



# Assessing the Likely Impact of Carbon Taxes on India's Exports, Domestic Production and Employment

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Revised Report

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## 1. Introduction

The concentration of carbon dioxide (CO<sub>2</sub>) in the atmosphere has been increasing over the last two decades at the average rate of about 0.5 percent per year. Some recent studies have indicated that inconceivable catastrophic changes in the environment will take place if the global temperatures increase by more than 2° C. It is believed that such an increase in global temperatures threatens both the ecosystem and the survival of humanity. A warming of 2° C corresponds to a carbon dioxide (CO<sub>2</sub>) concentration of about 450 ppm in the atmosphere. CO<sub>2</sub> concentration has already crossed 390 ppm (392 ppm by volume in July 2011)<sup>1</sup> and has been rising on average 2-3 ppm each year. Thus, if the present trend continues, the critical value will be reached in approximately 20 to 30 years from now, which makes it a major concern today.

If CO<sub>2</sub> emissions are halved by 2050 compared to the 1990 level, global warming can be stabilized below two degrees. This is shown by two studies published in the journal, *Nature* (Allen et al., 2009; Meinshausen et al., 2009). In contrast, between 1990 and 2009, CO<sub>2</sub> emissions have increased by about 38 percent (IEA, 2011a). The annual growth rate of CO<sub>2</sub> emissions at the global level in the 1990s was about one percent per year, while that in period 2000 to 2009 was higher at about 2.4 percent per year. All these make immediate containment of CO<sub>2</sub> emissions extremely important.

At the multilateral level, countries are currently engaged in intense negotiations for evolving appropriate responses to challenges posed by climate change, including measures to combat climate change. In this context, it may be mentioned that while the developed countries had undertaken greenhouse gas (GHG) reduction commitments under the Kyoto Protocol of 1997, the developing countries were not required to make any such commitments. This was based on the principle of “common but differentiated responsibility” (CBDR principle) which lies at the heart of the United Nations Framework Convention on Climate Change (UNFCCC) of 1992. The Kyoto Protocol was, however, not ratified by all developed countries. It was ratified late by Australia in 2007, and not ratified by the US. With the first commitment period ending in 2012, there have been a lot of activities in the last few years towards framing of a new commitment. A critical facet of recent discussions is the protest aired by the developed countries that they could not continue to shoulder the burden of mandatory obligations on their own, and the developing countries, which are major emitters of greenhouse gases, would need to undertake some commitments. The Copenhagen Accord of December 2009 reflects these ideas, and the Cancun Agreement of December 2010 further builds on these (Anuradha, 2011). It should be noted that neither the Copenhagen Accord nor the Cancun Agreement has the status of a legally binding treaty. The Copenhagen Accord is widely held as a political agreement between some parties but not all. The Cancun Agreement goes a step further in that it reflects the commitment of parties to

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<sup>1</sup> As reported in Wikipedia ([http://en.wikipedia.org/wiki/Carbon\\_dioxide](http://en.wikipedia.org/wiki/Carbon_dioxide) accessed 21-10-2011).

work on the principles contained therein. The significance of the Cancun Agreement is that it reflects a move towards more concrete obligations for developing countries for greenhouse gas reduction.

In the recently held UNFCCC conference at Durban in December 2011, the countries have agreed to have a legally binding deal that will require both developed and developing countries to cut their carbon emissions. The terms of the deal will have to be agreed by 2015 and will come into effect by 2020. The major emitters have targets to cut emission between now and 2020. But, these are voluntary targets and not legally binding.

While the Durban conference was successful in making a definite move towards legally binding emission reduction commitments for developing countries such as China and India, the deal did little to address the scale of emission cuts needed. Some feel that the deal may not be sufficient to keep in the rise in temperature within 2° C. Nicholas Stern, former World Bank chief economist and author of the landmark 2006 review of the economics of climate change, is of the view that the outcome of the Durban summit is a modest but significant step forward. The decision to move towards a unified system, with all countries having some form of legal commitments, removes an important obstacle and could allow, for example, the US to play a more participative and constructive role in the future (Harvey and Vidal, 2011).

### ***Interface of Trade with Measures for Combating Climate Change***

The interface of international trade with the measures for combating climate change has been receiving increasing attention (Asselt and Zelli, 2011). One serious concern of the developing countries in this regard is the possibility of some developed countries adopting unilateral trade measures in the form of border tax adjustments (BTA) to restrict exports of the developing countries to the developed country markets. The developed countries may take such measures on the ground that if they adopt measures to reduce substantially their GHG emissions, they may lose competitiveness of the energy intensity industries vis-à-vis the countries that do not adopt similar measures. Another argument is that in the absence of border tax adjustments, there may be emission leakage since the production of energy intensive products may shift to locations where it faces much less restrictions (i.e. shift to China, India and other developing countries) with the consequence that at the global level, the emissions may not reduce in accordance with the efforts made by the developed countries. Legislative efforts are underway in the US and the EU to cap GHG emissions, which contain provisions that provide ability to impose unilateral trade measures on imports from countries that do not have comparable GHG reduction norms (Anuradha, 2011).

It should be pointed out here that Article 3.5 of the UNFCCC provides for the use of unilateral trade measures. At the same time, it guards against the possibility of such measures being discriminatory and trade restrictive. Article 3.5 of the UNFCCC states: “Measures to combat climate change, including unilateral ones, should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade.” The article is, however, silent on the actual circumstances that might justify such measures. It appears that unilateral action under Article 3.5 is likely under two situations – one, if countries fail to arrive at greenhouse gas reduction commitments for the period beyond 2012 pursuant to the emission

reduction regime agreed to in the Kyoto protocol, and two, if countries feel that any agreement concluded does not meet the negotiating objectives (Anuradha, 2011). Evidently, absence of a satisfactory agreement on GHG emissions reduction beyond 2012 will be a fertile ground for adoption of unilateral trade measures. But, even if a satisfactory agreement is reached, inadequate compliance could trigger such unilateral measures (Anuradha, 2011).

One major issue about the unilateral trade measures is whether these are compatible with the WTO rules. Many commentators on this subject feel that any unilateral action involving carbon border adjustment of imports would be challenged under the WTO rules. A developing country could argue that the measure targets products that can be considered 'like' and therefore the unilateral measure is unjustified (Sindco, 2009). Furthermore, if the measure contains a determination of 'comparable action' (as do the measures for which legal processes are underway in the US and the EU), it can be argued that it is not applied to all countries as required by the most-favoured nation principle (Sindco, 2009). There are other issues which the developing countries could raise about the implementation of the measure. In fine, there are legal uncertainties about the unilateral trade measures and the final word will be with the judicial bodies of the WTO (Asselt and Gupta, 2009).

Given the serious concerns that the developing countries have with the unilateral border measures that the developed countries, particularly the US, may adopt, this study deals with introduction of carbon tax in the US, and tries to ascertain what impact it will have on India in terms of exports, output and employment, if the carbon tax in the US is accompanied by unilateral trade measures that restrict India's exports to the US.

The analysis presented in the Report has been undertaken in the context of the provisions of the Waxman-Markey bill of the US. The US has been planning to adopt an emission allowance program under the Waxman-Markey bill. Although this is an allowance program, for the purpose of empirical analysis, the provisions could be treated as resulting in a carbon tax on imports. The bill contains two kinds of provisions. First, grants of free emissions to certain energy intensive and/or trade intensive industries, which are likely to include Iron and Steel, Paper and Paperboard, Rubber manufacturing, Plastics, Organic and inorganic chemicals, and Petrochemicals. The amount of allowance would roughly depend on the sector's output, its carbon intensity and the additional "tax" created by the emission cuts. But, whether the allowance would be based on the industries' future and current output (like a production subsidy) or will be given as a lump sum transfer on their historical output, has not been made clear yet. However, the magnitude of the allowance would be related to carbon intensity in domestic production in either of the cases.

Second, the bill on the basis of some eligibility criteria same as for emission allowance (which is not been declared yet) requires importers of certain sectors to purchase allowances at the going market prices. As this restriction would impose a certain cost to the importers, it would serve as a border tax adjustment. But the magnitude of this border tax would depend on whether the purchase of allowance must cover the actual carbon content of imports or the carbon content in the comparable domestic output. Therefore, in this study, this additional cost to importers has been treated as carbon tax imposed by the US government and the impacts of both the options mentioned above have been analyzed.

## *Organization of the Report*

The Report is organized as follows. The next section, Section 2, discusses briefly some earlier studies that have been done on the impact of carbon tax on the US economy. A particular focus is on the impact that border tax adjustments will have on developing country exports to the US if such measures are adopted by the US. This is followed in Section 3 by a theoretical discussion on how developing countries would be impacted by the introduction of carbon tax in a developed country, if the tax is coupled with border adjustment. Section 4 takes up the case of India and makes an attempt to assess how India will be impacted by a carbon border tax in the US. Impact is assessed in terms of exports, domestic production and employment. Such assessment of impact is done also for some other developing countries, particularly China, Brazil and South Africa. Section 5 compares India and a few other developing countries with the US in terms of energy intensity and CO<sub>2</sub> emission intensity. This is obviously relevant in the context of the present study, especially for judging how a carbon border tax based on the carbon embodied in imports will impact different developing countries. Section 6 is primarily devoted to a discussion on India's Perform, Achieve and Trade Scheme – a market based mechanism that would improve energy efficiency in energy intensive large industries in India. A discussion on this scheme is important because it will counter the US argument to subject India's manufactured exports to the US to border tax adjustment. Finally, the main finding of the study and conclusions are given in Section 7.

