Impact of Trade on Energy Use and Environment in India: An Input-output analysis

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Abstract

International trade plays an important role in shaping the industrial structure of a country and consequently in affecting the country's environment. How trade affects the environment and how environmental regulations affect trade is a debatable issue among economists, environmentalists and world bodies like the WTO. The globalization process in due course makes this matter more and more evident. The goods and services produced in an economy are directly or indirectly associated with energy use and, according to the type of fuel utilized, with CO_2 emissions as well. This study aims at contributing to environment trade debate by evaluating the impacts of international trade on energy use and subsequently the emissions of carbon dioxide on the Indian economy during 1993-94 using Input-Output techniques. The paper has also constructed an index of pollution terms of trade from the energy and the carbon embodied in the exports and imports of India. Finally, the study will explore the implications of the EXIM policy of 2002. Study shows that India produces goods which are more environment friendly than the goods it imports thus indicating a large inflow of pollution embodied in trade. Though the Pollution terms of trade (PTOT) will be little bit below the border line during 2006-7 but the index is gradually moving higher from 1993-94 to 2006-7. The paper concludes by making a few policy suggestions.

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1. Introduction

The discussion on the relationship between trade and environment has raised a lot of debate. How trade affects the environment and how environmental regulation affects trade has been and still remains a matter of controversy. The trade-environment links, however, are complex and depend on many factors. Trade can be a powerful and positive instrument of growth and development when adequate environmental and macro economic policies are taken into consideration. The relationship between trade expansion and environmental protection has been characterised by two extreme viewpoints – promoting trade worsens environmental conditions and higher environmental standards impose an economic cost (Jaffe, et al., 1995). One manifestation of the above-described trade off is the hypothesis that increasing trade may encourage developing countries with weaker environmental protection to specialize in industries that create more pollution. This claim is referred to as Pollution Haven Hypothesis. A policy of trade liberalization is often suggested as a means of stimulating economic growth in developing countries. Trade liberalisation consists of policies aimed at opening up the economy to foreign investment and lowering trade barriers in the form of tariff reduction. However, while trade may stimulate growth it may simultaneously lead to more pollution either as a result of relocation of polluting industries from countries with strict environmental policy or due to increased production in dirty industries (WTO, 1998).

The United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in June of 1992, adopted Agenda 21 and the Rio Declaration in which the interest in trade and environment linkages were highlighted. They also emphasized the important role of trade and environment in achieving sustainable development and stressed the need to make trade and environmental policies mutually supportive.

In theory, increased pollution does not necessarily decrease welfare in the presence of optimal environmental policies. However, the general presumption is that optimal environmental policies are not in place, or may not be properly enforced in less developed countries. Grossman and Krueger (1992) show that under NAFTA, Mexico would actually specialize in unskilled labour-intensive activities, the United States would increase its output in pollution and capital-intensive industries, whereas Mexico's most polluting industries would contract.

Discussion of growth and the environment is closely related to the discussion of trade liberalisation and the environment particularly due to the large body of evidence associating trade liberalisation with increased growth. It is therefore obvious that trade liberalisation can have both positive and negative effects on the environment. Lucas et al. (1992), Birdsall and Wheeler (1992) etc. have performed statistical tests on the relationship between the degree of trade openness, growth and environmental quality. Lucas et al. show that fast growing closed economies became significantly more pollution - intensive in the 1970s and 1980s, whereas the opposite was true for more open economies. Fast growing open economies experienced mainly pollution - neutral structural change in the 1970s and a significant shift towards a less pollution-intensive structure in the 1980s. Birdsall and Wheeler present similar evidence on the above but with reference solely to Latin America. They also find similar trends to the global developing country data, where pollution-intensive industries have tended to locate in the less open economies. Wheeler and Martin (1992) show that in the pulp and paper industry, the more open the economy, the faster the cleaner technologies are adopted and diffused. They also show that a country's level of development has no independent effect on the adoption of clean technologies in industries.

Copeland and Taylor (2003) set out the two leading theories (pollution haven hypothesis and factor endowment hypothesis) linking international trade to environmental outcomes, developing the empirical implications, and examining their validity using data on measured sulfur dioxide concentrations from over 100 cities worldwide during the period 1971 to

1986. The empirical results are provocative. For an average country in the sample, free trade is good for the environment. There is little evidence that developing countries will specialize in pollution-intensive products with further trade. In fact, the results suggest just the opposite: free trade will shift pollution-intensive goods production from poor countries with lax regulation to rich countries with tight regulation, thereby lowering world pollution. The results also suggest that pollution declines amid economic growth fueled by economy-wide technological progress but rises when growth is fueled by capital accumulation alone.

The World Trade Organization (WTO) in its recent report analyzes the relationship between trade and environment (Nordstrom and Vaughan, 1999) and identifies the trade-environment issue as one of the fundamental matter to be faced by WTO members and, more generally, by the international community. WTO recognizes that trade and growth do not lead naturally to a more efficient use of natural resources (including energy) and to a better quality of the environment. On the contrary, it recognizes that foreign trade might magnify natural resources depletion and environmental degradation in some cases.

The issue becomes clear if one considers that, as a matter of fact, economic systems are not isolated from ecological systems. Actually, an economic system may be understood as a system that operates in a wider system: the ecological system. The economic system takes natural resources (matter, organic and inorganic, and energy) from the ecological system (environment) and returns waste and pollution to the latter in order to maintain and expand its own system organization (Daly, 1968; Ayres and Kneese, 1969; Georgescu- Roegen, 1971; Uman˜ a, 1981; Arrow et al., 1995; Proops et al., 1999). Nevertheless, when the economic system puts too much stress on the ecological system, problems may come up: shortage of non-renewable natural resources, overuse of renewable natural resources beyond their environmental regenerative capacity and overshoot of the ecological system beyond its absorptive capacity of waste and pollution. In short, the economic system may harm the ecological system by going beyond its carrying capacity. Thus, the economic system may damage its own sustainability, since both systems are deeply linked and influence each other.

There are basically three kinds of impacts on the environment and on natural resources use associated with international trade: scale, composition and technical effects (OECD, 1997; Jones, 1998; Nordstrom and Vaughan, 1999). The scale effect is related to positive impacts of international trade on economic growth that increases damages on the environment and on natural resources use. The composition effect is associated with impacts on industrial structure due to trade specialization that may be positive or negative on the environment: and on natural resources depletion is depending on each country's specialization. Finally, the technical effect is related to impacts of international trade on the production efficiency of an economy that is expected to reduce environmental damages and natural resources requirements of an economy. The net impact of international trade on the environment is a balance among all these effects.

Recently some environmentalists have been particularly concerned with the impacts that international trade might have on the effectiveness of climate change agreements (Wyckoff and Roop, 1994; Khrushch, 1996; Schaeffer and Sa, 1996; Lenzen, 1998). Their concerns are founded on the possibility of the occurrence of 'carbon leakage' from countries submitting to the agreements (Annex I countries) to countries not submitting to them (Non-Annex I countries). The argument is that if greenhouse gases emission policies focus mostly on the domestic market of Annex I countries, these countries might reduce their domestic GHG emissions 'artificially' by simply stopping certain goods (energy- and carbon-intensive goods, most probably) to import them from Non- Annex I countries. It suggests that international trade should be considered in the climate change agreements to avoid 'carbon leakage' to Non-Annex I countries. According to Wyckoff and Roop (1994), for instance, about 13%, on average, of the total carbon emissions of six OECD countries (Canada, France, Germany, Japan, the UK and the USA) were embodied in manufactured imports in the mid-1980s. The authors pointed out that this amount of carbon (300 MtC) was equivalent to one-fifth of the carbon emitted annually by the USA; it exceeded the level generated by Japan and it was more than double the amount emitted by France and Canada.

In this paper our prime concern is on air pollution (fossil fuel based) and the emission that generates from it i.e. mainly CO_2. We know that all goods and services produced in an economy (directly and/or indirectly) is associated with energy use and, according to the type of fuel utilized, with CO_2 emissions as well. For instance, an automobile company uses energy and emits CO_2 not only directly by manufacturing a car, but also indirectly because other companies make use of energy and emit CO_2 themselves to produce the car inputs (tyres, steel sheets, plastic parts, etc.), the inputs to the car inputs and so on. By applying input-output techniques, it is possible to trace the direct and the indirect energy use and CO_2 emissions associated with a product, assessing the so-called total energy and carbon embodied in it. Such techniques may be applied to estimate the energy and carbon embodied in products sold in the national or in the international markets.

