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Full Length Research Paper

Environmental change and agriculture: The role of international trade

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This study analyses the United States environmental impacts on agriculture intra-industry trade (IIT). The results indicate that there was a negative correlation between carbon dioxide emissions and intra-industry trade. According to the literature, this type of trade uses less pollution technology. We also 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, panel data.

INTRODUCTION

The economic integration processes in NAFTA (North American Free Trade Agreement), EU (European Union) and ASEAN (Association of Southeast Asian Nations) have raised interest in the relationship between trade liberalization and environmental impacts. In other words, the extent to which trade liberalization creates a negative externality. This argument is known in literature as pollution haven hypotheses (PHH), developed by Copeland and Taylor (1994). According to the theories of international trade, inter-industry is explained by the advantages, while 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 on less pollution-intensive industries.

Recent studies (Cole and Elliot, 2003; Cole et al., 2010) show that there is a negative correlation between pollutants (SO_2, CO, NO_2) and intra-industry trade. The central purpose of this manuscript is to examine how intra-industry trade affects distribution of pollutants between North and South countries. To test this, we use the carbon dioxide emissions of United States with trade partner of NAFTA, European Union and ASEAN over the period of 1995 to 2008, using a panel data analysis. This article contributes to the literature that evaluates the relationship between the environmental impacts on intra-industry trade in three ways. Firstly, and from a theoretical point of view, it means a step forward in the discussion of the validity of the Cournot style model. Secondly, at the empirical level, it contributes to the discussion of the development of this recent topic. Thirdly, it helps us understand 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 as follows; subsequently, the IIT based on Cournot style is explained and shows some empirical studies. Then, we formulate the hypothesis of our model followed by the methodology and research design, as well as the analyses of results and finally the conclusion.

RELATED LITERATURE ON INTRA-INDUSTRY TRADE POLLUTION

There are some empirical studies that analyze the link between pollution and trade. The common argument of these studies is that the pollutant emission embodied in international trade flows can have a significant impact on climatic changes (Kyoto Protocol). The IIT literature began in the 1960s, when Balassa (1966) 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 simultaneous exports and imports of a product within a country or a particular industry. Following Cournot style (Helpman, 1987; Helpman and Krugman, 1985), we consider two countries (home and foreign), and two goods (X and Y).

Where:

X- Represents a pollution–intensive good that is produced in home country.
Y- Pollution-intensive good that is produced in 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:

$$p = a - bQ \quad (1)$$

$$Q = xq + yq^{*} \quad (2)$$

The utility is represented as:

$$U = U\left[u_1(.),....u_t(.)\right]nq \quad (3)$$

which the consumers have identified as homothetic preferences within countries. Then, the Grubel and Lloyd (1975) index (the IIT) is given by:

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

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 emission of pollution decreases the share of intra-industry trade (IIT). Copeland and Taylor (1994) 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 the South specializes in pollution-intensive industries.

There are some empirical studies that analyse the link between pollution and trade. We list the recent research on the topic (Antweiler et al., 2001; Copeland and Taylor, 2003; Cole and Elliot, 2003; Kahn and Yoshino, 2004; Cole et al., 2010; Grether et al., 2010). Antweiler et al. (2001), and Copeland and Taylor (2003) examine the impact of sulphur oxides on trade. Cole and Elliot (2003) find a negative correlation between intra-industry trade and the rules of environment. This result shows that intra-industry use less pollution-intensive emission. Kahn and Yoshino (2004) 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. (2010) showed that environmental and industrial regulations are statistically significant determinants of Japanese net imports from the rest of the world, from non-OECD countries and China.

Grether et al. (2010) investigated the role of trade in worldwide SO_2 manufacturing. The results show that trade and their reallocation activities permitted a decrease of about 2 to 3% in world SO_2 emissions.

DEVELOPMENT OF HPYPOTHESIS

Hypothesis 1: There is a negative sign between intra-industry trade and the effects of pollution. 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., 2009; Fung and Maecheler, 2007) differentiated goods use less polluting technology. The level of emissions is decreasing with intra-industry trade. Cole et al. (2010) and Grether et al. (2010) suggested a negative sign for the coefficient of intra-industry trade.