## **2. Previous studies on the impact of Carbon Tax in the US**

There have been a number of studies on the impact of carbon price policies on the US economy, especially on energy intensive industries in the US.<sup>2</sup> The computable general equilibrium (CGE) models have generally been used for assessing the impact of a carbon tax (including cap-and-trade schemes).<sup>3</sup> Often, this has been done on the basis of the GTAP (Global Trade Analysis Project) database, which is a multi-sector (more than 50 sectors), multi-region database of output and trade flows and permits formulation of a general equilibrium model for the world economy. Some studies have used a national model. Others have used a global model in which the behavior of countries other than the US has been taken into account. To give an example of the former group of studies, the Inter-temporal General Equilibrium Model (IGEM) have been used by Jorgenson et al. (2007) who find that by 2020 the economic burden of greenhouse gas mitigation policy based on a revenue neutral carbon tax or a cap-and-trade system with emissions constrained to year 2000 level would be relatively small at about 0.5 to 0.7 percent of GDP. According to their analysis, substitution away from more costly inputs (energy) and towards

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<sup>2</sup> Such studies have been undertaken also for the EU (for example, Bollen and Brink, 2011), Japan (for example, Yano, et al., 2011; and Takeda, et al., 2011), and other countries such as Australia (Pezzey and Lambie, 2001), Indonesia (Yusuf and Resosudarmo, 2007) and Thailand (Malla, 2005). Some studies have covered both the US and the EU (for example, McKibbin and Wilcoxon, 2008). Some studies consider the impact of carbon price policies in respect of the entire block of industrialized countries (for example, Hübler, 2009).

<sup>3</sup> There have been studies on the US climate policy without employing a CGE model. See, for example, Houser et al. (2008).

cheaper materials, labour and capital, along with price induced technical change will help to reduce the adverse impact of carbon pricing policies. To give an example of the second group of studies, Adkins et al. (2011) apply a global CGE model based on GTAP-7 data. They consider eight countries/ regions, namely the US, Canada, Mexico, China, India, Rest of Annex-I<sup>4</sup> countries, Oil Exporters and Rest of the World, and 29 industries. Another example is Dong and Whalley (2009a) who consider four regions: the US, the EU, China and the rest of the world.

To list here some of the other studies undertaken on the impact of carbon pricing policies on the US economy, these include Ho et al. (2008), Adkins et al. (2010) and Fischer and Fox (2007, 2009a, 2009b) using GTAP based model, the US Energy Information Administration (EIA, 2009) using its NEMS model, the US Environment Protection Agency (EPA, 2009a) using the ADAGE model and the inter-agency US government using an updated version of the Fischer-Fox model (EPA, 2009b).<sup>5</sup> A common finding of these studies is that output based rebates are effective in containing output decline in energy intensive trade exposed industries caused by the carbon pricing policies.

Particularly relevant to the present study are the modeling attempts made in the context of carbon tax in the US where the model designing was done in accordance with the Waxman-Markey bill (the American Clean Energy and Security Act which was passed the US House of Representatives in June 2009 but did not subsequently get approval in the Senate). But, there have been other modeling attempts which took into account provisions of other bills. Metcalf et al. (2008), for instance, consider Larson proposal (H.R. 3416; America's Energy Security Trust Fund Act of 2007) and Stark-McDermott proposal (H.R.2069; Save Our Climate Act of 2007). The provisions relating to border tax adjustment in various bills for the US have been discussed by Asselt et al. (2009) among others.

A common finding emerging from many of the studies undertaken on the impact of carbon tax in the US is that the extent of emission leakage at the aggregate level is relatively low. The estimated leakage rate in the study of Adkins et al. (2011), for instance, is 6.3 percent. Such estimate reported in Fischer and Fox (2009b) is about 14 percent. However, for specific industries, the leakages could be high. In the estimates made by Fischer and Fox (2009a) for energy intensive industries, the baseline leakage rates are: 20 percent for chemicals, 39 percent for non-metallic mineral products, 11 percent for pulp, paper and printing, and 60 percent for iron and steel industry. The estimates of leakage rate in Adkins et al. (2010), similarly, are 27 percent for chemicals, rubber and plastics, 15 percent for ferrous metals, 10 percent for non-metallic mineral products, and 13 percent for non-ferrous primary metals manufacturing.

Studies have recognized that there are two sources of leakage: (a) through trade channel, replacement by domestic production by imports, and (b) through fall in world energy price induced by cuts in energy use in countries following carbon pricing policy with the consequence that non-policy countries are encouraged to step up their energy consumption. Empirical

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<sup>4</sup> Annex-I countries are parties to the UNFCCC and include industrialized countries and transition economies. These countries have ratified the protocol and have committed to reduce their emission level to targets that are mainly set below the 1990 level. (Wikipedia, accessed 28 November 2011).

<sup>5</sup> Other studies on carbon price policy using CGE models include Hübler (2009), Metcalf et al. (2008), and McKibbin and Wilcoxon (2008).

research undertaken on this issue indicates that the second source accounts for a substantial portion of the leakage. In the case of ferrous metal, for example, the estimates of Adkins et al. (2010) indicate that the US emissions will decline by about 4.6 million tons of CO<sub>2</sub> as a result of carbon pricing policy (based on carbon price of US\$ 15 per ton of CO<sub>2</sub> coupled with rebates for domestic producers). On the other hand, emissions in non-Annex I countries will go up by 0.96 million tons, of which only 0.2 million tons is due to increased exports to the US and 0.7 million tons is due increased carbon intensity in the non-Annex I countries, traceable to a decline in global energy prices. In this example, it can easily be seen that imposing border adjustment tax on imports from developing countries will not achieve much in reducing emission leakage. A similar conclusion may be drawn from the estimates of leakage presented in Fischer and Fox (2009a). In several products, only a small part of the leakage is due to production change, i.e. shift of production to another location. Evidently, in these cases too, border tax adjustment will not be able to curtail leakage substantially. By contrast, Elliott et al. (2010) find that increased CO<sub>2</sub> emissions in developing countries would undo over 20 percent of reductions made by the developed countries by virtue of imposing a carbon tax on producers of \$105 per ton C (\$29 per ton CO<sub>2</sub>) and the leakage gets eliminated when full border tax adjustments are applied. This finding of Elliott and associates which is at variance with the findings of several other studies could be an outcome of particular features of their model. Thus, it seems reasonable to conclude that even after full border tax adjustment is applied, a significant portion of the leakage which is connected with a fall in global energy prices may remain unaffected.

Turning now to the impact of carbon pricing policy on the US economy, Table 2.1 presents estimates of the medium-run effects on the US manufacturing industries obtained in the study by Adkins et al. (2010). This is the estimated effect of carbon being priced at US\$ 15 per ton of CO<sub>2</sub> coupled with rebates for domestic producers in accordance with the provisions of the Waxman-Markey bill. It would be noticed that in most cases, the effect on output is less than one percent. The effect on imports is positive in almost all cases. The effect on imports is, however, small, barring a few cases.

According to the estimates of Adkins et al. (2010), the long-run effect of carbon price and domestic output subsidy will be to reduce GDP of US by 0.09 percent. Evidently, the expected effect is rather small. As for India, they expect Indian GDP to go up by 0.77 percent. In a subsequent paper of the same authors (Adkins et al., 2011), the estimate of fall in the US GDP is 0.12 percent, while the increase in Indian GDP is estimated at 0.05 percent.<sup>6</sup> The estimated change in imports of manufactures is positive in almost all cases. It is small in magnitude, mostly one percent or less.

The estimates of the effect on output under unilateral and multilateral action reported in the study of Adkins et al. (2010) indicate that the adverse effect on the US economy emanating from the carbon price policy will be relatively lower if there is multilateral action by all Annex-I countries. The estimated effect on output in the medium-term under unilateral and multilateral action is shown in Table 2.2 in respect of energy intensive industries. It is seen from the table that the effect is relatively lower in a situation of multilateral action. A somewhat similar finding emerges from the analysis of Dong and Whalley (2009a) who in their model consider four

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<sup>6</sup> According to the model estimates of McKibbin and Wilcoxon (2008), the effect of US carbon tax with BTA on India's GDP is expected to be -0.1 percent.



regions, the US, the EU, China and rest of the world. Carbon pricing by the US increases US imports of high emission goods by 1.6 percent. If both the US and the EU adopt carbon pricing (at US\$ 100 per ton C) the increase in US imports of high emission goods is 1.5 percent. If both the US and the EU adopt BTA against China along with carbon pricing, the increase in US imports of high emission goods is lower at 1.24 percent. If both the US and the EU adopt carbon pricing and only US adopts BTA against China, the increase in the US imports of high emission goods is still lower at 0.63 percent.

**Table 2.1: Estimated Medium Term Effect on the US economy – A \$15/ton CO<sub>2</sub> tax with H.R. 2454 Allocations**

Sr no.	Industry	% change in production	% change in use	% change in imports
1	Food	-0.10	0.01	0.43
2	Textiles	-0.37	-0.13	0.17
3	Apparel	-0.06	0.03	0.04
4	Wood and furniture	-0.31	-0.20	0.03
5	Pulp and Paper Mills	-0.16	-0.08	0.14
6	Refineries	-5.66	-4.85	-1.25
7	Petrochemical manufacturing	-1.28	-0.48	2.57
8	Basic Inorganic Chemical Manufacturing	-1.28	-0.50	1.16
9	Other basic organic chemicals Mfg	-1.28	-0.55	1.19
10	Plastic and Material Resins	-1.28	-0.53	1.51
11	Artificial & synthetic fibers, Filaments	-1.28	-0.51	2.13
12	Fertilizers	-1.28	-0.43	0.75
13	Other chemical and plastics	-1.28	-0.38	0.67
14	Glass Containers	-0.60	-0.30	0.48
15	Cement	-0.60	-0.31	0.66
16	Lime and Gypsum	-0.60	-0.37	6.87
17	Mineral Wool	-0.60	-0.37	1.40
18	Other Nonmetallic minerals	-0.60	-0.32	0.47
19	Iron, Steel and Ferroalloy	-0.17	-0.30	-0.44
20	Alumina refining, primary and secondary Aluminium	-0.81	-0.31	0.12
21	Ferrous Metal foundries	-0.36	-0.34	-0.16
22	Non-Ferrous Metal foundries	-0.36	-0.34	NC
23	other primary metals	-0.81	-0.29	0.11
24	fabricated metals	-0.36	-0.31	-0.05
25	Machinery	-0.31	-0.28	-0.10
26	Computer and electrical equipments	-0.39	-0.19	-0.02
27	Motor Vehicles	-0.23	-0.08	0.04
28	Other Transportation Equipment Manufacturing	-0.23	-0.17	0.13
29	Miscellaneous Manufacturing	-0.12	0.14	0.33

Source: Computed from Table 14a of Adkins et al. (2010).  
NC= Not computed, as the value of imports is very small.

