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The Environment Effects and Intra-Industry Trade

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Abstract: The present article analyses the United States' environmental impact on agriculture intra-industry trade (IIT). The results indicate there is a negative correlation between carbon dioxide emissions and intra-industry trade. According to the literature, i.e. this type of trade uses less pollution technology. In addition, we have found that emissions increase with the level of production. The economic size has a positive influence on carbon dioxide emissions.

Key words: Environment · Intra-industry trade · United States and Panel Data

INTRODUCTION

According to the World Bank [1], the worldwide average emissions of CO_2 (metric tons per capita) stemming from burning of fossil fuels and cement manufacturing (carbon dioxide produced during consumption of solid, liquid and gas fuels and gas flaring) increased from around 50000 kt in 1960 to 156000 kt in 2007. Such evolutions had a major impact on the environment sustainability: the global mean surface temperature has increased by 0.3-0.6°C since the late nineteenth century and the global sea level has risen by 10-25 cm since then; there have been extreme weather events in different regions (though their statistical significance and connections to wider climate changes are still debated); extensive shifts in the composition and geographic distribution of the ecosystems are likely to occur etc. (see, for a synthesis of such effects, Houghton [2]). Several pollution enhancement mechanisms were identified in the recent literature. Among them, the international trade took an important place. In this context, the economic integration processes such the ones taking place in NAFTA, EU and ASEAN have raised interest in the relationship between trade liberalization and environmental impacts. In other words, the issue of the extent to which trade liberalization creates a negative externality for environmental processes becomes a part of pollution analysis.

The focal argument is known in literature as *Pollution Haven Hypotheses* (PHH), as developed by Copeland and Taylor [3]. The argument refers to the possibility that polluting industries concentrate in developing countries with low environmental standards and predicts that, under free trade agreements and mechanisms, multinational firms will relocate the production of their polluting goods to developing countries for taking benefits from such permissive standards.

This main dimension of the hypothesis is completed by the idea of dumping hazardous waste in developing countries - waste generated by developed countries (industrial and nuclear energy production) - and also by the possibility of unrestrained non-renewable natural resources extraction in developing countries by multinational corporations (see Aliyu [4] for a more detailed discussion).

According to the theories of international trade, inter-industry is explained by the advantages, whereas the intra-industry trade is explained by product differentiation. With the process of globalization and fragmentation, multinational companies relocate to other markets, where environmental rules are more flexible ("South"). Under this assumption the "South" specializes in pollution-intensive industries and the "North" specializes in less pollution-intensive industries.

Also, recent studies Cole and Elliot [5], Cole *et al.* [6] show that there is a negative correlation between pollutants (SO_2, CO_2, NO_2) and intra-industry trade.

The main purpose of this study is to examine how intra-industry trade affects distribution of pollutants

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between North and South countries. To test this, we use the carbon dioxide emissions of United States with trade partner NAFTA, European Union and ASEAN over the period 1995-2008, using a panel data analysis.

Thus, this article seeks to contribute to that field of literature which evaluates the environmental impact on intra-industry trade in three ways: firstly, from a theoretical point of view, it means a step forward in the discussion of the validity of Cournot style model; secondly, at an empirical level, it contributes to the discussion on the development of this recent topic; thirdly, it tries to provides some empirical evidences in order to clarify if the U.S. intra-industry trade affects the environment. The previous studies show that there is a negative correlation between both variables.

The structure of the paper is a follows. The next section explains the IIT based on Cournot style and present some empirical studies. In section 3 we formulate the hypothesis of our model. Section 4 shows the methodology and research design, while the fifth section analyses the results. The final section provides conclusions.

Intra-Industry Trade and Emviroment: The IIT literature began in the 1960s, when Balassa [7] pointed out that most of the growth in manufacturing followed the formation of a customs union in Europe. The first theoretical models of IIT were synthesized in Helpman and Krugman's model, which is a Chamberlin-Heckscher-Ohlin model. This is a model that combines monopolistic competition with the Heckscher-Ohlin (HO) theory, incorporating factor endowments' differences, horizontal product differentiation and increasing returns to scale.

The intra-industry trade (IIT) or two-way trade is defined as simultaneousexports and imports of a product within a country or a particular industry.

Following Cournot style Helpman [8] and Helpman and Krugman [9], we consider two countries (home and foreign) and two goods (X and Y). Where: X - represents a pollution-intensive good produced in the home country; Y - pollution-intensive good produced in the foreign-country. Both countries are relatively abundant in pollution.

Heckscher-Ohlin factors explain inter-industry specialization, while economies of scale and horizontal product differentiation explain IIT.

