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Potential impact of carbon barriers to trade: The case of India’s exports to the US under border tax adjustment

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Abstract

As countries are struggling to integrate economic interests with management of climate change, the nexus between trade, environment and climate change issues have brought new dimensions to the on-going integration process. Developed countries are bound by the Kyoto protocol wherein these countries were supposed to reduce their GHG emission by approximately 5.2 percent of the 1990 levels. Many developed countries have already adopted measures in order to meet the target of GHG emission reduction. However, competitiveness concerns in these countries, have led to proposals for tariff or border tax adjustments to offset any adverse impact of capping carbon emissions. Moreover, it is perceived by the developed countries that if developing countries do not join a post 2012 climate regime, emission intensive production units in developed countries may relocate to the developing nations (carbon leakage), that may undermine the global combat against climate change. The recent Waxman-Markey bill introduced in the US Congress, although now off the table, has provisions for trade sanctions against countries, which do not impose controls on carbon emissions, by levying tariffs on certain goods from developing countries. Trade intensity will be a factor along with energy intensity in determining the sectors that may be eligible for such trade measures. There is a call for adopting similar measures in Europe as well. Such border adjustment measures are going to be felt by a larger number of industries in the developing countries. Opinion is divided however on whether such border tax adjustments are permitted under the World Trade Organizations (WTO) law for taxable inputs that are not physically incorporated in the final product. There is also an apprehension that carbon or energy efficient related standards, both government and private, may proliferate affecting exports from developing countries. As per the WTO Agreement on Technical Barriers to Trade (TBT), standards and conformity assessment procedures should not create unnecessary obstacles to trade or be used as protectionist tools. Moreover, such interventions also violate the principle of 'CBDR' as outlined in UNFCCC.

We analyzed India-US trade as a case, since US is a very important trade-partner for India where exports to US accounts for 12 percent of India's total exports. Any future measure is perceived to have significant impact on India's total exports. We found that the estimated overall reduction in India's exports to US under two border tax adjustment scenarios (carbon tax of Euro 20 and 30 per ton) is 2.3 percent and 3.5 percent of India's exports to US in 2006-2007. Amongst the top 10 commodities exported to the US (2006-2007), iron and steel, cotton textiles, chemicals, are in CPCB list of 17 most polluting industries. Key products that are going to experience a decline in exports of more than 10 percent include, cement products, fertilizer, iron and steel, pulp and paper, glass and ceramic under both the scenario. In value terms, iron and steel sector will experience a maximum dip in revenue of Rs. 7.3 billion (under scenario 1) and Rs.11 billion (under scenario 2). i.e. 10 percent and 16 percent of the 2006-2007 level exports. Cotton textiles will be the sector to experience the second highest decline in revenue of Rs.6 billion (under scenario 1) and Rs.9 billion (under scenario 2). Such reduction in exports and hence revenue will affect the livelihoods of many. Hence, the

fundamental objective of sustainable development will be at stake. For effectively reducing CO2 emissions and protecting the global environment, while it is important to follow a low-carbon economy but the other two pillars of sustainable development should not be compromised.

1. Introduction

At a time when the international community is struggling to agree on a comprehensive, global effort to mitigate greenhouse gas (GHG) emissions, countries, primarily the developed ones, are planning to move unilaterally and explore and implement strategies that would curb local and global greenhouse gases emission. However, from various discussion and debates these strategies also have important trade implications and it becomes pertinent in this context to understand the possible consequences of such policies on global trade.

Ratification of the Kyoto Protocol by the developed nations and the consequent competitiveness concerns of industries particularly in developed nations have led to proposals for tariff or border tax adjustments to offset adverse impacts arising from domestic policies. At the same time it is perceived by developed countries that if developing countries do not join a post 2012 climate regime, emissions intensive production units in developed countries may relocate to the developing nations (carbon leakage), which will undermine the global combat against climate change. Such border adjustment measures are going to be felt by a larger number of industries in the developing countries who are not mandated by any GHG emission reduction. United States was one of the first countries to draft a bill (American Clean Energy and Security Act of 2009)[1] that would address competitiveness concerns of domestic industries and issues of carbon leakage in post Kyoto regime. Among other issues, the bill introduced sections on promoting international reductions in emissions by allowing imports only on procurement of appropriate amounts of carbon allowances to cover the imported goods being imported from developing countries. However exemptions on allowance procurement are allowed only if such imports are from least developed countries (LDC) or 'is a party to an international agreement to which US is a party and there exists a nationally enforceable and economy wide greenhouse gas emissions reduction commitment for that country that is at least as stringent as that of the United States'. If we exclude such countries from the list of nations from where US is currently importing, the possible impacted countries (based on GHG emissions and trade volume) will include some of the major developing countries of the world which are presented in figures 1 and figures 2

[1] http://www.epa.gov/climatechange/EPAactivities/economics/legislativeanalyses.html#americanClan, Accessed 12th October, 2011

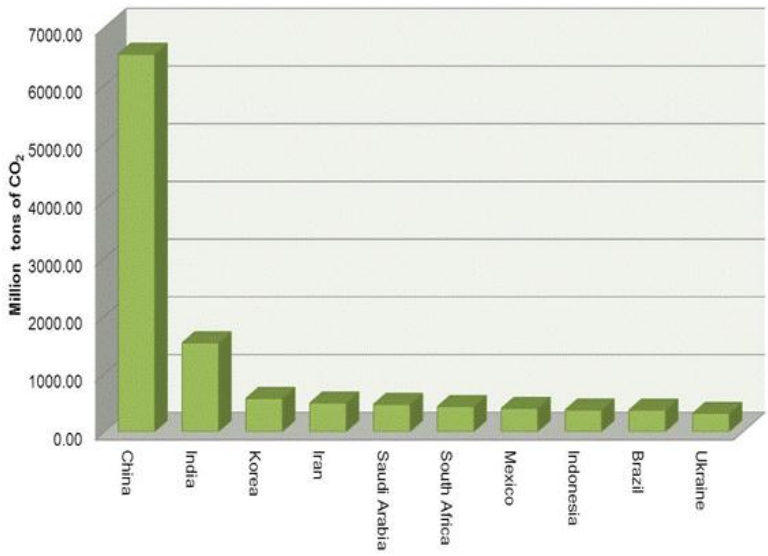

Figure 1: Ranking of countries, to be potentially impacted based on GHG emissions[2]

