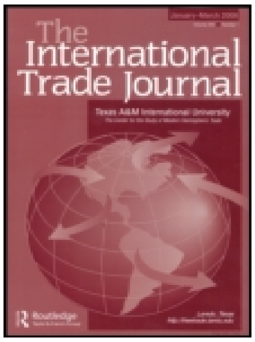

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This article aims at contributing to environment trade debate by evaluating the impacts of international trade on emissions of carbon dioxide, sulphur dioxide, and nitrogen oxides for the Indian economy during 90s using Input-Output techniques. The article has constructed an index of pollution terms of trade. Using the Input-Output table of 1991–92 and 1996–97 for India we have computed pollution terms of trade for the content of CO_2, SO_2, and NO_x. Results show that the indices are below 100, indicating that India produces goods that are more environment friendly than goods it imports, thus challenging the pollution haven hypothesis for India. The article has also offered explanations for these results.

* * * * *

I. INTRODUCTION

The dominant trend in the world economy in the 1990s was towards liberalization of trade. At the global level the decade witnessed a new round of negotiation under the General Agreement on Tariffs and Trade (GATT) that resulted in the formation of the World Trade Organization (WTO). At the regional level also,

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free trade agreements were initiated or strengthened in Europe, Asia, Africa, Latin America and North America. International trade plays an important role in shaping the industrial structure of a country and consequently in affecting country's environment. The WTO in its recent report has analyzed relationships between trade and environment (Nordstrom and Vahugan, 1999).

International trade allows a country to delink partially its domestic economic and ecological systems, as some goods can be produced by the other national economies (Daly, 1993; Pearce and Warford, 1993; Proops et al., 1999). In such cases impacts of producing goods affect the ecological system of the exporting country (where production takes place) rather than the ecological system of the importing country (where consumption occurs). In this sense it might be possible for one country but not for all to save its own carrying capacity by moving away from environmentally sensitive activities (natural resources and pollutant intensive activities). Thus some countries might gain environmentally from engaging in international trade and others might lose, according to their own choices. Furthermore, through international trade some countries might export carrying capacity and others import it.

Thus trade environment issue is now considered as a fundamental matter to be addressed by international community. Recently three kinds of environmental impacts of trade liberalisation are discussed in these regards: Scale, composition, and technological effects (OECD, 1997; Jones, 1998; Nordstrom and Vahugan, 1999). Scale effects occur when liberalization causes an expansion of economic activity—increase in output. If the nature of that activity is unchanged but the scale is growing, then pollution and resource depletion will increase along with output. Composition effects occur when increased trade leads nations to specialize in sectors where they enjoy a comparative advantage. When comparative advantage is derived from differences in environmental stringency then the composition effect of trade will aggravate existing environmental problems in the countries with relatively lax regulations. This is known as pollution haven effect. Technique effects or changes in resource extraction and production technologies can potentially lead to a decline in pollution per unit of output.

The debate on impacts of trade and environment, though not new, has gained much importance due to the Montreal Protocol, NAFTA, and Kyoto Protocol. Impacts of foreign trade on greenhouse gas emission have also been an issue recently in international negotiations on global warming that aim at curbing GHG emissions to prevent global climate change (UNFCC, 1992; Nordstrom and Vahugan, 1999). Thus what happens to the environment when international trade is liberalized is a matter of debate.

It is commonly assumed by economists and environmentalists alike that greater economic openness will lead to increased pollution in developing countries, as free trade will increase environmental degradation in developing countries. Among environmentalists, one common concern is that liberalized trade regimes and market driven exchange rates, by increasing the incentive for export, will lead to greater exploitation of natural resources (e.g., native forests). Secondly, free trade will increase industrial pollution in developing countries, through displacement of dirty industries from developed countries with stricter environmental regulation, and through competitive pressure on developing countries to reduce further their environmental standards.

There are at least three reasons to expect higher pollution intensity (i.e., more pollution per unit of output) in developing countries. First, environmental amenities are normal goods; higher income in the developed countries generates greater demand for cleaner air and water. Similarly, at lower levels of income and higher discount rates, income gains and jobs may be more valued relative to health and other costs of pollution. Second, the relative costs of monitoring and enforcing pollution standards are higher in developing countries, given scarcity of trained personnel, difficulty of acquiring sophisticated equipment, and the high marginal costs of undertaking any new governmental activity when the policy focus is on reducing fiscal burdens. Third, growth in developing countries results in a shift out of agriculture into industry, with rapid urban growth and large volume of investment in urban infrastructure. This is more likely to increase levels of pollution per unit of output. In developed countries, on the other hand, growth is associated with a move out of industry into services, and thus leads to decreasing levels of pollution for each unit of output. These structural differences are consistent with differences in comparative advantage and would be reinforced by free trade. For these reasons rising pollution intensity in developing countries would simply reflect differences across countries in the social cost comparative advantage of different mixes of polluting activities.

