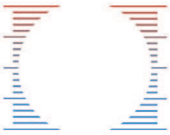

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Does industry concentration matter for pollution haven effects?*

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Abstract

This paper focuses on the role of firm's market power and industry concentration in a still debated issue of pollution haven effects or carbon 'leakage' represented as increased trade flows in the most polluting sectors from the developing world spurred by regulations in developed countries. A firm in a relatively competitive industry with less market power has no option to transfer costs of environmental regulations to consumers and may be more likely to resort to 'importing pollution' from places with lax environmental standards that insure cheaper inputs as a result of such regulations at home. This paper finds that a degree of industry's concentration has an effect on firms' margins of products that were affected by the EU ETS policy in 2005 and that are imported from the developing world. Firms in more competitive industries increased their imports of products affected by the EU ETS from the developing world post 2005 more than firms in a less competitive setting.

Keywords: Pollution haven, Imports, Industry concentration, EU ETS, Herfindahl-Hirschman Index

JEL Classification: F18, Q56, L11, C23, C35

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1 Introduction

The existence of pollution haven effects has been a long contended issue in both theoretical and empirical academic and policy research. Early theoretical works of Pethig (1976) and McGuire (1982) have first brought into light the possibility that the increased stringency of environmental regulations at home would, upon more trade liberalisation, lead to plant reallocation to or increased imports from countries with laxer environmental standards. Since this would have dire economic consequences, pollution haven debate has not lost its edge since and is still a focus of intense attention. Despite an impressive volume of both theoretical and empirical studies the debate has not been settled yet. See Copeland and Taylor (1994), Copeland and Taylor (1995), Markusen et al. (1995), Antweiler et al. (2001), Copeland and Taylor (1997), Copeland and Taylor (2004), Levinson (2009), Levinson and Taylor (2008), Dean and Lovely (2010), Javorcik and Wei (2004), Ederington et al. (2004), List et al. (2003), Keller and Levinson (2002), Cole and Elliott (2003), Cole et al. (2005), Cole and Elliott (2005) for some theoretical and empirical findings on pollution havens. Moreover, under a new heading of carbon 'leakage' the issue is again under scrutiny with revived vigour as policy makers and firms alike discuss possible negative effects of the new phase of an existing environmental regulation due to be introduced in the EU in 2013. The more recent literature by e.g. Broner et al. (2012), Cole et al. (2010) and Ederington et al. (2005) argues for a more differentiated empirical approach to pollution havens by stressing, amongst other things, the importance of looking at the imports from developing countries versus total imports and the importance of focusing on the most polluting sectors of the economy.

This paper builds on this idea and takes it one step further. It addresses a hitherto overlooked issue of differentiated effects market power and industry concentration have on imports from polluting industries in developing countries. Consider a firm in a relatively concentrated industry where each firm has more market power, it thus has more opportunities and may be more likely to pass costs incurred due to environmental regulations through on to a consumer. On the other hand, a firm in a competitive industry has no option to transfer costs of environmental regulations on to consumers and it therefore may be more likely to import cheaper inputs from countries with lax environmental standards to reduce its costs. Such imports are going to be 'dirtier' as the production process in developing countries is on average less technologically advanced than that of developed countries which means that firms in more competitive industries are going to be more prone to 'importing pollution' from developing world after an increase of environmental regulations at home. Similar line of reasoning is argued in Alexeev and Song (2010) that show that firms in more competitive setting are more likely to pay 'bribe tax'

that reduces their variable costs of doing business, compared to firms in less competitive environments. And Ritz (2009) show that carbon 'leakage' tends to be higher in more competitive markets or for firms producing homogenous products versus firms producing more differentiated varieties (something that I later use as an indirect measure of market power).

More specifically, this paper answers a following question - does the degree of industry's concentration affect firms' extensive and intensive margins of 'dirty' imports from the developing countries after the introduction of the EU ETS (European Union Emissions Trading System). The EU ETS is an EU wide regulation of emissions trading system introduced in 2005 whereby large CO_2 emitters in the EU were allocated a number of emission allowances. Ireland was under-allocated in a first phase of the EU ETS so a it is a good case to study since firms in Ireland found a biding constraint of whether to import from places with less strict environmental regulations or to produce or source at home (or even from the EU) with higher regulatory induced costs.[1] Although all Irish manufacturing firms are a focus of this analysis, where the EU ETS introduction comes into play is the importing decisions firms make. More specifically, this study focuses on the EU ETS affected imports by looking at firm-products from non-OECD countries with corresponding industry codes belonging to polluting sectors as classified and therefore affected by the EU ETS. So if a firm sources at least one product from the developing world which corresponds to a polluting industry under the EU ETS, this analysis looks at how, if at all, that sourcing pattern is affected post-EU ETS, i.e. post 2005, by the degree of concentration of the industry in which a firm operates.

This is an empirical study that utilises two Irish micro level datasets spanning the period of 2000-2009. The first is a census of manufacturing firms providing balance-sheet data - all main firm-level characteristics. The second is a trade transactions dataset with records from Customs on firms' international activities. The empirical strategy is to assess whether industry concentration after the EU ETS introduction in 2005 has had an effect on a number of products (extensive margin) or the value of products (intensive margin) sourced by a firm from the non-OECD and whose product code corresponds to industries most affected by the EU ETS.[2]

Results show that firms in more competitive industries have higher imports of 'dirty' products - those affected by the EU ETS introduction, from the developing world after the policy has been introduced compared to firms in less competitive industries. This

[1] Ireland was given fewer emission allowances as it had previously set very stringent Kyoto targets and it used the EU ETS as a tool to reach these targets, see Barry (2007) for more detail.

[2] Those industries are manufacturing of paper products, of petroleum and nuclear fuel products, of non-metallic products and of basic metals, although alternative broader definitions are also explored with similar results.

adjustments is observed on both extensive and intensive margins of imports and withstands a number of sensitivity checks. What these findings suggest is that market power does affect a degree to which we observe pollution haven effects and it is important to account for it when studying this issue. Carbon 'leakage' is not only found in import flows of polluting sectors from developing countries into developed ones but also to a larger extent by looking at firms in more competitive environments that react stronger to environmental regulations by increasing their share of 'dirty' imports.

The remainder of the paper is structured as follows: Section 2 describes the empirical methodologies employed in the paper and their main issues, Section 3 details the two datasets combined for the analysis and their main variables. Section 4 outlines the key findings, Section 5 then gives a summary of robustness checks and Section 6 concludes.

