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Flip side of the pollution haven: do export destinations matter?*

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COMMENTS ARE WELCOME

Abstract

This paper looks at a reverse side of the pollution haven argument by answering a question on whether environmental regulations of the destination, rather than source countries play a role. The study utilises a firm-level dataset with aggregate export destinations of Europe and rest of the world (ROW) to establish whether a firm adjusts its energy use in response to a decision to start exporting to a more (Europe) or a less (ROW) regulated destination. Although on average, no energy adjustments are found for these destinations, focusing on the most polluting industries or the most energy-intensive firms reveals that firms' decision to start exporting to Europe brings about significant energy improvements, unlike a decision to start exporting to the ROW. Further estimations suggest that no adjustments found for firms exporting to the ROW are consistent with exporting to non-OECD region.

Keywords: Export destinations, Energy, Firm level, Regulations
JEL Classification: F18, Q56, L23, C23

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1 Introduction

Effects of environmental regulations have been an intense focus of many political and academic debates for decades. Academic research has meticulously and thoroughly studied regulations' effects from as early as late 1970s.[1] The primary objective of the studies was to establish whether increased stringency of environmental regulations at home would lead to increased imports from countries with laxer environmental standards. As this would mean plant reallocation and possible job losses the interest in this debate is as acute now as it has been when it started. The perceived negative implications of stricter environmental regulations at home and laxer regulations in source countries became known as pollution haven effects. 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) for some findings on pollution havens.

The more recent literature by e.g. Ederington et al. (2005) and Cole et al. (2010) 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 of focusing on the most polluting sectors of the economy. A question that has not been addressed by a pollution haven literature so far is the reverse side of the argument. Do regulations of the destination country matter as well as the regulations of the source country for exporting firms? While the pollution haven effect suggests that an increase in regulation would lead to a relocation of production to a low-regulation location, affecting both the extensive and intensive export decisions, it does not discuss what other exporting firm choices might be affected. In particular, if strong policies result from consumer preferences for green goods, then a shift in destination regulation would also represent a shift in destination preferences. This in turn could impact other environmental decisions of firms in the source country. This paper takes a first step towards investigating this by examining energy usage as a function of destination market.

The study utilises a comprehensive Census dataset of Irish manufacturing firms from the period of 1991 to 2008. As no direct emission information is available in the data, the use is made of firms' energy consumption as this has been shown to be highly correlated with emissions.[2] Export destination information is available on an aggregate level for

[1] See e.g. early theoretical works of Pethig (1976) and McGuire (1982).

[2] See Eskeland and Harrison (2003) and Cole et al. (2008).

three destinations: Europe, USA, and all the rest of the world (ROW). The research question this study addresses is whether a firm significantly adjusts its energy using pattern before it starts exporting to either more developed and, hence, more regulated regions of the EU and the USA as opposed to the less regulated area of the rest of the world (ROW).

Why would destination markets matter, particularly for Irish firms, who already are subject to strong regulatory pressure at home? One possible explanation could lie in a difference between preferences. As the more developed markets are known to prefer higher standards of environmental quality, this could spur energy efficiency adjustments of firms starting to export there. This consideration may be of more importance in the industries that are big polluters, where highest improvements can be achieved per unit of abatement costs, such as the more polluting or the more energy intensive industries, in line with argumentation by Wheeler (2001).

Another possible consideration might be the energy efficiency of the end product of a firm. Some products are subject to mandatory energy labels, showing their energy efficiency to the consumer, such as domestic appliances, cars, light bulbs. There might be a connection between an improved energy efficiency of the end product and the manufacturing process employed to produce it, although this connection might be more tenuous.

Empirical evidence finds strong support for the first explanation. On average, there are no significant differences in energy use found between export starters to either more (the EU) or less (ROW) regulated destinations and their non-exporting counterparts. However, looking at various sets of more polluting industries as defined by Cole et al. (2005) for the UK, Cole and Elliott (2005) for the USA or at the set of industries affected by the EU ETS (European Union Emissions Trading Scheme) in the EU, reveals a significant difference in energy consumption there. On average a firm classified as a producer in one of the more polluting industries significantly reduces its energy intensity (measured as energy use per total sales) prior to starting to export to the EU the next period. No such adjustment is found for firms starting to export to ROW. A similar pattern is found when looking instead at firms in all sectors but leaving in the dataset only those with energy intensity above the median, i.e. most energy-intensive firms. This, however, does not hold when looking at all firms in the most energy-intensive industries.

