Ph.D. Synopsis

Title of the Thesis: Capital Inflows, Production Fragmentation and Environment

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Introduction

Capital Flows are considered as drivers of growth for an economy. Capital movements include all cross-border transfers in ownership of assets, company shares, bank loans and government securities recorded in the capital account of a nation's balance of payments. Foreign Direct Investment (FDI) is considered as one of the least volatile forms of capital flows. The spurt of globalization increased the capital flows across countries as well as increased the scope of production fragmentation fuelled by rapid advancements in ICTs (Rajan 2003, Hummels 2001, Krugman 1995, Grossman and Helpman 2005). Production fragmentation broadly refers to the splitting up of a good into its constituent parts, components and accessories (PCAs) that are produced, traded and distributed across spatially dispersed locations on the basis of their comparative advantages. Each country specialises in a particular stage of production sequence. According to Gereffi (2001), the phenomenon of international production fragmentation can take place through two channels. The first is by subcontracting, which involves arm's length transactions, wherein a firm can contract an overseas supplier to manufacture parts and components, while retaining key service functions, such as research and development and designing. The second involves creating international production networks (via FDI), resulting in vertically specialized trade. FDI-led international production networks are largely driven by multinationals involved in high technology, capital intensive production of customized and specialized parts and components wherein quality considerations are paramount.

As we know that production fragmentation refers to the process by which the production of goods and services is broken down into smaller and specialized tasks, often carried out by different companies or individuals in different locations. This process can be driven by various factors such as technological advancements, cost considerations, and market demands. One of the consequences of production fragmentation is the creation of global value chains, where different stages of production are dispersed across multiple locations around the world. As a result, the production process becomes more complex, and coordination between different actors becomes increasingly important. This can lead to challenges in managing the environmental impacts of production, as different actors may have different environmental standards and regulations, making it difficult to ensure that environmental standards are being met throughout the production process. The environmental impacts of production fragmentation can manifest in various ways. For example, increased transportation of goods and components across long distances can lead to higher greenhouse gas emissions and air pollution. Additionally, the use of different production methods and standards in different locations can lead to variations in environmental impacts, making it difficult to assess the overall environmental performance of the production process.

The phenomenal increase in the volume of international trade in the last four decades is significantly associated with environmental degradation (Copeland and Taylor, 2001; 2004; Antweiler and Trefler, 2002; Johnson and Noguera, 2012; etc). The predominant emphasis has thus far been on trade in final goods and the impact on environment, which goes back a long way. For example, Grossman and Krueger (1991) empirically investigated the impact of North American Free Trade Agreement (NAFTA) on environment. The extensive literature on pollution haven and factor endowment hypotheses also provides direct evidence in favor of how resource abundant developing countries record high emission due to outsourcing (see Copeland and Taylor, 2003; Cole, 2004; Xing and Kolstad, 2002; Eskeland and Harrison, 2003 for early evidence). The trade-environment debate revolves around the Pollution Haven Hypothesis (PHH). The pollution haven hypothesis states that countries with weak environmental regulations and standards attract foreign investment and industries seeking to avoid the costs of complying with environmental regulations in their home countries. This can result in the transfer of polluting industries and technologies to these countries, leading to higher levels of pollution and environmental degradation. The idea behind the pollution haven hypothesis is that businesses will seek out locations with the lowest costs of production, including environmental costs, in order to maximize profits. This can create a race to the bottom in terms of environmental standards, as countries compete to attract foreign investment by lowering their environmental regulations. This can be referred to as environmental divergence that free trade brings in.

It is duly documented that firm level optimization often results in cross-border fragmentation of production which subsequently influences the growth of trade in intermediate goods worldwide. In the previous decade also, the global share of intermediate inputs in world trade accounted for about 55 percent for most years (WTO, 2013) and for OECD countries only, it represented more than 50 percent of their total trade between 1995 and 2007 (Miroudot *et al*., 2009). In fact, the average growth rate of intermediate goods trade has been higher than the growth rate of world output. The growing importance of production fragmentation, trade in PCAs, capital flows signal the deepening structural interdependence of the world economy (Athukorala 2005, Ando 2006). But this interdependence may have an adverse effect on environment (Copeland and Taylor, 2004). While the effects of trade in final goods on the environment offer extensive evidence, the extant literature says fairly little about the estimates of damage due to trade in 'middle products' (*a' la* Sanyal and Jones, 1982). Indeed, for a long time the importance of middle products or intermediate goods has been widely discussed in the international trade literature, although the implications have remained confined to production reorganization, factor prices and income distribution, and generally economic development. Importantly, over the last few decades the share of trade in intermediate goods rose at a rapid pace across the world and this need to be duly addressed while dealing with issues in trade and environment. While some effects of international production fragmentation have been dealt with in the existing literature, such as that on productivity, wages, investment patterns, and generally production reorganization at the firm level, very few studies considered its impact on environment. As a rare piece, Dietzenbacher *et al*. (2012) show that when intermediate trade is accounted for, the perception that exports raise pollution in China appears to be overestimates. To reiterate, despite a growing literature on the relationship between trade and environment, the role played by fragmentation in production and trade in intermediate goods, on the environmental quality has not been addressed adequately, however. The relationship between intermediate goods trade and environment has been taken up for analysis in Chapter 3 of the thesis.

Apart from the rise in intermediate goods, one of the most important and identifiable patterns of international fragmentation is outsourcing. The term ‘outsourcing’ has been used for the first time in scientific publications in early 1980s.Outsourcing is a business practice where companies contract an outside supplier to produce goods and services on their behalf (Bhagwati, Panagariya and Srinivasan, 2004). More and more countries are outsourcing some stages of their production process with growing trade in intermediate goods. With increased fragmentation in production processes, firms tend to outsource certain segments of the production sequence in order to save costs and stay competitive in international product market. Outsourcing can be related to environment in several ways. Firms outsource in order to save on its costs and often it can be observed that the formal firms outsource some segments of its production processes to informal or smaller firms. The informal firms are not under the direct supervision of the government and the labour laws are less stringent, thus their cost of production is very low. In this process, it is expected that the production process carried out by the informal firms are more pollution intensive and thus outsourcing to these units may lead to a rise in pollution. The relationship between outsourcing and energy prices has been empirically tested in Chapter 2 where it has been discussed that how energy prices influence outsourcing decisions taken by a firm and how such decisions may lead to a higher level of emissions.

Further, the existing trade-environment literature has dealt with the relationship between environmental policy and environmental outcomes. Several works have pointed out that trade can endogenously affect environmental policy and industry characteristics. For example, trade can lead to improved environmental standards and also with greater liberalization in trade there is increase in income which will increase the demand for environmental goods since they are normal goods. Many countries use environmental policy as an instrument to attract more foreign capital and witness higher growth. It has been discussed in the trade-environment literature that less countries lowers their environmental standards in order to attract the pollution-intensive industries which leads to higher economic growth of the country. So, the developing countries has been often observed to use environmental policy instead of a trade policy in order to increase trade. In this process, the emissions level of the developing countries rises and also the world pollution rises, thus defeating the purpose of the policies taken towards reduction of carbon emissions. We highlight this issue in Chapter 4 of our thesis that how both trade policy and environmental policy interacts with each other to determine the final outcome and impact on a country's environment. All the chapters in the thesis are motivated to highlight the relationship between production fragmentation and environment.