**Table 2.2: Medium term effect on production of energy intensive manufacturing industries in the US, unilateral and multilateral action through carbon pricing policy**

(Percent change in production)

Industry	Unilateral action	Multilateral action
Paper and publishing	-0.16	-0.06
Petroleum and coal products	-5.66	-4.12
Chemicals, rubber, plastics	-1.28	-0.66
Non-metallic mineral products	-0.60	-0.47
Ferrous metals	-0.17	0.17
Non-ferrous primary metals	-0.81	-0.23

Source: Based on Table 14a of Adkins et al. (2010).

From a perusal of the studies on the effect of carbon pricing policy on the US, it is found that the estimated fall in the US GDP due to the carbon pricing policy is generally less than one percent. The studies by Adkins et al. (2010, 2011) and Jorgenson et al. (2007) mentioned above report estimates that indicate that the fall in GDP will be less one percent. This is true for several other studies. According to the estimates made by McKibbin and Wilcoxon (2008), the US carbon price policy will reduce the US GDP by about 0.7 percent. According to the estimates of Fischer and Fox (2009b), the production fall due to carbon tax will be about 0.2 percent. Aldy and Pizer (2009) report a slightly bigger impact on manufacturing. According to their estimates, pricing of CO<sub>2</sub> at US\$15 per ton would lead to an average production decline of 1.3 percent across U.S. manufacturing industries.

The analysis of the American Clean Energy and Security Act of 2009 by the EPA (EPA, 2009a) reveals that by 2020 output of energy intensive industries will fall by about 0.8 percent in case output-based rebates are not provided to domestic producers and by about 0.4 percent if such rebates are provided. The expected decline in GDP estimated by the ADAGE model is 0.26 percent for 2020. The estimate based on the IGEM model is 0.75 percent for that year. The EPA Report notes that the allowance price obtained by various models shows an upward trend over time. The estimates indicate that the allowance price will increase from US\$20-50 per ton of CO<sub>2</sub> in 2015 to US\$ 160-200 per ton of CO<sub>2</sub> in 2050. As a result, the adverse effect on GDP goes up over time. Going by the estimates of the ADAGE model for the Lieberman-Warner proposal, the decline in GDP due to carbon price policy will be about 0.7 percent in 2020, which will increase to about 2.4 percent in 2050.

Before concluding this discussion on the findings of the studies undertaken on the effects of the US or the EU carbon price policy, it should be pointed out that these studies present estimates of effects mainly for those economies, and do not provide information (or provide very little information) on how India is going to be impacted. Even though some studies give an estimate of the effect on Indian GDP, the sectoral break up of the effect is not provided. Also, the focus is often on GDP, welfare, carbon leakage, etc whereas from India's point of view, it is more important to get detailed information on how imports of the US, the EU etc from developing countries are going to be affected.

### *Limitations of the CGE models*

Since most of the research on the impact of carbon pricing policies is based on a CGE model commonly using the GTAP database, it is important to draw attention to certain limitations of such an analysis.

- First, the models rarely incorporate the carbon tax induced technological advance. There are exceptions such as Jorgenson et al. (2007). Thus, in most models, the focus is on the resource reallocation impact of the carbon pricing policies including the rebates and border tax adjustment. This must be contrasted with another body of literature that holds or tries to verify the belief that environmental regulations do not lead to any major loss of competitiveness (the Porter hypothesis; see Porter and van der Linde, 1995). There is empirical literature to suggest that the hypothesis of Porter is valid and firms do improve their productivity level on being subjected to stringent environmental regulations. The implication is that by disregarding the carbon tax induced technological advance, the CGE models tend to overstate the loss in competitiveness suffered by industrial firms in developed countries due to emission cuts and carbon tax.
- Second, the GTAP data based CGE models use the same set of elasticities of substitution for all countries. One may ask: will it be right to assume that the extent of substitution possibilities captured by the elasticity of substitution between imported goods obtained from two developed countries are the same as the extent of substitution possibilities between an imported good from a developing country and that from a developed country? It is not unreasonable to argue that the level of technology and hence the quality of product will differ between developed and developing countries, and hence the assumption of uniform elasticity of substitution across all country sources of imports is unrealistic. It appears that the GTAP database over-states the elasticity of substitution between imports obtained from a developed and a developing country.
- Third, the CGE models are like ‘black boxes’ and the reason why a particular type of result has been obtained is sometimes difficult to ascertain. At times, the results obtained may be counter-intuitive or hard to accept. This is illustrated by the findings of a CGE based study done on the carbon pricing policy in Japan (Yano et al., 2011). In one scenario, energy efficiency improvements in China and India according to the proposals made by these countries regarding reduction in CO<sub>2</sub> intensity have been taken into account. Interestingly, the model results indicate that energy efficiency improvements in China and India will cause an increase in the Global CO<sub>2</sub> emissions because of lowering of global energy prices. Many may find this finding of the CGE analysis hard to accept since energy efficiency improvements are aimed at reducing global CO<sub>2</sub> emissions.<sup>7</sup> This brings out that the results of the CGE model depends crucially on the structure of the model and assumptions made about (values assigned to) the parameters.
- Finally, two other weaknesses of CGE models may be highlighted, which have been noted by Wing (2004) in the context of CGE models dealing with carbon pricing. First,

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<sup>7</sup> At the same time, it needs to be recognized that an attempt to reduce CO<sub>2</sub> emissions by a set of countries may not fully succeed because increases in emissions by others following the fall in global energy prices may substantially neutralize the effect. Dong and Whalley (2009b) consider the impact of a uniform carbon tax used by all non-OPEC countries. If the tax rate is set at 20 percent, the emissions in non-OPEC countries fall about 11 percent. But, emissions in OPEC countries increase by 109 percent. Thus, at the global level, emissions fall by only three percent.

there is often an assumption of inelastic supply of labour and full employment. The implication is that the fall in labour demand in fossil fuel and energy using sectors does not get translated into unemployment. Rather, the labour market adjusts by lowering wages so that the surplus labour gets re-absorbed elsewhere. This may not be realistic because of impediments on labour mobility. Secondly, there is need for taking into account the “putty-clay” nature of capital,<sup>8</sup> which is missing at least in some of the models if not in most of them.

### ***Findings of a Paper by Mattoo and Associates***

The findings of a paper by Mattoo et al. (2009) require a more detailed discussion in the Report, since this study of Mattoo and associates, unlike most other such studies, finds that the climate policies of industrialized countries will have a significant adverse effect on developing countries. Mattoo and associates report that if industrialized countries impose carbon tax with a view to cut down their CO<sub>2</sub> emissions by about 20 percent and adopt border adjustment measures to take care of the concerns of competitiveness and carbon leakage using the emission intensity of the exporting countries, then there will be an additional tariff on exports of manufactures from China and India at the rate of about 26 and 20 percent respectively (for energy intensive manufacturing, the additional tariff will be 43 percent for China and 29 percent for India). This additional tariff will in turn lead to a fall in exports of manufactures from these two countries by about 20 percent (21 percent for China and 16 percent for India).<sup>9</sup> For low and middle income countries, the corresponding figure is 15 percent. If domestic carbon content in industrialized countries is taken as the basis for imposing carbon tax on imports, the adverse effect on developing countries will be much smaller. The fall in manufactured exports will be 3.4 percent for China, and 3.2 percent for India and low and middle income countries. These findings may be contrasted with the findings of a study by Takeda et al. (2011) who assess the impact of carbon price policies on Japanese economy. The study undertaken by Takeda and associates for the Japanese economy indicates that carbon price policy coupled with border tax adjustment on the basis of emission intensity of the exporting countries will lead to a fall in Japanese imports of energy intensive trade exposed products by about 3.5 percent. In case the Japanese emission levels are used, the fall in imports will be only one percent. In the scenario, where such policies are adopted by the US, the EU and Japan, the fall in Japanese imports are by 4.4 percent when BTA is based on exporting country carbon intensity, and 1.9 percent when it is based on Japanese carbon intensity.

The high estimates of the adverse effect on developing countries in the paper by Mattoo and associates seem to be attributable in part to their assessed price of carbon. In the study by Ho et al. (2008) for the US, the carbon price was taken as US\$ 10 per ton of CO<sub>2</sub>. In the study by Adkins et al. (2010, 2011) for the US, the carbon price has been taken as US\$ 15 per ton of CO<sub>2</sub>.

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<sup>8</sup> The “putty-clay” nature of capital means that the possibilities of inter-sectoral shift of capital or of changing the factor composition, i.e. the proportion between capital and other inputs (say, labor) get severely restricted once the investment has been done. Thus, there is flexibility ex-ante, but not ex-post.

<sup>9</sup> The the US imports of energy intensive manufactured products fall by about 10 percent, while that of the EU falls by about 39 percent. It seems that it is the fall in manufactured products imports of the EU that mainly drives the fall in exports of manufactured products of China and India.