2 Empirical Strategy

The paper aims to look at the effect of industry concentration on both the extensive and intensive margins of imports of a firm post the EU ETS policy introduction, that is, post 2005. There is a series of methodological issues that have to be addressed here. The first deals with different estimation techniques for assessing the effect on extensive margin - number of products and intensive one - (log) value of products. The second focuses on the measure of industry concentration and describes how the measure is constructed as well as various alternative measures that have been considered to ensure the validity of results.

This section is then going to proceed as follows. It starts by outlining an estimation equation and its main components. It then proceeds to discussing two distinct estimation techniques for obtaining main results - zero-inflated negative binomial model for extensive trade margin estimations and linear panel models for intensive trade margin estimations. It goes on to discuss the issues of measuring concentration of an industry, the measure chosen here to derive base results and several other approaches that test and support the findings.

The baseline regression has the following form:[3]

$$TradeMargin_{it} = \alpha Concentration_{jt} + \beta Concentration_{jt} * post05 + \gamma post05 + \delta X_{it} + \epsilon_{it} \tag{2.1}$$

[3]Note that this is a regression differences-in-differences approach as described in Angrist and Pischke (2009).

where the dependent variable - trade margin - is twofold and represents either a number of products that correspond to heavily polluting industries - 'dirty' products (extensive margin) or a log of total value of these products (intensive margin) imported from non-OECD countries. 'Dirty' products are products corresponding to industries of manufacturing of paper products (21), of petroleum and nuclear fuel products (23), of non-metallic products (26) and of basic metals (27) as these are the industries most affected by the EU ETS introduction.[4] The variable of interest here is an interaction term between a measure of concentration of an industry a firm is in and a dummy that switches from 0 before 2005 to 1 at 2005 and till 2009 - post EU ETS introduction effect. I cannot directly observe the consequences of the EU ETS regulation but since it has been introduced in 2005, the dummy switching on post 2005 is meant to capture this effect on firms in the dataset.[5] And because I specifically focus on imported products corresponding to the EU ETS affected industries, the post 2005 dummy should be a good approximation for the analysis.

The expectation here is that firms in less concentrated industries post 2005 will tend to import more 'dirty' products from the non-OECD world. Because the concentration rate is lower the more competitive the industry, β is expected to have a negative sign. Additionally, this specification controls for a separate effect of industry concentration and any other post 2005 influence. It also controls for a number of firm characteristics, such as a dummy for being an exporter, ownership dummy (where 1 assigns a foreign ownership and 0 - a domestic one), log labour productivity, energy, capital proxy, share of materials purchased from affiliates. It also includes product effects on 2-digit level.

2.1 Dependent variables

Due to the nature of the dependent variables two separate estimation techniques have to be employed to look at the effect that the concentration of an industry has on trade margins post ETS introduction.

Extensive trade margin is measured as a number of products. Firstly, the outcome of interest here is a count. Secondly, since a variable of interest is specifically a number of 'dirty' products - products whose code corresponds to industries affected by EU ETS introduction and that are imported from non-OECD countries, there is a considerable zero-inflation - about 70% of all observations for this variable are zeros. Thirdly,

[4]Section 5 confirms the same pattern of findings when EU ETS affected industries also include manufacture of fabricated metal products (28) and printing and publishing (22). NACE 2 digit level codes given in parentheses are codes corresponding to NACE Rev. 1.1.

[5]A number of checks is performed on the timing of the dummy switching, see Section 5 for more details.

dependent variable is a firm level variable and data form an unbalanced panel.

Because the dependent variable is discrete, the probability mass of the distribution is concentrated only on nonnegative values. Further, the data are heteroskedastic with the variance increasing with the mean, see Cameron and Trivedi (2005). This calls for nonlinear estimations by way of count regressions.[6] Furthermore, the large number of zeros needs to be modelled in as well. Two choices present themselves - zero-inflated Poisson model or zero-inflated negative binomial model. Both add a binary process to the count density. Following the work by Lambert (1992) these models add a binary process with density $f_1(\cdot)$ to a count density $f_2(\cdot)$. So, following Cameron and Trivedi (2005), if the binary process takes a value 0 with probability $f_1(0)$, then $y = 0$ and if it takes a value of 1 with probability $f_1(1)$ then y takes count values 0, 1, 2 .... from the count density $f_2(\cdot)$. Thus the zero count can occur in two ways - as a realisation of a binary process or a count process when the binary random variable takes a value of 1.

The density is:

$$g(y) = \begin{cases} f_1(0) + (1 - f_1(0))f_2(0) & \text{if } y = 0, \\ (1 - f_1(0))f_2(y) & \text{if } y \geq 1. \end{cases} \tag{2.2}$$

Here $f_1(\cdot)$ is a logit model and $f_2(\cdot)$ is a negative binomial density although Poisson density is tried in this study as well.

Both models have been run and zero-inflated negative binomial model proved to provide a better fit to the data with the overdispertion parameter being highly statistically significant so the main results are given using this model, although zero-inflated Poisson model provides a similar pattern of results.[7]

Alternative zero-inflated Poisson model with random effects using Markov Chain Monte Carlo (MCMC) methods is used to confirm the main outcomes of the above two models, it provides the same pattern of findings.[8] Lastly, to try and to a certain degree account for a panel structure of the dataset and firm fixed, time-invariant effects in the model, main firm control variables are demeaned. Standard errors are clustered at a level of a firm to account for repeated product observations per firm and an unbalanced nature of the longitudinal data.

Therefore, the main results of the effect of a concentration ratio of an industry a

[6] See Cameron and Trivedi (1986), Cameron and Trivedi (1998) and Cameron and Trivedi (2009) for more detail.

[7] Long and Freese (2005) package SPost was used to run a comparison of the models, although no robust standard error option was allowed. Outcomes of the *countfit* command suggested zero-inflated negative binomial model was a better fit to the data.

[8] The model is run using Hadfield (2010) package.

firm operates in post the EU ETS introduction in 2005 on the number of 'dirty' products imported from the non-OECD (extensive trade margin) are derived from the zero-inflated negative binomial model with demeaning and with robust standard errors clustered on a level of a firm.[9] Numerical outcomes are shown in table 1 in section 4. The coefficients in this table cannot be directly interpreted due to nonlinear nature of the model, but they give a good indication of the direction of the effects.