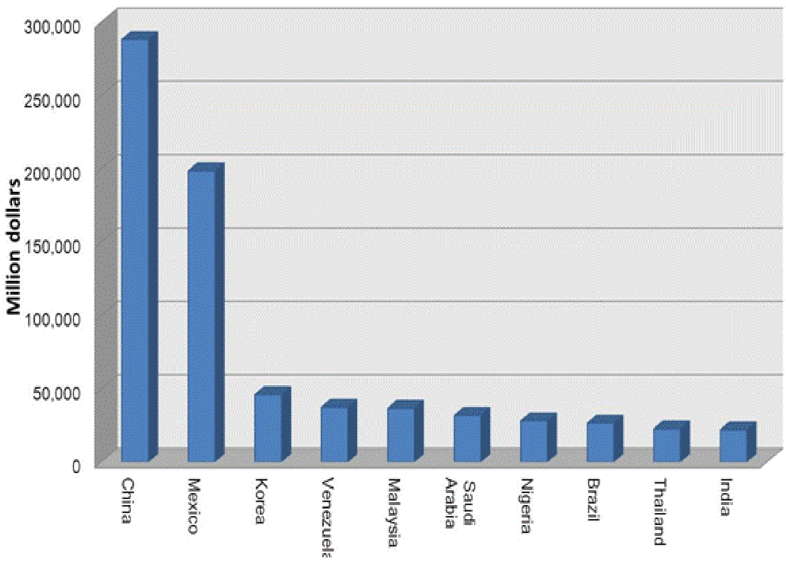

Figure 2: Countries that can be potentially impacted, based on their exports to US[3]

The European Commission too issued a communication in May 2010, in which it reviewed, among other things, the need for tools to address carbon leakage and competitiveness concerns.

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[2] Source: http://unfccc.int/ghg_data/ghg_data_unfccc/ghg_profiles/items/3954.php, Accessed 3rd May, 2011

[3] Source:http://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2007, Accessed 24th May, 2011

Civil society organistions / non-governmental organisation and companies in developed countries are also adopting various voluntary measures for climate change mitigation. Common strategies include carbon labeling, food miles, etc. Carbon labeling provides information about products' carbon footprint, and thus has the potential to facilitate consumer participation in climate change mitigation. In the United Kingdom, it is already a part of the Government's policy to encourage consumers to buy products with lower carbon emissions. Through food miles consumers are informed about the distance a particular item has covered to reach the ultimate point of selling (e.g., retail store) and are typically discouraged, through campaigns, to not buy products that have come from far off places. Apparently the initiative may be justified with regard to restricting trade in order to reduce avoidable transportation. However, it may be possible for a product to remain less carbon intensive even after it has been airlifted from Africa/Latin America to a store in Europe/US compared to similar products grown in the neighbourhood if carbon intensities of production processes are low.

Developing countries, however, expressed concerns and maintained that the use of environmental exception to impose additional taxes on imports from developing based on their emission or pollution levels is unfair to developing countries, because their levels of development, financial resources and technology are much lower than those of developed countries. The developing country perspective is based on the fact that economic and social development and poverty alleviation are the overriding priorities that international trade constitutes an important means of achieving these goals. These countries face barriers related to IPRs, lack of technology cooperation and inadequate funds that prevent them from having lower emission. It is perceived that such unilateral trade measures could have distortive effects on international trade, restrict the exports from developing countries and can adversely affect key sectors and factors of production (mainly labour) and consequently hinder the social and economic development.

At the same time, it would be interesting to know where developing countries stand in the presence of such unilateral trade measures. If climate-based or carbon-based trade measures become the order of the day, how will these countries be affected? What will be the macro and micro economic and social challenges? In particular it would be interesting to know the sectors that might be affected in select developing countries and how such challenges (if any) be overcome through actions and strategies at different levels global and national levels. The next section gives a brief review of literature on the issues. The third section describes the objectives and research questions addressed in the paper. The fourth section deals with the approach, methodology and data issues. The fifth sections analyses the results obtained. The sixth section discusses the potential impacts of border tax adjustments on exports. The seventh and last section concludes the paper.

2. Literature survey

There have been various studies conducted to estimate possible impacts of unilateral trade measures on trade, technology development and transfer, economic development. Initial studies, carried out a decade back, tried to develop linkages between the emerging international climate change policies and its impact on international trade and identified role of technologies in climate change mitigation. Some of the early studies have been conducted by Petsonk (1999), Hoerner and Müller (1996), Sampson (1999), Werksman (1999), Werksman and Santoro (1999), and Zhang (1998). However, these studies were mostly qualitative in nature and were based on hypothetical possibilities of potential conflicts[4].

2.1 Impact in developed countries

There have been more empirical studies conducted recently that have tried to estimate impact on competitiveness on domestic industries in the developed nations in presence of climate change policies with an objective to understand fear of carbon leakage. Pew Climate Centre paper undertook a study to estimate the potential "competitiveness" effect of a domestic cap-and-trade system on U.S. manufacturing industries, that can be used to regulate greenhouse gases. The study found that at a price of US $15 per ton of CO2 it is not likely to significantly impact competitiveness of U.S. manufacturing as a whole. But a subset of industries that are energy intensive, however, may face competitive pressures from abroad as their energy costs rise with the imposition of a carbon price[5]. A study by the World Bank (2010), finds no proof of competitiveness impact on energy intensive industries' in US in the presence of carbon taxes. Another study by the World Bank found that many energy-intensive industries in OECD countries where carbon taxes had been instituted actually increased exports. Alexeeva-Talebi et al. (2008)[6], the authors conclude that border tax adjustment protects domestic competitiveness more effectively; while an integrated emissions trading scheme achieves a greater reduction in emissions abroad. According to Matto et al. (2009) unilateral emissions cuts by industrial countries will have minimal carbon leakage effects.

At the same time, certain studies have found that domestic climate change policies will affect energy intensive industries in developed countries. For example Reinaud (2005), found that using the assumption of an per ton of carbon allowance price of €10, with the an objective of maintaining the market share, industries operational earnings may get affect from a modest to a significant level. Reinaud (2008) in another study analysed carbon leakage of various sectors and found that the aluminum and steel sectors can have higher leakages. An earlier study conducted by Gielen and Moriguchi (2002) found that if Japan and Europe introduce taxes on iron and steel @ of US $11 per ton of CO2 leakage can be as high as 35 percent by 2020. In another scenario, with a CO2 price of US$ 21/ton, the leakage rate can be as high as 50 percent by 2020. In another study Demailly and Quirion (2006) and Ponssard and Walker (2008), they tried to focus on the cap-and-trade policy system and found that cement has relatively high leakage rate and can range between 40 and 70 percent at a price of €20 per ton of CO2. Using general equilibrium models, Mckibbin and Wilcoxen (2009) used a carbon tax system which when implemented unilaterally in EU and US, respectively, resulted in a drop in real GDP in the range of 0.6-0.7 percent. At the same time there will be a carbon leakage of about 10 percent for EU and 3-4 percent for US.