Fischer and Fox (2009b) have used a CGE model to simulate the effects of a US\$50/ton C (about \$14 per ton of CO<sub>2</sub>) emission price implemented unilaterally in the US. The study undertaken by McKibbin and Wilcoxon (2008) take the carbon price as US\$ 20 and US\$ 40 per ton C (less than \$15 per ton of CO<sub>2</sub>). Some studies have used a somewhat higher figure. But, overall, the price range used for carbon in various studies is US\$ 10 to US\$ 50 per ton of CO<sub>2</sub>. The study by Mattoo and associates is very different, since they assess that the price of carbon per ton will be about US\$ 300 in EU, US\$ 250 in the US (i.e. about US\$ 70 per ton of CO<sub>2</sub>), US\$ 240 in Japan and about US\$220 in other Annex I countries. This is clearly quite high, and the use of such high price of carbon influences the estimated effects on developing countries. In support of this point that a carbon price of US\$ 70 per ton of CO<sub>2</sub> is high, it may be added that recently Australia has imposed carbon tax on its local firms. According to a media report, the rate of tax has been specified as Australian dollar 23 per ton of carbon. This comes to about 24 US dollar per ton of carbon (about US\$ 7 per ton of CO<sub>2</sub>). Further, according to some media report, citing International Emissions Trading Association, about 3.6 billion tons of carbon dioxide equivalent was trade globally in the first half of 2011 valued at about US\$ 71 billion. The price of carbon dioxide comes to about 20 US dollars per ton CO<sub>2</sub>.

Another factor that influences the results of the Mattoo et al. (2009) study is that they have based the tax on imports from developing countries on the level of carbon embodied in imports. In the study of Dong and Whalley (2009a), the increase in US imports of high emission goods is 1.6 percent if the carbon price is set at US\$ 200 per ton C (comparable to the price used by Mattoo and associates) and there is no BTA. The use of BTA against China and EU causes the US imports of high emission goods to fall by 2.5 percent. Dong and Whalley (2009a) observe that their estimates of the effect of carbon pricing coupled with BTA is much smaller than that of Mattoo and associates (2009) because while they base the tax on imports on domestic emission intensity, Mattoo and associates use the emission intensity of the exporting country. Thus, whether the domestic emission intensity or the exporting country emission intensity is used for the BTA makes a lot of difference. But, one can raise the question whether the latter option is compatible with WTO rules. Also, how big is the difference between the domestic emission intensity and the exporting country emission intensity matters a lot. This aspect receives attention in Section 5 of this Report.

### 3. Impact on a Developing Country

How would the carbon price policy of a developed country, say the US, impact a developing country in terms of its exports and production. This is analyzed in this section using a theoretical framework which is an extended version of the theoretical framework employed by Fischer and Fox (2009a). Instead of considering the entire economy, a particular sector is considered. A two-good, two-country partial equilibrium model is used since the impacts and adjustments can more clearly be seen in such a model.

Consider two countries, Home and Foreign. The home country is a developed one and the foreign country is a developing one. Home produces good  $H$  at a per-unit cost  $c_H(r_H)$  that rises with reductions  $r_H$  from the baseline emission rate  $e_H^0$ . For notational simplicity,  $c_H^0$  denotes

$c_H(0)$ , i.e., when reductions from baseline are zero. Foreign country produces good  $F$  at a per-unit cost  $c_F$  which is assumed to be fixed. Producers are assumed to be perfectly competitive.

Each country has a representative consumer who demands some of each good. Let home and foreign consumption of good  $H$  be  $h$  and  $x$ (exports), and let home and foreign consumption of good  $F$  be  $m$ (imports) and  $f$ . Consumer demand for each good is a simple function of the prices of both competing good in the country of consumption. Let the prices be denoted by  $p_H, p_X, p_M$  and  $p_F$ . The price of home good exported is denoted by  $p_X$ , and the price of foreign good imported is denoted by  $p_M$ . The prices  $p_H, p_X, p_M$  and  $p_F$  are equal to the (constant) marginal costs of production inclusive of any taxes or rebates.

Assuming constant elasticity demand functions, the components of demand in the two countries can be expressed as:

$$h = \alpha_h p_H^{\beta_{hH}} p_M^{\beta_{hM}} \quad \dots(1)$$

$$m = \alpha_m p_H^{\beta_{mH}} p_M^{\beta_{mM}} \quad \dots(2)$$

$$x = \alpha_x p_X^{\beta_{xX}} p_F^{\beta_{xF}} \quad \dots(3)$$

$$f = \alpha_f p_X^{\beta_{fX}} p_F^{\beta_{fF}} \quad \dots(4)$$

The market equilibrium conditions are

$$H = h(p_H, p_M) + x(p_X, p_F) \quad \dots(5)$$

$$F = f(p_X, p_F) + m(p_H, p_M) \quad \dots(6)$$

From the above equations, and applying differentiation, the change in foreign country production (i.e. the production in the developing country) can be derived as:

$$dF = f \left[ \beta_{fX} \frac{dp_X}{p_X} + \beta_{fF} \frac{dp_F}{p_F} \right] + m \left[ \beta_{mH} \frac{dp_H}{p_H} + \beta_{mM} \frac{dp_M}{p_M} \right] \quad \dots(7)$$

Consider now an emission price of  $t$  per unit of emission imposed in the home country and no adjustment mechanism. The price of the home good and the exported good (of the developed country sold to the developing country) may then be derived as:  $p_H = p_X = c_H(r_H) + t(e_H^0 - r_H)$ . The price of the foreign good and the imported good (produced in the developing country) is given by  $p_F = p_M = c_F$ . Taking into account this above mentioned change in the price of home good and the export good, and simplifying equation (7), the change in the production of foreign good  $F$  that results from the changes in prices may be written as:

$$dF = \frac{c_H - c_H^0 + te_H}{c_H^0} (\beta_{fX}f + \beta_{mH}m) \dots(8)$$

where  $e_H = e^0_H - r_H$ . And defining,  $\gamma$  as:

$$\gamma = \frac{c_H - c_H^0 + te_H}{c_H^0},$$

the following equation is obtained:

$$dF = \gamma(\beta_{fX}f + \beta_{mH}m) = \gamma(\beta_{fX}f) + \gamma(\beta_{mH}m) \dots(9)$$

In the above equation,  $\gamma$  represents the increase that takes place in the price of home good because of the costs associated with the reduction in emission level and the carbon tax paid on the reduced level of emission. The term  $\gamma(\beta_{fX}f)$  shows the additional local sales of the domestic industry in the foreign (developing) country because the exports from the developed country have become costlier due to emission control and carbon tax. This is positive. The term  $\gamma(\beta_{mH}m)$  reflects loss of competitiveness of the home country producers. Since the price of the home good becomes costlier, imports from the developing country increases replacing the domestically produced good in the home country. This is also positive. Evidently, with the imposition of carbon tax in the developed country, and in the absence of any border adjustment, the developing country gains. If (1) the rate of carbon tax is high, (2) the control of emission is more costly, and (3) the price elasticity of demand is high, the gains to the developing country will be greater.

Consider next border adjustment for imports in order to level the playing field between the home good and the imported good. It is assumed now that there is a carbon tax on imports of foreign good into the home market. It is assumed further that the tax will be applied on the basis of a policy-defined emission intensity,  $\hat{e}_F$ . Accordingly, the price of imported good  $p_M$  goes up; it becomes equal to  $c_F + t\hat{e}_F$ . The price of the foreign good sold in the foreign country's domestic market remains at the earlier level, i.e.  $p_F = c_F$ . There are several possibilities about  $\hat{e}_F$ . One possibility, the base case, is to take it as equal to the emission intensity of the foreign good, i.e.  $\hat{e}_F = e_F$ . Thus, the tax is based on emission embodied in the imported good. However, many of the proposed border adjustment policies that are thought to be WTO compliant involve a smaller border tax. Thus, one proposal is to base it on home country emission intensity (expected to be less than the embodied emission in imports of the good from a developing country), i.e.  $\hat{e}_F = e_H$ . Another proposal is to impose the tax on embodied emission above some baseline denoted by  $e_F^*$ , i.e.  $\hat{e}_F = e_F - e_F^*$ .

In the base case when the domestic industry is subject to carbon tax and the tax is imposed on emission embodied in the imported good, the change in production of foreign good,  $F$ , may be derived as:

$$dF = \frac{c_H - c_H^0 + te_H}{c_H^0} (\beta_{fX}f + \beta_{mH}m) + \frac{t\hat{e}_F}{c_F^0} (\beta_{mM}m) \dots(10)$$

The above expression may or may not be positive. Thus, carbon price policy in the home (developed) country will be beneficial to the foreign (developing) country for specific range of values of the parameters. If (1)  $\beta_{mH}$  is more or less equal to  $\beta_{mM}$  (i.e. the price elasticity of demand for imports with respect to price of the imported good is almost equal in absolute value to the price elasticity of demand for imports with respect to the price of domestic substitute) and (2) the carbon tax on imports does not exceed that on domestic production, then the carbon price policy of the developed country will be beneficial to the foreign country even when a tax is imposed on imports to level the playing field. Even if the above condition is not satisfied, the foreign country may still gain if there is a significant fall in exports from the home country to the foreign country because of the cost disadvantage created by carbon tax which permits larger sales of local firms in the foreign country to the local market. Evidently, a crucial factor is whether carbon tax on imports from the developing country will be based on emission embodied in imports or emission intensity of home (developed country) production. In the latter case, there is a greater probability that the foreign (developing) country will gain from the carbon policies of the home (developed) country.

The next policy measure to be considered is an export rebate. Since the domestic industry is put to a disadvantage by the carbon tax, a border rebate for exports may be provided to level the playing field abroad. Thus, there will be full emission pricing at home, but for exports, the value of emission in exports will be given a rebate. With this change, and maintaining carbon tax on imports, equation (10) gets transformed to:

$$dF = \frac{c_H - c_H^0}{c_H^0} (\beta_{fX} f) + \frac{c_H - c_H^0 + t e_H}{c_H^0} (\beta_{mH} m) + \frac{t \widehat{e}_F}{c_F^0} (\beta_{mM} m) \dots (11)$$

The above expression is lower in value than the expression in equation (10). The implication is that the gain to the developing country will be less, or the loss to the developing country will be greater, when the developed country producers subject to carbon tax get full rebate on exports. It should be pointed out that even after allowing for export rebate, the expression in equation (11) will be positive for certain parameter values. If the condition mentioned above regarding the price elasticities and carbon tax rates on domestic and imported goods hold true, the expression in equation (11) would be positive, i.e. the developing country will gain. Again, a crucial factor is whether the carbon tax on imports is based on emission embodied in imports or on the emission intensity of domestic production in developed countries.

