Environmental Regulation and Intra-Industry Trade: An Empirical Analysis

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Abstract

The objective of this paper is to examine the impact of stringency of environmental regulations on trade patterns within the intra-industry trade (IIT) framework. The study utilizes a panel dataset comprising of 36 countries for the time period 1990-2012. Four different pollution intensive industries, namely Pulp and Waste Paper, Dyeing and Tanning, Lime, Cement and Construction Materials and Iron Ore or Concentrates have been used for the analysis. The environmental stringency variable has been measured by the energy intensity of the trading countries. The results indicate that for the pulp and waste paper industry, a highly pollution-intensive industry, an increase in stringency in either country leads to a reduction in the share of IIT between the two trading partners, resulting in a fall in export competitiveness within this industry in both countries. The results for lime, cement and construction industry and iron ore and concentrates show that the environmental stringency indicator for one country is negative while for the other country it is positive. In contrast, for the dyeing and tanning industry, the environmental stringency coefficients of both trading partners are found to be positive but are significant for only one country.

Keywords: G-L index, Pulp and Waste Paper, Dyeing and Tanning, Energy Intensity, Lime, Cement and Construction Materials, Iron Ore or Concentrates.

JEL Classifications: F12, F14, F18, Q56

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1. Introduction

One aspect of the relationship between trade and environment deals with the plausible influence of environmental stringency on global trade patterns. The basic concern here stems from the claim that the low income (developing) countries will have relatively less stringent environmental regulations and, hence, have a comparative advantage in the production of pollution-intensive products. This will trigger the displacement of dirty industries from developed to developing countries, making developing countries pollution havens. This is known as the pollution haven effect. Additionally, more stringent environmental regulations in the exporter country would raise its costs of production and hence, its exports would reduce. But domestic consumers would now substitute foreign products for domestic ones, leading to a rise in imports. Hence, this will result in a loss of competitiveness, which would likely be more accentuated in the pollution-intensive industries.

However, several empirical studies (Birdsall and Wheeler, 1993; Eskeland and Harrison, 1997; Ratnayake, 1998; Cole, 2004; Temurshoev, 2006; Dietzenbacher and Mukhopadhyay, 2007) investigate this issue by taking environmental regulations as exogenous and do not find any evidence of the existence of the pollution haven hypothesis. One explanation for this could be that the environmental control costs form a small share in the total cost of production and thus higher environmental standards may hardly have any effect on comparative advantage patterns or the international competitiveness of a country (Chua, 2003). An alternate view of the pollution haven hypothesis is the Porter and Linde hypothesis which posits that stringent environmental regulations lead to productivity improvements and efficiency in the production process as countries are induced to innovate and invest in environmental-friendly techniques of production, in turn creating a comparative advantage in environmentally sensitive (pollution-intensive) sectors. Thus, the lack of empirical evidence in favour of a relationship between environmental regulation and trade flows could also be attributed to the Porter and Linde hypothesis.

Many studies have tried to test whether changes in environmental regulations affect trade patterns based on the Hecksher-Ohlin framework and have found inconclusive results. Van

Beers and Van den Bergh (1997) examine whether more stringent environmental regulations have an impact on inter-industry bilateral trade flows for a cross-section of 21 OECD countries in 1992. They find that the use of a more stringent environmental policy by a country exerts a negative influence on the exports of that country, while an increase in environmental stringency on the import side leads to a negative and significant impact on bilateral trade flows of that country. Harris et al. (2002) improve upon the empirical estimation of Van Beers and Van den Bergh (1997) by using a panel data set on 24 OECD countries for 1990-1996. In contrast to the latter, they find that the relative strictness of environmental regulations in the importing country has a significant and negative effect on total bilateral trade flows, while the regulations in the exporting country seem to be positively related to them. Furthermore, some recent studies which consider environmental regulations to be endogenously determined, find a significant link between trade flows and environmental regulations. For instance, Ederington and Minier (2003) investigate the impact of environmental regulations on inter-industry trade flows when environmental policy is modeled endogenously for U.S. and show that the impact of stringency of environmental regulation on net imports is positive and significant, implying that industries with higher pollution abatement costs tend to have higher level of net imports. Cole and Elliot (2003) examine the impact of environmental regulations on trade patterns within the traditional comparative advantage model. Here, they test whether the stringency of a country's environmental regulations affects net exports of its pollution intensive output. The data covers 60 developed and developing countries. The dependent variable is each country's net exports in one of four dirty sectors (iron and steel, chemicals, paper and pulp and non-ferrous metals) while the explanatory variables include a wide range of factor endowments and two measures of stringency of environmental regulations. The authors first consider the environmental regulations to be exogenous in their regression analysis and do not find environmental regulations to be correlated with net exports from dirty sectors. In a second estimation, the authors take into account the fact that environmental regulations could themselves be a function of trade flows and hence should be considered as endogenous. Here also the environmental regulation variable is found to be an insignificant determinant of net exports. They conclude that in a Hecksher-Ohlin-Vanek framework, environmental regulations do not appear to affect trade flows, irrespective of whether they are treated as exogenous or endogenous. Levinson and Taylor (2008) also examine empirically the effect of environmental regulations on trade flows using data on U.S. regulations and trade with Canada and Mexico for 130 manufacturing industries from 1977-1986. They find that the industries, whose abatement costs increased most, experienced the largest increases in net imports. Cole and Elliot (2003) focus on the linkage between IIT and environment and examine empirically whether environmental regulations have any impact on the composition of trade within the new trade-theoretic framework by using cross-sectional trade data for developed and developing countries for the year 1995. And they conclude that in the 'new' trade model, IIT shares are found to be a negative determinant of environmental regulation differentials, suggesting that falling environmental regulation differentials lead to falling inter-industry trade share, in favour of higher IIT.

