Intra-industry Trade and Environment in the SAARC Region

(An Application of the New Trade Theory)

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Abstract

The South Asian Association for Regional Cooperation (SAARC) countries are actively participating in the world trade. SAARC countries are engaged in both inter- and intra–industry trade. The volume of intra-industry trade is increasing in the SAARC region. Does increase in the intra-industry trade a source of environmental externalities in the region? This is a question, which is addressed in this thesis. Accordingly; this thesis investigates the trade and environment relationship by making use of the new trade theory. The new trade theory refers to the imperfect competition, increasing returns to scale, choice of variety and specialization in a limited range of production of differentiated goods. By using the new trade theory, this study thus examines the trade induced environmental effect that is disintegrated into three components; namely, scale effect, technique effect and selection effect. It is the selection effect that differentiates the effect of inter-industry trade from the effect of intra-industry trade on the environment. Earlier empirical studies generally ignored the selection effect due to frequent use of overall trade induced environmental composition effect in the trade and environment literature. Trade induced environmental composition effect emphasizes on environmental effect of trade due to change in factor intensity. But this thesis use trade induced environmental selection effect instead of trade induced environmental composition effect. The environmental selection effect is the change in emission level due to change in the selection of differentiated products, while trade induced environmental selection effect is the change in emission level due to change in the selection of differentiated products as result of trade liberalization. In the absence of data on differentiated products, empirical research studies suggest that number of firms can be used as a proxy for differentiated products. This study uses number of listed firms instead of differentiated products. The environmental scale effect is a change in the level of emission due to change in the scale of production; on the other hand trade induced environmental scale effect is a change in the level of emission due to change in the scale of production by virtue of trade liberalization and the environmental technique effect, shows the relationship between income and emissions; while trade induced environmental technique effect, shows the relationship between income and emissions due to trade liberalization. Disintegration of trade induced environmental effects is thus an integral part of this study. Another important element of this thesis is policy recommendations on the basis of empirical analysis.

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Chapter 1: Introduction

1.1. Background

The environment is becoming an important issue in international trade, while trade liberalization is creating issues that are concerned with both trade and the environment. The pertinent questions, whether the resulting trade expansion pollutes the environment more or less than before whether an emphasis on economies-of-scale in trade liberalization policies is assisting countries to make a check on pollution emission or not? The relationship between trade and environmental quality is ambiguous due to the structure of developing economies, sometime it is beneficial in the short run but harmful in the long run or vice versa (Crosby, 2008). Trade expansion may have direct as well as indirect trade-induced environmental effects. Comparative advantage theory of international trade (Ricardo, 1821) advocates that, free trade enables the economies to ensure both efficiency in production and in allocation of resources. Trade liberalization induces elimination of distortionary subsidies and pricing policies, thus improving the efficiency of resource allocation.

Economies with large polluting industries are blamed to be the major culprit of the environmental degradation, such as climate change. In the industrial sector having features of increasing return to scale with trade liberalization, total number of firms in the industry shrinks although each one of the remaining firms produces more than before. Trade expands the consumption basket and enables the consumers to use both local and imported varieties of goods. At the same time, when income level of a country increases due to trade openness; the country implements stricter environmental approach, which causes amplified pollution abatement activity and lesser emission intensity (Fung and Maechler, 2007).

The production of differentiated goods is not free from environmental effects. They certainly degrade the environment, the question is, what is the nature of these effects? How does the trade affect the trading nations? And whose liability is to mitigate the environmental damages of trade? These questions are frequently asked in trade and environment literature. Most of researchers trying to answer these questions, but recent developments in new trade theory open the new era for research. New trade theory is becoming important over the time, that's why intra-industry trade and environmental concerns are also increasing all over the world. This thesis is an attempt to find out the impact of trade on the environment in the South Asian Association for Regional Cooperation (SAARC) countries by applying the new trade theory.

The mounting pace of trade in differentiated products shows that intra-industry trade is becoming a significant aspect of global trade. Intra-industry trade is explained by differentiated goods while inter-industry trade is explained by comparative advantages. Intra-industry trade is to import and export, the same types of goods and services that fall in the same industry. For example, Intra-industry trade arises, if Germany exports cars to UAE and at the same time imports cars from Italy.

The environmental effects of such type of trade can be decomposed into three types of trade- induced environmental effects; namely, trade-induced environmental scale effect, trade-induced environmental selection effect and trade induced environmental technique effect. Trade-induced environmental selection effect occurs when change in number of firms (which is an economic variable) changes the environmental quality (environmental variable). Trade-induced environmental scale effect narrates the variation in environmental quality due to change in scale of production. Trade-induced environmental technique effect is impact of income on quality of environment (Aralas, 2010).

There is a gap in the literature on trade and environment under the new trade theory. To fill this gap Aralas (2010) investigates the trade and environment relationship in OECD countries by making an application of the new trade theory. For the SAARC countries, no such study is conducted to examine this relationship. Some economists like Fung and Maechler (2007) and Shahbaz, *et al*. (2012) study the importance of intra-industry trade in the SAARC, but these studies do not consider the implications of intra-industry trade for the environment. While Azhar, *et al*. (2007) point out the long run implication of overall trade liberalization for air pollution. Distinguishing itself from previous studies, this thesis is an attempt to fill the gap in the literature on intra-industry trade and environment, under the new trade theory in the SAARC region. More specifically, this thesis explores the trade-induced environmental effects, *i.e.*, selection effect, scale effect and technique effect due to intra-industry trade in the SAARC countries.

1.2. Overview of the SAARC Economies

In this section, we briefly examine the overall economic structure, trade flows and patterns and air pollution in the SAARC region.

1.2.1. Economic Structure of the SAARC Countries

Eight countries of the SAARC namely; Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka differ greatly in land area, GDP, population, trade patterns and environmental zones. They have common borders with one another and these countries have more or less similar level of human resources and economic development.

India is a large country in this region with vast land area, huge population, the greater share of GDP and GNP in the SAARC and a large trading country as compared to other SAARC associates (Akram, 2012). That`s why India has a great share of environmental degradation in the SAARC and blamed an environmental degrader in the region. But per capita and per kilometer square comparisons gives a different picture along with other SAARC countries (Behera, *et al*., 2011).

Pakistan and Bangladesh have some type of similar characteristics in this region. These two countries have identical GDP, GNP and population structure as compare to India. Their combined share of trade in the SAARC is considerable as compared to India (Akram, 2012). Contamination levels of air pollution of Pakistan and Bangladesh in SAARC are manageable as compare to India (Karim, 2001).

Sri Lanka is a small country in this region with a small share of total GDP, GNP, population and land area of SAARC. Trade share is also not very high but Sri Lanka has its own importance in the region (Akram, 2012).

These four countries of the SAARC region are at the similar stage of economic development. The share of the manufacturing sector is increasing in these countries. But the performance of these countries is unsatisfactory if we compare this region with the trade performance of other regional alliances. After comparing the SAARC and the ASEAN (Association of South East Asian Nations) regions, we come to know that the performance of the SAARC region is unsatisfactory. Each country has a specific role in the specialization of a narrow range of differentiated products. The specialization of a narrow range of products will not only source of cost effectiveness but also improves the quality of their products. So, in the best of the regional economic interest, intra-industry trade has its own importance (Akram, 2012).

1.2.2. Trade in the SAARC Region

The SAARC region has huge capacity to make itself an effective trading bloc in the world. The share of SAARC countries in world population is about 23 percent and considered a large market with massive profit making opportunities. By engaging in the intra-industry trade on the basis of product differentiation and economies of scale (due to large scale production), these countries can gain from the intra-industry trade (Akram, 2012).

