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ENVIRONMENTAL REGULATION AND REVEALED COMPARATIVE ADVANTAGES IN EUROPE: IS CHINA A POLLUTION HAVEN?

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Abstract

The relocation of more polluting industries in poorer countries due to gaps in environmental standards is known as the *pollution haven effect*, whereby the scale and the composition of output change across countries. Changes in the composition of the output mix might translate into changes of comparative advantages across countries, as revealed by trade flows. This paper focus on this issue and looks at the changes of bilateral revealed comparative advantages (RCAs) in the last decade between China and the major fourteen EU countries (EU14). Using industry level data on bilateral trade, air pollution, water pollution and several measures of environmental stringency, we find that, controlling for other factors that may have affected RCAs, such as labor costs, on average our EU14 countries have kept or improved their advantages with respect to China in both water polluting industries (such as paper and agro-based industries) and air polluting industries (such as basic metals and chemicals), while they have lost competitiveness in the more clean industries (such as machinery and fabricated metals).

JEL Classification: F14, F18.
Keywords: revealed comparative advantages, environmental regulation, industrial pollution.

Contents

* Bank of Italy, Economics, Research and International Relations.

I. Introduction[1]

In recent years the need to preserve and improve environmental quality has solicited increasing efforts to abate pollution worldwide; renewed effort in rich countries has become urgent fearing the still unknown consequences of climate change. The debate on sustainable emission targets and required abatement trends has become particularly intense at all levels raising coordination problems and free-riding concerns; in fact, while the quality of the environment does not depend only on the action taken within each country's boundaries, the burden of abatement costs can only be effectively imposed by governments on domestic producers and consumers.[2]

As long as a "healthier natural environment" is a normal good, demand for it tends to be higher in richer countries which impose more stringent environmental regulations as compared to poorer ones (so called "*environmental Kutznets curve" hypothesis*; Copeland and Taylor, 2003). However, pollution abatement poses additional burdens on domestic firms, especially those operating in the most polluting industries, shifting part of the inputs away from production to pollution abatement. If the cost burden is significant enough, it might hurt the international competitiveness of domestic firms, compared to firms located in countries with weaker environmental standards. The relocation of more polluting industries to poorer countries due to gaps in environmental standards is known as the *pollution haven effect,* whereby the *scale* and the *composition* of output change across countries (Copeland and Taylor, 2003).[3] The existence and the magnitude of such an effect depends on two things: (a) whether environmental regulations impose substantial additional *costs* on polluting industries, and (b) whether, absent other compensative policies, regulation *differentials* are large enough to impact on industry location, output composition and trade.[4]

Changes in the scale of activity affect directly profits and jobs within a country; changes in the composition of the output mix translate into changes of comparative advantages across

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[1] I would like to thank Xiaolan Fu, Herman Vollebergh and Valeria Rolli for insightful comments and suggestions on earlier versions of this paper. I am also grateful to Pietro Barone, Ivan Faiella, Marco Marinucci for valuable discussions.

[2] The possible option of imposing additional taxes on imports of goods from polluting producers encounters major legal and practical problems. For a discussion on coordination issues see OECD (2008).

[3] Copeland and Taylor (2004) distinguish between the *pollution haven effect* and the *pollution haven hypothesis*. The first is the *effect*, at the margin, on trade flows and plant location of tightening up environmental regulation in richer countries; the *hypothesis* instead refers to the implications for plant location and trade flows of a change in trade regimes between countries with different environmental regulations. In our analysis both things are at play, in that in the last ten years environmental regulation has become more stringent in richer countries and at the same time trade barriers have been reduced. Since our focus is on environmental regulation differentials we refer to *pollution haven effect*.

[4] We might consider the environment as an additional factor of production, together with capital, labor and land; as environmental services in poorer countries become relatively cheaper they will be embodied in a larger share in their exported goods. However, there is some evidence (Eliste and Fredriksson, 2002, and Grether and de Melo, 2004) that the most polluting industries often obtain compensating transfers from governments and tend to benefit from higher trade barriers.

countries. This paper focuses on this latter issue.[5] So far very few studies have tested the *pollution haven effect* on revealed comparative advantages in trade (Grether and de Melo, 2004 and Cole et al., 2005). The empirical literature has mainly looked at the effects of environmental regulation on plant location decisions and foreign direct investment (FDI) flows, either among different regions within the same country (Dean et al., 2005 and Zhang and Fu, 2008, for China and, among others, Keller and Levinson, 2002, for the US) or between countries with different levels of environmental regulation.[6] Results, in particular for the US, point to a weak relationship between plant location decisions, or FDI flows, and environmental regulation. Exploring the link between trade flows and environmental regulation seems more appropriate as it allows uncovering the impact of both plant location choices and other policy-induced changes in industrial output sizes. The literature looking at trade flows, however, also reaches mixed conclusions, with results being very sensitive to the choice of countries, the empirical specification and the definition of environmental regulation.[7]

In our analysis our measure of international specialization is an index of trade revealed comparative advantage (RCA). Previous studies with similar dependent variables tend to find no clear evidence of *pollution haven effects* (Grether and de Melo, 2004, for a set of 52 countries and Cole et al., 2005 for the US). We consider the major fourteen EU countries (EU14) and look at the changes in the contribution of each industry to the bilateral trade balance with China in the last decade. The recent surge of China as world's top exporter is often attributed not only to its low labour costs and rapid capital accumulation but also to its "export dumping" due to weak environmental standards compared to richer countries. On the other hand, some EU countries are regarded as those which have committed to the most stringent environmental regulation worldwide.

Aggregate green house gas emission intensity in the EU fell in the last decade, but comparatively less in manufacturing and construction industries than in other sectors of the economy; the decline has been particularly intense from 1996 to 2000; a renewed effort seem to be in place again since 2003 (Fig. 1). At the same time, environmental protection expenditures have remained constant in terms of GDP, around 0.4 per cent.

On the other hand, as documented in Dean and Lovely (2008), in China fast industrialization since 1978 has led to a rapid deterioration of the air quality and of many water sources. Against this background, in recent years there have been significant improvements in the environmental protection legislation, although enforcement is still very weak due to diverging economic interests

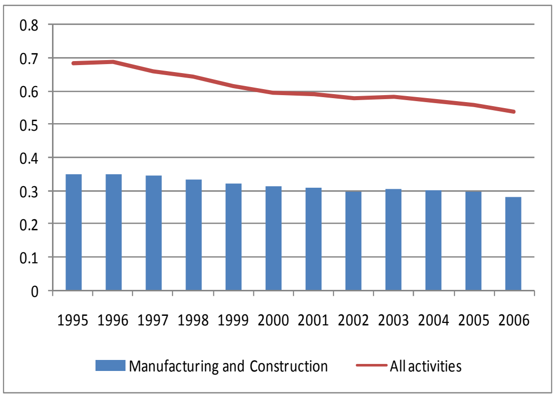
[5]For extensive surveys on the broader relationship between environmental regulation and international competitiveness see SWQ (2006) and United Nations (2006).

[6]A review of these studies can be found in Copeland and Taylor (2004) and Zhang and Fu (2008).

[7] Grether and de Melo (2004) and Pasurka (2008) offer a summary of the various specifications and findings. Table A4 in the appendix summarize the findings of the papers mostly related to the present article.