Chapter Divisions

The chapters of the thesis have been organized as follows:

Chapter 1: Introduction.

Chapter 2: Energy Prices and Production Outsourcing: An Empirical Analysis.

Chapter 3: Relationship between Trade in Intermediate Goods and Pollution in South Asia.

Chapter 4: Complementarity between Trade Policy and environmental Policy in Influencing Environment: A Theoretical Analysis.

Chapter 5: Conclusion.

References.

Summarization of Chapters

Chapter 1

This chapter focuses on introducing and motivating the reader to the broad area which is production fragmentation and environment. This chapter discusses all the concepts that is important to highlight before moving on to the empirical and theoretical analyses. The chapter also carries out a review of literature and connects our work to the existing literature, finding the research gaps and discussed how our study addresses this gap. the chapter concludes by mentioning the structure of the thesis.

Chapter 2

This chapter is dedicated to study the relationship between energy prices and the outsourcing decisions by Indian manufacturing firms. Specifically, this chapter emphasises on the testing of the relationship empirically and tries to validate the fact that apart from traditional factor costs (wages and rent), the costs of environmental inputs play an important role in determining the productive activities carried out by firms (in this case the intensity of outsourcing at the firm level is considered). The objective of this chapter is to see that how rising energy prices hurt formal firms and how they tend to outsource more in order to cut back on other costs of production.

Another dimension is that rising fuel costs hampers the profitability of larger firms, thus restricting them to carry out other productive activities. Coming to the link between such outsourcing activities and environment, it can be argued that the production processes that has been outsourced to the smaller sectors is expected to be more pollution-intensive and the increase in outsourcing may generate more pollution. However, we do not have any explicit abatement cost or carbon market in India, we leave this argument to be scientifically tested in the future. The outsourcing may also be dispersed geographically, rather than being located in a visible enclave. But these are open to further empirical verifications, since we do not have data to support these conjectures presently. To address this issue, the following hypothesis has been framed and the research question is validated using an empirical analysis.

Hypothesis: Energy price is an important determinant of outsourcing intensity of manufacturing firms.

The above hypothesis has been empirically tested in this chapter and the empirical analysis suggest that with increase in the prices of energy inputs (e.g., prices of power, fuel and water), the intensity of outsourcing by the Indian manufacturing firms tends to increase. With increasing production fragmentation for the last few decades, firms tend to outsource several parts of their production. This outsourcing is often been influenced by several factors. One of the most important factors is the 'cost' factor. The costs incurred in production of goods and services comprises of several types. Apart from the factor prices and the traditional input costs, firms in recent times have been charged with higher prices for using environment as an input for their production process. Many of the industries suffer from rising cost of energy while product prices tend to drop. In order to survive, firms tend to outsource some parts of their production activities to smaller units. The reason may be that the larger firms fail to substitute energy use with other inputs of production. If firms can substitute energy with something else then firms tend not to outsource even if energy prices rise. However, many formal firms will not be able to reduce labour costs or interest charges in the face of rising energy prices. This may be one of the reasons why they might outsource to firms outside their ambit, hence can substitute higher energy prices with lower labour costs for example. The informal sector production could be a case in point. However, we do not know if abatement costs are also borne by the informal sector because we do not have adequate information on this account. It will be tested in future research that energy price rise has substitution impact on other factor inputs or not. In this current study, we only put emphasis on the relationship between energy prices and outsourcing intensity. So, we try to establish the fact that how firms attach importance on the price of energy while making their outsourcing decisions apart from other factors.

For the empirical analysis, firm-level panel data has been collected from the PROWES Database (by CMIE). The period of this empirical analysis ranges from 2005 to 2018.[1] This empirical

[1] The year 2005 has been chosen as the starting year of our analysis due to several reasons. The year 2005 has been marked by huge FDI inflows, several overseas acquisitions by big Indian companies, stock market prices rose significantly, India's capital market performance was commendable, and several multi-billion-dollar investment plans were announced by Intel, Cisco and Microsoft in India.

analysis uses data on outsourcing activity by Indian manufacturing firms. In this paper we have selected firms from India's four industries namely chemical industry, machinery industry, metal industry and textile industry. There are several reasons behind the selection of these industries for our empirical study. Firstly, these industries are responsible for generating a significant amount of pollution in the Indian economy. Secondly, the employment generated by these four industries industry is also huge and plays a significant role in meeting basic needs of people and also improving the quality of life. Finally, and most importantly the number of firms enrolled in these four industries are huge compared to the firms enrolled in other industries in the PROWES database. The availability of so many observations was helpful to carry out this empirical analysis. Although the primary interest of the study rests on investigating the effect of change in energy prices on the outsourcing decisions by the firms while controlling for the firm-specific factors. In order to capture such firm-specific effects, six control variables have been considered namely salaries and wages, welfare and training expenses, sales, profit after tax, dividend rate, foreign exchange earnings and an interaction between energy prices and forex earnings.[2] Although there are several papers which have used the CMIE database to observe relationships between outsourcing and some economic variables but none of them used energy prices (power, fuel and water charges) as one of the control variables.

We considered the firm level data of all the financial and detailed records of several companies for the selected industries. The four industries include (1) Chemical (2) Machinery, (3) Metal, and (4) Textile. Apart from these four industries, we also take three more manufacturing industries for our study, the results of which are reported in the appendix. The period chosen for the analysis is 2005-2018.[3] So, we are basically considering a panel data where we will analyse each industry separately.

The following econometric specification has been used for the purpose of this study:

$$outsourcing_{it} = \alpha_{it} + \beta power_{it} + \gamma X_{it} + \varepsilon_{it} \quad (1)$$

where, $outsourcing_{it}$ depicts outsourced manufactured jobs by ith firm at period 't'. $power_{it}$ is the main exogenous variable (which stands for power, fuel and water charges) for firm 'i' at period 't' and finally X_{it}includes the set of six control variables namely, salaries and wages, staff welfare

[2] The selection of control variables has been motivated from Beladi, Dutta and Kar (2016); Chakraborty and Sundaram (2019); Mukherjee (2018); Stiebale and Vencappa (2018); Kar and Banerjee (2022); Kar and Dutta (2018).
[3] The year 2005 has been chosen as the starting year of our analysis due to several reasons. The year 2005 has been marked by huge FDI inflows, several overseas acquisitions by big Indian companies, stock market prices rose significantly, India's capital market performance was commendable, and several multi-billion-dollar investment plans were announced by Intel, Cisco and Microsoft in India.

