and Urban Economics., 33: 383–400.] and examines the impact of industry energy intensity and toxicity, measured by an energy index and a Toxic Release Inventory (TRI) index, on imports into the EU, at the 2-digit industry level from 1970 to 1999. We use the signing of the Maastricht Treaty to signify a period of more uniform and stringent community wide environmental standards (1993–1999), and identify the level of per capita GDP within an EU trading partner. We find an increased amount of EU energy intensive trade with poorer countries during the period with more stringent EU environmental standards. This result is not robust, however, when poorer countries are defined by OECD membership and geographic region. We do not find an increased amount of EU toxic intensive trade with poorer countries although there is some evidence of increased EU imports of toxic goods from poorer OECD and non-EU European countries. For our full sample of trading partners in all regions, the evidence supports the PHH for EU energy intensive trade, but not for toxic intensive trade. Results for regional trade analysis are less clear.

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1. Pollution havens

The 1990s was a decade in which environmental standards were tightened throughout the developed world. This rise in environmental stringency has led to a discussion about the pollution haven hypothesis (PHH). The PHH proposes that environmental stringency differences between developed and developing countries, encourages developing countries to specialize and gain a comparative advantage in the production of "dirty" goods. If the PHH holds, developed nations should observe a rise in imports of "dirty" goods from developing nations, during a period of increased environmental stringency. In this paper we examine the PHH with respect to the European Union (EU). In particular, we are interested in determining whether the EU has increased its imports of pollution intensive goods from poorer, less developed countries during a period of more stringent and uniform environmental standards.

There is a substantial theoretical and empirical literature on the PHH. Brunnermeirer and Levinson (2004) provide a good review and critique of this literature.[2] Much of the previous research focuses on the U.S., a fact likely due to the quality and coverage of U.S. data. In this paper we are able to look at the PHH from the perspective of the EU, something the previous literature has not yet done. We follow the strand of empirical literature that examines inter-industry FDI flows within a single county.[3] Levinson and Taylor (in press), Ederington, Levinson, and Minier (2005), Mulatu, Florax, and Withagen (2004), Kahn and Yoshino (2004), Cole (2004), Ederington and Minier (2003), Eskeland and Harrison (2003), and Kahn (2003) all examine whether industry imports (net imports or FDI) into the United States, (Mulatu et al. include Germany and the Netherlands as well) are influenced by increased domestic environmental stringency.

The literature on the PHH has found inconclusive evidence about its existence. One explanation for this inconclusive work is the endogeneity of environmental regulations. Ederington and Minier (2003) claim that some countries, the U.S. in particular, treat environmental regulations as endogenous — a secondary trade barrier, and this treatment of regulations may mask pollution haven behavior. They show that when environmental regulations are modeled as endogenous, environmental stringency has a significant impact on trade flows. As Levinson and Taylor (forthcoming) point out this theory assumes that environmental regulations impose a cost large enough to impact international competitiveness. An alternative explanation for the lack of evidence that pollution havens exist is that the additional costs of more stringent environmental standards are such a small fraction of total costs that they do not impact international trade competitiveness (Jaffe et al. 1995). However, Levinson and Taylor (in press) claim that neither of these explanations are the reason for the inconclusive evidence about the PHH, but rather the lack of evidence is due to the measure of industry dirtiness that studies have used, abatement costs.

Levinson and Taylor (in press) believe that the lack of consistent pollution haven results are not due to the endogeneity of environmental standards or the size of costs, but the endogeneity of abatement costs. They show that the use of pollution abatement costs as a measure of industry cleanliness may mask the pollution haven effect. In particular, they point out that a negative relationship may exist between pollution abatement costs and net imports due to unobserved foreign pollution taxes, which will conceal evidence of pollution haven behavior. In this paper we examine the impact of industry dirtiness on imports into the EU during a period of more stringent environmental standards. We use an energy index and a toxicity index similar to those that Kahn (2003)[4] and Kahn and Yoshino (2004) employ in order to avoid the endogeneity problem associated with the use of abatement costs that Levinson and Taylor (in press) describe. Kahn (2003) finds no strong evidence in support of the PHH — that the U.S. increased its imports in dirty industries during a period of more stringent environmental standards. We follow Kahn's (2003) approach to test the PHH for the EU.