4 http://www.unep.ch/etb/events/Trade%20and%20Climate%20Change/Brewer%20climate%20and%20trade%20paper.pdf, Accessed 24th January 2012.
5 http://www.c2es.org/docUploads/competitiveness-impacts-report.pdf , Accessed on 1 July 2011
6 ftp://ftp.zew.de/pub/zew-docs/dp/dp10056.pdf, Accessed 11th February, 2011

2.2 Impact in developing countries

There are limited studies that have estimated the impact of border tax adjustment on developing countries exports. Manders and Veenendaal (2008) had found that carbon based border taxes may entail a welfare loss for the rest of the world (developing countries). A study undertaken by Hubler (2009), with China as a case study, the author found that imposition of a carbon based border tax results in benefits for industrialized countries but China would be significantly worse off. China's manufacturing exports would decline by one-fifth and those of all low and middle income countries by 8 percent; the corresponding declines in real income would be 3.7 percent and 2.4 percent. Border tax adjustment based on the carbon content in domestic production would broadly address the competitiveness concerns of producers in high income countries but damage developing countries trade. A paper by ICTSD (2011) assessed the overall vulnerability of developing countries to possible EU BCAs, and identified where their specific vulnerabilities, in terms of products, lie. For this purpose, the trade flows originating from developing countries that would likely to face possible future EU BCAs were identified. The study had first identified the list of developing countries that are large GHG emitters whose share in global emissions is more than 0.5 percent. Based on these countries' export basket for EU, the paper identifies a list of sensitive products. Findings with respect to India suggest that the share of Indian exports to the EU of products that could be affected by possible border carbon adjustments could be as high as 24 percent. The same figures for China and Indonesia stood at almost 7 percent and 17 percent respectively.

Mattoo in 2009 estimated the possible decline of output and exports of energy-intensive manufactures in presence of possible border carbon adjustment taxes. A key factor affecting the impact of any border taxes is whether they are based on the carbon content of imports or the carbon content of domestic production. Quantitative estimates suggest that the former action when applied to all merchandise imports would address competitiveness and environmental concerns in high income countries but with serious consequences for trading partners. For example, China's manufacturing exports would decline by one-fifth while India's major manufacturing exports decline by 16 percent. The total decline in manufacturing output is estimated close to 3.5 percent in both countries. However, the average decline from all low and middle income countries is 8 percent.

2.3 Possible policies

Finally, there exist studies that have tried to address international competitiveness issues associated with border carbon adjustments. There are also studies that have tried to understand the role of policies to enhance international trade and climate change mitigation. As for example, Cosby (2007), identified areas and policies where action could enhance the contributions of international trade and investment to climate change mitigation options (clean technologies). Brewer (2008) present recommendations that will be beneficial to the development of climate change mitigation and international trade, investment and technology transfer - and the associated international institutional arrangements. UN secretary general's High-level Advisory Group on Climate Change Financing submitted a report that recognized the role of finance in technology development and transfer. Careful and wise use of public funds in combination with private funds can generate truly transformational investments. The study identifies sources and instruments for generating resources, combining instruments, and spending strategy. However, addressing such options may be not be that easy particularly in a situation when the developed countries are experiencing high fiscal stress.

Mattoo et al. (2009) suggests that one ways of ruling out border tax adjustments by industrial countries would be for developing countries to impose export taxes on carbon-intensive goods. This would have a number of advantages for developing countries. Because such an action would address both the competitiveness and environmental concerns in industrial countries, it would head off the pressure for BTAs in these countries. Developing countries would get to keep the tax revenues for themselves whereas with a BTA the importing country would obtain the revenues.

3. Objectives and key research questions

The current study is undertaken with the objective of addressing trade issues in climate change mitigation and adaptation from an Asian perspective. The project will examine the issues in carbon barriers to trade and their implications for trade competitiveness of developing countries as well as their implications for climate change mitigation and adaptation strategies. The study analyses the impact of India's export to US in the presence of any border tax adjustment. This is due to the fact that till date US has been the only developed country till date to develop a policy that had discussed about certain measures of addressing and a developing a broad mechanism of implementing broader adjustment measures. Although US has slipped from India's top export destinations, yet the share (11 percent) is still considered substantial and currently ranks only second after UAE (except the EU).

On the other hand, India is one of the top 20 countries exporting to the US. India's export has grown from US$ 6.6 billion to US$ 25.5 billion between 1996 and 2010 with a compound annual growth rate of 10.20 percent (Figure 3). A 'five yearly' CAGR shows that exports between 2001 and 2006 grew at more than 19 percent. However, post 2006, growth in exports fell sharply to 7.8 percent due shrinking demand arising from the global financial crisis. Some of the major exported products to US include precious stones, gems and jewellery, articles of apparel and clothing accessories and other textiles products, articles of iron and steel products, certain agricultural items and organic chemicals. These products represent more than 50 percent of the total exports.

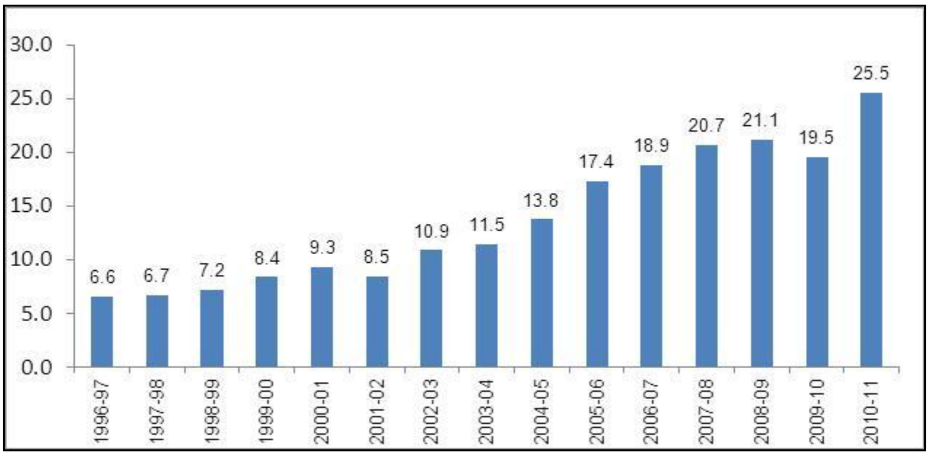

Figure 3: India's exports to US (in million US$)

Source: DGFT

It is may be interesting to note that despite having a significant share in India's exports to US, the share of such Indian products in US import basket is relatively small when compared with other developing countries.