The role of international trade in determining energy use and environmental damage is an interesting point, which 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,). Recent studies by Hann (2002), Gerihall et al (2002), Lange (2002), Wadeskog (2002), Lange and Hassan (2002), Przybylinski (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 both locally and globally. Energy and pollutants embodied in international trade have been assessed in these studies for particular countries as well as for the world economy (foreign commerce worldwide).Not surprisingly; a general conclusion has been that the more open the economy the larger the impact foreign commerce has on a country's figures. In spite of it, the mix of the products exported and imported and the technical efficiency in processing the products and their inputs might definitely affect the energy and pollutants flows towards and from a country. All those trade-oriented studies have been pointing out that imports and exports could not be neglected for a relatively open economy; otherwise, energy and environmental figures might be badly distorted for this economy.

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.

Machado et al. (2001) applies 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).

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 Input-Output tables. The paper 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 significant difference of CO_2 emission per production between these countries. The paper suggests that there are rooms to reduce CO_2 emission by re-allocating alternative technologies between these two countries. Ahmed (2002) has investigated how important international carbon flows are for a number of OECD countries.

In summary, the role played by foreign trade seems to be highly significant in affecting the use of natural resources (energy included) and in generating environmental damage in countries in particular, as well as globally. In addition, such a role might be enhanced in the future because of the ongoing process of globalization of the world economy. However, a

case by-case approach is still necessary to reveal whether or not particular policies should be designed to deal with the impacts of foreign commerce on natural resources use and on the environment.

Unfortunately in India the work is very few specially using I-O techniques. Recently Mukhopadhyay and Chakraborty (2004) have studied the impacts of international trade on emissions of CO_2, SO_2 and NOx in the Indian economy during 90s.

India embarked on a policy of economic liberalization in July 1991. The policies of the Indian government during the 1990s included fiscal policy reforms aimed at improving the budget balance; trade reforms aimed at improving the balance of payments and reducing inflation; industrial policy and factor market reforms; and financial sector reforms. The thrust of these reforms was to push the economy into export led growth. The rapid development of the Indian economy during the last decade, involving rapid growth of industry and agriculture, has created enormous pressure on its environmental resources. In the design of the new economic policy in India issues related to the environment were not sufficiently addressed. As a result there is a wide spread concern in India that trade liberalization measures, which were an important component of the reform process, could lead to environmental degradation.

The basic question will arise in this connection that 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 are going to be addressed by the terms of trade resolution.

The present paper aims at contributing to environment trade debate by evaluating the impacts of international trade on energy use and emissions of carbon dioxide in the Indian economy during 1993-94 using Input-Output techniques. The paper will estimate the energy terms of trade and pollution terms of trade of non-energy goods, which will test whether the pollution haven hypothesis is valid for India, or not. The energy and carbon balance of trade

has also been calculated to focus the actual situation. Further, the study also estimates the same for the 10th plan period by simulation exercise.

The outline of the paper is as follows: Section 2 discusses the trade scenario in India after liberalisation policy has been introduced. Section 3 develops the methodology. Data analysis is covered in Section 4. Results and discussions are presented in Section 5. Simulation exercises are experimented in Section 6. Section 7 concludes the paper.

2. Indian Trade Scenario

The hidden trade liberalization in India has started in the 1980s and its full effect came out during the 1990s. The Government of India had introduced liberalised trade policy in the year 1991. Faced with rising inflation (13.6%) and a Balance of Payments crisis in mid 1991, the Government of India introduced a fairly comprehensive package comprising trade and exchange liberalization, reduction of tax rates, industrial de-licensing, deregulation, currency devaluation and privatization of the public sector.

India, being a South East Asian developing country, normally exports the agricultural commodities and imports industrial manufacturing. But the composition of exported and imported commodities has changed after liberalised EXIM policy. The growth rate has been much higher for both exports and imports after liberalization. The annual average growth rate of exports increased from 7.6% during 1980/81-1991/92 to 10% during 1992/93-1999/2000 and that of imports has concurrently increased from 8.5% to 13.4% for the same period.

The reasons for such export increment goes to buoyancy in world demand and revival of world trade reflecting East Asian recovery bottoming out of some global commodity prices, coupled with trade policy initiatives taken by the government. On the other hand, the share of imported manufacturing goods rose by 35.8% in 1980-81 to 48% in 1990's and still more sharply to 78% in 1999-2000. The responsible sectors in this respect are electronic goods,

textile yarn, and fabrics and made ups, machinery, iron and steel, professional instruments. Most of these sectors are energy intensive.

During the 9th and 10th five year plans the Government of India has reshuffled its export and import policy. As a result, the shares of few exported commodities are escalating especially those which are energy intensive and on the other hand imported commodities are also rising. The average growth rate in India has increased by 5.6% p.a. during the eighth and ninth plan period. But it is projected to grow by 8% p.a. during the tenth plan. India's exports are also moving away from Resource based products to Technology based products in the post-liberalisation period. This is spelt out in India's Midterm Export Policy (2002-07) of March 31, 2002. Based on this strategic policy shift, India aims to have at least 1 percent share in total global exports. Foreign trade in India is also growing steadily assuming a significant role in country's gross domestic product (GDP). In the first phase (1990-91 to 2000-01) of economic reforms (lifting of quantitative restrictions on imports and exports), country's foreign trade as percentage of GDP increased to 21.8% in 2000-01 from 13.32% in 1990-91. In eight years (1992-93 to 2000-01) India's share in total global exports increased by 0.26% from 0.41% percent in fiscal 1992-93 to 0.67% in 2000-01. In next five years beginning fiscal 2002-03, India aims to raise the share further by 0.33% by 2006-07 to have 1% share of total world exports. This means the country has to achieve a compound annual growth rate in exports of 11.9% percent in US$ terms. In absolute terms this means increase in exports of about US$ 36 billion -- from US$ 44.56 bn to US$ 80.48 bn. Through 1990s while world trade value has increased 1.9 times, India's exports in US$ terms were up 2.5 times.

India's export as a percentage of imports has gradually increased from 75.36% of GDP in 1990-91 to 88.17% in 2000-01. Five major product groups led by petroleum crude account for 66% of country's total imports. Other product groups include pearls, machinery, gold and silver, electronic goods and organic & inorganic chemicals. In six years (1994-95 to 2000-01), the share of petroleum and other petro-products in India's total imports have increased by 10.84%; pearls by 3.97%; and electronic goods by 6.43%. Share of gold and silver in

country's total imports during this period has dropped by 6.79% and for organic and inorganic chemicals by 2.55%.

It is significant to note in this six-year period (1994-95 to 2000-01) India's export growth was always higher than the world average. According to World Trade Organization's statistics, India's export growth in 2000 was 16.46 percent against world export growth of 12.4 percent. These changes in trade pattern have important implications for the environment and the use of energy and other resources in the economy. The present work aims at contributing to this consequential issue.

3. The Methodology

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:

$X = Ax + Y$ ---------- (1)

The solution of (1) gives

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

Where $(I - A)^{-1}$ is the matrix of total input requirements.

Now let us consider the energy model

3.1 Energy model

To estimate energy use in traded commodities we have used energy input-output model. I is an identity matrix (nxn). For an energy input-output model, the monetary flows in the energy rows in equation (2) are replaced with the physical flows of energy to construct the energy flows accounting identity, which conforms to the energy balance condition (Miller & Blair 1985). We apply a "hybrid method" based on Miller and Blair (1985), and it always conforms to energy conservation conditions.

Therefore, in equation (2), X is a hybrid unit total output vector (nx1) in which the outputs of energy sectors are measured in million tonnes of oil equivalent (mtoe), while the outputs of other sectors are measured in million rupees (mrs). Y is a hybrid unit final demand vector (nx1), in which the final demands for different types of energy are measured in "mtoe", while the final demands for the outputs of other sectors are measured in "mrs". A is a hybrid unit technical coefficient matrix (nxn), in which the unit of the input coefficients of energy sectors from energy sectors is mtoe/mtoe; the unit of the input coefficients of energy sector from non energy sectors is mrs /mtoe; the unit of the input coefficients of non energy sectors from energy sectors is mtoe/mrs; and the unit of the input coefficients of non-energy sectors from non-energy sectors is mrs/mrs.

$$EX = E\,(I - A)^{-1}Y \text{ ---------- (3)}$$

Where E is a selective energy matrix (nxn), which is a diagonal matrix composed of ones and zeros, with ones appearing in the diagonal locations that correspond to energy sectors and all the other elements of the matrix being zeros.

By introducing L1 is a matrix (mxn) of the industrial consumption in energy units of m types of fuel per unit of total output of n industries on both sides of equation (3) we get

$$EL1X = EL1\,(I - A)^{-1}Y \text{ ---------- (4)}$$

From equation (4) $EL1\,(I - A)^{-1} = R$ carries the direct as well as indirect requirement (total) of energy intensity from industries.