In our empirical estimation we control for trade with other nations that have similar environmental standards and footloose industries as Ederington, et al. (2005) suggest. Ederington, et al. (2005) show that industry abatement costs are inversely related to industry mobility and once footloose behavior and trade with other industrialized countries is controlled for, higher industry abatement costs reduced net imports into the U.S. Cole (2004) cautions against only examining trade in a nation's dirtiest sectors. Cole shows that for a series of North–South trade-pairs net exports as a proportion of consumption is declining in the both the dirtiest and cleanest sectors, but that this effect is fairly small compared to other variables. In our case this should not be a problem as we are examining trade in all manufacturing industries.

Mulatu, et al. (2004) and Ederington and Minier (2003) find that environmental stringency alone does not determine the pattern of dirty trade but that industry and sector endowments, and state fixed effects also play a role. Eskeland and Harrison (2003) find that U.S. outbound investment is largest in sectors with *low* abatement costs, once they control for industry and sector effects. They offer little evidence in support of the PHH. We include country fixed effects but do not control for sector and industry endowments, due to data limitations.

In this paper we examine whether the EU has increased its imports of "dirty" goods from lesser developed countries during a period of more stringent environmental standards.

[2] Cole and Elliot (2003),Antweiler et al. (2001), Copeland and Taylor (2004, 2003, 1994) all provide theoretical models that examine the relationship between environmental regulation and trade.

[3] Millimet and List (2004), Fredriksson, List, and Millimet (2003), Keller and Levinson (2002), and Levinson (1996, 2000) examine the effect of stricter environmental standards on inter-state/county FDI. While Smarzynska Javorcik et al. (2004), Cole and Elliot (2003), Xing and Kolstad (2002), and Antweiler et al. (2001) examine the effect of environmental regulations on a firm's inter-country location choice.

[4] Kahn uses an energy index based on U.S. production technology, while we employ a similar index for the EU based on data compiled from the International Energy Agency (IEA) (OECD, 2004). The toxicity index is the same.

We use an energy and toxicity index as a measure of industry dirtiness to avoid the endogeneity problem associated with the use of abatement costs. In addition, we control for trade with industrialized countries, industry footloose characteristics, and include country fixed effects. The next section describes the rationale behind choosing 1993 to 1999 as the period of more stringent environmental standards in the EU. Section 3 outlines the data used in the study, while Sections 4 and 5 examine how the industry energy intensity index and industry toxicity index influence imports into the EU, respectively. Section 6 provides the discussion and conclusions of the paper.

2. New EU environmental policy implementation period

In 1957, six European States signed the Treaty of Rome and formed the European Economic Community (EC). The primary goal of the Treaty was to increase economic performance for member nations. No explicit provisions for environmental policies, environmental agencies, or environmental law were made (Jordan, 2005, p1). It was not until the late 1960s and 1970s when the U.S. Clean Air Act Amendments were passed, and Europe experienced a period of rising income and wages, that the EC became concerned about environmental issues. In 1972 at the Stockholm conference, the EC focused explicitly on environmental concerns for the first time. Although three Environmental Action Plans (EAPs) were passed there were no community wide laws enforcing regulation of these Acts, until 1986.

In 1986 the Single European Act was passed which included several structural changes: majority voting, harmonization of laws, and guidelines to govern Community environmental policy. However, it was the Maastricht Treaty, 1992, that revolutionized policy making in the EU. The "130" Articles of Maastricht require unanimity in passing environmental policy, with a few exceptions. Article 130r(2) states that environmental protection must be integrated into community wide policies (Wilkinson, 2002, p40). However, if harmonization of standards has an impact on the market, then the policy falls under Article 100a, where qualified majority voting is required and where no Member state has the ability to veto a proposal on their own (Wilkinson, 2002, p42). Under Article 189 of the Maastricht Treaty the EU has the power to issue binding directives to its member nations, allowing for centrally defined environmental controls (Oates and Portney, 2001). Oates and Portney contend, however, that the union requires "*de facto* unanimity" in policy making thus restricting their true power. Nevertheless the passage of the Maastricht Treaty allowed for centralized environmental policy making and provided a period of more stringent environmental policy for the entire Union.