Economists in the SAARC think that today`s South Asia has a variety of common characteristics with the Europe of the nineteen century. Development of international institutions, rising nationalism and regional associations are new sense of political and economic interaction (Tussie, 1998). The mode of trade is also changing due to trade reforms in the world. That`s why, trade of differentiating goods is becoming popular in this region. Over the time intra-industry trade volume is increasing and it is taking the place of inter-industry trade (Fung and Maechler, 2007).

Table 1.1 shows the commodity trade volumes. India, Pakistan, Bangladesh and Sri Lanka are major SAARC economies; therefore their data on inter- and intra-industry trade is available in Table 1.1. Afghanistan, Bhutan, Maldives and Nepal are other SAARC countries but UN (2011) does not provide the data for inter- and intra-industry trade of these countries due to non-availability of data from these countries.

Table 1.1: Commodity Trade Statistics

Country	Trade in Goods(Million US Dollar 2011)	Inter-industry Trade (Million US Dollar 2011)	Intra-industry trade (Million US Dollar 2011)
Afghanistan	-	-	-
Bangladesh	8482.4	7858.6	623.7
Bhutan	-	-	-
India	131272.8	52246.6	79026.2
Maldives	276.6	-	-
Nepal	580.1	-	-
Pakistan	15904.8	11610.5	4294.3
Sri Lanka	3970.7	3101.1	869.6

Source: United Nations Commodity Trade Statistics Database, 2011.
Note: (-) means not available.

1.2.3. Air Pollution in the SAARC Region

Air pollution is a common problem in the SAARC region. It is growing day by day in the SAARC countries. Industrial hubs in Pakistan like Lahore, Karachi, Peshawar, Rawalpindi, Hyderabad, Faisalabad, Gujarat, Sialkot, and Gujranwala are creating serious environmental problems. Atmospheric levels of carbon mono oxide, sulfur-dioxide and nitrous oxides are higher than safe limits. Some industries are taking measures to control air pollution. But, suitable technology for controlling air contamination has not yet been adopted in Pakistan (Parekh, *et al*., 2001).

The main sources of air contamination in Sri Lanka are vehicular and industrial emissions. Urban areas are mostly affected by air pollution. The intensity air pollution is low in rural areas, because of low concentration of industries in these areas. 80 percent industrial units in Sri Lanka are located in Colombo, Kalutara and Gampaha regions in the Western Jurisdiction.

The remaining is distributed all over the country. Chemical, food and textile sectors contribute 40 per cent of air pollution (Wittman and Caron, 2009).

India is investing in air pollution control programs but these programs have several gaps and weakness. Awareness about the possible damages of air pollution is widely presented in all segments of Indian society. Now manufacturing units are required to attain prior agreement from environmental authorities before starting new operations. Strict environmental standards have been set up for a number of highly polluting industries (Behera, *et al.*, 2011).

Air quality in Dhaka is very poor due to dust and vehicle emissions especially on the main roads. Industrial discharges are noticeable in some parts of the city. Outdoors industrial activities are also in practice. There are some highly populated and dense industrialized pockets in Dhaka, Chittagong and Khulna cities. But the situation with respect to air quality is not serious, partly because of prevailing natural environmental conditions which easily scatter the air emissions due to a flat topography and relatively high wind speeds most of the year (Karim, 2001).

The major SARRC countries from trade and environmental point of view are India, Pakistan, Bangladesh and Sri Lanka. Table 1.2 briefly explains the quick overview of SAARC countries. This thesis tries to take the issue of trade and environment in major SAARC countries under the new trade theory. Other SAARC countries are also contributing in trade and emissions, but their share is very small as compared to major SAARC countries, that`s why we are ignoring their emissions in our thesis.

Table 1.2: CO2 Emissions (kt) and Population Density

Country	Area km^2 2011 estimate	Population 2011 estimate	Population Density 2011 estimate	CO2 Emissions 2011 estimate
Afghanistan	647500	30419928	43.5/km^2	2206
Bangladesh	147570	161083804	1,033.5/km^2	50882
Bhutan	38394	742737	18.0/km^2	483
India	3287263	1210193422	371.7/km^2	1872734
Maldives	298	328536	1,102.5/km^2	841
Nepal	147181	26494504	180/km^2	3218
Pakistan	796095	180440005	226.6/km^2	177556
Sri Lanka	65610	20277597	323/km^2	14322

Source: UNFCCC (2011)

1.3. Objectives

The main objective of this thesis is to investigate the impact of intra-industry trade on the level of pollution (CO_2Emissions) in the SAARC countries. More specifically, the objectives are to examine the:

a. Trade-induced environmental selection effect.
b. Trade-induced environmental scale effect.
c. Trade-induced environmental technique effect.
d. Suggest policy recommendations.

1.4. Organization of the Thesis

The rest of the thesis is divided into four chapters. Chapter 2 illustrates the literature review. Chapter 3 provides the empirical methodology and discusses the data and its sources. Chapter 4 interprets the results of the study. The last chapter consists of conclusion and policy recommendations. The references can be found in the reference list at the end of the dissertation.

Chapter 2: Review of Literature

2.1. Introduction

A number of studies have been published after the emergence of SAFTA (South Asian Free Trade Area), which examine the trade patterns in the SAARC countries. But, a little heed has been paid to link trade with environment. The available studies examine the historic trends of trade liberalization and emission levels, only a few of them analyze the environmental effects of intra-industry trade. Intra-industry trade for the first time was studied by Verdoorn (1960) and this concept has revolutionized the international trade theory and policy. After that Grubel and Lloyd (1975) developed a popular index of intra-industry trade. Helpman and Krugman (1985) made various attempts to model intra-industry trade. Aralas (2010) extended the Krugman (1979) model of intra-industry trade by incorporating environment.

This chapter reviews the available literature on intra-industry trade in the SAARC countries, trade liberalization and environment and regional model of trade and environment.

2.2. Studies on Intra-industry Trade in the SAARC Region

Akram (2012) finds out the determinants of intra-industry trade between Pakistan and selected SAARC countries and concludes that specialization in a narrow range of products is not only a source of cost effectiveness but is also improving the quality of their products. So, in the best of the regional economic interest, intra-industry trade has its own importance.

Shahbaz, *et al*. (2012) examine the significance of intra-industry trade in Pakistan along with other trading associates by using data from 1980 to 2006 and final conclusion of their study narrates that distance and transportation costs have an inverse relationship with intra-industry trade. To minimize the inverse effects of distance and transportation costs Pakistan should focus on regional trade.

Empirical evidence of Fung and Maechler (2007) suggests that the increasing overall share of SAARC countries' trade takes the form of intra-industry rather than inter-industry trade. Share of intra-industry trade in India and Pakistan is increasing, but in Bangladesh and Sri Lanka intra-industry share is relatively constant. They also suggest that intra-industry trade is in the best interest of the SAARC region.

2.3. Studies on Trade Liberalization and Environment

The study by Alam (2010) examines strong evidence of the impact of overall trade liberalization, industrialization and human development on environmental degradation in Pakistan. The study also finds parallel effects of trade liberalization along with all other socioeconomic and demographic factors on economic growth. The results of this study imply that industrial and agricultural activities and rapidly growing urbanization affect the environment badly, while trade liberalization and human development are environmental friendly.

The study by Azhar, *et al*. (2007) examine the long run coefficient of overall trade liberalization and scale effect is considerably associated with air and water contamination. Thus, scale effect of trade intensity is hazardous for the environment and the scale of production is positively related to pollution. On the other hand, composition and technique effects inversely associated with pollution hence are beneficial to the environment. Overall finding advocates that to amplify the gains of trade liberalization, and to attain a sustainable development and high quality growth path, Pakistan ought to reduce the environmental costs related to industrial development.

