MSA-Management science journal
ISSN 2974-303x
Volume: 2, Issue:1, Year: 2022, pp. 1-43

ECONOMIC GROWTH, BILATERAL TRADE AND TRADE EMBODIED PM2.5 EMISSIONS IN INDIA AND BANGLADESH

Mansi Khandelwal
Department Of Economics
TERI School of Advanced Studies, New Delhi

Sukanya Das [1]
Department of Economics
Professor of Economics at TERI School of Advanced Studies, New Delhi

Badri Narayanan [2]
Senior economist with the School of Environmental and Forestry Sciences, University of Washington-Seattle

Email: badrinarayanang@gmail.com

Abstract *Not all that is produced is consumed by the country a major part of produced goods and services account for exports. In today's world of globalization volumes of export and import are increasing and so is the emission from production and consumption. So, with exports and imports of goods and services, indirect emissions are also traded by being embodied in the goods and services. Production-based and consumption-based accounting approaches are two different approaches to measuring emissions produced. Using PBA, developed countries can transfer the burden of emissions to developing nations, but CBA measures the emissions based on consumption. The study investigates the impact of the rise in investment in India (and Bangladesh) on PM2.5 emissions being produced in Bangladesh (and India) via international trade and quantifies it. Bangladesh is about to graduate from LDC status, which means that high tariffs are being imposed on Bangladeshi goods, an attempt is made to study the impact of the rise in tariffs on PM2.5 emissions produced and quantifies the change. The results indicate that with tariffs being imposed emissions fall in the case of the EU, Japan, and Oceania but not true with the US. Some policy implications are suggested on the same.*

Keywords:- Production-Based Emissions, Consumption-Based Emissions, LDC, tariffs, PM2.5, welfare, mortality

JEL Codes: xxx

[1] ORCID iD 0000-0003-4524-4247
[2] ORCID iD 0000-0001-9628-8173

Introduction:

A right that is not included in the list of fundamental rights is the right to clean air, despite being an important right for every individual. Every 9 out of 10 people live in cities with air quality exceeding the limit set by WHO. To name a few health problems caused by air pollution due to which people die every year are heart disease, chronic obstructive pulmonary disease, lung cancer, and acute respiratory infections. From 3 million premature deaths caused by outdoor air pollution in 2010, it is expected to increase to 6-9 million globally by 2060 (OECD,2016). As per a World Bank report (2015), air pollution costs the global economy more than $5 trillion annually in welfare costs, with the most devastating damage occurring in the developing world. In terms of welfare, air pollution costs more than $5 trillion annually to the global economy, of which the most catastrophic damages are experienced by developing nations (World Bank,2015). Exposure to ambient PM2.5 caused cardiovascular diseases and cancer leading to, 4.2 million premature deaths in 2016, as per WHO. Low- and middle-income nations have a lion's share in this figure. In 2013 alone, the world experienced a loss of 225 billion USD to the global workforce due to premature deaths caused by PM2.5 emissions (Keisuke Nansai 2021).

Air pollution in South Asia contributes to 22% of deaths on average, for India total cost of air pollution is estimated at around 4.5%-7.7% of the GDP and this cost will increase by more than double by 2060 (TERI 2019). Broadly the market effects of air pollution can be classified into 3 categories- reduced labour productivity, rise in health expenses and loss of crop yield. These all relate to making the GDP projection that is lower than the projection that excludes the economic effects of pollution (OECD,2016). These few figures do point out that air pollution is not something which can be taken lightly. Particulate Matter (PM2.5 and PM10), carbon dioxide ($C0_2$), nitrogen oxides (NOx), ammonia (NH_3), black carbon, carbon monoxide (CO), Sulphur dioxide ($S0_2$), volatile organic compounds (VOCs) and CFCs are the main air pollutants.

Carbonaceous compounds, inorganic ions and mineral dust constitute emissions of PM2.5. Direct PM2.5 emissions come from forest fires, burning of agricultural residue, inefficient fuel combustion, dust blown by wind in arid regions and secondary emissions being formed due to atmospheric chemical interaction between primary gas-phase pollutant precursors. Residential energy consumption, on- and off-road vehicles, energy generating, solvent use, industrial processes, and agricultural fertilizer application are different sources of processes releasing these precursors. “Once emitted, the chemical production of PM2.5 mass in the atmosphere is highly nonlinear” (Erin E. McDuffie 2021).

What do we often interpret as air pollution is which is directly visible, but what we tend to miss out is pollution embodied in different production and consumption activities. Not all that is produced is consumed by the country a major part of produced goods and services account for exports. In today’s world of globalization volumes of export and import are increasing and so is the emission from production and consumption. International trade is successful in reducing the boundaries associated to production and consumption.

Emissions resulting from export production contribute to 30% of the total global emissions (K. Kanemoto 2014). As per Wakeel, M., et al., (2016), Embodied emissions are the same as the emissions produced by an item from "cradle to grave". With the rise in free trade agreements between governments and attempts made to promote trade between countries, international trade is rising ever since then. With declining barriers and increased connectivity, international trade provides winners and losers from across the globe in terms of environmental consequences (Christina Prell 2015). Foreign direct investment, particularly from industrialized countries to developing ones, is one of the key factors of CO2 emissions in a country. FDI is heavily supported in emerging countries like India since it is seen as a vital factor in achieving high economic growth. High economic growth is supported via a rise in economic activities like production, international trade, extraction, and others. Globalization has enabled economic activities to increase across borders and national jurisdictions.

To achieve the benefits of globalization, nations are constantly making efforts to reduce regulations, environmental standards, and taxes. They are also entering into FTA with different nations. All these efforts have helped the nations to realize the potential of globalization, but along with benefits, unwanted damage is faced by the host country’s natural environment (Sharma 2019). It thereby implies that with rise in investment, there is a simultaneous rise in economic activity, including production, consumption, and international trade. While producing to support for the increased demand for a country’s export leads to rise in emissions of greenhouse gases along with other air pollutants. There exists a positive correlation between investment and emission proliferation, i.e., with rise in investment, there will be a rise in emission produced and vice-versa (Muchtar 2015).With a rise in bilateral trade between India and Bangladesh, this study will help to identify which country is a net exporter of embodied emissions of PM2.5 and who bears the cost in terms of premature deaths caused by PM2.5 emissions, so that a relevant course of action can be decided among the two neighboring nations.

Section 2 explains the relationship between India and Bangladesh along with their agreements over the years, bilateral trade and how the FTA has helped the two nations. Section 3 critically examines the literature on the research topic. Section 4 describes the methodology used and data sources. Section 5 showcases the results, followed by discussion and conclusion, policy implications and limitations of the study in Section 6.

Back ground

Study Site- India and Bangladesh

South Asia consists of a group of countries on the Indian tectonic plate, which is commonly referred to as the Indian subcontinent, it comprises India, Pakistan, Bangladesh, Nepal, Bhutan, Sri Lanka, and the Maldives. These 7 nations together cover 10% of the Asian continent which is equivalent to occupying 3.3% of the world's land surface area. 40% of the Asian population or a quarter of the world's population resides in the Indian subcontinent. Of the total region's population, 51% is exposed to concentrations of PM2.5 exceeding the Interim Target level set by WHO ($35\mu g\ m^{-3}$)(TERI 2019).

India and Bangladesh share a long coastline which makes them native markets for each other's goods and services. The reason for the native market is also because of the common language, similar demographics and factor endowments, taste, and preferences (Elahi 2019) along with heritage shared by the two neighboring countries (Yang 2007). The presence of a long coastline makes the delivery cheaper and faster (CHANDRIMA SIKDAR 2006). A good number of visits by the delegates of both nations has led to agreements been made on a variety of issues like the Land Boundary agreement (2015), Line of credit and investment, energy cooperation, health, and scholarship (S.K.S. YADAV 2016). Amongst the South Asian region, Bangladesh is India's largest trading partner whereas in the case of Bangladesh, India is its second-largest trading partner. In the fiscal year 2019-20, India's exports to Bangladesh totaled $8.2 billion, while imports totaled $1.26 billion (Ministry of External Affairs, India 2021).

More trade indirectly implies more embodied emissions via production and consumption-related activities. Both are developing economies and while undertaking development both produce tones of Green House Gases. Considering the mortality by different air pollutants, PM2.5 tops the list. A substantial number of people in India, Bangladesh, and Pakistan are exposed to a higher level of PM2.5 and other pollutants causing an increasing number of early deaths in the region (TERI 2019).

Throughout the changes in their mutual economic relations, issues that hampered the bilateral trade have occupied a key position. An FTA between the 2 nations is believed to improve the bilateral trade and economic ties of the neighbors. Policymakers along with researchers believe that Bangladesh's economy can benefit from FTA by enhancing its overall competitiveness with the available marketing network, skills and technology of Indian firms (CHANDRIMA SIKDAR 2006).

Since the very beginning, Bangladesh had always faced a trade deficit with India. The trade deficit shows an increasing trend from 2001-2015 (Elahi 2019). The trade intensity index for Bangladesh's exports to India is less than 1 since 2008, although a rise is seen in 2015 and 2016, it's still less than 1. Trade Intensity Index less than 1 implies that "Bangladesh is integrating with India at a slower rate than the rest of the world" (Rizwan 2020).

"Despite sharing long land borders, the proximity of maritime transport infrastructure, and feasible connectivity through inland waterways, UNESCAP (2020) highlights that bilateral trade costs between Bangladesh and India are 46% higher than that of Vietnam and India, a comparatively distant trading partner" (Baker 2021). It implies despite significant improvement in different subjects, this high bilateral trade cost disables both nations to utilize the synergies from bilateral trade (Rahman 2019).