In addition, there is limited support for the second explanations of firms improving their energy use if they produce one of the energy-labelled products and export it mostly to Europe.

To account for a highly aggregated nature of the rest of the world (ROW) region in the data, an additional dataset is used to make sure the results for the ROW are driven by developing, rather than developed countries in it. Detailed export destinations of each firm are known for a period of 2005-2007 in this additional dataset. When this information has been extrapolated onto a full firm-level dataset of 1991-2008, results have shown similar patterns for firms in the most polluting sectors. Firms operating in one of the more polluting sectors and starting to export to either Europe or OECD the next period on average significantly reduce their energy intensity prior to exporting. No such reductions are found for firms exporting to developing, non-OECD destinations.

To sum up, destination markets and regulations and preferences degree associated with them do matter but only for a subset of firms in the more polluting industries or for the more energy-intensive firms.

The remainder of the paper is structured as follows: Section 2 describes the dataset and main variables used for the analysis, Section 3 presents the empirical methodology employed in the paper, Section 4 outlines key findings. Section 5 then gives a summary of robustness checks and Section 6 concludes.

2 Data

2.1 Dataset and main variables

The firm level data on manufacturing firms used in this study come from the Irish Census of Industrial Production (CIP) - an annual census of manufacturing, mining and utilities. The Census is conducted by the Central Statistics Office (CSO) at both enterprise and plant level. The CIP covers all enterprises or plants with 3 or more people engaged. The period of the CIP data is 1991-2008. The list of manufacturing industries used is given in Table 4 in Appendix A.

The CIP dataset on manufacturing firms provides an unbalanced panel spanning 18 years and 10706 firms in total. Summary statistics of the main variables of interest are presented in table 6 in Appendix A.[3]

The relevant variables in the Census of Industrial Production are 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. Table 5 in

[3]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.

Appendix A presents a list of variables used and their definitions for the purpose of this analysis.

To proxy the environmental performance of firms, data on total energy spending on firm level is used, similar to Cole et al. (2008) and Eskeland and Harrison (2003). As the questions on fuel and power used were asked on the enterprise rather than plant level, enterprise dataset of the CIP is used. Most enterprises (more than 90%) in the Census are single-plant firms.

Dependent variable in the analysis presented below is therefore a firm's energy intensity (relative energy use) which is given by total energy use spending by a firm reported annually in the Census in proportion to its total sales (turnover), to bring the energy costs in perspective relative to firm's size.[4]

Exporting information on a firm level is given by a share of exports in total sales (turnover). This is being used to construct an exporter dummy on a firm level which equals 1 if a firm i is an exporter at a time t and 0 otherwise. This is also being used to split the sample into export destination groups as described in more detail below.

CIP provides further information on firm characteristics that are used as control variables in the study. Firm's productivity is measured as labour productivity, calculated as a total turnover per employee. There is 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 capitals assets, assuming 10% yearly depreciation rate overall. As earlier studies suggested that foreign ownership might have an effect on firm's environmental performance, an ownership variable indicating whether a firm is foreign- or domestic-owned is included.[5] Skill intensity of a firm (share of skilled labour in total labour) is included to see whether more skill-intensive firms might be more energy-efficient. In all of the analysis additional controls for year and industry effects are included too, in a form of year dummies and industry dummies at NACE 3 digit level.[6]

2.2 Export destinations

The dataset provides somewhat curtailed information on destinations. Generally, 4 major export destination groups are available - the EU, the UK, the USA and the rest

[4]Throughout the rest of the paper the term energy intensity and (relative) energy use will be used interchangeably to define the dependent variable as outlined above.

[5]See e.g. Albornoz et al. (2009), Cole et al. (2008), Cole et al. (2006).

[6]CIP uses NACE Revision 1.1. NACE 1.1 is a European statistical classification system of economic activities corresponding to ISIC Rev.3 at European level.

of the world. The CIP dataset allows to see what proportion of total sales goes to each of these four groups of countries, if any.

For the purpose of the analysis, the four export destination groups are aggregated up to two - exporters to Europe are those mostly exporting to the EU and the UK. In some analysis exporters to the USA are added to that group of more regulated destinations. The exporters to the rest of the world (ROW) are those firms who primarily export to the countries in the rest of the world group.