With revitalization of trade liberalization policies there has been a growing literature on the effects of international trade pattern on the environment. The methodologies employed to test this relationships are widely varied, as are the results (Gallagher and Ackerman, 2000).

II. SURVEY OF SELECTED LITERATURE

The role of international trade in determining the environmental damage has been addressed by specialists using Input-Output techniques (Wright, 1974; Fieleke, 1975; Antweiler, 1996; Proops et al., 1999; Munksgaard and Pedersen, 2001; Lenzen, 2001; Machado et al., 2001). Very recently studies by Haan (2002), Gerilla et al. (2002), Lange (2002), Wadeskog (2002), Lange and Hassan (2002), Hayami and Nakamura (2002), and Ahmed (2002) have also addressed the issues on trade and environment using I-O techniques. The main concern of these international trade oriented studies has been to evaluate how foreign trade affects environment locally and globally.

Antweiler et al. (2001) set out a theory of how openness to international goods markets affects pollution concentrations. They developed a theoretical model to divide trade's impact on pollution into scale, technique and composition effects and then examine this theory using data on sulfur dioxide concentrations from the Global Environment Monitoring Project. They found that international trade creates relatively small changes in pollution concentrations when it alters the composition, and hence the pollution intensity, of national output. Their estimate of the associated technique and scale effects created by trade implies a net reduction in pollution from these sources. Combining their estimates of scale, composition, and technique effects yields a somewhat surprising conclusion: freer trade appears to be good for the environment.

Though goods and services traded in a globally interdependent world, the consumption in each region is linked to green house gas emissions in other regions. Although the green house gas responsibility of the inhabitants of a region is determined by their consumption of domestically produced goods or imported commodities international negotiations on emission reductions focussed solely on national emissions, i.e. emissions arising from the respective country. Thus, greenhouse gases embodied in international trade are neglected. Recently, Munksgaard and Pedersen (2001) have highlighted this point. They have demonstrated in their work that the Danish greenhouse gas balance is dependent on whether producer or consumer responsibility is assumed. It has been argued that in order to get equitable reduction targets, international trade has to be taken into account when assessing national responsibilities for abating climate change.

Most studies dealing with energy and greenhouse gases in a closed and open input-output model employ single region models. These single region studies are based on the assumptions that commodities imported from foreign countries are produced using domestic production technology and energy inputs. However, this assumption is not necessarily valid. Recently, Lenzen and Mungsgaard (2002) have made an extension of the existing single region model as described by Munksgaard and Pedersen (2001) and Lenzen (2001) by introducing a multi regional input-output model to calculate the amount of energy and green house gases embodied in a value unit of commodities produced for Danish final consumption.

Some specialists have been particularly concerned with the impacts that international trade might have on the effectiveness of climate change agreements. Among them work of Wyckoff and Roop (1994) can be mentioned. According to the article, global warming policies based on reducing domestic greenhouse gas emissions ignore the carbon embodied in international trade flows, which could be important if emission reduction schemes include only a subset of emitting countries. This analysis shows and discusses implications of the finding that a significant amount (about 13%) of the total carbon emissions of the six largest OECD countries is embodied in manufactured imports.

Machado et al. (2001) apply I-O techniques to the Brazilian economy to evaluate the total impacts of international trade on its energy use and CO_2 emissions. Results show that in 1995 in Brazil carbon embodied in the exports of non-energy goods are larger than the relevant amounts embodied in the imports of non-energy goods. Haan (2002) has derived environmental balance of trade by analysing the trade relationships for a number of trade patterns of the Netherlands. These bilateral environmental balances of trade are further analyzed by tracking down differences in the absolute levels of export and import and eco efficiencies (pollution or natural resource requirements per money unit of product). Lange and Hassan (2002) have shown that the structure of exports of Botswana, Namibia, and South Africa is heavily weighted by water intensive products based on agriculture, forestry and related activities, and mining, as in many developing countries. Since water is a scarce resource in these countries they have assessed using a CGE model the introduction of the user pays principle for water pricing in South Africa and Botswana.