Intensive margin estimations are more straightforward. Value of 'dirty' imports from non-OECD is taken in logs and to circumvent the issue of zeros, a very small number is added to those observations to allow for log transformation.[10] Estimation results are then derived from running both fixed and random effects linear panel models with robust standard errors clustered on a level of a firm.

The models are obtained by subtracting the time-averaged model from the original model, see Cameron and Trivedi (2005) and Wooldridge (2002) for more detail.

$$y_{it} - \overline{y_{it}} = (x_{it} - \overline{x_{it}})'\beta + (\epsilon_{it} - \overline{\epsilon_{it}}) \tag{2.3}$$

2.2 Industry Concentration

Another important question to be addressed in this section is how to measure industry concentration. A measure of industry concentration reflects how much market power a firm has within an industry. If an industry is populated by only a few very large firms it is reasonable to expect each firm to have a lot of market power and industry concentration to be quite high. On the other hand, if an industry is characterised by a high number of small firms, concentration is small and each firm faces a high competitive pressure by other companies within this industry. A fairly standard approach to measure industry concentration is to calculate a Herfindahl-Hirschman Index (HHI). Herfindahl-Hirschman Index (HHI) is calculated by taking a sum of the squares of the market shares of firms within an industry.

[9] Similar results are found when employing Poisson model with firm fixed effects that does not account for zero-inflation.

[10] As pointed out by Silva and Tenreyro (2006), albeit for a gravity model, such an approach could lead to biased estimates so zero-inflated negative binomial model is also run on values of 'dirty' imports with similar results although significance values differ depending on an industry concentration measure.

A formula for Herfindahl-Hirschman Index is:

$$HHI = \sum_{i=1}^{N} s_i^2 \tag{2.4}$$

where s_i is a market share of a firm i in an industry and N is a number of firms in that industry. The higher the value of the Herfindahl-Hirschman Index the higher the level of industry concentration. A competitive setting is therefore characterised by low values of HHI.

For this study the Herfindahl-Hirschman Index was constructed in a variety of ways. Base results are derived from calculating HHI with firm's turnover within an industry taken to be a market share and a level of aggregation to be NACE 2 digit level. However, to ensure the validity of findings, NACE 3 digit level of industry aggregation has been tried out too with similar outcomes. Further, because Irish economy is very open and export-oriented, a firm's market share was also taken to be turnover minus its export share to try and proxy for a share of a company on the domestic market. The main findings remain similar.

However, even taking out the exported share of turnover of Irish firms does not account for sales made in Ireland by firms from outside of Ireland. One could also think of the market for Irish firms being broader than home country and encompassing the whole of the EU. Since the data on the concentration ratio of the EU industries are not available, an attempt to circumvent the issue was made by using Rauch classification of differentiated versus homogenous goods. The underlying intuition for using this classification is that firms face more competition in the homogenous goods industries. Using this as a proxy for industry concentration measure provided broadly similar outcomes, see section 5 for details.

Another important issue with the Irish data is that CSO only records an industry code of a primary activity of a firm - the activity that accounts for the largest share in its turnover. It is possible, therefore, that over time firms that have their activities spanning several NACE 2 digit industries are recorded in the data as changing their industry classification. This happens when the largest share of turnover shifts from one industry activity to another within a firm. Those firms are not a majority within the dataset, certainly not on 2 digit level but they are present and need to be dealt with.[11] For the base estimations, those firms are removed. Leaving them in the dataset does not alter main conclusions.

To try and solve these problems I double check the findings with yet another measure

[11]Firms changing their industry classification represent about 9% of the total.

of industry concentration - total market share of several top firms in an industry. CR3, CR5 or CR4 and CR8 are used frequently in the literature. CR3 is a measure showing a total market share held by 3 largest firms in an industry. CR5 would total a market share of 5 largest firms in an industry, etc. It is calculated as a sum of market shares of the top firms. For example, CR3 is calculated as follows:

$$CR3 = \sum_{i=1}^{3} s_i \tag{2.5}$$

Multiple estimations with CR3/CR4/CR5 and CR8 industry concentration indices, both time variant and averaged over the data period show the findings holding consistently for the intensive margin. Extensive margin findings are slightly less robust although the direction of the effect stays the same.[12]

3 Data

This study builds on a combined firm-product level dataset of Irish manufacturing firms. This dataset spans a period of 2000-2009. Below is the description of the two datasets comprising the combined one used in the paper. The matching of the two datasets was performed by statisticians at the Central Statistics Office Ireland (CSO).

3.1 CIP Dataset and main variables

The main source of firm level data on manufacturing firms used in this study is the Irish Census of Industrial Production (CIP) - an annual census of manufacturing, mining and utilities firms. The Census is conducted by the Central Statistics Office (CSO) at both enterprise and plant level.[13] The CIP covers all enterprises or plants with 3 or more people engaged. The period of the CIP data is 1991-2009. The list of manufacturing industries used is given in Table 4 in Appendix A.[14]

[12]More checks for the measure of industry concentration have been undertaken and are outlined in section 5.

[13]For more information on this and other datasets described here, please visit web-site of the Central Statistics Office Ireland at http://www.cso.ie/.

[14]CIP uses NACE Revision 1.1 up to 2007. NACE 1.1 is a European statistical classification system of economic activities corresponding to ISIC Rev.3 at European level. From 2008 onwards CIP uses NACE Revision 2 classification which was re-classified back to Revision 1.1. using correspondence tables provided by Eurostat.

The CIP dataset on manufacturing firms provides an unbalanced panel spanning 19 years and over 10000 firms in total. The relevant variables in the Census of Industrial Production are primary industrial classification (at 2-, 3- and 4-digit NACE level), country of ownership, total turnover, export share (as a % of turnover exported), employment (measured as total employed), skill level, total labour costs, total gross earnings (wage), outsourced R&D expenses, aggregate investments, freight charges, total purchases of fuel and power (energy): solid fuels, petroleum products, natural and derived gas, renewable energy sources, heat, electricity.[15]

This dataset is used to construct the main variable of interest - industry concentration, as well as utilise firm level information to provide controls at the firm level. Firms' turnover (total sales) information is used to construct industry concentration ratio. For some of the further checks, CIP data are used to deduct a share of exports from the total turnover of a company to proxy the amount of firm's total domestic sales.

