On the relationship between trade and sustainable transport: A quantitative assessment of the importance of environmental performance and transport externalities

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Abstract

This paper analyses the effect of international trade, environmental performance and transport externalities on an indicator that might be used for monitoring the progress on the integration of the principles of sustainable transport into national policies: CO_2 emissions arising from transport of goods. In a first step, an indicator for global transport emissions is calculated by using existing information on CO_2 emissions. Second, a trade-weighted distance indicator is constructed by taking into account the relative growth of maritime exports, as sea transport is less pollutant than terrestrial and air transport. Third, we analyse the relationship between trade and global transport emissions according to existing environmental performance levels. To do so, we consider both a *narrow* and a *broad* indicator of environmental performance. Finally, we study the role of transport externalities. By considering different regions within Spain and their trading partners over the period 2000-2008, we are able to distinguish two different shapes for the relationship between trade and global transport emissions and, in particular, a U-inverted shape for trade with trading partners with a lower environmental performance. Our results show that environmental performance reduces global transport emissions related to trade activities. In addition, negative externalities for the environment derived of transport facilities agglomeration co-exist, although they might be partially offset by national regulations that guarantee the commitment towards a *clean* environment.

Keywords: sustainable transport; global transport emissions; environmental performance; transport externalities; Spanish exports.

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1. Introduction

Increasing trade liberalisation has had important economic consequences in terms of exports and, hence, transport emissions. Interestingly, transport is one of the most contaminating economic activities in terms of CO_2 emissions, although transport modes differ in terms of pollution (Zafrilla *et al.* 2012). In the World Ocean Review (2014) it could be recently read: "according to International Maritime Organization (IMO) estimates, world shipping is responsible for about 3 per cent of global CO_2 emissions. Of the total emissions from the transportation sector, shipping accounts for 10 per cent, road traffic 73 per cent and air traffic 12 per cent. Losses from pipelines contribute 3 per cent, and rail traffic 2 per cent. Experts predict that, unless further measures are taken to protect the climate, emissions from the transportation sector will double by 2050. From shipping they could approximately treble." In this vein, Cristea *et al.* (2013) have shown that international transport emissions will rise faster than trade, due to both a rise in trade at a distance and an expansion of air cargo. According to their obtained results, rail and road usage is substantially reduced while international aviation and maritime transport increases quickly.

Although it might seem that, from a sustainable transport perspective, international trade is harmful for the environment, it is important to note that previous related research assumed away changes in modal usage within a particular trade flow over time. From a different framework and in support of international trade, Esty and Porter (2001) highlighted that limiting trade is a "recipe for environmental failure", as economic growth is a key mechanism for improving environmental results. As pointed out by Moldan *et al.* (2012) "the objective, then, is to conserve natural resources to ensure continued development and to support all life" (page 5) and they state that sustainable transport is one of the European Union (EU) main objectives within the environmental realm.

In order to shed some light on the relationship between trade and sustainable transport, we focus on the role of exports instead of intra-national trade as there is emerging micro-level evidence showing that exporters have lower CO_2 emissions than comparable domestic firms (Forslid et al. 2012). In particular, the present paper aims to analyse the determinants of global transport emissions in a multi-regional and multi-country framework. We account for changes in modal usage, environmental performance and transport externalities. To do so, we focus on the Spanish case.

The critical issue of country identification warrants further discussion. On the one hand, Spain's main trading partners are EU members.[1] On the other hand, Spanish transport of goods within Europe is road intensive (Tarancón and Del Río, 2007). Therefore, to trade more in shorter distances might be bad for the environment if goods are mainly transported by road. Specifically, Tarancón and Del Río (2007) quantify the contribution of transport sectors, accounting separately for emissions from households, to the overall CO_2 emissions in Spain, being 3.63% in terrestrial transport, 1.86% in air transport and 0.86% in sea transport in year 2000.

The most recent literature that quantifies the effect of trade liberalisation on transport-related CO_2 emissions uses a general equilibrium framework (CGE) (Cristea *et al.* 2013, Vöhringer *et al.* 2013) and then, their results depend on parameter assumptions. Otherwise, we focus on partial equilibrium and we take into account both regional and country data as well as information of transport CO_2 that include emissions from international aviation and international maritime bunkers. So, we rely on the information provided by the International Transport Forum (ITF).

[1] Main export partners: France 16.8%, Germany 10.8%, Italy 7.7%, Portugal 7.1%, the UK 6.5% (in 2012). Source: The World Factbook.

Methodologically speaking, in a first step, we use trade data (total and maritime) and geographical distance among trading partners to calculate a trade-weighted distance indicator. We use this measure to study whether there is a turning point for which increasing trade at longer distances do not imply higher trade-related transport emissions. In a second step, we focus on existing environmental performance, as we expect that the abovementioned constructed trade-weighted distance has a different effect on those trading partners that commit towards a *clean* environment. To account for variability over time, as well as regional and country heterogeneity, we consider both a *narrow* and a *broad* indicator of environmental performance. Finally, spatial econometrics techniques are used to take into account the importance of transport externalities, i.e. the agglomeration of transport investment which might have substantial spillovers on emissions (agglomeration effect). In this sense, Spain is an interesting case to study as this country is characterised by an extensive network of roads, railways, rapid transit, air routes and ports.

Our paper is organised as follows. In Section 2 we present the main hypotheses and links to the existing literature. Section 3 and 4 include the explanations about the methodology and indicators used, respectively. The main results and simulations are presented in Section 5. The final section contains our conclusions and policy implications.

2. Hypotheses and links to existing literature

There are two main streams of literature that have a bearing on the interdependences between international trade and sustainable transport. First, the original trade and environmental literature focused on identifying how comparative advantage influenced the effect of trade liberalisation on reducing local pollutants such as sulphur dioxide that were primarily related to industrial production. With competing pollution haven and factor endowment effects, some countries gained and some countries lost. In the long term, the positive effect of trade liberalisation on income leads to a technique effect: higher income translates into a cleaner environment when the environment is a normal good, as makes people demand a cleaner environment through domestic policy instruments (Copeland and Taylor, 1994; Antweiler *et al.* 2001). More recently, this strand of literature was concerned with global pollutants (Cole and Elliot, 2003; Managi *et al.* 2009).

Trade liberalisation may change the extensive and intensive margins of trade and expand trade to more distant countries along the lines of a gravity model (see for example, Bensassi *et al*, 2012 and Florensa *et al*, 2014). One issue that has been recently addressed is that international trade requires international transportation of goods, which in turn generates emissions (Vöhringer *et al.* 2013), then transportation is a consequence of the pattern of specialisation that is driven by comparative advantage. When taking into consideration various combinations on how trade and climate policies could go forward, Vöhringer *et al.* (2013) state that "regional trade liberalisation [for instance] is expected to lead to increased short-distance transport and decreased long-distance transport. A regional carbon tax may lead to an increase in emissions by non-taxing countries, through the much discussed carbon leakage effect" (page 281). In this vein, Cristea *et al.* (2013) show that with trade liberalisation, distant trade rises and land modes fall, while Bensassi *et al.* (2013) claim that the geography of international trade should be considered as a source of pollution. Specifically, Bensassi *et al.* (2013) argue that trading over short distances should generate lower emissions than trading over long distances, however, this positive relationship between distance and emissions, could be offset by the use of different transport modes, as less energy-intensive modes of transport are used over longer distances (i.e. sea transport).

Going into the implications of the work by Bensassi *et al.* (2013), Cristea *et al.* (2013) and Vöhringer *et al.* (2013) and for the case of Spain, we might expect that global transport emissions increase with geographical distance, but up to a point from which longer distances are not reflected on higher global transport emissions. In this sense, it seems plausible that if there is an increase of exports from Spanish regions addressed to countries further apart, an increase in trade might be *good* for the environment, as global transport emissions decrease. Then, our first hypothesis is that there is a U-inverted relationship between our trade-weighted distance indicator and global transport emissions (H1).