So equation (4) explains the total energy use from fossil fuel sector in India from production activities.

The assessment of the energy embodied in exports is quite obvious since exports (P) are a part or a component of the total final demand (Y). By pre-multiplying the total energy-intensity by the exports (P) vector, one can assess the total energy embodied in exports (E_{ex}), as described by the (Eq. (5) :

$E_{ex} = R^* P$ ---------- (5)

Export vector P has been treated here in two ways to derive (1) sectoral contribution of energy content in export and 2) total energy content in export. Similarly, the derivation of import is given in equation (6) below.

Regarding imports, it depends on the aim of the study: if for a particular country or for an international energy flow analyses (Herendeen and Bullard, 1976). In the latter, a new vector of total energy-intensity coefficients has to be estimated based on IO tables of the exporter countries. In this study, however, the idea is to assess the energy 'saved' or 'displaced' by India by importing non-energy goods. Here we assume identical technology (Heckscher-Ohlin) to find out the energy content of imports of India from rest of the world. Accordingly, the proper vector of total energy-intensity coefficients to be used in assessing the energy embodied in imports (E_{im}) is the same estimated for final demand (and also used for exports):

$E_{im} = R^* M$ ---------- (6)

Import vector M here is also treated in two ways to derive sectoral and total energy content in import.

3.2 Emission model

Total amount of carbon emission from fossil fuel combustion can be calculated as a function of output of industries. By introducing carbon emission coefficient in equation (4) we get

$F = CEL1X = CE\ L1\ (I - A)^{-1}\ Y$ -------- (7)

Here F as a vector, giving the total quantity of CO_2 emission from fossil fuel combustion only.

C is a vector of dimension m (1xm), of coefficients for CO_2 emission per unit of fossil fuel burnt.

In equation (7) CEL1 carries only direct requirement of CO_2 intensities from industries and CE L1$(I - A)^{-1}$ = CR=S gives the direct as well as indirect requirement of CO_2 intensity from industries .

So equation (7) explains the CO_2 emissions due to fossil fuel combustion in India from production activities.

For estimation of CO_2 emission we need to extend the above conventional input-output framework in one important respect i.e. we have to compute the amount of CO_2 emission that takes place in the production of various activity levels. We consider the IPCC guideline in the following manner. We apply the fuel specific carbon emission factors of fossil fuel sector of the respective Input- Output table to estimate the total CO_2 emitted by coal and oil sector. We use an emission factor of 0.55 (mt of CO_2)/mt for coal and 0.79(mt of CO_2)/mt for oil to arrive at carbon emissions by different sectors due to coal and oil separately.

Then we follow the normal convention of measurement, of carbon dioxide equivalent units. For conversion to CO_2 units the carbon emission figures are multiplied by 3.66. It gives the total quantity of CO_2 emitted owing to burning of fossil fuel (coal, oil) inputs used by various production industries.

For estimating total CO_2 contents in export and imported commodities we simply multiply the CO_2 intensities with export and import vector but for deriving sectoral contribution we constructed nxn matrices of export and import.

$C_{exp} = S * P$ ---------- (8)

Equation (8) measures the CO_2 content in exported commodities (energy and non-energy).

$C_{imp} = S * M$ ---------- (9)

Equation (8) derives the CO_2 content in imported commodities (energy and non-energy). Here also we assume identical technology (Heckscher-Ohlin) to find out the CO_2 content of imports of India from rest of the world.

3.3 Trade model

To estimate the energy balance of trade and emission balance of trade we need to extend the energy model and the emission model as given in the trade model below. It will also help us to derive Energy and pollution terms of trade.

The difference between equation (5) and (6) will help us to measure energy balance of trade i.e.,

Eex - Eim = R*P -R* M ---------- (10)

Finally to derive the CO_2 balance of trade by subtracting the equation (8 & 9) we get in equation (10).

C_{exp} - C_{imp} = S * P - S * M ---------- (11)

Now to estimate the energy terms of trade and pollution terms of trade we will consider the vector content of exports per unit of exports(nx1) and vector content of imports per unit of imports (nx1) only.

E_{tot} = R* P / R* M ---------- (12)

Thus, a measure of relative pollution content of trade i.e. Pollution Terms of Trade (PTOT) is given in equation (13)

P_{tot} = S * P / S * M ---------- (13)

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 a higher pollution content than its exported goods.

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.
Here we have considered the impact of non energy goods only because we know that flow of energy goods are mostly captured by non energy goods.

4. Data Analysis

To implement the model and to calculate the energy and pollution terms of trade we require Input - Output data, energy flow data and CO_2 data.

4.1 Input-Output Data

The basis of the data of this study is an Input-Output table of the Indian economy for the year 1993-94 prepared by the Central Statistical Organisation (CSO), Government of India (2000). Input-Output table is Commodity by Commodity consisting of 115 x 115 sectors. These have been aggregated to 48 sectors on the basis of the nature of commodities and trade and energy intensiveness.

Here we have considered three energy sectors coal, crude oil and natural gas and electricity. Other 112 non energy sectors have been aggregated to 45 non-energy sectors by considering export and import share. Thus, aggregated Input-output table of this study consists of 48 x 48 sectors.

4.2 Energy Flow Data

We convert the monetary units of energy sectors into physical unit from the energy data published by ministry of petroleum and natural gas (2001) report. Three energy sectors like coal as thousand tonnes, crude petroleum in thousand tonnes, natural gas in million cubic meter and electricity in GWH have been converted into one common unit, which is million tonnes of oil equivalent (mtoe).

4.3 Data on emissions of pollutants

The CO_2 emissions from fossil fuel combustion have been estimated by IPCC (Inter governmental panel on climate change) guideline.

5. Results and Discussion

The total energy and carbon intensity coefficients by commodity for the Indian economy in 1993-94 are presented in tables 1 and 2 (from equation 6 and equation 3) respectively. These tables provide the intensity coefficients for energy as well as non-energy sectors also. Here energy sectors are measured in mtoe/mtoe and non-energy sectors as mtoe/mrs in table 1. But in table 2 the emission from energy sectors are measured in mt of carbon/ mt of carbon and non-energy as mt of carbon/mrs.

In this paper we have considered two energy sectors i.e. coal & lignite and crude oil & natural gas. Regarding energy intensity we have observed that electricity is the most energy intensive due to high coal intensity. The second most important sector is petroleum product, which is very much crude oil intensive.

Actually CO_2 is released mainly from the fossil fuel combustion and biomass combustion. Here we deal with the fossil fuel combustion only. Electricity sector contributes 40% of the total emission and due to high crude oil consumption petroleum product sector accounts for more than 25% of total emission in the country. The sectors, which are identified as energy intensive, are also CO_2 intensive. So the other energy intensive as well as CO_2 intensive sectors like coal tar products, cement, fertilizer, inorganic heavy chemical, iron and steel, non-ferrous metal and transport deserve particular mention.

The study estimates carbon intensity for both the energy and non-energy commodities.

Let us check with the share. From tables 1 and 2 it can be observed that the energy and carbon intensity of cement is .00020 mtoe/mrs and .00044mtc/mrs respectively, for iron and steel the above contributions are .00017 mtoe/mrs and .00038mtc/mrs. Fertilizer is also one

of the most energy intensive sector which contributes .00018 (mtoe/mrs) for energy and .00047 (mtc/mrs) for carbon.

The major primary sources in determining the total primary energy and carbon coefficients for the above sectors are coal & lignite and crude oil and natural gas mainly. On the other hand the less energy and carbon intensive sectors are other services 2 (very negligible energy use), other services 1(.00004mtoe/mrs and .00010mtc/mrs), communication (.00001mtoe/mrs and .00003mtc/mrs), insurance (.00001mtoe/mrs and .00003mtc/mrs) and crop sectors (sectors 4--7) together (.00004mtoe/mrs and .00010mtc/mrs) deserve mention.

For assessing energy and carbon embodied in non-energy commodity trade accounts (export and import of non-energy goods) the relevant coefficients are those of non-energy goods in tables 1 and 2.

Table 3 presents the non-energy trade accounts of exported and imported commodities of India in monetary values for 1993-94. It is possible to understand from table 3 that the so-called energy intensive commodities altogether sum to 25% of total exports of non-energy goods in monetary value in 1993-94. This group of commodities sums to 40% of total imports of non-energy goods in monetary value in the same year. Though the total sum of the balance shows a positive return i.e. 19813 mrs in 1993-94 but the energy sector mainly dominated by the imported crude oil, which creates a difference between, energy exported commodities and imported one. The greater performance of the petroleum sector is mainly due to crude oil. Besides export of other energy intensive goods is higher than the imported one.