Cosbey (2008) inquires that supporters of trade liberalization are worried that debates about environmental protection will be exercised as a tool of protection for them against competition from abroad. Champions of the environment are anxious that free trade will be employed as a justification to present inadequate weight to environmental goal and too much weight to maximization of market measured GDP.

Bhagwati (2002) argues that, “A variety of groups are creating problems for free trade, including environmentalists and political groups as well as human rights activists and traditional lobbies who express their agendas in the language of justice and rights.”

Aralas (2010) critically reviews the trade and environment literature. She comes up with the following findings: firstly, trade–environment relationship is mostly based on traditional trade theories; secondly, relationship between environment and new trade theory focuses on environmental regulations; and thirdly there is no proper model that reveals the consequences of intra-industry trade for environmental performance in the closed and open economy.

Cole and Elliot (2003) examine that rise in income due to trade creates the demand for better environmental technologies endogenously. Openness of trade enables the economies to access to foreign technologies. In this way trade liberalization provides an endogenous technique effect. Technique effect is one of the major effects in the trade and environment literature, which is integral part of the Environmental Kuznets curve. Environmental Kuznet Curve is a hypothetical relationship between various indicators of environmental degradation and income per capita.

Dean (1992) states on the basis of trade and investment data that pollution intensive industries shift from developed nations to other industrial countries instead of less developed countries. In the investigation of race to the bottom in environmental protection laws, the evidence to support the hypothesis remains mixed. He finds that the environmental impact of trade liberalization mostly depends on the nature of pollution, whether it is local or global.

2.4. Regional Models of Trade and Environment

Dean (2002) examines the impacts of trade intensity on water pollution. She modified the Copeland-Taylor model by incorporating endogenous environmental policy and trade openness; both directly affect the environment, through trade-induced composition effect and technique effect. She claims that China has a comparative advantage in the trade of pollution-intensive goods, so that trade liberalization has negative impact on environmental quality. So, trade liberalization is economically beneficial for China but environmentally harmful.

Taylor, *et al*. (2001) report that air pollution is directly associated with openness of trade and scale effect, by using the data of sulfur dioxide from 293 sites over the period of 1971 to 1996. The composition effect and technique effect are negatively related to pollution. This study uses traditional (inter-industry trade) empirical tools for measuring the trade-induced environmental effects, therefore cannot explain intra-industry trade and environment relationship. For regional investigation of intra-industry trade Aralas`s (2010) model is favorable which is developed for OECD countries.

Markusen (1975) includes two regions in his model to examine the firm level efforts in environmental tax behavior in an imperfect competitive market with increasing returns to scale.

This hypothetical framework demonstrates that competition in environmental taxes may result in either pulling out the pollution oriented firm out of the market when the environmental damages of pollution is extremely crucial, or two regions will reduce each other`s pollution tax rate when disutility of pollution is low.

Beghin, *et al.* (2002) model examines the trade integration, environmental degradation, and public health in Chile. By using a CGE model they proved that, without liberalization Chile has cheaper and dirtier energy sources, which pollutes the environment. However, if trade liberalizes with appropriate environmental standards there would be significant welfare gains for Chile. This approach emphasizes on an inspection about the relationship between trade policy and environmental policy.

Aralas (2010) states that production is a source of pollution, intra-industry trade brings three environmental effects, which are described as trade-induced environmental scale effect due to the growth of production and enhancement in economies of scale, trade related environmental selection effect due to the entry and exit of firms resulting from competition from other countries and trade-induced technique effect a change in environmental quality due to change in level of income. Trade and environment relationship presents three analyses. Firstly, it builds up a trade and environment mechanism for an economy that produces pollution intensive differentiated products. Secondly, the production of dirty goods is illustrated to show four types of environmental effects; the scale, the technique, the composition and the selection effects. Thirdly, it explains the link between trade intensity or openness of trade and environment. The total impact of intra-industry trade can be explained by summing the scale, technique and selection effects.

2.5. Concluding Remarks

The above review of literature suggests that a large body of studies are available that separately deals with the issue of international trade and environmental externalities. Only a few studies are available that bridge the issues of both disciplines to assess their causes and effects. Besides, only a few studies provide the linkage between intra-industry trade and environment by using the framework developed by the new trade theory. To the best of our knowledge, there is no study available for the SAARC region that examines the relationship between intra-industry trade and environment. This thesis is therefore an attempt to fill this gap by employing econometric methods for the purpose of estimating the intra-industry trade and environmental relationship in SAARC region.

Chapter 3: The Model

3.1. Introduction

This chapter deals with the theoretical and empirical frameworks used to examine the relationship between intra-industry trade and environment. Section3.2 provides the mathematical models, section 3.3 based on 3.2 discusses empirical models of intra-industry trade and environment, section 3.4 describes the measurements of variables. Finally, section 3.5 outlines the empirical strategy.

3.2. Mathematical Model

We follow the Aralas (2010) model, who introduces the environmental selection effect of trade using the features of the new trade theory. The Aralas`s model is based on the new trade theory developed by Krugman (1979). The present study thus makes an effort to examine environmental effects of trade in the SAARC region by using the Aralas model.

According to the Aralas model the market structure is monopolistically competitive and firms produce differentiated goods, while pollution is a ‘joint’ product. Firms have the same technology and produce goods with a large number of product varieties. Production technology is increasing returns to scale. Producers are identical except in the design of their product and able to differentiate their products without incurring additional cost. Finally, countries are identical in size, technology and preference and there is zero transportation cost.

3.2.1. Consumption

There are N numbers of consumers having similar preferences in the economy. Consumers do not derive utility from leisure. Each consumer receives positive utility from consuming i^{th} good but obtains negative utility from pollution. Social damage from pollution comes from disutility imposed on consumers. The consumer can maximize his utility within limited budget, in this framework total income is equal to consumer`s wage, in this case consumer utility maximization can be expressed as follows.

$$\max \mathrm{U}_{x_i} = \sum_{\mathrm{i=1}}^{\mathrm{n}} \mathrm{v}(\mathrm{x_i}) - \sum_{\mathrm{i=1}}^{\mathrm{n}} z_i . . . (1)$$

subject to y=w

where,

$\mathrm{y}=\sum_{\mathrm{i=1}}^{\mathrm{n}} \mathrm{p_i x_i}$

(The consumer can maximize his utility within limited budget)

$\mathrm{p_i}$ =Price of the i^{th} good.

u =Utility from consumption of goods.

n =Total number of varieties.

y =Total income.

i =Any particular variety.

x = Good providing utility.

w =Wage.

z_i =Disutility from pollution.

3.2.2. Production

The model assumes the locally emitted pollutants, the trans-boundary pollutants are not considered. There is increasing returns to scale with initial positive fixed cost, constant marginal cost due to which average cost decreases in firms. A part of the output is allocated for abatement, $\mathbf{q_i \theta}$, remaining part $(\mathbf{1-\theta})\mathbf{q_i}$ is sold in the market for consumption purpose. This relationship can be expressed by the following form:

$$(1- \theta)q_i = Lx_i \ . \ . \ . \ (2) \qquad ; \quad 0 \leq \theta < 1$$

where;

θ = Abatement of pollution.

q_i = Output.

L = Total number of labor employed in production.

In Equation (2) $\mathrm{Lx_i}$ is total demand $(locally\ produced\ goods + imports)$ and $(1-\theta)\mathrm{q_i}$ is the total supply $(locally\ supplied\ goods + exports)$ after adjusting for the abatement activity.