Mehra and Kohli (2018) have explained the strategic interactions between the strictness of environmental regulations and IIT flows with a theoretical framework involving two trading partners, Home and Foreign. Their findings indicate that with IIT, if Home is a net exporter, an increase in environmental stringency leads to a rise in Home's share of IIT with Foreign. This has been explained through the scale and selection effects. Furthermore, the opposite result holds when Home is a net importer. This study has been undertaken to supplement the above theoretical predictions with sound empirical evidence. This has been done by ascertaining the impact of stringency of environmental regulations on the share of intra-industry trade (IIT) using four pollution intensive industries namely, pulp and waste paper, lime, cement and construction, iron ore or concentrates and dyeing and tanning for a panel dataset of 36 countries. The environmental stringency indicator has been calculated as the energy intensity of a country using two kinds of energy statistics - first, the total final consumption of energy (Mtoe) in a country in one year; and second, the total primary energy supply (Mtoe) in a country in one year. The results suggest that changes in environmental regulations do impact the share of IIT between trading partners. And, the sign of this impact depends on whether the country in question is a net exporter or net importer of the concerned variety of good. The paper is divided into four sections. The next section explains the empirical model as well as the data sources and methodology used for estimation. It also discusses the choice of pollution intensive industries used for the analysis. This is followed by the third section which analyzes the results of empirical estimation. The last section presents the conclusion of the paper.

2. Empirical Model

To test whether a rise in the strictness of environmental regulations has any impact on intra-industry trade flows between countries, a panel dataset comprising of cross-country data for 1990 to 2012 has been utilized, unlike Cole and Elliot (2003) who only work with a cross-sectional dataset. A total of top 36 trading (developed and developing) countries based on the sum of their exports and imports have been considered for the analysis. The empirical model takes the following form:

$$|\ln(GL_{ijt})| = \beta_0 + \beta_1 \ln|pcGDP_{it} - pcGDP_{jt}| + \beta_2 \ln|K_{it}/L_{it} - K_{jt}/L_{jt}| + \beta_3 \ln(Dist_{ij}) + \beta_4 Adj_{ij} + \beta_5 \ln(SER_{it}) + \beta_6 \ln(SER_{jt}) + \varepsilon_{ijt},$$

where,

ln denotes natural logarithm;

GL_{ijt} is the bilateral Grubel-Lloyd (GL) index between countries i and j, in year t;

$pcGDP_{it}$, $pcGDP_{jt}$, the per capita GDP of countries i and j, respectively, in year t;

K_{it}/L_{it}, K_{jt}/L_{jt}, the capital-labour ratio of countries i and j, respectively, in year t;

$Dist_{ij}$, distance between countries i and j;

Adj_{ij}, is a dummy variable equal to one if countries i and j are adjacent, that is, share a common land border, and zero otherwise;

SER_{it}, SER_{jt}, the relative strictness of environmental regulations in countries i and j, respectively, in year t; and

ε_{ijt}, the white noise disturbance term.

2.1 Data sources

The dependent variable here is the share of intra-industry trade between two countries i and j. This was calculated using the Grubel-Lloyd (G-L) index having the following specification:

$$GL_{ij,k} = 1 - |exports_{ij,k} - imports_{ij,k}| / (exports_{ij,k} + imports_{ij,k})$$

where, k=1,2…..N are the number of industries.

All trade data used in this analysis has been taken from the World Integrated Trade Solution (WITS) database, jointly developed by the World Bank and United Nations Conference on Trade and Development (UNCTAD) at Standard International Trade Classification (SITC) revision 3 at the 3-digit level of classification. The basic information source is the United Nation Statistical Division's COMTRADE (Commodity Trade) database. This has been used to calculate the G-L index for each country pair in the sample for each year. The commodity trade analysis has been done for four pollution intensive industries: pulp and waste paper, iron ore or concentrates and lime, cement and construction materials, and dyeing or tanning extracts.

The data on per capita GDP data for each country has been taken from World Bank database. The data for physical capital stock was taken to be the Gross Fixed Capital Formation (formerly Gross Domestic Fixed Investment) from the World Bank, World Development Indicators. The labour data comprises of people aged 15 and older who meet the International Labour Organization (ILO) definition of the economically active population, that is, all people who supply labour for the production of goods and services during a specified period. It includes both the employed and the unemployed. This information was also taken from World Development Indicators, World Bank. The data for distance between the countries has been taken from Haveman's page[1].