Esty and Porter (2001) presented a series of results showing that environmental output varies not only with income levels, as suggested by the environmental Kuznets Curve literature, but also with the sophistication of a nation's regulatory regime. In fact, important differences in environmental performance occur among countries at similar economic levels. In this regard, carbon mitigation policies may affect energy usage and the emissions it generates. Then, CO_2 emissions derived from transport activities should be considered not only at the origin, but also at the destination of trade flows. For Spain, Zafrilla *et al.* (2012) argue that there is a significant improvement in energy and environmental efficiency from 2000 onwards, which is explained, in part, by the application of environmental policies. In addition, the effect of trade on transport emissions might be sensitive to the fact that Spanish trading partners have also implemented environmental regulations, such as environmental provisions in regional integration agreements (RTAs) and carbon taxes. For example, Baghdadi *et al.* (2013) distinguished between RTAs with environmental provisions and those that do not include any harmonisation in environmental standards as part of the agreements, finding that RTAs that include environmental provisions are able to contribute to lower global transport emissions. Nonetheless, the framework followed by Baghdadi *et al.* (2013) does not allow to analyse the role of trade on the environment for different regions within a specific country, as is our case, as RTAs are negotiated at country-level. Nonetheless, we could argue that if origin regions and/or destination countries have implemented environmental standards, there is a commitment towards a *clean* environment that might be reflected on lower transport-related emissions.

The importance of international cooperation in environmental issues is discussed in Vöhringer *et al.* (2013). These authors highlight that emissions from international transport are conditional on the type and extent of trade and climate policies considered. According to results provided in Vöhringer *et al.* (2013), if international cooperation includes climate policies, emissions decrease. These authors conclude that emissions from international transport always increase, although they do not consider the actual modal split in conjunction with environmental performance. In fact, they obtain that the larger growth rate of international transport emissions is due to an agriculture effect, as this sector is characterised by both large trade barriers and high transport costs. In this aspect, if transport literature is taken into account, this argument is not very realistic for at least two reasons. First, it ignores the importance of containerisation for world trade (Bernhofen *et al.* 2013) and second, it also ignores the existence of trade imbalances, i.e. international trade flows are heavily imbalanced between areas (Márquez-Ramos *et al.* 2011). In fact, even more than container traffic, transport flows in the bulk sector are usually subject to directional imbalance. Mineral resources are often geographically distant from where they are processed. Large ore and coal freighters and crude oil tankers are therefore only transporting cargo in one direction, from the port of shipment to the port of discharge and they usually return empty (World Ocean Review, 2014). Therefore, the increase of world trade might balance trade between different regions and then, part of the vessels capacity might not be filled with empty containers. It is also important to highlight that Vöhringer *et al.* (2013) use the GTAP database, which makes no attempt to ascribe differences in emission intensities to environmental performance. Instead, it tracks energy used and emissions produced. As a result, possible feedback effects on emissions working through environmental policy are ignored.

The approach followed in the present research allows to take into consideration both environmental performance and changes in modal usage within a particular trade flow over time. Then, pursuing the implications of the work of Esty and Porter (2001), Zafrilla *et al.* (2012) and Baghdadi *et al.* (2013), our second hypothesis tests whether our trade-weighted distance indicator leads to lower transportation-related emissions for trade with countries with higher environmental performance (H2).

With regard to the second stream of literature, a series of empirical studies in regional economics have analysed the role of regional spillovers on trade flows by introducing spatial lags in autorregresive models (see Alamá-Sabater *et al.* 2011 and 2013, for the case of a coastal country –Spain and LeSage and Polasek, 2008 for the case of a landlocked country -Austria). These authors use information on transport facilities to analyse the role of transport externalities, finding that transportation networks matter for trade flows. In the same vein, transport externalities should matter for emissions, as transport facilities concentrate trade traffics and generate emissions. Therefore, we argue that an additional issue should be considered to study the relationship between trade and sustainable transport when taking into account the agglomeration of transport investments: the structure of the territory.

Figure A.1 (Appendix) shows how the distribution of the different regions might have an effect when introducing transport externalities in the analysis. The five matrixes show five different territories, which are all composed by 16 regions. Imagine that we are interested on emissions in neighbouring regions to A and B, as we are interested on trade flows between A and B. Both A and B have three neighbours in territories 1 and 2: C-D-E and F-G-H, respectively. Nonetheless, whereas in territory 1, D (neighbour to A) and G (neighbour to B) are neighbours, regions do not overlap in territory 2. In territory 3, A and B have three and six neighbours, respectively. In this case, two neighbours to A (E and D) are neighbours to two neighbours to B (G and F). In territory 4, both A and B have five neighbours, and three neighbours of A are neighbours of three neighbours to B. Finally, both C and D are neighbours of A and B in Territory 5. Along these lines, our third hypothesis state that the structure of the territory has consequences in terms of magnitude and significance when introducing it as a criteria for vicinity to analyse the role of spatial interactions, i.e. the agglomeration effect might be harmful for the environment (H3), as it is expected, for example, that higher concentration of emissions occur in Territory 5 than in Territory 2, leading to higher global pollution levels.

Table 1 summarises the three abovementioned hypotheses. The level of environmental performance in trading partners in shown on the horizontal axis, and the expected relationship of the trade-weighted distance and transport externalities with global transport emissions is shown on the vertical axis. The table is divided into four quadrants. On the horizontal axis, Quadrants III and IV (Quadrants I and II) represent those trade exchanges of Spanish regions with high (low) environmental performance countries.

Following this table, we can see that it is expected that the agglomeration effect increases global transport emissions, as we might expect an increase of emissions if there are larger transport facilities in neighbouring regions that contribute to concentrate traffics and trade flows (Quadrants II and IV). Nonetheless, the relationship between the trade-weighted distance indicator and global transport emissions depends on environmental performance. It might be expected that transport emissions derived of increasing exchanges of goods with those trading partners that are committed towards a *clean* environment decrease over time (Quadrant III). Meanwhile, it might be expected that increasing trade with further apart countries with low environmental performance increases emissions, up to a turning point that reflects the reduction of emissions derived of the use of more efficient modes of transport (Quadrant I).

Table 1. Summary of the hypotheses

Trade-weighted distance effect	Quadrant I U-inverted shape between trade-weighted distance and global transport emissions (H1)	Quadrant III Inverse relationship between trade-weighted distance and global transport emissions (H2)
Agglomeration effect	Quadrant II Increases global transport emissions (H3)	Quadrant IV Increases global transport emissions (H3)
	Low	*High* *Environmental performance*

3. Methodology

On the one hand, long-distance sea transportation is more fuel-efficient than short-haul trucking. This means that CO_2 emissions per kilometre of distance decrease with distance. On the other hand, overall CO_2 emissions increase with distance for a given transportation technology. The last piece of information is the empirical distribution of transportation distances, i.e. the trade weights. So we lay out the following fundamental relationship:

$$E(d) = T(d) \cdot \mu(d) \cdot d \qquad (1)$$

For a given distance d, total transportation-related emissions are the product of trade volume T(d) at distance d (in euros), the unit emissions for transportation of distance μ(d) (in CO_2 per km and euro), and the transportation distance (in km). This fundamental relationship focuses on trade value instead of weights for two reasons. First, products that are heavy and that are transported long distances, are more likely to be seaborne, and second, road transport is concentrated in the trade of proximate partners in Europe. As a result, road transport represents a very small share of kilometres-kilogram shipped (Cristea *et al.* 2013).