While the Treaty provides for centralized policy (such as Climate Change Policy)[5] it leaves the actual implementation to the member countries and there is concern that compliance and enforcement of environmental policy did not occur in a uniform fashion (Oates and Portney, 2001). If some nations that were supposed to meet environmental standards were not in compliance, this would provide a downward bias on any pollution haven effect. Environmental policy in the EU grew throughout the entire time period of the study (1970–1999). However, community wide policy changes did not occur until 1993. Therefore we use this period to depict a period of new EU implementation that represents more stringent environmental policies in the EU. If more stringent environmental policy in the EU led to increased importation of products of dirty industries, it should be most noticeable for 1993 onward.[6]

3. EU trade

The purpose of this paper is to examine the PHH with respect to the EU. We start by defining the EU as the fifteen countries that joined by 1995, each country is included as part of the EU from the year that they join.[7] The International Trade by Commodity Statistics (ITCS) (OECD, 2004), provides the value of imports by commodity (2-digit SITC) into each OECD[8] country from an individual trading partner nation between 1970 to 1999 in current U.S. dollars.[9] We deflated the value of imports using the International Financial Statistics (IFS, 2004) to provide the value of imports in constant 1995 U.S. dollars. In total there are 108,057 observations, this represents imports into the EU in 59 industries, between 1970 and 1999, where the number of trading partners vary from 88 to 129. The ITCS data enabled us to identify imports into the EU from an individual exporting country and therefore include control variables and fixed effects for each trade partner, i.e. exporting nation.

To identify those EU trading partners that have low per capita incomes, we split the trading partners into three income categories, High, Middle, and Low income countries, similar to Kahn (2003). High income countries are those with incomes in the top one third of the other trading partners' income. Middle income countries are those countries with incomes in the middle third of all other trading partners' income and Low income countries are those with incomes less than one third ($3,489 in 1996 dollars) of all other trading nations' income. Per capita income comes from the Penn

[5] Under the Kyoto Protocol, which the EU signed, the EU is required to reduce greenhouse gas emissions 8% below 1990 levels, by 2008-2012. However individual member states reductions vary from 28% in Luxembourg to an increase of 27% by Portugal. The individual members requirements were determined under the June 1998 "Burden Sharing Agreement" (The Kyoto Protocol, 2005).

[6] We recognize that using a dichotomous variable as a proxy for environmental regulations is not a perfect measure. The problem is that environmental regulations are difficult to measure. An advantage of using a dummy variable is that it is more likely to be exogenous to the variable of interest, policy changes, than actual pollution measures.

[7] Belgium, Germany, France, Italy, Luxembourg, and the Netherlands joined in 1957, Denmark, Ireland, and United Kingdom joined in 1973, Greece joined in 1981, Spain and Portugal joined in 1986, and Austria, Finland, and Sweden joined in 1995. In 2004 Poland, Lithuania, Estonia, Latvia, Hungary, Slovenia, Slovakia, Malta, Czech Republic, and Cyprus joined. The data comes from EUROPA – the European Union on-line: http://europa.eu.int/ accessed May 20, 2006.

[8] Belgium and Luxembourg are reported together.

[9] The EU trades in all 59 industries every year, however, the number of trading partner countries fluctuates from year to year.

Table 1 – Summary statistics for all EU Nations from 1970 to 1999

Variable	Definitions and units	Mean	SD	Min	Max
Imports	Imports 1996 U.S. dollars	80,925	514,338	0.10	1.90E+07
Energy index	Industry energy intensity (tons of oil equivalent) /value added tons per value added in thousands of 1995 U.S. dollars	1.46	0.67	1.05	5.84
Toxic index	Industry toxic release inventory/value added pounds per value added in thousands of 1995 U.S. dollars	497.23	599.74	19.42	2239.78
per capita GDP	Exporting country per capita gross domestic product constant 1996 U.S. dollars	6423	6111	424.28	32,127
Low income	Countries in the bottom third of the other trading partner's income	3489	2260	319	10,824
Middle income	Countries in the middle third of the other trading partner's income	11,522	2656	7179	18,793
High Income	Countries in the top third of the other trading partner's income	20,026	3608	13,690	32,127
Fixed capital costs	Industry capital costs millions 1995 U.S. dollars	3085	5139	0.42	37,812
Crude oil prices	1996 U.S. dollars per barrel	20.4	9.67	10.21	49.41
Dictatorship	0 to 10 where 10 is the highest level of dictatorship	5.43	4.22	0	10
Terms of trade	Unit value of exports/unit value of imports	1.09	0.75	0.05	17.36
Trend	1970=0	15.76	8.63	0	29

Observations = 108,057.