The work of Gerilla et al. (2002) has studied the transfer of technology between China and Japan and its effects on the embodied carbon emissions generated from the transfer based on the intercountry I-O table of Japan and China for 1985 and 1994. The results show that increased emission of embodied carbon has occurred due to the transfer of technology. Przybylinski (2002) has analyzed the bilateral flow of trade between Poland and Germany to find out their effects on environment in both countries. Full effects are measured using I-O tables. This article aims at constructing the balance of pollution flows between these two countries for 1995, considering main types of air pollutants.

Recently, Hayami and Nakamura (2002) have linked the I-O table of Japan and Canada using trade data and estimated CO_2 emission through bilateral trade between each sector (405 sectors in Japan and 479 sectors in Canada). They have found a significant difference of CO_2 emission per production between these countries. This article suggests the reallocation of alternative technologies to reduce CO_2 emission between these two countries. Ahmed (2002) investigated how important international carbon flows are for a number of OECD countries. This article uses the OECD input-output and SSIS databases, together with assumptions on the amount of carbon embodied in different energy sources, to estimate the total amount of energy and carbon embodied in the imports of manufactured goods and services in each country.

While many previous studies have documented the effects of trade on pollution measures in several developing and developed countries, this article focuses on the "Environmental Effects of Trade in India." The question we address is simple: in the countries like India, has greater openness defined in terms of trade regimes been associated with pollution intensive industrial development? More generally, are open economies more likely to be so called pollution havens? The above issues have been focused in this article.

III. MODEL

The model starts with the basic concepts of the Input-Output framework of Leontief (1951). Mathematically, the structure of the input-output model can be expressed as:

$$X = Ax + Y \tag{1}$$

The solution of (1) gives

$$X = (I - A)^{-1}Y \tag{2}$$

where $(I - A)^{-1}$ is the matrix of total input requirements. To estimate CO_2, SO_2, and NO_x emission we have used the energy input-output model. Actually the results are given in million tons of carbon per million rupees unit. I is an identity matrix $(n \times n)$.

We have computed the amount of CO_2, SO_2, and NO_x emission that takes place in the production of various activity levels by applying the fuel specific carbon, sulphur and nitrogen emission factors. For that we use an emission factor of 0.55 (million tons of CO_2)/million ton for coal and 0.79 (million tons of CO_2)/million ton for oil to arrive at carbon emissions by different sectors due to coal and oil separately. For sulphur emission factor we have used .003 (million tons of SO_2)/million ton for coal and .015 (million tons of SO_2)/million ton for oil. For nitrogen emission .018 (million tonnes of NO_x)/million ton for coal and .001 (million tonnes of NO_x)/million ton for oil.

Then we follow the normal convention of measurement, of carbon dioxide, sulphur dioxide and nitrogen oxides in carbon sulphur and nitrogen equivalent units respectively. For conversion to CO_2, SO_2, and NO_x units the carbon, sulphur and nitrogen emission figures are multiplied by respective molecular weight ratio of 3.66, 2, and 3.28. It gives the total quantity of CO_2, SO_2, and NO_x emitted owing to burning of fossil fuel (coal, oil) inputs used by various production industries. Now let us consider the *Emission Model*.

Emission Model

Now the CO_2, SO_2, or NO_x emission from fossil fuel combustion can be calculated from industrial fuel data for each emission separately in the following manner.

$$(3) \qquad F = CL1X = CL1(I - A)^{-1}Y$$

Here F as a vector, giving the total quantity of CO_2, SO_2, or NO_x emission from fossil fuel combustion only. C is a vector of dimension m $(1 \times m)$, of coefficients for CO_2, SO_2, or NO_x emission per unit of fossil fuel burnt. $L1$ is a matrix $(m \times n)$ of the industrial consumption in energy units of m types of fuel per unit of total output of n industries. So Eq. (3) gives us the total CO_2, SO_2, or NO_x emission due to fossil fuel combustion. In Eq. (3) $CL1 = S$ carries only direct requirement of CO_2, SO_2, or NO_x intensities from industries and $CL1(I - A)^{-1}$ gives the direct as well as indirect requirement of CO_2, SO_2, or NO_x intensity from industries. So Eq. (3) explains the CO_2, SO_2, and NO_x emissions due to fossil fuel combustion in India from production activities.

Trade Model

For estimation of the *Trade Model* we need to extend the above formulation as: Y *denotes* the final demand. Now we separate out the final demand vector as domestic final demand and net exports. So it will be

$$Y = Y^d + Y^{X-M}.$$

Let us consider that India engages in trade with other countries. The net export of India is defined by Y^{x-m}.