expenses, sales of companies, profit after tax, dividend rates, total foreign exchange earnings and the three interaction terms between power and wages, between power and profit after tax and between power and forex earnings. Here we deflate each variable by total capital and make all the variables size neutral and take care of firm size heterogeneity. The full structural form specifications to answer our hypothesis is as follows:

$$outsourcing_{it} = \alpha_{it} + \beta_1 power_{it} + \gamma_1 wpay_{it} + \gamma_2 pat_{it} + \gamma_3 forex_{it} + \gamma_4 sales_{it} + \gamma_5 divr_{it} + \gamma_6 welfare_{it} + \gamma_7 (powerXforex)_{it} + \varepsilon_{it} \quad (2)$$

We estimate equation (2) using fixed effects regression model[4] where α_{it} represents the industry fixed effects. The error terms are given as ε_{it}. Further, it is important to report the functional nature of the empirical relation and therefore, the *identification* is of concern, which performs best under strict exogeneity of factors affecting the dependent variable. Indeed, one of the foremost challenges that an empirical study with panel data can potentially face is that of presenting a clear identification strategy with regard to the empirical analysis. Identification issues can arise due to reverse causality, or omitted variable bias, or both. For equation (2) one can argue that outsourcing decisions taken by firms may affect the energy prices through increased demand for energy rather than energy prices driving the need for production reorganization. Thus, we offer results from dynamic panel regressions to rule out possible endogeneity biases.

The empirical results for the fixed effects regression analysis of all the four manufacturing industries indicates that there is a positive relationship between energy prices and outsourcing intensity for Indian manufacturing firms. The dynamic panel estimates also suggests the same results confirming the robustness of our empirical study. We present the fixed effects regression table and the Arellano-Bond estimates separately for only one manufacturing industry, the results of other industries have been reported in the thesis and skipped here for brevity.

Table 1: Fixed Effects Regression Results for Chemical Industry

Dependent variable: outsourced manufacturing jobs/total capital (outsource)

Independent Variables	Regression (1)	Regression (2)	Regression (4)	Regression (5)	Regression (6)
power	0.0239** (0.0102)	0.0605*** (0.00886)	0.0241** (0.0104)	0.0188* (0.00998)	0.0190* (0.0100)
forex	0.00554***	0.00906***	0.00758***	0.00447***	0.00474***

[4] *The Hausman Specification Test has been conducted and the test result suggests that our data best fits the fixed effects model. The test results has been provided in the appendix.*

	(0.00153)	(0.00146)	(0.00155)	(0.00148)	(0.00139)
wpay	0.0494***		0.0660***	0.0685***	0.0520***
	(0.00694)		(0.00691)	(0.00588)	(0.00687)
sales	0.188***	0.208***	0.227***	0.180***	0.176***
	(0.0408)	(0.0410)	(0.0414)	(0.0375)	(0.0401)
pat	0.0359***	0.0406***		0.0362***	0.0330***
	(0.00315)	(0.00310)		(0.00310)	(0.00309)
divr	-0.00162*	-0.00130	0.000475	-0.00258***	-0.00144*
	(0.000842)	(0.000847)	(0.000837)	(0.000804)	(0.000842)
welfare	0.342***	0.618***	0.377***		0.365***
	(0.0811)	(0.0717)	(0.0825)		(0.0808)
interaction term	-2.65e-06**	-1.66e-06	-1.73e-06	-2.30e-06**	
	(1.19e-06)	(1.17e-06)	(1.21e-06)	(1.17e-06)	
Constant	-0.991***	0.368***	-1.260***	-0.888***	-0.905***
	(0.295)	(0.0258)	(0.300)	(0.269)	(0.291)
Observations	4,352	4,352	4,353	4,631	4,375
R-squared	0.221	0.216	0.193	0.216	0.220
Number of id	792	792	793	835	792

Standard errors in parentheses
Chi-square test statistic (Hausman test) in favor of fixed effects model is governed by a low value of $\chi 2 < 0.05$*. This is true for the above results.*
*Note:*** significant at 1% level; ** significant at 5% level; * significant at 10% level. Source: Own calculations.*

In all the fixed effect regression results we find that the coefficient associated with outsourcing is positive and statistically significant for all the four industries. This indicates that irrespective of the industries to which the firms belong, the formal and larger firms are expected to increase their outsourcing intensity with rise in energy prices. This validates our hypothesis that formal firms which are under the purview of government regulations outsource production in parts to smaller firms in order to cope with rising energy prices and increase their profitability. The formal firms will not be able to reduce labour costs or interest charges in addition to rising energy prices. This may push the formal firms to outsource outside their ambit, in order to substitute higher energy prices with lower labour costs. This can be one of the reasons for the outsourcing of activities to informal sectors. Apart from the relation between energy price and outsourcing intensity, we delve into the relation between other covariates and the dependent variable. For example, we find that wages, sales, profit after tax, dividend rate, forex earnings and welfare expenses in most of the alternative empirical specifications are positive and statistically significant.

Besides the usual covariates, we have introduced an interaction term. In the interaction term, we chose to interact energy prices with total foreign exchange earnings of the firms in the various industries. The coefficient is expected to capture the net effect of a rise/fall in power variable on outsourcing for a firm for a given level of foreign exchange earnings, or conversely the net effect of foreign exchange earnings on outsourcing for a given level of energy prices. Technically, the coefficient of the interaction term captures the joint effect of energy prices and forex earnings on outsourcing intensity. From the fixed effects regression results it can be seen that the interaction term is negative and statistically significant. The negative sign of the interaction term del(outsource)/del(forex)= (coefficient of forex) + (mean power cost) x (coefficient of interaction) implies that for a given average value of power expenses, as the foreign earnings rise, firms tend to outsource less, perhaps because the export market demands compliance and certificates from environmental authorities, which outsourcing to smaller uncontrolled units does not support. So, firms under this criterion should keep larger output in-house, hence the negative interaction effect, which is statistically significant.