The key research questions include:

- What are the current energy/carbon intensities of the major products exported from India to the US?
- How vulnerable are these products to future changes in climate change policies at import destinations countries like US?

4. Approach and Methodology

The overall approach has been divided into two parts (i) qualitative and (ii) quantitative. Qualitative analysis includes detailed survey of literature to understand the state of arts as well as identification of relevant issues and concerns of key stakeholders. Various policy and legal documents, trade agreements, and proceedings of meetings at various fora like the WTO etc, are also reviewed. Quantitative analysis include estimation of energy and carbon intensity of key exported products, estimation (including secondary collection) of price elasticity of exported products to major developed countries and finally using these estimates along with possible carbon based border measures to estimate the changes in exports from India.

4.1 The Input-Output Model

In the first step, carbon intensity of select exported products will be estimated using input-output model.

The structure of the input-output model can be expressed as:

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

In the above identify (i) X is a vector of dimension (Nx1) industrial output, Y is a vector of dimension (Nx1) final demand vector of the economy and A is a technical co-efficient matrix (NxN) that describe the interdependence of outputs of different industries of the economy.

Re-arranging the terms gives us the following

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

Here $(I - A)^{-1}$ is the matrix of total input requirements and I is an identity matrix of dimension (NxN). The carbon embodiment estimation of exported goods model is as follows.

Let R denote consumption of 'M' types of fuels used across 'N' sectors. This is represented the following matrix form:

$$\mathbf{R} = \begin{bmatrix} R_{11} & R_{12} & \cdots & R_{1N} \\ R_{21} & B_{22} & \cdots & R_{2N} \\ R_{M1} & R_{M2} & \cdots & R_{MN} \end{bmatrix} \text{ .... (iii)}$$

E is the emission intensity matrix

$$\mathbf{E} = [\ |E_{11} \quad E_{12} \quad \cdots \quad E_{1M}|] \text{ .... (iv)}$$

Therefore the total sectoral emission matrix is given by the expression:

$$\mathbf{TE} = \left[[|E_{11} \quad E_{12} \quad \cdots \quad E_{1M}| * \begin{vmatrix} R_{11} & R_{12} & \cdots & R_{1N} \\ R_{21} & B_{22} & \cdots & R_{2N} \\ R_{M1} & R_{M2} & \cdots & R_{MN} \end{vmatrix} * (I - A)^{(-1)}] \right]$$

Let us represent the elements of total emission expression as $|e_{11} \quad e_{12} \quad \cdots \quad e_{1N}|$ .... (v), where e_{1j} represents the total direct and indirect CO2 emission from use of fossil fuel in the above matrix.

Therefore, emission per unit if output produced is given as

$$\mathbf{TE/X} = [(e_{11})/\Sigma X_{1j} \quad (e_{12})/\Sigma X_{2j} \quad \cdots \quad (e_{1N})/\Sigma X_{Nj}] \text{ .... (vi)}$$

Here $(e_{11})/\Sigma X_{1j}$ is the emission embodied in the product to produce 1 unit of output 1. Similarly $(e_{12})/\Sigma X_{2j}$ is the amount of emission embodied in one unit of output 2. Finally emission embodied to produce 1 unit of output N is given by $(e_{1N})/\Sigma X_{Nj}$.

Now we consider India's exports to countries to be considered under the study, e.g. United States. We represent $E(us)_1^X$ as India's exports to US for output 1. Similarly, $E(us)_2^X$ represent the exports for output 2. If we multiply the export row matrix with I_j, (where I_j,= (1, 1,...1)' is a (N x 1) vector) then we get a matrix of (NxN) dimension with exports represented along the diagonal of the matrix. This is represented below:

$$I_j * [E(us)_1^X \quad E(us)_2^X \quad \ldots.. \quad E(us)_N^X] = \begin{bmatrix} E(us)_1^X & 0 & 0 \\ 0 & E(us)_2^X & 0 \\ & & \\ 0 & 0 & E(us)_N^X \end{bmatrix} \text{ ..... (viii)}$$

Finally the emission embedded in exports is given by.

$$[(e_{11})/\Sigma X_{1j} \quad (e_{12})/\Sigma X_{2j} \quad \cdots \quad (e_{1N})/\Sigma X_{Nj}] * \begin{bmatrix} E(us)_1^X & 0 & 0 \\ 0 & E(us)_2^X & 0 \\ & & \\ 0 & 0 & E(us)_N^X \end{bmatrix}$$

Further, multiplying carbon embodiment estimates in exports for each commodity with export elasticity and scenario based border carbon tax will give the potential reduction in exports

4.2 Key data and sources

The basic data used for the analysis is India's latest input output table for the year 2006-2007, published by ministry of statistics and program implementation (MoSPI). Data on India's exports to US have been used from Directorate General of Foreign trade (DGFT) database, ministry of commerce. Consumption of various fuels (like, coal, petroleum products, natural gas and electricity), in various sectors and the corresponding emission factors have been used from various sources. The data, year of analysis and the key sources are presented in table 1.