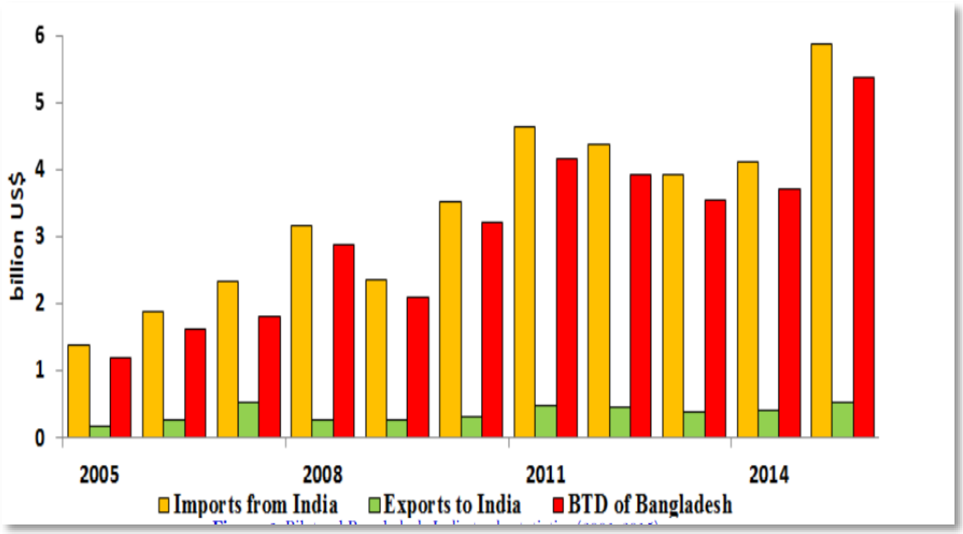

Figure 1: Bangladesh-India Bilateral Trade, 2005-2015
Source: Rahman (2019)

FTA between India and Bangladesh

Overtime different studies have worked on the effect of FTA on these neighbors, but majority of studies identified employed GTAP to find the results. Kim et. al. (2014) used GTAP to study the impact of FTA between India and Bangladesh under 3 different scenarios- a full FTA and a partial FTA in which India removes all its import tariffs on Bangladesh but the latter remove only 75% and 50% in different scenarios. In the case of full FTA (for all commodities) India gains in terms of welfare and real GDP, whereas Bangladesh reports a decline in these two variables. In case of 75% tariff reduction by Bangladesh, India again experiences a rise in welfare and real GDP (0.01%), but no change in real GDP for Bangladesh, and welfare falls. In Scenario III, Bangladesh reduces its import tariff by only 50% on Indian imports, leading to an increase in real GDP (0.05%) and welfare to rise. Welfare for India rises but real GDP remains unchanged. The following study suggests that a preferential FTA between India and Bangladesh (scenario III) should be taken by the government of India and Bangladesh.

A super FTA between India and Bangladesh is proposed by Chandrima Sikdar, 2006 using a comparative advantage framework. Super FTA implies each country can access the other's technology along with free trade. With access to trading partner's technology, ", India is likely to adopt the superior technology that Bangladesh uses to produce Services". From a regular FTA India gains 1% whereas, 51.7% gains are seen in the case of Bangladesh. A dynamic analysis using GTAP was conducted by (Yang 2007) to observe the effects of FTA on economic performance in the short-run and long-run, under different factor market assumptions. In the short run, the model assumes that all factors of production are fixed, except the supply of skilled and unskilled labour, whereas in long run all factors of production are fixed excluding the supply of capital at the regional level. Trade between both nations rises along with rise in welfare both in the short as well as long run. An increase in terms of trade occupies a significant proportion of this rise in GDP and welfare. Rise is seen in the manufactured goods sector, as now each partner can access the other cheaply (duty-free). The potential benefit to Bangladesh is higher than that of India, the reason being improved market access. "There are advantages of an FTA for Bangladesh. It will force two countries to move out of the present commodity-by-commodity approach in negotiations and allow free market access bilaterally for all commodities except an agreed short negative list".

Production-based and Consumption-based emissions

IPCC guidelines to maintain National Emissions Inventories are based on territory-related production. The UNFCCC system boundary "include[s] all greenhouse gas emissions and removals taking place within national (including administered) territories and offshore areas over which the country has jurisdiction" (Peters 2008). As per IPCC guidelines, national CO2 inventories are based on the "consumption of fossil fuel within a country". This emission accounting approach is known as production-based accounting. "It estimates the greenhouse gas emissions from all the oil, coal, and gas consumed in a country by private households, industrial production of goods and services, and electricity production" (Mader 2018). "Production-based emissions allocate emissions to production and include all emissions from domestic production, regardless of whether it is to serve domestic or overseas markets" (Deloitte Access Economics,2015).

Two key limitations of this approach are- international transportation is not a part of any country and carbon leakage is possible with this method (Lirong Liua 2018), (Boya Zhang 2020) and (Peters 2008). The main issue in the case of international transportation is that firstly they are not taking place within a well-defined territory and there also exist problems related to assigning proper responsibility and the availability of data is poor. The pollution haven hypothesis states that due to flexible regulations in some nations, nations with strict environmental regulations, shift their factories to former nations. Goods produced by these less stringent nations are imported by countries with strict regulations, directly linking the reduction in emissions of a country with a rise in others.

Production-based emissions tend to paint an incomplete picture of emissions produced by a country, due to their incapability to include international trade-related emissions. According to IPCC, carbon leakage is, "the increase in CO2 emissions outside the countries taking domestic mitigation action divided by the reduction in the emissions of these countries" (Deloitte Access Economics,2015). It was found that approximately 5 Gt of embodied CO2 is transferred from non-Annex I to Annex I countries via international trade (Peters 2008). (Karakaya 2019) Developed countries outsource their emission burden to developing nations, so PBA proves useful to those developed nations and concerns being raised on nations which have huge emission intensive industries. The latter exporting nations claims that importer is the one responsible for those emissions and therefore bear it.

To overcome the limitations of production-based emissions accounting, Consumption-based emissions accounting (CBA) comes forward. CBA "allocate emissions to consumption, explicitly take into account emissions embedded in international trade flows, and includes emissions embedded in imports but excludes emissions from goods and services produced to serve overseas markets" (Deloitte Access Economics,2015). CBA is calculated by subtracting emissions from exports and includes emissions associated with transportation along with embodied emissions in the inventories of the importing countries (Mader 2018). According to E. Kim et al. (2019), PBA is calculated using the emission factor and energy consumption of each and every industrial sector. Consumption-based emissions are derived from production-based by subtracting emissions caused by production and adding back emissions associated with the consumption of imported goods. The consumption-based emissions determine who is accountable for producing air pollutants and who bears the financial burden of reducing emissions.

CBA looks at emissions from the perspective of the final demand of a nation, instead of production. Globally both CBA and PBA report the same emissions, but they differ at regional levels, in the form of allocation. Considering a specific nation, differences in both figures can exist, the spread of difference will depend on the nature and degree of international trade a nation engages in (Deloitte Access Economics,2015). CBA also suffers from some limitations. While calculating CBA complex calculations are required, which are solved with the help of assumptions indirectly leading to increased uncertainty. CBA migrates from one extreme (production) to the other (consumption), which can be mitigated by utilizing shared responsibility. Shared responsibility means a collective decision that needs to be taken by different governments (Peters 2008). Many papers focused on studying the CO2 embodied emissions in different regions of the world, but eventually, studies focused on other emissions like sulfur dioxide, PM emissions, and other air pollutants.

If a nation has a huge trade deficit (with other nations), there is a high possibility that CBE will be higher than PBE. If energy-intensive products are exported by a nation with respect to imports, then CBE might be less than PBE (Karakaya 2019).

LITERATURE REVIEW

Why PM2.5 emissions?

Black carbon and organic carbon directly form PM2.5 emissions, whereas other harmful gases like ammonia, nitrogen, and sulfur oxide form PM2.5 via chemical reactions in the atmosphere (OECD,2016). Studies suggest that fine particles, explicitly PM2.5 (having a diameter of 2.5 micrometers or less) is more detrimental than PM10 (having a diameter of 10 micrometers or less). These fine particles are metal carriers. A study conducted in the US shows that persistent exposure to PM2.5 emissions results in a rise in mortality among adults. Annually 1 million premature deaths occur on account of atmospheric fine particle pollution. “Anthropogenic PM2.5 causes an estimated 3.5 million cases of chronic obstructive pulmonary disease (COPD) and 220,000 lung cancer deaths each year” (Lindsay Miller 2018). TERI Report (2019) found out that in the domain of different air pollutants, PM2.5 is the highest contributor to deaths. The cost of PM2.5 air pollution's health burden was 10% of Bangladesh's welfare loss (US$370 million).

Changes in PM10 and PM2.5 concentrations are linked to disease incidence in the human respiratory and cardiovascular systems, as well as population mortality rates (Guizhi Wang 2016). PM2.5 levels have been linked to a variety of human health issues. Mortality-causing health consequences of PM2.5 are as follows- respiratory disease, cardiovascular disease, asthma, acute bronchitis, chronic bronchitis (Lindsay Miller 2018), and outpatient visits to pediatrics and internal medicine are also linked to PM2.5 pollution (Guizhi Wang 2016). These evidences do suggest that PM2.5 emissions are more hazardous than other pollutants, therefore studying its impact is more relevant so useful policy action can be taken.