World Tables version 6.1 (Heston et al., 2002) and is reported yearly from 1970 to 1999. It is measured as real per capita income in constant dollars indexed on a set of 1996 international prices.

We relate EU imports in an industry to the level of pollution intensity in that industry, while controlling for the trading partner's level of income. Following Kahn (2003) we use a log–log form (a gravity model — Wall (1999)) to capture the elasticity between industry imports and industry energy intensity and toxicity. The following equation is estimated:

$$\ln \text{import}_{pit} = \beta_0 + \beta_1 \ln \text{Dirty}_{di} + \beta_2 \ln \text{Dirty}_{di} {*}\text{Low Income}_p {*}\text{New EU implementation} + \beta X + e_{it} \quad (1)$$

where ln is the natural logarithm and import_{pit} represents imports into the EU from trading partner nation p in industry i in year t. Each observation of the dependent variable is industry-level imports from a particular country in a given year. Wall (1999) provides an example of how the gravity equation may be used to capture the costs of protection and shows that including fixed effects instead of geographic distance improves the explanatory power of the gravity model. Dirty_{di} represents the level of dirtiness by type d (energy intensity or toxicity) in industry i. LowIncome_p indicates that country p is in the bottom one third of trading nations' income. NewEUimplementation represents the new EU implementation time period, the period of more stringent environmental standards (1993–1999).[10] The energy/toxic index is interacted with Low Income and the new EU implementation period (1993–1999) to test for a PHH effect. e_{it} represents the appropriate error term.

The vector X contains some controls such as the level of dictatorship, industry fixed capital costs, OECD, crude oil prices, terms of trade, a trend variable, and nation fixed effects. Following Kahn (2003) we generate a dictatorship variable by inverting the democracy variable from the Polity IV dataset (Marshall and Jaggers, 2002) and subtracting it from 10. Dictatorship ranges from 0 to 10 with 10 being the highest level of dictatorship or the lowest level of democracy.[11] Ederington, Levinson, and Minier (2005) show that the fixed capital costs in an industry affect that industry's mobility. They find that the dirtiest industries also have the highest fixed costs and are therefore less likely to relocate (not footloose). In order to control for any 'footloose' behavior we include a measure to capture fixed costs. This value come from the STAN database (OECD, 2003) and is the industry average gross fixed capital formation. It is deflated and converted into 1995 U.S. dollars, using IFS (2004) and then converted into SITC revision 2 format. Fixed cost provides the average 2-digit industry fixed capital formation. In addition, Ederington, Levinson, and Minier (2005; 2004) also acknowledge the necessity of controlling for trade with OECD nations. We include a dummy variable that is equal to 1 if the partner nation, p, is a member of the OECD and 0 if they are not.

The crude oil price, obtained from the Energy Information Administration (EIA, 2002), is the domestic first purchase price in the U.S., measured in real 1996 U.S. dollars. Crude oil prices are included because production in developing countries is highly dependent on fossil fuels, and we would like to account for any exogenous oil shocks that might impact developing countries exports. Terms of trade for each exporting country are included and come from the International Financial Statistics (IFS, 2004).[12] A trend variable is also included in the estimation. Summary statistics are provided in Table 1. All

[10] We varied the implementation period by a year on both sides of the 1993 demarcation; this did not change the results in a meaningful way.

[11] To capture possible non-linearities in the democracy variable we included it as a quadratic function. This did not alter the results substantially.

[12] In the case where the terms of trade were missing, we substituted with the regional terms of trade. For example if Ethiopia's terms of trade for 1980 was missing, we used the terms of trade for Africa in 1980.

of the results are estimated using Huber–White standard errors.[13]

To test the PHH, that the EU had increased imports of "dirty" goods from low income countries during a period of more stringent environmental standards we examine the interaction between Dirty, Low Income, and the New EU Implementation period. If β_2 (β_4) is positive this would support the PHH for energy (toxic) intensive goods.