CIP provides further information on firm characteristics that are used as control variables in the study. Firm productivity is measured as labour productivity, calculated as a total turnover per employee. There are no data on capital stock in the CIP but there is information on capital flows that is used to construct a capital proxy as an accumulated measure of firm's capital additions built over the whole period minus sales of capital assets, assuming 10% yearly depreciation rate overall. The study further accounts for ownership - by way of a dummy variable taking on a value of 1 if a firm is foreign-owned and 0 for a domestically-owned company. The analysis further controls for a firm's energy use since a more energy-dependent firm may be more likely to be affected by a regulation that is aiming at (the products of) the more polluting industries as those most of the time tend to be very energy intensive too. Further, CIP provides some information on the percentage of materials that are purchased from a company's affiliates. Since the dependent variables in this study are either quantity or value of imports, this would help control for any of the purchases made from affiliated firms.

3.2 International trade dataset and main variables

A second dataset used for the analysis is an international trade dataset of Irish firms involved in exporting or importing activities and reporting their transactions to the customs authorities. It includes information on the country of origin of an imported good and the country of destination of an exported good, value and quantity of a good and its

[15]Monetary values are deflated using Industrial Producer Price Indices with year 2005 as a base, provided by the CSO. Energy variables are deflated using the CSO Wholesale Price Indices for Energy Products with year 2005 as a base.

classification at CN8 level (8 digit level of Combined Nomenclature classification) and, where available, a corresponding PRODCOM code of a good.[16] The data are available for a period of 2000-2009. Most of the trading firms in the CIP dataset are found in the international trade dataset. The quality of matching is somewhat diminished for very big firms with turnover exceeding €5 bln.[17] For the main analysis those firms are left in the dataset but their exclusion does not alter any main conclusions.

Product codes, value of the transactions and country of origin information provide the main ingredients for constructing dependent variables for the analysis. Although the CN8 code of the product provides a very rich detailed information of what kind of product it is and how or what it is made of, this information is not used in the study. The product code and where possible PRODCOM codes are mapped into a more narrow classification of 2, 3 and 4 digit NACE level to help identify products that correspond to the EU ETS affected industries of paper products, petroleum and nuclear fuel products, non-metallic products and basic metals. The study also uses this more aggregated classification to control for fixed effects on products side.

This information is then used to create a count of products that a firm imports from a certain destination region. What this in actuality does is count the number of different goods or varieties falling under a polluting EU ETS classification that a firm imports from non-OECD region thus creating one of the dependent variables for the analysis - a firm's extensive margin of trade. Where applicable, the dataset provides information on the quantity of a good in tonnes and a value of a good in Euro thousands. Due to the fact that the quantity information is not as widely available, this paper settles down on just counting a number of different goods a firm imports and not their physical quantity. The analysis also looks at the combined value of those products. The log transformation of the total value of the products that correspond to the EU ETS affected industries imported from the non-OECD represents a second dependent variable for the analysis - a firm's intensive margin of trade. Information on country of export destination and import origin is given as a country code or a full name of a country.[18] Import origin

[16]Classification of CN8 codes changes over time with small adjustments year on year and big CN8 code overhauls in 2002 and 2007. The changes in codes over time are not always one-to-one: some codes are split into several and several old codes may be aggregated into one. Therefore, to account for and concord those classification changes over time I follow closely the methodology as developed by Pierce and Schott (2012) and further elaborated by Bernard et al. (2012). Source programmes used courtesy of Justin R. Pierce and Ilke Van Beveren.

[17]This is due to the fact that two datasets use different identifiers - a firm's id in the CIP and VAT number for the international trade dataset and the mapping is not very clear-cut for very big companies in the datasets.

[18]The international trade dataset has some limitations. I cannot trace whether a firm re-sells an imported product to another firm or sells it to a final consumer. This, however, should not significantly affect the results. Neither is it documented in the international trade dataset if a firm buys an imported product from a retailer in Ireland, only direct imports by manufacturing firms are observed.

information is used to classify an origin of imports as non-OECD country (developing world) or OECD or the EU country for robustness analysis later in the paper to compare imports from developing with imports from developed world dynamics.[19]

While the Irish economy is well-known for being very export-oriented, it also relies heavily on imports. The mean number of products an Irish firm exported over the period 2000-2009 is just over 100 and the average number of products it imported during the same period is almost three times as high. On the other hand, exports are much more diversified destination wise with an average number of firm's export destination countries between years 2000 and 2009 being 44 and the average number of import origin countries being 32. The mean value of exports is also several times higher than that of imports over the period observed. So the Irish firms' export is based on a fewer number of dearer products than their imports but is more geographically dispersed.

To sum up, the firm level dataset CIP provides all main controls used in the study and the studied variable of interest. International trade dataset allows to construct two main dependent variables in this study as well as some additional ones for checking and contesting the main findings. Table 5 in Appendix A presents a full list of variables used in this analysis and their definitions.[20]

4 Effect of industry concentration on extensive and intensive margins

This section presents the findings on both external and internal margins of imported goods from non-OECD whose code corresponds to the NACE code of an industry affected by the EU ETS introduction in 2005. Methodological issues and models are discussed in the previous section 2. Results for both trade margins are shown and discussed separately.

4.1 Extensive Margin

Table 1 presents the results of the zero-inflated negative binomial model with demeaning of the main control variables and controls for product codes on 2 digit level. The model as described in section 2 consists of two parts - firstly, it looks at what variables

[19]EU here is taken to include all new members who joined post 2004 to avoid breaks in classification.

[20]Some data cleaning has been done prior to running the analysis. Any negative or missing values of main firm level variables, such as energy use or turnover, in few instances where possible were replaced using values from previous and later years, the rest - set to missing. The top .25 percentile of energy intensity observations is removed to control for extreme outliers.

Table 1: Extensive trade margin outcomes

Zero-inflated negative binomial regression		
	Coefficient	S.E. (clustered by id)
HHI	11.5678	(50.3279)
HHI*Post 2005	-149.8183**	(70.8419)
Post 2005	0.659***	(0.1294)
Exporter	0.9351	(0.7095)
Ownership	-0.0115	(0.2198)
Log Labour Productivity	0.1862	(0.1341)
Energy Intensity	13.1067***	(4.8267)
Capital	-2.18e-07***	(7.87e-08)
% materials from affiliates	0.0005	(0.0019)
Inflate		
Exporter	-0.315	(0.9665)
Ownership	-0.9246**	(0.3369)
Log Labour Productivity	-0.3072	(0.2186)
Energy Intensity	3.7703	(2.9864)
Capital	-0.00004	(0.00004)
alpha	0.6389	(0.1882)
Number of observations	921619	
Nonzero obs	280586	
Zero obs	641033	
Number of firms	3403	
Wald chi2(41)	465.68	
Prob > chi2	0.0000	
Log pseudolikelihood	-895598.3	
Inflation model	logit	