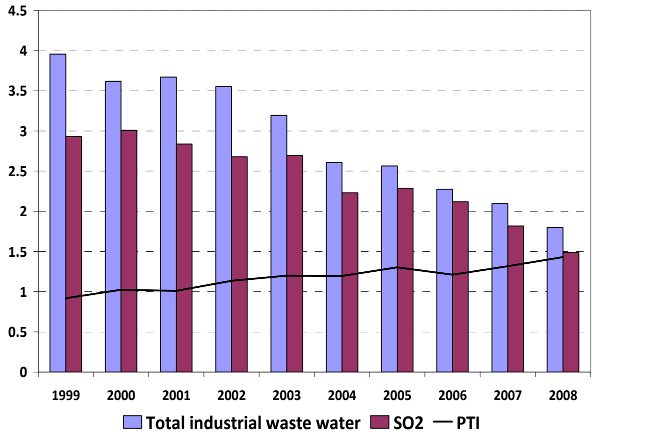
between central and local governments (Zhang and Fu, 2008). Nonetheless, recent available data show a certain effort in pollution abatement and treatment: in the last decade total investment in industrial pollution treatment (PTI) has shown an increasing trend in terms of GDP, surpassing 1.4 per cent in 2008, while water and air industrial emissions (per unit of output) declined steadily (Fig. 2).

Fig. 1 EU15: Green house gas emission intensity (tons/thousand value added euros; 1995 prices)



Source: EuroStat data and author's elaboration.

Fig. 2 China: Total investment in pollution treatment (PTI) as percentage of GDP; Total waste water discharge (kilos/yuan output; 1995 prices) and Sulphure dioxide (SO_2 ; kilos/thousand yuan output; 1995 prices) in industry



Source: CEIC and author's elaborations

In this paper we analyze the evolution of the structure of bilateral trade between EU countries and China in relation to environmental regulation; in doing so, we suggest a new strategy to look at this relationship, which allows to overcome the endogeneity problems associated with the measures of environmental regulation usually adopted in the literature, such as pollution abatement costs (PAC).[8] We use industry-level data on air-and-water-pollution intensities in China and a cross-country index of environmental stringency first constructed by Dasgupta et al. (1995) and recently extended by Eliste and Fredriksson (2002). Robustness checks are conducted by using: i) an additional measure of pollution intensity by industry (the global warming potential (GWP) of emissions per unit of output, in Europe); ii) two additional measures of environmental stringency (GDP per capita and greenhouse gas emissions).

Preliminary findings on the evolution of the structural bilateral trade between China and EU14 countries in 18 manufacturing industries in the period from 1996 to 2006, indicate that, after controlling for other factors affecting trade flows (such as labour costs), there is no evidence of a pollution haven effect. In particular we find that:

[8] On the endogeneity issue, see Section II.

i) on average our EU14 countries have kept or improved their comparative advantages with respect to China, as revealed by their bilateral trade, in both water-polluting industries (such as paper and agro based industries) and air-polluting industries (such as basic metals and chemicals);

ii) on average our EU14 countries have, instead, lost competitiveness in cleaner and more internationally-mobile industries (such as communication equipment and office and computing machinery), presumably in response to unfavourable unit-labour-cost differentials and higher capital accumulation in China.

The paper unfolds as follows: Section II discusses endogeneity problems of pollution abatement costs as proxy for environmental regulation; Section III presents briefly some statistical evidence on pollution intensities and revealed comparative advantages in China and Europe; Section IV presents our estimation strategy; Section V reports estimation results and Section VI concludes.

II. Pollution abatement costs and environmental regulation

In principle, the pollution abatement effort in a given country reflects the stringency of its environmental regulation. To evaluate and compare the effective cost burden of pollution abatement and control (PAC) expenditures we would like to have a reliable measure of such expenditures by industries and time. Unfortunately such information is not readily available for a sufficient number of countries and time length, and comparison among countries for which data are available must be taken with great caution, since definitions differ from country to country.[9] The most comprehensive set of data on PAC expenditures and investments, sometimes also specified as pollution treatment expenditures (PTE) or investments (PTI), are collected by the OECD (OECD Environmental Compendium 2008) and the Euro Stat (2008). In the OECD data the breakdown within countries at most distinguishes between public and business sector; in the Euro Stat data the breakdown refers to broad industries: manufacturing, electricity, gas and water supply and mining and quarrying. The time span covered varies from country to country, for some countries data date back to the eighties. However, even in these favourable cases, time series are highly discontinuous and again hardly comparable across countries. Moreover, as data are too aggregated across sectors, PAC expenditures are likely to be endogenous, in that, as the output composition within a macro-

[9] For a comprehensive survey of available industrial-level PAC data, and their measurement and comparability problems, see Pasurka (2008).

industrial-branch changes, PAC expenditures change accordingly.[10] Therefore, such measures are unsuitable to reflect the stringency of environmental regulation in a given country at a given time.

An alternative way to evaluate pollution abatement costs is by observing polluting emissions per unit of output over time, by highly disaggregated industrial sectors. In fact, under the assumption that the output composition *within* a finely defined industrial branch does not change dramatically, the evolution of emission intensities would provide an indirect indication of the stringency of environmental regulations. Unfortunately, however, there are no time series of emissions per unit of output by industrial sectors and by country readily available. Emissions per unit of output at 2-digit ISIC classification are available for China in 1995 and 2004 and for six major European countries mainly for the year 2000.[11] For the EU and other advanced countries, emissions per unit of output for the last fifteen years can be recovered only for the economy as a whole or for macro-industrial branches, however, being endogenous to changes in output mix, are not suitable to our analysis.[12]

To overcome endogeneity and data shortage problems, in our empirical approach we use a country-level index of environmental regulation to be interacted with an industry-level index of pollution intensity; the methodology will be made clear in Section IV. As for country-level indexes of environmental regulation, in our empirical analysis we use three different measures. The first ($STRING_i$) is a cross-country index, first constructed by Dasgupta (1995) and recently extended by Eliste and Fredriksson (2002), based on detailed information about the environmental regulatory framework on water, air pollution, land use and biodiversity; higher values of the index correspond to higher level of environmental standards.[13] A second measure of environmental stringency is given by the level of GDP per capita in 1995 ($PCGDP_i$); higher levels of GDP per capita should be associated with higher environmental standards. Finally, we consider an index of greenhouse gas

[10] For an extensive discussion on the endogeneity problems that arise when using pollution abatement costs as proxy of environmental stringency, see Levinson and Taylor (2008).

[11] For Italy, detailed data for industrial emissions at 2-digit NACE-ISIC classification have been recently released by the National Statistics Bureau, ISTAT (http://www.istat.it/dati/dataset/20070625_00/).