An interesting extension of the above model is to allow for a third country. Let that be a developed country, which is hereafter referred to as country-X. Thus, imports of the home country are partly sourced from country-X and the remaining portion from the developing country. The effect of the carbon price policy of the home country now depends on the policy adopted by country-X. It is needless to say that the gains to the developing country from the carbon price policy of the home country will be relatively greater if country-X itself adopts as stringent a carbon price policy as done by the home country, than otherwise.



## 4. Empirical Analysis – Effect of US Carbon Price Policy on India and other Developing Countries

This section presents estimates of the impact of US carbon price policies on India, China and a number of other developing countries. Section 4.1 outlines the methodology adopted. Section 4.2 describes the scenarios considered. Section 4.3 presents estimates of loss of exports of developing countries to the US market, and the consequent impact on manufacturing value added and employment in the developing countries. Section 4.4 carries the analysis further for India. It goes into the indirect effects on various sectors of the economy and thus estimates the total direct and indirect effect on employment and output.

### 4.1 Methodology

Unlike the studies that use CGE, the analysis presented here is based on a partial equilibrium approach. This has the advantage that the magnitude of impacts and their causes can more easily be understood.

For the purpose of the analysis, the US manufacturing is divided into 29 industries. This follows the classification or industry grouping used by Adkins et al. (2010) since some basic data as well as the estimates of impacts of certain components of the carbon price policy are taken from that study. For the same reason, the analysis undertaken here is based on the data for 2006, which is the year for which Adkins et al. (2010) have undertaken their analysis.

For each industry, the demand structure is assumed to be nested, as commonly done in CGE studies. At the upper level, the demand for a commodity gets distributed between domestically sourced and imported. At the lower level, the demand for imports gets distributed between two groups of countries, those which are subject to carbon tax when their products are imported into the US and those which are not subject to such tax.<sup>10</sup>

Let  $X_A$  denote aggregate demand for the product of an industry in the US. Let  $X_D$  and  $X_M$  be respectively the domestic and imported components of the demand. The substitution elasticity at this level is given by  $\sigma^m$ . The demand functions may accordingly be specified as:

$$X_D = \alpha^D \left( \frac{PA}{PD} \right)^{\sigma^m} X_A \quad \dots(12)$$

$$X_M = \alpha^M \left( \frac{PA}{PMT} \right)^{\sigma^m} X_A \quad \dots(13)$$

$$PA = \frac{\alpha^D PD^{1-\sigma^m} + \alpha^M PMT^{1-\sigma^m}}{1} \dots(14)$$

<sup>10</sup> The demand structure assumed for the study follows Mensbrugghe (2009) who has used such a structure for studying the impact of agricultural trade reforms.

In these equations, PA is the aggregate price of the product, which is taken as a non-linear aggregation of two component prices: the price of domestically sourced product (PD) and the price of imported product (PMT).

In the second nest, aggregate imports, XMT, are broken up by two groups of countries: one group comprising of countries that are subject to carbon border tax when their manufactured products are imported into US (hereafter, country group subject to carbon border tax or country group  $m$ ) and the other comprising of countries that are not subject to any such tax (hereafter, country group  $p$ ). For these two country groups, subscripts  $m$  and  $p$  are used.<sup>11</sup> The demand functions for imports from country groups  $m$  and  $p$  may be specified as:

$$XM_m = \alpha^m \left( \frac{PMT}{PM_m} \right)^{\sigma^w} XMT \quad \dots(15)$$

$$XM_p = \alpha^p \left( \frac{PMT}{PM_p} \right)^{\sigma^w} XMT \quad \dots(16)$$

$$PMT = \left[ \alpha^p PM_p^{1-\sigma^w} + \alpha^m PM_m^{1-\sigma^w} \right]^{1/(1-\sigma^w)} \quad \dots(17)$$

In the above equations, the substitution elasticity between imports from the two groups of countries is denoted by  $\sigma^w$ . The prices of imports from the two groups of countries are given by  $PM_p$  and  $PM_m$ . Without loss of generality, it may be assumed that  $PM_p$  includes cost, insurance and freight, while  $PM_m$  is the CIF value plus carbon border tax at the rate  $\tau$ . It may be noted that the aggregate price of imports, PMT, is a non-linear combination of the prices of imports from the two group of countries,  $m$  and  $p$ .

For the country group  $m$ , the price elasticity of demand with respect to their tax inclusive price may be derived as:<sup>12</sup>

$$\varepsilon_{m,m} = -\sigma^w + s_m[\sigma^w - \sigma^m s_D] \quad \dots(18)$$

where

$\sigma^m$  = elasticity of substitution between aggregate imports of a product and domestic supply of the product;

$\sigma^w$  = elasticity of substitution between imports of a product from country group  $p$  verses country group  $m$ ;

$s_D$  = share of absorption met from domestic supply of the product; and

$s_m$  = share of imports from country group  $m$  in aggregate imports of the product.

<sup>11</sup> In one scenario, China and India are included in group  $m$ , and the rest of the countries in group  $p$ . In another scenario, China, India and 12 other selected developing countries are included in group  $m$ , and the rest of the countries in group  $p$ .

<sup>12</sup> For derivation, see Mensbrugge (2009).

For the country group  $p$ , i.e. the countries not subject to carbon border tax, their exports to the US goes up when the other group is subjected to carbon border tax (due to substitution among alternate sources of imports). The relevant elasticity is shown below:

$$\varepsilon_{p,m} = s_m[\sigma^w - \sigma^m s_D] \dots(19)$$

The elasticities of substitution  $\sigma^m$  and  $\sigma^w$  have been taken from GTAP database (see Annex-A). The estimates available for various manufacturing industries have been mapped into the 29 industries considered in this study. The share of absorption met from domestic supply of the product,  $s_D$  has been computed from data on domestic consumption and import reported in Adkins et al. (2010). The parameter,  $s_m$ , which is the share of imports from country group  $m$  in aggregate imports of the product, has been computed from country-wise detailed data on US imports for the year 2006. Data on US import at 4-digit level disaggregated by source country have been used to work out import data for the 29 industries under study with source country-wise disaggregation.

Sixteen countries/ regions have been considered for the analysis. These are China, India, 12 other selected developing countries (Brazil, Chile, Columbia, Indonesia, Malaysia, Mexico, Nigeria, Philippines, Thailand, South Africa, Venezuela, and Vietnam), OECD countries (except the US) and the rest of the world. The 12 developing countries chosen for the study, other than China and India, have been selected on the criteria of GDP and emission level. China, India and the other 12 developing countries chosen for the study together account for a dominant portion of GDP of the developing world. The same applies to their share in the aggregate CO<sub>2</sub> emissions of the developing world.

It may be explained here that the impact of BTA is estimated in two steps. In the first step, the estimates of the medium-run effect on production, use and imports made by Adkins et al. (2010) (using a CGE model) for a tax rate of US\$ 15 per ton of CO<sub>2</sub> are applied to the actual data on production, use and imports in 2006, and then in the next step, the effect of BTA is superimposed using the elasticities described in equations (18) and (19).

## 4.2 Scenarios

Seven scenarios are considered for the analysis, which are described in Table 4.1. In three scenarios, it is assumed that the border tax adjustment will be done only for imports from China and India, and the carbon tax will not be imposed on imports on other countries including the OECD countries and the other developing countries. In the other four scenarios, it is assumed that besides China and India, the other 12 developing countries selected for the study will be subject to carbon tax on exports made to the US. In all the seven cases, it is assumed that the US adopts carbon price policy according to the American Clean Energy and Securities Act, 2009, with the output-based allowance allocations incorporated into the estimates. The effect that the carbon price policy with output based allowance will have on different sectors of the economy has been estimated by Adkins et al. (2010) taking the carbon price of US\$ 15 per ton of CO<sub>2</sub>. The sector-wise production, use, exports and imports data are first altered taking into account the estimates of effect of carbon pricing in Adkins et al. (2010) and then the BTA is applied.

While the first two scenarios assume a carbon price of US\$ 15 per ton of CO<sub>2</sub> as done by Adkins et al. (2010), in the other five scenarios, a much higher price of US\$ 50 per ton of CO<sub>2</sub> has been assumed. The first four scenarios assume that the carbon tax will be based on the emission intensity in the US (industry-wise emission intensities have been taken from the study of Adkins et al. (2010)). The last three scenarios allow for the possibility that the tax may be based on emission embodied in imports. Thus, the emission intensity of the exporting country has been taken into account. The analysis presented in Section 5 below indicates that the emission intensity of China and India (at market exchange rate) far exceeds that of the US. The average of the estimated emission intensity for manufacturing (for 2006) for a number of developing countries including China and India is found to be about three times that of the US. Accordingly, the applicable carbon tax on imports from China, India and other 12 selected developing countries has been taken to be three times the tax that would have been applied if the US emission intensities were used. This is broadly in line with the paper by Mattoo et al. (2009).

**Table 4.1: Scenarios Considered in the Study**

Scenario	Countries covered by BTA	Carbon price assumed, US\$ per ton of CO <sub>2</sub>	Basis of carbon tax on imports
A	China and India	15	US emission intensity
B	China, India and other 12 selected developing countries	15	US emission intensity
C	China and India	50	US emission intensity
D	China, India and other 12 selected developing countries	50	US emission intensity
E	China and India	50	Exporting country emission intensity (developing country average: taken as three times the US intensity)
F	China, India and other 12 selected developing countries	50	Exporting country emission intensity (developing country average: taken as three times the US intensity)
G	China, India and other 12 selected developing countries	50	Exporting country emission intensity based on PPP (Assumption: Chinese emission intensity is 1.7 times the US intensity. For India, the figure is taken as 1.5. For the group of the other 12 developing countries selected for the study, the figure is again taken as 1.5 on average).