Standard errors, clustered by id, in parentheses $***p < 0.01, **p < 0.05, *p < 0.1$
Dependent variable: firm's count of 'dirty' products imported from non-OECD.
The model includes 2 digit product dummies, means of explanatory variables and a constant, which are not reported here.

make it more or less likely that a firm has a zero outcome on the dependent variable - a count of imported products and then it estimates for the whole distribution the direction of effect of independent variables of interest. The first part of the model is shown under the heading *Inflate* and is estimated using a logit model. It shows that only one firm level variable has a significant negative probability of a firm having a zero outcome variable. Specifically, foreign firms are more likely to have a non-zero number of 'dirty' products imported from the developing world. The top part of the results in table 1 shows the effects of interest, namely the effect of concentration ratio - Herfindahl-Hirschman Index (HHI) post 2005, after the EU ETS introduction, on the number of 'dirty' products being imported from non-OECD. Also included are the concentration index itself and post 2005 time dummy to account for the overall effects of industry concentration and the EU ETS introduction, as well as a number of firm level controls, means of main control variables

and dummies for products at 2 digit level. The coefficients in the table show the direction of the effect, as the model is nonlinear, one cannot directly interpret the results.

Regarding the directionality of the effects, what the signs of the coefficients in table 1 suggest is that if a firm is operating in a more competitive setting (lower HHI) it is more likely to import a larger number of 'dirty' products from non-OECD after 2005, i.e. a larger number of products with codes corresponding to industries affected by the introduction of the EU ETS in 2005. And vice versa, firms in relatively more concentrated industries tend to import fewer of the 'dirty' products from non-OECD post 2005. Introduction of the EU ETS in general seems to have encouraged all firms to increase the import of 'dirty' products from non-OECD.[21] Additionally, more energy intensive firms import more products from non-OECD, as they could be seen to be more reliant on 'dirty' imports. Higher capital translates into fewer 'dirty' products imported from the developing world and might reflect an effect of a technology upgrade.

To help understand the magnitude of the effect of interest and gauge the economic significance of the result, the following calculations were performed. A one standard deviation increase in the Herfindahl-Hirschman Index (HHI) post 2005 from the mean observed in the estimation sample would reduce the mean number of 'dirty' products imported from non-OECD by *10 percentage points*. And bringing that index from the sample mean to a maximum value of industry concentration observed in the sample would reduce the mean count of 'dirty' products imported from non-OECD by *70 percentage points*.

So the results suggest that the effect of introduction of the EU ETS differs for firms in relatively more versus relatively less concentrated industries. And the higher the competitive pressure the more are firms inclined to import the products affected by the regulation from regions with laxer environmental standards and legislation.

4.2 Intensive Margin

Results for estimating the intensive margins of 'dirty' imports from the developing world reveal similar dynamics. Tables 2 and 3 show output for estimating, accordingly, random and firm fixed effects models with log value of 'dirty' imports affected by the EU ETS introduction from non-OECD as a dependent variable. Post 2005 HHI concentration ratio has the same effect on the value of 'dirty' products from non-OECD as on their number - the more concentrated the industry the lower the value of ETS affected products a firm imports from the developing world and, vice versa, the more competitive the setting

[21]The results are largely driven by known big polluters such as China, India, Russia, Brazil but removing these countries from the data does not reverse the results.

Table 2: Intensive trade margin outcomes, random effects estimations

	Firm random effects model
HHI	66.7513
	(62.3537)
HHI*Post 2005	-133.9404**
	(54.8484)
Post 2005	0.5277***
	(0.1044)
Exporter	-0.0098
	(0.0615)
Ownership	0.0126
	(0.1163)
Log Labour Productivity	0.495***
	(0.1699)
Energy Intensity	3.9573**
	(1.8251)
Capital	1.30e-07*
	(7.39e-08)
% materials from affiliates	-0.0024
	(0.0054)
Number of observations	921619
Number of firms	3403
Wald chi2(36)	143.19
Prob > chi2	0.0000

Standard errors, clustered by id, in parentheses $***p < 0.01, **p < 0.05, *p < 0.1$
Dependent variable: firm's log value of 'dirty' products imported from non-OECD.
The model includes 2 digit product dummies and a constant, which are not reported.

a firms finds itself in, the higher the value of EU ETS affected products that it imports from countries with laxer environmental regulations. Post 2005 variable similarly has a positive effect on the log value of imported products for all firms. And more energy intensive firms also tend to import higher value of 'dirty' products from non-OECD. Unlike the extensive margin estimations, more productive and capital using firms import a higher (log) value of ETS affected, 'dirty' products from developing world. Although the latter result is likely driven by the outcome that more productive firms import higher value of products overall.[22]

Random effects estimations are the most fitting here as what we are really interested in is the comparison between firms on how the concentration ratio after 2005 affects 'dirty' imports from developing countries. However, within estimations (with firm fixed effects taken out) are very similar in terms of directionality of effects and their magnitudes.

To sum up, the main story told by the outcomes shown here is that when looking

[22]A positive link between productivity and importing has been shown in the literature, see e.g. Smeets and Warzynski (2010), Castellani et al. (2010), McCann (2009) or Muûls and Pisu (2009).

Table 3: Intensive trade margin outcomes, firm fixed effects estimations

	Firm fixed effects model
HHI	55.8722
	(68.4577)
HHI*Post 2005	-131.5425**
	(55.6689)
Post 2005	0.5236***
	(0.1047)
Ownership	0.0087
	(0.1246)
Log Labour Productivity	0.521***
	(0.1793)
Energy Intensity	4.2875**
	(1.9934)
Capital	1.25e-07*
	(7.34e-08)
% materials from affiliates	-0.0024
	(0.0054)
Number of observations	921619
Number of firms	3403
F(35,3402)	3.69
Prob > F	0.0000

Standard errors, clustered by id, in parentheses $***p < 0.01, **p < 0.05, *p < 0.1$
Dependent variable: firm's log value of 'dirty' products imported from non-OECD.
The model includes 2 digit product dummies, a constant and firm fixed effects, which are not reported.

at the pollution haven effect, it would seem that it affects firms differently depending on how much competitive pressure they are facing from their peers in an industry. If a firm is up against a relatively tougher competitive setting, it is more likely to increase its reliance on importing the products most affected by regulations from countries where such regulations are weak or non-existent. Adding on to previous finding of pollution haven effects and carbon 'leakage' being more prominently visible when focusing specifically on 'dirty' imports from developing world rather than on aggregate trade flows, one also needs to factor in an industry concentration to further pinpoint the effect.