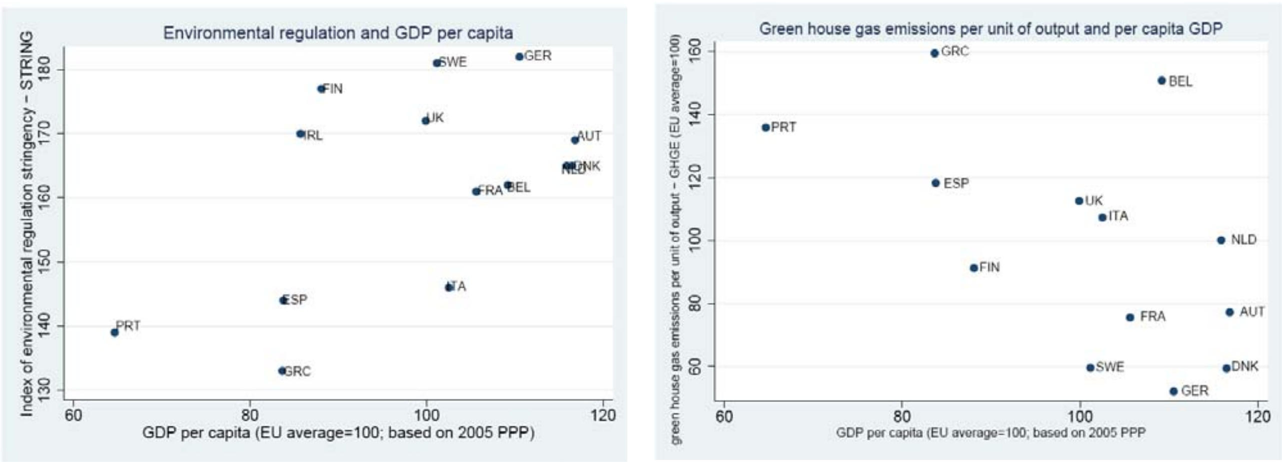
[12] The EuroStat is developing a framework to collect industry-level time-series data on emissions linked to economic accounts (EuroStat 2001). Up to now EuroStat has made available only data on total Carbon dioxide emissions from 1995 to 2004 classified by NAICS in manufacturing, mining and services for a large number of countries within EU27 (http://epp.eurostat.ec.europa.eu/portal/page?_pageid=0,1136239,0_45571444&_dad=portal&_schema=PORTAL). However an inspection of the data reveal that: (a) there are many missing values over time and across industries; (b) the number of manufacturing branches for which it is possible to express emissions in intensive form, using gross value added classified by NACE, is at most 11; (c) intensities can be expressed only in terms of value added, because output volumes are not available for the same classification; (d) emission intensities show several suspicious inconsistencies which makes it hard to believe that those emissions can be confronted with national account data on value added. Data and elaborations are available from the author upon request.

[13] The index is based on Country Reports prepared for the 1992 United Nations Conference on Environmental and Development.

emissions per unit of output in manufacturing and construction, averaged over the period 1995-2005 (*GHGE*$_i$); countries with more stringent regulation should score lower values of this index[14]

Figure 3 below shows the dispersion of our proxies for environmental stringency across the European countries in our sample; Table 1 sows how the three measures are correlated with each other.[15] Even though we concentrate on *STRING*$_i$, *PCGDP*$_i$ and *GHGE*$_i$ in our analysis, for completeness purposes, we also report two additional indexes, the *Environmental Protection Index* (*EPI*$_i$) and the *Sustainable Society Index* (*SSI*$_i$); countries with better environmental standards should score higher values for these indexes.[16] It is worth noting that the dispersion across EU countries is appreciable; in general correlations between these indexes are quite high, with the exception of those between *PCGDP*$_i$ and *EPI*$_i$ and *PCGDP*$_i$ and *SSI*$_i$.

Fig. 3 Environmental regulation proxies in fourteen EU countries



Source: author's elaborations on data from Eliste and Fredricson (2002), Euro Stat and World Bank.

[14] This latter measure is from Euro Stat and reported in Table A3 in the Appendix.

[15] The index PCGDP is constructed by taking the ratio of each country per capita GDP to the average of the sample countries, multiplied by 100; the index GHGE is given by the ratio of the average emission intensities in the 1995-2005 period in each country to the sample average, multiplied by 100. As shown in Table 1 the index by Eliste and Fredriksson (STRING) shows a correlation coefficient equal to 0.53 with PCGDP in 1995, such a correlation grow to 0.8 in 2005; the correlation coefficient with GHGE is equal to -0.74; the correlation coefficient between PCGDP and GHGE is equal to -0.56.

[16] Regression results with these two indexes are qualitatively similar to those found in the main regressions; they available from the author upon request.

Table 1. Correlations between measures of environmental stringency

	$STRING_i$	$PCGDP_i$	$GHGE_i$	EPI_i	SSI_i
$STRING_i$	1.00				
$PCGDP_i$	0.53	1.00			
$GHGE_i$	-0.74	-0.56	1.00		
EPI_i	0.50	-0.03	-0.62	1.00	
SSI_i	0.53	0.29	-0.66	0.74	1.00

III. Pollution intensities by industry and bilateral RCA

The 18 manufacturing industries considered are ranked by pollution intensity according to *sulphur dioxide* (SO_2) air emissions and *chemical oxygen demand* (COD) of water discharge in China; an additional measure is provided by the *global warming potential* (GWP) emissions per unit of output in Italy, which is chosen as representative for Europe (see columns 1 to 6 in Table 2).[17]

Industries are further classified as either resource-based (RB) or non-resource-based (NRB). This distinction is important, as RB industries are characterized by a very low degree of international mobility compared to NRB ones. Consequently, they may react differently to changes in environmental regulation. We will elaborate further on this issue in Section VI.

For each industry we also compute an index of bilateral trade-revealed comparative advantage (RCA) with respect to China. Our measure is not straightforward and deserves some explanations. We compute sectoral RCAs for each EU14 country as follows:

$$RCA_{ij} = \left[\frac{X_{ij} - M_{ij}}{X_{ij} + M_{ij}} - \frac{\sum_{j=1}^{18} X_{ij} - \sum_{j=1}^{18} M_{ij}}{\sum_{j=1}^{18} X_{ij} + \sum_{j=1}^{18} M_{ij}} \right] * \frac{X_{ij} + M_{ij}}{\sum_{j=1}^{18} X_{ij} + \sum_{j=1}^{18} M_{ij}} * 100 \, . \qquad (1)$$

Where: *i* is the EU reporting country (*i*=1,...14); *j* is the industrial sector (j=1,...,18); X_{ij} (M_{ij}) are country *i*'s bilateral exports (imports) to (from) China in sector *j;* values are expressed in current US dollars. Equation (1) measures directly the contribution of each sector to the bilateral trade

[17] We concentrate on SO_{2j} and COD_j emissions because the other two emissions available for China, SMOKE and DUST (particulate), are strongly correlated with SO_{2j}. The Global Warming Potential (GWP) emission index, instead, aggregates three greenhouse gases CO_2, N_2O and CH_4 (with weight 1, 310 and 21 respectively). Moll et al. (2007) have calculated GWP per unit of output by 2-digit ISIC classification in 1995 or 2000 for seven European countries (Denmark, Germany, Italy, Netherlands, Spain, Sweden and United Kingdom). Italian GWP emissions show the highest correlation with any other European country, on average the correlation coefficient is equal to 0.91.

balance; such a measure does not depend on the size of the overall balance, but only on its composition.[18]

An inspection of Table 2 reveals that RCA changes over the period 1996-2006 for the average of EU14 countries (column (7)) tend to be negatively correlated with the pollution intensity measures, that implies that Europe's comparative advantages with respect to China have actually tended to worsen in the cleanest industries and to improve in the dirtiest ones.[19]