Tables 4 and 5 provide us the energy content in exported commodities and energy content in imported commodities (equation 4 and 5). The total energy content of exported commodities from non energy goods is 55 mtoe/mrs, out of which crude-oil shares 29.248 mtoe/mrs. The top five sectors in this respect are railway and transport, other non metallic mineral products, miscellaneous manufacturing, petroleum products and chemicals. We have also observed

that the above five sectors are primarily influenced by crude oil except other metallic mineral product, which has a coal dominance. The total energy content of imported commodities from non-energy goods is 107 mtoe/mrs, out of which crude-oil shares 65%. Among sector classification petroleum sector dominates as 43.11mtoe/mrs, but the other top five are machinery, coal tar products influenced by coal mainly, iron and steel, organic heavy chemicals and fertilizer.

If we consider the energy net trade balance of non-energy commodities (-51.241 mtoe/mrs) from table 8 (equation 10) the result corroborates that energy content of imports is higher than that of exported commodities. Petroleum products, machinery, coal tar products, iron and steel, organic heavy chemicals and fertilizer follow the negative returns. The positive returns of energy intensive non-energy commodities are incurred by railway and other transport equipment, other non-metallic mineral products, textile groups and leather and leather products.

Tables 6 and 7 present the carbon content in exported commodities and carbon content in imported commodities (equation 8 and 9). The total CO_2 content of exported commodity is 137 mtc/mrs out which 60% captured by crude oil sector and the rest influenced by coal. The major sectors like railway and transport, petroleum product, other non-metallic mineral products, chemicals, readymade garments are also significant. If we analyse the CO_2 content of imported goods the picture derives quite similar pattern. Here also the crude oil turns out as 150 mtc/mrs out of the total 178mtc/mrs. The major contribution made in this respect is by petroleum products (119.83 mtc/mrs). Other contributions are by machinery, coal tar products, iron and steel, organic heavy chemicals, fertilizer, electrical machinery equipment and miscellaneous manufacturing.

Like energy balance of trade the net carbon trade (equation 10) also derives a negative contribution i.e. -41 mtc/mrs (table 8). The major positive returns in this respect are made by railway and transport, other non-metallic mineral product, textile groups with ready made garments, leather and leather products. The negative return is followed by petroleum product, coal tar product, organic heavy chemicals and fertilizer.

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

From the model we have computed energy and pollution terms of trade of India in 1993-94. The results are presented in table 9. The result obtained is 52.16% for energy terms of trade of non-energy goods. Moreover, the pollution terms of trade for non-energy goods share is 76% in 1993-94. The values of Pollution terms of trade (PTOT) indices are below 100 indicating that India produces and exports goods that are more environment friendly than the goods it imports. Thus the results indicate a large inflow of energy intensive goods and pollution embodied in trade in India. Tables 4-8 ratify the same.

India is exporting goods produced in clean production processes and importing a large share of goods produced abroad in dirty production processes. The pollution terms of trade combine the technological and compositional effects to reflect the two policy options that the country faces: either clean up domestic production facilities or import the goods produced in environmentally unfriendly ways from abroad.

It should also be noted that exports must often meet the product standard to the extent that clean products require clean processes. The Government of India is also concerned with environmental problems and has set up Central Pollution Control Board .The different state governments have also set up State Pollution Control Board. These bodies are actively engaged in maintaining 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 minimization 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 organize existing and new efforts on energy conservation in various sectors of the economy for achieving a targeted energy savings of about 5000mw 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 liberalisation of trade in India during 90's has accentuated the process further.

The picture will be limpid if we look at the situation during the tenth plan i.e. for 2006-7. This will be done by simulation exercises.

6. Simulation Exercises

Three different types of simulation exercises have been attempted in this study.

1) To check the carbon and energy content of exports and imports during 1998-99, we have considered the **A** matrix of 1993-94 and export and import of 1998-99. Here we have considered 1998-99 under study to estimate the situation at the beginning of the Ninth Plan.
2) In accordance with the growth strategy of the 10th five- year plan (2001-2 to 2006-7) the **aggregated final demand, export and import growth** are assumed to be increased by 7.9%, 12.38% and 17.13% p.a. respectively upto 2006-7. Here we consider the technical coefficient matrix and the composition of trade of 1993-94**.**
3) By considering the projected composition of trade for 48 sectors during 2006-7 as assumed in the tenth plan report. But the technical coefficient matrix is assumed to be same as 1993-94.

Simulation 1 (table 10) presents somewhat similar picture of 1993-94. The exports increased by 22% but the imports by 42% during 1993-94 to 1998-99. The reason behind the

low value of the PTOT (.76) is higher import growth resulting from energy and pollution intensive goods.

If we analyse the results of the ***simulation exercise 2*** it follows the similar pattern of 1993-94 (table11). Both energy and the pollution terms of trade are .49 and .64 respectively which are below 100. The percentages are slightly downward than those of 1993-94, which indicate that though the export growth rate is high but not enough to exceed the import growth. The result reflects only the expanded volume of export and import because the composition of export and import remains fixed (1993-94). It can also be stated in this context that pollution abatement strategies and act undertaken by the government of India are responsible for this result which does not support the Pollution Haven Hypothesis.

But the *simulation exercises 3* provide us a little different kind of results (table 12). Though the energy and pollution embodied in exports are little lower than the imports but the contribution is far above than the previous simulation exercises.

If we compare the results we observe that in 1993-94 the PTOT was .76, while according to the simulation exercises 2 it declines to .63 but considering the composition of trade in third simulation exercises the PTOT goes up to .97. This indicates that if the composition of trade changes than the traditional type and the tariff reduction is made possible by 15% then India moves towards Pollution Haven Hypothesis.

The picture will be more transparent if we study the composition of India's principal exported and imported commodities elaborately in 2006-7(table 13). The following sectors are expected to constitute the highest share of exports like fishery products (2.83%), other food and beverages (1.17%), miscellaneous textile products (6.23%), Readymade garments (13.73%), petroleum products (6.2%), total chemicals (13%), iron and steel (5.3%), communication (3.35%) and beverages (3.62%) during the tenth plan. As far as the projections for the export of food items is concerned it may be mentioned that these are subject to availability of surplus, and priority would be given to domestic nutritional requirements. However, with an increase in agricultural production of 4% during the tenth

plan and with limited domestic demand, efforts would be on to increase export of processed items. This includes exports of horticultural products, particularly processed foods and vegetable spices and dairy products. The overall growth in export of agriculture and allied products has been projected to be around 9%. Few sectors have reduced their export contribution from 1993-94 to 1998-99 and are likely to be declining in the tenth plan also. Among them all crops item and edible oil and tea coffee processing deserve mention. The expected share corroborates that shifting of exports are likely to be from agricultural based products to technology and machinery oriented.

For the sector wise import projections it is expected that crude petroleum would continue to have the highest share (12.27%), followed by total chemicals (11.49%), machinery (10.8%), transport equipments (7.53%), followed by electrical and non electrical machinery (5.48%) and communications (8.60%). Import of food items is projected to be relatively low except edible oils (4.90%).

The policy reforms have aimed at creating an environment for achieving rapid increase in exports to make it an engine for achieving higher economic growth. Depending on the international environment and domestic exigencies, various export policies have been formulated from time to time. More recently a number of steps have been taken to enhance the export growth. This includes reduction in transaction costs through decentralization, simplification of procedures and various other measures. Steps have been taken to promote exports through multilateral and bilateral initiatives. Additionally, identification of the thrust sectors and focus regions in order to encourage export of quality branded goods double weightage has been accorded to exports made by units having ISO or equivalent status. Other measures include promotion of agricultural exports, market access initiative, setting up of business-cum-trade facilitation centres and trade portals.

The EXIM policy 2002 has removed all quantitative restrictions on agricultural exports. Some of the sector specific packages in the policy include incentives for export of jewelry, leather and textiles, handicrafts and other items from the small-scale sector. The reduction of customs duty on import of rough diamonds to zero per cent; reduction in value addition norms for export of plain jewelry from 10 to 7 percent to achieve a quantum jump in jewelry

exports. The policy also marks the launching of a new programme called special focus on cottage sector and handicrafts, keeping in view that the small-scale products form 50% of India's exports. In addition to the merchandise exports, there is a scope for increasing exports from the service sectors as India has highly skilled manpower and a large industrial base. This is being tapped for electronic and computer software, engineering consultancy, banking, insurance, tourism etc. The policy is geared towards nearly doubling India's present exports of about $45 billion to more than $80 billion over the tenth plan by 2007. The aim of the EXIM policy is to focus on the import baskets of our major trading partners (USA, JAPAN and EU) in the context of India's export basket, and arrive at focus products and focus markets for India. The export strategy aims to achieve 1% share in world exports by 2006-7, from 0.67% in 2001. These changes in trade pattern during tenth five-year plan will have environmental impact as indicated by the values of PTOT (.97), which is on the higher side.