The three hypotheses mentioned in Section 2 should be tested in a (spatial-temporal) bilateral framework, as there is no internationally agreed allocation mechanism for emissions from international aviation and international maritime bunkers. Therefore, we take into account the scale of these emissions, and not their national “ownership” by the following relationship that considers not only geographical distance, but also bilateral trade flows between origin i and destination j over time t:

$$E(d)_{ijt} = T(d)_{ijt} \cdot \mu(d)_{jt} \cdot d_{ij} \qquad (2)$$

As this paper aims to estimate the determinants of (trade-related) carbon dioxide transport emissions, first, we include the index from equation (2) as a regressor in an autoregressive model that allows a non-constant elasticity between CO_2 emissions and $E(d)_{ijt}$ and we specify the dependent variable as a bilateral measure of global transport emissions. We use the first temporal lag of the dependent variable to construct the spatial lag, and hence to control for transport externalities, to avoid endogeneity problems as suggested by Márquez-Ramos (2013):

$$\ln CO2_{ijt} = \eta_0 + \eta_1 \ln E(d)_{ijt} + \eta_2 (\ln E(d)_{ijt})^2 + \eta_3 \ln E(d)_{ijt} \cdot regul_{jt} + \eta_4 (\ln E(d)_{ijt} \cdot regul_{jt})^2 +$$
$$+ \eta_5 BP_i + \eta_6 BF_i + \rho_1 (W_t) \ln CO2_{ijt-1} + \delta_{\text{it}} + \psi_{jt} + \alpha_t + \omega_{ijt}$$
(3)

In equation (3), ln denotes natural logs, ω_{ijt} is the error term; δ_{it} and ψ_{jt} are exporter-time and importer-time fixed effects that capture time-varying exporter and importer scale, composition and technique effects (Grossman and Krueger, 1991),[2] as well as the variability of other economic and legal indicators that have been shown to determine environmental performance, such as the rule of law, protection of property rights, and technological strength (Esty and Porter, 2001). By doing so, we are able to avoid problems arising from an omitted-variable bias that might exist if there are omitted variables correlated with the variables of interest (trade-weighted distance and transport externalities), opposite to previous literature that introduced country-time variables, such as population, land area, income and openness, to control for scale, technique and composition effects and that rely on the use of additional econometric techniques to deal with the endogeneity of the variables (Baghdadi *et al.* 2013).

Next, we interact the variable $E(d)_{ijt}$ with a dummy variable that takes the value of one if the trading partner j has a high environmental performance, and zero otherwise. In a first step, we consider whether regions i ($regul_{it}$) and countries j have implemented environmental standards in year t ($regul_{jt}$). In a second step, we use a dummy variable that takes the value of one if the importing country presents a higher environmental performance than the average in the sample, and zero otherwise.

Note that quadratic functions are frequently used in applied economics to capture decreasing or increasing marginal effects (Wooldridge, 2009) and then, we include two quadratic terms of *lnE(d)*, as the effect of this variable on emissions might turn around (hypothesised in H1). By doing so, the elasticity of global transport emissions with respect to *E(d)* is $\eta_1 + 2\eta_2 \ln E(d)_{ijt}$, so that it depends on the log of *E(d)*. Similarly, the elasticity of global transport emissions with respect to *E(d)* when the importer has a high environmental performance is $\eta_1 + \eta_3 + 2\ln E(d)_{ijt}(\eta_2 + \eta_4)$.

BP_i and BF_i are additional controls in the form of dichotomic variables that take a value of one when i share a common border with Portugal (BP) or France (BF), as it is expected that border regions concentrate trade traffics and emissions.

In order to take into account the direction of the causality in our regressions (i.e. if the transport facilities in neighbouring regions are larger and regions have polluted more in previous years, then emissions increase), the effect of the interaction of the lagged

[2] The scale effect is linked to the size of the economy (i.e. increased economic activity leads *ceteris paribus* to increased emissions); the composition effect to its capital/labour endowments (i.e. changed specialisation patterns across countries and sectors with different emission intensities can trigger changes in overall emissions) and the technique effect to the new production technologies available (i.e. through increased income and technology transfer, trade can lead to cleaner production technologies).

dependent variable on emissions is analysed. In this way, we are be able to isolate the effect of the interaction of lagged global transport emissions (in year t-1 = for example, 2007) and neighbours' transport facilities on emissions (in t = for example, 2008).

Finally, α_t are time-specific dummies that control for factors common to all regions and countries. They allow to capture, for instance, the effect of oil prices and of other events that are time specific and affect CO_2 emissions, such us the boom in the housing sector or the beginning of economic and financial crisis in Spain (Zafrilla *et al.* 2012). Furthermore, it has been well recognised that a key driver of transportation is the cost of fuel. During the time of the oil price spike in July 2008, some authors even foresaw the age of deglobalisation as costlier transportation would surely reduce trade. The time period covered by the empirical work covers one oil price shock.

Estimation of equation (3) is central to analyse whether changes on global transport emissions might be due to changes on the geography of the international trade, environmental performance and transport externalities: The sign and magnitude of η_1 and η_2 tests for Hypothesis 1 (H1); the sign and magnitude of η_3 and η_4 test for Hypothesis 2 (H2) and the sign and magnitude of ρ_1 tests for Hypothesis 3 (H3).

4. Indicators

The empirical model involves all the 19 Spanish regions at NUTS2 as origins and 29 countries as destinations.[3] Our time framework covers the period 2000-2008 as the most recent research for Spain covering this time framework has shown that emissions from international freight transport have been increasing and corroborate that there is a change of mode of transport for agricultural trade from the EU: shipping decreases while transport by road increases (López *et al.* 2013). The presence of missing/zero values in the bilateral trade flows data reduces the sample to 3,816 observations.

The data and variables used in this research come from different statistical sources, which are listed in the Appendix A. Summary statistics of the variables *lnCO2* and *lnE(d)* are also presented in Appendix A (see Table A.1 and Table A.2). The largest Spanish regions are those that present higher CO_2 transport emissions (Andalusia, Catalonia and Castile-Leon), whereas the United States is the country with the largest CO_2 transport emissions in our sample. Two landlocked Spanish regions (Castile and Leon and La Rioja) present the lowest value of *lnE(d)*; while the highest value of this variable is for a number of Spanish regions with New Zealand as a trading partner.

4.1. On the measurement of global transport emissions

With regards to CO_2 transport emissions, Vöhringer *et al.* (2013) refined the transport data from GTAP in their CGE model and CO_2 emissions were attributed using data from the International Energy Agency (IEA); Cristea *et al.* (2013) converted trade flow data expressed in value terms into ton-km and then applied emission coefficients and Bensassi

[3] **Exporting regions:** Andalusia, Aragon, Asturias, Balearic Islands, Basque Country, Canary Islands, Cantabria, Castile-La Mancha, Castile and Leon, Catalonia, Ceuta, Extremadura, Galicia, La Rioja, Madrid, Melilla, Murcia, Navarra, Valencia. Of these regions Aragon, Castile-La Mancha, Castile and Leon, Extremadura, La Rioja, Madrid, and Navarra are landlocked.

Importing countries: Australia, Austria, Belgium, Brazil, Canada, Chile, the Czech Republic, Denmark, Finland, France, Germany, Greece, India, Indonesia, Ireland, Italy, Japan, Malaysia, Mexico, the Netherlands, Poland, Portugal, South Africa, South Korea, Sweden, Thailand, Turkey, the United Kingdom and the United States. Of these countries Austria and the Czech Republic are landlocked. Trade, transport facilities and transport environmental data restrict our sample of destination countries.

et al. (2013) used CO_2 emissions per capita. A major limitation, which is already taken into account in Cristea *et al.* (2013), is that to measure emissions related to global transportation with national statistics capture emissions from short-haul transportation within their border. However, these statistics typically will not incorporate emissions from sea and air transportation as most of these emissions occur outside the jurisdiction of individual countries. As a consequence national statistics capture only a very small part of transportation-related emissions from global trade.