Table 2. S02 and COD emissions in China (kilos per thousand yuan output, 1995 yuan) and changes of RCAs in EU14 by industrial sector.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sectors	**COD emissions per unit of output in China (2004)**	**SO2 emissions per unit of output in China (2004)**	**GWP emissions per unit of output in Italy (2000)**	**COD rank**	**SO2 rank**	**GWP rank**	**EU14 Average RCA changes (1996-2006)**
Resource-based (RB) industries							
Coke and Petroleum	0.08	0.85	5.11	10	6	3	-0.01
Pulp, paper, paper products, printing and publishing	5.21	1.41	1.46	1	2	5	0.01
Food products, beverages and tobacco	1.16	0.44	0.34	2	8	8	0.16
Wood	0.92	1.15	0.33	3	4	9	-0.15
Non-resource-based (NRB) industries							
Non-metallic minerals	0.14	4.26	9.76	6	1	1	-0.18
Basic metals	0.12	1.26	5.96	7	3	2	0.99
Chemicals	0.67	1.13	1.80	4	5	4	0.39
Rubber and Plastics	0.10	0.26	0.49	9	11	6	0.55
Motor vehicles	0.06	0.06	0.44	12	15	7	1.58
Textiles, textile products, leather and footwear	0.66	0.54	0.31	5	7	10	2.05
Fabricated metals	0.08	0.32	0.30	11	9	11	-0.19
Machinery	0.05	0.18	0.23	14	12	12	-0.02
Transport equipment	0.06	0.06	0.22	13	16	13	-0.42
Furniture and Other Mfg.	0.12	0.28	0.20	8	10	14	1.10
Medical, Precision and Optical Instruments	0.05	0.08	0.19	15	14	15	1.01
Electrical Machinery	0.02	0.16	0.16	18	13	16	0.62
Communications Equipment	0.03	0.03	0.16	17	18	17	-5.10
Office and Computing Machinery	0.03	0.03	0.06	16	17	18	-2.40

Source: Dean and Lovely (2008); Moll et al. (2007); EUKLEMS database; OECD-STAN bilateral trade database and author's elaborations.

Note: Sectors are classified according to the 2-digit ISIC rev. 3 nomenclature. RB indicates resource-based industries, NRB non-resource-based industries based on UNIDO definitions reported in Malatu et al. (2004). RCA are based on equation (1), changes are computed on the difference between the average value of index over the period 2001-2005 and the average value of the index in the period 1996-2000.

[18] The index varies between -50 and +50 and the sum across all the *j* sectors is equal to zero. A positive (negative) sign of the index in sector *j* indicates that the reporting EU country has a comparative advantage (disadvantage) in that sector, relative to all other sectors. This index allows to rank the products according to their importance, takes into account intra-industry flows and allows for international comparisons (Marconi and Rolli, 2008). Detailed data for each country in the sample are reported in Table A2 in the Appendix.

[19] The evolution of bilateral trade RCAs with respect to China clearly does not describe the entire sectoral evolution of production in EU14; indeed, if we look at the evolution of value added by industry we find a positive correlation with the rankings by pollution intensity (0.5), meaning that in the last decade the cleanest industries have benn also the most dynamic ones in Europe (see also Appendix, fig. A1a and A1b).

Also, it is interesting to note that, despite possible differences in pollution intensities between EU countries and China due to different output mix or eco-efficiency, the ranking of industries by SO_2 emissions in China (column (5)) and by GWP emissions in Europe (column (6)) are quite similar (correlation of 0.8).

IV. The empirical strategy

The model - In order to measure the impact of environmental regulation on the evolution of the structure of bilateral trade between EU14 countries and China, we want a dependent variable as much as possible independent of macroeconomic effects. In much of the existing empirical literature, the dependent variable is specified as industry's net exports normalized by industry's value added, we use, instead, our index of RCA described in equation (1) departing from the literature in two ways: (a) we take bilateral, instead of total trade; (b) we normalize net exports by gross flows (a normalization better suited for international comparisons). [20]

We estimate the following equations:

$$\Delta RCA_{ij(2006-1999)} = \alpha_j + \alpha_i + \beta_1 RVASH_{ij(1995)} + \beta_2 ULC_{ij(1995)} + \beta_3 SO2_j * string_i + \beta_4 COD_j * string_i + \varepsilon_{ij} . \tag{2}$$

$$\Delta RCA_{ij(2006-1999)} = \alpha_j + \alpha_i + \beta_1 RVASH_{ij(1995)} + \beta_2 ULC_{ij(1995)} + \beta_3 GWP_j * string_i + \varepsilon_{ij} . \tag{3}$$

Where our dependent variable $\Delta RCA_{ij(2006-1999)}$ is the change of bilateral RCA_{ij} between country *i* and China in sector *j*, in the 1999-2006 period; $RVASH_{ij}$ is the share of value added of sector *j* in country *i*, in real terms, relative to the average sector share across EU14 in 1995.[21] ULC_{ij} is the unit labour cost in sector *j* in country *i*; it is measured as nominal wage over value added at 1995 prices. The next three variables are our variables of interest, i.e., the *pollution haven* variables. These variables are constructed interacting industry-specific pollution intensities (as measured by SO_{2j} emissions, *CODj* emissions, or, alternatively in equation (3), *GWPj* emissions) with country-specific indexes of environmental regulation ($string_i$). The methodology of interacting an industry characteristic (in our case pollution intensity) with a country characteristic (in our case, the stringency of environmental regulation) was proposed by Rajan and Zingales (1998). These interacted variables have the advantage of varying across industries and countries and should capture the *pollution haven effect.* We expect that a more stringent environmental regulation should

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[20] See Bugamelli, 2001; OECD, 2005 and Marconi and Rolli, 2008.

[21] The value added share of sector *j* in country *i* is normalized with respect to the EU14 average share of sector *j.* A similar role would be played by trade specialization by sector at the beginning of the period. Indeed, running regressions replacing RVASH with the index of "*Export specialisation relative to OECD23 and total manufacturing (XSPEC23M)*" taken from OECD STAN, leaves results qualitatively unchanged. Results are available from the author upon request.

induce a worsening of RCAs in more polluting industries and, conversely, an improvement in less polluting ones.

$RVASH_{ij}$ and ULC_{ij} are intended to capture, respectively, Hecksher-Ohlin-Samuelson (henceforth H-O-S) and Ricardian determinants of RCAs. According to the H-O-S theory, which assumes same technologies across countries, countries specialize according to their relative factor endowments; this means that relative industrial composition, as captured by the relative shares of value added in industry *j* of country *i*, $RVASH_{ij}$, should reflect relative endowments in European countries. For the Ricardian argument, instead, countries tend to specialize according to their relative productivity, summarized by unit labor costs (ULC_{ij}). As it is plausible that both endowments and technology play a role in shaping RCAs with respect to China, we include both variables in our regression. Negative (positive) coefficients for initial specialization differentials should capture convergence (divergence) of endowments, while unit labor costs differentials should capture Ricardian comparative advantages.[22]

In order to correct for high volatility in trade data first we take 3-year moving averages of RCAs, and subsequently we take the average over the latest ten-years available. Finally, α_j and α_i capture industry and country-specific fixed effects, reducing the omitted variable bias. The choice to concentrate on bilateral trade between EU countries and China eliminates the need to control for tariffs and other common variables.

As the pollution intensity of industries might differ between China and Europe in equation (3) we use the Global Warming Potential of industries in Europe (GWP_j), as alternative industry-specific pollution variable. In Table 3 we report the correlations between industrial-pollutant intensities; it is worth nothing that with GWP_j and SO_{2j} are highly correlated (0.87).