Table 1: Key data sources

Sl. No	Data	Year	Source[7]
1	India's latest Input-Output table	2006-2007	MoSPI & Planning Commission
2	India exports to US	2006-2007	DGFT
3	Consumption of Coal	2006-2007	TEDDY, Energy Stats MoSPI, Coal Stats Ministry of Coal, ASI
4	Petroleum products consumption	2006-2007	TEDDY, Energy Stats MoSPI, PETSTAT MoP&NG, ASI
5	Consumption of natural gas	2006-2007	TEDDY, Energy Stats MoSPI, PETSTAT MoP&NG, ASI
6	Consumption of electricity	2006-2007	TEDDY, Energy Stats MoSPI, PETSTAT MoP&NG, ASI
7	Possible carbon based import taxes/price per unit of allowance	2006-2007	From secondary literature survey/ETS price of carbon
8	Price elasticity of demand for India's goods in US		From literature survey

5. Analysis and results

The starting point of the analysis is India's latest input output table for the year 2006-2007 consisting of 130 sectors, as published by the ministry of statistics and programme implementation (MoSPI), Govt of India. The table has then been modified into 43 sectors input output table by grouping sectors on the basis of the nature of commodities and trade pattern. The input output table consisting of 130 sectors has been consolidated into approximately 30 key sectors. The key sectors include, agriculture and animal husbandry services, animal food and related products, cement and cement products, coal and coal tar, cotton textiles, electricity, fertilizers, glass and ceramic products, iron and steel, jems

[7] Ministry of Statistics and Program Implementation (MoSPI); Directorate General of Foreign Trade (DGFT), Ministry of External Affairs, Govt. of India; TERI Energy Data Directory Yearbook (TEDDY); Annual Survey of Industries (ASI); Petroleum Statistics (PETSTAT), Ministry of Petroleum and Natural Gas (MoPNG)

and jewellery, machinery (electrical and non-electrical), petroleum products, pulp and paper, plastic and related products, sugar, rubber and rubber products, etc.

Coal, petroleum products, natural gas and electricity are four forms of energy mostly consumed in these sectors and have been considered in the study. Data related to consumption of fuels in these sectors have been taken from various sources. Data on sectoral consumption of coal and electricity in physical units are provided in Annual Survey of Industries in India (ASI) Vol I (2006-2007). However, consumption of petroleum products and natural gas in physical units by the above sectors are estimated indirectly by dividing their consumption (in monetary units) with their appropriate weighed unit prices. Key petroleum products analysed include liquefied petroleum gas (LPG), naphtha, high speed diesel oil, light diesel oil, furnace oil and motor spirit and pet coke. LPG is widely considered as a domestic fuel and has very little industrial application. On the other hand, naphtha, furnace oil, LDOs and pet coke have very high industrial usage. Weighted prices of these products have been estimated using data from PETSTAT, published by the ministry of petroleum and natural gas. The estimated consumption of fossil fuel in these sectors is presented in table 2.

Table 2: Energy consumption by various sectors for the year 2006-2007

	Coal (Th Ton)	Pet Product (Th Ton)	Natural Gas (Th Ton)	Electricity (GWh)
AAHS	241	2867	0	961
AFRP	145	349	0	1579
CEMENT	25020	4539	659	11000
CHMLS	4040	3002	3858	9115
COL&COLTAR	5	234	0	448
COT-TEX	3947	1444	522	21282
ELC	331500	3124	10618	344
FERT	2879	3714	7708	1616
GLS&CR	2282	1015	5	1842
IR&ST	19204	2206	5952	40121
J&JLY	0	12	0	228
L&LP	43	90	0	612
MACH-E	63	1178	4	5031

	Coal (Th Ton)	Pet Product (Th Ton)	Natural Gas (Th Ton)	Electricity (GWh)
MACH-NE	98	539	414	2340
NATG	2	43	0	447
OFPBTP	1623	769	1	6162
OTHMET	13825	831	786	12345
OTHMIN	62	982	16	1682
OTHR-MAN	12	165	0	459
PEST	17	89	0	561
PET-PRD	5	3740	0	567
PLP&Pr	4920	386	0	3902
PLST	47	266	0	4120
Rb&RbP	158	234	0	1645
SUGAR	216	211	0	591
TR-AGR-MACH	35	37	0	266
TRANSP	37	490	0	4420
W&WP	44	46	0	476
SERVICES	0	32231	2	51020

Coal finds largest application in thermal power production due to the fact that almost 56 percent of electricity in India is still generated from coal and lignite consuming almost three hundred and thirty million tonnes based on 2006-2007 estimates. Cement follows next with a total coal consumption of twenty five million tonnes for the same year. Cement is the largest consumer of petroleum products within industrial sector category. One of the reasons for this is due to the fat the cement is India's largest consumer of pet coke, a by-product, derived from the refining of crude. The cement industry is able to use high volumes of pet coke as the presence of high sulphur content in pet coke is neutralized by the use of limestone in the clinkerisation process. Other major consumers of petroleum products include fertilizer, power, chemicals and iron and steel. Top two consumers of natural gas include electricity and fertilizers that consumed more than ten and seven million tonnes respectively. With regard to electricity, iron and steel is the largest consumer of electricity.

The sectoral fuel consumption was used along with fuel specific emission intensity to estimate the total sectoral carbon emissions as well as the emissions per unit of produced products. The emission coefficients by fuel type used in this study are 1.614 and 3.102 tons of CO2 per ton of coal and petroleum products respectively, and 0.0021 tons of CO2 per cubic metre of natural gas. These coefficients are arrived by considering emissions by fuel type in tons per Giga Joule (tons/GJ) after adjusting for the calorific values of the fuel types used in India (Parikh et.al). The emission intensity for electricity generation is the weighted average emission from electricity generation from various sources. Emission coefficient by fuel type is presented in table 3.

Table 3: Emission coefficient by fuel type

Fuel name	Output weight	Emission factor (tons/GJ)	Indian Calorific value (GJ/ton)	Emission Coefficient (tons of CO2 per ton of fuel)
Coking coal	0.0728	0.0255	16.7472	1.5677
Non-coking coal	0.8574	0.0261	16.7472	1.6045
Lignite	0.0699	0.029	16.7472	1.7777
Total coal				**1.614**
Petroleum products		**0.0202**	**41.868**	**3.1024**
Natural gas		**0.0153**	**0.038**	**0.0021**
Electricity				**0.0009#**

Source: *J Parikh et al., Ministry of Power, Government of India*

Finally using the sectoral consumption and the emission factors and applying relation identified in (iii) in the methodology, total carbon emission was estimated as presented in figure 4.