Therefore, we use two different sources for environmental outcomes. First, we calculate a multiplier for regional (CO_2 equivalent) emissions from the figures provided by the Spanish Ministry of Agriculture, Food and Environment (MAGRAMA, 2013).[4] Second, we use the information provided by the ITF on CO_2 transport emissions, which is the only worldwide data on transport emissions.

Cristea *et al.* (2013) state an important drawback of the ITF data: "even if one were to track fuel loaded to individual ports this would be of limited use as ships and planes refueling in a particular port could be carrying cargo of any type between any country pair in the world. Without knowing where fuel is used we cannot evaluate the total emissions associated with a particular trade flow" (page 155), then what it is needed are emissions data linked to individual flows rather than worldwide aggregates. In favour of ITF dataset it might be mentioned that Cristea *et al.* (2013) calculate the quantity of transportation services performed by each mode in each origin–destination–product trade flow, and then multiply by emissions for each mode, yielding to alternative transportation emissions that are close to matching emissions estimates from the ITF based on aggregate fuel usage worldwide.

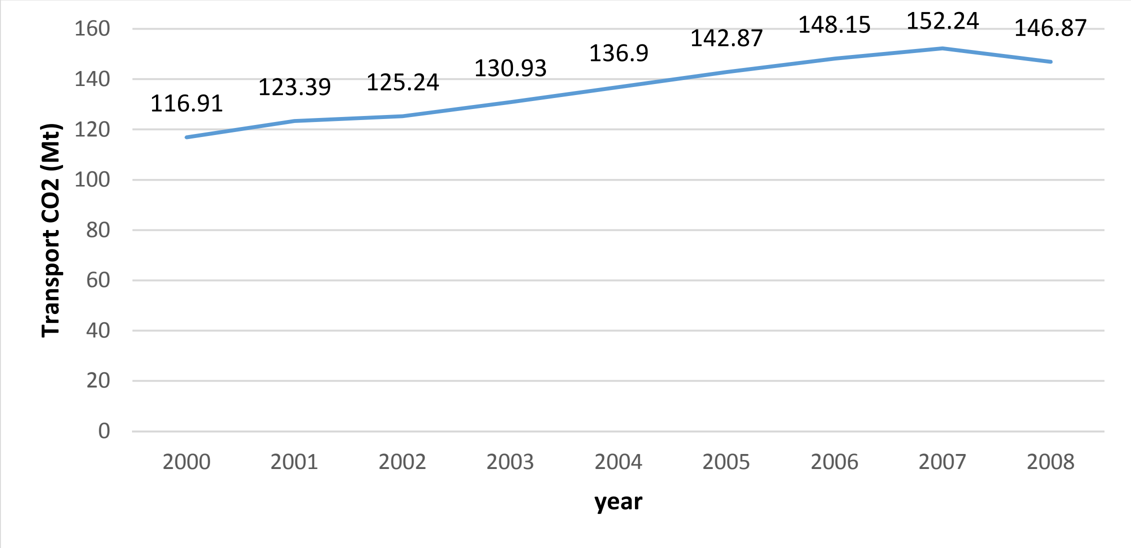
As we focus on exports from Spanish regions to international destinations, we argue that sectoral dissaggregation is not so important to capture the variation of emissions that occur as a consequence of the usage of different transport modes when the geography of trade flows is taken into account: conteneirisation is highly important for Spanish exports. In fact, two Spanish ports are among the top 50 world container ports, these being Valencia (in the Valencian region) and Algeciras (in Andalusia).[5]

Figure 1 shows that there has been an increase on global transport emissions in Spain over the period considered in the analysis. Transport activities account for a high percentage of CO_2 from fuel combustion (equal to 41.32% in 2008), however, it is important to highlight that not all these emissions are trade-related, as the vast majority is due to domestic transportation, and most of that is probably due to household transportation rather than industrial transportation.

[4] MAGRAMA (2013) provides with the equivalent CO2 emissions by region and of all Spain. The list of the major categories of activities is as follows: the energy sector industries; combustion in manufacturing industries and construction, transportation, combustion in other sectors, industrial processes, use of solvents and other products, agriculture, land use changes and forestry, and waste treatment and disposal.

[5] See http://www.worldshipping.org/about-the-industry/global-trade/top-50-world-container-ports

Figure 1. Transport CO_2 Mt (2000-2008).



Source: ITF

According to the ITF data, worldwide international maritime plus international aviation transportation was responsible for 2.92% of total emissions in 1990, 3.5% in 2000 and 3.52% in 2008. Although these figures do not change significantly over the time framework considered in this paper, they do not include international road and rail transport. It is important to highlight that these modes might represent a significant fraction of international trade for land-adjacent partners, for example in North America and Europe (Cristea *et al.* 2013). In the case of Spain, and with regard to overland transport, the Pyrenees form a major natural barrier between the Iberian Peninsula and the rest of Europe. With the exception of the coastal strips, the Pyrenees do not currently possess any significant road or rail infrastructure that connects Spain with France. Therefore, it is the desire of the EU and Spain to enhance the permeability of the overland transport networks crossing the Pyrenees (de Oña et al, 2004). In addition, the disadvantage for Spain in the longer-distance European freight markets is partly due to the different railway track gauge used in Spain and France, which clearly makes transit across their common border very challenging. The track gauge has received particular attention in the existing transport literature as it has limited the volume of direct international traffic between the Iberian Peninsula and the rest of the European continent (Martí-Henneberg, 2013). Therefore, transport emissions derived of international rail transport might not be of great importance for the case of Spanish exports. Otherwise, international road transport is very important and, hence, we rely on the information provided by Tarancón and Del Río (2007) that quantify the contribution of transport sectors to the overall CO_2 emissions in Spain in 6.35% (excluding emissions from households, year 2000), meanwhile, for trading partners, we use the overall share of international transport in global energy-related CO_2 emissions reported by Vöhringer *et al.* (2013), which is equal to 5%.

The methodology followed at the present paper aims at capturing CO_2 changes due to trade increases by taking into account estimated CO_2 emissions from trade-related transportation. Therefore, in a first step, we construct the following indicator for global transport emissions (in logs is the dependent variable in equation 3):

$$CO2_{ijt} = \left[\frac{em_{it}}{\sum_{i=1}^{19} em_{it}} \cdot em_{Spain,t} \right] \cdot 0.0635 + \left[em_{jt} \right] \cdot 0.05 \qquad (4)$$

Where *em* denotes CO_2 emissions, i is the origin region, j is the destination country and t the corresponding year. The information of $em_{Spain,t}$ and em_{jt} variables is from the ITF (IEA CO_2 from fuel combustion, Mt), and em_{it} is CO_2 emissions (in kt) obtained from MAGRAMA (2013). Finally, it is important to note that for rail and road transport modes it is relatively easy to measure and assign carbon emissions (Cristea et al. 2013), then although they are not disaggregated in the statistics provided by the ITF, they are considered in CO_2 from fuel combustion.