CGE Modeling

According to Burfisher (2021), the computable General Economy model is an “economy-wide” model as it provides a proper description of different actors in an economy (producers and consumers), their behaviors, and the linkages between them. CGE model is based on the basic circular flow of a global economy concept. CGE model follows equations from economic theory. All exogeneous, endogenous and market clearing constraints are employed in this model, which are then solved simultaneously to find a set of prices and quantities at which every market is in equilibrium in the economy.

“Computable in CGE model describes the capability of this type of model to quantify the effects of a shock on an economy. General means that the model encompasses all economic activity in an economy simultaneously – including production, consumption, employment, taxes and savings, and trade – and the linkages among them. Equilibrium occurs at that set of prices at which all producers, consumers, workers, and investors are satisfied with the quantities of goods they produce and consume, the industry in which they work, the amount of capital they save and invest, and so forth". CGE model allows economists to create what-if scenarios, which are further used to analyze how the economy will respond to different policy changes. Economists create disequilibrium while conducting an experiment in the CGE model. A static CGE model enables economists to conduct before and after comparison when a shock is given to the economy. The model will indicate which sectors/ players will be affected negatively and positively after the shock and how the allocation of goods and services changes. Social Accounting Matrix and Parameter elasticities are two components of a CGE model dataset.

The "Air Pollution Multinational Computable General Equilibrium (AMCGE) model" is used by Euijune Kim (2019) to study how national economic growth can affect trade and PM2.5 emissions in the case of China, South Korea, and Japan. Using a CGE model, with the help of Environmentally extended Input-Output simulations, L. Liua et. al. (2018) studied the formulation of integrated industrial GHG mitigation policies from both a production and consumption standpoint. A greater decline in GHG will be seen if Production-Based Policies are applied to primary industries, whereas using consumption-based policies is useful to the industries working at the end of the industrial chains.

Another known CGE model is WorldScan used by J. Bollen (2015) to examine the co-benefits of emission reduction (in the case of air pollutants) taking place because of climate policies. Structural changes caused by climate policies are considered to find out the impact of different air pollutants. Co-benefit refers to the decline in air pollutants caused by climate policy being employed in a particular region. The study showed a direct link between co-benefits' value and more costly climate policy being undertaken. Also, climate policies allowing for consistent carbon prices lead to enlarged co-benefits being produced especially in poor South/ China.

Human capital (HC) amended human capital (AHC), cost of illness (COI), and contingent valuation methods are commonly used to assess the economic impacts of air pollution (CVMs). PM2.5 leads to increased medical costs and labour losses which further disrupts the market functioning leaving an impact on equilibrium. So, any change in one sector's demand and supply will automatically cause change in other sectors to occur. The before mentioned methods (HC, AHC, COI and CV) is unable to account for these changes. In order to conduct an economy wide analysis due to loss in productivity CGE model is used G. Wang et al., (2016).

Trade Embodied Emissions

Boya Zhang (2020) mentions that "The International Federation of Institutes for Advanced Studies (IFIAS) was the first to present the concept of "embodiment," which used "embodied energy" to represent the energy required directly and indirectly to allow a system to produce a specific good or service. An extension of this concept is "embodied emission," which is used to measure the emission produced by a product or service throughout its entire manufacturing process".

E. Kim et al. (2019) undertook the integration of "environmental modules for PM2.5 emissions and premature mortality with a multinational economic model in a single consolidated structure". Segregation of the PM2.5 spatial flows in terms of production-based emissions (PBE) to study the supply process and consumption-based emissions (CBE) to study the demand process was done. Positive spillover effects on international trade were seen in the case of PBE and CBE of PM2.5 due to an increase in investment in China amongst the 3 nations. Rise in import demand by Japan and South Korea is leading to 563 additional premature deaths to rise, implying that former two nations are economically accountable for PM2.5 emissions in China

(Yanyan Xiao 2018) using Input-Output tables and satellite account of disease burden for each country and sector to demonstrate the process of international trade affecting disease burden caused by PM emissions. It was discovered that India and China account for more than 50% of the global airborne disease burden, but most PM emissions occur outside of Asia. There are 3 reasons for such differences in "the embodiment of high amounts of airborne disease in commodities originating in China and India- the high volume of the commodities exported, the large working population in these industries: and high airborne disease risks in these industries".

A reversal of the EKC effect was observed by Prell et al., (2015) between economic development and carbon transfers. Implying that in the early stage of economic development a nation heavily imports of carbon via international trade, then in the middle stage of development they become net exporters of carbon and towards the final stage they again become the net carbon importers. "Most importantly, due to historical patterns of unequal exchange, countries with the highest level of economic development would be the ones importing carbon-intensive goods, thus externalizing environmental costs to less-developed noncore countries that are on the industrialization bandwagon". Results indicate that the rate of environmental consumption along with the present consumption rate is almost similar, difference is present in terms of the burden of environmental degradation being shifted to other countries.

Wakeel, M., et al., (2016) specifies embodied emissions as the emissions produced by an item from "cradle to grave". Direct as well as indirect emissions together constitute embodied emissions. "Direct PM2.5 emissions are those that are produced on-site during production processes for socio-economic activities, whilst indirect PM2.5 emissions are those that are produced during production processes of items or products that are consumed in other sectors". Association between national income, pollution, and trade was established by Copeland and Taylor (1994). Impact of income generated via international trade is different than that of change in income due to national growth. Free trade boosts growth of a nation thereby elevating the real incomes. But a change is seen in terms of change in composition of national output which further leads to alteration of incidence and level of pollution. "Developed economies have been net importers of emissions in international trade and developing economies have been net exporters because their products feature lower technologies and higher emission intensities" (Zhenyu Wang 2018).

A study was done in China (Yan Yunfeng 2010) with the objective of estimating China's CO2 embodied international trade using the input-output life cycle assessment method. For the study year 1997-2007, there was an increasing trend observed for both China's export and import embodied CO2 emissions, but export embodied emissions always exceeded the import embodied emissions. that there was a 449% rise in export embodied emissions, decomposing the change in emissions in terms of scale, composition, and technical effect shows a 450% (of 449% increase) was due to scale effect, 47% increase was contributed by composition effect while there was 48% reduction in emissions due to technique effect. China's CO2 embodied in imports was only 327%. Of the total CO2 emissions caused in China, approximately 10.03%- 26.54% were produced to fulfill China's export demand.

Zhangqi Zhong (2018) using multi region input-output tables to determine the embodied emissions of sulfur oxides in international trade. With 1.16 times increase in global sulfur oxides emissions embodied in trade from 1995-2011, mainly from anthropogenic energy consumption, results propose that global SOx emissions are on a rise. USA, China, Canada, Germany, and India occupy the top rank holders in the global sulfur dioxide emissions. Densely populated countries like China and India report the highest anthropogenic energy consumption in effect to the developed economies.

K. Kanemoto (2014) found out that developed nations' emissions have increased allowing for trade adjustment, rather than decreased. Sectors that reported a decline in their domestic release of emissions are those in which imports have increased i.e., those sectors are importing more embodied CO2 via imports. Considering the flow of CO2 embodied emissions, it was taking place primarily outside Kyoto Annex B signatory countries. China's growth was export-oriented, nearly 30% of the emissions in 2005 were associated with export production. Due to such a high share in emissions, China proposed that responsibility for emissions should be shared equally by the producer and final consumer.

H. Y. Zhao et al., (2015) for the first time in literature tried to quantify the virtual air pollutant emissions embodied in interprovincial trade in China. A large share of emissions is outsourced by coastal provinces to the inland provinces through imports. Interprovincial trade significantly redistributed emissions.

FTA and Emissions

"The main objective of a free trade area is to boost trade and prevent the trade from having a negative effect on the environmental quality of both the signatory countries and their trading partners" (Marta Bengoa 2021).

Muchtar (2015) uses GTAP to analyze the impact of the reduction in import tariffs on agricultural and non-agricultural goods under two different scenarios in Indonesia. A rise in investment is seen in case of the agriculture and service sectors, leading to rise in emissions. K. Tian et. al., (2022) Removal of import tariffs reduces trade and production costs between nations thereby increasing international trade with and amongst the RCEP nations. Considering the emission intensities don't change, carbon emissions are bound to increase. Removing tariffs on all traded commodities between RCEP members CO2 emissions rise by 789.1 Mt, which is approximately 75.4% of the increased global CO2 emissions.

H. Akahori et.al (2017) uses GTAP to find the impact of the Trans-Pacific Partnership, consisting of 12 member partners. Although the GHG emissions would increase globally and in member nations, but the increase is small when compared with other major Asia-Pacific FTA's. M. Islam et. al. used the gravity model to analyze the impact of US- China trade war on CO2 embodied emissions and they discovered that rise in tariff rate due to trade war will lead to rise in CO2 emissions imported in the manufacturing sector.

L. Zhou (2017) states that environmental provisions can be categorized in the following way- (i) "measures to protect and/or enhance the environment", which is attained by reaching out to various parties to take measures for air pollution controls along with undertaking environment-friendly R&D (ii) "cooperation on environmental issues, including sector-specific provisions " connecting with different parties on sharing data with knowledge on pollution controls, exchange of information taking place between experts, researchers, delegations and taking collabourative efforts in organizing seminars and workshops. It's expected that RTA's having environmental provisions will be more efficient for the environment rather than RTAs with no provision for the environment to make. Focus of type II environmental provision is on the environmental cooperation will lead to nations with poorer environmental quality to improve because of cooperation, particularly for the southern nations. It was found out that environmental damage 9 in terms of PM2.5 emissions) will be more in RTAs without environmental provisions and vice-versa. Convergence in PM2.5 can be achieved via RTAs with environmental provisions. Muchtar (2015) suggests that "Trade Related Environmental Measures (TREMs) and Environment Related Trade Measures (ERTMs) could be coordinated in coherent manner".