The stringency of environmental regulations variable is the most crucial variable for this analysis because the results of the model would be strongly dependent on the choice of the indicator measuring the strictness of environmental regulations. However, the scarcity and heterogeneity of environmental data across countries makes it difficult to construct a common environmental policy indicator for such a large panel dataset. Many earlier studies have worked with different methods to calculate environmental stringency. For example, Tobey (1990) followed Walter and Ungalow (1979) and used an ordinal input oriented variable based on information collected from national government replies to

[1]http://www.macalester.edu/research/economics/PAGE/HAVEMAN/Trade.Resources/Data/Gravity/dist.txt

questionnaires as the environmental stringency indicator, whereas Van Beers and Van den Bergh (1997) employed output oriented indicators and constructed two strictness measures for 1992. The first one was based on seven societal indicators, the data on which is published only irregularly. Hence, it is not possible to develop this type of strictness measure for each year spanning the analysis period of 1990-2012. The second one was composed from two indicators: first, the level of energy intensity in 1980 and second, the change of energy intensity from 1980 – 1991 by a ranking procedure. Since, data availability of energy consumption and energy supply is easily available across countries for different years, the environmental regulation stringency indicator for two trading countries i and j (here onwards denoted by SER_{it} and SER_{jt}) in this study have been calculated as the energy intensity of the ith and jth country, respectively. These energy intensity measures are based on two indicators: total final consumption of energy (Mtoe) in country i in year t; and total primary energy supply (Mtoe) in country i in year t. This provides for two variants of environmental stringency indicators. The data for these two indicators have been taken from International Energy Agency (IEA) Statistics.

2.2 Environmental and Trade Aspect of Industries

The pollution-intensive industries are defined as those characterized by high levels of toxic release after efforts have been made to control the pollution, compared with other industries (Jenkins et al., 2002). Tobey (1993) classifies industries with pollution abatement costs of 1.85 per cent or more of the production costs as pollution-intensive. The following discussion individually explores the environmental and trade aspects of the four industries considered for the analysis.

2.2.1 Pulp and Waste Paper Industry

According to a report by the United Nations (2012), the major pulp and paper producing nations include the USA, Canada, Japan, China, Finland, Sweden, Germany, Brazil and France. In 2012, USA, Canada and Brazil were the top exporting countries of pulp and paper products. They accounted respectively for 21, 15.2 and 10.6 per cent of world exports. On the other hand, China was the top destination with 34.4 per cent of world imports in 2012, followed by Germany and USA with 8.8 and 7 per cent of world imports, respectively. Table 1 shows that in 2012, the value of exports of pulp and waste paper (SITC group 251) dropped by 10.6 per cent to reach 44.4 billion US dollars. Similarly, imports dropped by 12.2 per cent to 50.1 billion US dollars in 2012. In 2012, exports of pulp and waste paper accounted for 0.2 per cent of total world exports.

Both wood pulp as well as waste paper are intermediate commodities and are used as raw materials in the production of paper, paperboard, and other wood-fiber-based products (USITC, 2002). The paper industry involves large-scale tree-cutting leading to deforestation and other associated environmental imbalances. Pulp and waste paper industry also results in emissions of SO_2, NO_x and particulate matter during the chemical process of kraft pulping[2]. These lead to respiratory effects like mucous membrane irritation and headache. Furthermore, water pollution issues arise from contaminated waste water from paper and pulp mills which can cause eutrophication of fresh water bodies leading to death of aquatic organisms. The wood derivatives dissolved in the pulping liquors are the main contributors to both BOD (Biological Oxygen Demand) and COD (Chemical Oxygen Demand). Solid waste is also generated in pulp and paper mills consisting of different types of sludge like green liquor sludge, wastewater treatment sludge, chemical flocculation and deinking sludge which could be potentially carcinogenic (Bajpai, 2015).

2.2.2 Iron Ore or Concentrates

As the prime raw material for steel, iron ore is critical for all sectors of an economy both for consumer products and for infrastructure. Iron ore demand is the highest in countries such as China that are experiencing rapid economic growth and where new buildings are being built at a rapid pace (Steinweg and Schuit, 2014). While Australia and Brazil are home to the largest iron ore mines in the world, large quantities of iron ore are also mined in countries such as Guinea, Congo, Sierra Leone and Liberia. Table 2 shows how the share of trade for iron ore and concentrates (SITC group 281) has increased over the years from both imports and exports being just 0.2 per cent of world trade in 1998 to

[2] Kraft Pulping is a process to create high-strength type of pulp, known as kraft pulp, by mixing wood fibres with a solution of caustic soda and sodium sulphide and cooking them inside a digester. Kraft pulp is used in the production of printing and writing papers, tissues, coffee filters and other consumer products.

rising up to 0.9 and 0.7 per cent in 2012 respectively. A sharp decline in total export and import values can be discerned in the years 2009 and 2012 from Table 2.

The mining for iron ore creates adverse environmental and social impacts. Mining activities can change topography and vegetative land cover, consequently, influencing the amount and rate of surface water run-off. This intensifies the irregularity in stream flows and can have a dramatic impact on aquatic life. Underground mining usually has less impact on soil and vegetation relative to surface mining, but it can lead to considerable quantities of acid or alkaline drainage[3]. According to a report on energy and environmental profile of the U.S. mining industry in 2002 by BCS incorporated, industrial agglomeration[4] generates by-products such as CO_2, sulfur compounds, chlorides, and fluorides which are harmful for the environment as well as human beings.

2.2.3 Lime, Cement and Construction Materials

Cement products are essential for construction and civil engineering, while lime is irreplaceable for the steel industry, as well as construction materials, paints, plastics, and rubber. Table 3 shows that the value of exports of lime, cement, and fabricated construction materials, except glass and clay (SITC group 661) increased by 4.8 per cent to 29.6 billion US dollars in 2012. Imports also increased by 3.1 per cent and amounted to 29.7 billion US dollars. Also the exports of lime, cement, and fabricated construction materials, except glass and clay accounted for 0.2 per cent of total world exports in 2012. The top exporting countries in 2012 were China, Italy and Turkey which accounted for respectively 20.5, 8 and 6.2 per cent of world exports while USA, France and Germany were the three major destinations (UN, 2012).