Product Demand:

$$p = \alpha - bQ \tag{1}$$

$$Q = xq + yq^{*} \tag{2}$$

The utility is represented as:

$$U = U\,[u_1(.),...,u_t(.)]nq \tag{3}$$

Such a formulation implies that the consumers have identical and homothetic cross-countries preferences.

Then the Grubel and Lloyd [10] index (the IIT) is given by:

$$\text{IIT}=1 - \frac{|xq - yq^{*}|}{\left(xq + yq^{*}\right)} \tag{4}$$

The IIT index as given by (4) depends on the relative factor endowments and other country characteristics. Therefore, we can test the hypothesis that a high pollution emission decreases the share of intra-industry trade (IIT).

Copeland and Taylor [11] present a theoretical model of *Pollution Haven Hypothesis* (HPP). The authors consider two countries (North and South). The North uses less pollution-intensive industries, while South specializes in pollution-intensive industries.

There are some empirical studies that analyze the link between pollution and trade. The common argument of these studies is that the pollutant emissions embodied in international trade flows can have a significant impact on climatic changes as well as on participation and effectiveness of global environmental policies such as Kyoto Protocol. For instance, Peters and Hertwich [12] estimate for 2001, based on a sample of 87 countries, that globally there are over 5,3 Gt (almost 22% of total emissions) of CO_2 embodied in international trade. Antweiler *et al.* [13] and Copeland and Taylor [3] examine the impact of sulphur oxides on trade. Cole and Elliot [5] find a negative correlation between intra-industry trade and the rules of environment. This result shows that intra-industry use less pollution-intensive emission.

Moreover, Kahn and Yoshino [14] use the sulphur dioxide, carbon monoxide and nitrogen dioxide to explain how trade liberalization affects the environment (negative externality).

The study of Cole *et al.* [6] show that environmental and industrial regulations are statistically significant determinants of Japanese net imports from the rest of the word, non-OECD countries and China. Furthermore, Grether *et al.* [15] investigates the role of trade in worldwide SO_2 manufacturing. The results show that trade and the reallocation activities permit a decrease of 2-3% in world's SO_2 emissions.

There are also several country-focused studies, examining the impact of international trade on origin and host economic spaces' CO_2 emissions. For instance, Machado [16] involves a commodity-by-industry IO model in hybrid units in order to study the impact of foreign trade on the energy use and CO_2 emissions of the Brazilian economy. Kratena and Meyer [17] find that CO_2 emissions embodied in Austrian imports are considerably higher than CO_2 emissions embodied in exports. Sánchez-Chóliz and Duarte [18] provide evidences for the Spanish case: sectors like transports, mining and energy, non-metallic industries, chemical and metals are the most relevant CO_2 exporters; other services, construction, transports and food are the biggest CO_2 importers, whose final demand embodies more than 70% of the CO_2 emissions. Yu and Wang [19] document that in 1997 and 2002, the carbon emission transfer from the United States to China by Sino-U.S. merchandise trade reached 37.1975 Mt C and, respectively, 47.1960 Mt C.

Overall, the literature highlights the importance of international trade for the global distribution of pollution effects.

Development of Hypotheses: Following the research literature, we are developing the next research hypotheses:

Hypothesis 1: There is a negative sign between intra-industry trade and pollution effects.

Literature's Perspective: The intra-industry trade is explained by differentiated goods, while inter- industry trade is explained by the comparative advantages. According to the literature Wang *et al.* [20], Fung and Maecheler [21] differentiated goods use less polluting technology. The level of emissions is decreasing with intra-industry trade. Cole *et al.* [6] and Grether *et al.* [15] suggest a negative sign for the coefficient of intra-industry trade.

Hypothesis 2: The emissions increase with the level of production.

Literature's Perspective: The hypothesis 2 is supported by Grossman and Krueger [22] and Antweiler *et al.* [13].

Hypothesis 3: There is a negative correlation between capital abundance and pollution.

Literature's Perspective: Cole *et al.* [6] and Grether et al. [15] found a negative sign for such correlation.

Hypothesis 4: The economic size has a positive effect on carbon emission.

Literature's Perspective: According to empirical model Cole *et al.* [6] and Grether *et al.* [15] a positive sign is expected.

Methodology and Research Design: The present study uses the carbon dioxide emissions as dependent variable. The carbon dioxide emissions include CO_2 produced during the consumption of solid, liquid and gas fuels and gas flaring. The source of this variable is Carbone Dioxide Information Analysis Centre, Environment Sciences Division, US.