Efforts to increase trade liberalization by Malaysia lead to an increase in CO2 emissions by 0.14% whereas 4 local pollutants decreased (Shokrinia 2016). A similar pattern was observed in the case of African FTA by Marta Bengoa (2021), CO2 emissions increased by 0.3%, non-CO2 GHGs increased by 19.6% but air pollutants observed a decline by 21.5%.

Bangladesh as an LDC

In 1975, Bangladesh joined Least Developing Country (LDC) group, and almost after 50 years of remarkable growth Bangladesh is all set to graduate from LDC status in 2026. Graduating from LDC is a major benefit in terms of improving the country's image (Noriyoshi 2021). Bangladesh can achieve this huge success in its exports due to the presence of the following benefits provided by WTO- "the Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement, the Agreement on Agriculture, and the Agreement on Subsidies and Countervailing measures" and "duty-free & quota-free (DFQF) market access along with Rules of Origin" (UNDESA,2019) and (UNCDP,2022). Being an LDC until now, Bangladesh was not supposed to reciprocate trade preferences to its trading partners, upon graduation Bangladesh will now have to offer the same trade benefits to the signatory partner, which implies that FTA are proving costly to Bangladesh (Abdin 2018).

Upon graduation in 2026, Bangladesh will be subject to withdrawals of International Support Measures (ISM) which are granted to all LDC nations (UNDESA,2019). From 2010-2019, Bangladesh's exports increased from 8-13% on yearly basis. An important reason for such remarkable growth is the low cost of production leading to a rise in competitiveness (Baker 2021). The export of Textile and Clothing (T&C) sector of Bangladesh accounts for approximately 70% of the LDC's T&C export making it the largest exporter in the group. Bangladesh is also the second-largest exporter of T&C in the world. "The most important impacts of Bangladesh's graduation relate to trade and include the loss of LDC specific market access provisions, LDC-specific special and differential treatment and flexibilities under WTO rules and regional agreements, and certain training and capacity building mechanisms", "The main impacts are expected to be under the Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement, the Agreement on Agriculture and the Agreement on Subsidies and Countervailing measures" and "duty-free & quota-free (DFQF) market access along with Rules of Origin" (UNDESA,2019) and (UNCDP,2022).

Now Bangladesh is required to pay 5-5.5 million USD on yearly basis to the UN. EU is an important export destination for Bangladesh. Until now the country has benefited from the EU's Everything but Arms (EBA) scheme which will be present for 3 years from graduation, but once these benefits are removed tariffs will be imposed on different exports. 83% of the country's exports belong to the T&C sector on which preferential tariffs of 9.6% will be applied by the EU. Now exports from Bangladesh will be subject to a stricter Rules of Origin (RoO) policy. Due to existing working conditions in Bangladesh and issues concerning labour rights and worker safety raised by the EU, there could be serious implications faced by Bangladesh due to this. US has already removed Bangladesh's important products from the LDC-specific preference scheme since 2013 on account of labour safety issues (UNDESA,2019).

Once the benefit granted to Bangladesh as an LDC is taken away, it is expected to face an average incremental tariff of 6.5%. Incremental Tariffs imposed by the EU, Canada, and non-EU nations can rise to 8.7%, 7.3%, and 3.9% respectively (Ehsan 2021). Removal of TRIPS would imply more rigid adherence to intellectual property rights-related issues. Bangladesh will also lose access to technical aid and capacity-building assistance (Ehsan 2021) and (UNDESA,2019).

In the case of Japan and Australia, a crucial part of Bangladesh's exports is not covered under the standard Generalized System of Preferences (GSP) scheme i.e., they will face tariffs under the Most

Favored Nation (MFN) scheme. Australia will impose strict RoO on Bangladesh upon graduation. Bangladesh doesn't have LDC agreements with Canada on garment exports and, after graduation, Bangladesh will be subject to GSP/MFN tariffs on clothing products. The range of GSP/ MFN tariffs is 10-16.8% (Baker 2021). Bangladesh is in constant conversation with different countries in terms of FTA, PTA, and CEPA considering graduation in 2026 (UNCDP,2022). As per the Government of Bangladesh, constant efforts are made to enter into different negotiations amongst 44 countries for Preferential Trade Agreement along with FTA with 11 nations (Ehsan 2021).

Research Gap

The above literature clearly specifies that PM2.5 emissions are more detrimental to human health causing premature mortality as compared to other air pollutants. Studies do specify the supremacy of CGE model over other methods to evaluate the damage caused by embodied emissions over the other existing method to calculate the economic cost of embodied emissions.

"Clearly, emissions embodied in trade have played an increasingly important role in regional CO2 emissions in a globalizing world; however, insufficient attention has been paid to the driving forces of bilateral emission transfers, especially the developing regions, which are the focuses of our study" (Jing Meng 2018). This statement identifies the lack of studies done on developing nations like India. Though studies done in India include multi-regional analysis, none focuses on bilateral trade embodied emissions. Through my study, I wish to contribute to the literature by analyzing the bilateral trade embodied emissions of two developing and neighboring countries (India and Bangladesh) and investigate how one country's economic growth affects production- and consumption-based emissions in neighboring countries. I wish to evaluate the impact of the emissions of PM2.5 on economic costs in India and Bangladesh and analyze the flows of PM2.5 emissions in terms of origin and destination, so that appropriate action can be taken by the two governments. Studies in the past did focus on different aspects due to FTA between India and Bangladesh, but all failed to consider the impact on emissions. Bangladesh is an LDC and is all set to graduate in 2026, and many reports and organizations are considering its impact on key economic variables and getting prepared with a steady plan. But the literature reviewed so far missed the environmental impact

MSA-Management science journal
ISSN 2974-303x
Volume: 2, Issue:1, Year: 2022, pp. 1-45

of the graduation, so the study tries to consider the impact of graduation on key economic variables along with PM2.5 emissions,

Objectives

To investigate how one country's economic growth affects production- and consumption-based emissions in neighboring countries (India and Bangladesh).

What is the impact of the emissions of PM2.5 on welfare and foregone labour output in India and Bangladesh?

To investigate the results of the Free Trade Agreement (FTA) b/w India and Bangladesh

To analyze the impact, if the tariff rate for Bangladesh is the same as that of India, then what would be the impact on PM2.5 emissions.

Datasources And Methodology

Data Source

So, in my study, I am using a customized extension of GTAP 10a for the base year 2014, which was provided by Dr. Badri Narayanan Gopalakrishnan. My dataset consists of 35 nations covering 38 sectors (Annexure). GTAP 10 was launched in 2019, with 141 countries over 65 different sectors for the base year of 2004, 2007, 2011 and 2014. This is for the first time when GTAP provided data for 9 different air pollutants (black carbon (BC), carbon monoxide (CO), ammonia (NH_3), non-methane volatile organic compounds (NMVOC), nitrogen oxides (NO_x), organic carbon (OC), particulate matter 10 (PM10), particulate matter 2.5 (PM2.5) and sulfur dioxide (SO_2)).

A report by World Bank in collabouration with Institute for Health Metric and Evaluation (2016), using GBD dataset has published data for different impacts of PM2.5 in terms of number of deaths caused by air pollution, loss of welfare and foregone labour output.

<u>Methodology</u>

Global Trade Analysis Project (GTAP)

GTAP is a database that is maintained and originally developed by Prude University, US. It was first released in 1992, its purpose was to help quantitative researchers working on international economic issues. Overtime developments have happened in terms of the number of countries, sectors, and different extensions, enabling GTAP to cater to the interest of a wide range of researchers in fields related to trade, environment, population, energy, and climate change, with a long history of systematic improvements (Jintai Lin 2019). "Fully documented, publicly available, global database, with a standard modelling framework. It's a software for manipulating the data and implementing the standard model" (Hertel 1997). "The GTAP CGE model is a multiregional, multi-sector economic equilibrium model" (Jintai Lin 2019) & (Badri Narayanan 2021). GTAP assumes- a perfectly competitive market exists, producers minimize cost using the CRS production function whereas consumers maximize their utility (Badri Narayanan 2021), and the input market is clear along with Armington hypothesis for international trade (Jieming Chou 2021). The model follows the same intuition as that of an open circular economy.