A tight environmental policy obliges the firms to cut down the emissions and start greater abatement activity. The ‘domino effect’ of the policy is a decrease in emission intensity per unit of output.

$$e = \left(\frac{w\beta}{\tau(\emptyset - 1)}\right) \;...(3)$$

where,

$e \geq 0, \beta \geq 0, \tau \; \geq 0$

e = Emissions per unit of output.

w = Wage.

β = Labor coefficient.

τ = Emission tax rate.

$\emptyset$ = Change in emission intensity due to change in part of output allocated for consumption.

Emission per unit of output or emission intensity is denoted by e_i. e_i is equal to $\frac{z_i}{q_i}$, the relationship between emissions and emission per unit of output is given as;

$$z_i \; = \; e_i q_i \; ... \; (4)$$

Emission tax is given by Equation (5)

$$\tau = -\left[\left(\frac{1}{\psi}\right)\varphi\rho^{-1}\left(\frac{w\beta}{(\emptyset-1)}\right)q\right]^{\frac{1}{(1+\rho)}} \quad ... \; (5)$$

where,

$$\psi = \left(np^{\frac{\rho}{(\rho-1)}} + n^{*}p^{*\frac{\rho}{(\rho-1)}}\right)^{1-\rho}$$

Equation (5) can also be expressed in the functional form as.

$$\tau = \tau(\psi\ , w\ , \beta\ , \rho)$$

β = Productivity of labor parameter.

ρ = The preference parameter.

φ= Marginal disutility of pollution.

w = Wage.

n = Number of domestic firms.

ψ = Domestic and foreign product varieties.

p = Domestic price.

n^* = Number of foreign firms.

p^* = Foreign price level.

Negative sign in Equation (5) on the right hand side is due to the marginal disutility of pollution (φ).

Using Equation (2), Equation (4) can be rewritten as:

$$z_i = e_i q_i \Rightarrow \sum_{i=1}^{n} e_i\, q_i = \sum_{i=1}^{n} e_i \left(\frac{Lx_i}{(1-\theta_i)}\right) \quad \ldots (6a)$$

Total labor, L, in the closed economy, is predetermined and balance across firms, this implies that:

$$\sum_{i=1}^{n} z_i = \frac{L \sum_{i=1}^{n} e_i x_i}{(1-\theta_i)} \Rightarrow nz = L.n.ex/(1-\theta) \quad ...(6b)$$

Letting $nz = Z$is total pollution due to production and we can explain Equation (6a) by rewriting in differential form (hats indicate the percentage change yields):

$$\hat{Z} = \hat{n} + \hat{e} + \hat{q} \quad ...(7a)$$

Equation (7a) can be written in more detailed form

$$\hat{Z} = \hat{n} + \hat{L} + \hat{x} + \hat{e} - (1 - \hat{\theta}) \quad ...(7b)$$

Equation (7b) decomposes the pollution into:

Selection effect = $(\hat{n})$

Scale effect = $(\hat{L} + \hat{x} - (1 - \hat{\theta}))$

Technique effect = $(\hat{e})$

where, $\hat{Z}$ is the percentage change in total emission, $\hat{n}$ is percentage change in number of firms due to openness of trade or trade liberalization, $\hat{e}$ is the percentage change in number of emission per unit output due to openness of trade and $\hat{q}$ is percentage change in output after change in trade intensity. Equations (7a) and (7b) basically show the impact of intra-industry trade on environment that is a sum of scale, technique and selection effects.

3.2.3. Reduced Form Equation

Equation (7b) shows the *demand for pollution*[1], while Equation(5) is the *supply of pollution*[2] from a regulatory authority. After decomposing Equation (5) into its basic determinants and by joining demand and supply for pollution, we can get a reduced form equation:

$$\hat{Z} = \Lambda_1\hat{n} + \Lambda_2\hat{S} + \Lambda_3\hat{w} + \Lambda_4\hat{n}^* + \Lambda_5\hat{p}^* + \Lambda_6\hat{L} + \Lambda_7\hat{\rho} + \Lambda_8\hat{\beta} + \Lambda_9\hat{\emptyset} + \Lambda_{10}\hat{\varphi}... (8)$$

Equation (8) recounts the emission level due to economic variables. The level of emissions is affected by total number of domestic firms (**n**), the output produced for the purpose of consumption (**S**), Wage (**w**), imported product varieties ($\mathbf{n}^*$), the world price level (p^*), factor of production in the economy (**L**), the preference parameter (**ρ**), the productivity of labor parameter (**β**), the elasticity of emission with respect to the fraction output allocated towards consumption ($\emptyset$) and the marginal disutility of pollution (**φ**).

3.3. Empirical Model of Intra-industry Trade and Environment

This section contains four sub-sections. Subsection 3.3.1 discusses the environmental effects in closed the economy, sub-section 3.3.2 explains the environmental effects in the open economy context and sub-sections 3.3.3 and 3.3.4 derive a linear model of trade-induced environmental effects and a quadratic model of trade-induced environmental effects respectively for our estimations.

[1]Demand for pollution is from producers, for producing goods Taylor, et al. (2001).
[2]Supply of pollution is from government/regulatory authority, because government/regulatory authority allow producers to produce goods which emit pollution Taylor, et al. (2001).

3.3.1. Environmental Effects in Closed Economy

Since measures and data for SAARC countries particularly on β, ρ, ∅ and φ are not available; therefore they are studied as unobserved country parameters in the model. For estimation purpose, we follow Aralas (2010) procedure. Equation (7a) which is decomposed into environmental scale, selection and technique effect can be expressed by using a linear form of emissions in metric tons per square kilometer with respect to time (t) and country (k) in the following equation:

$$Z_{kt}^{c} = \alpha_0 + \alpha_1 FIRM_{kt} + \alpha_2 SCALE_{kt} + \alpha_3 INC_{kt} + u_{kt} \; ... \; (9a)$$

Z_{kt}^{c} is emission of CO_2 per square kilometer. The basic reason of using $\left(\frac{CO_2}{km^2}\right)_{kt}$ is standardization of emission according to the size of the country. Because we have a large country India and a small country Sri Lanka in SAARC. The comparison of the emission level without standardization is irrational. Without standardization of emissions we can get biased results, which may be unreliable. Taylor, *et al*. (2001) use this technique to analyze trade and environment relationship for OECD countries by using different pollutants.

$FIRM_{kt}$ is used to show the environmental 'selection effect'. This effect is due to a change in the number of firms in the economy on the basis of selection of product variety. FIRM includes all kinds of companies, which are engaged in production of goods. FIRM is basically density of firms in per squared kilometer of country k at time t. The theory suggests that in general, the greater the firm's density is the greater is the level of pollution. In our empirical model $FIRM_{kt}$ is the country-specific number of listed companies per squared kilometer. Total number of firms in large economy such as in India is very high and the number of firms in a small economy such as Sri Lanka is very small. If we use these numbers without standardization we may get biased results. Aralas (2010) used $\left(\frac{No.of Listed\ companies}{km^2}\right)_{kt}$ for standardization of $(FIRM)_{kt}$ variable. Therefore, we are using this standard mechanism for our estimations.

$SCALE_{kt}$ is used to show the 'environmental scale effect'. Scale of production is the production of all goods and services within the boundary of a country. In our empirical model scale of production is measured by the gross domestic product (GDP). It is hypothesized that the greater is the scale of production greater is the level CO_2 emissions. We use following Taylor, *et al*. (2001) scale of production $(SCALE)_{kt}$, which is country-specific and defined as $\left(\frac{GDP}{km^2}\right)_{kt}$.