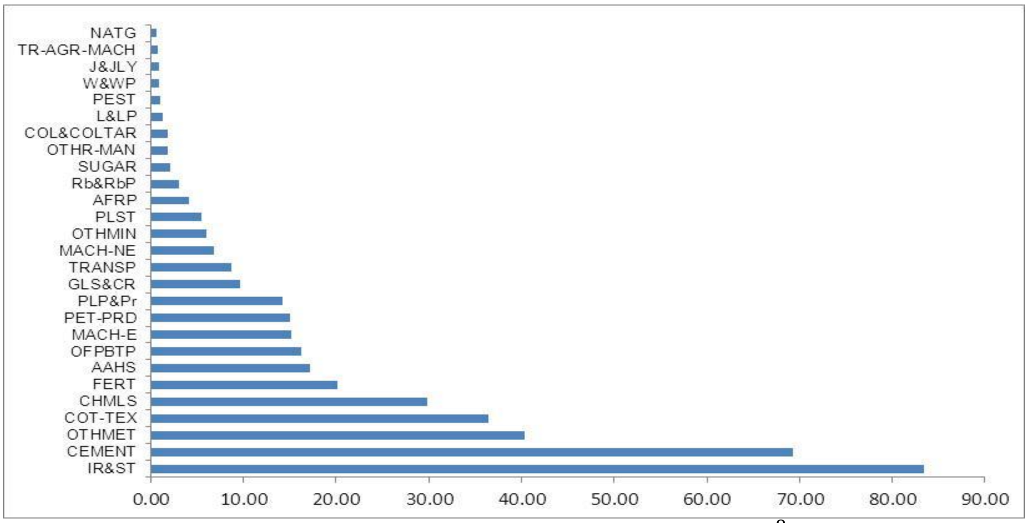

Figure 4: Estimated sectoral CO2 emission (million tonnes)[8]

Based on the above exercise, the total carbon dioxide emission due to economic activities for the year 2006–07 has been estimated at 1210 million tonnes. Indian government in its second emissions inventory with the reference year 2007 estimated the total CO2 emission as 1221.76 Mt or 1.22 Gt (inclusive of land use, land use change and forestry) (MoEF, 2010). Electricity is the largest emitter of carbon dioxide with a total emission of 591 million tonnes. Other major emitters of CO2 include iron and steel, cement, textiles, fertilizers, etc. Of the total direct emissions, coal and lignite account for 737 million tonnes, which accounts to almost 60 percent of the total emissions. Petroleum products account almost 23 percent of the total emission followed by electricity and natural gas.

Next we estimate the direct CO2 emission per unit of output as presented in table4. This is arrived at dividing the total emission by output of the different sectors.

Table 10.3: Direct CO2 emission per unit of output (Kilo ton/Rs million)

	Coal	**Petroleum Products**	**Natural Gas**	**Electricity**	**Total**
AAHS	0.00006	0.00135	0.00000	0.00011	0.00152
AFRP	0.00010	0.00049	0.00000	0.00057	0.00116
CEMENT	0.13803	0.05168	0.00000	0.03175	0.22146
CHMLS	0.00222	0.00341	0.00000	0.00262	0.00825
COL&COLTAR	0.00001	0.00139	0.00000	0.00067	0.00208
COT-TEX	0.00274	0.00207	0.00000	0.00774	0.01256

[8] The figure excludes CO2 emission from power sector. The emission from electricity generation from coal was estimated at 863 million tonnes

	Coal	Petroleum Products	Natural Gas	Electricity	Total
ELC	0.31395	0.00611	0.00001	0.00017	0.32024
FERT	0.01036	0.02759	0.00003	0.00304	0.04102
GLS&CR	0.01504	0.01380	0.00000	0.00635	0.03519
IR&ST	0.01218	0.00289	0.00000	0.01332	0.02840
J&JLY	0.00000	0.00006	0.00000	0.00030	0.00036
L&LP	0.00033	0.00144	0.00000	0.00249	0.00426
MACH-E	0.00003	0.00112	0.00000	0.00121	0.00236
MACH-NE	0.00010	0.00119	0.00000	0.00131	0.00261
NATG	0.00003	0.00147	0.00000	0.00390	0.00540
OFPBTP	0.00089	0.00087	0.00000	0.00176	0.00351
OTHMET	0.01378	0.00171	0.00000	0.00644	0.02193
OTHMIN	0.00018	0.00591	0.00000	0.00256	0.00865
OTHR-MAN	0.00004	0.00115	0.00000	0.00081	0.00201
PEST	0.00025	0.00268	0.00000	0.00430	0.00722
PET-PRD	0.00000	0.00475	0.00000	0.00018	0.00493
PLP&Pr	0.01427	0.00231	0.00000	0.00592	0.02251
PLST	0.00015	0.00170	0.00000	0.00668	0.00853
Rb&RbP	0.00068	0.00209	0.00000	0.00372	0.00649
SUGAR	0.00126	0.00253	0.00000	0.00180	0.00558
TR-AGR-MACH	0.00031	0.00066	0.00000	0.00122	0.00219
TRANSP	0.00004	0.00114	0.00000	0.00261	0.00379
W&WP	0.00034	0.00075	0.00000	0.00194	0.00303

As can be seen from the above table, Cement and Electricity are two most carbon intense sectors. In both these sectors most of the emissions is due to the use of coal, the major fuel for them. Clinker is another source of emission in the cement production process and emission on this account is more than that due to use of fuels in the cement sector. Fertilizer, steel, glass and ceramic, other metals, etc.

are the other major carbon intense sectors. Of these, in Fertilizer the emission arises primarily due to the use of petroleum products, while in steel and in the emission arises mostly from the use of coal and electricity. Other sectors especially agriculture and animal husbandry, food and food products processing industries, etc. have much lower CO2 intensity. However, it is important to note that in table 10.2 emission coefficients per unit of output not only depend on the energy use, the total emissions would also depend on the volume of sectoral output.

6. Import demand elasticity and impacts on exports

From the international trade theory a change in import tariff will affect total imported price of a product which in turn will affect the total demand of the product. In other words, the effect of change in tariffs on foreign market access broadly depends on the price elasticity of demand over and above the price elasticity of supply and they together determine the overall price elasticity of exports. Hence market access effect can be decomposed into the market effect and competitive effect. If there is a fall in import price then import demand will experience an upward shift. This effect termed 'market effect' describes the effect of changes in relative prices on overall imports. If tariff rates are lowered, the market effect will expand the markets. The 'competitive effect' however, suggests that even if tariff reduction results into higher import demand, for an individual country, the effect of such increase may not be significant due to low price elasticity for its products. A country's exports face competition not only from domestic producers in the importing region, but also from "third country" exporters to that region. With fall in the import prices, terms of trade changes for all the exporting countries. However some countries are able to exploit the export potential due to greater price competitiveness, while others fail to do so. Thus, normally the dominant relative price competition occurs among exporters.