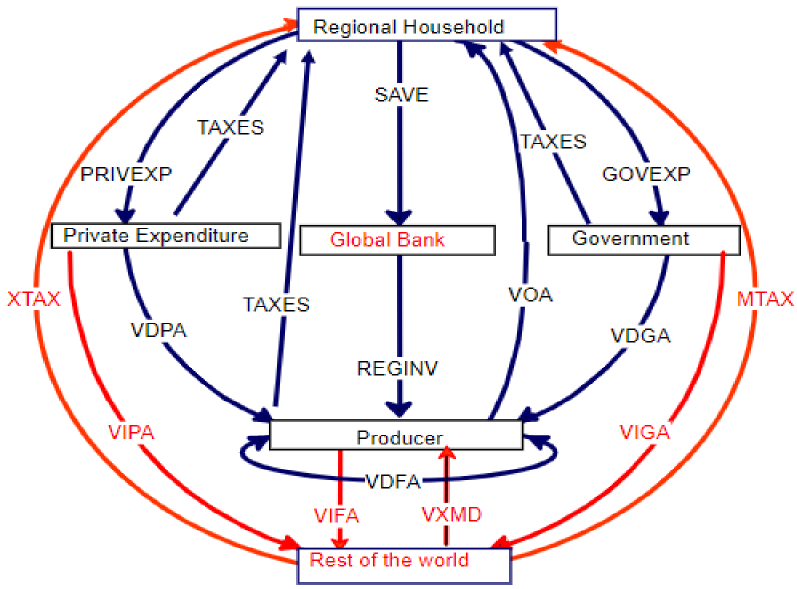

Figure 2- Graphical Presentation of GTAP framework
Source- Hertel (1997)

Different components of the open economy constitute- a regional household, government sector, producers/firms, global bank, and the rest of the world. “VOA represents Value of Output at agents’ prices of endowment commodities. VDFA – Value of domestic purchases by firms at agent’s prices. VDGA - Value of domestic purchases by government households at agent’s prices. VXMD – Value of exports at market prices by destination. VIPA- Value of imports payments to ROW from the private household. VIGA – Value of imports payments to ROW from government households. VIFA - Value of imports payments to ROW from firms. REGINV – sale of investment goods to satisfy the regional household’s demand for savings. The global bank acts as an intermediary for global savings and regional investment, XTAX- represents tax on exports and MTAX represents tax on imports”. Regional household follows an aggregate utility function (Cobb Douglas function) to incur expenses across 3 different sectors that are- private, government, and savings. Cobb-Douglas utility function ensures that the same weights are distributed across the 3 sectors (Hertel 1997). The blue lines here indicate the transactions happening within a domestic economy, whereas the red lines denote the transactions happening with the rest of the world. The arrow sign shows the direction of the flow of money.

With the help of different sub-models regarding the production process, consumption, and government expenditures of different nations, GTAP is then able to integrate these sub-models into a multi-country, multi-sector, general equilibrium model via international commodities trade (Jieming Chou 2021).

Theoretical Framework for Emissions in GTAP

Emissions in the model are a function of output and input to supplement the standard GTAP model. Emissions of different air pollutants are provided for a variety of imported as well as domestic commodities for government consumption, private consumption, and intermediate inputs. GTAP’s results are shown in terms of % change in each air pollutant’s emission due to % change in a specific economic variable. “From output-linked emissions for air pollutants and non-CO2

GHG emissions, whose percent change is the same as the percent change in output, input-linked emissions, and consumption-linked emissions. Also, emissions linked with intermediate inputs and endowment use by firms, are separately identified in the model". The below equation shows "the accounting equation for Air Pollutants (AP) denoted by AP, for a given sector i and region s, while the emissions associated with the inputs are summed up across industries j" (Marta Bengoa 2021).

$$AP_{2i,s} = \sum_{j} APinputs_{j,i,s} + APHouseholds_{i.s} + APOutput_{i,s}$$

The below equations would show the linkage for inputs, consumption, and output respectively, in a simple way. Equations below are linearized and are based on level equations capturing the emission intensities. While doing the same emissions intensities are assumed to be constant before and after simulations, i.e., "these equations do not capture any behavioral relationship between different variables and emissions, but instead, they are simply accounting linkages between them" (Marta Bengoa 2021).

$$\%\Delta\ in\ APinputs_{i,j,s} = \%\Delta\ in\ firms'\ input\ qf_{i,j,s}$$
$$\%\Delta\ in\ APHouseholds_{i,j,s} = \%\Delta\ in\ household\ consumption\ qp_{i,s}$$
$$\%\Delta\ in\ APoutput_{i,s} = \%\Delta\ in\ output\ qo_{i,s}$$

The units for PM2.5 emissions reported by the model are in Gigagrams (Gg). Closure changes were made in GTAP, for investment shock in each country, investment (for India and Bangladesh) was swapped with technical change in a region. Then investment was increased by 10%. Similarly, for FTA and other tariff changes, respective tariff changes were given to obtain the required results. Mostly all the results were reported in % change, which was later converted to absolute changes.

Assumptions

MSA-Management science journal
ISSN 2974-303x
Volume: 2, Issue:1, Year: 2022, pp. 1-45

A crucial assumption is made while interpreting the results, with any change in investment in India and Bangladesh and FTA (between the two), no new improvement in the technology for reducing air pollution is happening in either nation. Change in welfare, mortality and foregone labour output, the data was used from Global Burden of Disease, which showcased these variables for the year 1990-2013. While calculating the changes in welfare, mortality, and labour output, it was assumed that the figures for 2013 were similar to that of 2014 and calculations were carried forward.

Results

Investment shock in India

Table 1- Results of Investment Shock in India by 10%

Regions	Change in trade balance (In millions USD)	Change in Welfare (In millions USD)	Change in Real GDP (In millions USD)
India	-4,775.64	1,41,002.6	1,51,233.9
Bangladesh	-45.57	100.38	5.44
ROW	4821.3	11,309.6	1172.85

Table 2- Change in PM2.5 Emissions due to rise in Investment in India

Regions	Change in PBE (In Gg)	Change in CBE (In Gg)
India	95.02	526.075
Bangladesh	-0.3	0.123

With the increase in Investment in India by 10%, there is a rise in imports, welfare, and real GDP for both India and Bangladesh. The rise in CBE is more than the rise in PBE, this is due to the rise in imports by India. In the case of PBE maximum % change was observed in plant-based fiber, vegetable oils and fats and coal. But healthcare (7.038%), public services (7.059%) reported the maximum % change in CBE, considering the absolute PM2.5 emission change (437.9 Gg) is observed in coal. There is a rise in imports which explains a rise in CBE for Bangladesh, but PBE reports a decline. An equal number of sectors reported an increase and decrease in % change of PM2.5 in Bangladesh in PBE. Wheat reported the maximum% decline (of 2.48%), whereas maximum positive change was observed in coal (0.485%). Cereal grains account for the maximum % (of 0.667) rise in CBE, but coal records the greatest decline of 0.171%. The above results show the change in PBE and CBE for India and Bangladesh, considering all the other nations in the world i.e., not specific to change in India's investment shock's exclusive effect on Bangladesh in terms of emissions.

Table 3- Change in Bilateral Trade of Bangladesh- India, and PM2.5 due to trade

Change in Bilateral exports of Bangladesh to India (in USD million)	Change in PM2.5 in Bangladesh to meet export Supply (in Gg)	Change in Bilateral Imports of Bangladesh from India	Change in PM2.5 in India to meet Bangladesh's import demand
4.717	0.078	656.803	1.728

Taking the proportion of change in India's exports to the rest of the world and to Bangladesh, then multiplying the same with the change in total PBE for India reports with change in investment in India, PM2.5 emitted in India to meet Bangladesh's import demand (from India) accounts to 1.728 Gg. Again, getting the results from the proportionate method (discussed above) change in PM2.5 emissions in Bangladesh to meet India's import demand (due to the rise in investment in India) is 0.078 Gg. An increase in investment in India (by 10%) is responsible for a rise in PM2.5 emissions in Bangladesh by 0.078 Gg.

The sector's showcasing the highest % rise in bilateral exports between Bangladesh and India were- wheat, plant-based fiber, light, and heavy manufacturing industries. Woolen products, paddy-rice and meat products were contributing to a high rise in bilateral imports between Bangladesh- India.

Table 4: Change in Deaths, welfare losses and foregone labour output

	Change in deaths due to PM2.5 over 1990-2014 (in millions)	Change in total welfare losses due to PM2.5 over 1990-2014 (in millions USD)	Change in total foregone labour output due to PM2.5 over 1990-2014 (in millions USD)
India	11.51	1,28,06,304	8,52,736
Bangladesh	0.241870	8,21,847	53,976

This table shows the impact of a marginal increase in Investment in India (by 10%) will cause deaths to rise (caused by PM2.5) to meet Bangladesh's export supply. Similarly, due to the rise in investment in India, the results show an increase in PM2.5 mortality to meet India's import demand. Although these figures show accumulated deaths, welfare losses, and foregone labour output from 1990-2014.

Investment Shock in Bangladesh

Table 5- Results of Investment shock in Bangladesh (10% rise)

Regions	Change in the trade balance (In millions USD)	Change in Welfare (In millions USD)	Change in Real GDP (In millions USD)
India	15.45	23.65	5.5
Bangladesh	-627.63	11228.74	11,592.14
ROW	612.18	374.28	29.23

Table 6- Change in PM2.5 emissions due to investment shock in Bangladesh

Region	PBE (Change in Gg)	CBE (Change in Gg)
India	0.033	0.018
Bangladesh	6.501	11.784

With the rise in Investment in Bangladesh, there is a rise in welfare and real GDP for India and Bangladesh. India experiences a rise in exports, while Bangladesh observes a rise in imports. Both PBE and CBE emissions rise for India and Bangladesh.

With an observed rise in imports for Bangladesh, the rise in CBE is more than a change in PBE for Bangladesh. A max % rise was seen in the case of wool (21.67%), wheat (10.57%), and a minimum rise was seen in the processed rice sector (4.38%) for PBE. Considering the change in CBE for PM2.5, the least change was observed in cereal grains (of 3.76%) while healthcare, public services, and other services reported a similar change (of 7.6-7.78%).

The change in PBE is more than CBE for India with the rise in investment in Bangladesh as India experiences a trade surplus. The processed rice sector had a maximum decline of 0.026%. Whereas plant-based fiber recorded the maximum rise (of 0.088%) in PBE and increased by 0.05% in the case of CBE. Cereal gains nec. and oil witnessed a decline of 0.001% in PM2.5 CBE.