INC_{kt} shows environmental technique effect. INC_{kt} is basically national income of a country. In the trade environment and Environmental Kuznet Curve literature this variable is frequently used by environmental economist. In our empirical model the income of country k is represented by $(INC)_{kt}$ which is income per capita $\left(\frac{GNP}{L}\right)_{kt}$. The purpose of using per capita of a variable is standardization. Taylor, *et al*. (2001) and Aralas (2010) use $\left(\frac{GNP}{L}\right)_{kt}$ in their research. India is a large country in the SAARC region and it`s gross national income is not comparable with other countries like Pakistan, Bangladesh and Sri Lanka. But gross national income per capita is comparable.

3.3.2. Environmental Effects in the Open Economy

Equation (9a) does not express the effect of trade liberalization, so we include a trade variable in Equation (9a). Equation (9a) can be rewritten as:

$$Z_{kt}^{c} = \alpha_0 + \alpha_1 FIRM_{kt} + \alpha_2 SCALE_{kt} + \alpha_3 INC_{kt} + \alpha_4 TR_{kt} + u_{kt} \ldots \text{(9b)}$$

TR_{kt} is used to examine the effect of overall trade on the level of emissions. $(TR)_{kt}$ is defined as the openness of trade in term of trade intensity and calculated as the import plus export ratio to GDP $\left(\frac{(X+M)}{GDP}\right)_{kt}$. k is used to show the k[th] country and t is used for a specific time period. Trade intensity is thus the share of total trade in the GDP. The greater the share of trade in the GDP the greater will be trade intensity of a country and thus more open will be the economy to foreign competition. Use of trade intensity is very common in the literature, Fung and Maechler (2007) and Aralas (2010), Shaista and Shafiqur (2011) and Taylor, *et al*. (2001) used this variable to assess the impact of trade on the environment. Following this tradition, we also include this variable in our model.

3.3.3. Linear Model of Trade-induced Environmental Effects

Equation (9b) only shows the effect of selection of product variety, scale of production, income and trade on the environment. But, it does not represent the trade-induced environmental effects; namely, trade-induced environmental selection effect, trade-induced environmental scale effect and trade-induced environmental technique effect. To derive trade–related environmental effects, an interaction term TR_{kt} can be introduced along with the variables representing the scale of production, income per capita, and number of firms to represent the trade-induced environmental scale, technique and selection effects. Following is the linear model that can be used to examine the trade-induced environmental effects:

$$Z_{kt}^{c} = \alpha_0 + \alpha_1 FIRM_{kt} + \alpha_2 SCALE_{kt} + \alpha_3 INC_{kt} + \alpha_4 TR_{kt} + \alpha_5 SLTR_{kt} + \alpha_6 SCTR_{kt} + \alpha_7 TECTR_{kt} + u_{kt} \ldots \text{Model-A}$$

where, $SLTR_{kt}$ variable shows the change that trade brings about in number of firms. Trade creates a fall in the number of firms due to economies-of-scale internal to the firms.

This is because economies of scale make it valuable for a country to specialize in the production of only a limited range of products. The effect of a change in the number of firms on the level of emissions as a result of the change in 'trade intensity is called 'trade-induced environmental selection effect'. In our empirical specification domestic companies per squared kilometer along with the openness of trade is trade-induced environmental selection effect $(SLTR)_{kt}$, this very effect differentiates the intra-industry trade from inter-industry trade. In simple words, we can say it is used to show the intra-industry-trade-induced environmental selection effect (see also, Aralas, 2010).

$SCTR_{kt}$ variable shows that change in the trade intensity that brings a change in scale of production. The effect of the change in scale of production at the level of emissions due to a change in trade intensity is called 'trade-induced environmental scale effect'. In our empirical specification $SCTR_{kt}$ is the k_{th} country`s gross domestic product per squared kilometer interacted with trade intensity (this is trade-induced environmental scale effect) at time t (see also Aralas, 2010 and Taylor, *et al*. (2001).

Income per capita is used to determine the environmental technique effect. To find the trade-induced environmental technique effect we interact the income per capita with trade intensity $(TECTR)_{kt}$. Taylor, *et al*. (2001) and Aralas (2010) both use this trade-induced environmental technique effect in their work on trade and environment. Trade-induced environmental technique effect shows the effect of change in the income level on the level of emissions as a result of changes in trade intensity.

3.3.4. Quadratic Model of Trade-induced Environmental Effects

The use of per capita national income and trade intensity and their non-linear effects are consistent with some studies of the environmental kuznet curve, pollution haven hypothesis, race to the bottom and resource curse hypothesis (see also Aralas, 2010). Taylor, *et al*. (2001) and Aralas (2010) suggest an alternative specification, by including squared terms to the general linear representation in their models; therefore this study represents a non-linear representation in Model-B. The Environmental Kuznet Curve also advocates that trade and environmental relationship is not linear. It may be quadratic or cubic. To resolve the above mentioned possibilities, following functional form is designed as Model-B.

$$Z_{kt}^{c} = \alpha_0 + \alpha_1 FIRM_{kt} + \alpha_2 SCALE_{kt} + \alpha_3 INC_{kt} + \alpha_4 {INC^2}_{kt} + \alpha_5 TR_{kt} + \alpha_6 {TR^2}_{kt} + \alpha_7 SLTR_{kt} + \alpha_8 SCTR_{kt} + \alpha_9 TECTR_{kt} + u_{kt} \ldots \text{Model-B.}$$

3.4. Measurements of Variables

We measure variables used in the two models as the following:

Change in the number of firms is represented by $FIRM_{kt}$. This study uses number of domestic companies, listed in the stock market, to represent the $FIRM_{kt}$. The $FIRM_{kt}$ in the model is in the intensive form, it is number of listed domestic companies per square kilometer $\left(\frac{No.of Listed\ companies}{km^2}\right)_{kt}$. Scale effect can be calculated by dividing the gross domestic product per square kilometer $\left(\frac{GDP}{km^2}\right)_{kt}$. Per capita national income can be reflected by gross national product per capita $\left(\frac{GNP}{L}\right)_{kt}$ earned. The total trade of the country is sum of import and export.

Openness of trade is total trade to GDP ratio$\left(\frac{(X+M)}{GDP}\right)_{kt}$. Trade-induced environmental selection effect is represented by $\left(\frac{No.of Listed\ companies}{km^2}\right)_{kt} * \left(\frac{(X+M)}{GDP}\right)_{kt}$.Trade-induced environmental scale effect is represented by $\left(\frac{GDP}{km^2}\right)_{kt} * \left(\frac{(X+M)}{GDP}\right)_{kt}$. Trade-induced environmental technique effect is represented by $\left(\frac{GNP}{L}\right)_{kt} * \left(\frac{(X+M)}{GDP}\right)_{kt}$.

3.5. Empirical Strategy

This section describes the empirical strategy for estimation by using pragmatic relationships and empirical conditions. To do so, we discuss in this section data sources and the estimation procedure.

3.5.1. Data Sources

Data on GDP, GNP, Import, Export, Population, CO_2 emission and Number of listed companies are taken from World Development Indicators. GDP, GNP, Export and Import data are used in dollar term and with the base year 2000. Data of the major SAARC countries` area are taken from SAARC (2012) . In our estimation, time period spans 23 years from 1988 to 2010 and cross sections contains 4 countries namely; India, Pakistan, Bangladesh and Sri Lanka. The total panel thus consists of 92 observations.