Since a lot of firms export to many and not just one destination, the division into two export destination groups has been performed based on the majority rule. If over 60% of the firm's export share has been going to the EU/UK (sometimes including the USA too) group, then those firms are labelled as exporters to Europe/EU. If over 60% of firm's exporting share has been going to the rest of the world, then those firms are put into exporters to the ROW category.

Firms whose majority export destinations changed over time are not considered in the analysis, as it might result in confusion when trying to identify any adjustments associated with a decision to start exporting to a particular destination.

2.3 International trade data

An auxiliary dataset is being used to run a robustness check in the paper. It's international trade dataset of Irish firms involved in exporting or importing activities. It includes information on the country of origin of the imported good and the country of destination of the exported good, value of the good and its classification. The data are available for only a limited period of 2005-2007.

For the purposes of this study the use is made of only that part of the dataset that contains detailed export destination and trade value of goods exported to a certain destination. See Section 5 for more details on the methodology of this exercise and its findings.

3 Empirical Strategy

The main focus of the paper and the main research question that it aims to answer is whether there is a significant adjustment in firms' energy behaviour before they start exporting to a more regulated area of the EU or a less regulated area of all other countries in the world (ROW).

The main empirical methodology is applying fixed effects estimations - within estimations in a panel setting, making use of repeated firm observations over the available time period (up to 18 years). The main focus is on changes in relative energy use (proxy for energy intensity) one period before, at time $t-1$, associated with the changes in exporting status within a firm at a time t, holding other things at $t-1$ equal.

The focus on relative energy use one year before exporting is motivated by an effect transportation or learning from exporting or other changes might have on energy use when a firm starts exporting. To have a clear picture of whether exporting induces a firm to significantly adjust its energy using pattern in a preparation to exporting either to the EU or to other countries of the world, any possible clouding influences of these effects should be excluded. If a regulation/preferences effect is there, firms starting to export to the EU would improve their energy intensity (decrease their relative energy use) compared to non-exporting firms one period before in an effort to prepare and streamline their production, possibly introducing better technologies that would help cut energy usage. However, to further justify the findings, the specification at time t is run too.

Unobserved, time invariant firm fixed effects are eliminated by time demeaning - subtracting the individual means of the variables as in (Wooldridge (2002), p.267):

$$Y_{it} - \overline{Y_{it}} = (X_{it} - \overline{X_{it}})\beta + U_{it} - \overline{U_{it}} \tag{3.1}$$

where Y is a variable of interest, X - covariates and U - an error term. More specifically, what is being estimated here has a following form:

$$\left(\frac{\text{Energy}}{\text{Turnover}}\right)_{it-1} = \text{Exporter}_{it} + \text{Controls}_{it-1} + \epsilon_{it-1} \tag{3.2}$$

Energy intensity is measured as firm's total energy purchased relative to its turnover, Controls includes ownership dummy, size (total wage bill) and size squared, capital, skill intensity, year and industry (at NACE 3 level) dummies.[7] Since energy intensity variable on the left hand side is proportioning the costs of energy by turnover of the firm to account for its size, labour productivity, measured as turnover per worker is therefore excluded from the control variables on the right hand side. An additional account is taken of firm's size and its squared measure instead, together with a proxy for capital.[8]

[7] In some specifications total employment is used instead of wage to control for size but this does not change any of the derived results.

[8] To make sure exclusion of labour productivity is not affecting the main results, estimations are re-run with labour productivity included on the right hand side, see Section 5.

Exporter_{it} dummy is the main variable of interest here. Conditioning on other firm characteristics one period before, this variable shows how a future change in exporting status affects firm's energy intensity prior to start of exporting. More specifically, whether a firm switching to exporting in period t, adjusts its energy intensity at a time $t-1$ in a way significantly different from that of a non-exporting firm.

Alternatively, as mentioned above, to confirm some of the main findings, estimations of the model at a time t to estimate contemporaneous effects of change in export status are run:

$$\left(\frac{\text{Energy}}{\text{Turnover}}\right)_{it} = \text{Exporter}_{it} + \text{Controls}_{it} + \epsilon_{it} \tag{3.3}$$

To single out the effect due to export start only, the sample is limited to firms who switch to exporting during their reported CIP life-span, contrasting them with firms who never exported. In order to make sure the effect captured is that of a firm switching from non-exporting to exporting status (0 to 1 in terms of the variable of interest) and not the other way round, the sample is trimmed to include only the non-exporting firms and firms that switch to exporting just once in their observed in the data life-span. Firms that stop exporting are excluded from the sample.