5 Robustness Checks

A number of additional estimations were performed to test viability of alternative hypotheses and to expand on the main results. Some of these estimations are shown in table 7 in Appendix A, the rest of the output is available on demand.

Other measures of industry concentration

Section 2 touches upon issues of measuring industry concentration as this is a crucial variable of interest in this study. For the baseline results shown in section 4 concentration ratio is constructed as Herfindahl-Hirschman Index (HHI) with industries defined at 2-digit NACE level and market share taken to be firm's turnover (total sales). These outcomes are confirmed with HHI constructed with industries defined at 3 digit level and when using normalised HHI which also accounts for both firms' market share and a number of firms in an industry. Intensive margin results are further supported by using time invariant HHI, averaged over 10 years of data; by using alternative measures of concentration - CR3-8 - sum of market shares of 3, 4, 5 and 8 biggest firms in an industry and with HHI constructed only based on a number of firms in an industry, thus implicitly assuming equal market shares per firm. Extensive margin results for all these measures retain their sign but their significance drops slightly below conventional levels.

One of the main concerns regarding a measure of market share of Irish firms is that Irish economy is a small open economy heavily dependent on exports. To take account of that a firm's total turnover measure minus export sales is introduced as a base for HHI construction, as a check to gauge the effect of Irish firms' market power at home. Intensive margin outcomes hold out very well with extensive margin results retaining their sign. However, it could be argued that export orientation of the Irish economy makes the entire EU more likely to be 'home' market for Irish companies. In the absence of the EU wide sectoral HHI a proxy is devised to account for a degree of competitive pressure a firm might face on a market irrespective of its geographic boundaries. Specifically, I utilise Rauch classification to construct a dummy variable for a market power in an industry. Rauch classification of industries at 2 to 4 digit NACE level is provided courtesy of Fitzgerald and Haller (2010). The idea behind this is that firms in industries producing more differentiated goods would have more market power and firms in industries producing homogenous products would face a higher competitive pressure. To be comparable with HHI results I construct this dummy variable as 0 for industries producing homogenous or reference priced goods - more competitive setting and 1 for industries producing differentiated goods - more concentrated setting. Using this new variable, extensive and intensive margin estimations are re-run. Again, intensive margin results prove more robust and show the same negative and significant effect of interaction term of this new measure of industry concentration and post 2005 dummy, meaning that firms in more competitive industries import relatively more 'dirty' imports from 'dirty' destinations. Extensive margin results though retaining the sign are no longer significant at conventional levels.

Post 2005 dummy as a proxy for the EU ETS policy

The EU ETS has been introduced in 2005, that is why 2005 has been chosen as a

switching point for a dummy to represent the effect of the policy, which interacted with industry concentration ratio provides the main results for the trade margins. However, a sensitivity analysis should be performed around this date. Firstly, I run a number of falsification or placebo tests when the dummy variable would switch on at a year different from 2005. 2002 and 2003 are tried as switch years instead. Interaction of these dummies with industry concentration ratio has proved to have no significant effect on extensive or intensive margins of 'dirty' imports from non-OECD. The dummies themselves still displayed a positive effect on both margins which means that post 2005 effect observed in the previous section might be a part of a longer tendency of all firms to increase their imports from the developing countries. Since the EU ETS has been announced and discussed well in advance it is not infeasible to expect some sort of an anticipation effect of the policy, indeed, this is supported by the data as the interaction between the concentration ratio and the post 2004 dummy becomes significant. Secondly, post 2005 dummy is replaced with a time trend which is also interacted with HH index. This interaction does not have any significant influence on the number of 'dirty' products from the non-OECD for firms in a more versus less competitive setting.

Imports from other regions

What if the observed effect of industry concentration ratio is the same for all imports of a firm and not just those affected by the ETS or, perhaps, for all ETS affected imports irrespective of their country or region of origin? To test the first claim, the estimations as reported in tables 1 and 2-3 are repeated replacing the dependent variable with a count or a log value of all firm's imports. The interaction of the concentration ratio with a post 2005 dummy is insignificant in those estimations. Similar results are achieved when looking at the imports of 'clean' goods from the non-OECD as the dependent variable. Regarding the second possibility, the main estimations are once again repeated, this time looking at 'dirty' imports from the developed world with higher environmental standards - OECD or EU. The effect of industry concentration ratio post 2005 becomes statistically insignificant for both trade margins from both of these regions. Another way to check the results is to run a triple difference in difference with dependent variable being all 'dirty' imports by a firm. The variable of interest would then be a triple interaction term between a post-2005 dummy, concentration ratio of an industry and a dummy for non-OECD ('dirty' import origin). Such triple difference-in-difference exercise shows that the results hold significantly.

Continuous importers

Setting up a new import channel as a result of a policy measure means incurring a significant fixed cost and firms in more competitive industries may be less likely to be able to pay it. It is therefore important to show that the results are driven by firms

that have been importing 'dirty' products from the developing world prior to the policy taking place and have been intensifying the use of that import channel after the policy introduction. I focus on firms that had non-zero imports prior to 2004 and show that for this sub-sample firms in a more competitive setting increased their 'dirty' imports from the non-OECD after the EU ETS introduction relatively more compared to firms in less competitive industries. The magnitudes of the effects are much larger than those reported in section 4. This confirms that the main findings of the paper are mostly due to firms that had already established imports from non-OECD and therefore new non-OECD importers or even importers who switch from the EU or OECD 'dirty' imports to non-OECD 'dirty' imports as the result of the policy introduction are not likely to be a big issue here.

Alternative definitions of the EU ETS affected industries

To thoroughly check the findings, I also expand the number of industries affected by EU ETS introduction to include an industry of manufacture of fabricated metal products, except machinery and equipment (NACE Rev. 1.1. 2-digit code of 28) and, to follow some accounts, an industry of printing and publishing (NACE code 22). Both of those broader definitions of the EU ETS affected products show exactly the same, and even, in case of addition of industry code 28, statistically stronger pattern of empirical evidence that has been demonstrated in section 4.

Industry level estimations

Since industry concentration ratio is an industry level variable, all estimations are also re-run on industry level at NACE 2 digit. Dependent variables and control variables are then constructed as mean values within an industry. Since there is no zero inflation problem for the number of products on industry level a negative binomial count model is used to derive extensive trade margin estimations. The main results on industry level display the same dynamics for both trade margins.