Manufacturing process in cement and lime industry mainly includes generation of air pollutants, fuel consumption, wastewater and solid waste generation and noise pollution. The most notable impacts of cement and lime manufacturing are PM emissions while NO_x emissions are fostered in the high temperature combustion process of the cement

[3] http://www1.eere.energy.gov/manufacturing/resources/mining/pdfs/iron.pdf
[4] After milling the iron ore, concentrates are agglomerated to improve blast furnace operations that utilize iron ore. This is known as industrial agglomeration.

kiln. The cement and lime production process is energy intensive and produces plenty of CO and CO_2 which is mainly associated with fuel combustion (IFC, 2007). Heavy metals like lead, cadmium, and mercury can be released as prime emissions from cement manufacturing. Cement kilns, due to their strongly alkaline atmospheres and high flame temperatures of about 2000°C, are capable of using high calorific value waste fuels. The use of waste fuel can lead to emissions of VOC (Volatile Organic Compounds), PCDD (Polychlorinated dibenzodioxins), PCDF (Polychlorinated dibenzofurans), HF, HCl and toxic metals and their compounds if not properly controlled and operated. Wastewater is generated mainly from utility operations for cooling purposes in different phases of the process. Another potential waste stream involves the kiln dust removed from the bypass flow and the stack (IFC, 2007). Thus, cement and lime industry contributes to pollution on all fronts, be it air, water, noise or solid waste generation making it a highly pollution-intensive industry.

2.2.4 Dyeing and Tanning Extracts

Dyeing is the process of adding color to textile products like fibers, yarns, and fabrics. There are mainly two classes of dye: natural and man-made. Over time, the natural products began to be substituted by synthetic or aniline dyes obtained from coal-tar products. These synthetic dyes are brighter, more permanent, easier to use, are less costly and afford a wider range of colors[5]. Tanning, on the other hand, is the process of employing animal's skins to produce leather which is more durable. Tanning may be carried out using plant or mineral products. The tanning agents used include the plant product known as tannin and salts of chromium. Once tanned, the leather becomes useful for a variety of products like jackets, gloves, shoes, handbags, wallets, briefcases, etc.

The major exporters and importers for products of this sector in the year 2012 can be seen from Tables 4 and 5 respectively. These tables show Italy, Germany and Spain as the top exporting countries in 2012. They accounted respectively for 11.3, 9.9 and 7.8 per cent of world exports while the top destinations were China, USA and Japan, together comprising 23 per cent of world's total imports of dyeing or tanning extracts. The value of exports of dyeing and tanning extracts, and synthetic tanning materials (SITC group

[5] http://www.faculty.ucr.edu/~legneref/botany/tandye.htm

532) decreased by 3.2 per cent to reach 2.1 billion US dollars in 2012, and the imports showed a decrease of 5.6 per cent and totaled 2.7 billion US dollars during the same year (UN, 2012).

Dyeing and tanning industries also cause environmental deterioration in many different ways. The main air pollutants from dye manufacturing are VOC, NO_x, HCl and SO_x. Besides, the wastes that are considered to be toxic comprise of wastewater treatment sludges and process residues from the manufacture of chrome yellow and orange pigments, molybdate orange pigments, zinc yellow pigments, chrome and chrome oxide green pigments, iron blue pigments, and azo dyes[6]. The presence of organic substances in water also affects the DO (Dissolved Oxygen) (Ratna and Padhi, 2012). The biological oxidation of organic compounds brought about in aerobic conditions requires DO. If the system has low DO, anaerobic bacteria take over which leads to formation of CH_4, H_2S and NH_3 (Khopkar, 2004) thus causing harm to the environment.

Tanning industry is considered to be a major source of water pollution and tannery waste-water in particular, is a potential environmental concern (Ros and Ganter, 1998). Tanning industry wastes poses serious environmental impact on water through its high oxygen demand, discoloration and toxic chemical constituents (Song et al., 2000). Tannery waste characteristically contains a complex mixture of both organic and inorganic pollutants. The discharge of solid waste and wastewater containing chromium is the main environmental problem. The emissions from the tanning process into the air are primarily related to energy use, organic solvents and dyes. The pollutants of concern within the tanning industry include chlorinated phenols, azodyes, cadmium compounds, cobalt, copper, antimony, barium, lead, selenium, mercury, zinc, arsenic, PCB (Polychlorinated Biphenyls), nickel, formaldehyde resins and pesticides residues (Mwinyihija, 2010).

[6] http://www.ifc.org/wps/wcm/connect/2b23c4004885526cab84fb6a6515bb18/dye_PPAH.pdf?MOD=AJPERES

3. Estimation Results and Analysis

This section deals with the results from the estimation of the empirical model and their interpretation. Table 6 reports the mean, standard deviation and range of each of the variables used in the analysis. The data here has been measured for countries at multiple points in time resulting in 595 total trade pairs. Although, in the empirical analysis, the dependent variable is the natural logarithm of the G-L index, the summary statistics of the G-L index have been reported here. It can be seen that the range of the G-L index for all industries is quite wide. For instance, for iron ore or concentrates, it attains a maximum value of one and a minimum value of zero, while for other industries, the maximum value asymptotically hovers around one. A high value of the G-L index implies that more of intra-industry trade is taking place between the trading partners.