Finally, $string_i$ ($string_i$= $STRING_i$, $PCGDP_i$, $GHGE_i$) is the index of the stringency of environmental regulation in country *i*. $PCGDP_i$ and $STRING_i$ should act in the same direction, that is higher levels of the index should imply higher demand for environmental protection; on the

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[22] RVASH should be interpreted as a comprehensive measure of relative factor endowments, possibly reflecting both physical and human capital. For robustness check we construct also a measure of physical and human capital intensities (k_{ij} and h_{ij}) given by the interaction of industry-specific intensities (k_j, h_j) with country-specific endowments of physical and human capital (k_i, h_i), as suggested in Nunn (2007). In this case the equation becomes:

$$\Delta RCA^{C}_{ij(2006-1999)} = \alpha_j + \alpha_i + \beta_1 (k_{j(1995)} * k_{i(1995)}) + B_1 (h_{j(1995)} * h_{i(1995)}) + \beta_2 ULC_{ij(1995)} + \beta_3 (GWP_j * string_i) + \varepsilon_{ij}$$

Industry-specific human and physical capital intensities are derived from US data. As results are essentially unchanged, we do not report them; they are available from the author upon request.

contrary, $GHGE_i$ works in the opposite direction (higher values of GHGE indicate more polluting emissions per unit of output and, therefore, lower environmental standards).

Table 3. Correlations between industrial pollutant

	SO_{2j}	SO_{2j}*RB	SO_{2j}*NRB	COD_j	COD_j *RB	COD_j *NRB
COD_j	0.21			1		
COD_j *RB		0.68			1	
COD_j *NRB			0.28			1
GWP_j	0.87			-0.04		
GWP_j *RB		0.15			-0.19	
GWP_j *NRB			0.95			0.18

The data - Trade data, classified by 2-digit NACE-ISIC rev. 3 nomenclature, are from the OCSE-STAN Bilateral Trade database. Data on value added and labour compensations are from the EUKLEMS database (available at http://www.euklems.net/), these data are classified by 2-digit NACE –ISIC rev.3 nomenclature. Data on SO_{2j} and COD_j emissions (kilos per thousand of 1995 Yuan in 2004), classified by 2-digit ISIC rev.3 nomenclature, are from Dean and Lovely (2008) and are reported in Table 2 above and Table A1 in the Appendix. Industry-level data on "Global warming potential" are from Moll et al (2007). The variable *STRING* is from Eliste and Fredricson (2002). Greenhouse gas emissions in manufacturing and construction and value added for EU14 are from Euro Stat. Per capita GDP at 1995 prices and 2005 purchasing power parities are from the World Bank. The *Environmental Performance Index (EPI)* is from http://epi.yale.edu/Home; the *Sustainable Society Index (SSI)* is available at http://www.sustainablesocietyindex.com/ssi-2008.htm.

V. Results

As anticipated in the previous section, the expected signs of our coefficients are the following:

β_1 <0 (>0) indicates convergence (divergence) of relative endowments;

β_2 <0 indicates that higher unit labour costs differentials tend to worsen RCAs with respect to China;

β_3 <0 and β_4<0 indicate that countries with more stringent environmental regulations tend to reduce their RCAs with respect to China in air and water polluting industries (the sign should be positive when the stringency variable is proxied by GHGE);

Regression results are reported in Tables 4 and 5. The first thing to note is that the dummy that distinguish between RB and NRB industries plays an important role in identifying convergence, labour cost effects and pollution haven effects. Results for equation (2) and (3) (reported in Tables 4 and 5, respectively) show as expected, negative and statistically significant values for β_1 and β_2; moreover, those coefficients are larger in absolute value in NRB industries, meaning that EU countries have tended to diminish their RCAs with respect to China in the more mobile industries with high unit-labour costs and relative high value-added shares at the beginning of the period.

Turning our attention to the pollution variables, as we can see from the bottom part of Table 4 there is evidence that, within the subsample of NRB industries, the EU14 countries have tended to improve their RCAs in the most polluting industries, especially the most water polluting ones. This pattern is robust to the definition of environmental stringency. It is worth noting, however, that if we change the classification of the paper and printing industry (ISIC 21-22), including it in the NRB subsample, while all signs and significance of the other coefficients are unchanged, that for the water-pollution variable (interacted with the NRB dummy, $(COD_j * string_i) * NRB$) lose its significance, reflecting the fact that the paper and printing industry is the most water-polluting industry and EU14 countries have, on average, slightly improved their RCAs with respect to China in this sector (see Table 2 and A2).[23]

As for the RB industry subsample, the coefficients associated with the pollution variables in Table 4 are not significant, meaning that, if we measure pollution according to SO_2 emission intensities in China, we cannot really detect any pattern due to environmental regulation.

If we look at correlations shown in Table 3, we see that it is precisely in RB industries that SO_{2j} emissions per unit of output in China and GWP_j emissions in Europe show the lowest correlation. Therefore, in regressions (3) we replace the pollution haven variables of equation (2) with $GWP_j * string_i$. Results are reported in Table 5.

Overall, when we measure pollution according to the GWP_j we find that for NRB industries the direction of the impact is the same as before; i.e. $\beta_{3,NRB}>0$ (<0) for string=$STRING_i$, $PCGDP_i$ (string=$GHGE_i$)), with the coefficient associated to $STRING_i$ and $GHGE_i$ still very significant (at 5% and 1% level, respectively). As for RB industries, instead, although the coefficients of our *pollution haven* variables are not significant, their signs are now reversed, pointing to a de-

[23] Results are available from the author upon request.

specialization away from pollution-intensive sectors (relative to China) because of their environmental impact ($\beta_{3,RB}$ <0 (>0) for *string= STRING$_i$, PCGDP$_i$ (string=GHGE$_i$)*).[24,25]

Summing up, after controlling for unit labour costs, endowment-convergence effects and the degree of international mobility, there is no evidence that environmental regulation enacted in Europe has negatively affected the structure of bilateral trade with China in a predictable way. This conclusion holds true when different definitions of pollution-intensity and environmental regulation are considered. Only in few RB industries (such as Coke and Petroleum and Wood) there might have been a tendency in Europe to de-specialize away with respect to China in response to a stricter environmental regulation.

[24] Results, however, are sensitive to the inclusion of paper and printing among the RB industries. When we exclude this industry from the RB subsample, the *pollution haven* parameters associated to RB industries become significant, again pointing to a de-specialization away from pollution-intensive RB industries. However, RB-industries are a few (now just three out of eighteen) and the result might not be robust; in this respect, results obtained on NRB-industries is more interesting, as they hold including or not the paper industry.

[25] Our findings seem coherent with Moll et al. (2007) based on NAMEA tables for seven EU countries. In their words: *"Perhaps contrary to expectation there is no dominant trend of net shifting (i.e. 'exported' pressures minus' imported' pressures) of pressures abroad in the four pressure categories* [Global Warming Potential, acidifying substances, ozone precursor substances and Direct Material Input] *except for material extraction*". A similar finding for the US is documented in Levinson (2008).