The analysis in Section 5 later in the Report brings out that the gap between the US emission intensity of manufacturing and the average emission intensity of manufacturing of developing countries is relatively less when the comparison is made on the basis of PPP exchange rate. In the seventh scenario, therefore, this aspect has been incorporated. Also, a difference has been made between China and other developing countries. For China, a higher tax rate has been assumed.<sup>13</sup>

It will be noticed from Table 4.1 that for several scenarios a carbon price of US\$ 50 per ton of CO<sub>2</sub> has been assumed. This is much higher than the carbon price assumed by Adkins et al. (2010) and Fischer and Fox (2009a, 2009b). But, it is not unreasonable. Under the Stark-McDormott proposal, the carbon price will start from US\$ 10 per ton of CO<sub>2</sub> and then rise over time to about US\$ 70 per ton of CO<sub>2</sub> by 2050 (see Metcalfe et al., 2008). Elliott et al. (2010) in their model consider the carbon prices range from \$15 to \$175 per ton C (\$4 to \$48 per ton CO<sub>2</sub>). In the model used by Wing (2004), the carbon price range considered is US\$ 50 to US\$ 200 per ton C. The price range considered in the study of Dong and Whalley (2009a) is from US\$ 50 to US\$ 200 per ton C. In both cases, the upper point of the range is about US\$ 55 per ton of CO<sub>2</sub>. Tekeda et al. (2011) in their study of carbon pricing policy of Japan take the carbon price in the range of 90 to 100 US\$ per ton of CO<sub>2</sub>. Thus, the figure of US\$ 50 per ton of CO<sub>2</sub> used in scenarios C through G is not unreasonable. It may be viewed as serving as the upper limit of the range in which the carbon price in the US is likely to lie.

### **4.3 Estimates of Impact on China, India and other Developing Countries**

The estimates of change in US imports of manufactured products from China, India and the group of 12 other selected developing countries consequent upon the imposition of carbon tax on imports from such countries are presented in Tables 4.2 through 4.8. These correspond to the seven scenarios considered in the study. If the carbon tax rate is US\$ 15 per ton of CO<sub>2</sub> or thereabout, which is the assumption made in several earlier studies on the impact of US climate policy, the effect on imports from developing countries is small. India's exports of manufactures to the US go down by about 2 percent. For the products of energy intensive trade exposed industries such as basic metals and chemicals, the impact is relatively greater. India's exports to the US go down by about 5 percent. The impact on China is slightly lower in relative magnitude when comparison is made with the existing level of exports made by China to the US. But, the absolute value of cut in Chinese exports to the US is much larger than that for India. The adverse effect on India and China are slightly lower when the other 12 selected developing countries are also subjected to the carbon tax than when they are not.

The adverse effect on India and other developing countries goes up substantially when the carbon price is set at US\$ 50 per ton of CO<sub>2</sub> rather than US\$ 15 per ton (as in scenarios A and B). Estimates presented in Tables 4.4 and 4.5 indicate that the imposition of carbon tax on imports based on a carbon price of US\$ 50 per ton of CO<sub>2</sub> will reduce India's exports of

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<sup>13</sup> Ideally, for each industry, the carbon border tax should be allowed to vary from country to country. This has not been done, except for some difference made between China and other 13 developing countries considered for the study. Estimates of carbon intensity at individual industry level for the various developing countries could not be obtained. This is the reason why, in the simulation exercise, an almost uniform tax rate for each industry has been used.

manufactures to the US by about 6 to 7 percent. The exports of energy intensive manufactured products will go down by about 15 to 16 percent. A more or less similar effect will be there on China and the other 12 developing countries selected for the study.

The adverse effect on India and other developing countries gets accentuated if the carbon tax imposed by the US is based on the carbon embodied in the imports rather than on domestic producers' carbon intensity. In this case, as Table 4.7 shows, the exports of manufactures fall by about 12 to 16 percent, while the exports of energy intensive manufactured products fall by about 33 to 38 percent. The market lost by China, India and the 12 other selected developing countries will be taken up by other countries. In particular, it may be noted that the OECD countries as a group will increase their exports to the US. Their exports of manufactures go up by 5 percent and that of energy intensive manufactured products go up by about 8 percent. The increase in exports from OECD countries is about half of the loss of exports suffered by China, India and the 12 selected developing countries. The implication is that the imposition of a high rate of carbon tax on imports from developing countries significantly benefits the US domestic manufacturing industry.

The estimates for scenario G is presented in Table 4.8. Here, the issue of using emission intensity based on PPP exchange rate rather than market exchange rate is brought in. Ideally, sector-wise PPP should be used. Due to lack to data, the overall PPP has been used to estimate the emission intensity of manufacturing, and the average across a select set of developing countries has been taken as the basis for making the estimates. For China, the emission intensity (at PPP) is taken to be 1.7 times that of the US. For India, the relevant ratio is taken as 1.5. The ratio could not be computed for each of the other 12 selected developing countries. For seven of them, some rough estimates of the emission intensity of manufacturing have been made. The average for the seven countries is not very different from that for India. Hence, for the groups of 12 selected developing countries, the average emission intensity (at PPP) has been taken as 1.5 times that of the US.

Comparing Tables 4.7 and 4.8, it is found that switching to PPP based emission intensities from market exchange rate based emission intensities will provide substantial benefit to the manufacturing industries of developing countries subject to US carbon tax with the rate of tax being determined on the basis of carbon embodied in imports. The fall in imports of manufactured products from the developing countries considered for the study (consequent upon the imposition of carbon tax) becomes lower; it comes down from about 12 to 16 percent to about 6 to 8 percent. In the case of India, the fall in India's exports of manufactured products to the US is about 15 percent when market exchange rate based emission intensity is used for ascertaining the rate of carbon tax, which gets lower to about 8 percent when PPP exchange rate based emission intensity is used.

**Table 4.2: Change in US Imports of Manufactured Products, by Source Country and Product Group, Scenario -A (US \$ million)**

Industry group	China	India	12 other selected developing countries	OECD	Rest of the world	All
Food products, textiles, leather products and apparel	-538.5	-137.6	124.3	153.9	182.5	-215.5
Wood, furniture, pulp, paper and printing	-870.7	-14.5	114.7	354.4	24.8	-391.3
Refinery products and petrochemical manufacturing	-8.7	-3.4	0.5	1.8	1.0	-8.7
Plastics, synthetic fiber etc	-133.4	-14.6	16.6	57.7	7.7	-66.0
Chemicals and products	-507.9	-82.5	31.4	304.6	43.7	-210.6
Cement and other non-metallic mineral products	-206.2	-9.8	32.4	68.9	18.5	-96.1
Basic Metals	-832.0	-162.5	124.5	383.8	132.6	-353.7
Fabricated Metals	-184.9	-8.2	43.2	42.2	12.1	-95.6
Machinery and transport equipment	-1128.3	-26.4	275.1	470.9	91.5	-317.2
Miscellaneous Manufacturing	-122.6	-10.7	15.3	57.2	10.9	-49.9
All industries	-4533.2	-470.2	778.0	1895.4	525.3	-1804.7
Energy intensive trade exposed industries	-2068.2	-279.4	231.6	1011.7	210.7	-893.6
All industries, change in imports as % of actual	-1.5	-2.1	0.2	0.2	0.3	-0.1
EITE, change in imports as % of actual	-5.0	-5.5	0.3	0.4	0.3	-0.2

**Table 4.3: Change in US Imports of Manufactured Products, by Source Country and Product Group, Scenario –B (US \$ million)**

Industry group	China	India	12 other selected developing countries	OECD	Rest of the world	All
Food products, textiles, leather products and apparel	-438.3	-115.7	-500.8	318.8	301.9	-434.1
Wood, furniture, pulp, paper and printing	-761.5	-12.7	-502.8	591.3	39.8	-645.9
Refinery products and petrochemical manufacturing	-7.2	-3.1	-1018.4	29.1	16.7	-982.9
Plastics, synthetic fiber etc	-119.3	-13.0	-108.5	103.7	14.2	-122.9
Chemicals and products	-481.5	-78.6	-457.4	550.0	83.9	-383.7
Cement and other non-metallic mineral products	-179.7	-8.4	-182.0	136.3	35.0	-199.0
Basic Metals	-743.2	-142.3	-1339.3	994.0	346.6	-884.1
Fabricated Metals	-144.0	-6.4	-166.1	88.7	25.4	-202.3
Machinery and transport equipment	-861.2	-20.4	-1214.1	1207.6	180.7	-707.3
Miscellaneous Manufacturing	-108.6	-9.5	-36.4	74.8	14.3	-65.4
All industries	-3844.5	-410.1	-5525.8	4094.2	1058.5	-4627.7
Energy intensive trade exposed industries	-1886.8	-251.6	-3384.7	2158.0	509.0	-2856.1
All industries, change in imports as % of actual	-1.2	-1.9	-1.5	0.5	0.5	-0.3
EITE, change in imports as % of actual	-4.6	-5.0	-4.9	0.8	0.8	-0.6



**Table 4.4: Change in US Imports of Manufactured Products, by Source Country and Product Group, Scenario -C (US \$ million)**