4 Empirical implications of export destinations

This section presents findings for the adjustments of firms' energy behaviour before they start exporting to more versus less regulated destinations. As outlined in Section 3, results are derived for export-starters with majority of their export going either to a more regulation export destination of Europe (sometimes including the USA) versus a less regulated destination of the rest of the world (ROW). These export starters are compared to non-exporters, although some robustness checks are run on that, see Section 5 for more detail. The main variable of interest is the effect export start has on firm's relative energy use one period before as per specification in equation 3.2.

4.1 Average effects of export destinations

We start by looking at whether on average export destination matters for export starters. Table 1 shows the estimation results. No significant changes in relative energy use are found for firms exporting into either of the destination areas, when they are compared with non-exporters.

Table 1: Exporters to Europe vs ROW, mean effects

	Mean effects
Exporter to EU+USA	0.03863
	(0.06896)
Exporter to ROW	0.10584
	(0.13528)
Ownership_{t-1}	0.00994
	(0.22396)
Size_{t-1}	-0.19054*
	(0.10181)
Size^2_{t-1}	0.38505*
	(0.23358)
Capital_{t-1}	-0.12118
	(0.17564)
Skill_{t-1}	0.04074**
	(0.01761)
Observations	13957
Number of firms	2586
R-squared	0.09

Standard errors in parentheses $***p < 0.01, **p < 0.05, *p < 0.1$
Dependent variable: total energy purchase per turnover at time $t-1$.
The reported coefficients are standardised. Variables are standardised by subtracting off their means and dividing by their standard deviations, see Wooldridge (2006), page 195.
The model includes year and 3 digit industry dummies and a constant, which are not reported.

4.2 The most polluting industries

However, as argued on the source country regulation side by e.g. Ederington et al. (2005) and Cole et al. (2010) a more differentiated approach is needed when attempting to discern an effect of regulations. The more polluting industries are found to be more responsive than all other industries to regulatory pressure at home, resulting in significant changes of their sourcing patterns from abroad. Similar dynamics might be true for when deciding to start exporting to destinations known to have higher environmental preferences. Besides, pollution abatements costs in the most polluting industries are likely to yield larger improvements, compared to less polluting ones. The next step, therefore, is to focus on industries classified as the most polluting ones as the effect of export destination country regulations is more likely to be found there.

Later the analysis is also performed on the most energy-intensive firms and industries, and firms producing in one of the industries subject to energy-efficiency labels of their end products.

To identify the most polluting sector, I follow a classification of Cole et al. (2005) that lists the most polluting industries for the UK, based on various emissions, of Cole and Elliott (2005) that has similar list for the USA. I also take a set of industries affected by the EU ETS (the European Union Emissions Trading Scheme) in the EU. Table 8 in Appendix A lists the details of what groups of industries were looked at as the most polluting. There is a significant overlap of industries in all three groups with industries of pulp and paper, coke, petrolium products, non-metallic products and basic metals manufacturing being present in all 3 groups. Table 2 reports results for export starters to Europe and the ROW if they are producing in one of the heavily polluting industries in first two rows.[9]

Table 2: Exporters to Europe vs ROW, mean effects on the most polluting industries

	USA classification	UK classification	EU ETS classification
Exporter to EU, polluting	-0.26640*	-0.33842**	-0.57707**
	(0.13741)	(0.16589)	(0.25763)
Exporter to ROW, polluting	0.50526*	0.49078	1.37616***
	(0.30590)	(0.30984)	(0.10124)
Exporter to EU	0.12776	0.11690	0.09398
	(0.08580)	(0.07608)	(0.06890)
Exporter to ROW	-0.07536	-0.07530	0.00045
	(0.11397)	(0.11443)	(0.09921)
Ownership_{t-1}	0.01128	0.01560	0.01716
	(0.22347)	(0.22307)	(0.22183)
Size_{t-1}	-0.19226*	-0.19066*	-0.18918*
	(0.10161)	(0.10161)	(0.10180)
Size^2_{t-1}	0.36702	0.35544	0.33227
	(0.22952)	(0.22852)	(0.22620)
Capital_{t-1}	-0.09973	-0.08916	-0.06610
	(0.17033)	(0.16875)	(0.16514)
Skill_{t-1}	0.03880**	0.03877**	0.03917**
	(0.01781)	(0.01775)	(0.01773)
Observations	13957	13957	13957
Number of firms	2586	2586	2586
R-squared	0.09	0.09	0.09

Standard errors in parentheses $***p < 0.01, **p < 0.05, *p < 0.1$
Dependent variable: total energy purchase per turnover at $t-1$, all coefficients are standardised.
The model includes year and 3 digit industry dummies and a constant, which are not reported.