There exists many studies that have tried to estimate the price responsiveness (elasticity) of India's exports with respect to US demand, Some of them include Bhagwati and Srinivasan (1975), Wadhwa (1998), Srinivasan (1998) provide estimates of price responsiveness of India's exporter items to US. Other studies by Virmani (1991), Joshi and Little (1994), Krishnamurthy and Pandit (1995) and Roy (2002) also point to significant price responsiveness of India's exports. Aggarwal (2004) quantitatively assesses likely changes in India's market access opportunities for Indian exports owing to tariff reductions by the USA. The study identifies particular products for India at the ISIC 4-digit level of disaggregation that are possible tariff sensitive. The author divides the relative percentage change in the export prices (i.e. total price effect) into two components viz. the market effect and the competitive effect. The import product price in US from India as estimated using the above approach is presented in table 5.

Table 5: Price elasticities of key exported products from India to US

Sl. No	Product description	Elasticity	Sl. No	Product description	Elasticity
1	Manufacture of transport equipment not elsewhere classified	20.2	22	Manufacture of special industrial machinery and equipment except metal	2.27

Sl. No	Product description	Elasticity	Sl. No	Product description	Elasticity
2	Manufacture of fertilizers and pesticides	7.9	23	Manufacture of chemical products not elsewhere classified	2.12
3	Shipbuilding and repairing	6.7	24	Printing publishing and allied industries	2.09
4	Manufacture of electrical appliances and housewares	6.4	25	Manufacturing industries not elsewhere classified	2.05
5	Manufacture of pulp paper and paperboard articles not elsewhere classified	6.1	26	Manufacture of structural clay products	2.01
6	Manufacture of pulp paper and paperboard articles not elsewhere classified	5.8	27	Manufacture of pottery china and earthenware	1.92
7	Soft drinks and carbonated waters industries	5.4	28	Manufacture of motor vehicles	1.92
8	Manufacture of furniture and fixtures primarily of metal	5.0	29	Manufacture of watches and clocks	1.67
9	Manufacture of containers and boxes of paper and paperboard	5.0	30	Manufacture of made-up textile goods except wearing apparel	1.59
10	Manufacture of rubber products not elsewhere classified	4.5	31	Manufacture of basic industrial chemicals except fertilizers	1.41
11	Manufacture of office computing and accounting machinery	4.4	32	Manufacture of photographic and optical goods	1.31
12	Manufacture of rail road equipment	4.3	33	Tyre and tube industries	1.27
13	Manufacture of plastic products not elsewhere classified	4.3	34	Manufacture of cutlery hand tools and general hardware	1.10
14	Manufacture of soap and cleaning preparations perfumes cosmetics and other toi	4.1	35	Canning preserving and processing of fish crustacea and similar foods	1.03

Sl. No	Product description	Elasticity	Sl. No	Product description	Elasticity
15	Manufacture of electrical apparatus and supplies not elsewhere classified	4.0	36	Manufacture of products of leather and leather substitutes except footwear and	0.98
16	Manufacture of radio television and communication equipment and apparatus	3.7	37	Manufacture of sporting and athletic goods	0.98
17	Iron and steel basic industries	3.0	38	Manufacture of metal and woodworking machinery	0.92
18	Manufacture of vegetable and animal oils and fats	2.8	39	Manufacture of professional and scientific and measuring and controlling equipm	0.79
19	Canning and preserving of fruits and vegetables	2.7	40	Manufacture of drugs and medicines	0.71
20	Manufacture of glass and glass products	2.5	41	Manufacture of jewellery and related articles	0.55
21	Manufacture of synthetic resins plastic materials and man-made fibres except gl	2.4	42	Manufacture of fabricated metal products except machinery and equipment not - el	0.32

Source: *Aggarwal, 2004*

Using these elasticity estimates, impact of carbon taxes on India's exports to US was estimated under two carbon tax scenarios viz. (i) € 20/ton, (ii) € 30/ton. The taxes are the average and peak prices of carbon that was traded in the European market for the 2006-2007. The EU price has been considered due to non-availability US carbon price data. With regard to tax imposition, there may exist various options. The first option can be a border tax adjustment based on the carbon content embodied in the domestically produced good in the importing country (i.e. US); which can be termed as Border Tax Adjustment based on Domestic Unrestricted carbon content (BTADU) (Mattoo, et. al, 2009). As for example, if the United States has a CO2 tax of, say, US$10 per ton and the direct and indirect CO2 content in car production in the United States is 20 tons, the United States could apply a CO2 tax of U$200 on the imports of cars. Border tax adjustment based on the carbon content in domestic production would broadly address the competitiveness concerns of producers in high income countries and less seriously damage developing country trade.

The other option is a similar tax adjustment except that it is based on the carbon content embodied in imports, Border Tax Adjustment based on Foreign Unrestricted carbon content (BTAFU). In the same example, if the direct and indirect CO2 content in Indian car production is 40 tons, the United States would apply a CO2 tax of US $400 on the imports of cars from developing countries (Mattoo, et.al). Here we consider the second option. This option will give us the maximum impact on developing countries' exports in the presence of border carbon tax. Using the elasticity estimates of different exported commodities along with the possible border tax, the overall and product specific impact in exports to US is presented in table 6.

Table 6: Impact on India's exports to US under two BTA scenarios

	Total Exports	Share of exports in total	Percent decline under scenario € 20/ton	Percent decline under scenario € 30/ton
CEMENT	1540.73	0.02%	53.38	80.07
FERT	126.89	0.00%	39.48	59.23
PLP&Pr	29147.26	0.34%	12.69	19.04
IR&ST	674667.68	7.95%	10.81	16.21
GLS&CR	24792.31	0.29%	10.16	15.24
PLST	77888.89	0.92%	4.75	7.12
SUGAR	1013.33	0.01%	3.73	5.60
Rb&RbP	105032.69	1.24%	3.39	5.08
COT-TEX	2158154.98	25.42%	2.88	4.32
W&WP	11789.02	0.14%	2.86	4.29
OTHMET	176056.02	2.07%	2.62	3.92
OTHMIN	171153.35	2.02%	2.55	3.83
TRANSP	251448.9	2.96%	1.94	2.91
MACH-E	811423.19	9.56%	1.70	2.54
OFPBTP	70252.98	0.83%	1.53	2.29
CHMLS	810818.64	9.55%	1.48	2.23
OTHR-MAN	297980.78	3.51%	1.01	1.51
AAHS	286654.08	3.38%	0.74	1.11