Hypothesis 2: The emissions increase with the level of production. Hypothesis 2 is supported in Grossman and Krueger (1993) and Antweiler et al. (2001).

Hypothesis 3: There is a negative correlation between capital abundance and pollution. Cole et al. (2010) and Grether et al. (2010) found a negative sign.

Hypothesis 4: The economic size has a positive effect on carbon emission. According to empirical model (Cole et al., 2010; Grether et al., 2010) a positive sign is expected.

METHODOLOGY AND RESEARCH DESIGN

The present study uses the carbon dioxide emissions as a dependent variable. The carbon dioxide emissions include CO_2 produced during 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 (1975). Grubel and Lloyd (1975)

Table 1. The environment effects and intra-industry trade: Descriptive statistics.

Variable	Mean	Standard deviation	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. Hausman test.

Null hypothesis	GLS estimates are consistent
Asymptotic test statistics	Chi-square (3)=42.050
P-value	0.000

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

$$IIT_{it} = 1 - \frac{|X_i - M_i|}{(X_i + M_i)} \Leftrightarrow IIT_{it} = \frac{(X_i + M_i) - |X_i - M_i|}{(X_i + M_i)} \quad (1)$$

The agriculture intra-industry trade between United States and NAFTA, European Union and ASEAN for the period between 1995 and 2008 are constructed from the OECD at the five-digit level of the standard international trade classification (SITC) in US dollars:

$$\text{Scale: } \frac{GDP}{Area} \quad (2)$$

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

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

$$\frac{K}{L} \quad (3)$$

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 is World Development Indicators:

$$POP = \frac{Population}{AREA} \quad (4)$$

Model specification

$$LogCO_2 = \beta_0 + \beta_1 X_{it} + \delta t + \eta_i + \varepsilon_{it} \quad (5)$$

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; ε_{it} is a random disturbance assumed to be normal, and identical distributed (IID) with E (ε_{it})=0; Var (ε_{it}) = $\sigma^2 \succ 0$.

Sample and descriptive statistics

Table 1 gives information about descriptive statistics.

EMPRICAL RESULTS

Given the model and data in which fixed effects estimation would be appropriate, Hausman-test tests whether random-effects would be almost as good. The Hausman test rejects the null hypothesis, random-effects versus fixed effects (Table 2). In our case, the random-effects estimator was excluded because our sample is not random. The fixed effects estimator is reported in Table 3. The explanatory power is 50% (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 in accordance to previous studies (Cole and Elliot, 2003). Wang et al. (2009) and Fung and Maecheler (2007), 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 significant and positive coefficient.

Table 3. The environment effects and intra-industry trade: Fixed effects estimator (dependent variable: carbon dioxide emissions).

Explanatory variable	Fixed effect	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)	*
$\overline{R^2}$	0.50		
Observations	247		

T-statistics (heteroskedasticity corrected) are in round brackets; ***/**/*- statistically significant, respectively at the 1, 5, and 10% level.

Grossman and Krueger (1993) and Antweiler et al. (2001) also found this sign. We validate the hypothesis that emissions increase with the level of production. Capital abundance (LogK/L), the dominant paradigm predicts a negative sign. The result confirms a negative effect on the pollution emission. The index of capital abundance shows that labor-intensive products are more polluting. As expected, the variable population density (LogPOP) has a significant and positive effect on carbon emissions (Cole et al., 2010; Grether et al., 2010).

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. Econometrics estimations support the hypothesis formulated. Our results are robust with theoretical models. As our research shows, there is a negative correlation between intra-industry trade and carbon emissions. On the other hand, the emissions increase with the level of production, this result is in line with those obtained by Grossman and Krueger (1993) and Antweiler et al. (2001).

The results for the index of abundance of capital show that the labour-intensive products are more polluting. However, this study has some limitations. For future research, we need to introduce a dynamic panel data (GMM-System) (Blundell and Bond, 2000) with the aim to solve the endogeneity and serial autocorrelation.

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