Exporter to EU and Exporter to ROW dummies control for average effect of exporting to either destination. The first two rows of the table produce key results for this study.

[9] There are no majority export starters to the USA in the more polluting industries or industries with their products subject to energy labels so the analysis is effectively carried out for export starters to either Europe or ROW.

They show that, on average, when controlling for the mean effect of exporting to either destination, those firms who produce in the one of the more polluting industries tend to significantly improve on their energy intensity before starting to export to Europe but not when they start exporting to ROW. The magnitudes differ due to differences in classification of the most polluting industries either according to the list made for the USA, UK or the EU ETS respectively but the overall trend is the same. Firms in the most polluting sectors exporting to ROW either do not exhibit any adjustments in energy use associated with export start or actually increase their energy use before starting to export, depending on the industries included. This finding, however, is not very robust to other specification tests.

4.3 High energy intensity and energy labels

Another category of firms under consideration are high-energy intensity firms (firms with relative energy intensity of above median) or all firms in energy-intensive industries. Similar to firms in the most polluting industries, those firms might also have a higher benefit of improving their energy use before starting to export to a more regulated and demanding area of the EU. Moreover, previous study by Batrakova and Davies (2010) found that if regulations and preferences are expected to have any improving effects on exporters' energy use, those technology adjustments will be happening on the higher end of firms' energy intensity distribution. Therefore, the focus group here is twofold: firms with energy intensity above the median or all firms in the top 6 energy-intensive industries.[10]

Table 3 demonstrates outcomes of estimations for these two groups of firms. Results show that while starting to export to the EU for all firms in the most energy-intensive industries has no effect on relative energy use (similar to export starters to the ROW), there is a clear significant downward adjustment of relative energy use for export starters to the EU when the sample is trimmed to include only firms with relative energy use (energy intensity) above median. And no significant changes in energy use are found for the more energy-intensive firms starting to export to the ROW.

This would suggest that energy intensity does matter for introducing significant adjustments in energy when starting to export to the EU, but only on the level of a firm, not an industry. Again, for firms exporting to the rest of the world region with lower degree of regulations, this does not matter.

[10]The most energy-intensive industries are food; textiles; coke, petrolium products; rubber and plastic products; non-metallic products; basic metals.

Table 3: Exporters to Europe vs ROW, high energy-intensity firms/industries

	High energy-intensity firms	High energy-intensity industries
Exporter to EU+USA	-0.11231**	0.11108
	(0.04861)	(0.08992)
Exporter to ROW	-0.33205	-0.00781
	(0.30392)	(0.12687)
Exporter to EU+USA, heavy		-0.19683
		(0.13188)
Exporter to ROW, heavy		0.39690
		(0.40196)
Ownership_{t-1}	0.13417	0.00870
	(0.10004)	(0.22282)
Size_{t-1}	-0.03945	-0.18667*
	(0.16544)	(0.10214)
Size^2_{t-1}	-0.82909	0.37023
	(1.38813)	(0.23073)
Capital_{t-1}	0.38626	-0.10992
	(0.29693)	(0.17170)
Skill_{t-1}	0.03609**	0.04135**
	(0.01670)	(0.01743)
Observations	7090	13957
Number of firms	1630	2586
R-squared	0.09	0.09

Standard errors in parentheses $***p < 0.01, **p < 0.05, *p < 0.1$
Dependent variable: total energy purchase per turnover at time $t-1$, all coefficients are standardised.
High energy intensity: all firms with relative energy use at above median level.
The model includes year and 3 digit industry dummies and a constant, which are not reported.

As a last step, I single out those industries, whose products are subject to energy labels. Those are production of white goods, cars and light bulbs when those are sold on the European market. Repeating the analysis as performed above reveals that there is only tenuous evidence as to the fact that starting to export to the EU might bring about energy adjustments for firms producing one of those goods. This is not entirely surprising as there is not necessarily a direct connection between improving energy efficiency of the end products and improving energy efficiency of their manufacturing process as a result. However, there is some evidence on absolute energy use improvements for EU exporters and although the finding is not very robust, it points towards existence of such connection in some cases.[11]

[11] Results not reported here to save space, but available on request.