The static panel data models were estimated with pooled ordinary least squares (OLS), fixed effects (FE) and random effects (RE) estimators. The F statistics tests the null hypothesis of same specific effects for all countries. If we accept the null hypothesis, we could use the OLS estimator. The Hausman test can decide which model is better: random effects (RE) versus fixed effects (FE). The FE model was selected because it avoids the inconsistency due to correlation between the explanatory variables and the country-specific effects.

Explanatory Variables: The index of intra-industry trade (IIT): the present study uses the index of Grubel and Lloyd [10].

Grubel and Lloyd [10] define IIT as the difference between the trade balance of an industry *i* and the total trade of the same industry. In order to make comparisons easier between industries or countries, the index is presented as a ratio, where the denominator is total

$$IIT_{it} = \frac{(X_i + M_i) - |X_i - M_i|}{(X_i + M_i)} \tag{5}$$

The agricultural intra-industry trade data between United States and NAFTA, European Union and ASEAN for the period 1995 to 2008 are provided by OECD at the five-digit level of the Standard International Trade classification (SITC) in US dollars.

$$\text{Scale}: \frac{GDP}{Area} \tag{6}$$

Where: GDP is gross domestic product converted to international dollars using purchasing power parity rates - World Bank [1]; Area (sq.km) is the surface area i.e. a country's total area, including areas under inland bodies of water and some coastal waterways. The source of this variable is Food and Agriculture Organization.

Capital abundance is the Gross fixed capital formation (formerly gross domestic fixed investment) including land improvements; plant, machinery and equipment purchases, construction of roads, railways and alike, schools, offices, hospitals, private residential dwellings and commercial and industrial buildings. The source of this proxy is World Bank [1].

$$\frac{K}{L} \tag{7}$$

Population density (people per sq. km) is midyear population divided by land area in square kilometers. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship - except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin. The source isWorld Bank [1].

$$POP = \frac{Population}{AREA} \tag{8}$$

Model Specification

$$LogCO_2 = \beta_0 + \beta_1 X_{it} + \delta t + \eta_i + \varepsilon_{it} \tag{9}$$

Where CO_2 is the US carbon dioxide emissions, X is a set of explanatory variables. All variables are in the logarithm form; η_i is the unobserved time-invariant specific effects; δt captures a common deterministic trend; $å_{it}$ is a random disturbance assumed to be normal and identical distributed (IID) with E (ε_{it})=0; Var (ε_{it}) = $\sigma^2 > 0$. Sample and descriptive statics.

Table 1 provides information about the involved variables:

It appears that there is an important heterogeneity of the variables especially for LogIIT and LogPOP. Thus, the estimation methodology should treat the bias that can be induced by such diversity in the data.

Empirical Results: The fixed effects estimator is reported in Table 2. The explanatory power is 50 per cent (Adjusted R^2=0,50). All explanatory variables are significant (LogIIT at 5%, LogSCALE, LogK/L at 1% and LogPOP at 10% level).

The intra-industry trade (LogIIT) is statistically significant, with an expected negative sign. This result is according to previous studies Cole and Elliot [5]. Wang *et al.* [20] and Fung and Maecheler [21] consider that intra-industry trade uses less polluting technology. The level of emissions is decreasing with intra-industry trade.

As expected, the variable scale (LogSCALE) has a significant and positive coefficient. Grossman and Krueger [22] and Antweiler *et al.* [13] also found such sign. These results provide empirical evidences for the hypothesis that emission of CO_2 increases with the level of production.

For the capital abundance (LogK/L), the dominant paradigm predicts a negative sign. The result confirms the existence of such negative effect on the pollution emission.

As expected, the variable population density (LogPOP) has a significant and positive effect on carbon emissions Cole *et al.* [6] and Grether *et al.* [15].

In order to check the robustness of our results, we also apply a GMM-System estimation. The GMM-System methodology – as proposed by Arellano and Bover [23],

Table 1: The environment effects and Intra-industry Trade: Descriptive statics

Variables	Mean	St Dev	Minimum	Maximum
$LogCO_2$	1,294	0,006	1,284	1,308
LogIIT	10,368	0,559	9,236	11,717
LogSCALE	7,188	0,471	6,866	8,711
Capital abundance (LogK/L)	12,266	0,067	12,117	12,357
Population density (LogPOP)	1,950	0,560	0,508	2,700
Observations	247			

Table 2: The environment effects and Intra-industry Trade: Fixed effects estimator (Dependent variable: Carbon dioxide emissions)