3.5.2. Estimation Procedure

For empirical purpose panel data estimation technique is used to estimate models A and B. There are plenty of advantages of using panel data technique over cross section and time series analysis. Longitudinal or panel data set follows a given sample of individuals over time and thus provides multiple observations for each individual in the sample. The panel data technique usually gives researchers a large number of data points, increasing the degree of freedom and reducing the co-linearity among the regressors and hence it improves the efficiency of econometric estimates. On contrary to single cross section analysis, the panel data technique provides the dynamics of individual country behavior and consistent estimation, where unobserved individual heterogeneity is assumed to be distributed independently of regressors.

3.5.3. Unobservable Variables

To deal with unobserved variables; two way fixed effect model is employed for specification. So, the error term u_{kt} is given below:

$$u_{kt} = \xi_t + \zeta_k + \upsilon_{kt}$$

Where, ξ_t is a time-specific effect, ζ_k is a country effect and υ_{kt} is an idiosyncratic measurement error for country (k) at time (t).

Chapter 4: Empirical Estimation and Results

4.1. Introduction

This chapter verifies our theoretical and empirical framework. This chapter is divided into three sections. Section 4.2 provides descriptive statistics. Section 4.3 shows the results of panel unit root test and section 4.4 and 4.5 shows the results of Model-A and the results of Model-B respectively.

4.2. Descriptive Statistics

Descriptive statistics are used to describe the basic numerical characteristics of data in the thesis. The descriptive statistics reported in Table 4.1 which includes measures of the central tendency, i.e., mean and median, tell us where the middle of a bunch of the data lie. A measure of statical dispersion is also examined by the standard deviation in the descriptive statistics. It is obvious that all of the data lie between the maximum and minimum values, therefore, descriptive statistics consist of maximum and minimum values for all variables.

Table 4.1: Descriptive Statistics

Variables	Mean	Median	Maximum	Minimum	Std.Dev.
CO2	0.203764	0.174545	0.594293	0.051471	0.119403
SEL	0.001767	0.001497	0.003734	0.000507	0.001024
SCALE	197935.1	167605.6	562305.9	57569.87	115259.8
TEC	544.7253	494.2137	1264.971	284.8037	218.5473
TRADE	0.402279	0.331381	0.886365	0.114822	0.214649
SLIIT	0.000207	6.31E-05	0.000743	4.10E-06	0.000233
SCIIT	17421.63	10828.87	49133.34	460.4349	15053.95
TECIIT	57.17841	29.99695	177.5299	3.249965	54.40008

4.3. Panel Unit Root Tests

Panel data consists of both time-varying and time-invariant regressors; there is a probability of having correlation between the error terms and the presence of the heteroscedasticity. The presence of a unit root in the panel data series at the level may have some econometric problems, so firstly we have to remove the unit root. The first difference in these series is taken and then again testing the presence of the unit root. That is, non-stationary time series are I (1) process. Then these I (1) series are included in the analysis. The results of the unit root test are presented in the Table 4.2.

Phillips-Perron Fisher Unit Root Test (Chi-Square)

The PP-*Fisher* chi-square tests shows that the individual *unit root test* is based on *Phillips-Perron*-type tests. $(FIRM)_{kt}$ is stationary on individual intercept and individual trend and intercept but it is non-stationary on none at level. Z^{c}_{kt}, $SCALE_{kt}$ and INC_{kt} are non-stationary at level but at first difference these variables are stationary on individual trend and intercept. $(SLTR)_{kt}$ and $(TECTR)_{kt}$ are stationary on individual intercept, individual trend and intercept and none at level. TR_{kt} at first difference is non-stationary on individual intercept but stationary on individual trend and intercept and none at level. $(SCTR)_{kt}$ is only stationary on individual intercept but it is non-stationary on none and individual trend and intercept at level (Table 4.2).

We make all non-stationary variables stationary for our estimation. While choosing between the fixed effects (FE) and random effects (RE) models, Hausman test is performed for Model-A and Model-B.

Table 4.2 : Unit Root Test

Null: Unit root (assuming individual unit root process)				
Variable	Phillips-Perron Fisher Unit Root Test (Chi-Square)			
	Individual Intercept	Individual Trend and Intercept	None	Pool Series
Z_{kt}^{c} (1st Difference)	55.4221 (0.0000)	55.5298 (0.0000)	39.7554 (0.0000)	
$(FIRM)_{kt}$	17.7304 (0.0233)	14.3433 (0.0732)	2.2147 (0.9737)	
$SCALE_{kt}$ (1st Difference)	*6.10270* *(0.6357)*	15.9734 (0.0428)	2.05609 (0.9792)	
INC_{kt} (1st Difference)	15.6210 (0.0481)	27.2130 (0.0006)	8.50808 (0.3855)	
TR_{kt} (1st Difference)	4.19082 (0.8395)	43.9071 (0.0000)	5.31171 (0.0000)	
$(SLTR)_{kt}$	40.6996 (0.0000)	51.537 (0.0000)	58.7605 (0.0000)	
$(SCTR)_{kt}$	39.0315 (0.0000)	5.20946 (0.7350)	0.65145 (0.9996)	
$(TECTR)_{kt}$	47.2391 (0.0000)	38.0571 (0.0000)	59.2063 (0.0000)	

Note: Figures in parentheses are representing the P-values

The Hausman Test for the Model-A

The Hausman test rejects the random effects model in favor of the fixed effects models (see Table 4.3). We therefore conclude that the FE estimates are efficient and consistent as compare to those of RE estimates. This result leads us to conclude that the relationship of intra-industry trade with environmental degradation in SAARC region is effected by fixed events rather than the random events.

Table 4.3 : Test Summary of Hausman Test

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	60.5460	7	0.0001

4.4. Results of Model-A

Model-A is a linear model for trade-induced environmental effects, which is already discussed in section 3.2.3. Table 4.4 shows the results of the linear model for trade-induced environmental effect. Hausman test is used to examine whether a fixed effects model or random effects model is suitable for model. In our describing Model-A, Hausman test is in favor of the fixed effects model.

Linear Model of Trade-induced Environmental Effects

In Model-A dependent variable Z_{kt}^{c} is pollution and we use CO_2 emissions as a pollution variable. Model A is a simple linear model, representing the explanatory variables:

Table 4.4: Estimation Results of the Linear Model of Trade Induced Environmental Effects

Dependent Variable		Z_{kt}^{c}		
Periods included		23		
Cross-sections included		4		
Total panel (balanced) observations:		92		
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-0.498783	0.055045	-9.061408	0.0000
FIRM	-0.169533	0.102402	-1.655553	0.1017
SCALE	0.396919	0.032661	12.15283	0.0000
INC	0.801864	0.115651	6.933469	0.0000
TR	0.491325	0.037818	12.99172	0.0000
SLTR	0.172173	0.095104	1.810366	0.0739
SCTR	0.328395	0.083839	3.916992	0.0002
TECTR	-0.496572	0.133679	-3.714667	0.0004
R-squared		0.937047		
Adjusted R-squared		0.935448		
Log likelihood		119.0678		
F-statistic		617.2584		
Prob (F-statistic)		0.000000		
Durbin-Watson stat		1.023309		

The sign of $(FIRM)_{kt}$ coefficient is negative. This sign is statistically insignificant and the economic interpretation is also opposite to our theoretical framework. But in case of production of differentiated goods the process of fragmentation increases along with assembling procedure; in assembling the level of emission decreases. When the number of firms are small, the smaller the activity of assembling and firms have to do all processing from beginning to end, which is the cause of greater level of emissions during the production (Hart and Ahuja, 1996). That's why our sign of $(FIRM)_{kt}$ is negative. This sign shows that when the number of firms per square kilometer decreases by one unit, the pollution will increase by 0.169 units and vice versa (Table 4.4). Another reason of this abnormal sign may be an imperfect competition in the market and industry promotion policies of SAARC countries. Fewer firms are more influential in government decisions as compared to a large number of firms; therefore we can say a small number of firms may be harmful for the environment due to low competition and government leniency to these firms.