4.2. The trade-weighted distance

To construct the trade-weighted distance, there is not comparable information among Spanish regions and importing countries of unit emissions for transportation of distance (μ). When transporting goods, the differences between CO_2 emissions are explained by factors that vary by region/country such as the type, size and weight of vehicle, route, distance, etc. (López *et al.* 2013) In this line, Cristea *et al.* (2013) constructed regional modal shares for aggregated geographical and economic areas in the year 2004, as well as emissions per tonne-km of transport services (by mode). What it is clear in Table 3 of Cristea *et al.* (2013), is that the maritime mode is the most efficient as it is the mode that emits the lowest emissions per tonne-km to the atmosphere. Then, as we aim to capture the change that derives of increasing maritime trade (the less pollutant mode used for international transportation of goods), we construct the trade-weighted distance indicator $E(d)_{ijt}$ as the interaction of the ratio of (lagged) maritime trade on (lagged) total trade and geographical distance as follows: [6]

$$E(d)_{ijt} = \frac{\text{X\_mar}_{ijt}}{X_{ijt}} \cdot Dist_{ij} \qquad (5)$$

Where *X_mar* denotes bilateral maritime exports from region i to country j, *X* denotes total bilateral exports from i to j and *Dist* is geographical distance between i and j. This indicator proxies for the evolution of comparative advantages that might change the relative volume of maritime transport over longer distances. *E(d)* increases might be due either to the increase in the travelled distance by traded goods or to the increase on the relative importance of maritime trade. According to H1, we expect a positive effect of this indicator on global transport emissions, but up to a turning point, when higher distances do imply a change to a more efficient mode of transport.

4.3. Environmental performance

Esty and Porter (2001) focus on various aspects of a country's environmental regulatory system, including not only standards, but also implementation and enforcement mechanisms, and associated institutions. In this research, firstly, we use a *narrow* definition of environmental performance and restrict our analysis to existing standards in

[6] We rely on previous year maritime and total exports to prevent endogeneity problems.

origin regions and destination countries. Specifically, we construct an environmental standards dummy by using information on countries that have a carbon tax provided by the Center for Climate and Electricity Policy, as well as information about specific environmental standards in Spanish regions (REAF, 2013).

Secondly, we use the Environmental Performance Index (EPI, 2006 and 2008) to construct a country-level proxy for environmental performance, understood in a *broad* sense, in destination countries. EPI data are available only for two years over the time framework considered in this research: 2006 and 2008. In addition, the 2008 EPI improves upon the 2006 EPI and differs in several structural and substantive areas. Therefore, they are not directly comparable (Esty *et al.* 2008).

The EPI presents a country-level ranking, where top-ranked have invested in water and air pollution control and other elements of environmental infrastructure and have adopted policy measures to mitigate the harms caused by economic activities (high scores of this index indicate a high level of environmental performance). The EPI allows to quantify and numerically benchmark the environmental performance of a country's policies and, according to Moldan *et al.* (2012), although the overall EPI ranking does not tell us which country is actually on a sustainable path, it provides a sense of which countries are doing best in terms of reaching common environmental targets.

4.4. Transport externalities

As pointed out in Section 3, a spatial lag is constructed to control for transport externalities. In particular, the spatial lag aims to capture the effect of an increase in transport emissions due to the agglomeration of transport facilities in neighbouring regions to the origin.

When taking into account agglomeration of transport facilities, it is important to focus on the role of intermodality. According to the World Shipping Council, *intermodalism* can be defined as a system whereby standard-sized cargo containers can be moved seamlessly between different modes of transport, typically specially adapted ships known as containerships, barges, trucks and trains. Because the cargo does not need to be unloaded from the container every time it is moved from one mode to the other it is a very efficient and fast system of transportation.[7]

In a first step, we base on the inventory of logistics facilities provided by Alamá-Sabater *et al.* (2012) to illustrate the structure of the Spanish territory (see Figure A.2 and A.3 in Appendix A). Alamá-Sabater *et al.* (several years) use the number and size of logistics facilities in the year 2007 to calculate a transport connectivity index in Spain. These figures illustrate the structure of the territory in Spain from a sustainable transport approach, as well as they intuitively show the importance of accounting for the agglomeration effect, as it might significantly affect global transport emissions.

Alamá-Sabater *et al.* (several years) focus on the importance of intermodality and on the definition of logistics facility, which is a physical location where goods can be stored or transferred to different modes of transport and where their transportation can be organised. It is worth noting that a number of locations such as those that only handle freight are not included in the inventory provided by Alamá-Sabater *et al.* (2012), whereas others which are not very active in the market are included. For example, Andalusia, the most populated region in Spain and the second largest, has the highest number of logistics facilities. The large number of facilities in Andalusia must be assessed in terms of specialisation and intermodal development, bearing in mind the heterogeneity this region

[7] See Glossary of the World Shipping Council http://www.worldshipping.org/about-the-industry/glossary-of-industry-terms

displays in regard to other more advanced Spanish regions in terms of logistics (Márquez-Ramos *et al.* 2013). With this limitation in mind and taking into account the data available, we follow Márquez-Ramos and Aparisi-Caudeli (2013) and Márquez-Ramos (2013) and focus on Spanish ports to delve deeper into the relative importance of facilities for freight in terms of international competitiveness. By using information about sea traffic from the Annual Accounts of the Spanish Port Authorities, Márquez-Ramos and Aparisi-Caudeli (2013) show the relative importance of Spanish sea ports, as well as the evolution of the relative importance of port facilities by region over 2000-2008. These data are reported in Table A.3 (Appendix A). Appendix B provides a detailed explanation of the construction of the spatial lag.

5. Empirical study

5.1. Main results

In a first step, equation (3) is estimated using pooled Ordinary Least Squares (OLS) and standard deviations robust to heteroskedasticity. Nonetheless, as there is a time dimension, correlation among successive residuals is possible, affecting t-statistics and p-values. We prove the existence of autocorrelation by inserting the prediction of lagged residuals in regression, which is found to be significant. Therefore, in a second step, we estimate a so called long-run variance with Newey-West standard errors and then, estimation of variance-covariance matrix is robust against heteroskedasticity and autocorrelation.

The different columns in Table 2 show the obtained results for the inclusion of different variants of equation (3). Column 1 presents results of including the *E(d)* variable and its square term, together with BP, BF and the spatial lag. Columns 2 and 3 include instead the variable *E(d)* when is interacted with the environmental regulations dummy. First (Column 2), the environmental regulations dummy refers to origins (regional environmental standards), second (Column 3), it refers to destinations (country environmental standards). As we find that only the interaction of *E(d)* variable with trading partners' environmental standards is significant on global transport emissions for Spanish regional exports, columns 4-6 show the results of estimating equation (3) with this (second) interaction.

Results in column 4 show that global transport emissions increase when the trade-weighted distance indicator increases, but up to a point, as the square term of this variable is negative signed and significant. The turnaround value of $\ln E(d)_{ijt}$ is equal to 2.5 [0.005/(2*0.001)] and around 10.2% of the sample exceeds this point (see Table A.2, Appendix A). This result confirms the two offsetting effects stated in Bensassi *et al.* (2013) and that shipping companies use more efficient transportation technology as transportation distances increases, in line with H1.

The results obtained also support H2. First, *E(d)* interacts with the regional environmental standards dummy (column 2) and second, *E(d)* interacts with the importer's standards dummy (column 3). Nonetheless, only when *E(d)* interacts with the (country) environmental standards dummy, we find a significant and an inverse relationship between the weighted-trade distance variable and global transport emissions. Specifically, if Spanish regions export more to countries with high environmental performance, understood in the *narrow* sense of the term, global transport emissions decrease. However, it is important to note that this decrease presents a minimum, as the squared term of this variable is positive and significant. This minimum is found for large