TABLE 4. EU14 BILATERAL RCAs WITH RESPECT TO CHINA AND POLLUTION PER UNIT OF OUTPUT IN CHINA

$$(2)\ \Delta RCA^{C}_{ij(2006-1999)} = \alpha_j + \alpha_i + \beta_1 RVASH_{ij(1995)} + \beta_2 ULC_{ij(1995)} + \beta_3 SO2_j * string_i + \beta_4 COD_j * string_i + \varepsilon_{ij}$$

Variable	(1) STRING		(2) PCGDP		(3) GHGE	
$RVASH_{ij(1995)}$	-1.18***		-1.21***		-0.74**	
$ULC_{ij(1995)}$	-4.34*		-4.41*		-3.94*	
$SO2_j * string_i$	1.58*		1.04		-0.77**	
$COD_j * string_i$	0.69		-0.1		-0.23	
R-squared	0.25		0.24		0.27	
$RVASH_{ij(1995)} * RB$	-0.88	-1.12*	-0.92	-0.99*	-1.04*	-1.24**
$RVASH_{ij(1995)} * NRB$	-1.23**	-1.27***	-1.31***	-1.32***	-0.24	-0.16
$ULC_{ij(1995)} * RB$	-1.63*	-1.60*	-1.39	-1.38*	-1.61	-1.36
$ULC_{ij(1995)} * NRB$	-6.16**	-6.03**	-6.40**	-6.54**	-5.61**	-5.44**
$(SO2_j * string_i) * RB$	0.70		-1.95		-0.46	
$(SO2_j * string_i) * NRB$	1.62*		1.04		-0.89***	
$(COD_j * string_i) * RB$		0.92		-0.12		-0.42
$(COD_j * string_i) * NRB$		27.19***		25.38***		-12.93***
Adj R-squared	0.26	0.30	0.26	0.29	0.29	0.34
Observations	248	248	248	248	231	231

Notes: Dependent variable $\Delta RCA^{C}_{ij(2006-1999)}$ from eq. (1). ***, **, * indicate that the parameter estimate is significant respectively at 1%, 5% and 10% level. Standard errors are robust to heteroskedasticity. All the regressions include country and industry dummies. The heading of the columns (STRING, PCGDP and GHGE) indicate the definition of environmental stringency adopted in the regression. The dummy RB (NRB) take value 1 if the industry is classified as resource based (non-resource based), zero otherwise (see table 1).

TABLE 5. EU14 BILATERAL RCAs WITH RESPECT TO CHINA AND GLOBAL WARMING POTENTIAL PER UNIT OF OUTPUT IN EUROPE

$$(3)\,\Delta RCA^{C}_{ij(2006-1999)} = \alpha_j + \alpha_i + \beta_1 RVASH_{ij(1995)} + \beta_2 ULC_{ij(1995)} + \beta_3 GWP_j * string_i + \varepsilon_{ij}$$

Variable	(1) STRING	(2) PCGDP	(3) GHGE
$RVASH_{ij(1995)}$	-1.18***	-1.22***	-0.75**
$ULC_{ij(1995)}$	-4.37**	-4.45**	-4.07*
$GWP_j * string_i$	4.47*	3.31	-2.23**
R-squared	0.24	0.24	0.27
$RVASH_{ij(1995)} * RB$	-0.93	-0.87	-1.10*
$RVASH_{ij(1995)} * NRB$	-1.27***	-1.31***	-0.32
$ULC_{ij(1995)} * RB$	-1.50*	-1.26	-1.22
$ULC_{ij(1995)} * NRB$	-6.27**	-6.36**	-5.78**
$(GWP_j * string_i) * RB$	-6.03	-9.04	2.78
$(GWP_j * string_i) * NRB$	5.39**	3.44	-2.70***
Adj R-squared	0.26	0.25	0.29
Observations	248	248	231

Notes: Dependent variable $\Delta RCA^{C}_{ij(2006-1999)}$ from eq. (1). ***, **, * indicate that the parameter estimate is significant respectively at 1%, 5% and 10% level. Standard errors are robust to heteroskedasticity. All the regressions include country and industry dummies. The heading of the columns (STRING, PCGDP and GHGE) indicate the definition of environmental stringency adopted in the regression. The dummy RB (NRB) take value 1 if the industry is classified as resource based (non-resource based), zero otherwise. Column (a) refers to the RB-NRB classification reported in Table 1. Column (b) refers to the same classification but the paper and printing industry (ISIC 21-22) is classified as NRB.

VI. Conclusion

In recent years the international debate on climate change, sustainable greenhouse gas emissions and required investment in pollution abatement has become particularly intense at all levels, raising coordination problems and free-riding concerns. If poorer countries have weaker environmental standards with respect to richer ones, we may expect they enjoy lower production costs in more polluting industries and therefore international competitiveness gains in these industries (*pollution haven effect*). This paper analyzes whether and how environmental regulation has affected the pattern of bilateral trade between China and fourteen EU countries (EU14) in the last decade. The analysis is relevant because, on the one side, EU has promoted itself as the region committed to the most stringent environmental regulation while, on the other side, China is often indicated as a *pollution haven.*

We test the hypothesis regressing the changes of bilateral RCAs between our EU14 countries and China in 18 manufacturing sectors on initial factor endowments, unit labour costs and industry-specific pollution intensities interacted with country-specific measures of environmental stringency. We find no evidence of a pollution haven effect. In particular, we find that:

i) on average our EU14 countries have kept or improved their advantages with respect to China in both water-polluting industries (such as paper and agro-based industries) and air-polluting industries (such as basic metals and chemicals);

ii) on average our EU14 countries have lost competitiveness in the more mobile and clean industries (such as communication equipment and office-and-computing machinery). This latter result has occurred in response to unfavourable unit labour cost differentials and higher capital accumulation in China.

We conclude that for the more mobile industries traditional factors still play a dominant role in shaping international competitiveness of European industries. Such results may reflect, on the one side, the fact that the additional costs eventually imposed by environmental regulation in Europe are compensated by the savings due to higher energy and eco-efficiency standards (Vollebergh, 2007, and Moll et al., 2007), and, on the other side, the fact that environmental regulation in China might have become more stringent. Our findings seem in line with those recently reported by the OECD/IEA (2008).

Results, however, must be interpreted with caution for at least two reasons: first they are based on a rather broad industry classification (18 manufacturing sectors), which does not allow to control for changes in the output mix within sectors (that is, toward a cleaner composition in Europe compared to China); and, second, even though the environmental regulation in Europe has not affected the structure of manufacturing activities, it might have affected its scale.

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Appendix

Table A1. China: Polluting emissions by industry and type of pollutant in 2004

Classifications of Industries			Emissions (kg/1000 yuan output, 1995 prices)			
ISIC Rev.3 2-digit code	Industry name	Resource Based (RB) Non Resource Based (NB)	COD	SO2	Smoke	Dust
15	Food Products and Beverages	RB	1.59	0.59	0.66	0.04
16	Tobacco	RB	0.02	0.05	0.03	0.01
15-16	Food products, beverages and tobacco	RB	1.16	0.44	0.49	0.03
17	Textiles	NRB	0.73	0.7	0.27	0.03
18	Wearing Apparel	NRB	0.44	0.35	0.17	0.02
19	Leather Shoes	RB	0.7	0.23	0.16	0.01
17-19	Textiles, textile products, leather and footwear	NRB	0.66	0.54	0.23	0.02
20	Wood	RB	0.92	1.15	1.38	0.58
21	Paper	RB	6.95	1.86	1.08	0.07
22	Printing	RB	0.08	0.09	0.07	0.00
21-22	Pulp, paper, paper products, printing and publishing	RB	5.21	1.41	0.82	0.05
23	Coke and Petroleum	RB	0.08	0.85	0.58	0.19
24	Chemicals	NRB	0.67	1.13	0.54	0.16
25	Rubber and Plastics	NRB	0.1	0.26	0.11	0.05
26	Non-metallic minerals	NRB	0.14	4.26	3.24	14.07
27	Basic metals	NRB	0.12	1.26	0.50	0.90
28	Fabricated metals	NRB	0.08	0.32	0.14	0.10
29	Machinery	NRB	0.05	0.18	0.12	0.08
30	Office and Computing Machinery	NRB	0.03	0.03	0.03	0.01
31	Electrical Machinery	NRB	0.02	0.16	0.12	0.41
32	Communications Equipment	NRB	0.03	0.03	0.03	0.01
33	Medical, Precision and Optical Instrum	NRB	0.05	0.08	0.02	0.0
34	Motor vehicles	NRB	0.06	0.06	0.07	0.06
35	Transport equipment	NRB	0.06	0.06	0.07	0.06
36	Furniture and Other Mfg.	NRB	0.12	0.28	0.19	0.34

Source: Dean and Lovely (2008) and author's elaborations.