While a positive interaction term may represent a pollution haven result an alternative theory is that tariffs in that industry have been reduced during the period of more stringent environmental standards. Imports in a given industry may rise during this period due to trade liberalization. We were not able to control for industry specific tariffs as that data is not currently available for the EU, however, recent work by Ederington, et al. (2004) found that dirtier industries are not disproportionately subjected to lower tariffs. Therefore we assume that a positive interaction between Dirty, Low Income, and the New EU Implementation period indicates a possible pollution haven result.

4. Energy index and results for fossil fuel pollution havens

The first measure of industry dirtiness that we use is an energy intensity index similar to the one used by Kahn and Yoshino (2004), Eskeland and Harrison (2003), Kahn (2003), and Xing and Kolstad (2002). However, we use an index based on EU production. This index denotes those industries that are dirty in the sense that they use a lot of fossil fuels in the production process. Eskeland and Harrison (2003) and Kahn (2003) have shown that energy consumption may be used to proxy for pollution intensity.

The index comes from the International Energy Agency (IEA) (OECD, 2004) and is calculated as the total energy balance for the EU (measured in thousand tonnes of oil equivalent (ktoe)) divided by value added (Statistical Analysis of Science, Technology, And Industry STAN, OECD (2003)) and is reported for an industry at the 2-digit ISIC revision 3 level. We converted this value into SITC[14] revision 2 format using the correspondence tables provided by the United Nations (United Nations Correspondence Tables, 2005) and Jon Haveman (2005).[15],[16] The mean value of the Energy index is 1.46, see Table 1. This value is interpreted as, 1.46 tonnes of oil equivalent used per thousand dollars of value added. We want to hold technology constant so that changes in trade patterns may be attributed to a change in the composition of goods that the EU produces and not the cleaning of technology. We prefer the result based on the 1999 energy index, as this represents the cleanest level of technology. Given the time period of the study (1970 to 1999) it seems likely that industry energy intensity changed. In order to account for both of these factors we tested the PHH with an energy index based on 1970, 1980, 1990, and 1999 data, and the results for the years other than 1999 are reported in the Appendix.

We estimate Eq. (1) and the results for the 1999 energy intensity index are shown in column (1) Table 2. For the energy index there is some evidence of pollution haven behavior, β_2 is positive and significant. This implies that imports of industries with higher energy intensities from low income countries rise during a period of more stringent environmental standards (β_2)— a PHH result. In Eq. (1) both imports and the "dirty" indices are in logs, so the relationship between the

Table 2 – The impact of industry energy intensity on imports into the EU from 1970 to 1999

Ln (imports)	(1) Full sample	(2) OECD	(3) Non-OECD	β
Energy index	−0.323***	−2.151***	0.392***	β_1
	(−6.624)	(−26.14)	(6.96)	
Energy index*low income*New EU Implementation	0.250**	0.236	−0.328***	β_2
	(2.37)	(0.79)	(−2.90)	
Toxic index	−0.023***	0.095***	−0.066***	β_3
	(−3.41)	(8.04)	(−8.04)	
Toxic index*Low income* New EU implementation	−0.005***	0.075***	−0.021*	β_4
	(−5.09)	(3.21)	(−1.64)	
New EU implementation	−0.033	−0.446***	0.062	
	(−0.81)	(−6.92)	(1.06)	
Low income	−0.463***	−0.265**	−0.500***	
	(−5.90)	(−2.45)	(−3.33)	
Middle income	−0.263***	−0.062	−0.291**	
	(−4.28)	(−0.88)	(−2.11)	
Dictatorship	−0.0002	−0.038***	0.018***	
	(−0.43)	(−4.93)	(3.71)	
Fixed capital costs	−0.0001***	−0.0001***	−0.0001***	
	(−38.57)	(−32.66)	(−26.68)	
OECD	5.45***			
	(26.79)			
Crude oil prices	0.009***	0.010***	0.009***	
	(10.23)	(5.77)	(8.30)	
Terms of trade	−0.038***	0.134	−0.038***	
	(−3.05)	(1.33)	(−3.11)	
Trend	0.104***	0.135***	0.098***	
	(68.38)	(43.37)	(55.51)	
Constant	3.432***	8.71***	3.352***	
	(20.64)	(48.76)	(15.59)	
F-statistic	901.26	511.7	471.48	
Observations	108,057	23,811	84,246	
R-squared	0.50	0.42	0.38	

* 10% significant level; **5% significant level; ***1% significant level.
t-statistics are in parentheses.
Fixed effects for each exporting country are included and not reported.
These results represent the energy and toxicity index for the base year— 1999.