Y^X is defined as the vector of export only and Y^m as vector of imports. Now the pollution content of trade is obtained by the following manner. Here we have considered the vector $(n \times 1)$ content of exports per unit of total exports as $Y^{Xi}/I'_j Y^x$, where $I'_j = (1, 1, \dots, 1)'$ is an $I \times 1$ vector and similarly it will be $Y^{mi}/I'_j Y^m$ for $(n \times 1)$ vector of imports. After putting diagonal matrix for the above two vectors it will become $Y^{Xi}/I'_j Y^x$ $(n \times n)$ and $Y^{mi}/I'_j Y^m$.

Now we define the pollution content of exports per unit of exports as

$$F^{EXPORTS} = CL1(I - A)^{-1} Y^{Xi}/I'_j Y^x \tag{4}$$

Now define the pollution content of imports per unit of imports as

$$F^{IMPORTS} = CL1(I - A)^{-1} Y^{mi}/I'_j Y_m \tag{5}$$

Equation (4) gives us the sector specific pollution content of exports per unit of exports and (5) derives it for imports only.

To estimate the *pollution terms of trade* we will consider the vector content of exports per unit of exports and vector content of imports per unit of imports only. Thus, a measure of relative pollution content of trade PTOT is given by (Antweiler, 1996)

$$\text{(6)} \qquad \text{PTOT} = F^{EXPORTS}/F^{IMPORTS} = \frac{CL1(I-A)^{-1}Y^{Xi}/I_j'Y^x}{CL1(I-A)^{-1}Y^{mi}/I_j'Y^m}$$

This measure is the ratio of the pollution content of 1 million rupees of exports relative to the pollution content of 1 million rupees of imports. A country gains environmentally from trade in relative terms whenever its imported goods have higher pollution content than its exported goods. Another way of looking at the index is as a trade weighted pollution intensity index.

When the pollution terms of trade are greater (smaller) than 100, that particular country's exports contain more (less) pollution than it is receiving through imports. It combines the technological and compositional effects to reflect the two policy options that a country faces: either clean up domestic production facilities or import the goods produced in environmentally unfriendly ways from abroad.

The measurement of the pollution terms of trade encounters a technical problem: data on environmental technology (as expressed through the technology matrix) are difficult to get. Hence it is necessary to impose the assumptions of identical technologies for other countries.

IV. DATA

To implement the model and to calculate the pollution terms of trade we require Input-Output data and CO_2 data for the year 1991–92 and 1996–97, respectively.

Input-Output Data

The study uses two Input-Output tables of the Indian economy for the years 1991–92, and 1996–97 prepared by the Government of India, Planning Commission (1995, 2000). Input-Output tables are Commodity by Commodity tables consisting of 60×60 sectors. These 60 sectors are a good proxy for India's exports and imports because it broadly covers all sectors of the economy. To make the commodity classification comparable between the two data sets, the input-output tables had to be aggregated to 34×34 tables. This input-output aggregation procedure was on the basis of the nature of commodities and trade and energy intensiveness. In order to obtain comparability over time, the 1996/7 table was expressed in 1991/2 prices using the appropriate price indices. Here we have considered three energy sectors coal, crude oil and natural gas and electricity separately and other 57 non energy sectors have been aggregated to 31 non-energy sectors by considering export and import share. Thus, aggregated Input-output tables of this study consist of 34×34 sectors.

Data on Emissions of Pollutants

The CO_2, SO_2, NO_x emissions from fossil fuel combustion have been estimated by IPCC (Inter governmental panel on climate change) guideline where, Total emissions = (Actual fuel consumption) $*$ (Carbon/sulphur/nitrogen emission factor) $*$ (Fraction of carbon/sulphur/nitrogen oxidized) $*$ (Molecular weight ratio).

V. RESULTS AND DISCUSSION

Is India gaining or losing environmentally by engaging in international trade? Using an index, which measures the pollution terms of trade, the empirical assessment of environmental gains for India has been made.

From the model we have computed pollution terms of trade of India for CO_2, SO_2, and NO_x in 1991–92 and 1996–97 on the basis of Eq. (6) as described in model section. The results are presented in Table I.

The value obtained is 58.83% for CO_2 in 1991–92 and came down to 47.71% in 1996–97. Similar patterns of results are also observed for the other pollutants like SO_2 and NO_x. The values of the indices of Pollution Terms of Trade (PTOT) of the three pollutants have declined in India during reform period. The values of PTOT indices are below 100 indicating that India exports goods that are produced more environment friendly than goods it imports.