Table A2. RCA with respect to China in selected EU countries

ISIC	Sector	AUT	BEL	DEN	FIN	FRA	GER	GRC	IRL	ITA	NLD	PRT	ESP	SWE	U K
						1997-1999									
15-16	Food products, beverages and tobacco	-0.44	0.22	8.55	-0.04	-0.16	-0.81	0.13	2.05	-0.71	4.03	-0.12	0.67	-1.56	0.30
17-19	Textiles, textile products, leather and footwear	-13.59	-7.47	-15.44	-15.92	-11.00	-11.44	-1.31	-4.63	-10.07	-4.97	-2.96	-5.45	-14.73	-5.62
20	Wood	1.43	-0.21	-0.10	-0.31	-0.34	0.07	-0.10	-0.28	-0.37	-0.38	1.39	-0.17	-1.21	-0.22
21-22	Pulp, paper, paper products, printing and publishing	0.72	0.13	0.59	3.72	0.21	0.19	0.02	0.30	-0.06	0.64	5.90	0.32	1.91	0.24
23	Coke and Petroleum	-0.02	0.02	-0.20	-0.20	-0.46	-0.13	0.10	..	-0.23	-0.07	..	-0.05	-0.89	0.04
24	Chemicals	1.11	11.20	0.69	0.49	1.06	1.45	2.72	8.03	0.54	3.35	1.05	2.83	-0.07	1.35
25	Rubber and Plastics	-0.64	-0.55	-1.05	-1.01	-1.68	-0.86	-0.12	-0.27	-1.16	-0.77	-0.79	-0.64	-1.15	-0.82
26	Non-metallic minerals	-0.52	0.80	-0.56	-0.49	-0.05	-0.28	1.18	-0.22	0.47	-0.31	-0.38	0.85	-0.92	0.03
27	Basic metals	1.90	0.54	0.11	0.36	1.20	0.96	0.03	0.15	0.25	-0.26	0.09	1.02	0.09	0.73
28	Fabricated metals	-1.05	-0.78	-0.25	-0.48	0.45	-0.92	-0.39	-0.47	-0.64	-0.07	-0.48	2.36	-2.19	0.53
29	Machinery	17.66	4.27	8.13	8.61	4.31	15.32	-0.65	0.70	19.03	6.42	-0.38	3.60	1.71	4.70
30	Office and Computing Machinery	-1.84	-1.52	-0.33	-2.66	-4.13	-3.32	-0.20	0.52	-1.17	-5.89	-0.60	-1.07	-0.50	-1.16
31	Electrical Machinery	0.96	-1.01	1.69	-3.54	0.52	-0.20	-0.27	-2.94	-1.29	-0.18	0.66	0.62	0.26	-0.66
32	Communications Equipment	-1.27	1.11	-0.15	16.24	-0.20	0.74	0.01	-0.87	-0.33	-0.04	-1.54	-1.17	22.19	2.23
33	Medical, Precision and Optical Instrum	-0.14	-1.15	0.84	-0.44	-0.74	0.18	-0.17	-0.22	-1.22	0.50	-0.37	-0.98	-0.04	0.50
34	Motor vehicles	0.71	0.52	1.21	0.30	2.42	2.43	0.00	-0.02	1.10	0.24	0.90	0.38	0.81	0.73
35	Transport equipment	0.62	-0.16	0.25	-0.13	14.92	1.54	-0.01	0.08	0.68	0.71	-0.07	-0.04	0.26	0.81
36	Furniture and Other Mfg.	-5.59	-5.96	-3.96	-4.51	-6.34	-4.91	-0.98	-1.99	-4.81	-2.95	-2.27	-3.08	-3.99	-3.70
						2004-2006									
ISIC	Sector	AUT	BEL	DEN	FIN	FRA	GER	GRC	IRL	ITA	NLD	PRT	ESP	SWE	U K
15-16	Food products, beverages and tobacco	-0.38	0.23	4.12	0.24	0.71	-0.59	0.61	1.24	-0.24	1.29	-0.08	0.53	-0.69	0.70
17-19	Textiles, textile products, leather and footwear	-10.26	-5.44	-9.85	-6.48	-7.27	-7.27	-0.45	-2.20	-7.26	-1.70	-3.54	-3.83	-10.84	-4.67
20	Wood	0.11	-0.29	-0.35	0.14	-0.26	-0.22	-0.06	-0.54	-0.26	-0.11	1.25	-0.18	-0.56	-0.31
21-22	Pulp, paper, paper products, printing and publishing	0.44	0.01	0.01	3.36	0.16	0.28	-0.03	0.55	0.06	0.32	1.90	0.24	5.19	0.10
23	Coke and Petroleum	-0.08	-0.16	-0.01	0.00	-0.16	-0.32	0.00	0.00	-0.32	-0.04	0.24	0.06	-1.05	-0.04
24	Chemicals	0.74	8.80	1.83	0.78	2.37	1.64	0.09	4.09	1.11	4.02	-1.54	3.33	2.10	2.28
25	Rubber and Plastics	0.23	-0.47	-0.31	-0.44	-0.56	-0.15	-0.13	-0.23	-0.46	-0.12	-0.93	-0.19	-1.12	-0.42
26	Non-metallic minerals	-0.09	-0.38	-0.42	-0.29	-0.07	-0.24	-0.03	-0.30	-0.58	-0.12	-0.39	-0.31	-1.03	-0.21
27	Basic metals	1.93	1.70	-0.04	4.65	1.29	2.50	0.26	-0.03	0.85	1.03	-0.44	0.54	3.70	1.63
28	Fabricated metals	-0.58	-0.54	-0.33	-0.37	-0.54	-0.58	-0.14	-0.30	-0.47	-0.09	-1.19	-0.27	-2.73	-0.59
29	Machinery	15.57	4.62	9.57	12.04	3.13	13.92	0.32	0.28	12.23	3.21	0.07	1.25	8.74	3.22
30	Office and Computing Machinery	-4.77	-2.97	-1.28	-5.90	-5.88	-8.75	-0.10	-10.19	-1.04	-6.70	-1.17	-1.24	-0.68	-1.24
31	Electrical Machinery	0.34	0.27	1.18	-5.13	0.92	0.68	0.03	-0.91	0.35	0.20	-0.58	1.30	1.01	0.07
32	Communications Equipment	-5.28	-2.11	-2.13	-0.77	-2.39	-7.04	0.00	9.55	-1.71	-3.03	9.57	-1.91	2.82	-0.77
33	Medical, Precision and Optical Instrum	0.90	-0.09	1.64	0.84	0.43	1.50	0.06	0.42	-0.46	2.59	-0.66	-0.07	1.10	1.08
34	Motor vehicles	2.80	0.31	0.98	0.07	2.18	5.74	0.00	-0.03	0.55	0.19	0.97	1.65	1.71	1.30
35	Transport equipment	2.09	-0.20	-0.37	-0.61	9.57	2.58	-0.09	0.05	-0.01	0.03	-0.23	0.95	-1.41	1.22
36	Furniture and Other Mfg.	-3.70	-3.30	-4.25	-2.15	-3.63	-3.68	-0.35	-1.43	-2.32	-0.98	-3.25	-1.83	-6.26	-3.34

Source: OECD-STAN bilateral trade data and author's elaborations.