Table 2: Dynamic Panel Estimates (GMM Estimation for Chemical Industry)

Dependent variable: outsourced manufacturing jobs/total capital (outsource)

Independent Variables	Regression (1)	Regression (2)	Regression (3)	Regression (4)	Regression (5)	Regression (6)
outsource $_{t-1}$	0.364*** (0.0176)	0.396*** (0.0173)	0.364*** (0.0177)	0.388*** (0.0178)	0.338*** (0.0173)	0.363*** (0.0176)
power	0.168*** (0.0184)	0.213*** (0.0179)	0.170*** (0.0184)	0.195*** (0.0185)	0.162*** (0.0186)	0.157*** (0.0182)
forex	0.00558*** (0.00186)	0.00882*** (0.00183)	0.00601*** (0.00186)	0.00890*** (0.00187)	0.00513*** (0.00187)	0.00234 (0.00174)
wpay	0.0621*** (0.00884)		0.0645*** (0.00882)	0.0627*** (0.00902)	0.0867*** (0.00860)	0.0638*** (0.00880)
sales	0.215*** (0.0678)	0.253*** (0.0688)		0.232*** (0.0692)	0.232*** (0.0668)	0.165** (0.0669)
pat	0.0363*** (0.00416)	0.0365*** (0.00424)	0.0366*** (0.00416)		0.0353*** (0.00427)	0.0338*** (0.00410)
divr	-0.00357*** (0.000737)	-0.00304*** (0.000746)	-0.00361*** (0.000738)	-0.00190*** (0.000726)	-0.00383*** (0.000726)	-0.00338*** (0.000736)
welfare	0.0818 (0.0772)	0.162** (0.0769)	0.0939 (0.0771)	0.0924 (0.0787)		0.0787 (0.0772)
power x forex	-7.65e-06*** (1.67e-06)	-8.71e-06*** (1.70e-06)	-6.96e-06*** (1.65e-06)	-6.44e-06*** (1.70e-06)	-7.82e-06*** (1.71e-06)	
Constant	-1.738*** (0.495)	-1.936*** (0.503)	-0.173*** (0.0359)	-1.867*** (0.505)	-1.879*** (0.483)	-1.358*** (0.490)
Observations	2,788	2,788	2,788	2,788	2,957	2,811
Number of id	622	622	622	622	656	623

Standard errors in parentheses

*Note:*** significant at 1% level; ** significant at 5% level; * significant at 10% level.*

Source: Own calculations.

The results show that the estimates obtained under FE remain valid even after accounting for correction of potential endogeneity. In other words, following incorporation of the instruments power charges show positive (and statistically significant) relation with outsourcing intensity and that the covariates maintain direction and significance exactly as in the previous results. Overall, the dynamic panel estimations provide a resounding support to the results obtained under the static fixed effects estimates and prove that outsourcing intensity is significantly affected by energy prices while controlled for a set of important covariates.

Chapter 3

This chapter empirically tests how trade in intermediate goods affects total emission of carbon dioxide for South Asian countries. Since, South Asian countries account for a significant share of world trade in intermediate goods and also suffer from relatively high pollution levels, estimating this relationship should be policy relevant. In this regard, it is useful to mention that this empirical analysis is one among the scant attempts at linking intermediate goods and pollution, such as that in Xu *et al*. (2020) where it shows that trade in intermediate goods have been responsible for significant environmental damages in the US. For developing countries, the effect seems reversed as trade in fragments lead to greater local pollution for low-technology countries. It is well-known that the developed countries delegate more pollution-intensive components offshore and transfer the burden of environmental pollution (Zhang, 2020). This is one of the most crucial relations between trade in intermediate goods and carbon emission. There is allied evidence on East Asian countries (Zhang, 2015) where trade in intermediate goods actually moderates out the pollution effects of direct energy consumption in these countries.

It follows from the existing empirical literature that intermediate goods trade can be measured by two approaches namely input-output (I-O) analysis and trade flow analysis. The trade flow analysis requires data which focuses on the flow of products while the I-O analysis consists of data based on flow of products (values) across borders. Presently, we consider the trade flow analysis for South Asian countries. For this, the trade data on intermediate goods is collected from the United Nations (UN) COMTRADE database according to the Broad Economic Categories (BEC) classification. [5] The intermediate goods data is collected for eight South Asian countries, namely, Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. The period of this empirical analysis ranges from 1998 to 2018. To capture the negative impact on environmental quality we use the most commonly used measure – emission of harmful gases. In the existing literature, emission data of many harmful gases has been used, including, sulfur dioxide, nitrogen dioxide, carbon dioxide (CO_2), etc. We chose CO_2 as a measure of environmental pollution since according to a recent inventory report (2021) by the United States Environmental Protection

[5] BEC classification system is an international three digit product classification system. This is not an independent system since it is based on the Standard International Trade Classification (SITC) system. It was first published in 1971 and revised in 1976, 1986 and 1988. Presently, the BEC classification system has revision version 3.

Agency (EPA), almost 80% of all greenhouse gas emissions in the US for 2019 can be attributed to CO_2. The statistics seems similar for developing countries also. The country-level data on annual per-capita carbon dioxide emission (*in tons*) has been collected from *Global Change Data Lab.*[6]

A modified version of the EKC model has been used in order to consider trade in *intermediate goods as one the main independent variable* ($Intermediate_{it}$) for the i^{th} country and t^{th} year while controlling for per capita income and other country-specific variables ($\underline{X}$). For the empirical estimates we break up trade in intermediate goods for the eight South Asian countries into exports and imports and conduct two separate, but identical, set of exercises. The classification of intermediate trade into two components should allow us greater precision with regard to the source and magnitude of emission due to trade fragmentation. Therefore, equation (1) yields to the following two sub-specifications:

$$CO_{2it} = \alpha_{Ei} + \overline{\beta}_E * InterExports_{it} + \beta_{iE} * \underline{X}_{it} + \theta_{Et} + \gamma_{Ei} + \varepsilon_{it} \qquad (3)$$

and $$CO_{2it} = \alpha_{Ii} + \overline{\beta}_I * InterImports_{it} + \beta_{iI} * \underline{X}_{it} + \theta_{It} + \gamma_{Ii} + \varepsilon_{it} \qquad (4)$$

The intermediate trade variable, in two parts (equation 3 and 4), includes data on total intermediate exports and imports for country '*i*' in year '*t*', while $\underline{X}_{it}$ includes the set of control variables, namely gdp per capita, agricultural share (as percentage of gdp), industrial share (as percentage of gdp), net foreign direct investment inflows for each country for a given year, exports to high income economies (percentage of total exports), imports from high income economies (percentage of total imports), and taxes on trade (as percentage of revenue). To conduct panel regression, we have tested for panel unit roots and found that the variables are stationary at levels. θ_{Et} and θ_{It} represent country fixed effects for the two specifications, respectively, while γ_{Ei} and γ_{Ii} represents time fixed effects. The error terms are given as ε_{it}. The separation of intermediate trade into components also helps to lessen concerns about endogeneity in composite models because even for developed countries it has been convincingly argued (see Bas and Strauss-Kahn, 2014 for recent evidence on France; and Görg, 2000 for US-EU trade) that imported intermediates affect exports by raising productivity at the firm level, by creating varieties and greater opportunities for trade. This is largely the story for developing countries also.

The empirical results for the fixed effects regression analysis on intermediate exports is presented in Table 3.[7] In all the seven regressions presented here, we see that the coefficient associated with intermediate exports is (a small) positive but highly significant statistically. This indicates that the South Asian countries with growing emphasis on trade in intermediate commodities are expected

[6] This is an UK-based non-profit organization under the leadership of Wendy Carlin, Sir David Hendry and Stefano Caria.