As per the Hausman test, a fixed-effects estimation is found to be a better fit than random effects for all four industries. In addition, the LR test and the Wooldridge test were also conducted for each industry to check for possible presence of heteroscedasticity and/or autocorrelation, respectively. The problem of heteroscedasticity was found to be prevalent in all the four industries, while the problem of autocorrelation is also present in all industries except for lime, cement and construction materials. These issues have been corrected for by employing a cross-sectional time-series feasible generalized least squares (FGLS) regression.

It is imperative to discuss the expected signs of some of the coefficients based on existing literature before the actual estimation. According to Durkin and Krygier (2002), similar GDP per capita between countries will have a positive impact on the intra-industry trade share, that is, $\beta_1 < 0$. A common border will tend to increase the share of IIT, that is, $\beta_4 > 0$ (Johansson, 1993; Hansson, 1989). In contrast, a greater distance between the trading partners would affect the IIT share negatively, that is, $\beta_3 < 0$ (Hansson, 1994; Johansson, 1993). While, similarity of capital – labour endowments would lead to an increase in the share of intra-industry trade, that is, $\beta_2 < 0$ (Cole and Elliot, 2003). It now remains to be seen as to how the environmental stringency measures of the two countries affect the share of intra-industry trade between them, that is, the sign and statistical significance of the regression coefficients β_5 and β_6 in the empirical model. Intuitively, the impact of a rise in environmental stringency on IIT share would be channelized through the following effects. Firstly, an increase in the environmental stringency in a country Home would add to the cost of production and hence its export competitiveness would be reduced resulting in a fall in exports (a first-order effect). Secondly, consumers would substitute away from costlier Home varieties and move towards cheaper Foreign varieties and hence import demand would increase (a first-order effect). Thirdly, a lower production in Home would reduce the demand for its factors of production and, hence, the cost of production. This decrease in the cost of production, in addition to the greater stringency and the resultant higher prices in Home would lead to new firms entering into the Home industry. Due to the introduction of new varieties in Home, the domestic consumers partly switch back their demand for imported varieties toward Home leading to a fall in the level of imports (a second-order effect). Since the first order effect on exports would be stronger than the ambiguous effect on imports, the net effect on IIT share would depend on whether the country is a net exporter or net importer of the variety. Hence, if the country is a net exporter and it implements greater environmental stringency, the IIT share should increase while, if it is a net importer, then greater environmental stringency results in a fall in IIT share between the trading partners (Mehra and Kohli, 2018).

Table 7 presents the estimation results for the four industries while using the environmental stringency index calculated on the basis of total primary energy consumption of countries. And Table 8 provides the estimation results using the alternate measure of environmental stringency that is, based on the total primary energy supply of countries. The standard errors are reported in parentheses. Table 7 shows that both the coefficients of SER_i and SER_j are found to be negative and statistically significant for the pulp and waste paper industry, that is, an increase in stringency in either country would lead to a reduction in the share of IIT between the two trading partners. For instance, a rise in the energy intensity of the j^{th} country by 1 per cent reduces the IIT share by 0.038 per cent for pulp and waste paper industry. This could be attributed to the fact that pulp and waste paper is one of the most polluting industries of the world and therefore, a greater environmental stringency would result in higher costs of production of pulp and waste paper in both countries, in turn leading to a drastic fall in export competitiveness within this industry in both countries. The results for lime, cement and construction industry and iron ore and concentrates are a little different and show that the environmental stringency indicator for the i^{th} country is negative and significant while for the j^{th} country it is positive and significant. For instance, a rise in the energy intensity of the j^{th} country by 1 per cent raises the share of IIT by about 0.23 per cent for iron ore or concentrates while the IIT share is reduced by 0.52 per cent when energy intensity of i^{th} country is increased by 1 per cent.

Additionally, for the dyeing and tanning industry, the coefficients of both SER_i and SER_j are found to be positive but are significant for only the j^{th} country. This might be because even though dyeing or tanning extracts is a pollution-intensive industry, it is not a highly energy-intensive industry, and in this study, the stringency indicator is based only on primary energy consumption and/or supply. Therefore, these results might not reflect the true relationship that actually exists between the two variables. In Table 8 however, SER_i has a positive and significant coefficient for dyeing and tanning implying that more systematic results could be derived by using some comprehensive measure as an environmental stringency indicator. Moreover as perceived from Tables 7 and 8, the coefficient of SER_i and SER_j is greatest for iron ore or concentrates industry while it is least for pulp and waste paper industry.

Furthermore, the difference in per capita GDP variable has a negative sign for pulp and waste paper but a positive sign for the rest of the industries. The reason could be the presence of relatively greater inter-industry trade rather than intra-industry taking place in these industries, since a positive sign for this variable means more divergent economies are actually trading more in these industries (Caporale, 2014). For example, the Indian cement industry is the second largest producer of cement in the world just after China, but ahead of U.S. and Japan (Burange and Yamini, 2008) which implies that the other countries would look up to India and China for cement and other construction products, while in turn, the former would trade cement and construction materials for other goods which are in scarce in those countries instead of acquiring different varieties for cement. The factor-endowment ratio differential has the correct sign for all the industries, but it is not significant for iron ore and concentrates and lime, cement and construction industry.