values of *E(d)* (the turnaround value of $\ln E(d)_{ijt}$ is equal to 7 [0.014/(2*0.001)]). However, the variable $regul_{jt}$ is equal to one only for a number of European countries, and so these results should be taken with caution in farther countries. Figure A.3 (Appendix A) visually presents the two effects for H1 and H2.
The two dichotomic variables that are included as extra factors that affect global transport emissions (sharing a border with Portugal, BP, and with France, BF) are positive signed, although the variable border with Portugal is not statistically significant in our preferred specification (column 4). According to these results, global transport emissions are around 5% higher for Spanish regions neighbouring France than in the rest of Spanish regions. This result supports that road transport generates higher global-transport related emissions than maritime trade. In this case, trucks from Spanish regions, Portugal or/and North of Africa have to pass through regions neighbouring France to arrive to their main European trading partners. In fact, 76.62% of total exports from Spain to France are transported by road in year 2008, while only 15.77% are transported by sea.[8]
Bilateral dummies for border with Portugal (BP_{ij}) and border with France (BP_{ij}) have also been included in the regression instead of BP_i and BF_i. Specifically, these variables take the value of one when origin regions share a border with Portugal and j is Portugal (BP_{ij}) and when origin regions share a border with France and j is France (BF_{ij}). Similar results are obtained for the rest of the variables of interest, although BP_{ij} is positive and significant, and BF_{ij} is not significant. The fact that France has a higher environmental performance (EPI equal to 87.8 in 2008) than Portugal (EPI equal to 85.8 in 2008) might be behind these results.[9]
This analysis also aims to obtain unbiased estimates for regional spillovers. Transport externalities (i.e. agglomeration effect) have, *ceteris paribus*, a positive effect on global transport emissions. When beta coefficients are used to compare the magnitude of the effects in terms of standard deviations (Wooldridge, 2009), the highest beta coefficient is, in absolute terms, for the spatial lag and, second, for the interaction of the trade-weighted distance indicator with the environmental standards dummy (column 5, Table 2). In line of these findings, and once the scale, composition and technique effects are controlled for, transport externalities play the largest role on the increase of global transport emissions.
Finally, the EPI is used instead of the *narrow* measure of environmental regulations existing in importing countries. This index is only available for the years 2006 and 2008 and then the number of observations is importantly reduced when estimating equation (3).[10] In order to be able to compare the EPI in 2006 and 2008 (see Esty *et al.* 2008), we introduce the information provided by this variable as a dummy ($regul\_epi_{jt}$) that takes the value of one for those countries that display a value of EPI higher than the sample average in the corresponding year t (2006 or 2008), and zero otherwise (see Table A.1, Appendix A). In this case, the spatial lag is positive signed and significant and, although we obtain the expected signs for the *E(d)* variables, they are not statistically significant.[11] Therefore, we focus on a more homogeneous sample of Spanish trading partners according to their EPI. Column 6 in Table 2 displays the results obtained for those countries that are below the sample average with regards to environmental performance, i.e. when $regul\_epi_{jt}$ is equal to 0, providing evidence of the hypothesised U-inverted shape between the trade-weighted distance indicator and global transport emissions (H1).

[8] Source: Datacomex
[9] Full results are available upon request.
[10] Column 6 is estimated using pooled OLS and standard deviations robust to heteroskedasticity.
[11] Full results are available upon request.

Table 2. Main results.

	(1)	(2)	(3)	(4)	(5) beta coefficients of 4	(6)
$\ln E(d)_{ijt}$	0.004**			0.005**	0.013	0.005**
	2.007			2.492		2.564
$(\ln E(d)_{ijt})^2$	-0.000*			-0.001***	-0.019	-0.001**
	-1.958			-2.772		-2.168
$\ln E(d)_{ijt} \cdot regul_{jt}$		0.002	-0.015**	-0.019***	-0.039	
		0.21	-2.334	-2.931		
$(\ln E(d)_{ijt} \cdot regul_{jt})^2$		-0.001	0.002**	0.002***	0.032	
		-1.002	2.296	2.996		
Border with Portugal	0.025	0.133***	0.035	0.03	-0.011	0.079***
	1.024	3.944	1.202	1.242		6.446
Border with France	0.051***	0.082***	0.050**	0.047**	0.022	-0.020**
	4.859	4.37	2.233	2.092		-2.051
Spatial lag	2.057***	2.053***	2.039***	2.027***	0.075	0.746***
	12.586	12.674	12.523	12.436		2.793
Constant Term	1.466***	1.437***	1.469***	1.468***		3.039***
	46.524	36.503	89.061	51.35		112.94
Number of observations	3816	3816	3816	3816		389

Notes: ***, **, * indicate significance at the 1%, 5% and 10% levels, respectively. T-statistics are displayed below each coefficient. The dependent variable is CO_2 transport emissions (in logs). Column 6 shows the results for years 2006 and 2008 for Spanish regions with trading partners that present a lower EPI than the sample average.

5.2. Simulations[12]

We want to simulate the change in global transport emissions as a consequence of changes on geographical distance, assuming that the other variables do not change. Then, we calculate:

$$\%\Delta CO2 \approx \left[\eta_1 + 2\eta_2 \ln E(d)_{ijt}\right]\%\Delta E(d)_{ijt} \qquad (6)$$

As pointed out in Section 3, the elasticity of emissions with respect to *E(d)* depends on the log of *E(d)*, and hence on distance. Then we substitute the average value of the ratio $\frac{X\_mar_{ijt}}{X_{ijt}}$ in our sample (equal to 0.489), and we give different values to the distance variable. Thus, an increase in distance from, for example, 500 km to 1,000 km decreases global transport emissions by about $-0.739\% \approx \left[0.005 - 2 \cdot 0.001(6.193)\right]100\%$, while an increase in distance from 5,500 km to 6,000 km decreases global transport emissions by about $-0.1\% \approx \left[0.005 - 2 \cdot 0.001(7.984)\right]9.091\%$. Therefore, there is a decreasing impact of the *E(d)* variable on global transport emissions with increasing geographical distance.

[12] These results are not included to save space. Full results are available upon request.

Finally, if we take distance as fixed in 5,704 km (average value in the sample), an increase of the share of maritime trade over total trade from 10% to 20%, which supposes an increase of 100% in *E(d)*, reduces global transport emissions by about 0.9%.

6. Conclusions and policy implications

The original trade and environmental literature focused on identifying how comparative advantage influenced the effect of trade liberalisation on reducing local pollutants. Nonetheless, this avenue is more complicated for a global pollutant as is the case of CO_2 emissions, where individual countries have little direct influence on global emissions. Unlike local pollutants, many rich countries have not committed to climate policies. Moreover, because significant parts of the transportation related emissions are outside national boundaries, domestic policies do not affect them. For example, consider the battle over the EU's attempt to make international airlines participant in the EU Emission Trading System.

We have analysed the determinants of global transport emissions in a multi-regional and multi-country framework by taking into account the role of changes in modal usage, as well as two additional factors that play a key role on the relationship between trade and sustainable transport, thus being the environmental performance and transport externalities. Specifically, we analyse if higher relative maritime exports bound to further away international destinations have decreased transportation-related emissions, taking into account not only environmental performance in destination countries, but also regional transport externalities that might be harmful for the environment.

In addition, this paper has introduced a number of indicators related to the environmental quality in the field of transport of goods, which might be used to manage environmental levels created from the perspective of sustainable development. In this sense, we have paid special attention to the main problems inherent to indicators that might be used when empirically testing for the relationship between trade and sustainable transport. First, related to the construction of an indicator that properly proxies for global transport emissions and, second, to the use of a trade-weighted distance indicator that considers the possibility of intermodality and changes in modal usages in favour of more efficient transport modes as longer geographical distances are travelled.

Our results provide empirical evidence of the existence of a U-inverted relationship between global transport emissions and the trade-weighted distance indicator if Spanish regions trade with low environmental performers (H1), either when we use an environmental performance indicator in a *narrow* sense or in a *broad* sense. In addition, we show the importance of the commitment towards a *clean* environment through higher levels of environmental performance in trading partners: global transport emissions decrease if the trade-weighted distance indicator with higher environmental performers increases (H2). Finally, by using techniques borrowed from the regional science literature, we are able to provide evidence of the damaging role of transport externalities on the environment, as the agglomeration effect increases global transport emissions (H3).