[7] To make a choice between fixed effects model and random effects model, the Hausman test (Hausman, 1978) has been conducted and it supports FE.

to witness higher levels of (per capita) carbon dioxide emissions in the process. between regression 2 and regression 7 we add important covariates such as GDP per capita, industry share in total output, agriculture's share in total output, net inflow of foreign capital, export share to high income destinations and trade taxes (viz. export duties and other restrictions). In column 2, the rise in GDP per capita buttresses the impact of intermediate exports. In column 3, the rise in industry's share in GDP neutralizes the impact of GDP by bringing down the emission. This implies that as long as the intermediate goods are industrial output from the south Asian countries these do not exacerbate emission level in the region. This is also true for agricultural share in GDP which does not raise emission. The coefficient of *agrishare* is positive but not significant. The level of emission rises with net capital inflow into these countries, although the magnitude is very small (but, statistically significant at 1% level, column 5-7). This can possibly be attributed to the fact that south Asian countries are not too selective about the kind of FDI that flows in, ending up with investments mainly to the pollution intensive sectors. The variable ‘export to high income economies’ as in column 7 is positive and strongly significant (1% level) in the presence of all of the above variables, except *agrishare*. Notably, column 7 also includes the trade taxes variable which dampens the emission level significantly. The evidence suggests that despite environmental pressure on developing countries to deliver cleaner products to rich countries, the reality is starkly different. While it cannot be tested empirically in this attempt, but it seems that in order to remain competitive the South Asian countries continue to remain pollution-intensive. Overall, trade in intermediate goods (exports, here) leads to more pollution following rise in the volume of trade for eight south Asian countries.

In order to explore the mechanism which helps to reduce emission, we chose to *interact* intermediate exports with industrial share in the country. The interaction term in this structure should help to identify if the main explanatory variable. i.e., intermediate export (or import) jointly with one of the controls supports or reverses the hypothesis. The industrial share in the country interacted with (components of) intermediate trade can identify whether pollution is generated in the industrial belts of south Asian countries or not. In our analysis using the FE (table 1, column 6) we do find that if intermediate exports originate more and more from the industrial base it actually lowers emission. We do not find a significant effect of agricultural production of intermediate exports (although negative) on emission, and do not report here. Technically, the coefficient of the interaction term captures the joint effect of industrial share and intermediate exports on emission. It is possible that the overall impact is neutralized or even reversed under interaction effects, because structurally it comes from the following relation (4), where the variable *Interaction* is a product of [$(InterExports)_{it} * (Industryshare)_{it}$] determining the marginal impact of a one unit rise in one variable on the level of per capita emission at a given value of the other variable:

$$CO_{2it} = \alpha_{Ei} + \overline{\beta}_E * InterExports_{it} + \beta_{iE} * \underline{X}_{it} + \beta_{jE} * Interaction + \theta_{Et} + \gamma_{Ei} + \varepsilon_{it} \quad (5)$$

$$\frac{\partial CO_{2it}}{\partial (InterExports)_{it}} = \overline{\beta}_E + \beta_{jE} * (Industryshare)_{it} \tag{6}$$

$$\frac{\partial CO_{2it}}{\partial (Industryshare)_{it}} = \beta_{jE} * (InterExports)_{it} + \beta_{kE} \tag{7}$$

where $k \in i = 1,2...n$ and $j \neq i$.

The variable on the right-hand-side of equations (4a) and (4b) are estimated at the mean value given the aggregative nature of the problem and determines the overall impact of own effect and the effect of the other variable. For example, using equation (4a) and the empirical estimates in Table 1 column 6 we find that the marginal impact of a rise in intermediate export on CO_2 emission has an own effect ($\overline{\beta}_E$ =1.11e-11) and an interaction effect (β_{jE} = -3.07e-13) at the mean value of $(Industryshare)_{it}$, for each year across the set of countries. The emission may therefore rise, fall or remain constant depending on the relative strength of these terms. In other words, for a unit rise in intermediate exports channelled through greater production at the industrial level the overall emission may even fall for the group of south Asian countries. But more importantly, we find a threshold level of $(Industryshare)_{it}$ from equation (4a) at which per capita emission remains constant even when intermediate export rises:

$$\frac{\partial CO_{2it}}{\partial (InterExports)_{it}} = \overline{\beta}_E + \beta_{jE} * (Industryshare)_{it} = 0$$
$$\Rightarrow (Industryshare)_{it}^{Threshold} = (-\overline{\beta}_E / \beta_{jE}) = 36.15 \tag{8}$$

The same procedure and results hold for the effects of intermediate imports on CO_2 emission (not shown here).

Table 3: Fixed Effects (Intermediate Exports)

Dependent variable: per-capita carbon dioxide emissions

Independent Variables	Regression (1)	Regression (2)	Regression (3)	Regression (4)	Regression (5)	Regression (6)	Regression (7)
Intexp	6.46e-12 *** (1.13e-12)	4.40e-12*** (4.72e-13)	4.51e-12 *** (4.41e-13)	4.53e-12 *** (4.54e-13)	2.63e-12*** (8.51e-13)	1.11e-11*** (3.77e-12)	2.60e-12 *** (9.07e-13)
gdppercap_current		0.000191*** (7.84e-06)	0.000185*** (7.44e-06)	0.000186*** (8.46e-06)	0.000184*** (7.41e-06)	.0001887*** (8.02e-06)	0.000215*** (1.74e-05)

Indshare			-0.0180*** (0.00417)	-0.0178*** (0.00432)	-0.0192*** (0.00447)	-.01599*** (.005202)	-0.0214*** (0.00583)
Agrishare				0.000654 (0.00363)			
FDI					6.83e-12 ** (2.66e-12)	7.32e-12** (2.63e-12)	5.38e-12* (2.88e-12)
exp_highincome						.0013582 (.00122)	0.00489*** (0.00180)
taxes_trade							-0.00980** (0.00434)
Industry-Interaction						-3.07e-13** (1.35e-13)	
Constant	0.862*** (0.0284)	0.529*** (0.0179)	0.950*** (0.0990)	0.932*** (0.141)	0.980*** (0.106)	.81877*** (.1280)	0.842*** (0.154)
Observations	130	130	130	130	129	128	96
R-squared	0.213	0.868	0.886	0.886	0.892	0.865	0.849
Number of groups	8	8	8	8	8	8	7

Standard errors in parentheses.
Chi-square test statistic (Hausman test) in favor of fixed effects model is governed by a low value of χ2 < 0.05. This is true for the above results.
*Note:*** significant at 1% level; ** significant at 5% level; * significant at 10% level. Source: Own calculations.*

Table 4 Robustness Check (Intermediate Exports)

Independent Variables	Regression 1 Robust SE	Regression 2 FE VCE Cluster
Intexp	7.76e-12 *** (2.46e-12)	7.76e-12*** (2.46e-12)
gdppercap_current	.0002112*** (.0000423)	.000211*** (4.10e-05)
Indshare	-.0180722** (.0062052)	-.01807** (0. 0062)
FDI	5.78e-12*** (6.27e-13)	5.78e-12*** (6.27e-13)
exp_highincome	.0041416*** (.0010318)	.004142*** (.001032)
taxes_trade	-.008233*** (.0019653)	-.00823*** (.00196)
Industry-Interaction	-1.87e-13** (8.10e-14)	-1.87e-13** (8.10e-14)
Constant	.7822*** (0.1399)	.7822*** (.1399)
Observations	96	96
R-squared	0.7752	0.7752
Number of groups	7	7