One thing to be noted is that the factor endowment differential variable captures the supply side effects while the per capita GDP differential variable tries to capture the demand side effects on IIT. When one of them is dropped, say the factor-endowment ratio, the coefficient of the other variable, that is, per capita GDP differential reduces, implying that the variable which is incorporated into the regression picks up the effects of the omitted variable. And, when per capita GDP differential variable is dropped, the capital-labour ratio differential becomes positive and statistically significant. These results have been furnished in Tables 9, 10, 11 and 12. Additionally, the adjacency variable has an expected positive sign for cement and iron ore concentrates but a negative sign for dyeing or tanning extracts which is not statistically significant. The coefficients of the distance variable show surprising results with most of them being positive, although they are not statistically significant. In the gravity model, a greater distance is expected to affect trade negatively. But here, the results show otherwise. A study by Brulhart (2009) uses data for 1161 industries at the SITC five digit level of classification for 56 countries and runs a similar regression for 1965, 1990 and 2006 and traces the annual estimated coefficients on distance over the sample period. The author reports that while the elasticity of intra-industry trade with respect to distance was about -1.46 in 1965, it has attained a value of -0.7 now, which is only half as large as some forty years earlier. The author states that the reduction in the sensitivity of aggregate bilateral IIT with distance has been impelled essentially by IIT in intermediate goods suggesting that two-way trade in intermediate products on an average spans larger distances than two-way trade in primary and final goods.

4. Conclusion

An empirical estimation to test the impact of environmental stringency on IIT trade share has been attempted in this paper by using a panel dataset of 36 countries from 1990-2012. Two environmental stringency indicators were constructed for each country for each year based on total energy consumption and/or total primary energy supply. The impact of a change in stringency of environmental regulations on the share of IIT was tested for four pollution intensive industries: pulp and waste paper, iron ore or concentrates, lime or cement or construction materials and dyeing or tanning extracts. The results showed that except for dyeing or tanning, the signs of the stringency variables were as expected and highly statistically significant. Inconclusive results for dyeing or tanning might be because the stringency variable considered has been proxied by energy intensity of trading partners. Furthermore, the signs and significance of environmental stringency still holds even after dropping out capital-labour differential and GDP differential variables from the regression. Thus, it can be concluded that a change in strictness of environmental regulations does affect IIT flows between countries.

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TABLES

Table 1: Imports and Exports, 1998-2012, in current prices (SITC 251)

		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Values in Bln US$	Imp.	18.6	19.8	27.1	21.6	21.1	24.0	28.3	30.1	33.1	40.2	46.5	34.0	49.1	57.0	50.1
	Exp.	16.8	16.8	24.3	19.0	18.8	21.9	24.7	25.8	29.7	36.7	40.7	30.8	43.7	49.7	44.4
As a percentage of SITC section (%)	Imp.	7.9	8.7	11.0	9.2	8.8	8.3	7.6	7.2	6.7	6.5	6.1	6.3	6.5	5.8	5.3
	Exp.	8.1	8.6	11.4	9.4	8.8	8.5	7.7	7.0	6.6	6.7	6.2	6.3	6.3	5.6	5.3
As a percentage of world trade (%)	Imp.	0.3	0.3	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Exp.	0.3	0.3	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.3	0.3	0.2	0.3	0.3	0.2

Source: UN COMTRADE, 2012

Table 2: Imports and Exports, 1998-2012, in current prices (SITC 281)

		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Values in Bln US$	Imp.	13.0	11.3	13.1	12.8	13.1	16.8	29.5	40.6	47.5	65.7	108.4	77.3	131.9	184.3	158.6
	Exp.	9.9	8.2	9.2	9.1	9.9	11.3	16.5	28.0	33.2	40.0	67.5	56.8	103.5	149.8	126.7
As a percentage of SITC section (%)	Imp.	5.5	4.9	5.3	5.5	5.4	5.8	7.9	9.8	9.6	10.7	14.2	14.3	17.4	18.7	16.9
	Exp.	4.8	4.2	4.3	4.5	4.6	4.4	5.1	7.6	7.4	7.3	10.4	11.5	15.0	16.8	15.0
As a percentage of world trade (%)	Imp.	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.4	0.4	0.5	0.7	0.6	0.9	1.0	0.9
	Exp.	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.5	0.7	0.8	0.7

Source: UN COMTRADE, 2012

Table 3: Imports and Exports, 1998-2012, in current prices (SITC 661)

		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Values in Bln US$	Imp.	11.6	12.0	12.2	12.7	13.1	15.1	18.0	21.9	25.2	29.2	31.4	25.3	26.4	28.8	29.7
	Exp.	10.9	10.9	10.9	11.1	12.2	13.3	15.7	19.0	22.8	26.0	31.0	24.4	25.5	28.2	29.6
As a percentage of SITC section (%)	Imp.	1.4	1.5	1.4	1.5	1.5	1.5	1.4	1.5	1.5	1.5	1.4	1.6	1.4	1.3	1.4
	Exp.	1.3	1.4	1.3	1.3	1.4	1.3	1.2	1.3	1.4	1.3	1.4	1.6	1.3	1.2	1.3
As a percentage of world trade (%)	Imp.	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Exp.	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Source: UN COMTRADE, 2012

Table 4: Top Exporting Countries or areas in 2012 (SITC 532)