Table 7- Change in Bilateral Trade between Bangladesh- India and PM2.5 emissions

Change in Bilateral exports of Bangladesh to India (in USD million)	Change in PM2.5 in Bangladesh to meet export Supply (in Gg)	Change in Bilateral Imports of Bangladesh from India (in USD millions)	Change in PM2.5 in India to meet Bangladesh's import demand (in Gg)
37.254	0.141	267.848	1.524

Taking out the results using different proportions, India is responsible for additional 0.141Gg of PM2.5 emissions, whereas India produces an additional 1.524Gg of PM2.5 emissions to fulfill Bangladesh's import demand. Paddy and rice along with gas experienced a maximum % change in Bangladesh exports to India, whereas oil reported a maximum % change in imports from India (by Bangladesh).

Table 8- Change in Deaths, welfare losses and foregone labour output

	Change in deaths due to PM2.5 over 1990-2014 (in millions)	Change in total welfare losses due to PM2.5 over 1990-2014 (in millions USD)	Change in total foregone labour output due to PM2.5 over 1990-2014 (in millions USD)
India	10.58	1,12,94,448.67	7,52,065.77
Bangladesh	4.3	14,85,646.5	97,572

This table shows the impact of a marginal increase in Investment in Bangladesh (by 10%) will cause deaths to rise (caused by PM2.5) to meet India's export supply. Similarly, due to the rise in investment in Bangladesh, the results show an increase in PM2.5 mortality to meet Bangladesh's import demand. Although these figures show accumulated deaths, welfare losses, and foregone labour output from 1990-2014.

FTA b/w India and Bangladesh

Table 9- Results from FTA between India and Bangladesh

Variables	Change in trade balance (in USD millions)	Change in welfare (in USD millions)	Change in real GDP (in USD millions)
India	-142.85	632.42	30.25
Bangladesh	54.73	-139.05	43.94
ROW	88.11	-523.39	-102.22

Table 10- Changes in PM2.5 emissions due to FTA

	PBE (Change in Gg)	CBE (Change in Gg)
India	0.089	4.078
Bangladesh	-0.241	-0.474

There is a rise in imports, welfare and real GDP for India. Bangladesh also records a rise in exports and real GDP, although the welfare declines. The rise in exports for Bangladesh is due to its export-oriented growth as it's an LDC nation having preferential tariffs with different trading partners. Change in PBE is more than the change in CBE for Bangladesh. Also entering into FTA with India on all traded commodities will lead to an increase in Bangladesh's exports to India but Bangladesh will still have a high trading deficit with India. A possible reason contributing to a fall in welfare for Bangladesh could be the loss of tariff income from India on imports (from India).

FTA for Bangladesh would lead to a fall in PM2.5 emissions but this is not true for India. Imports are increasing for India, which explains why CBE changes by more (not PBE).

By following the Production Based Accounting approach for Bangladesh most sectors reported a decline in emissions. Light manufacturing reports a maximum decline (of 2.31%) and PM2.5 emissions increase in woolen products (3.68%) the most. Following CBE, all sectors report a decline except for rubber and plastics, their emissions increased by 0.093%, and the minimum decline was seen in the case of healthcare and other services (of 0.408%). The textile and wearing apparel sector report the maximum rise in PBE PM2.5 emissions of all sectors (of 0.548%) and the least change is seen in the pharma sector (of -0.371%). Plant-based fiber records the highest change (of 0.082%) and fishing recorded the least (-0.12%) change in CBE in India. But considering an absolute change in CBE for India, coal shows the highest change of 3.48Gg followed by the heavy manufacturing sector of 0.6Gg. With FTA being employed PM2.5 reduces by 0.0225Gg.

Table 11- Change in Bilateral Trade between Bangladesh- India and PM2.5 emissions

Change in Bilateral exports of Bangladesh to India (in USD million)	Change in PM2.5 in Bangladesh to meet export Supply of India (in Gg)	Change in Bilateral Imports of Bangladesh from India (in USD million)	Change in PM2.5 in India to meet Bangladesh's import demand (in Gg)
37.254	-0.0225	3039.964	0.7911

The maximum % change in Bangladesh exports to India was seen in dairy products, vegetable oils, and crop nec. The sectors reporting the highest % change in Bangladesh's imports to India were woolen, gas, textiles & wearing apparel, light manufacturing, rubber & plastic. From this bilateral trade, it is observed that the rise in

Bangladesh's exports is coming from the primary sector whereas imports are based on the secondary sector.

FTA leads to a fall in emissions for Bangladesh and PM2.5 emissions rise for India (while meeting each other's import demand). From an environmental perspective, FTA is not desirable between the two nations. The FTA with all tariffs being removed by both nations is not the first best option for both nations, as in Bangladesh, it leads to huge welfare losses, and for India, the PM2.5 emissions rise.

Bangladesh as an LDC

Table 11- Changes due to tariff being imposed on Bangladesh by EU

	Trade Balance (in USD millions)	Change in welfare (USD millions)	Change in Real GDP (in USD millions)	Change in PM2.5 emissions (in Gg)
Bangladesh	642.02	-2,162.16	-390.44	-2.31
EU	19.84	1,467.77	204	0.1

Table 12- Changes due to tariff being imposed on Bangladesh by Japan

	Trade Balance (in USD millions)	Change in welfare (USD millions)	Change in Real GDP (in USD millions)	Change in PM2.5 emissions (in Gg)
Bangladesh	0.356	-0.987	-0.031	-0.0024
Japan	-0.008	0.369	0	0.0000026

Table 13- Changes due to tariff being imposed on Bangladesh by US

	Trade Balance (in USD millions)	Change in welfare (USD millions)	Change in Real GDP (in USD millions)	Change in PM2.5 emissions (in Gg)
Bangladesh	0.004427	- 0.01144	0	-0.000108
US	-0.001852	0.005697	0	0.0000017

Table 14- Changes due to tariff being imposed on Bangladesh by Oceania

	Trade Balance (in USD millions)	**Change in welfare (USD millions)**	**Change in Real GDP (in USD millions)**	**Change in PM2.5 emissions (in Gg)**
Bangladesh	16.908	-57.12	-10.37	-0.06013
Oceania	0.6117	24.066	9.875	-0.0035

Imposing the same tariff rate of India on Bangladesh, as it will be graduating in 2026 to infer the impact of tariffs on PM2.5 emissions being produced in Bangladesh. Although the tariff rate imposed on Bangladesh might be lower by some developed partners and higher by others in different sectors. This is just an attempt to look specifically at emissions of PM2.5 after there is any change in tariffs. The tariff change imposed on Bangladesh is done separately on GTAP, i.e., this tariff imposition exercise is not done simultaneously for all developed partners of Bangladesh. As CGE modeling is being used, these results are not specifically showing the impact of tariff change on Bangladesh with respect to a partner nation, i.e., these results include the changes in the aggregate sense.

In all 4 cases, Bangladesh experiences a rise in exports and a fall in welfare, real GDP, and PM2.5 emissions. Out of all four cases, the minimum change occurs in the US-Bangladesh case. As the US has already imposed high tariff rates on Bangladesh and in some sectors the tariff rates are higher than in India. This is on account of labour safety issues. On an aggregate level the change in PM2.5 emissions in the case of the US, Japan, and Oceania are minute, and if calculations are done regarding their PM2.5 emissions made to fulfill each partner's import demand the numbers would be very different. Although exports are rising in each scenario, with the transition from LDC, there is a change in manufacturing destinations by different nations to other LDCs like Vietnam and others. This is a huge loss for Bangladesh, leading to the declining welfare of Bangladesh.

Table 15- Change in PM2.5 emissions and Bilateral trade with developing countries specifically occurring due to change in tariffs

	Change in Bilateral exports of Bangladesh with partner (In millions of USD)	Change in Bilateral imports of Bangladesh with partner (In millions of USD)	Change in PM2.5 emissions (In Gg, due to change in trade of exports of Bangladesh with each partner)
EU	-5,236.67	-286.976	-8.508
Japan	4.755	-0.0607	-0.058
US	-0.0444	-0.00056	0.009
Oceania	-267.81	-2.056	-0.43

Earlier results from table11-14, shows the exports for Bangladesh are rising, but digging deep into each trading partner, the results turn out to be different. Leaving aside Japan, there is a loss of exports for Bangladesh, when it losses its LDC status and the maximum loss of export is in the case of EU of 5236.67 USD million. Change in PM2.5 emissions to meet the existing import demand of different partners also reports a decline, except for the US. Although Bangladesh, still has a trade surplus with these nations, given the loss of exports, there will be a huge loss of welfare, livelihood, and real GDP. It is the textile and apparel sector that reports the maximum loss of exports.

Conclusion And Discussion

With trade liberalization efforts being made by countries, volumes of international trade are on a rise. Many RTAs and FTAs are formed to enhance trade between partners. When it comes to accounting for emissions, two different methods are used- PBA and CBA. With the use of PBA, developed countries could easily reduce their emissions, i.e., by not producing and importing the emission intensive goods.

But if we consider, CBE, then emission accounts of developed nations are increasing ever since. As the literature above mentions, the differences in PBA and CBA results also prove the differences in the different accounting approaches and the figures turn out to be huge. So, accounting for increase in emissions vi a PBA and CBA between India and Bangladesh, so that we can identify which nation is causing emissions in other and held it responsible for the change in PM2.5 emissions. With this identification, we can hold the other country responsible and seek for damages, welfare changes, foregone labour output.

If we increase investment in India by 10%, India would be emitting 1.728Gg to meet Bangladesh's import demand and on the other hand Bangladesh will be emitting 0.078Gg of PM2.5 emissions to meet India's export supply. If there is an increase in investment in Bangladesh by 10%, PM2.5 emissions will increase by 0.1416 Gg, to meet India's export supply. But India emits 1.524Gg (more) PM2.5 emissions to produce for imports by Bangladesh. One of the reasons to undertake FTA is reduction in emissions and other GHGs, but in this study, this objective doesn't seem to fulfil.