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5: GMM Estimates (Intermediate Exports)

Dependent variable: per-capita carbon dioxide emissions

Independent Variables	Regression (1)	Regression (2)	Regression (3)	Regression (4)	Regression (5)	Regression (6)	Regression (7)
CO_{2t-1}	0.864*** (0.0508)	0.376*** (0.0924)	0.322*** (0.0907)	0.323*** (0.0910)	0.287*** (0.0896)	0.2581*** (0.0894)	0.315*** (0.105)
Intexp	1.22e-12* (7.37e-13)	3.11e-12*** (6.41e-13)	3.35e-12*** (6.03e-13)	3.22e-12*** (6.14e-13)	1.99e-12** (8.69e-13)	8.31e-12** (3.85e-12)	1.95e-12** (9.12e-13)
gdppercap_current		0.000110*** (.0000102)	0.000116*** (.0000131)	0.000113*** (.0000163)	0.000121*** (.0000157)	.0001321*** (.0000184)	0.000139*** (.0000172)
indshare			-0.0144** (0.00590)	-0.0152** (0.00607)	-0.0162*** (0.00584)	-.0114314* (.006113)	-0.0138** (0.00697)
agrishare				-0.00349 (0.00475)			
FDI					5.66e-12** (2.60e-12)	5.94e-12** (2.54e-12)	4.65e-12* (2.74e-12)
exp_highincome						.0019488 (.0015315)	0.00396* (0.00235)
taxes_trade							-0.00365 (0.00465)
Interaction-Industry						-2.23e-13* (1.36e-13)	
Constant	0.150*** (0.0446)	0.360*** (0.0493)	0.723*** (0.158)	0.812** (0.202)	0.786** (0.157)	.57038** (0.196)	0.491* (0.285)
Observations	111	111	111	111	111	111	83
Number of groups	8	8	8	8	8	8	7

Standard errors in parentheses
*Note:*** significant at 1% level; ** significant at 5% level; * significant at 10% level.*
Source: Own calculations.

The static fixed effects estimates subjected to stationarity conditions for the variables in the panel suggests a rise in emission due to expansion in trade of intermediate commodities. The direct relation between intermediate exports and imports and the per capita emission level is subjected to a number of control variables in conformity with influential early research. For example, we find that GDP per capita is always positive and statistically significant across a number of alternative empirical specifications. The net inflow of foreign capital also raises emission unambiguously. The share of industrial output in GDP, however, contrary to general perception does not cause higher pollution. A possible explanation is that the industrial base for South Asian countries is on average small and shrinking over time, such that the marginal increase in the share is not environmentally harmful. To explore this connection further, we estimated the marginal effects of a rise in intermediate exports and imports, separately on CO_2, and determined the threshold levels of industrial shares. Under the fixed effects estimates, we found that the threshold level of industrial share which does not increase emission level despite rise in intermediate exports is 36.15%. If robust standard errors are applied to the fixed effects the threshold rises to 41.49%. Importantly, the same threshold settles at 37.26% for the dynamic analysis that we carried out subsequently to correct for potential endogeneity related biases in the aforementioned specifications. On average this seems appropriate for South Asian countries, since greater industrialization might have harmful environmental impact following rise in export of intermediate goods. The industrialization threshold is however lower for intermediate imports all through the analysis. For the fixed effects panel regression where the main independent variable is intermediate imports the industrial threshold is 33.87%. For robust standard errors, the estimate for industrial threshold rises marginally to 34.79%. In section 5 we obtained similar estimates under the GMM specifications for intermediate imports affecting per capita CO_2 and find that the industrial threshold stays at 34.26% in between the above estimates. Generally speaking, the covariates in this exercise may support rise in pollution due to greater fragmentation in trade in all specifications.

Chapter 4

This chapter makes an attempt to find out the link between production fragmentation and environment with the help of a theoretical model. The model is constructed to find out how intermediate goods play an important role when it comes to the relation between trade and environment. In this model, we have considered a small open economy that consists of three sectors: an export sector X, an import competing sector Y and a non-traded sector Z. Sector X and Y produces goods with the help of two primary factors,labour, L and capital, K while sector Z uses the product of sector Y as an intermediate input and labour as another input for production. Industry X is labour intensive and does not pollute. Industry Y is capital intensive and generates pollution as a by-product and it is protected by a tariff, t.This assumption is consistent with the existing literature inenvironmental economics, where capital intensive sector is assumed tocause pollution. Pollution affects environment and hence in the rest ofthis chapter an increase in pollution leads to environmental degradation. We assume constant returns to scale in production technology and consider Z to be the numeraire commodity where the price of Z has been assumed to be one. In this model, we considered a structure similar to a developing country where there is a labor-intensive agricultural exportable and a capital-intensive importable. The importable is an intermediate good while there is another non-traded sector which is produced after assembling the intermediate goods with the help of labor input.

The production functions for the three industries are as follows:

$$X = X(L_X, K_X) \qquad (1)$$

$$Y = Y(L_Y, K_Y) \qquad (2)$$

$$Z = Z(L_Z, Y) \qquad (3)$$

where $f_j > 0, f_{jj} < 0, f_{js} > 0; j, s = (L, K, Y), j \neq s, f = X, Y, Z, H_f = 0$.

Factor inputs show diminishing returns, and H_f stands for the Hessian determinant in sector f. All the production functions are homogeneous of degree one in their corresponding inputs. Both labour and capital are assumed to be non-specific and mobile across sectors. This implies that the wage rate and the rental price are same across the sectors. Total factor endowments are $(\bar{L} = L_X + L_Y + L_Z, \bar{K} = K_X + K_Y)$.We assume that one unit of pollution is generated for each unit of Y produced. This is referred to as the base level of pollution denoted by B. However, the producers can access abatement technology. For simplicity we assume that the abatement technology uses only good Y as an input. For a given base level of pollution B, the amount of abated pollution, A, can be written as the following functional form, $\lambda A(Y_a, B)$, where Y_a is the amount of resources used for abating pollution. Here λ is treated as a parameter which can be affected by technological change. The net pollution emissions (E)is nothing but B-A, or:

$$E = \{Y - \lambda A(Y_a, Y)\} \qquad (4)$$

Assuming $A(Y_a, Y)$ to be linearly homogeneous, increasing and concave in Y_a and Y. Thus, we can write

$$A(Y_a, Y) = Ya(\theta) \qquad (5)$$

Where $\theta = {}^{Y_a}/_{Y}$ is the fraction of output Y allocated to abatement, and $a(\theta) = A(\theta, 1)$. Assuming that abatement cannot be carried out without inputs and it is also not possible to abate fully the whole pollution even if all inputs are used, i.e., $a(0) = 0$ and $\lambda a(1) < 1$. This implies that marginal abatement cost is increasing and there are diminishing returns to abatement activity for a given level of base pollution.