It is clear from Table I that imported related pollution is much larger than the export pollution in India. Thus India gains in terms of emissions from trade. It is also observed that India increased its gain overtime. Thus India cannot be characterised as a pollution haven.

A look at the composition of exports and imports in India (Table II) indicate several features. Exports are primarily dominated by primary products (other agricultural commodities, fishing, other food and beverages) having a share of 28% in 1991–92 and 23.80% in 1996–97. Textile products (17.50% in 1991–92 and 16.11% in 1996–97) contributed a good share. On the other hand, crude petroleum natural gas and petroleum products (15% in 1991–92 and 20% in 1996–97, respectively), non-metallic product (approximately 10% in both the year), iron and steel (3% in both the year), non-electrical goods and transport services (25% in 1991–92 and 29% in 1996–97) are major items in import baskets. These products are source of pollutant while the exportable generate less pollution (Tables III, IV, V, VI). It is evident from these tables that textile products which are export items though generate higher levels of pollution are, however, outweighed by the pollution generated by import items like petroleum product, iron and steel, non electrical machinery sector.

Exports must often meet the product standard and to the extent that clean products require clean processes. The Government of India is also concerned with environmental problems and has set up a Central Pollution Control Board. The different state governments have also set up a State Pollution Control Board. These bodies are actively engaged to maintain the environmental standards. Moreover, wide ranges of instruments are used including legislation and regulation, fiscal incentives, voluntary agreements, and educational programmes. Several policy declarations and laws have contributed to the minimisation of GHG emission in India. These include the Forest Act (1980), the Air Pollution Act (1981, amended in 1987), the National Conservation Strategy (1992), and a Policy Statement on Abatement of Pollution (1992). More direct contributions to limiting growth in CO_2 emission are brought about by the government's energy efficiency and conservation programmes and renewable energy programmes.

Policies for improving the energy efficiency and conservation have been introduced during the Eighth Five Year Plan. A comprehensive "National Energy Efficiency Programme" was launched during this period to coordinate and organise existing and new efforts on energy conservation in various sectors of the economy for achieving a targetted energy savings of about 5000 mw in the electricity sector and 6 million tonnes of oil in the petroleum sector during the plan period. Various measures have been taken by the different industries in India to ensure quality and clean products for access to industrial countries market for exportable.

The dominance of fossil fuels in the import basket is the major cause of high pollution content. Results show that trade in India during the 90s has accelerated the process further.

Table I
Pollution Terms of Trade of India for CO_2, SO_2, and NO_x in 1991–92 and 1996–97

	1991–92			1996–97		
	CO_2	SO_2	NO_x	CO_2	SO_2	NO_x
Pollution embodied in exports	.000136	.000007	.000005	.000116	.000004	.000003
Pollution embodied in imports	.000232	.000013	.000009	.000244	.000014	.000009
Pollution terms of trade	.588309	.506780	.540640	.477120	.322809	.406271
Pollution terms of trade*100	58.83	50.78	54.06	47.71	32.28	40.62

Table II
Share of Exports and Imports During 1991–92 and 1996–97

Sectors	Export Share ∗ 100 (1991–92)	Import Share ∗ 100 (1991–92)	Export Share ∗ 100 (1996–97)	Import Share ∗ 100 (1996–97)
Coal and lignite	0.0357	0.5378	0.0066	1.7624
Crude petroleum and natural gas	0.0000	7.9617	0.0624	9.0818
Electricity	0.0161	0.0000	0.0000	0.0000
Cereals and pulses	0.8739	0.7253	2.4510	0.6276
Other agricultural commodities	5.8925	1.4963	1.6518	0.9016
Tea and coffee	0.8186	0.0000	1.2388	0.0000
Animal husbandry	0.3132	0.6305	0.4819	0.3231
Fishing	2.1913	0.0055	1.8576	0.0001
Other metal and non metallic product	1.3409	9.6781	0.7729	9.5915
Sugar	0.0750	0.0143	0.2987	0.0018
Edible oils	0.0000	0.0221	0.4926	1.6166
Other food and beverages	2.8776	0.8923	4.4664	0.0491
Cotton textiles	4.8032	0.0961	6.0260	0.1623
Other textiles	12.8744	0.9197	10.1140	0.5848