[13] We also clustered the data using a unique identifier. The identifier was unique for each partner country in a given industry in a given year. The standard errors were the same as the White-Huber corrected standard errors.

[14] There is some measurement error introduced when we convert industries from ISIC revision 3 code to SITC revision 2 formats.

[15] http://www.macalester.edu/research/economics/PAGE/HAVEMAN/Trade.Resources/TradeConcordances.html%20and">http://www.macalester.edu/research/economics/PAGE/HAVEMAN/Trade.Resources/TradeConcordances.html and http://unstats.un.org/unsd/cr/registry, accessed September 7, 2005.

[16] Other studies have pointed out that there is a significant amount of heterogeneity at the 4-digit level that is masked when trade data is summed to the 2-digit level. Unfortunately we do not have EU trade data at the 4-digit level, so any result that we find with 2-digit data is likely to be an underestimate of the true condition.

Table 3 – Summary of the results from the regional analysis

Imports	(1) Non-EU Europe	(2) Africa	(3) North America	(4) Asia & Oceana	(5) Latin America & the Caribbean	β
Energy	−2.158***	0.821***	−0.475**	−0.586***	0.569***	β_1
Energy*low income* New EU implementation	0.315	0.126	0.283	0.328	−0.212	β_2
Toxic	0.054***	−0.029**	0.084***	−0.142***	−0.013	β_3
Toxic*low Income * New EU implementation	0.032*	−0.045*	0.069	0.033*	−0.094***	β_4
R-squared	0.46	0.27	0.56	0.37	0.32	

*10% significant level; **5% significant level; ***1% significant level.
Eq. (1) was estimated for each region — the following variables were included and not reported: New EU implementation, low income, middle income, dictatorship, fixed capital costs, crude oil prices, terms of trade, trend and country fixed effects— full results are available on request.

interactions and imports may be expressed as an elasticity. So β_2 may be interpreted as, a 1% increase in industry energy intensity is associated with a 0.25% *increase* in imports from low income countries during the period of more stringent environmental standards. This evidence of an EU pollution haven effect for fossil fuels is fairly robust with respect to the base year for energy technology. The point estimates for the PHH interaction coefficient are positive for all base years and statistically significant for all but 1990.

Other results are that the EU imports fewer goods from low income and middle income countries relative to high income countries and more goods from OECD countries relative to non-OECD countries. The variable for fixed costs has the expected negative sign; an increase in the average fixed cost of an industry is associated with reduced EU imports in that industry. High crude oil prices are associated with more imports. Terms of trade are negative and significant; higher prices of exports relative to imports are associated with reduced imports from that trading partner. The trend is positive and significant.

To test whether the EU is less likely to engage in “dirty” trade with more developed countries that may have similar environmental standards we split the sample into non-EU OECD and non-EU non-OECD countries and estimate Eq. (1) for each subsample. The results for the OECD and non-OECD countries are shown in columns (2) and (3) respectively in Table 2.

In the OECD sample, β_2 is insignificant while for the non-OECD sample it is negative. EU imports of industries with higher energy intensities are lower from low income, non-OECD countries, during the period of more stringent environmental standards — a rejection of the PHH for non-OECD countries. The composition of the two subsamples is quite different in that approximately 20% of the OECD subsample is low income while approximately 80% of the non-OECD subsample is low income. It must be low income countries in general that are driving the initial result and when separated by OECD membership, they do not have the same impact. To further test which regions are most likely to export energy intensive goods to the EU, we split the sample by regional definition and estimated Eq. (1) for each subsample. When the data are divided, we end up with the following regions: (1) non-EU Europe, (2) Africa, (3) North America, (4) Asia and Oceana, and (5) Latin and Central America. The results are shown in Table 3. In all cases β_2 is insignificant — no regional pollution haven behavior occurred.