FTA between India and Bangladesh, leads to rise in emissions for India and decline in emissions for Bangladesh. To enter in an FTA, both countries should be benefitting, but Bangladesh faces huge welfare losses and India emits more PM2.5 emissions environmental loss is happening in India. Removing tariffs on all traded goods and services is not the best way to help both nations in reducing emissions and achieving high bilateral trade by partners.

Irrespective of the investment increase in India, Bangladesh, and the FTA between both countries, Bangladesh’s trade deficit with India continues to widen. Considering FTA, Bangladesh’s trade deficit increased by 2,934.632 USD million.

There is an increase in GDP in both nations (in all different scenarios), as seen in a dynamic analysis conducted using GTAP by Yang (2007). A reason for part of this change could be due to variation in terms of trade (with tariffs being removed). India experiences an improvement in terms of trade whereas a decline in Bangladesh. But welfare for India and Bangladesh increases in a study by Yang (2007), but in my study, the welfare results are not similar, and welfare for Bangladesh faces a great decline. This rise in trade is showing the potential prospects from the gain of new market access under FTA for both nations. Considering the change in PM2.5 emissions due to FTA, Bangladesh benefits but India faces an increase in emissions.

Due to the multiplier impact of the Ready-Made Garment (RMG) sector, it is roughly equal to 7% of the country's GDP. Not only does the RMG sector generate jobs, but it also allows more women to enter the labour force, allowing them to contribute to house rents and school costs enabling Bangladesh to achieve its sustainable development goal (SDG) of providing full employment and equal participation in the workforce (Ehsan 2021). Of all the sections of society, women benefitted the most from these trade preferences, increasing equality amongst the nation. Women account for most of the low-skilled workforce in LDCs and an increase in exports and domestically produced goods due to additional market access provision leads to a rise in the return of the women in the labour force (Baker 2021). Reciprocating the trade benefits Bangladesh will enter after graduation (Abdin 2018) implies a loss of tariff revenue that was earlier received being an LDC member.

Policy Recommendation

Considering accounting of emissions solely based on PBA is not the perfect way to look at the emission inventory of the nation. Emissions must be considered from the viewpoint of consumption, i.e., CBA. Differences in the CBA and PBA are huge (considering India and Bangladesh in the present study). The responsibility for the emissions should belong to the consumer rather than the producer, thereby sufficient economic compensation should be made by the consumer. From the study PM2.5 emissions produced by one country to meet the import demand of another is being recognized, so each country must make sufficient compensation to the other for the losses in productivity and mortality.

There have been FTA imposed by developed nations which have added environmental provisions in the FTA, thereby leading to reduction of emissions, convergence is achieved in environmental standards. A preferential trade agreement that optimizes the welfare of India and Bangladesh, as well as reduces the emissions should be undertaken by both governments.

Although trade between India and Bangladesh proves costly vis-a-vis other trading partners. Like bilateral trade between India and Vietnam costs 46% less than bilateral trade between India and Bangladesh. It implies that both nations have not utilized the benefits of their common land borders and waterways. Secondly, a large amount of informal trade is happening, making estimates paint a somewhat hazy picture. Reducing trade costs will help reduce informal trade, which requires a more wholesome trade integration on different issues. There is a need to adopt cleaner technology and adopt other measures to reduce PM2.5 emissions.

Setting up new research institutes, both for undertaking new technological development to reduce emissions of GHGs and other air pollutants along with institutes to reduce trade costs. Also, more educational institutes could be set up in collabouration.

Bangladesh will be graduating in 2026, which will lead to the imposition of trade tariffs by the different trading partners. Bangladesh can realize the reduced tariff rates via the GSP+ scheme of the EU but is not eligible on the grounds of human rights, environmental standards, and climate change among others. Bangladesh has already lost the benefits of reduced tariff by the US in 2013 due to labour safety issues, not to lose such benefits Bangladesh need to work on them. Along with tariff benefits, Bangladesh will be more sustainable in the long run. Although Bangladesh is in constant conversation with different trading partners to enter into FTAs, PTAs, and RTAs. But in order to sustain its export-oriented growth and minimize the welfare changes and export losses, Bangladesh needs to make swift economic collabourations.

Limitation of the study

Bangladesh is set to graduate in 2026, so the impact of different benefits lost (as an LDC) will be felt in 2027 and afterward and within this duration, many changes are bound to happen. There are concerns about using CGE modeling to find out the impact on Bangladesh in terms of accuracy of results as the CGE analysis won't consider the exchange rate risk, political risk, and instability over investor confidence globally as well as domestically. "Using an aggregate economic model to estimate the impact of qualitatively different outcomes risks trying to derive a single number to represent gains and losses which are not capable of comparison" (UNDESA,2019).

The study uses the data for 2014, from 2014 to the present day itself many changes in tariffs have taken place till date. But this study tried towards quantifying the impact on different variables due to gradation taking place in 2026 with a focus on change in PM2.5 emissions being emitted after Bangladesh graduates.

In detail analysis could be conducted in terms of decomposition of change in emissions, in terms of scale, technique and composition effect. As CGE model is not a reliable method for evaluating the impact of graduation, the partial equilibrium model could be used to study the sectors mainly affected by graduation (particularly in the textile sector and pharmaceutical sector).

REFERNCES

'Carbon Analytics Australia's Performance in the G20 Supported by Origin Energy'. Deloitte Access Economics: Carbon Analytics. Deliotte, 2015.

'Ex Ante Assessment of the Possible Impacts of the Graduation of Bangladesh from the Category of Least Developed Countries'. Secretariat of the Committee for Development Policy, United Nations Department for Economic and Social Affairs, 1 April 2019.

Abdin, M. D. "Post-LDC Challenges for Bangladesh Economy." Post-LDC Challenges for Bangladesh Economy (February 6, 2018) (2018).

Akahori, Hirokazu, Daisuke Sawauchi, and Yasutaka Yamamoto. "Measuring the changes of greenhouse gas emissions caused by the trans-pacific partnership." Sustainability 9, no. 5 (2017): 715.

Ali, Nawazeesh Muhammad. "Formal Trade Between India and Bangladesh: An Empirical Analysis." (2016): 9.

Baker, Paul 'IMPACT OF LDC GRADUATION ON THE TEXTILES AND CLOTHING SECTOR'. EIF-WTO, 30 April 2021.

Bengoa, Marta, Somya Mathur, Badri Narayanan, and Hanna C. Norberg. "Environmental Effects of the African Continental Free Trade Agreement: A Computable General Equilibrium Model Approach." J. Afr. Trade 8 (2021): 36-48.

Bollen, Johannes. "The value of air pollution co-benefits of climate policies: analysis with a global sector-trade CGE model called WorldScan." Technological Forecasting and Social Change 90 (2015): 178-191.

Burfisher, Mary E. Introduction to computable general equilibrium models. Cambridge University Press, 2021.

Chepeliev, Maksym. "Development of the Air Pollution Database for the GTAP 10A Data Base." (2020).

Chou, Jieming, Fan Yang, Zhongxiu Wang, and Wenjie Dong. "The Impact on Carbon Emissions of China with the Trade Situation versus the US." Sustainability 13, no. 18 (2021): 10324.

Ehsan, Zaeem-Al. "LDC Graduation of Bangladesh-In Search of Coping Strategies for the Bangladeshi RMG Industry." (2021).

Franzen, Axel, and Sebastian Mader. "Consumption-based versus production-based accounting of CO2 emissions: Is there evidence for carbon leakage?." Environmental science & policy 84 (2018): 34-40.

Hertel, Thomas Warren. Global trade analysis: modeling and applications. Cambridge university press, 1997.

Islam, Moinul, Keiichiro Kanemoto, and Shunsuke Managi. "Growth potential for CO2 emissions transfer by the United States-China trade battle."

Kanemoto, Keiichiro, Daniel Moran, Manfred Lenzen, and Arne Geschke. "International trade undermines national emission reduction targets: New evidence from air pollution." Global Environmental Change 24 (2014): 52-59.

Karakaya, Etem, Burcu Yılmaz, and Sedat Alataş. "How production-based and consumption-based emissions accounting systems change climate policy analysis: the case of CO2 convergence." Environmental Science and Pollution Research 26, no. 16 (2019): 16682-16694.

Kathuria, Sanjay, and Nadeem Rizwan. "Benefits of Cooperating with Big Neighbors: The Case of Bangladesh and India." In Trade and Regional Integration in South Asia, pp. 109-127. Springer, Singapore, 2020.

Kim, Chanwahn, Mohammad Masudur Rahman, and Laila Arjuman Ara. "Economic impact of the proposed Bangladesh–India FTA: potentials and realities." South Asian Journal of Global Business Research (2014).

Kim, Euijune, Seung-Woon Moon, and Shigemi Kagawa. "Spatial economic linkages of economic growth and air pollution: developing an air pollution-multinational CGE model of China, Japan, and Korea." The Annals of Regional Science 63, no. 2 (2019): 255-268.

Li, Jiashuo, Mengmeng Shi, Peng Cai, Byron Alejandro Galvez Campos, Xihao Song, B. Chen, Qing Yang, and Hui Chen. "How external trade reshapes air pollutants emission profile of an urban economy: a case study of Macao." Ecological indicators 94 (2018): 74-82.

Lin, Jintai, Mingxi Du, Lulu Chen, Kuishuang Feng, Yu Liu, Randall V Martin, Jingxu Wang et al. "Carbon and health implications of trade restrictions." Nature communications 10, no. 1 (2019): 1-12.