Wood and wood product	0.0404	0.0730	0.0749	0.5217
Paper and paper product	0.0711	1.5411	0.3050	1.6009
Leather and leather product	6.0490	0.0928	2.6343	0.2583
Rubber and plastic	2.3616	0.2754	1.7232	0.5021
Petroleum products	1.9657	6.7829	0.8651	10.8827
Fertilizer	0.2199	2.7446	0.0744	1.6884
Chemicals	5.1017	10.7212	5.4414	8.1731
Other non metallic and non ferrous metal	0.9654	2.1224	9.4332	2.4077
Iron and steel	0.6013	3.3632	1.5459	2.8810
Other non electrical machinery	2.4368	17.1813	2.3659	9.7376
Communication and electronic equipment	0.8999	4.4465	1.6372	2.9538
Other manufactured equipment	13.7431	13.2521	4.1614	9.2888
Transport services	6.8719	8.5953	4.5270	19.5305
Communication	0.2035	0.3480	0.1341	2.2712
Trade	10.8949	0.0000	15.3353	0.0000
Other services	15.4613	5.4744	19.8210	2.5985
Sugarcane	0.0000	0.0000	0.0000	0.0000
Khansari	0.0000	0.0000	0.0000	0.0000
Cement	0.0000	0.0055	0.0000	0.0011
Construction	0.0000	0.0000	0.0000	0.0000

Table III
Total Intensity of CO_2, SO_2, and NO_x in 1991–92 and 1996–97
(Million Tonnes of CO_2, SO_2, and NO_x/Million Rupees)

	1991–92			1996–97		
Sectors	CO_2	SO_2	NO_x	CO_2	SO_2	NO_x
Coal and lignite	0.000152	0.000005	0.000004	0.000191	0.000006	0.000005
Crude petroleum and natural gas	0.000058	0.000003	0.000002	0.000105	0.000006	0.000004
Electricity	0.000908	0.000016	0.000021	0.000603	0.000018	0.000017
Cereals and pulses	0.000106	0.000005	0.000004	0.000087	0.000004	0.000003
Other agricultural commodities	0.000047	0.000002	0.000001	0.000036	0.000002	0.000001
Tea and coffee	0.000032	0.000001	0.000001	0.000018	0.000001	0.000000
Animal husbandry	0.000034	0.000001	0.000001	0.000017	0.000000	0.000000
Fishing	0.000041	0.000003	0.000001	0.000033	0.000002	0.000001
Other metal and non metallic product	0.000108	0.000005	0.000004	0.000128	0.000006	0.000004
Sugar	0.000089	0.000004	0.000003	0.000075	0.000003	0.000002
Edible oils	0.000199	0.000006	0.000005	0.000063	0.000002	0.000002
Other food and beverages	0.000116	0.000004	0.000003	0.000090	0.000003	0.000002
Cotton textiles	0.000176	0.000006	0.000005	0.000144	0.000005	0.000004

Other textiles	0.000148	0.000005	0.000004	0.000103	0.000003	0.000003
Wood and wood products	0.000055	0.000002	0.000001	0.000072	0.000003	0.000002
Paper and paper products	0.000285	0.000007	0.000007	0.000211	0.000005	0.000006
Leather and leather products	0.000076	0.000003	0.000002	0.000093	0.000003	0.000003
Rubber and plastic	0.000101	0.000004	0.000003	0.000138	0.000004	0.000004
Petroleum products	0.001151	0.000105	0.000060	0.000949	0.000078	0.000042
Fertilizer	0.000409	0.000021	0.000015	0.000448	0.000028	0.000017
Chemicals	0.000167	0.000008	0.000005	0.000235	0.000006	0.000006
Other non metallic and non ferrous metal	0.000344	0.000012	0.000010	0.000262	0.000009	0.000008
Iron and steel	0.000475	0.000014	0.000013	0.000447	0.000010	0.000012
Other non electrical machinery	0.000172	0.000006	0.000005	0.000154	0.000005	0.000004
Communication and electronic equipment	0.000082	0.000003	0.000002	0.000088	0.000003	0.000002
Other manufactured equipment	0.000148	0.000005	0.000004	0.000129	0.000004	0.000004
Transport services	0.000242	0.000016	0.000010	0.000161	0.000010	0.000006
Communication	0.000035	0.000001	0.000001	0.000031	0.000001	0.000001
Trade	0.000045	0.000002	0.000001	0.000037	0.000001	0.000001
Other services	0.000040	0.000001	0.000001	0.000031	0.000001	0.000000
Sugarcane	0.000063	0.000003	0.000002	0.000048	0.000002	0.000001
Khansari	0.000166	0.000008	0.000006	0.000103	0.000004	0.000003
Cement	0.000554	0.000011	0.000013	0.000627	0.000012	0.000016
Construction	0.000165	0.000006	0.000005	0.000127	0.000004	0.000003