Fig. A1a index of value added by manufacturing sector in 2005 (1999=100) and sector's global warming potential (GWP)

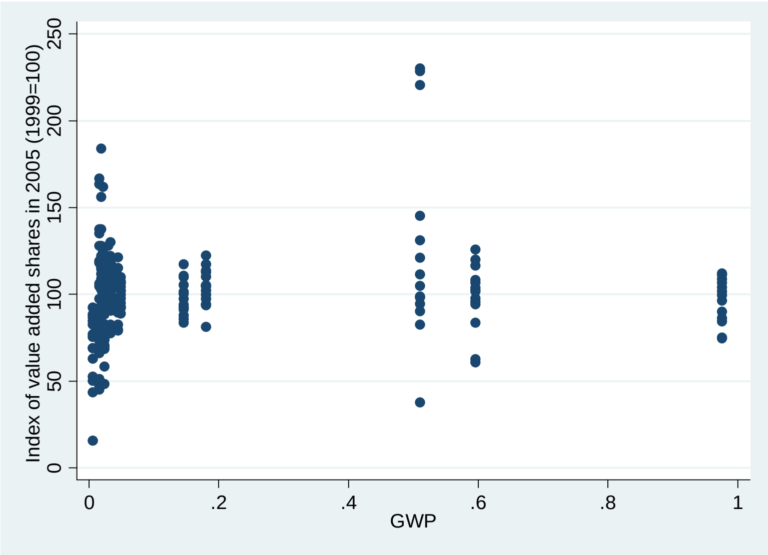
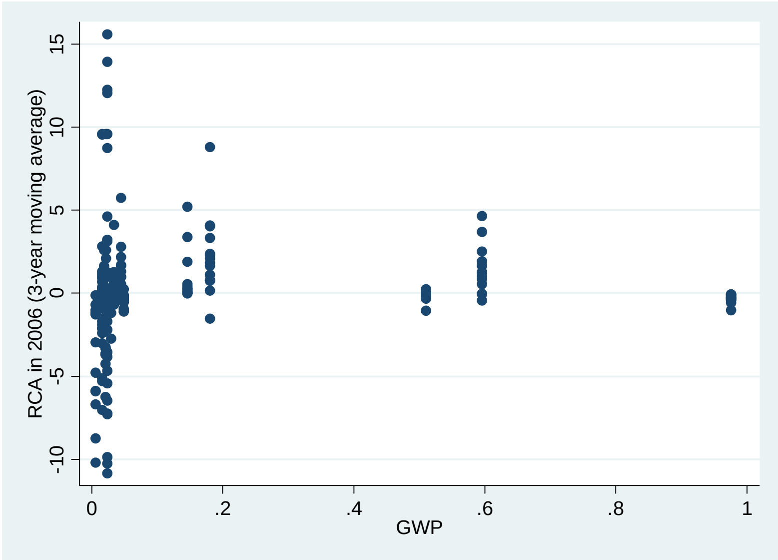


Fig. A1b. RCAs with respect to China by country and manufacturing sector in 2006 and sector's global warming potential (GWP)



Source: Author's elaborations on EUKLEMS and OECD Data.

Table A3. EU: Greenhouse emissions intensity - Manufacturing and construction industry (tons/thousand value added euros; 1995 prices)

year	Austria	Belgium	Denmark	EU15	Finland	France	Germany	Greece	Italy	Netherlands	Portugal	Spain	Sweden	UK
1995	0.32	0.66	0.23	0.35	0.47	0.30	0.22	0.62	0.42	0.43	0.54	0.48	0.28	0.46
1996	0.32	0.65	0.24	0.35	0.45	0.31	0.22	0.65	0.41	0.43	0.52	0.42	0.28	0.46
1997	0.34	0.59	0.23	0.35	0.42	0.31	0.21	0.66	0.42	0.40	0.53	0.45	0.27	0.45
1998	0.30	0.63	0.23	0.33	0.37	0.31	0.20	0.63	0.39	0.39	0.51	0.43	0.24	0.44
1999	0.28	0.59	0.23	0.32	0.35	0.28	0.20	0.55	0.41	0.38	0.51	0.42	0.21	0.44
2000	0.27	0.58	0.22	0.31	0.32	0.28	0.18	0.58	0.41	0.35	0.51	0.42	0.20	0.42
2001	0.27	0.57	0.22	0.31	0.29	0.28	0.18	0.54	0.39	0.34	0.48	0.44	0.20	0.43
2002	0.28	0.54	0.22	0.30	0.28	0.27	0.18	0.51	0.38	0.35	0.48	0.44	0.19	0.39
2003	0.28	0.54	0.22	0.31	0.28	0.27	0.18	0.47	0.40	0.36	0.48	0.46	0.19	0.39
2004	0.27	0.50	0.21	0.30	0.27	0.26	0.19	0.74	0.41	0.35	n.a.	n.a.	0.17	0.38
2005	0.28	0.47	0.19	0.30	0.25	0.26	0.19	n.a.	0.39	0.35	n.a.	n.a.	n.a.	0.38
2006	0.26	0.45	n.a.	0.28	n.a.	0.25	0.18	n.a.	0.38	0.35	n.a.	n.a.	n.a.	n.a.

Source: Eurostat data and author's elaborations.

Table A4. Most recent and related studies on trade and pollution haven effect

Paper	Countries/years	Industry details	Dependent variable	Environmental regulatory variables	Control variables	Results
Malatu et al. (2004)	Germany, Netehrlands and US 1977-1992	9 two-digit-ISIC manufacturing industries	Net Exports/Value Added in industry	Capital expenditure for pollution abatement and control/Gross fixed capital formation (PACE)	GFCF, Skilled and Unskilled labor, R&D expenditures, Tariffs	**Mixed evidence:** PACE negative and significant for the US, negative and not-significant for Germany, positive and significant for the Netherlands.
Grether and de Melo (2004)	52 countries 1981-1998	5 most polluting industries and 5 cleanest industries in the US (3-digit ISIC)	Total RCA (descriptive analysis); Bilateral trade (gravity equation)	GDP per capita	GDP, Distance, Borders, Land lockedness, Quality of infrastructure	**No evidence**: RCA decompositions revealed no evidence of trade flows being driven by regulatory gap (some positive evidence for the nonmetallic and metallic sectors); result confirmed by gravity model estimation: explanation high natural barriers to trade in the typical heavily polluting industries.
Cole et al. (2005)	US 1978-1994	96 3-digit SIC manufacturing industries	RCA; Net Exports/Value Added	Pollution Abatement Costs/Value Added (PAC)	Non-wage value added share, share of value added to skilled workers, Tariffs	Pollution abatement costs do have negative effects on net trade, however there is **no evidence** of falling specialization in dirty industries in the US. Explanation: factor intensities more important, dirty industries are more phisical and human capital intensive.
Levinson and Taylor (2008)	US, Canada and Mexico 1977-1986	130 3-digit manufacturing industries in US	US bilateral Net Exports/Value Added	Pollution Abatement Costs/Value Added (PAC)	Tariffs	**Evidence** of pollution haven: an increase in PAC lead to an increase of US net imports from Mexico and Canada.