Liu, Lirong, Guohe Huang, Brian Baetz, and Kaiqiang Zhang. "Environmentally-extended input-output simulation for analyzing production-based and consumption-based industrial greenhouse gas mitigation policies." Applied energy 232 (2018): 69-78.

McDuffie, Erin E., Randall V. Martin, Joseph V. Spadaro, Richard Burnett, Steven J. Smith, Patrick O'Rourke, Melanie S. Hammer et al. "Source sector and fuel contributions to ambient PM2. 5 and attributable mortality across multiple spatial scales." Nature communications 12, no. 1 (2021): 1-12.

Miller, Lindsay, and Xiaohong Xu. "Ambient PM2. 5 human health effects—Findings in China and research directions." Atmosphere 9, no. 11 (2018): 424.

Monitoring of Countries Graduating and Graduated from the List of LDC Category: Bangladesh'. Committee for Development Policy 24th Plenary Session. United Nations, February 2022.

Murshed, Muntasir, and Syed Margub Elahi. "Problems of Bilateral Trade Deficit between Bangladesh and India: A 2SLS Regression Analysis." International Journal of Business, Economics and Management 6, no. 4 (2019): 215-231.

Nansai, Keisuke, Susumu Tohno, Satoru Chatani, Keiichiro Kanemoto, Shigemi Kagawa, Yasushi Kondo, Wataru Takayanagi, and Manfred Lenzen. "Consumption in the G20 nations causes particulate air pollution resulting in two million premature deaths annually." Nature communications 12, no. 1 (2021): 1-12.

Narayanan, Badri, and Somya Mathur. "The potential impact of GHG reductions on air pollution in India." Journal of the Asia Pacific Economy 26, no. 2 (2021): 344-360.

Peters, Glen P. "From production-based to consumption-based national emission inventories." Ecological economics 65, no. 1 (2008): 13-23.

Prell, Christina, and Laixiang Sun. "Unequal carbon exchanges: understanding pollution embodied in global trade." Environmental Sociology 1, no. 4 (2015): 256-267.

Rana, Ritu, and Manoj Sharma. "International trade, foreign direct investment, economic growth and CO2 emissions: a study of India." Interdisciplinary Environmental Review 20, no. 1 (2019): 73-82.

Sarker, Md Nazirul Islam, and Md Ziaur Rahman. "Geopolitical influence and trade between Bangladesh and India." Bangladesh Journal of Public Administration (2019).

Sikdar, Chandrima, Thijs Ten Raa, Pierre Mohnen, and Debesh Chakraborty. "Bilateral trade between India and Bangladesh: A general equilibrium approach." Economic Systems Research 18, no. 3 (2006): 257-279.

Siriwardana, Mahinda, and Jinmei Yang. "Effects of proposed free trade agreement between India and Bangladesh." South Asia Economic Journal 8, no. 1 (2007): 21-38.

Solaymani, Saeed, and Mehdi Shokrinia. "Economic and environmental effects of trade liberalization in Malaysia." Journal of Social and Economic Development 18, no. 1 (2016): 101-120.

Takashi, U. S. A. M. I., and F. U. K. U. O. K. A. Noriyoshi. "Implications of Bangladesh's Graduation from Least Developed Countries Status on Japanese Companies." Journal of Contemporary Research in Social Sciences 3, no. 2 (2021): 28-39.

Tian, Kailan, Yu Zhang, Yuze Li, Xi Ming, Shangrong Jiang, Hongbo Duan, Cuihong Yang, and Shouyang Wang. "Regional trade agreement burdens global carbon emissions mitigation." Nature Communications 13, no. 1 (2022): 1-12.

Wakeel, Muhammad, Siyuan Yang, Bin Chen, Tasawar Hayat, Ahmed Alsaedi, and Bashir Ahmad. "Network perspective of embodied PM2. 5–A case study." Journal of cleaner production 142 (2017): 3322-3331.

Wang, Guizhi, SaiJu Gu, Jibo Chen, Xianhua Wu, and Jun Yu. "Assessment of health and economic effects by PM2. 5 pollution in Beijing: a combined exposure–response and computable general equilibrium analysis." Environmental technology 37, no. 24 (2016): 3131-3138.

Wang, Zhenyu, Jing Meng, and Dabo Guan. "Dynamic driving forces of India's emissions from production and consumption perspectives." Earth's Future 8, no. 8 (2020): e2020EF001485.

Wang, Zhenyu, Jing Meng, Heran Zheng, Shuai Shao, Daoping Wang, Zhifu Mi, and Dabo Guan. "Temporal change in India's imbalance of carbon emissions embodied in international trade." Applied energy 231 (2018): 914-925.

World Bank, and Institute for Health Metrics and Evaluation. "The Cost of Air Pollution: Strengthening the Economic Case for Action." (2016).

Xiao, Yanyan, Joy Murray, and Manfred Lenzen. "International trade linked with disease burden from airborne particulate pollution." Resources, Conservation and Recycling 129 (2018): 1-11.

Yunfeng, Yan, and Yang Laike. "China's foreign trade and climate change: A case study of CO2 emissions." Energy policy 38, no. 1 (2010): 350-356.

Zhao, H. Y., Q. Zhang, D. B. Guan, S. J. Davis, Z. Liu, H. Huo, J. T. Lin, W. D. Liu, and K. B. He. "Assessment of China's virtual air pollution transport embodied in trade by using a consumption-based emission inventory." Atmospheric Chemistry and Physics 15, no. 10 (2015): 5443-5456.

Zhong, Zhangqi, Xu Zhang, and Wei Shao. "Measuring global energy-related sulfur oxides emissions embodied in trade: a multi-regional and multi-sectoral analysis." Natural Hazards 95, no. 1 (2019): 401-418.

Zhou, Li, Xi Tian, and Zhengyi Zhou. "The effects of environmental provisions in RTAs on PM2. 5 air pollution." Applied Economics 49, no. 27 (2017): 2630-2641.

ANNEXURE

A.i. List of Regions/ Countries from GTAP dataset

Table A.i.- List of countries from GTAP dataset

List of Regions/Countries	
Oceania	Vietnam
China	Bangladesh
Rest East Asia	India
Brunei	Nepal
Laos	Pakistan
Singapore	Sri Lanka
Rest South Asia	Other America
Rest South East Asia	United States
Japan	Brazil
Korea	Uruguay
Taiwan	EU_25
Cambodia	Rest of World
Indonesia	Egypt
Malaysia	Rest of Africa
Philippines	Coted Ivoire
Thailand	Nigeria
Kenya	South Africa
Mozambique	

A.i.2. List of Sectors in GTAP dataset

Table A.i.2. List of Sectors in GTAP dataset

Sectors	Full form	Sectors	full form
pdr	Paddy rice	Tex	Textiles
wht	Wheat	Wap	Wearing apparel
gro	Cereal grains nec	lea	Leather products
v_f	Vegetables, fruit, nuts	lum	Wood products
osd	Oil seeds	ppp	Paper products, publishing
c_b	Sugar cane, sugar beet	p_c	Petroleum, coal products
pfb	Plant-based fibers	crp	Chemical, rubber,plastic prods
ocr	Crops nec	nmm	Mineral products nec
ctl	Cattle, sheep, goats, horses	i_s	Ferrous metals
oap	Animal products nec	nfm	Metals nec
rmk	Raw milk	fmp	Metal products
wol	Wool, silk-worm cocoons	mvh	Motor vehicles and parts
frs	Forestry	otn	Transport equipment nec
fsh	Fishing	ele	Electronic equipment

coa	Coal	ome	Machinery and equipment nec
oil	Oil	omf	Manufactures nec
gas	Gas	ely	Electricity
omn	Minerals nec	gdt	Gas manufacture, distribution
cmt	Meat: cattle,sheep, goats,horse	wtr	Water
omt	Meat products nec	cns	Construction
vol	Vegetable oils and fats	trd	Trade
mil	Dairy products	otp	Transport nec
pcr	Processed rice	wtp	Sea transport
sgr	Sugar	atp	Air transport
ofd	Food products nec	cmn	Communication
b_t	Beverages and tobacco products	ofi	Financial services nec
osg	PubAdmin/ Defence/Health/Educat	isr	Insurance
dwe	Dwellings	obs	Business services nec
		ros	Recreation and other services

Table A.i.3. : Sectoral Aggregation

Sectors	Aggregation
PublicSector	Public Admin/Defense/Education/Healthcare
OthServices	Dwellings, Recreation and other services, Business services, financial services
TransComm	communication, Air transport, sea transport, transportation NEC, trade
Util_Cons	Water, construction, gas manufacturing and distribution, electricity
light manufacturing	leather products, Paper products, publishing, Wood products, Metal products, Motor vehicles and parts, Manufacturing NEC, Transport equipment nec
TextWapp	Textiles and Wearing apparel
Heavy manufacturing	Petroleum, coal products, Mineral products NEC, Ferrous metals, Metals NEC, Electronic equipment and Machinery, and equipment nec

A.iii.4.- PM2.5 and welfare data for India and Bangladesh

Table A.iii.4.- PM2.5 and welfare data for India and Bangladesh

	Mean annual ambient PM2.5 emissions ($\mu g/m^3$)		Total deaths from Air Pollution		Total welfare losses (Million 2011 USD, PPP adjusted)		Total labour output foregone (Million 2011 USD, PPP adjusted)	
	1990	2013	1990	2013	1990	2013	1990	2013
India	30.25	46.68	10,43,182	14,03,136	1,04,906	5,05,136	28.742	55.37
Bangladesh	29.92	43.36	92,880	1,54,898	6.379	27.452	1.195	2.579

Source- Cost of Air Pollution Report, 2016