7. Conclusions

This study aims at contributing to the debate about the impacts of international trade on energy use and environmental pollution by analyzing the Indian case for energy use and carbon emissions in the year 1993-94.

During the period 90s, the Indian economy had embarked on the liberalization process. In this sense, it is a good opportunity to evaluate the influence of a progressive freer trade environment on the energy use and carbon emissions.

Accordingly, a commodity-by-commodity input-output model in hybrid units was constructed to estimate total energy and carbon intensity coefficients by commodity for the Indian economy in 1993-94. Then, these coefficients were applied to calculate the energy and the carbon embodied in the country's non-energy commodity exports and imports for the same years. Findings showed that India registered negative net energy and carbon balances in the years considered, although the difference between energy and carbon

embodied in exports differ. In other words, India was a net importer of energy and carbon in the 1993-94.

The question of what effect openness has on the extent of industrial pollution in developing countries is, of course, an empirical one. This study deals with an analysis of the impacts of trade liberalisation on energy use and environment in India. The most important conclusion from the result obtained therein is that India cannot be characterized as a pollution haven. The idea was that an increase of trade implies extra pollution because exports increase but less pollution because imports increase (which are no longer produced at home any more). To have a pollution haven the first effect exceeds the second effect, thus leading to increase in the net effect in pollution. Pollution haven exports dirty products and imports relatively clean products. Conversely however, it is clear from the present study that import related pollution is much larger than the export related pollution. Hence India gains in terms of emission from trade. It should be noted that for a country to be characterized as pollution haven it is necessary that a country losses from trade, while its trading partner (here as rest of the world) gains. The pollution haven hypothesis can thus be accepted only if both conditions are fulfilled. If one of the two conditions is not satisfied (as is the case for India) the hypothesis is rejected.

Thus, the present paper challenges the Pollution Haven Hypothesis arguing that liberalization of trade policy in India has not been associated with pollution intensive industrial development. The findings of this study are in conformity with those of Birdsall and Wheeler (1993) on Latin America especially Chile. From case studies and econometric evidence they conclude that protected economies are more likely to favour pollution intensive industries while openness actually encourages cleaner industries through the importation of developed country pollution standards. However, in future the situation might change in India. Simulations performed 2006-7 show increase in the net amounts of energy and carbon emissions embodied in India's trade thus influencing country’s total energy use and total carbon emissions significantly.

Since, India is likely to move towards pollution haven in future, it calls for a critical look at the existing trade and environmental policies which are not integrated. This paper suggests the need for integrated trade environmental policies in order to harmonize India's trade targets in future with environmental priorities including those related to international commitments with respect to Agenda 21 and the UN Framework Convention for Climate Change (enforced by protocols, or not).

It is important to emphasize that the pollutant studied in this paper – Carbon dioxide - is one of many pollutants that may be affected by trade. There are many other environmental consequences not analyzed by this work. Clearly much more work could and should be done along these lines. So further research in this area is needed.

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Table 1: Total energy intensity coefficients of Indian economy by commodity in 1993-94(energy commodity in mtoe/mtoe and non-energy commodities in mtoe/mrs)

	Energy intensity (mtoe/mtoe & mtoe/mrs)	Coal	Crude oil & natural gas	total
1	Coal & lignite	.02621	.02013	.04634
2	Crude oil &natural gas	.00779	.01631	.02411
3	Electricity	4.7737	2.0260	6.7997
4	Food crops	.00001	.00002	.00003
5	Cash crops	.00000	.00001	.00001
6	Plantation crops	.00000	.00000	.00000
7	Other crops	.00000	.00001	.00001
8	Animal husbandry	.00000	.00000	.00000
9	Forestry and logging	.00000	.00000	.00000
10	Fishing	.00000	.00001	.00001
11	Mineral products	.00001	.00002	.00003
12	Sugar	.00001	.00001	.00002
13	Edible oil	.00001	.00001	.00003
14	Tea and coffee processing	.00002	.00002	.00005
15	Beverages	.00002	.00001	.00003
16	Cotton textile	.00002	.00002	.00004
17	Woolen & silk textile	.00003	.00002	.00005
18	Jute, hemp, mesta textiles	.00002	.00002	.00005
19	Miscellaneous textile products	.00002	.00002	.00004
20	Readymade garments	.00001	.00001	.00003
21	Wood & wood products	.00001	.00001	.00002
22	Paper &paper products	.00007	.00002	.00009
23	Leather & leather products	.00001	.00001	.00003
24	Rubber products	.00003	.00002	.00006
25	Plastic products	.00003	.00002	.00006
26	Petroleum products	.00000	.00057	.00058
27	Coal tar products	.00031	.00016	.00048
28	Inorganic heavy chemicals	.00008	.00004	.00013
29	Organic heavy chemicals	.00006	.00005	.00011
30	Fertilizers	.00005	.00013	.00018
31	Chemicals	.00004	.00003	.00008
32	Other non metallic mineral products	.00007	.00004	.00011
33	Cement	.000017	.00003	.00020
34	Iron & steel	.00013	.00003	.00017
35	Non-ferrous basic metals	.00007	.00003	.00010
36	Misc. metal products	.00006	.00002	.00009
37	Machinery	.00004	.00002	.00007
38	Electrical machinery &equipment	.00003	.00002	.00006
39	Rail &other transport equipment	.00004	.00002	.00006
40	Miscellaneous manufacturing	.00003	.00002	.00006
41	Construction	.00004	.00002	.00006
42	Gas & water supply	.00001	.00001	.00002
43	Railway &other transport service	.00002	.00006	.00009
44	Communication	.00000	.00000	.00001
45	Trade	.00000	.00000	.00001
46	Otherservices1	.00002	.00001	.00004
47	Insurance	.00000	.00000	.00001
48	Otherservices2	.00000	.00000	.00000

Table 2: Total CO_2 intensity coefficients of Indian economy in 1993-94 by commodity (energy commodity in mtc/mtc and non-energy commodities in mtc/mrs)

	Carbon intensity (mtc/mtoe & mtc/mrs)	Coal	Crude oil & natural gas	total
1	Coal & lignite	.05453	.05616	.11069
2	Crude oil &natural gas	.01622	.04552	.06174
3	Electricity	9.93092	5.65234	15.5832
4	Food crops	.00002	.00006	.00008
5	Cash crops	.00001	.00003	.00004
6	Plantation crops	.00000	.00001	.00002
7	Other crops	.00001	.00003	.00004
8	Animal husbandry	.00000	.00001	.00002
9	Forestry and logging	.00000	.00001	.00002
10	Fishing	.00000	.00004	.00004
11	Mineral products	.00002	.00005	.00008
12	Sugar	.00002	.00004	.00006
13	Edible oil	.00003	.00004	.00008
14	Tea and coffee processing	.00005	.00008	.00013
15	Beverages	.00004	.00004	.00008
16	Cotton textile	.00005	.00006	.00011
17	Woolen & silk textile	.00006	.00006	.00013
18	Jute, hemp, mesta textiles	.00006	.00007	.00014
19	Miscellaneous textile products	.00004	.00005	.00010
20	Readymade garments	.00003	.00005	.00009
21	Wood & wood products	.00002	.00003	.00005
22	Paper &paper products	.00015	.00006	.00021
23	Leather & leather products	.00003	.00004	.00007
24	Rubber products	.00007	.00008	.00015
25	Plastic products	.00006	.00008	.00014
26	Petroleum products	.00001	.00161	.00162
27	Coal tar products	.00066	.00046	.00112
28	Inorganic heavy chemicals	.00018	.00012	.00030
29	Organic heavy chemicals	.00012	.00015	.00028
30	Fertilizers	.00010	.00036	.00047
31	Chemicals	.00009	.00010	.00019
32	Other non metallic mineral products	.00015	.00011	.00026
33	Cement	.00036	.00008	.00044
34	Iron & steel	.00027	.00010	.00038
35	Non-ferrous basic metals	.00015	.00009	.00024
36	Misc. metal products	.00013	.00008	.00021
37	Machinery	.00009	.00007	.00017
38	Electrical machinery &equipment	.00007	.00007	.00014
39	Rail &other transport equipment	.00008	.00006	.00015
40	Miscellaneous manufacturing	.00007	.00007	.00014
41	Construction	.00008	.00005	.00014
42	Gas & water supply	.00003	.00003	.00006
43	Railway &other transport service	.00005	.00018	.00023
44	Communication	.00002	.00001	.00003
45	Trade	.00002	.00002	.00004
46	Otherservices1	.00004	.00005	.00010
47	Insurance	.00001	.00001	.00003
48	Otherservices2	.00001	.00001	.00002