Country or area	Value (million US$)	Avg. Growth (%) 08-12	Growth (%) 11-12	World share %	
					Cum.
World	2091.8	6.8	-3.2	100.0	
Italy	235.5	4.9	-3.9	11.3	11.3
Germany	206.6	3.9	-8.5	9.9	21.1
Spain	163.7	10.1	0.9	7.8	29.0
Netherlands	148.2	14.7	5.7	7.1	36.0
France	138.7	4.5	-4.5	6.6	42.7
USA	120.2	3.9	1.4	5.7	48.4
South Africa	90.9	10.3	4.1	4.3	52.8
Denmark	90.9	17.4	-8.8	4.3	57.1
Argentina	89.4	5.5	7.9	4.3	61.4
Turkey	74.2	3.3	-10.9	3.5	64.9
Brazil	72.6	6.6	-0.3	3.5	68.4
Peru	69.0	19.1	-46.6	3.3	71.7
India	67.6	13.2	12.2	3.2	74.9
United Kingdom	57.9	-1.3	1.2	2.8	77.7
Ireland	51.5	8.3	-8.9	2.5	80.2

Source: UN COMTRADE, 2012

Table 5: Top Importing Countries or areas in 2012 (SITC 532)

Country or area	Value (million US$)	Avg. Growth (%) 08-12	Growth (%) 11-12	World share %	Cum.
World	2717.9	9.4	-5.6	100.0	
China	251.1	10.3	-2.7	9.2	9.2
USA	199.7	13.1	25.7	7.3	16.6
Japan	176.5	5.9	5.7	6.5	23.1
Italy	141.6	5.8	-11.4	5.2	28.3
Germany	126.1	5.5	-22.1	4.6	32.9
Mexico	125.9	13.2	-44.7	4.6	37.6
Spain	108.0	12.7	-26.5	4.0	41.5
Russian Federation	96.4	49.9	222.0	3.5	45.1
Netherlands	92.7	30.5	100.0	3.4	48.5
France	91.5	10.7	-14.0	3.4	51.9
United Kingdom	86.9	16.3	-0.4	3.2	55.1
India	82.7	0.0	3.7	3.0	58.1
Brazil	70.5	10.1	2.5	2.6	60.7
Viet Nam	*60.8*	34.2	75.9	2.2	62.9
Rep. of Korea	60.4	4.3	0.7	2.2	65.2

Source: UN COMTRADE, 2012

Table 6 Summary Statistics

Variables	Obs.	Mean	Std. Dev.	Min.	Max.
lnpcgdpdiff	13685	9.284406	1.274319	0.6931472	11.49408
lnklratiodiff	13685	8.528688	1.21807	0.009627	10.53389
lndist	13685	8.691764	0.9662548	5.159193	9.896872
Adj	13685	0.0420168	0.2006348	0	1
glindex (Pulp & Waste Paper)	13685	0.2957293	0.2224113	0	0.999887
glindex (Lime, Cement & Construction)	13685	0.2785887	0.2934194	1.04e-07	0.999885
glindex (Iron Ore or Concentrates)	13684	0.1679436	0.262209	6.96e-10	1
glindex (Dyeing & Tanning)	13685	0.3437311	0.31174	3.03e-07	0.9999572
lnserc1i	13685	1.389531	0.6423838	0	3.105902
lnserclj	13685	1.409464	0.6615215	0	3.105902
lnserp1i	13685	2.119002	1.873731	0	13.80158
lnserp1j	13685	2.247363	1.730386	0	13.80158

Source: Own Estimation

Table 7: Estimation Results with Stringency Index based on Total Primary Energy Consumption

(Dependent Variable = logarithm of GL index)

Variables	Pulp and Waste Paper	Lime, Cement and Construction Materials	Iron Ore or Concentrates	Dyeing or Tanning Extracts
PcYdiff	-0.0116169*** (0.0022941)	0.0574501** (0.0242241)	0.1164046*** (0.040356)	0.0736776*** (0.0228696)
K/Ldiff	-0.006049*** (0.002065)	-0.0120333 (0.024962)	-0.0376606 (0.0411241)	-0.0617373*** (0.0232806)
distance	-0.0303535*** (0.0040635)	0.0251701 (0.0277174)	0.0941002** (0.038878)	0.0269818 (0.0235888)
adjacency	-0.0444045** (0.0214076)	0.0883501 (0.1211001)	0.3132897* (0.1807058)	-0.0312625 (0.1108251)
SER_i	-0.0271194*** (0.0034497)	-0.2908912*** (0.0579674)	-0.5207126*** (0.096537)	0.0319603 (0.0291419)
SER_j	-0.0383245*** (0.0035229)	0.0644069* (0.0345929)	0.2392446*** (0.0490077)	0.07003** (0.0290119)
Observations	595	595	595	595

***, ** and * indicate significance at the 1%, 5% and 10% respectively.

Table 8: Estimation Results with Stringency Index based on Total Primary Energy Supply

(Dependent Variable = logarithm of GL index)

Variables	**Pulp and Waste Paper**	**Lime, Cement and Construction Materials**	**Iron Ore or Concentrates**	**Dyeing or Tanning Extracts**
PcYdiff	-0.016294*** (0.0024077)	0.0746151*** (0.0240728)	0.1492769*** (0.0398522)	0.0791874*** (0.0226869)
K/Ldiff	-0.0072488*** (0.0021877)	-0.0110181 (0.0251184)	-0.0318268 (0.040974)	-0.0599545*** (0.0232742)
distance	-0.0252128*** (0.0042185)	0.0072926 (0.0270911)	0.05347 (0.0378631)	0.021421 (0.0232684)
adjacency	-0.0593902*** (0.0217972)	0.0776854 (0.1209123)	0.3120614* (0.1810723)	-0.0160251 (0.1112755)
SER_i	-0.0045297*** (0.0011642)	-0.0231843*** (0.008339)	-0.1863837*** (0.0456759)	0.0337675*** (0.0095262)
SER_j	-0.0017065 (0.0013798)	0.0285068** (0.0142172)	0.0161555 (0.0179668)	-0.0015786 (0.0106453)
Observations	595	595	595	595