4.4 Contemporaneous effect of exporting

Although the main focus of the paper is to establish whether firms adjust their energy intensity one period before starting to export according to the perceived preferences and regulatory strength of an export destination, these energy saving adjustments may not fully come through and bear fruit until the time a firm actually starts exporting. Therefore, the estimations are repeated for time t according to the specification as defined by equation 3.3 in previous Section. Selected results are reported in table 9 in Appendix A to save space as they confirm the main findings described above.

Before moving on to extensive testing of the robustness of the key findings, let's go over these again. The empirical evidence supports the notion that firms starting to export to the EU adjust to regulatory and preferences pressure there, but only if those firms produce in one of the more polluting industries or are energy-intensive. There is only weak evidence that producing energy-labelled products and exporting to EU leads to energy improvements as well. Starting to export to ROW does not compel firms to improve on their energy use.

5 Robustness Checks

An extensive array of robustness checks was performed on the key findings pertaining to energy improvements found for firms exporting to the EU in the more polluting sectors as compared to firms exporting to ROW. Robustness checks are described in detail below.

More detailed export destinations

The main concern of using export destination of the rest of the world is the high degree of aggregation of that region. It might include both developed, OECD countries and developing, non OECD ones. That would confuse the estimations as the expectations are that the firms improve their energy use before they export to a more regulated destination, as opposed to a less regulated one. To try and circumvent this data issue, a use is made of an additional dataset which details firms' trade transactions in the period of 2005-2007. The exact export destinations are known for those firms. Using information from the trade transactions dataset the firms are divided into majority Europe, OECD or non-OECD exporters based on the same method as described in detail in Section 2. Europe region here comprises all EU members - old and new ones and non-EU European countries: Switzerland, Norway and Iceland. Since the detailed data on export destinations are available for just the three years of 2005-2007, the assumption is made that a majority exporter into one of the major destination groups defined above in that period is a majority exporter into that group for the whole duration of the CIP firm-level dataset of 1991-2008.[12] The same estimations are then repeated as in Section 4. The results confirm significant energy improvements one period before for firms in the more polluting sectors starting to export to Europe or OECD the next period, found in main estimations. The absolute magnitude of the relative energy adjustments is higher for firms exporting mostly to the OECD than Europe, which would conform with the prediction of the productivity hypothesis.[13] What's more important, the absence of such improvements is found for firms in the more polluting sectors mostly exporting to the developing, non-OECD region, which would suggest that the ROW results found in the main estimations are driven by the developing, not developed set of countries in that group.[14]

Do non-exporters drive the results?

It might plausibly be the case that firms who are less efficient about their energy select into staying non-exporters. The energy efficiency improvements observed for export starters to the EU in the most polluting sectors could then be simply driven by the fact that non-exporters they are compared to are extremely energy inefficient. To check that the results are not driven by this, the same fixed effects estimation as in table 2 was run for just a sample of export starters to both destinations as compared to each other and not to non-exporters. The downward energy adjustment (energy improvement) observed for the export starters to EU is still present and statistically significant.

The results also hold when reducing the sample to the more polluting industries to only compare the more polluting exporters and non-exporters.

Do firms that have always been more energy efficient select into EU export?

Another serious issue to consider is interpretation of the energy improvement of export starters to the EU one year before exporting, which, although continuing consistently onto the next year of export start, might be a sign of more energy-efficient firms selecting into exporting to Europe. To see whether it's the firms that have always been more energy efficient that self-select into exporting to the EU and not ROW, specification as

[12]An assumption not entirely presumptuous, as firms exporting most of their value to Europe or OECD in 2005-2007, have probably done so beforehand too. Firms mostly exporting to the developing region might have started off by exporting to Europe first, in which case the effect found would represent a lower bound estimate. The reverse situation of firms exporting to developing region first, before turning to be a majority exporter to Europe or OECD is deemed not very likely. Europe is the closest destination for Irish firms and therefore it takes a lower productivity cut-off to start exporting there.

[13]The findings of Chaney (2008), Helpman et al. (2008), Bernard et al. (2007), Eaton et al. (2004) and others suggest that only the most productive firms export to farther destinations. And with energy being an input in the production process, the productivity effect might be observed - firms starting to export to farther destinations reduce their energy use one period before as a part of an overall performance improvement prior to exporting, in addition to any regulatory or preferences pressure.