Table3: Exports and imports of non energy goods by the Indian economy in 1993-94

	Non energy commodities(code)	Export In mrs	Import In mrs	share of export(%)	Share of import(%)	net balance (% & mrs)	
4	Food crops	11429.69	3850.964	1.301231	0.448537	0.852694	7578.726
5	Cash crops	7659.674	605.651	0.872028	0.070543	0.801485	7054.023
6	Plantation crops	1164.485	554.045	0.132573	0.064532	0.068041	610.4405
7	Other crops	15985.56	11806.816	1.819901	1.375187	0.444714	4178.739
8	Animal husbandry	219.8985	1261.052	0.025035	0.14688	-0.12185	-1041.15
9	Forestry and logging	3383.041	5030.148	0.385148	0.585881	-0.20073	-1647.11
10	Fishing	17212.57	214.981	1.959593	0.02504	1.934553	16997.59
11	Mineral products	10857.97	83999.701	1.236143	9.783778	-8.54764	-73141.7
12	Sugar	1993.442	30.805	0.226947	0.003588	0.223359	1962.637
13	Edible oil	32617.13	12424.12	3.713349	1.447086	2.266263	20193.01
14	Tea and coffee processing	9823.211	47.394	1.118339	0.00552	1.112819	9775.817
15	Beverages	2392.173	136.22	0.272341	0.015866	0.256475	2255.953
16	Cotton textile	28528.77	825.25	3.247903	0.09612	3.151783	27703.52
17	Woolen & silk textile	12655.15	11406.692	1.440746	1.328583	0.112164	1248.462
18	Jute, hemp, mesta textiles	2391.868	602.153	0.272306	0.070135	0.202171	1789.715
19	Miscellaneous textile prod	11262.49	2491.086	1.282197	0.290147	0.99205	8771.408
20	Readymade garments	60160.02	1990.878	6.849013	0.231885	6.617128	58169.14
21	Wood &wood products	1839.036	328.256	0.209368	0.038233	0.171135	1510.78
22	Paper & paper products	4242.248	23280.186	0.482965	2.711535	-2.22857	-19037.9
23	Leather & leather products	31338.03	3182.35	3.567728	0.370661	3.197067	28155.68
24	Rubber products	6586.15	1989.44	0.749811	0.231718	0.518093	4596.71
25	Plastic products	7317.375	2515.883	0.833058	0.293035	0.540023	4801.492
26	Petroleum products	10130.17	73578.055	1.153286	8.569927	-7.41664	-63447.9
27	Coal tar products	10.64948	15724.908	0.001212	1.831542	-1.83033	-15714.3
28	Inorganic heavy chemicals	3780.771	15463.019	0.430428	1.801039	-1.37061	-11682.2
29	Organic heavy chemicals	11184.76	33417.545	1.273347	3.892274	-2.61893	-22232.8
30	Fertilizers	1160.02	20777.034	0.132064	2.419983	-2.28792	-19617
31	Chemicals	38361.92	36265.725	4.367374	4.224013	0.143361	2096.197
32	Other non metallic mineral	62741.12	17584.167	7.142863	2.048098	5.094765	45156.95
33	Cement	1434.897	3.907	0.163358	0.000455	0.162903	1430.99
34	Iron & steel	17267.46	35600.067	1.965841	4.146481	-2.18064	-18332.6
35	Non-ferrous basic metals	4233.364	27845.281	0.481954	3.24325	-2.7613	-23611.9
36	Miscell metal products	11048.1	3850.342	1.257789	0.448465	0.809324	7197.76
37	Machinery	15682.71	96164.656	1.785423	11.20068	-9.41525	-80481.9
38	Electrical mach &equipment	23367.21	53567.734	2.660277	6.239246	-3.57897	-30200.5
39	Rail & other transport eqp	16781.59	80583.961	1.910527	9.385933	-7.47541	-63802.4
40	Miscellaneous manufacturing	73887.84	85257.868	8.411879	9.930322	-1.51844	-11370
41	Construction	0	0	0	0	0	0
42	Gas and water supply	80.68193	0	0.009185	0	0.009185	80.68193
43	Railway &other transport service	88142.09	9765.685748	10.03468	1.137448	8.897228	78376.4
44	Communication	291.1125	223.2	0.033142	0.025997	0.007145	67.91253
45	Trade	121726.6	0	13.85816	0	13.85816	121726.6
46	Otherservices1	91620.18	77402.9	10.43065	9.015422	1.415223	14217.28
47	Insurance	4381.888	6911.638145	0.498863	0.805026	-0.30616	-2529.75
48	Otherservices2	0	0	0	0	0	0
	total	878375	858561.76	100	100		19813.35

Table 4: Energy content of exports in the Indian economy during 1993-94 by commodity (energy commodity in mtoe/mtoe and non-energy commodities in mtoe/mrs)

	Energy content of exports	Coal	Crude oil & natural gas	total
1	Coal & lignite	.01032	.00792	.01824
2	Crude oil &natural gas	.01320	.02762	.04083
3	Electricity	.00001	.00000	.00002
4	Food crops	.14446	.25268	.39715
5	Cash crops	.04615	.08538	.13154
6	Plantation crops	.00322	.00619	.00941
7	Other crops	.10086	.18712	.28798
8	Animal husbandry	.00070	.00111	.00181
9	Forestry and logging	.00931	.02306	.03238
10	Fishing	.06437	.25069	.31507
11	Mineral products	.12837	.22497	.35334
12	Sugar	.02341	.03074	.05416
13	Edible oil	.51068	.57841	1.08909
14	Tea and coffee processing	.23947	.28383	.52331
15	Beverages	.04818	.03563	.08382
16	Cotton textile	.74876	.65518	1.40395
17	Woolen & silk textile	.42422	.30504	.72927
18	Jute, hemp, mesta textiles	.07785	.06453	.14239
19	Miscellaneous textile products	.25413	.23618	.49032
20	Readymade garments	1.13555	1.13769	2.27325
21	Wood & wood products	.02166	.02135	.04302
22	Paper &paper products	.31457	.09739	.41196
23	Leather & leather products	.50755	.49894	1.00650
24	Rubber products	.22680	.19233	.41913
25	Plastic products	.22316	.21770	.44087
26	Petroleum products	.08608	5.84974	5.93582
27	Coal tar products	.00337	.00178	.00516
28	Inorganic heavy chemicals	.32821	.16774	.49595
29	Organic heavy chemicals	0.69544	.62201	1.31746
30	Fertilizers	.05894	.15207	.21101
31	Chemicals	1.67705	1.47818	3.15524
32	Other non metallic mineral products	4.53906	2.52577	7.06484
33	Cement	.24885	.04408	.29293
34	Iron & steel	2.28678	.65073	2.93752
35	Non-ferrous basic metals	.31145	.14430	.45576
36	Misc. metal products	.72205	.31861	1.04066
37	Machinery	.73617	.42371	1.15988
38	Electrical machinery &equipment	.87659	.59018	1.46677
39	Rail &other transport equipment	.68500	.40109	1.08610
40	Miscellaneous manufacturing	2.53518	2.03303	4.56822
41	Construction	0	0	0
42	Gas & water supply	0.00136	.00089	.00226
43	Railway &other transport service	2.39149	5.74505	8.13654
44	Communication	.00288	.00197	.00485
45	Trade	1.18523	.91193	2.09717
46	Otherservices1	2.09631	1.76844	3.86475
47	Insurance	.02774	.03081	.05855
48	Otherservices2	0	0	0
	Non energy total(4-48)	**26.7488**	**29.2484**	**55.9973**

Table 5: Energy content of imports in the Indian economy during 1993-94 by commodity (energy commodity in mtoe/mtoe and non-energy commodities in mtoe/mrs)