Outliers

To make sure results are not driven by outliers, the main estimations are repeated with the top and bottom 1% of observations of main control variables removed from the data. This does not change any of the results.

Alternative models

Some alternative models are also run on the basic specification to confirm the results. Apart from already mentioned zero-inflated Poisson model, a zero-inflated Poisson model with random effects using Markov Chain Monte Carlo (MCMC) methods is also employed. Both of those models confirm the main outcomes. Hurdle model also provides the same pattern of findings. Fixed effects Poisson model has also been employed to make sure extensive margin results are not driven by firm fixed effects and the outcome of interest

remains unchanged suggesting that it is indeed not due to firms' unobserved effects.

Ownership

Including a dummy for ownership status in the regressions does not provide much information about how patterns of margins of 'dirty' import from non-OECD differ for domestic firms and MNEs. To address this issue, I split the sample and run separate trade margin estimations for domestic-owned and foreign-owned firms. Majority of firms in the sample (90%) is domestic-owned. A broad trend of the findings suggests domestic firms react more on the extensive margin to the competitive pressure post EU ETS regulation introduction, whilst MNEs that find themselves in more competitive industries are more likely to adjust their intensive margins of 'dirty' imports from the developing world post 2005.

Other checks

Observed results are not driven by firms in industries that are affected by the EU ETS policy. Results also hold when big firms (turnover $>$ €5 bln) for whom the matching of two datasets was more difficult, are taken out.

As one industry - of petroleum and nuclear fuel products (23) in Irish data is extremely concentrated, it has been removed from the construction of the concentration ratio to test the robustness of the findings and when this is done, the results still hold.

6 Conclusions

This paper builds on previous extensive research on empirical examinations of pollution haven effect, specifically the recent more heterogeneous approach moving away from studying aggregate trade flows to focusing on 'dirty' goods that are more affected by environmental regulations and their flow from developing country origins to developed world destinations. This study demonstrates that when looking at pollution havens it is important to also account for a market power of a firm or the extent of concentration of an industry a firm operates in. If a firm is facing a tougher competition in an industry, introduction of an environmental regulation that is likely to increase its costs of production or sourcing from home will see that firm's imports of products affected by the regulation increase from developing countries with laxer regulations. These imports are both cheaper and 'dirtier' and since firms in a more competitive setting have less market power to pass the costs of environmental regulations through on to consumers they are likely to increase their reliance on these imports to cut their costs. And vice versa, firms in more concentrated industries with more market power will have an option of passing

the costs through to consumers and might be less inclined to increase their reliance on importing.

This hypothesis is tested with a firm-product level dataset of Irish manufacturing firms spanning 2000-2009 period. The environmental regulation that is being looked at is an introduction of the EU ETS (European Union Emissions Trading System) in 2005 which affected the industries of paper products, petroleum and nuclear fuel products, non-metallic products and basic metals. This study looks at how imports of the products of these industries purchased by a firm from non-OECD countries is affected by the industry concentration after the introduction of the policy. I focus on both extensive and intensive import margins.

The empirical findings show that the EU ETS had an effect on firms' margins of trade in the policy affected goods relatively more in more competitive setting. Firms in more competitive industries increased their 'dirty' imports from the non-OECD more than firms in less competitive industries after the introduction of the policy which increased the cost of these 'dirty' goods at home. This outcome holds out under a scrutiny of various checks and suggests that when looking at pollution havens it is also important to account for firms' market power.

These findings have somewhat ambiguous policy implications suggesting that if policy makers wish that firms keep producing at home or source locally versus increasing their reliance on 'dirty' imports following an introduction of an environmental regulation, they should increase industry concentration. The latter, however, has a number of negative implications as more competitive setting is associated with lower mark-ups, higher rate of innovation, etc. Another policy implication that follows from this study is that policy makers should consider consumption based pollution or carbon tax versus a production based one.

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A Appendix

Table 4: List of NACE 2 digit industries in the Census of Industrial Production (CIP)

NACE Code	Description
15	Manufacture of food products and beverages
16	Manufacture of tobacco products
17	Manufacture of textiles
18	Manufacture of wearing apparel; dressing and dyeing of fur
19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
21	Manufacture of pulp, paper and paper products
22	Publishing, printing and reproduction of recorded media
23	Manufacture of coke, refined petroleum products and nuclear fuel
24	Manufacture of chemicals and chemical products
25	Manufacture of rubber and plastic products
26	Manufacture of other non-metallic mineral products
27	Manufacture of basic metals
28	Manufacture of fabricated metal products, except machinery and equipment
29	Manufacture of machinery and equipment n.e.c.
30	Manufacture of office machinery and computers
31	Manufacture of electrical machinery and apparatus n.e.c.
32	Manufacture of radio, television and communication equipment and apparatus
33	Manufacture of medical, precision and optical instruments, watches and clocks
34	Manufacture of motor vehicles, trailers and semi-trailers
35	Manufacture of other transport equipment
36	Manufacture of furniture; manufacturing n.e.c.

NACE classification followed in this study is NACE Rev 1.1 - a European statistical classification system of economic activities corresponding to ISIC Rev.3 at European level.

Table 5: Definition of variables

Variable	Description
Count 'dirty' imports from non-OECD	Number of products imported from non-OECD whose code corresponds to industries of manufacturing of paper products (21), of petroleum and nuclear fuel products (23), of non-metallic products (26) and of basic metals (27) as these are the industries most affected by the EU ETS introduction.
Log value 'dirty' imports from non-OECD	log value of products imported from non-OECD whose code corresponds to industries of manufacturing of paper products (21), of petroleum and nuclear fuel products (23), of non-metallic products (26) and of basic metals (27) as these are the industries most affected by the EU ETS introduction.
Herfindahl-Hirschman Index	HHI is constructed taking firm's turnover as a market share and at a NACE 2 digit level of aggregation. Variety of other options is tried out for robustness.
CR3/4/5/8	Alternative industry concentration measure constructed as a sum of market shares of top 3, 4, 5 or 8 firms in an industry. Market shares are taken to be turnover and a level of aggregation is NACE 2 digit.
Total energy use	Total energy spending by a firm as declared in the CIP.
Energy intensity	Firm's total energy spending per turnover (total sales).
Exporter	Dummy variable equal to 1 if a firm exports in any given year and 0 otherwise.
Ownership	Dummy variable equal to 1 if a firms is foreign-owned and 0 if it is a domestic firm.
Labour Productivity	Total turnover divided by the number of employees.
Capital	Firm's capital additions built over the whole period minus sales of capitals assets, assuming 10% yearly depreciation rate overall.
Skill	% of managerial/technical and clerical personnel in total employment.
R&D	Research and development services supplied to the enterprise.
% materials purchased from affiliates	% of materials that are purchased or imported from firm's affiliates.