***, ** and * indicate significance at the 1%, 5% and 10% respectively.

Table 9: Estimation Results after Omitting the log of Per-Capita GDP Differential Variable with Stringency Index based on Total Primary Energy Consumption

(Dependent Variable = logarithm of GL index)

Variables	Pulp and Waste Paper	Lime, Cement and Construction Materials	Iron Ore or Concentrates	Dyeing or Tanning Extracts
K/Ldiff	-0.0090376*** (0.0016593)	.0316359* (0.0177245)	.0522104** (0.0257578)	-0.0055638 (0.0154004)
distance	-0.028365*** (0.0041957)	.0273922 (0.0275726)	0.0946138** (0.0390755)	0.0301 (0.0235265)
adjacency	-0.0267281 (0.0220071)	.0749101 (0.1220519)	0.2810539 (0.1811584)	-0.0477071 (0.1105049)
SER_i	-0.022144*** (0.0032858)	-0.3015586*** (0.0586375)	-0.5356393*** (0 .0960448)	0.0372694 (0.0290708)
SER_j	-0.0332676*** (0.0033466)	0.0732129** (0.0342428)	0.2546841*** (0.0487749)	0.0807145*** (0.0287851)
Observations	595	595	595	595

***, ** and * indicate significance at the 1%, 5% and 10% respectively.

Table 10: Estimation Results after Omitting the log of Per-Capita GDP Differential Variable with Stringency Index based on Total Primary Energy Supply

(Dependent Variable = logarithm of GL index)

Variables	Pulp and Waste Paper	Lime, Cement and Construction Materials	Iron Ore or Concentrates	Dyeing or Tanning Extracts
K/Ldiff	-0.0112492*** (0.0017375)	0.0416889** (0.0179026)	0.0864932*** (0)	.0017856 (0.0150732)
distance	-0.0244991*** (0.0043662)	0.0169307 (0.0271508)	0.0506896 (0)	0.0227344 (0.0232115)
adjacency	-0.0405134* (0.0224217)	0.0692819 (0.1240409)	0.2693419 (0)	-0.0335851 (0.1109022)
SER_i	-0.0037487*** (0.0010961)	-0.1004582*** (0.0223467)	-0.1924605*** (0)	0.0350284*** (0.0095177)
SER_j	-0.0007061 (0.0013002)	0.0281658* (0.0144604)	0.0141477 (0)	-0.0016077 (0.0106373)
Observations	595	595	595	595

***, ** and * indicate significance at the 1%, 5% and 10% respectively.

Table 11: Estimation Results after Omitting the log of Capital-Labour Differential Variable with Stringency Index based on Total Primary Energy Consumption

(Dependent Variable = logarithm of GL index)

Variables	Pulp and Waste Paper	Lime, Cement and Construction Materials	Iron Ore or Concentrates	Dyeing or Tanning Extracts
PcYdiff	-0.0137762*** (0.0019029)	0.0484747*** (0.017284)	0.0872801*** (0.0253109)	0.0282239* (0.0151439)
distance	-0.0277105*** (0.0041987)	0.0247897 (0.0276865)	0.0920767*** (0.0389584)	0.0246564 (0.0235819)
adjacency	-0.0398963* (0.0220918)	0.0874934 (0.121393)	0.3108326* (0.1809046)	-0.0360058 (0.1108554)
SER_i	-0.0209751*** (0.0032674)	-0.290447*** (0.0579901)	-0.5177287*** (0.0964584)	0.0278669 (0.0291114)
SER_j	-0.0317295*** (0.0033457)	0.063972* (0.0345521)	0.2373607*** (0.0491044)	0.0684205** (0.029016)
Observations	595	595	595	595

***, ** and * indicate significance at the 1%, 5% and 10% respectively.

Table 12: Estimation Results after Omitting the log of Capital-Labour Differential Variable with Stringency Index based on Total Primary Energy Supply

(Dependent Variable = logarithm of GL index)

Variables	Pulp and Waste Paper	Lime, Cement and Construction Materials	Iron Ore or Concentrates	Dyeing or Tanning Extracts
PcYdiff	-0.0176429*** (0.00198)	0.0601297*** (0.0173444)	0.1244163*** (0.0244955)	0.0347079** (0.0147108)
distance	-0.0239309*** (0.0043544)	0.0156045 (0.0272859)	0.052067 (0.0379349)	0.0196023 (0.0232732)
adjacency	-0.0546082** (0.0224474)	0.0845674 (0.1234815)	0.3102282* (0.1813021)	-0.0202411 (0.1113379)
SER_i	-0.0033534*** (0.0010985)	-0.0965649*** (0.0223257)	-0.1861318*** (0.0455554)	0.0334063*** (0.0095289)
SER_j	-0.000906 (0.0013042)	0.0278174* (0.0143972)	0.015143 (0.0179632)	0.002835 (0.0106394)
Observations	595	595	595	595

***, ** and * indicate significance at the 1%, 5% and 10% respectively.