Explanatory Variables	Fixed Effects	t-Statistics	Significance
LogIIT	-0,756	(-2,548)	**
LogSCALE	0,086	(5,424)	***
Capital abundance (LogK/L)	-0,091	(-4,62)	***
Population density (LogPOP)	0,056	(1,965)	*
R^2	0,50		
Observations	247		

T-statistics (heteroskedasticity corrected) are in round brackets

***/**/*- statistically significant, respectively at the 1%, 5% and 10% level

Table 3: Carbon dioxide emissions and Intra-industry Trade: GMM-System estimator

Explanatory Variables	Coefficient	t-Statistics	Significance
$LogCO_{2t-1}$	0.342	(4.710)	***
LogIIT	-0.013	(-0.848)	
$LogIIT_{t-1}$	0.011	(0.612)	
LogSCALE	0.176	(2.580)	**
$LogSCALE_{t-1}$	-0.173	(-3.530)	***
Capital abundance (LogK/L)	0.052	(3.500)	***
Capital abundance $(LogK/L)_{t-1}$	-0.088	(-4.130)	***
Population density (LogPOP)	-0.090	(-0.095)	
Population density $(LogPOP)_{t-1}$	0.070	(0.058)	
Constant	1.324	(3.070)	***
M2	1.63 [0.103]		
Sargan	13.93 [1.000]		
Observations	182.00		
Countries	18.00		

T-statistics (heteroskedasticity corrected) are in round brackets. The null that each coefficient is equal to zero is tested using the second-step robust standard errors

***/**/*- statistically significant, respectively at the 1%, 5% and 10% level. M1 and M2 are tests for first-order and second-order serial correlation in the first-differenced residuals, asymptotically distributed as N(0,1) under the null hypothesis of no serial correlation (based on robust two-steps GMM estimators). Sargan is a test of the over-identifying restrictions, asymptotically distributed as χ^2, under the null of instruments' validity (two-steps estimators)

Blundell and Bond ([24],[25]) and Windmeijer [26] - is involved because estimators like fixed and random effects, IV or standard GMM may yield to biased results. Also, since a small panel sample may produce "downward bias of the estimated asymptotic standard errors" in the two-step procedure Baltagi [27], we use the "Windmeijer correction" for the estimated standard errors. More exactly, Windmeijer [26], [28] observes that part of downward bias which can appear for the standard errors in small samples is due to extra variation caused by the initial weight matrix estimation being itself based on consistent estimates of the equation parameters. In order to correct this bias, it is possible to calculate bias-corrected standard error estimates which take into account the variation of the initial parameter estimates. We employ a version of this correction applicable for GMM models estimated using an iterate-to-convergence procedure.

There are several advantages of the GMM-SYS over other static or dynamic panel estimation methods. Among these: static panel estimates, as the OLS models, are subjected to the problem of dynamic panel bias Bond [29]; in our database, we have 18 countries (N) analyzed over a period of 14 years (T) and the literature includes several arguments for dynamic panel model being specially designed for a situation where "T" is smaller than "N" in order to control for dynamic panel bias Bond [29]; Baltagi [27]; the problem of the potential endogeneity can be easier addressed in dynamic panel models than in static and OLS models, since all variables from the regression which are not correlated with the error term (including lagged and differenced variables) can be potentially used as valid instrumental variables; the dynamic panel model is able to identify short and long-run involved effects Baltagi [27]. Also, the GMM-System exploits the stationarity restrictions, while the first-differenced GMM estimator can behave poorly when the time series are persistent.

Thus: In the GMM-System framework, scale and capital abundance are remaining statistically significant and their lagged values are displaying the "right" sign. However, the outcome of this methodology is less conclusive for intra-industry trade and population density variables.

CONCLUSIONS

In recent years, research on the relationship between environmental effects and intra-industry trade has increased. The objective of this study was to analyze the link between carbon emissions and agriculture IIT in United States. Econometric estimations support, at least partially, the formulated hypotheses. Our results are robust in respect to theoretical models and fit in the results of mainstream literature.

As our results show, there is a negative correlation between intra-industry trade and carbon emissions. Still, this result is sensitive to the estimation methodology. On the other hand, the emissions increase with the level of production, this result being in line with those obtained by Grossman and Krueger [22] and Antweiler *et al.* [13]. The results for the index of capital abundance show that labor-intensive products are more polluting.

However, this study has some limitations. Firstly, a sounder theoretical framework should be adopted in order to provide details about the involved transmission channels of intra-industry impact on CO_2 emission. Secondly, the dataset should be extended and more cases should be considered. Overall, a more detailed analysis is required especially for a better theoretical and empirical analysis of the medium and long term-industry effects on environment as these are described in trade literature.

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