Our main policy implication is that the detrimental effect on the environment arising from transport facilities agglomeration might be partially offset by international cooperation on environmental performance. Furthermore, the fact that high maritime trade at a distance with high environmental performers as importers significantly decreases global transport emissions, while existing subnational environmental standards do not, point towards the importance of political coordination at national level for an actual commitment towards a *clean* global environment.

Recently, it has been proposed the use of new variables to classify countries according to their level of environmental performance. This study shows the importance of data and analysis of environmental problems over time. Nonetheless, there is a lack of comparable time-series at both country and regional level. Then, as regards further research, we suggest not only to continue with the effort made by international organisations with indicators such as the EPI, which seeks to highlight the value of indicator-based environmental decision making, but also the construction of an environmental performance index at regional level for a cross-section of countries and for several years. In this way, more in-depth and reliable information will be made available regarding the relationship between trade and sustainable transport.

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Appendix A

Figure A.1. The importance of the structure of the territory for emissions

Territory 1

A	C		
E	D		
		G	F
		H	B

Territory 2

A	C
E	D
G	F
H	B

Territory 3

A	C		
E	D		
	G	F	
	H	B	K
	I	J	

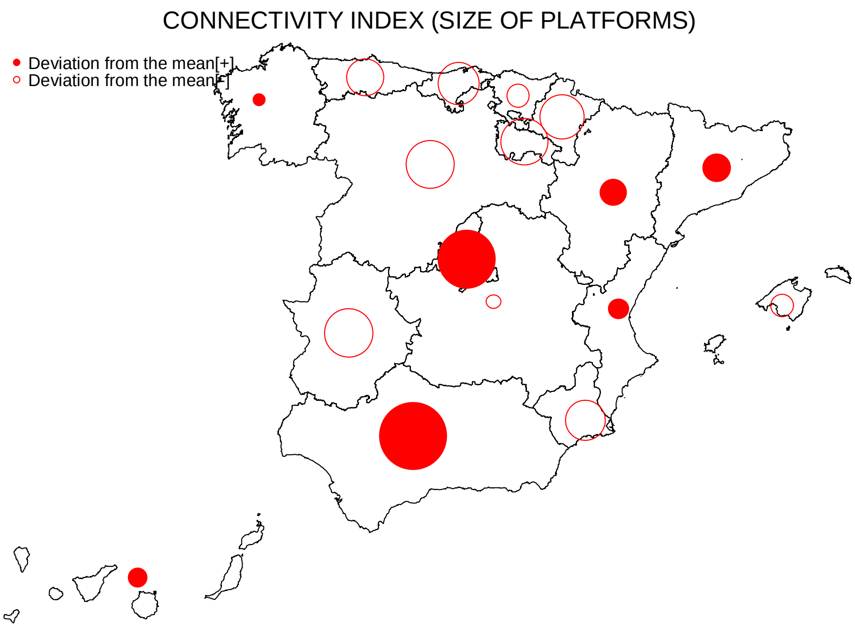
Territory 4

G	A	C	
F	E	D	
K	J	I	
L	B	H	

Territory 5

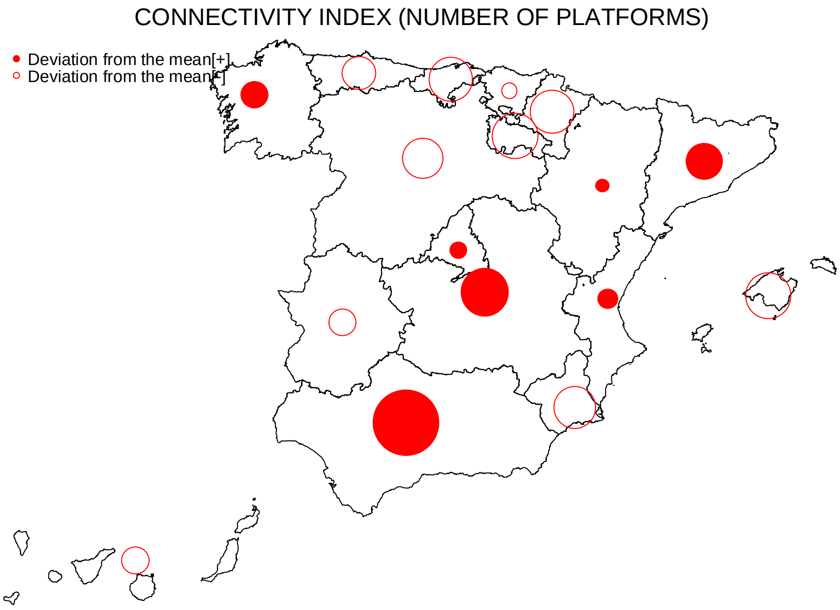
A				
C	D			
B				

Figure A.2: Spanish regions. Size of logistics platforms



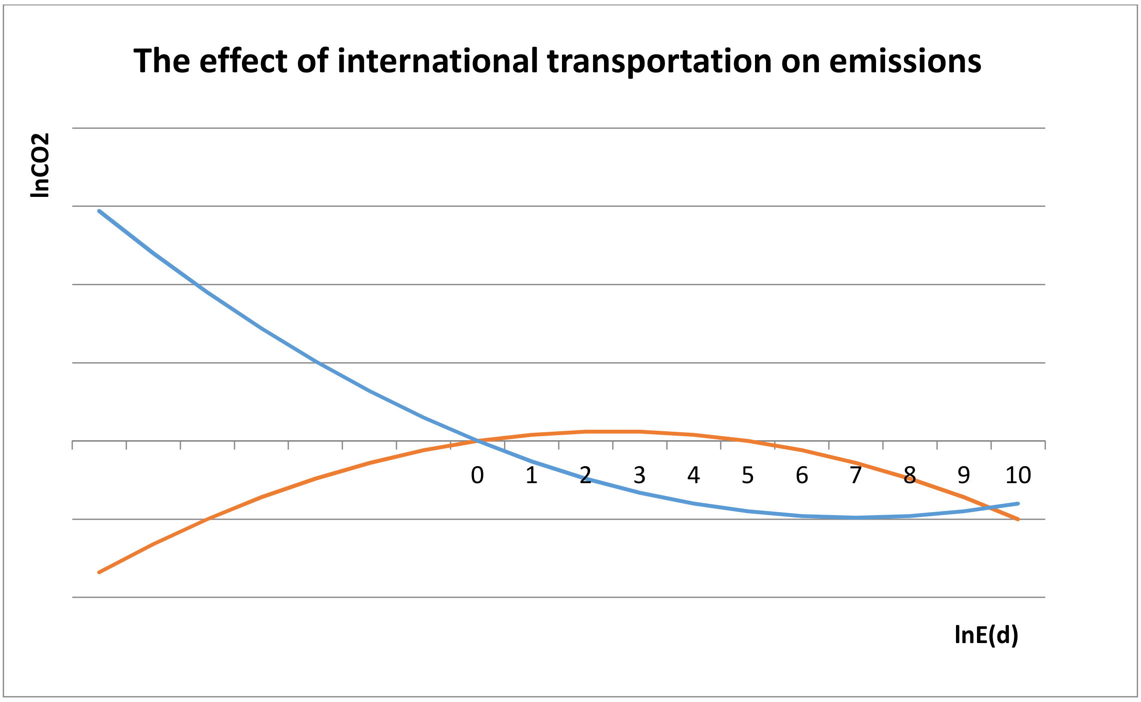
Source: Alamá-Sabater *et al.* (2012).

Figure A.3: Spanish regions. Number of logistics platforms



Source: Alamá-Sabater *et al.* (2012).