Second variable in Model-A is $SCALE_{kt}$, the sign of this variable is according to the prediction of the theory. This variable is statically significant in our model. The sign of $SCALE_{kt}$ coefficient shows that when scale of production of an economy increases by one unit, the level of CO_2 emissions will increase by 0.397 units (Table 4.4). The increase in scale of production may be beneficial for the economy but it is harmful to the environment. The results Taylor, *et al*. (2001) also justifies harmful outcomes of the scale effect for environmental quality, which is used in this study. Finding of Azhar, *et al*. (2007) also point out that scale effect are considerably associated with air and water contamination. Thus, scale effect of trade intensity is hazardous for the environment and the scale of production is positively related to pollution.

INC_{kt} shows a positive impact on the level of emissions. t-value and p-value validate this variable in the model. The coefficient of INC_{kt} is positive. This coefficient shows, one unit change in $\mathrm{INC_{kt}}$ variable brings 0.802 units change in the level CO_2 emissions in the same direction (Table 4.4). Boopen and Vinesh (2009) also justify the positive relationship of income and CO_2 emissions.

The sign of trade variable coefficient is positive. t-stat and p-value are statically significant. The economic and environmental interpretation of positive sign shows that one unit change in trade intensity brings 0.492 units change in the level of emissions in the same direction (Table 4.4). The positive sign is due to the brown technology. SAARC is developing a region and SAARC countries adapt used and brown technology of developed countries. This sign may also be positive due to trade of dirty goods. Dean (2002) also claims that trade liberalization has negative impact on environmental quality.

But the sign of trade-induced environmental selection effect $(SLTR)_{kt}$ is according to the literature and our expectations. One unit change in $(SLTR)_{kt}$ brings 0.172 units change in the level of emissions. Intra-industry trade-induced environmental selection effect shows that due to competition with the trade opening amount of firms decrease, this decrease in the number of firms has a positive impact on the environment (Table 4.4). Aralas (2010) also points out that trade-induced environmental selection effect is pro environmental.

Aralas (2010) states that when trade opens total number of firms decrease in the region, to meet the demand of the region, the remaining firms in the industry have to increase their scale of production, this is cause of increase in the level of pollution. The coefficient of trade-induced environmental scale effect shows that one unit change in $(SCTR)_{kt}$ brings 0.328 units change inthe level of emissions. In our analysis, trade-induced environmental scale effect shows that increase in scale of production (after the openness of trade) is a source of increase in the level of emissions. The coefficient of trade-induced environmental scale effect is 0.328, which is lower than the coefficient of environmental scale effect 0.397 (Table 4.4). These results show that trade is relatively beneficial for environment as compared with no trade.

Sign of trade-induced environmental technique effect $(TECTR)_{kt}$ is also according to the theory. This sign is negative and shows that increase in per capita national income due to trade enhancement improves the environmental quality. The coefficient of $\mathrm{TECTR_{kt}}$ shows that one unit increase in $TECTR_{kt}$ brings 0.497units reduction in the level of emissions (Table 4.4). The results of Taylor, *et al*. (2001) and finding of Azhar, *et al*. (2007) are also justifying that trade-induced environmental technique effect is environment friendly.

$\mathrm{R}^2$and adjusted-$\mathrm{R}^2$are 0.934 and 0.931, respectively, very high which show that our estimation is highly explained. The value of $R^2$is high because our time period is long and the cross sections are very short. Values of R^2 and adjusted-R^2show that Model-Ais a best fitted model. The *F-stat* is 251.61 which is quite robust. Prob. (F-statistic) shows that variables of Model-A are highly significant in our estimation.

The Hausman Test for the Model-B

In our describing the Model-B, Hausman test suggests that the fixed effects (FE) model is a more appropriate model for estimation as compared to the random effects (RE) model . We therefore conclude that the FE estimates are efficient and consistent as compare to those of RE estimates. This result leads us to conclude that the relationship of intra-industry trade with environmental degradation in SAARC region is effected by fixed events rather than the random events.

Table 4.5 : Test Summary of Hausman Test

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	64.9760	9	0.0001

4.5. Results of Model B

Model-B is a quadratic model for trade-induced environmental effects, which is discussed in section 3.2.4 of chapter 3. Table 3 shows the results of quadratic model for trade-induced environmental effects.

Quadratic Model of Trade-induced Environmental Effects

Model B is a non-linear model. Squared terms of TR and INC are included in Model-B. Because theory suggests the relationship of TR and INC is non-linear. Openness of trade/trade intensity and per capita gross national income effects can also be explained in quadratic form bitterly. The environmental kuznet curve also verifies a nonlinear relationship of these variables. Therefore, we include a square terms of trade intensity and per capita gross national income in our model.

Table 4.6 : Estimation Results of Quadratic Model of Trade Induced Environmental Effects

Dependent Variable			Z_{kt}^{c}	
Periods included			23	
Cross-sections included			4	
Total panel (balanced) observations:			92	
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-1.180843	0.117402	-10.05809	0.0000
FIRM	-0.160711	0.069578	-2.309791	0.0235
SCALE	0.621934	0.121097	5.135832	0.0000
INC	2.380950	0.344951	6.902292	0.0000
TR	0.248916	0.065261	3.814141	0.0003
SLTR	0.082552	0.065754	1.255477	0.2130
SCTR	0.334663	0.070972	4.715413	0.0000
TECTR	-0.509975	0.118101	-4.318115	0.0000
INC^2	-0.567939	0.101995	-5.568319	0.0000
TR ^2	-0.109372	0.028928	-3.780819	0.0003
R-squared			0.952473	
Adjusted R-squared			0.951330	
Log likelihood			144.0378	
F-statistic			868.0708	
Prob (F-statistic)			0.000000	
Durbin-Watson stat			1.153155	

The sign of $(FIRM)_{kt}$ coefficient is negative. This sign shows that when the number of firms per square kilometer decreases by one unit, the pollution will increase by 0.161 units and vice versa (Table 4.6). The sign is opposite to the theory; it may be due to weak environmental regulation in the region. Another reason of this abnormal sign may be an imperfect competition in the market and industry promotion policies of SAARC countries. Batabyal and Beladi (2001) states that environmental regulation in the Indo-Pak are not sufficient that's why empirical work of environmental economics may be contrary to theoretical work. In case of production of differentiated goods the process of fragmentation increases along with assembling procedure; in assembling the level of emission decreases. When the number of firms are small, the smaller the activity of assembling and firms have to do all processing from beginning to end, which is the cause of greater level of emissions during the production (Hart and Ahuja, 1996). That's why our sign of $(\mathrm{FIRM})_{\mathrm{kt}}$ is negative.

Another variable in Model-B is $SCALE_{kt}$, the sign of this variable is according to our expectations. The sign of $SCALE_{kt}$ coefficient shows that when scale of production increases by one unit, the level of CO_2 emissions will increase by 0.622 units (Table 4.6). The increase in scale of production may be beneficial for the economy but it is harmful to the environment. Taylor, *et al*. (2001) also justifies harmful effects of scale effect for environment which is used in this study. Finding of Azhar, *et al*. (2007) also pointing out that scale effect are considerably associated with air and water contamination. Thus, scale effect of trade intensity is hazardous for the environment and the scale of production is positively related to pollution.

The coefficient of INC_{kt} is positive. This coefficient shows, one unit change in INC_{kt} variable brings 2.381 units change in the level CO_2 emissions in the same direction (Table 4.6). Boopen and Vinesh (2009) also justify the positive relationship of income and CO_2 emissions.