	Total Exports	Share of exports in total	Percent decline under scenario € 20/ton	Percent decline under scenario € 30/ton
L&LP	97939.03	1.15%	0.68	1.02
AFRP	136079.59	1.60%	0.20	0.29
J&JLY	2161740.57	25.46%	0.08	0.12
Others	134724.02	1.59%	0.00	0.00
TOTAL	**8490424.9**	**100%**	**2.34**	**3.50**

From the above table we see the total decline in India's exports to US in presence of two tax scenarios are 2.34 percent and 3.5 percent respectively. Now, if we analyze the impact by sector, the sector whose exports are found to be affected significantly in the presence of border carbon adjustment is cement. The expected decline under two scenarios is estimated to be 53.38 percent and 80.07 percent respectively with respect to 2007 cement exports to US. However, the decline is not significantly going to impact the sector as export share of cement to US is very low (i.e. 0.02%) when compared with total export basket to US. Moreover, Malaysia and UAE were the major destinations for India's Cement exports during 2007 and these two countries together accounted for 63 percent of India's total cement exports. Germany and Maldives come next in the order accounting for 6.8 percent and 5.7 percent respectively[9].

The next potentially impacting sector is fertilizer, whose exports are expected to decline by 39 percent and 59 percent respectively. Again, the possible decline will not have a significant economic loss since the share of fertilizer in total exports is the lowest. Most the exports (i.e. ~ 65%) are towards developing countries like (Mozambique, Oman, Nepal, United Arab Emirates and Bangladesh). Exports to US account for approximately 2.5 percent of the total fertilizer exports.

Other sectors that might experience substantial fall in exports are pulp and paper, iron and steel and glass and ceramic. Under €20/ton of BTA, the respective decline in exports to US of products from these sectors will be 12.69 percent, 10.81 percent and 10.61 percent, while for €30/ton, the respective decline will be 19.04 percent, 16.21 percent and 15.24 percent. Out of these three sectors, iron and steel product exports may have a substantial impact due to relatively high share of 8 percent in the US export basket. Moreover, US is the most important export destination of iron and steel products and in 2006-07, and the share was 16.7 percent of the total iron and steel exports.

With regard to glass and ceramic, the product may not have significant share relevance in total export basket to US, yet US is the second largest export destination and is only next to UAE. India's export to US is 11 percent of the total glass and ceramic exports from India and reduced exports will significantly bring substantial loss to the sector.

[9] http://newsletters.cii.in/newsletters/mailer/trade_talk/pdf/Cement%20Industry%20in%20India-%20Trade%20Perspectives.pdf, Accessed 23rd July, 2012

India is one of the largest producers as well as exporters of cotton yarn in the world and account for more than 3 percent per cent of global textiles and clothing trade. US is one of the largest export destinations of cotton textiles for India. In 2007, cotton textiles accounted for more than one-fourth of the total exports to US. India is among the top five countries exporting such products. China leads the list with a share of almost 31 percent, while India's share is approximately 6 percent. The above information indicates how significant US is as an export destination of cotton textiles products. It is estimated that in the presence of border carbon taxes, the possible decline in cotton exports will be 2.8 percent and 4.32 percent respectively. The decline (in percentage terms) may not be very significant compared to the export decline as observed for other manufacturing exports, yet, in terms of decline in export revenue (Rs 6210 million) the sector tops the list. The textile sector employs nearly 35 million people and after agriculture, is the second-highest employer in the country. Its importance is underlined by the fact that it accounts for around 4 percent of gross domestic product, 14 percent of industrial production, 9 percent of excise collections, 18 percent of employment in the industrial sector, and 16 percent of the country's total exports earnings[10]. Hence, even a marginal dip in export will have significant socio economic impact particularly loss in employment, income, and government revenue generation among other developmental parameters.

Finally in the gems and jewellery sector, the overall decline in exports to US may very high as evident from table 11.12, yet, it is important to understand the importance US has as the largest export destination for India's gems and jewellery products. As per 2006-07 export figures, export share to US out of total gems and jewellery exports, was almost 30 percent. Other major export destinations include Hong Kong (22 percent), UAE (21 percent), Belgium (9 percent) and Israel (5 percent). The bulk of the jems and jewellery sector is in the unorganized sector and employs an estimated 3.3 to 3.4 million. More than 35 percent of the people working are involved in jewellery manufacturing units. Since, US is the largest market, as per 2007 figures, particularly for jewellery items and products, any decline in export will have substantial impact in the overall employment. Most of them are involved in manufacturing units that are skill intensive, loss in employment will result in difficulty in finding alternate sources of income. India has already experienced huge loss in employment of more than 100000 skilled and semi skilled man power within in a span of six to eight months when the world experienced one of the largest economic recessions in recent times. This clearly indicates the how vulnerable the sector is to any change in exports.

7. Conclusion

One of the key reasons behind the proposal of the carbon border tax adjustment is to compensate the loss of competitiveness of carbon intensive products due to CO2 abatement actions. India's significant share of income flows from exports primarily to developed countries, and any decline in such income would not only impact the national income but would also have serious socio-economic implications. In this paper, we estimated the impact of US' border tax adjustment on India's exports, using the input output model framework. It is estimated that India's exports to US will decline by 2.34 percent and 3.5 percent under two different scenarios, viz., €20/ton and €30/ton. Although it may be argued that the negative impact may taper off with time where India may find alternate export

[10] http://www.legalpundits.com/Content_folder/THETEXTILEINDUSTRYREPORT290710.pdf

destinations or export products with low energy or carbon intensity, it is perceived that short to medium term challenges will be very high and the situation can further be complicated due to ongoing global economic recessions which the world is yet to recover from completely.

In the context of global economic integration, imposition of tariff based on carbon content will have negative effects not only on India but on all major developing countries while not ensuring that global emissions will get reduced. For effectively reducing CO2 emissions and protecting the global environment, it is important to follow a low-carbon economy but not compromising on the other two pillars of sustainable development. Developing countries are relatively more vulnerable, and they do have significant interest in mitigation efforts made by the global community as a whole. They need to develop technical, institutional and human capabilities to face the increasing challenge of adaptation and mitigation (Nanda and Bhattacharjya, 2011).

Developing countries should also contribute to the global efforts of climate change mitigation as much as they can. But this should be in accordance with a multilateral framework that adheres to the principles of equity as well as on the common but differential responsibilities and considers the development needs and priorities. Unilateral measures to impose certain conditions on developing countries are unlikely to make any positive contribution to global efforts to mitigate climate changes that are urgently needed.

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