Putting (5) in (4), the pollution emission equation can be rewritten as,

$$E = \{1 - \lambda a(\theta)\}\, Y \qquad (6)$$

The equilibrium conditions for the production sector of the economy have been specified in this section. Apart from the abatement activities undertaken by the firms, we assume that the government imposes taxes on pollution emissions to reduce pollution. In this case, since sector Y is responsible for generating pollution, thus this is the only sector in the economy which is assumed to carry out abatement activities and pay pollution taxes to reduce emissions.

The general production functions in equation (1) to (3) are reconstructed into corresponding profit functions in equations (7) to (9) as follows:

$$\pi_X = P_1 X(L_X, K_X) - wL_X - rK_X \qquad (7)$$

$$\pi_Y = (1+t)P_2 Y(L_Y, K_Y) - wL_Y - rK_Y - \tau E - (1+t)P_2\theta Y$$

Substituting Z from eq (6) in π_Y

$$\pi_Y = (1+t)P_2 Y(L_Y, K_Y) - wL_Y - rK_Y - \tau\{1-\lambda a(\theta)\}Y - (1+t)P_2\theta Y \qquad (8)$$

$$\pi_Z = Z - wL_Z - P_2(1+t)Y \qquad (9)$$

Since both labour and capital are mobile across sectors, we can write $w_X = w_Y = w_Z = w$ and $r_X = r_Y = r$ where w_i is the wage rate of per unit labour employed in sector i; i = (X, Y, Z) and r_j is the rental rate of per unit capital employed in sector j; j = (X, Y).

Proposition 1: *Withdrawal of tariff as a trade policy may conditionally lower emission for a threshold level of abatement cost.*

After solving the profit maximizations and using total differentiation and Cramer's rule we find the following results:

$$\frac{dL_X}{dt} = \frac{[(1-\theta)(Y_L P_1 P_2 X_{KK} + Y_L P_2 M Y_{KK}) - (1-\theta)(Y_K P_1 P_2 X_{LK} + Y_K P_2 M Y_{LK})]Z_{YY}}{\Delta} > 0 \qquad (22)$$

$$\frac{dK_X}{dt} = \frac{[(1-\theta)(Y_K P_1 P_2 X_{LL} + Y_K P_2 M Y_{LL}) + (\theta-1)(Y_L P_1 P_2 X_{KL} + Y_L P_2 M Y_{KL})]Z_{YY}}{\Delta} < 0 \qquad (23)$$

$$\frac{dY}{dt} = \frac{(1-\theta)\begin{bmatrix} P_1 Z_{YK}(X_{LL}Y_K - X_{KL}Y_L) + MZ_{YK}(Y_{LL}Y_K - Y_{KL}Y_L) + \\ P_1 Z_{YL}(X_{KK}Y_L - X_{LK}Y_K) + MZ_{YL}(Y_{KK}Y_L - Y_{LK}Y_K) \end{bmatrix} + P_1 M\Delta}{\Delta} \qquad (24)$$

Simplifying eq (24), we get

$$\left.\frac{dY}{dt}\right|_{\bar{\theta}} = \frac{(1-\bar{\theta})C}{\Delta} + P_1 M$$

where $M = P_2(1+t)(1-\theta) - \tau\{1-\lambda a(\theta)\}; \quad M > 0$

and $C = \frac{P_1 Z_{YK}(X_{LL}Y_K - X_{KL}Y_L) + MZ_{YK}(Y_{LL}Y_K - Y_{KL}Y_L) +}{P_1 Z_{YL}(X_{KK}Y_L - X_{LK}Y_K) + MZ_{YL}(Y_{KK}Y_L - Y_{LK}Y_K)}; C > 0$

Another important aspect that can be noted from the model is that with fall in tariff rate, the import of Y rises which leads to a reduction in domestic production of Y. This in turn implies a lower level of pollution since the Y sector is responsible for generating pollution. This result is in contrast to the findings of the existing literature since in the trade-environment studies it has been found that with liberalization, the developing countries tend to specialize in the production of pollution-intensive goods and this leads to greater degree of environmental damage. But the findings of our model suggests that with reduction of tariff, the developing countries substitute domestic production of Y with high quality intermediate imports[8] which leads to a reduction in pollution. This contradicts the pollution haven hypothesis.

(25)

We assume that $\frac{dY}{dt} > 0$ which implies that

$$\theta < 1$$

According to our assumption as $\theta < 1$, it implies that $\frac{dY}{dt} > 0$.

As we can see that for a given threshold level of abatement cost $(\theta = \bar{\theta})$, with a change in the tariff rate, the domestic production of Y changes and moves in the same direction, i.e., a rise in tariff rate would lead to a rise in the production of Y and vice versa. The interpretation can be that with an increase in the tariff rate, the relative price of imports rises leading to the fall in imports. Now, Y being a capital-intensive good requires more capital in order to be produced at a larger scale domestically. On the other hand, the relative price of exportable commodity X falls leading to higher demand for exportable in the international market. As the Y sector expands, it attracts more and more units of capital, which is released from sector X and employed in sector Y. Thus, the employment of capital in X falls while the labour employment in X rises to cope up with increased demand for exportable in the international market following a rise in tariff rate. Now, since production of Y generates pollution as a by-product, a rise in domestic production of

[8] High quality imports refer to the importable goods that has been imported from the developed countries. Since the developed countries have stricter environmental regulation, they carry out the production of goods in an environmentally friendly processes using advanced technologies.

commodity Y following a rise in tariff rate, leads to higher amount of pollution. If higher tariff rates are imposed on the importable in order to protect the domestic industry from international competition, then we can see from the above model that it leads to higher pollution level. Thus, we can infer that our proposition is valid since for a given threshold level of theta, withdrawal of tariff as a trade policy may actually lower emission due to a fall in domestic production of Y.

To find out the impact of tariff on the emissions level of the country, we do the following exercise.

Taking a percentage change in variables in equation (4) and substituting dY/dt in it yields

$$\frac{1}{E}\frac{dE}{dt} = [1 - \lambda a(\bar{\theta})]\frac{1}{Y}\frac{dY}{dt}$$

$$\frac{dE}{dt} = [1 - \lambda a(\bar{\theta})]^2\left[\frac{(1-\bar{\theta})C}{\Delta} + P_1 M\right] > 0 \qquad (26)$$

Plug this dY/dt in equation (4). Take a percentage change for all variables in 4 with respect to t. Plug dy/dt. That gives what exactly happens to net pollution E in terms of abatement cost.