Table IV

CO_2 Embodied in Exports and Imports in 1991–92 and 1996–97

(Million Tonnes of CO_2/Million Rupees)

	Year			
	1991–92		1996–97	
Sectors	CO_2 Embodied in Exports	CO_2 Embodied in Imports	CO_2 Embodied in Exports	CO_2 Embodied in Imports
Coal and lignite	0.000000	0.000000	0.000000	0.000003
Crude petroleum and natural gas	0.000000	0.000004	0.000000	0.000009
Electricity	0.000000	0.000000	0.000000	0.000000
Cereals and pulses	0.000000	0.000000	0.000002	0.000000
Other agricultural commodities	0.000002	0.000000	0.000000	0.000000
Tea and coffee	0.000000	0.000000	0.000000	0.000000
Animal husbandry	0.000000	0.000000	0.000000	0.000000
Fishing	0.000000	0.000000	0.000000	3.8E−11
Other metal and non metallic product	0.000001	0.000010	0.000000	0.000012
Sugar	0.000000	0.000000	0.000000	0.000000
Edible oils	0.000000	0.000000	0.000000	0.000001
Other food and beverages	0.000003	0.000001	0.000004	0.000000

Cotton textiles	0.000008	0.000000	0.000008	0.000000
Other textiles	0.000019	0.000001	0.000010	0.000000
Wood and wood product	0.000000	0.000000	0.000000	0.000000
Paper and paper product	0.000000	0.000004	0.000000	0.000003
Leather and leather product	0.000004	0.000000	0.000002	0.000000
Rubber and plastic	0.000002	0.000000	0.000002	0.000000
Petroleum products	0.000022	0.000078	0.000008	0.000103
Fertilizer	0.000000	0.000011	0.000000	0.000007
Chemicals	0.000008	0.000017	0.000012	0.000019
Other non metallic and non ferrous metal	0.000003	0.000007	0.000024	0.000006
Iron and steel	0.000002	0.000015	0.000006	0.000012
Other non electrical machinery	0.000004	0.000029	0.000003	0.000015
Communication and electronic equipment	0.000000	0.000003	0.000001	0.000002
Other manufactured equipment	0.000020	0.000019	0.000005	0.000012
Transport services	0.000016	0.000020	0.000007	0.000031
Communication	0.000000	0.000000	0.000000	0.000000
Trade	0.000004	0.000000	0.000005	0.000000
Other services	0.000006	0.000002	0.000006	0.000000
Sugarcane	0.000000	0.000000	0.000000	0.000000
Khansari	0.000000	0.000000	0.000000	0.000000
Cement	0.000000	0.000000	0.000000	0.000000
Construction	0.000000	0.000000	0.000000	0.000000

Table V

SO_2 Embodied in Exports and Imports in 1991–92 and 1996–97

(Million Tonnes of SO_2/Million Rupees)

Sectors	Year			
	1991–92		1996–97	
	SO_2 Embodied in Exports	SO_2 Embodied in Imports	SO_2 Embodied in Exports	SO_2 Embodied in Imports
Coal and lignite	0.000000	0.000000	0.000000	0.000000
Crude petroleum and natural gas	0.000000	0.000000	0.000000	0.000000
Electricity	0.000000	0.000000	0.000000	0.000000
Cereals and pulses	0.000000	0.000000	0.000000	0.000000
Other agricultural commodities	0.000000	0.000000	0.000000	0.000000
Tea and coffee	0.000000	0.000000	0.000000	0.000000
Animal husbandry	0.000000	0.000000	0.000000	0.000000
Fishing	0.000000	1.80075E−10	0.000000	2.7E−12
Other metal and non metallic product	0.000000	0.000000	0.000000	0.000000
Sugar	0.000000	0.000000	0.000000	5.9E−11
Edible oils	0.000000	0.000000	0.000000	0.000000
Other food and beverages	0.000000	0.000000	0.000000	0.000000