Overall the results indicate that the EU induced pollution haven behavior in energy intensive goods when looking at global trade, i.e. the full sample. However, for the OECD and each regional definition β_2 was insignificant, and for the non-OECD sample β_2 was negative. While the EU increased its imports of energy intensive goods from low income countries during a period of more stringent environmental standards, it did not engage in energy intensive trade with low income countries separated by membership in the OECD or geographic region.

5. Toxic index and results for toxic pollution havens

The second measure of industry pollution is the Toxic Release Inventory (TRI) index[17] (Environmental Protection Agency (EPA), 2007). The toxic index is the total on-site and off-site toxic releases reported for chemicals defined as carcinogens by Occupational Safety and Health Administration (OSHA). This index is measured in pounds at the 2-digit, 1987 SIC level. We obtained a measure of the value added for each manufacturing industry and divided the pounds of emissions by value added, to obtain the toxic index. The mean value of the toxic index is 497.23 and is interpreted as 497.23 lb of carcinogenic toxins are generated per thousand dollars of value added, see Table 1. We used the TRI of OSHA carcinogens for a single year, 1999, similar to the construction of the energy index.[18] This value was then converted into Standard International Trade Classification (SITC) revision 2 format as described above.

The results for the toxic index are shown in column (1) Table 2. In this case β_4 is negative. Imports of industries with higher toxicity levels are *lower* from low income countries during the period of more stringent environmental standards. A 1% increase in industry toxicity is associated with a 0.005% *decrease* in imports from low income countries during the period of more stringent environmental standards. The results

[17] We also considered using the Industrial Pollution Projection System (IPPS) (World Bank, 2004) index. The IPPS index is the sum of the total lower bound values of toxic pollution intensity for air, water, and land. The value is calculated with respect to the Total Value of Output (Pounds/1987 US $ Million) and provided at the 4-digit level. As Kahn (2003) points out this index is missing numerous industries at the 4-digit level and probably has substantial measurement error. While the correlation between the TRI and IPPS index is 0.77, due to possible measurement error we decided to not to use the IPPS index as a measure of industry dirtiness.

[18] Unlike the energy index we were only able to obtain the TRI index for 1990 and 1999. The results did not vary significantly between the two years.

from the non-OECD sample are identical to the initial results. Both results are evidence against the PHH for the EU for toxic pollution.

For the OECD sample, β_4 is positive and significant. This result implies that the EU was more likely to import goods in toxic industries from low income OECD countries during a period of more stringent environmental standards — a weak PHH result. The regional results in Table 3 show that β_4 is negative for EU trade with Africa, Asia & Oceana, and Latin & Central American regions — a non-PHH result. The only region in which the EU displayed any pollution haven behavior is for non-EU Europe.

Overall, our results provide evidence against the PHH for toxic pollution. For the full sample and non-OECD countries the coefficient for the toxic index interaction with low income countries during the period of more stringent EU environmental policy is negative and statistically significant, not positive as we would expect if there were a pollution haven effect. The positive sign for the toxic pollution interaction term for EU trade within the OECD and for trade with non-EU European countries provides only weak evidence in support of the EU fostering pollution havens in toxic pollution.

6. Discussion and conclusion

The overall results vary depending on the definition of industry dirtiness. There is evidence that the EU imported an increased amount of energy intensive goods from poorer nations during a period of more stringent environmental standards. This result is not consistent when we break down trading partners by membership in the OECD and regional definition. Apparently low income countries all together are driving the pollution haven effect, but that this is not a regional effect.

The results are different for toxic imports. The EU imported an increased amount of toxic goods from poorer OECD countries during the period of more stringent environmental standards, but for the full sample of all trade partners this effect was reversed. From our study it appears that lesser developed non-EU European countries or lesser developed OECD countries may have been pollution havens of toxic goods for the EU, but overall the EU reduced its imports of toxic goods from low income countries.