From the above equation (26) we can see that the emissions fall followed by a reduction in tariff rate for a given threshold level of theta. The reduction in tariff would instigate the domestic firms to substitute domestic production with imported intermediates. The reduction in the production of Y in turn leads to a fall in pollution emissions.

As we can see that for a given threshold level of abatement cost $(\theta = \bar{\theta})$, with a change in the tariff rate, the domestic production of Y changes and moves in the same direction, i.e., a rise in tariff rate would lead to a rise in the production of Y and vice versa. The interpretation can be that with an increase in the tariff rate, the relative price of imports rises leading to the fall in imports. Now, Y being a capital-intensive good requires more capital in order to be produced at a larger scale domestically. On the other hand, the relative price of exportable commodity X falls leading to higher demand for exportable in the international market. As the Y sector expands, it attracts more and more units of capital, which is released from sector X and employed in sector Y. Thus, the employment of capital in X falls while the labour employment in X rises to cope up with increased demand for exportable in the international market following a rise in tariff rate. Now, since production of Y generates pollution as a by-product, a rise in domestic production of commodity Y following a rise in tariff rate, leads to higher amount of pollution. If higher tariff

~~rates are imposed on the importable in order to protect the domestic industry from international competition, then we can see from the above model that it leads to higher pollution level. Thus, we can infer that our proposition is valid since for a given threshold level of theta, withdrawal of tariff as a trade policy may actually lower emission due to a fall in domestic production of Y.~~

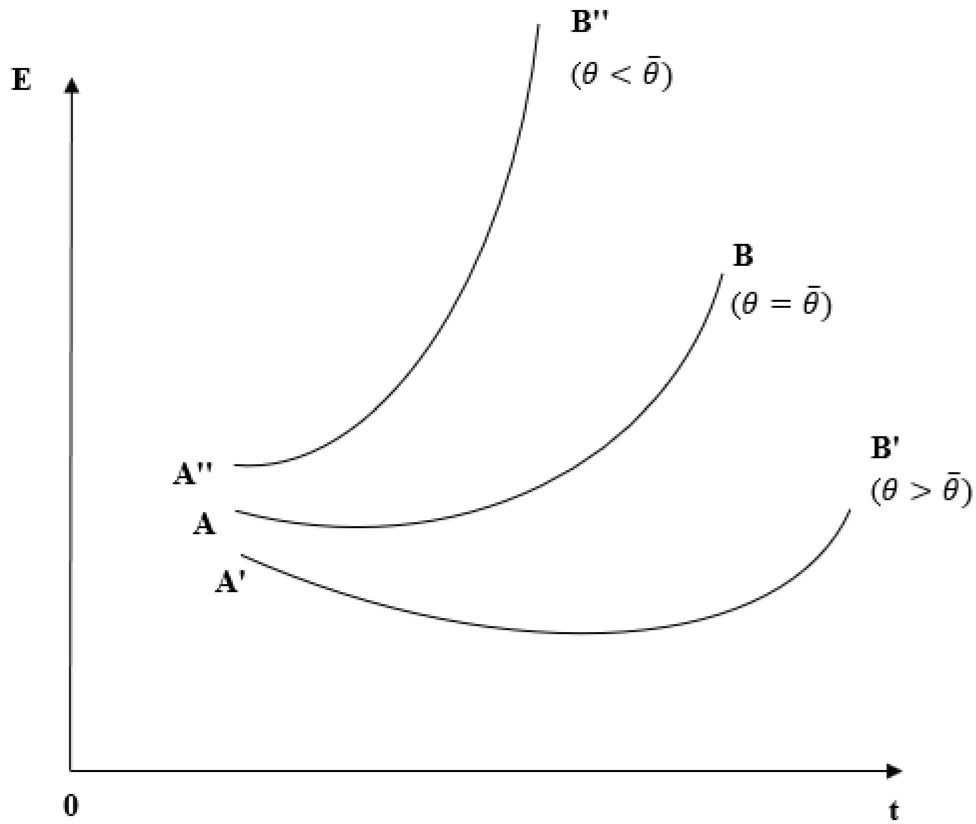
Proposition 2: *When $\theta > \bar{\theta}$, a trade policy is less effective while if $\theta < \bar{\theta}$, a withdrawal of tariff would reduce emissions at a much larger scale.*

To prove this proposition, we conduct a partial change in dE~~Y~~/dt with respect to theta~~-bar~~.

$$\frac{\partial}{\partial\theta}\frac{dE\text{¥}}{dt} = 2[1-\lambda a(\bar{\theta})](-\lambda)\frac{\partial a}{\partial\theta}\left[\frac{(1-\bar{\theta})C}{\Delta} + P_1 M\right] + [1-\lambda a(\bar{\theta})](-\frac{C}{\Delta}) - \frac{A}{\Delta} < 0$$

Thus, it can be seen that $\frac{dE\text{¥}}{dt}$ is falling with rise in theta. This signifies that for higher values of theta the slope of the emissions curve $(\frac{dE\text{¥}}{dt})$ is lower compared to lower values of theta. For $\theta > \bar{\theta}$, the relationship between E and t becomes weaker, i.e., with a rise in tariff rate, the domestic production of Y rises but at a very slow rate and hence the rise in pollution is lower. The reason behind this may be the higher amount of abatement cost for which it is not profitable for the producers to increase domestic production when restrictive trade policy is imposed. Similarly, withdrawal of tariff rate would not reduce the emissions to that extent because the domestic producers would prefer to keep producing domestically and reap the extra revenue from a higher relative price of importable in order to compensate for the higher abatement costs. On the contrary if $\theta < \bar{\theta}$, withdrawal of tariff rate may actually lower emission since the rate of fall in domestic production of Y is significant and thus the pollution emissions fall rapidly. Graphically it can be seen that for $\theta > \bar{\theta}$, the slope of the curve $A'B'$ is less than the slope of the curve AB (for a given value of $\theta = \bar{\theta}$). For $\theta < \bar{\theta}$, the slope of the emissions curve rises which is denoted by $A''B''$ and is steeper than the original emissions curve AB. This shows that the effectiveness of the tariff policy in reducing emission depends on the level of abatement cost. For a higher level of abatement cost, the trade policy is less effective while for abatement cost lower than the threshold level, trade policy is more effective in influencing emission. Since we considered a setup of a developing country, this result is just the opposite if compared to the trade-environment literature where free trade is expected to increase pollution in a less developing economy. In this hypothetical set up, we find that free trade is actually good for the environment if abatement costs are lower than a threshold level.

Figure 1: Relationship between Tariff Rate and Import competing sector



Chapter 5

Finally, this chapter concludes including the discussions of all the results and summarizing them to infer that how production fragmentation affects environment of a country and how different policies can be constructed by the government of different countries to solve the rising environmental problems.

In conclusion, production fragmentation can have significant environmental impacts, as the production process becomes more complex and dispersed across multiple locations. Addressing these impacts will require coordinated efforts across different actors in the production chain, as well as a commitment to sustainable production and consumption practices.