	Energy content of imports	Coal	Crude oil & natural gas	total
1	Coal & lignite	.01447	.01111	.02559
2	Crude oil &natural gas	.66325	1.38799	2.05124
3	Electricity	0	0	0
4	Food crops	.04867	.08513	.13381
5	Cash crops	.00364	.00675	.01040
6	Plantation crops	.00153	.00294	.00448
7	Other crops	.07449	.13820	.21270
8	Animal husbandry	.00402	.00637	.01039
9	Forestry and logging	.01385	.03429	.04814
10	Fishing	.00080	.00313	.00393
11	Mineral products	.99311	1.74046	2.73357
12	Sugar	.00036	.00047	.00083
13	Edible oil	.19452	.22032	.41484
14	Tea and coffee processing	.00115	.00136	.00252
15	Beverages	.00274	.00202	.00477
16	Cotton textile	.02165	.01895	.04061
17	Woolen & silk textile	.38237	.27495	.65733
18	Jute, hemp, mesta textiles	.01959	.01624	.03854
19	Miscellaneous textile products	.05621	.05224	.10845
20	Readymade garments	.03757	.03764	.07522
21	Wood & wood products	.00386	.00381	.00768
22	Paper &paper products	1.72627	.53449	2.26076
23	Leather & leather products	.05154	.05066	.10220
24	Rubber products	.06850	.05809	.12660
25	Plastic products	.07673	.07485	.15158
26	Petroleum products	.62522	42.4882	43.1134
27	Coal tar products	4.98896	2.64096	7.62993
28	Inorganic heavy chemicals	1.34235	.68604	2.02840
29	Organic heavy chemicals	2.07784	1.85844	3.93629
30	Fertilizers	1.05570	2.72384	3.77955
31	Chemicals	1.58541	1.39741	2.98283
32	Other non metallic mineral products	1.27214	.70788	1.98003
33	Cement	.00067	.00012	.00079
34	Iron & steel	4.71462	1.34162	6.05624
35	Non-ferrous basic metals	2.04861	.94919	2.99780
36	Misc. metal products	.25164	.11103	.36267
37	Machinery	4.51412	2.59815	7.11227
38	Electrical machinery &equipment	2.00953	1.35295	3.36249
39	Rail &other transport equipment	3.28932	1.92605	5.21538
40	Miscellaneous manufacturing	2.92530	2.34588	5.27119
41	Construction	0	0	0
42	Gas & water supply	0	0	0
43	Railway &other transport service	.26496	.63652	.90148
44	Communication	.00221	.00151	.00372
45	Trade	0	0	0
46	Otherservices1	1.77101	1.49402	3.26503
47	Insurance	.04376	.04859	.09236
48	Otherservices2	0	0	0
	Non energy total(4-48)	**38.5667**	**68.6719**	**107.238**

Table 6: Carbon content of exports in the Indian economy during 1993-94 by commodity (energy commodity in mtc/mtc and non-energy commodities in mtc/mrs)

	Carbon content of exports	Coal	Crude oil & Natural gas	total
1	Coal & lignite	.02147	.02211	.04358
2	Crude oil &natural gas	.02746	.07708	.10454
3	Electricity	.00003	.00002	.00005
4	Food crops	.30054	.70496	1.00550
5	Cash crops	.09602	.23821	.33424
6	Plantation crops	.00671	.01727	.02398
7	Other crops	.20983	.52204	.73188
8	Animal husbandry	.00145	.00310	.00455
9	Forestry and logging	.01938	.06434	.08372
10	Fishing	.13392	.69940	.83333
11	Mineral products	.26705	.62765	.89471
12	Sugar	.04871	.08577	.13448
13	Edible oil	1.06239	1.61371	2.67610
14	Tea and coffee processing	.49819	.79186	1.29005
15	Beverages	.10025	.09940	.19965
16	Cotton textile	1.55769	1.82788	3.38557
17	Woolen & silk textile	.88254	.85103	1.73358
18	Jute, hemp, mesta textiles	.16196	.18005	.34202
19	Miscellaneous textile products	.52869	.65893	1.18762
20	Readymade garments	2.36234	3.17402	5.53637
21	Wood & wood products	.04507	.05958	.10466
22	Paper &paper products	.65441	.27172	.92614
23	Leather & leather products	1.05588	1.39199	2.44788
24	Rubber products	.47182	.53660	1.00842
25	Plastic products	.46426	.60736	1.7163
26	Petroleum products	.17907	16.3200	16.4991
27	Coal tar products	.00702	.00498	.01201
28	Inorganic heavy chemicals	.68279	.46797	1.15076
29	Organic heavy chemicals	1.44677	1.73535	3.18212
30	Fertilizers	.12261	.42427	.54689
31	Chemicals	3.48884	4.12395	7.61280
32	Other non metallic mineral products	9.44279	7.04660	16.4893
33	Cement	.51769	.12299	.64068
34	Iron & steel	4.75727	1.81548	6.57276
35	Non-ferrous basic metals	.64792	.40260	1.05053
36	Misc. metal products	1.50211	.88889	2.39100
37	Machinery	1.53148	1.18210	2.71359
38	Electrical machinery equipment	1.82361	1.64654	3.47015
39	Rail &other transport equipment	1.42503	1.11901	2.54405
40	Miscellaneous manufacturing	5.27404	5.67192	10.9459
41	Construction	0	0	0
42	Gas & water supply	.00284	.00250	0.00535
43	Railway &other transport service	4.97511	16.0279	21.00
44	Communication	.00600	.00549	.01149
45	Trade	2.46569	2.54418	5.00988
46	Otherservices1	4.36105	4.93372	9.29477
47	Insurance	.05772	.08595	.14368
48	Otherservices2	0	0	0
	Non energy total(4-48)	**55.6467**	**81.5995**	**137.246**

Table7: Carbon content of imports in the Indian economy during 1993-94 by commodity (energy commodity in mtc/mtc and non-energy commodities in mtc/mrs)

	Carbon content of imports	Coal	Crude oil & natural gas	Total
1	Coal & lignite	.03011	.03101	.06112
2	Crude oil &natural gas	1.37979	3.87232	5.25212
3	Electricity	0	0	0
4	Food crops	.10126	.23752	.33878
5	Cash crops	.00759	.01883	.02642
6	Plantation crops	.00319	.00821	.01141
7	Other crops	.15498	.38557	.54056
8	Animal husbandry	.00836	.01777	.02614
9	Forestry and logging	.02881	.09567	.12449
10	Fishing	.00167	.00873	.01040
11	Mineral products	2.06601	4.85566	6.92168
12	Sugar	.00075	.00132	.00207
13	Edible oil	.40467	.61467	1.01934
14	Tea and coffee processing	.00240	.00382	.00622
15	Beverages	.00570	.00566	.01136
16	Cotton textile	.04505	.05827	.09793
17	Woolen & silk textile	.79547	.76708	1.56255
18	Jute, hemp, mesta textiles	.04077	.04532	.08610
19	Miscellaneous textile products	.11693	.14574	.26268
20	Readymade garments	.07817	.10503	.18321
21	Wood & wood products	.00804	.01063	.01868
22	Paper &paper products	3.59124	1.49115	5.08240
23	Leather & leather products	.10722	.14135	.24858
24	Rubber products	.14252	.16208	.30460
25	Plastic products	.15962	.20882	.36845
26	Petroleum products	1.30067	118.536	119.837
27	Coal tar products	10.3787	7.36795	17.7467
28	Inorganic heavy chemicals	2.79256	1.91397	4.70653
29	Organic heavy chemicals	4.32262	5.18483	9.50746
30	Fertilizers	2.19621	7.59919	9.79541
31	Chemicals	3.29820	3.89860	7.19681
32	Other non metallic mineral products	2.64648	1.97491	4.62140
33	Cement	.00140	.00033	.00174
34	Iron & steel	9.80801	3.74295	13.5509
35	Non-ferrous basic metals	4.26180	2.64813	6.90994
36	Misc. metal products	.52349	.30978	.83328
37	Machinery	9.39091	7.24852	16.6394
38	Electrical machinery equipment	4.18050	3.77458	7.95509
39	Rail &other transport equipment	6.84291	5.37343	12.2163
40	Miscellaneous manufacturing	6.08562	6.54472	12.6303
41	Construction	0	0	0
42	Gas & water supply	0	0	0
43	Railway &other transport service	.55121	1.77581	2.32703
44	Communication	.00460	.00421	.00881
45	Trade	0	0	0
46	Otherservices1	3.68432	4.16812	7.85244
47	Insurance	.09104	.13558	.22663
48	Otherservices2	0	0	0
	Non energy total(4-48)	**28.8613**	**149.986**	**178.847**