Table 6: Summary statistics for the estimation sample

Variable	Mean	Std. Dev.	Min	Max	N
Count 'dirty' imports from non-OECD	0.676	1.408	0	17	992056
Log value 'dirty' imports from non-OECD	0.8433	1.9214	0	10.5134	992056
Herfindahl-Hirschman Index	0.0008	0.001	0.0002	0.0295	992056
CR3	0.0027	0.0035	0.0006	0.0399	991625
CR4	0.003	0.0038	0.0007	0.0436	991467
CR5	0.0032	0.0041	0.0007	0.0473	990818
CR8	0.0038	0.0047	0.0007	0.0555	989560
Total energy use	2101.52	7241.97	0	141234.7	992055
Energy per turnover	0.0169	0.0324	0	14.8034	991770
Log total energy use	5.7536	2.0329	0	11.8582	992055
Export share	69.6	38.273	0	100	992056
Total Turnover	405351.9	1295405.85	0	13432622	991806
Total Earnings	15268.87	30493.98	0	278681.31	991748
Total Employed	410.67	710.018	0	4515	991549
Labour Productivity	570.62	1189.69	0	15325.18	991429
Log Labour Productivity	5.5297	1.1231	0.0001	9.6373	991429
% High-Skilled	36.65	21.137	0	100	992056
Capital	51879.17	272960.64	-70373.586	3116508.3	985804
R&D	2137.77	14721.21	0	1189696.88	992056
Ownership	0.5758	0.4942	0	1	992056
% materials purchased from affiliates	11.658	23.2	0	100	992056

Reported are mean values over the period of 2000-2009. All monetary values are in EUR thousands.

Table 7: Some robustness estimations, extensive 'dirty' imports margin

	'Clean' imports[1]	Time trend[2]	Placebo switch in 2002[2]	With industry capital intensity[3]	OECD imports[4]	Continuous non-OECD importers[3]	Time-invariant HHI[3]	Broader definition of 'dirty' including fabricated metal products[3]
HHI	-96.1433	48.3841	-82.9659	30.6925	-24.0777	10.0098	-46.5286	1.8902
	(59.3775)	(89.5633)	(86.8953)	(48.1112)	(56.1670)	(43.8879)	(430.1874)	(70.1490)
HHI*Time Interaction	-12.4817	-19.7393	-3.3048	-164.2716**	-104.7791	-214.7833**	-953.696	-163.4169***
	(46.4712)	(15.3872)	(82.9967)	(68.5637)	(64.1923)	(107.688)	(636.1869)	(56.2547)
Post 2005	0.2786***	0.1296***	0.3895**	0.7025***	0.0493	0.5237***	0.6878***	0.6423***
	(0.0678)	(0.0246)	(0.1560)	(0.1263)	(0.0624)	(0.1541)	(0.1265)	(0.1155)
Exporter	0.6397***	0.7965	1.1484	0.9104	-0.1323	0.3329	1.0041*	0.8064
	(0.1647)	(0.7007)	(0.7464)	(0.6658)	(0.3726)	(0.3446)	(0.5391)	(0.6872)
Ownership	-0.1803*	0.0025	-0.1694	-0.0068	0.0161	0.2958**	-0.1311	-0.2227
	(0.1001)	(0.2140)	(0.3959)	(0.2247)	(0.0742)	(0.1510)	(0.2847)	(0.2124)
Log Labour Productivity	0.1671***	0.1126	0.3053**	0.1810	-0.0648	0.1008	0.0763	0.1763
	(0.0382)	(0.1446)	(0.1480)	(0.1299)	(0.0421)	(0.1636)	(0.1314)	(0.1112)
Log Energy	0.057**		0.0597		0.0088	0.1643	0.1024	0.0068
	(0.0272)		(0.1483)		(0.0288)	(0.1528)	(0.1263)	(0.0926)
Log Energy Intensity		13.4079**		14.7937***				
		(5.7066)		(5.0239)				
Capital	-8.33e-08**	-2.53e-07***	1.30e-08	-2.57e-07***	-5.33e-08	-3.55e-07*	-4.31e-07***	-4.60e-07***
	(3.88e-08)	(8.89e-08)	(2.60e-07)	(8.28e-08)	(3.60e-08)	(1.93e-07)	(1.55e-07)	(9.48e-08)
% materials from affiliates	-0.0001	0.0005	0.0003	0.0004	0.0006	-0.0028*	0.0003	0.0006
	(0.0005)	(0.0017)	(0.0018)	(0.0019)	(0.0009)	(0.0016)	(0.0018)	(0.0014)
Industry capital intensity				7.47e-07				
				(5.05e-07)				
alpha	1.2195	0.5780	0.7075	0.6327	0.6769	0.3406	0.5885	1.4429
	(0.0945)	(0.2438)	(0.1931)	(0.1770)	(0.0712)	(0.1202)	(0.1502)	(0.3201)
Number of firms	3404	3403	3404	3403	3404	294	3404	3404
Wald chi2(41)	1815.08	434.36	273.79	478.68	1644.19	1361.82	329.18	372.37
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Log pseudolikelihood	-2901306	-890819.7	-907059.9	-894147.6	-2664625	-469846.5	-899273.6	-1337044

Standard errors, clustered by id, in parentheses $***p < 0.01, **p < 0.05, *p < 0.1$
Estimated by zero-inflated negative binomial model, which includes non-reported 2 digit product dummies, means of explanatory variables and a constant.
Zero inflation part of the model not reported to save space but available on request.
[1] Dependent variable: firm's count of 'non-dirty' or 'clean' products imported from the non-OECD.
[2] Dependent variable: firm's count of 'dirty' products imported from non-OECD. Post 2005 replaced by time trend or post 2002 respectively.
[3] Dependent variable: firm's count of 'dirty' products imported from non-OECD.
[4] Dependent variable: firm's count of 'dirty' products imported from OECD.
Depending on the estimations controls of energy use vary between absolute energy use or energy intensity, this does not alter any of the main results.