[14]Caveat to bear in mind, the results for non-OECD destination are obtained in a less restricted specification, which does not exclude export starters which have subsequently stopped exporting. Such as it is, there is no definite way of knowing whether this has an influence on the results due to a small number of export starters into that area within the more polluting sectors.

in equation 3.2 was run for deeper lags of $t-2$ and $t-3$. Results show no significant difference in energy use there. So, there is no significant energy improvement observed before one year prior to export start for firms exporting to the EU in the more polluting sectors.

Export-platform FDI

Ireland has been known for attracting export-platform FDI. The results presented in Section 4, however, are not driven by this. In fact, very few foreign owned firms actually are export starters in the sample. Most of them are continuous exporters. This means that for the most part the analysis is conducted on domestically owned firms starting to export.

Absolute values of energy use

Main results are derived from a specification having firms' relative energy use on the left hand side - relative to total sales to account for scale. When substituting absolute energy use on the left hand side, main findings display the same dynamics as relative ones, that are presented in the main estimations. Again, absolute energy adjustments are only found for firms exporting to the EU in one of the more polluting sectors, according to the list of industries as specified by Cole et al. (2005) for the UK, Cole and Elliott (2005) for the USA or at the set of industries affected by the EU ETS (European Union Emissions Trading Scheme) in the EU.

EU expansion

Since the period covered in the analysis includes the EU expansion time in 2004, estimations were re-run on the separate period of pre- and post-expansion. Results hold for before 2004.

UK as a separate region

UK plays an important role as a major destination of Irish exports. To see whether this destination alone is responsible for all the observed outcomes, the firms were divided into majority exporters to the UK, the EU and ROW. Results show that it is a weight of combined UK and EU shares that matter and not one of these destinations separately.

Results also hold for a number of other checks.[15] Accounting for firms' labour productivity, which was not included due to possible problem of sales variable already being present on the left hand side, does not affect any main findings. Neither does including firm's importing status.

Results hold when reducing the sample to post 1994 to account for CSO data collection issues and when controlling for destination or industry specific year effects. Results also hold if export share of one region is 2/3 of the total or more.

[15] General remark is in order, that the results are the most robust to a battery of various checks when chemicals sector is removed from a list of the most polluting industries.

6 Conclusions

This study sets out to look at whether destinations of export and different degrees of regulations and preferences associated with them matter on a level of a firm. The analysis is done by making use of Irish manufacturing firm level data from the period of 1991-2008 that allows to distinguish between broadly defined export destinations of Europe and the rest of the world (ROW). The main prediction that is being tested is that stricter environmental preferences and regulations in the EU would lead to some firms improving their energy use before commencing to export there. In contrast, the rest of the world is seen as a less regulated area and firms deciding to start exporting there would not necessarily undergo such improvements. As adhering to perceived tighter standards and preferences is more cost-effective for the most polluting or energy-intensive firms, they become the main focus of this analysis. Although industries whose end-products are subject to mandatory EU energy efficiency labels are studied too.

This prediction is borne out by the data. Firms starting to export to the EU significantly reduce their energy use if they are either in one of the most polluting industries according to several classifications previously outlined in literature, or if those firms are on the higher end of energy intensity (relative energy use) distribution. Firms starting to export to the rest of the world do not significantly alter their relative energy use. The latter finding is likely to be driven by the developing, non-OECD countries comprising this aggregate region and not by the more developed nations within it. There is also some, albeit, weak evidence to the effect that some energy improvements might also occur on the absolute energy levels for firms starting to export to the EU if their end products are subject to energy-labelling regulations.

So, the study has found strong evidence that firms do respond to the regulatory pressure and strong environmental preferences of the developed region of the EU where the energy improvements and abatement are the most efficient, i.e. the more polluting industries and the more energy-intensive firms. This might have some important policy implications, such as that signing free trade agreements with countries with higher environmental regulations may result in some motivation of the most polluting home exporters to improve their energy use.

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.

Datawork

Some essential data cleaning was performed prior to commencing the analysis. All of the changes are described below.

Negative or missing values of fuel and export share and zero values of employment, earnings and turnover in few instances where possible were replaced using values from previous and later years, the rest - set to missing.

For instances of export shares bigger than 100 their values were replaced using values from previous and later years. Export share values that could not have been replaced were treated as follows. Firms which did not have export share equal to 100 in any other years were dropped from the sample. If a firm had at least one occurrence of export share equal to 100 in other years the value of export share larger than 100 was set to 100.

The top .25 percentile of relative energy use observations is removed to control for extreme outliers.