Cotton textiles	0.000000	0.000000	0.000000	0.000000
Other textiles	0.000000	0.000000	0.000000	0.000000
Wood and wood product	0.000000	0.000000	0.000000	0.000000
Paper and paper product	0.000000	0.000000	0.000000	0.000000
Leather and leather product	0.000000	0.000000	0.000000	0.000000
Rubber and plastic	0.000000	0.000000	0.000000	0.000000
Petroleum products	0.000002	0.000007	0.000000	0.000008
Fertilizer	0.000000	0.000000	0.000000	0.000000
Chemicals	0.000000	0.000000	0.000000	0.000000
Other non metallic and non ferrous metal	0.000000	0.000000	0.000000	0.000000
Iron and steel	0.000000	0.000000	0.000000	0.000000
Other non electrical machinery	0.000000	0.000001	0.000000	0.000000
Communication and electronic equipment	0.000000	0.000000	0.000000	0.000000
Other manufactured equipment	0.000000	0.000000	0.000000	0.000000
Transport services	0.000001	0.000001	0.000000	0.000001
Communication	0.000000	0.000000	0.000000	0.000000
Trade	0.000000	0.000000	0.000000	0.000000
Other services	0.000000	0.000000	0.000000	0.000000
Sugarcane	0.000000	0.000000	0.000000	0.000000
Khansari	0.000000	0.000000	0.000000	0.000000
Cement	0.000000	0.000000	0.000000	1.5E−10
Construction	0.000000	0.000000	0.000000	0.000000

Table VI

NO_x Embodied in Exports and Imports in 1991–92 and 1996–97

(Million Tonnes of No_x/Million Rupees)

Sectors	1991–92		1996–97	
	NO_x Embodied in Exports	NO_x Embodied in Imports	NO_x Embodied in Exports	NO_x Embodied in Imports
Coal and lignite	0.000000	0.000000	0.000000	0.000000
Crude petroleum and natural gas	0.000000	0.000000	0.000000	0.000000
Electricity	0.000000	0.000000	0.000000	0.000000
Cereals and pulses	0.000000	0.000000	0.000000	0.000000
Other agricultural commodities	0.000000	0.000000	0.000000	0.000000
Tea and coffee	0.000000	0.000000	0.000000	0.000000
Animal husbandry	0.000000	0.000000	0.000000	0.000000
Fishing	0.000000	1.08805E−10	0.000000	1.6E−12
Other metal and non metallic product	0.000000	0.000000	0.000000	0.000000
Sugar	0.000000	0.000000	0.000000	4.5E−11
Edible oils	0.000000	0.000000	0.000000	0.000000
Other food and beverages	0.000000	0.000000	0.000000	0.000000
Cotton textiles	0.000000	0.000000	0.000000	0.000000

Other textiles	0.000000	0.000000	0.000000	0.000000
Wood and wood products	0.000000	0.000000	0.000000	0.000000
Paper and paper products	0.000000	0.000000	0.000000	0.000000
Leather and leather product	0.000000	0.000000	0.000000	0.000000
Rubber and plastic	0.000000	0.000000	0.000000	0.000000
Petroleum products	0.000001	0.000004	0.000000	0.000004
Fertilizer	0.000000	0.000000	0.000000	0.000000
Chemicals	0.000000	0.000000	0.000000	0.000000
Other non metallic and non ferrous metal	0.000000	0.000000	0.000000	0.000000
Iron and steel	0.000000	0.000000	0.000000	0.000000
Other non electrical machinery	0.000000	0.000000	0.000000	0.000000
Communication and electronic equipment	0.000000	0.000000	0.000000	0.000000
Other manufactured equipment	0.000000	0.0000006	0.000000	0.000000
Transport services	0.000000	0.0000009	0.000000	0.000001
Communication	0.000000	0.0000004	0.000000	0.000000
Trade	0.000000	0.000000	0.000000	0.000000
Other services	0.000000	0.000000	0.000000	0.000000
Sugarcane	0.000000	0.000000	0.000000	0.000000
Khansari	0.000000	0.000000	0.000000	0.000000
Cement	0.000000	0.000000	0.000000	1.9E−10
Construction	0.000000	0.000000	0.000000	0.000000

VI. CONCLUSION

The present work evaluates the impacts of international trade on environment in India during liberalized period using input-output model. Using an index, which measures the pollution terms of trade (PTOT), we have assessed the environmental gains for India. The paper has calculated pollution terms of trade of India for three types of pollutants CO_2, SO_2, and NO_x in 1991–92 and 1996–97. The results of the article show that indices of PTOT are below 100 and have declined during reform period. Thus the findings clearly reveal that in terms of pollution, India gains from trade. According to the pollution haven hypothesis we would expect that a developing country loses from trade while its trading partner gains. But our evidence yields a somewhat surprising conclusion that trade is good for environment and also does not support pollution haven hypothesis for India. Since there are many other environmental consequences not analyzed by this work, further research in this area is needed.

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