Industry group	China	India	12 other selected developing countries	OECD	Rest of the world	All
Food products, textiles, leather products and apparel	-1740.0	-442.0	414.2	512.8	608.2	-646.8
Wood, furniture, pulp, paper and printing	-2750.1	-45.7	382.3	1181.5	82.6	-1149.5
Refinery products and petrochemical manufacturing	-26.9	-10.1	1.8	6.0	3.5	-25.7
Plastics, synthetic fiber etc	-415.9	-45.5	55.5	192.3	25.7	-187.9
Chemicals and products	-1609.3	-259.4	104.7	1015.5	145.8	-602.7
Cement and other non-metallic mineral products	-573.0	-31.1	108.1	229.7	61.7	-204.6
Basic Metals	-2396.6	-462.5	414.9	1279.3	442.0	-723.0
Fabricated Metals	-605.2	-26.8	144.1	140.6	40.3	-307.1
Machinery and transport equipment	-3723.1	-87.1	916.9	1569.8	304.9	-1018.6
Miscellaneous Manufacturing	-406.5	-35.5	51.0	190.7	36.4	-164.0
All industries	-14246.5	-1445.8	2593.4	6318.1	1750.9	-5029.9
Energy intensive trade exposed industries	-6185.7	-828.9	771.9	3372.4	702.3	-2168.0
All industries, change in imports as % of actual	-4.6	-6.6	0.7	0.7	0.9	-0.3
EITE, change in imports as % of actual	-15.0	-16.4	1.1	1.2	1.1	-0.5

**Table 4.5: Change in US Imports of Manufactured Products, by Source Country and Product Group, Scenario –D (US \$ million)**

Industry group	China	India	12 other selected developing countries	OECD	Rest of the world	All
Food products, textiles, leather products and apparel	-1418.4	-372.4	-1633.2	1062.5	1006.2	-1355.3
Wood, furniture, pulp, paper and printing	-2412.0	-40.2	-1585.3	1970.8	132.8	-1933.9
Refinery products and petrochemical manufacturing	-22.5	-9.3	-3198.6	97.0	55.8	-3077.5
Plastics, synthetic fiber etc	-374.4	-40.5	-339.1	345.6	47.2	-361.3
Chemicals and products	-1528.0	-247.7	-1446.2	1833.3	279.6	-1109.0
Cement and other non-metallic mineral products	-507.6	-26.9	-540.7	454.2	116.5	-504.5
Basic Metals	-2173.9	-412.7	-3818.1	3313.2	1155.4	-1936.0
Fabricated Metals	-473.1	-21.0	-545.5	295.8	84.7	-659.0
Machinery and transport equipment	-2846.9	-67.4	-4009.3	4025.3	602.4	-2296.0
Miscellaneous Manufacturing	-360.2	-31.5	-120.8	249.5	47.6	-215.5
All industries	-12117.0	-1269.7	-17236.8	13647.2	3528.3	-13448.0
Energy intensive trade exposed industries	-5701.9	-756.3	-10201.5	7193.5	1696.6	-7769.8
All industries, change in imports as % of actual	-3.9	-5.8	-4.8	1.6	1.8	-0.8
EITE, change in imports as % of actual	-13.8	-14.9	-14.6	2.6	2.6	-1.7

**Table 4.6: Change in US Imports of Manufactured Products, by Source Country and Product Group, Scenario -E (US \$ million)**

Industry group	China	India	12 other selected developing countries	OECD	Rest of the world	All
Food products, textiles, leather products and apparel	-4804.0	-1200.1	1242.5	1538.5	1824.7	-1398.4
Wood, furniture, pulp, paper and printing	-7169.2	-118.8	1147.0	3544.4	247.7	-2348.9
Refinery products and petrochemical manufacturing	-65.6	-22.6	5.4	18.0	10.4	-54.5
Plastics, synthetic fiber etc	-1045.0	-113.2	166.4	576.9	77.1	-337.7
Chemicals and products	-4242.4	-671.6	314.2	3046.4	437.3	-1116.1
Cement and other non-metallic mineral products	-1224.1	-82.4	324.2	689.1	185.0	-108.1
Basic Metals	-5159.8	-958.4	1244.6	3837.8	1326.0	290.1
Fabricated Metals	-1725.6	-76.5	432.4	421.7	120.8	-827.2
Machinery and transport equipment	-10853.8	-253.7	2750.7	4709.5	914.8	-2732.6
Miscellaneous Manufacturing	-1200.9	-105.0	152.9	572.0	109.1	-471.8
All industries	-37490.4	-3602.3	7780.3	18954.3	5252.8	-9105.3
Energy intensive trade exposed industries	-14538.8	-1897.2	2315.7	10117.1	2106.9	-1896.2
All industries, change in imports as % of actual	-12.0	-16.3	2.2	2.2	2.7	-0.5
EITE, change in imports as % of actual	-35.2	-37.5	3.3	3.6	3.2	-0.4

**Table 4.7: Change in US Imports of Manufactured Products, by Source Country and Product Group, Scenario –F (US \$ million)**

Industry group	China	India	12 other selected developing countries	OECD	Rest of the world	All
Food products, textiles, leather products and apparel	-3929.5	-1016.8	-4616.0	3187.6	3018.7	-3356.0
Wood, furniture, pulp, paper and printing	-6336.1	-105.3	-4115.3	5912.5	398.4	-4245.8
Refinery products and petrochemical manufacturing	-56.2	-21.3	-8197.5	291.0	167.5	-7816.6
Plastics, synthetic fiber etc	-956.3	-102.8	-857.6	1036.7	141.6	-738.4
Chemicals and products	-4045.0	-643.5	-3805.2	5500.0	838.8	-2155.0
Cement and other non-metallic mineral products	-1107.3	-72.4	-1295.4	1362.6	349.5	-762.9
Basic Metals	-4820.5	-888.5	-7923.7	9939.7	3466.3	-226.7
Fabricated Metals	-1361.9	-60.4	-1570.2	887.3	254.2	-1851.0
Machinery and transport equipment	-8343.4	-197.1	-11715.3	12075.8	1807.1	-6372.9
Miscellaneous Manufacturing	-1065.9	-93.2	-357.3	748.4	142.8	-625.2
All industries	-32022.1	-3201.4	-44453.4	40941.5	10584.9	-28150.4
Energy intensive trade exposed industries	-13651.7	-1775.3	-24169.5	21580.5	5089.7	-12926.3
All industries, change in imports as % of actual	-10.3	-14.5	-12.3	4.7	5.4	-1.6
EITE, change in imports as % of actual	-33.0	-35.1	-34.6	7.7	7.7	-2.8

**Table 4.8: Change in US Imports of Manufactured Products, by Source Country and Product Group, Scenario –G (US \$ million)**

Industry group	China	India	12 other selected developing countries	OECD	Rest of the world	All
Food products, textiles, leather products and apparel	-2362.1	-545.2	-2412.7	1593.8	1509.3	-2216.9
Wood, furniture, pulp, paper and printing	-3959.8	-58.2	-2289.1	2956.3	199.2	-3151.7
Refinery products and petrochemical manufacturing	-36.5	-13.0	-4604.9	145.5	83.7	-4425.1
Plastics, synthetic fiber etc	-610.5	-58.2	-486.5	518.4	70.8	-566.1
Chemicals and products	-2512.7	-357.6	-2094.3	2750.0	419.4	-1795.3
Cement and other non-metallic mineral products	-783.2	-39.3	-758.0	681.3	174.8	-724.4
Basic Metals	-3396.7	-565.1	-5171.8	4969.8	1733.2	-2430.6
Fabricated Metals	-795.9	-31.1	-809.7	443.7	127.1	-1066.0
Machinery and transport equipment	-4811.4	-100.4	-5974.2	6037.9	903.6	-3944.6
Miscellaneous Manufacturing	-610.3	-47.1	-180.5	374.2	71.4	-392.3
All industries	-19879.2	-1815.2	-24781.8	20470.8	5292.4	-20713.0
Energy intensive trade exposed	-9102.8	-1060.4	-14335.0	10790.2	2544.8	-11163.1
All industries, change in imports as % of actual	-6.4	-8.2	-6.9	2.3	2.7	-1.2
EITE, change in imports as % of actual	-22.0	-21.0	-20.6	3.9	3.9	-2.4

***Comparison with the results of Mattoo et al. (2009) Study***

Mattoo et al. (2009) estimate that the US imports of energy intensive manufactured products will fall by about 10 percent if industrialized countries impose carbon tax with a view to cut down CO<sub>2</sub> emissions by about 20 percent and adopt border adjustment measures in accordance with emission embodied in imports. The estimates obtained in this study are not comparable with those of Mattoo and associates because the estimates of this study reflect the outcome of unilateral action while Mattoo and associates consider multilateral action. Also, the estimates of this study are based on partial equilibrium framework, while the estimates of Mattoo and associates take into account the general equilibrium effects. Yet, it is worth noting that according to the estimates obtained in this study, US carbon pricing policy along with carbon tax on imports on the basis of carbon embodied in imports would make the US imports of energy intensive products from developing countries to go down by about 30 to 35 percent. Prima facie it would appear that the estimates of effect of US carbon pricing policy on energy intensive manufactured imports from developing countries obtained in this study are bigger than those obtained by Mattoo and associates. This is actually not true. The share of China, India and the other 12 selected developing countries in the US imports of energy intensive products is about 25

percent. Thus, if imports from other countries do not change, imports from these 14 developing countries will have to fall by about 40 percent if the aggregate US imports of energy intensive manufactured products have to fall by 10 percent. In effect, therefore, the results of Mattoo and associates indicate a larger fall in developing country manufactured exports to the US than what the results of this study do.

It may be mentioned in passing that Mattoo et al. (2009) estimate that due to the carbon pricing policy in industrialized countries coupled with BTA there will be an additional tariff of about 30 percent on imports of energy intensive manufactured products from India, and about 40 percent additional tariff on imports of such products from China. By comparison, the computations made for this study indicate that the additional tariff on imports of energy intensive manufactured products from India and China will be lower.