Table 8: Energy and Carbon balance of trade in Indian economy during 1993-94

	Sectors	Energy net trade(mtoe/mtoe & mtoe/mrs	Carbon net trade(mtc/mtc & mtc/mrs)
1	Coal & lignite	-.0073	-.0175
2	Crude oil &natural gas	-2.0104	-5.1476
3	Electricity	2.5342E-05	5.8077E-05
4	Food crops	.26334	.66672
5	Cash crops	.12114	.30782
6	Plantation crops	.00494	.01257
7	Other crops	.07528	.19132
8	Animal husbandry	-.0086	-.0216
9	Forestry and logging	-.0158	-.0408
10	Fishing	.31114	.82292
11	Mineral products	-2.3802	-6.027
12	Sugar	.05332	.13241
13	Edible oil	.67425	1.65675
14	Tea and coffee processing	.52079	1.28383
15	Beverages	.07905	.18829
16	Cotton textile	1.36334	3.28764
17	Woolen & silk textile	.07194	.17102
18	Jute, hemp, mesta textiles	.10655	.25592
19	Miscellaneous textile products	.38187	.92494
20	Readymade garments	2.19802	5.35315
21	Wood & wood products	.03535	.08598
22	Paper &paper products	-1.8488	-4.1563
23	Leather & leather products	.90429	2.19931
24	Rubber products	.29253	.70318
25	Plastic products	.28929	.70318
26	Petroleum products	-37.178	-103.34
27	Coal tar products	-7.6248	-17.735
28	Inorganic heavy chemicals	-1.5324	-3.5558
29	Organic heavy chemicals	-2.6188	-6.3253
30	Fertilizers	-3.5685	-9.2485
31	Chemicals	.17241	.41598
32	Other non metallic mineral products	5.08481	11.868
33	Cement	.29214	.63895
34	Iron & steel	-3.1187	-6.9782
35	Non-ferrous basic metals	-2.542	-5.8594
36	Misc. metal products	.67799	1.55772
37	Machinery	-5.9524	-13.926
38	Electrical machinery &equipment	-1.8957	-4.4849
39	Rail and other transport equipment	-4.1293	-9.6723
40	Miscellaneous manufacturing	-.703	-1.6844
41	Construction	0	0
42	Gas & water supply	.00227	.00535
43	Railway &other transport service	7.23506	18.6761
44	Communication	.00113	.00268
45	Trade	2.09717	5.00988
46	Otherservices1	.59972	1.44233
47	Insurance	-.0338	-.083
48	Otherservices2	0	0
	Non energy total(4-48)	**-51.241**	**-41.601**

Table 9: Energy and Pollution terms of trade of non energy goods of India in 1993-94

Energy embodied in exports of non energy goods	55.9564 mtoe/mrs
Energy embodied in imports of non energy goods	107.23 mtoe/mrs
Energy terms of trade	.5217
Energy terms of trade*100	52.17
Pollution embodied in exports (CO_2) of non energy goods	137.246 mtc/mrs
Pollution embodied in imports(CO_2) of non energy goods	178.845 mtc/mrs
Pollution terms of trade	.7674
Pollution terms of trade*100	76.74

Table 10: Simulation exercise 1 - Energy and Pollution terms of trade of non energy goods of India in 1998-99

Energy embodied in exports of non energy goods	120.8468
Energy embodied in imports of non energy goods	234.1037
Energy terms of trade	.519282
Energy terms of trade*100	51.92
Pollution embodied in exports (CO_2) of non energy goods	290.2966
Pollution embodied in imports(CO_2) of non energy goods	583.8213
Pollution terms of trade	.49482
Pollution terms of trade*100	49.48

Table 11: Simulation exercise 2 - Energy and Pollution terms of trade of non energy goods of India in 2006-7

Energy embodied in exports of non energy goods	67.107
Energy embodied in imports of non energy goods	138.016
Energy terms of trade	.4862
Energy terms of trade*100	48.62
Pollution embodied in exports (CO_2) of non energy goods	204
Pollution embodied in imports(CO_2) of non energy goods	319
Pollution terms of trade	.6394
Pollution terms of trade*100	63.94

Table 12: Simulation exercise 3 - Energy and Pollution terms of trade of non energy goods of India in 2006-7

Energy embodied in exports of non energy goods	333.71
Energy embodied in imports of non energy goods	355.78
Energy terms of trade	.9379
Energy terms of trade*100	93.79
Pollution embodied in exports (CO_2) of non energy goods	845.1529
Pollution embodied in imports(CO_2) of non energy goods	870.5461
Pollution terms of trade	.9712
Pollution terms of trade*100	97.12

Table 13: The share of export and import of non-energy goods by the Indian Economy in 1993- 94, 1998-99 and 2006-7(projected)

		199394exp	exportshare9899	**export2006-7**	199394imp	Import share199899	**import2006-7**
4	Food crops	1.301231	3.303329	**2.261209**	0.448537	0.80022	**1.268794**
5	Cashcrops	0.872028	0.162973	**0.012401**	0.070543	0.040248	**1.068698**
6	Plantation crops	0.132573	1.129108	**1.212696**	0.064532	0.049894	**0.300941**
7	Other crops	1.819901	1.29006	**0.83639**	1.375187	0.971909	**0.075823**
8	Animal husbandry	0.025035	0.095568	**0.86156**	0.14688	0.116711	**0.039971**
9	Forestry and logging	0.385148	0.72436	**0.396224**	0.585881	0.696535	**0.058612**
10	Fishing	1.959593	2.187364	**2.830403**	0.02504	0.040766	**0.017577**
11	mineral products	1.236143	1.382951	**0.274017**	9.783778	8.138543	**9.36739**
12	sugar	0.226947	0.007457	**1.177759**	0.003588	0.50192	**0.04489**
13	edibleoil	3.713349	1.068667	**0.281316**	1.447086	3.542346	**4.904027**
14	Tea and coffee processing	1.118339	2.04472	**0.334579**	0.00552	0.035565	**0.001289**
15	beverages	0.272341	0.968346	**3.624092**	0.015866	0.264707	**1.167625**
16	cottontextile	3.247903	4.267367	**5.462393**	0.09612	0.281219	**0.096159**
17	woolen&silktextile	1.440746	1.962855	**0.61821**	1.328583	0.627725	**0.619752**
18	Jute, hemp, mesta textiles	0.272306	1.549078	**0.210581**	0.070135	0.043265	**0.019524**
19	Miscellaneous textile products	1.282197	1.588111	**4.233164**	0.290147	0.449661	**1.48029**
20	Readymade garments	6.849013	11.29756	**13.73852**	0.231885	0.452834	**0.092568**
21	Wood & wood products	0.209368	0.123131	**0.076615**	0.038233	0.08685	**1.680965**
22	paper &paper products	0.482965	1.685569	**0.463412**	2.711535	3.830811	**2.210177**
23	Leather &leather products	3.567728	3.560299	**3.984693**	0.370661	0.212763	**0.582804**
24	Rubber products	0.749811	0.650247	**2.090259**	0.231718	0.270957	**0.254722**
25	Plastic products	0.833058	0.54872	**0.878804**	0.293035	0.327862	**0.55615**
26	Petroleum products	1.153286	0.220361	**6.208212**	8.569927	5.342283	**12.272643**
27	Coal tar products	0.001212	0.000849	**0.000363**	1.831542	2.256149	**0.427622**
28	Inorganic heavy chemicals	0.430428	0.340611	**2.731169**	1.801039	2.409796	**3.499337**
29	Organic heavy chemicals	1.273347	2.459642	**5.313639**	3.892274	3.043647	**3.079691**
30	Fertilizers	0.132064	0.466499	**0.009754**	2.419983	1.593202	**1.131529**
31	chemicals	4.367374	4.647525	**5.143588**	4.224013	3.995106	**5.049096**
32	Other non metallic mineral products	7.142863	11.36572	**5.670173**	2.048098	0.283843	**0.844058**
33	Cement	0.163358	0.073742	**0.15016**	0.000455	0	**0.005659**
34	Iron& steel	1.965841	2.018252	**5.339722**	4.146481	2.526966	**2.940946**
35	Non-ferrous basic metals	0.481954	0.41622	**3.63135**	3.24325	11.33177	**1.814913**
36	Miscell metalpro	1.257789	1.432064	**0.513383**	0.448465	0.595435	**0.104706**
37	Machinery	1.785423	2.152466	**0.086314**	11.20068	10.4343	**10.680724**
38	Electrical machinary & equipment	2.660277	1.994488	**2.744648**	6.239246	4.424099	**5.4868**
39	Rail &other transport equipment	1.910527	1.614706	**1.885598**	9.385933	1.148663	**7.53495**
40	Miscellaneous manufacturing	8.411879	11.15702	**5.832915**	9.930322	6.882522	**7.058178**
41	Construction	0	0	**0**	0	0	**0**
42	Gas&Water supply	0.009185	0	**0.002748**	0	0	**0**
43	Railway&othtransportserevice	10.03468	5.0128	**3.002124**	1.137448	5.44751	**0.265567**
44	Communication	0.033142	1.719595	**3.358983**	0.025997	2.040491	**11.60199**
45	Trade	13.85816	7.74	**4.146013**	0	0	**0**
46	otherservices1	10.43065	2.150757	**3.120588**	9.015422	1.085675	**2.104887**
47	Insurance	0.498863	0.48392	**0.149247**	0.805026	0.210016	**0.187954**
48	otherservices2	0	0	**0**	0	0	**0**