Table 5: Definition of variables

Variable	Description
Relative energy use	Total fuel and power purchase (energy) as declared by firms in the CIP, scaled down by total labour costs.
Exporter	Dummy variable equal to 1 if a firm exports in any given year and 0 otherwise. For matching estimations exporters are defined as firms that switch to and stay exporting: firms that do not export 3 years prior to switching to exporting and then export for at least 3 years. We contrast firms that switch to and stay exporting with firms that have never exported.
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.
Size	Total earnings.

Table 6: Summary Statistics, Manufacturing

Variable	Mean	Std. Dev.	Min	Max
Total energy use	220.04	1569.74	0	121904.20
Energy per turnover	0.0299	0.041	0	2.834
Export share	25.68	36.42	0	100
Total Turnover	16966.48	188678.73	0	11416253
Total Earnings	1268.87	4831.02	0	232037.38
Total Employed	50.30	144.35	0	4554
Labour Productivity	140.90	350.04	0	14471.48
% High-Skilled	25.04	18.82	0	100
Capital	2571.40	36515.90	-84260.71	3897787
R&D	355.99	11396.25	0	1248941.38

Reported are mean values over the period of 1991-2008. All monetary values are in EUR thousands.

Table 7: Exporters vs non-exporters

Exporter	Rel. energy	Productivity	Total Earnings	Employment	% High-Skilled	Capital	N
Europe	0.0326	148.39	1055.84	44.82	25.03	1823.64	3727
Europe, heavy	0.0357	196.25	1014.82	34.27	24.00	3698.12	1216
ROW	0.0223	108.02	824.61	33.79	32.61	13780.99	77
ROW, heavy	0.0277	103.09	1264.08	46.56	34.62	28890.79	36
No	0.0303	106.25	440.73	20.08	21.61	416.60	12708

Reported are mean values over the period of 1991-2008. All monetary values are in EUR thousands.

Table 8: The most polluting 2 digit industries

Classification	Industries
Cole et al. (2005) for the UK	wood (20); pulp and paper (21); coke, petrolium products (23); chemicals (24); non-metallic products (26); basic metals (27).
Cole and Elliott (2005) for the USA	tobacco (16); leather and leather products (19); wood (20); pulp and paper (21); coke, petrolium products (23); chemicals (24); non-metallic products (26); basic metals (27); fabricated metal products (28).
Set of industries affected by the EU ETS (the European Union Emissions Trading Scheme)	pulp and paper (21); coke, petrolium products (23); non-metallic products (26); basic metals (27).

Indicated in parentheses are the NACE 2 digit industry number under Rev 1.1.

Table 9: Exporters to Europe vs ROW, mean effects at time t

	Mean effects	USA classification	UK classification	ETS classification
Exporter to EU, polluting		-0.25384**	-0.34401**	-0.67418***
		(0.11964)	(0.14202)	(0.22267)
Exporter to ROW, polluting		0.04756	0.04823	-0.22423***
		(0.13474)	(0.12889)	(0.07558)
Exporter to EU	-0.00265	0.07944	0.07473	0.06020
	(0.05998)	(0.07256)	(0.06544)	(0.05914)
Exporter to ROW	-0.01861	-0.03882	-0.03250	-0.00487
	(0.07019)	(0.11596)	(0.08745)	(0.07258)
Ownership_t	0.01749	0.01947	0.02424	0.03234
	(0.20953)	(0.20917)	(0.20880)	(0.20730)
Size_t	-0.18347*	-0.18467*	-0.18237*	-0.18104*
	(0.10087)	(0.10079)	(0.10091)	(0.10065)
Size_t^2	0.41520*	0.39314*	0.37713	0.35518
	(0.24164)	(0.23831)	(0.23720)	(0.23077)
Capital_t	-0.11891	-0.09592	-0.08291	-0.06411
	(0.16682)	(0.16260)	(0.16098)	(0.15409)
Skill_t	0.04236**	0.04176**	0.04157**	0.04227**
	(0.01706)	(0.01700)	(0.01703)	(0.01702)
Observations	17022	17022	17022	17022
Number of firms	3088	3088	3088	3088
R-squared	0.09	0.09	0.09	0.10

Standard errors in parentheses $***p < 0.01, **p < 0.05, *p < 0.1$
Dependent variable: total energy purchase per turnover at t, all coefficients are standardised.
The model includes year and 3 digit industry dummies and a constant, which are not reported.

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