The sign of trade variable coefficient is positive. The economic and environmental interpretation of positive sign shows that one unit change in trade intensity brings 0.249 units change in the level of emissions in the same direction (Table 4.6). The positive sign is due to the brown technology. SAARC is developing a region and SAARC countries adapt used and brown technology of developed countries. This sign may also be positive due to trade of dirty goods. Dean (2002) also claims that trade liberalization has negative impact on environmental quality.

$SLTR_{kt}$ is intra-industry trade-induced environmental selection effect. Sign of coefficient$SLTR_{kt}$ is according to the theory but the t-value and p-values are 1.25 and 0.213 respectively, which are statically insignificant (Table 4.6). The economic interpretation of value of coefficient shows that one unit change in $SLTR_{kt}$ brings 0.082 units change in the level of CO_2 emissions. Aralas (2010) also points out that trade-induced environmental selection effect is pro environmental.

$SCTR$ shows the trade-induced environmental scale effect, the p-value and t-value for this variable are very good. Value of $SCTR$ coefficient is 0 .335; which shows that a one unit increase in $SCTR$ brings 0.335 units increase in the level of emissions in the same direction (Table 4.6). Aralas (2010) states that when trade opens total number of firms decrease in the region, to meet the demand of the region, remaining firms in the industry have to increase their scale of production, this is cause of increase in the level of pollution.

The coefficient of $TECTR_{kt}$ is -0.51, negative sign of this coefficient shows that a one unit increase in $TECTR_{kt}$ decreases the level of emissions 0.51 units and vice versa (Table 4.6). This is beneficial for the environment. The results of Taylor, *et al*. (2001) and finding of Azhar, *et al.* (2007) are also justifying that trade-induced environmental technique effect is environment friendly.

The squared term of INC_{kt} shows that increase in income level is a source of decrease in the level of emissions and vice versa. The value of coefficient $(INC_{kt})^2$ is -0.568 this shows that one unit change in quadratic term of INC_{kt} brings 0.568 units reduction in the level of CO_2. This negative sign also justifies the inverted *U*-shaped environmental kuznet curve hypothesis (EKC), EKC states that higher the income level the better will be environmental quality or we can say the lesser will be polluted environment.

Trade intensity in square term shows a negative impact on level of emission. The sign of the coefficient is according to the theoretical framework and our expectations. Negative sign shows that this variable is beneficial for the environment. This variable shows that a one unit increase in square term of trade intensity brings -0.109 units change in the level of CO_2 emissions (Table 4.6). Results of both squared term of per capita gross national income and trade intensity are according to theory. The negative sign of the squared term of trade liberalization or trade intensity very much supportive in trade and environmental quality analysis to justify that higher the trade intensity the better the environmental quality.

R^2 and adjusted-R^2 are 0.952 and 0.951 respectively, very well which shows that our estimation is highly explained. The value of R^2 is high due to the long time period and the cross section is very short. The *F-stat* is 868.071 which is quite significant.

Chapter 5: Conclusion and Policy Recommendation

5.1. Conclusion

International trade deals with both homogenous and differentiated goods. Trade-induced environmental effects of an integrated open economy can be expressed by factors which are used for inter-industry as well as intra-industry trade. In this thesis, an investigation of panel data from SAARC countries provides the evidence of the following results.

- Strong empirical indication, from our analysis, supports the hypotheses postulated by the theory that emission levels of CO_2 is increasing due to environmental scale effect and decreasing due to trade-induced environmental scale effect. The coefficient of environmental scale effect in Model-A is 0.397 which is greater than the coefficient of trade-induced environmental scale effect estimated in Model-A (*i.e.*, 0.328). It implies that trade is better for the environment
- On the other hand the coefficient of environmental scale effect in Model-B is 0.622 which is also greater than the coefficient of trade-induced environmental scale effect in Model-A (i.e., 0.335). This coefficient also verifies that trade is beneficial for the environment.
- Increase in trade intensity/openness of trade is beneficial for the quality of the environment. Model-B shows that the coefficient of trade-induced environmental selection effect is 0.082 which is relatively better than the coefficient of trade-induced environmental selection effect (0.172) in Model-A.
- The coefficient of overall trade is 0.249 in Model-B which shows the negative impact of trade on environment, while the coefficient of trade in squared term which show an increase

in trade intensity/ trade liberalization is -0.109. This coefficient explains that the trade liberalization has a positive impact on environmental quality.

- Trade-induced environmental technique effect is beneficial for the environment, while environmental technique effect is hazardous for environment in both models A and B. In Model-B environmental technique effect is initially hazardous for the environment due to increase in income, but as income intensity increases this environmental technique effect becomes a source environmental improvement.

The results of our analysis are expected to resolve the some of the issues on trade and environment debate in the SAARC region, whether intra-industry trade is good or bad for the environmental quality? This thesis is different from the previous research work in the area of trade and environment; because it has highlighted trade-induced environmental selection effect which is associated with the intra-industry trade.

5.2. Policy Recommendations

Policy of trade liberalization is often suggested as a mean of stimulating economic growth in developing countries, but these policies have unconnected agenda regarding environmental issues. Given the potential benefits of trade liberalization policies, it is also important to examine whether such policies are pro-environment or anti-environment. The links between trade and the environment are multiple, complex and important. Our policy makers should be aware of the trade-off between economic growth and environmental sustainability. Environmental regulations can be based on a win-win situation for economists and environmentalists by involving all stakeholders of inter-industry and intra-industry trade in the region to improve the environmental quality. Following are some policy recommendations to solve the environmental problems.

- Intra-industry trade is the source of CO_2 emissions. Intra-industry trade is also a source of CO_2 emissions but to a lesser degree. Trade-induced environmental selection effect can be controlled by creating competitive environment in the SAARC region that can be ensured by focusing more on intra-industry trade. Furthermore, hazardous effects of intra-industry trade can be removed by investing more on the green technology and research and development.
- Scale of production is a major source of increase in CO_2 emissions. Therefore we recommend that the scale of production should be achieved through the application of the technology, which is likely to be reducing the level of pollution.
- Initially the GNP per capita may be harmful to the environment but with the passage of time as it grows, it creates beneficial impacts for the environment. Therefore, environmental quality should be improved by making concentrating efforts to increase the level of income on sustained basis.
- Trade brings greater income for the country that allows it to allocate more resources for education and environmental awareness, which in turn enables and motivates the people to demand better environmental standards. Besides, additional income earned from trade can be directly used for environmental improvements. Therefore, we strongly recommend that, our policymakers introduce policies that promote and expand trade in the SAARC region.

5.3. Limitations

The environmental effects of differentiated products are studied and modeled with reference to various trade circumstances. Due to lack of information about intra-industry trade and product varieties, it is very difficult to make a framework of intra-industry trade and environment. Information on differentiated products was difficult to obtain and the environmental impacts of trade liberalization are particularly difficult to measure for developing countries. These limitations encountered the environmental impacts of the intra-industry trade. Particularly, the reservations for production procedures have major concerns, where the scale of production increase. No consideration is given to variations in production techniques, technology and innovations with the passage of time. Modification in production systems can be valuable in environmental footings but these are difficult to measure in our thesis. Difficulties in data availability also bound the thesis and create the uncertainties in the future course. Measures and data for the SAARC countries particularly β, ρ, $\emptyset$ and φ are not available; therefore they are studied as unobserved country parameters in the model. Non-availability of data for the differentiated product variable in the SAARC countries is a big problem that`s why, we use number of firms instead of product variety for expressing environmental selection effect. Due to non-availability of data for all the SAARC countries, we have only used selected countries for this thesis.

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