Figure A.3. Relationship between the trade-weighted distance indicator and CO_2 transport emissions



Notes: Red line: if $regul_{jt}$=0; Blue line: if $regul_{jt}$=1

Table A.1. Variables and data sources used

Variable	Description	Source
CO_2 transport emissions	Composite index measuring trade-related transport emissions at both regional and country-level	MAGRAMA (2013) and the Key Transport and Greenhouse Gas Indicators by Country (International Transport Forum: http://www.internationaltransportforum.org)
Exports	Bilateral exports in thousands of euro (total and maritime)	Datacomex (http://datacomex.comercio.es)
Distance	Distance between regional capitals (km)	http://www.indo.com/distance
Spatial lag	See Appendix B	Márquez-Ramos (2013)
Environmental standards at origin	Dummy variable that is equal to one for those regions with specific environmental regulations in year t. In particular: ANDALUSIA: Impuesto sobre emisión de gases a la atmósfera. Ley 18/2003, de 29 de diciembre, por la que se aprueban medidas fiscales y administrativas (B.O.J.A. nº 251, de 31 de diciembre de 2003). ARAGON: Impuesto sobre el daño medioambiental causado por la emisión de contaminantes a la atmósfera. Decreto legislativo 1/2007, de 18 de septiembre, del Gobierno de Aragón, por el que se aprueba el Texto Refundido de la Legislación sobre los impuestos medioambientales de la Comunidad Autónoma de Aragón. (BOA núm. 117, de 3-10-07). CANARY ISLAND: Impuesto especial sobre combustibles derivados del petróleo. Ley 5/1986, de 28 de julio, del Impuesto Especial de la Comunidad Autónoma de Canarias sobre combustibles derivados del petróleo (B.O.C. nº 90, de 1 de agosto de 1986) GALICIA: Impuesto sobre la contaminación atmosférica. Ley 12/1995, de 29 de diciembre, del impuesto sobre la contaminación atmosférica (DOG 30/12/95). MURCIA: Impuesto por emisiones de gases contaminantes a la atmósfera. Ley 9/2005, de 29 de diciembre, de Medidas Tributarias en materia de Tributos Cedidos y Tributos Propios año 2006 (B.O.R.M. suplemento nº 3 del nº 301, de 31 de diciembre de 2005).	REAF (2013)
Environmental performance (in a *narrow* sense) at destination	Dummy variable that is equal to one for those countries with carbon taxes in year t Finland, the Netherlands, Sweden and Denmark had a carbon tax during the full period taken into account, and the United Kingdom since 2001.	Center for Climate and Electricity Policy http://www.rff.org/centers/climate_and_electricity_policy/Pages/Home.aspx
Environmental performance (in a *broad* sense) at destination	Dummy variable that is equal to one for those countries with an environmental performance index higher than the average in the sample, 0 otherwise. In 2006 equal to one for Australia, Austria, Canada, Chile, the Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Malaysia, the Netherlands, Portugal, Spanish regions, Sweden, the United Kingdom and the United States. In 2008 equal to one for Austria, Brazil, Canada, Chile, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Malaysia, Portugal, Spanish regions, Sweden and the United Kingdom.	EPI (2006 and 2008) and Esty *et al.* 2008

Table A.2. Summary statistics

	Variable	**lnCO2**		
	Percentiles[13]	Smallest		
1%	0.9854606	0.772029		
5%	1.186458	0.7751307		
10%	1.334263	0.7953299	Obs	4959
25%	1.811601	0.7991709	Sum of Wgt.	4959
50%	2.730808		Mean	2.644282
		Largest	Std. Dev.	1.022416
75%	3.187512	5.7011		
90%	3.921285	5.702273	Variance	1.045334
95%	4.167395	5.702634	Skewness	0.6715862
99%	5.689145	5.704354	Kurtosis	3.745746
	Variable	**lnE(d)**		
	Percentiles	Smallest		
1%	-2.331578	-8.16492		
5%	0.9294855	-8.151197		
10%	2.43162	-7.195305	Observations	3816
25%	4.911638	-5.137431	Sum of Wgt.	3816
50%	7.447233		Mean	6.580744
		Largest	Std. Dev.	2.862742
75%	8.944097	9.682304		
90%	9.228703	9.6829	Variance	8.195293
95%	9.421242	9.6829	Skewness	-1.200039
99%	9.618037	9.685064	Kurtosis	4.188152
	Variable	**lnE(d)*regul$_{jt}$**		
	Percentiles	Smallest		
1%	0	-3.514684		
5%	0	-1.408233		
10%	0	-0.9301536	Observations	3816
25%	0	-0.6521158	Sum of Wgt.	3816
50%	0		Mean	0.9266109
		Largest	Std. Dev.	2.146273
75%	0	8.622098		
90%	5.348464	8.674767	Variance	4.606487
95%	6.394486	8.712378	Skewness	2.039142
99%	7.596456	8.741046	Kurtosis	5.536243

[13] A percentile indicates the relative standing of a data value when data are sorted into numerical order, from smallest to largest.

Table A.3. Relative importance of port facilities by region (% of sea traffic over total sea traffic in Spain)

Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**% increase**
Valencia	11.33	12.10	12.68	12.81	12.81	13.22	13.97	14.57	16.07	41.94
Murcia	5.13	5.83	6.03	5.60	5.69	6.12	5.55	4.98	5.44	6.03
Catalonia	17.06	16.80	17.12	16.98	17.28	17.33	17.13	18.12	17.93	5.12
Andalusia	25.18	26.15	25.34	26.13	25.75	25.61	26.02	25.80	24.94	-0.94
Canary Islands	9.80	10.05	9.79	10.34	10.31	10.16	9.91	9.64	9.32	-4.92
Basque Country	9.84	9.10	8.64	8.96	9.49	8.98	9.54	9.33	9.32	-5.28
Balearic Islands	3.12	3.12	3.08	3.11	2.92	3.02	3.15	3.03	2.84	-9.04
Galicia	7.92	7.55	7.77	7.66	7.50	7.30	7.00	7.06	7.09	-10.47
Cantabria	1.58	1.48	1.50	1.43	1.46	1.52	1.28	1.30	1.16	-26.47
Asturias	7.07	6.58	6.74	6.30	6.13	6.09	5.73	5.46	5.12	-27.58
Ceuta	0.86	0.69	0.66	0.49	0.48	0.46	0.53	0.55	0.60	-30.45
Melilla	1.11	0.55	0.66	0.20	0.18	0.19	0.18	0.17	0.16	-85.39

Source: Márquez-Ramos and Aparisi-Caudeli (2013).

Appendix B

To test for the existence of transport externalities, we follow Márquez-Ramos (2013) and construct a spatial matrix considering three criteria: geographical contiguity, relative importance of port facilities in origin regions, and the quality of port infrastructure in destination countries. In particular, the weight matrix takes into account the relative importance of port facilities in (first-order) neighbours to the origin, as well as the quality of ports in destination countries. First, we calculate an origin-destination matrix where rows identify origin regions and columns destination countries. Second, we construct matrix A by using the relative importance of port facilities in the origins neighbouring regions, this matrix A varies by row. Third, we use information provided by the World Economic Forum to construct matrix B which measures port quality in destination countries, this matrix B varies by column. Fourth, following Alamá-Sabater *et al.* (several years) scores of every matrix are derived as an index relative to the maximum and minimum achieved by both origin regions and destination countries. Therefore, elements of matrices A and B take a value between 0 and 1 calculated according to equation (B.1):

$$Port\ \ facilities = \frac{(actual\, value - observed\ \min value)}{(observed \max\ value - observed \min value)} \qquad \text{(B.1)}$$

If region i neighbours regions with a high relative importance of port facilities in Spain, the element in matrix A is near 1; in addition, if country j presents a high quality of port infrastructure, the element in matrix B is near 1. Fifth, Matrix W is constructed with the sum of A and B, and finally, by stacking a row-standardized spatial weight matrix W and multiplying it by the dependent variable we can estimate the spatial lag vector ρ, which captures the magnitude of port facilities in neighbouring regions addressed to different destinations on the dependent variable.