The two indices of industry dirtiness that we use provide different results; this is not surprising as they each measure different types of pollution. Energy intensity captures those industries that use a lot of fossil fuels in the production process, while industries that have high toxicity measures are those that produce significantly large amounts of carcinogens during the production process. The results suggest that poorer countries in general have a comparative advantage in the production of energy intensive industries relative to similar industries in the EU, particularly when these industries are more heavily regulated. However, this is a joint effect and does hold when poorer countries are divided by regional definition and OECD membership.

The opposite is true for highly toxic industries. Once these industries become more heavily regulated within the EU, poorer OECD countries gain a comparative advantage in the production and export of these industries and we observe increased toxic trade between the EU and poorer non-EU European/OECD countries. This effect only holds for poorer OECD and non-EU European countries. In general we find that when toxic industries became more heavily regulated within the EU, this did not affect domestic industries comparative advantage and the EU reduced its imports of toxic goods from poorer countries in general.

There are some caveats to our results that should be considered. First we use a toxicity index based on U.S. technology. The toxic index represents a measure of industry toxicity based on 1999 U.S. technology, and the energy index captures the cleanness of EU technology in 1999. Table 1 in the Appendix displays a summary of the results when we use an energy index based on 1970, 1980, and 1990 technology. For energy intensity, we observe a pollution haven result in all cases although the coefficient for 1990 is not statistically significant. By choosing 1999 as our base year for technology we are using the cleanest technology and may mask potential pollution haven behavior.

A case can be made that our estimates of the effect of stringency of EU environmental policy on the pollution intensity of imports is too low. Previous studies have found that significant variation in pollution intensity between 4-digit industries exists within a 2-digit industry specification (Levinson and Taylor (forthcoming); Ederington, et al. (2005); Ederington and Minier (2003); Kahn (2003)). These studies show that by aggregating production to the 2-digit level, we are underestimating the pollution haven effect, resulting in a downward bias of the results. If we had been able to estimate the import equation with industries that are more narrowly defined, we probably would have found stronger impacts.

Another factor that may mask a pollution haven effect is that we ignore the pollution content of intermediate goods. The EU may change the composition of goods that it produces. Instead of producing a final good that requires importing a dirty intermediate good, the EU imports the final good. This change in behavior will appear to be a reduction in the imports of dirty goods, although the EU may still be consuming the same number of final goods. An additional factor that may mask pollution haven behavior is increasing energy intensities in developing countries. If developing countries have become more energy intensive over time this will drive production costs up and these countries will be unable to produce and export as many energy intensive goods as before. This change in trade would appear as a reduction in energy intensity trade when in fact that is not the case.

Future work will try to reexamine this question using more disaggregated data. In addition there are some interesting policy issues to consider, in particular the impact of increased community wide environmental stringency on EU enlargement. The ten countries that are new EU entrants in 2004 are heterogeneous jurisdictions that are fairly new to the democratic process. These countries are likely to focus on increasing their income as they become integrated into the EU. The incoming countries tend to be less developed than the EU and it is likely that it will have a comparative advantage in the production of dirty goods. Overall EU entrants may be resistant to strict uniform enforcement of environmental regulations. The fact that the EU imports dirty goods from new entrants may have some interesting implications as enlargement and integration continues.

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Appendix A

Table A.1 – The impact of industry energy intensity on imports into the EU — when the energy index is based on 1990, 1980, & 1970 technology

Ln (imports)	Energy index 1990	Energy index 1980	Energy index 1970
Energy index	−0.072*	−0.452***	−0.100***
Energy index*low income* New EU implementation	0.024	0.257***	0.11***
TRI index	−0.042***	0.019***	0.041***
TRI index*low income* New EU implementation	−0.034***	−0.068***	−0.071***
New EU implementation	−0.043	−0.036	−0.009
Low income	−0.467***	−0.460***	−0.393***
Middle income	−0.264***	−0.261***	−0.222***
Dictatorship	−0.002	0.002	0.0001
Fixed capital costs	−0.0001***	−0.0001***	−0.0001***
OECD	5.473***	5.472***	5.615***
Crude oil prices	0.009***	0.009***	0.009***
Terms of trade	−0.038***	−0.037***	−0.047***
Trend	0.105***	0.105***	0.104***
R-squared	0.5	0.5	0.5
Observations	108057	108057	91052

*10% significant level; **5% significant level; ***1% significant level.

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