### ***Impact on the domestic manufacturing sector in developing countries***

While the estimates of fall in exports by China, India etc to the US market are substantial in case the carbon price is set at US\$ 50 per ton of CO<sub>2</sub>, the impact on the domestic manufacturing industry in these countries is relatively much smaller. This may be seen from Tables 4.9 and 4.10. Considering the estimates obtained for India, it may be seen that even in the worst scenario, the fall in manufacturing value added due to reduced exports to the US is only about 1.4 percent. For employment, the corresponding figure is about 1.5 percent. These estimates have been made by applying for each industry the value added to output ratio to the estimates of fall in exports to the US and similarly by applying the employment-output ratios for various industries.<sup>14</sup> The analysis being based on partial equilibrium overstates somewhat the reduction in value added and employment. It seems reasonable to argue that in case a carbon tax on imports of the US leads to a fall in India's exports of manufactures to the US, the Indian producers may partly mitigate this adverse effect by exporting to other destinations. Thus, the actual impact on value added in Indian manufacturing is likely to be less than 1.4 percent, and the actual impact on employment in Indian manufacturing less than 1.5 percent. This argument would apply also to China and other developing countries. The actual impact on manufacturing value added and employment will be less than the estimates shown in Tables 4.9 and 4.10.

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<sup>14</sup> The employment to output ratio and value added to output ratio have been computed for various industry groups for each of the 16 developing countries selected for the study using data from the *Yearbook of Industrial Statistics*.

**Table 4.9: Estimated Value Added Loss due to Reduced Manufactured Exports to the US**

Country/ Scenario	A	B	C	D	E	F	G
	Change in Value Added (US\$ billion)						
China	-1.4	-1.2	-4.2	-3.6	-11.0	-9.5	-5.9
India	-0.2	-0.2	-0.6	-0.5	-1.4	-1.2	-0.7
12 other selected developing countries	0.3	-2.0	0.9	-6.1	2.8	-15.5	-8.7
All	-1.3	-3.3	-3.9	-10.2	-9.6	-26.2	-15.4
	Change in Value Added % Actual manufacturing value added						
China	-0.14	-0.11	-0.42	-0.36	-1.09	-0.94	-0.59
India	-0.19	-0.16	-0.57	-0.50	-1.41	-1.25	-0.71
12 other selected developing countries	0.03	-0.22	0.10	-0.68	0.31	-1.73	-0.97
All	-0.06	-0.16	-0.19	-0.51	-0.48	-1.31	-0.77

Note: For description of Scenarios, see Table 4.1

**Table 4.10: Estimated Employment Loss due to Reduced Manufactured Exports to the US**

Country/ Scenario	A	B	C	D	E	F	G
	Change in Employment (000 nos.)						
China	-92	-78	-292	-248	-785	-670	-410
India	-13	-11	-40	-34	-106	-91	-49
12 other selected developing countries	22	-77	75	-250	224	-691	-366
All	-82	-166	-257	-532	-668	-1453	-825
	Change in employment % Actual manufacturing employment						
China	-0.16	-0.13	-0.50	-0.43	-1.35	-1.15	-0.70
India	-0.17	-0.14	-0.54	-0.46	-1.45	-1.24	-0.67
12 other selected developing countries	0.06	-0.19	0.18	-0.62	0.55	-1.70	-0.90
All	-0.08	-0.16	-0.24	-0.50	-0.63	-1.37	-0.78

Note: For description of Scenarios, see Table 4.1

It has been explained above that the impact of BTA has been estimated in two steps. In the first step, the estimates of the medium-run effect on production, use and imports made by Adkins et al. (2010) for a tax rate of US\$ 15 per ton of CO<sub>2</sub> are applied to the actual data on production, use and imports in 2006, and then in the next step, the effect of BTA is superimposed using the elasticities described in Section 4.1. In several scenarios, the carbon tax rate has been taken as US\$ 50 per ton of CO<sub>2</sub>. But, the estimates of Adkins et al. (2010) are for the tax rate of \$15 per ton CO<sub>2</sub>. They do not provide estimates for a higher level of tax. To take care of this point, an alternate estimate for scenario D has been made in which the estimates of Adkins et al. (2010) of the effects on production, use and imports has been proportionately raised to reflect the effect of a tax rate of US\$ 50 per ton of CO<sub>2</sub> and then BTA has been applied. The difference is marginal. This may be seen from Table 4.11.

**Table 4.11: Effects of BTA on China, India and other selected Developing Countries: Alternate specification of Scenario D**

Country/scenario	All manufacturing industries, change in US imports as % of actual	Energy intensive trade exposed manufacturing industries, change in US imports as % of actual	Change in Value Added % Actual manufacturing value added	Change in employment % Actual manufacturing employment
<b>China</b>				
- Scenario D	-3.9	-13.8	-0.36	-0.43
- Scenario D modified	-3.9	-13.9	-0.36	-0.43
<b>India</b>				
- Scenario D	-5.8	-14.9	-0.50	-0.46
- Scenario D modified	-5.8	-15.0	-0.51	-0.46
<b>Other 12 selected developing countries</b>				
- Scenario D	-4.8	-14.6	-0.68	-0.62
- Scenario D modified	-4.8	-14.6	-0.68	-0.62

Note: Modification to Scenario D is explained in text.

### ***Effect US carbon policy on Brazil and South Africa***

In the analysis presented above, the effects of US carbon pricing policy (accompanied by border tax adjustment) on manufactured exports, and value added and employment in manufacturing in China, India and a group of 12 developing countries have been assessed. The estimates of the effects of US carbon pricing policy on Brazil and South Africa are presented next and a comparison is made with China and India.



Table 4.12 presents estimates of reduction in US imports of manufactured products from China, India, Brazil and South Africa and the group of other 10 selected countries due carbon pricing policy in the US accompanied by border tax adjustment. The estimates are shown by categories of products. The estimates for four scenarios namely B, D, F and G are shown in the table (description of the scenarios are given in Table 4.1). These four scenarios have been chosen for the analysis because in these scenarios all 14 developing countries selected for the study are subject of carbon border tax at the US.

Table 4.12 brings out that the reduction in manufactured products exports of Brazil to the US far exceeds that for India. In scenario F, Brazil's exports loss is US\$ 5.8 billion whereas India's exports loss is US\$ 3.2 billion. The same holds for the other three scenarios considered, namely B, D and G. The manufactured exports loss of Brazil is much greater than that of India.

The loss of manufactured products exports of South Africa is significantly less than that of India, but the difference is relatively small when one considers the energy intensive trade exposed industries. For such industries, the loss in India's exports to the US in scenario F is US\$ 1.8 billion, while that of South Africa is US\$ 1.2 billion.

In comparison with India, Brazil and South Africa, the exports loss of China is far greater. In scenario F, China's loss of manufactured exports to the US is US\$ 32 billion as against India's exports loss of US\$ 3.2 billion, Brazil's exports loss of US\$ 5.8 billion and South Africa's exports loss of US\$ 1.4 billion. In scenario D which assumes that the carbon border tax in the US is based on carbon intensity of domestic products of the US, the exports losses of manufactured products of China, India, Brazil and South Africa (to the US market) are 12.1, 1.3, 2.5 and 0.6 billion US\$ respectively.

For South Africa and Brazil, the loss of exports of products of basic metals industries forms a dominant part of the total loss of exports of manufactured products to the US. In the case of South Africa, about two-third of the exports loss relates to basic metals.

In percentage terms, the exports loss is greater for Brazil and South Africa than that for China and India. In scenario F, for instance, the percentage of exports loss to the US for manufactured products is 10 percent for China and 15 percent of India. But, for Brazil and South Africa, the corresponding figures are 22 percent and 31 percent respectively. This basically reflects the fact that energy intensive product have a larger share in manufactured exports of Brazil and South Africa to the US than the share of such products in the manufactured exports of China and India to the US.

**Table 4.12: Change in US Imports in Different Scenarios, China, India, Brazil and South Africa (US\$ million)**

Industry group	Scenario B					Scenario D				
	China	India	Brazil	South Africa	10 other selected developing countries	China	India	Brazil	South Africa	10 other selected developing countries
Food products, textiles, leather products and apparel	-438.3	-115.7	-68.8	-4.9	-427.1	-1418.4	-372.4	-223.3	-16.0	-1393.9
Wood, furniture, pulp, paper and printing	-761.5	-12.7	-123.9	-5.9	-372.9	-2412.0	-40.2	-387.0	-18.3	-1180.0
Refinery products and petrochemical manufacturing	-7.2	-3.1	-35.6	-0.4	-982.4	-22.5	-9.3	-111.2	-1.3	-3086.0
Plastics, synthetic fiber etc	-119.3	-13.0	-4.4	-0.2	-103.8	-374.4	-40.5	-13.9	-0.8	-324.5
Chemicals and products	-481.5	-78.6	-45.4	-20.8	-391.2	-1528.0	-247.7	-143.7	-64.3	-1238.2
Cement and other non-metallic mineral products	-179.7	-8.4	-35.0	-21.0	-126.0	-507.6	-26.9	-109.4	-67.7	-363.5
Basic Metals	-743.2	-142.3	-429.4	-153.7	-756.2	-2173.9	-412.7	-1221.5	-429.4	-2167.3
Fabricated Metals	-144.0	-6.4	-4.0	-0.4	-161.7	-473.1	-21.0	-13.0	-1.3	-531.1
Machinery and transport equipment	-861.2	-20.4	-68.1	-9.0	-1136.9	-2846.9	-67.4	-224.8	-29.7	-3754.8
Miscellaneous Manufacturing	-108.6	-9.5	-0.7	-0.4	-35.3	-360.2	-31.5	-2.4	-1.2	-117.2
<b>All industries</b>	<b>-3844.5</b>	<b>-410.1</b>	<b>-815.3</b>	<b>-216.8</b>	<b>-4493.7</b>	<b>-12117.0</b>	<b>-1269.7</b>	<b>-2450.2</b>	<b>-630.0</b>	<b>-14156.6</b>
Energy intensive trade exposed	-1886.8	-251.6	-641.0	-201.5	-2542.2	-5701.9	-756.3	-1880.6	-579.7	-7741.2
All industries, change in imports as % of actual	-1.2	-1.9	-3.2	-4.9	-1.4	-3.9	-5.7	-9.5	-14.2	-4.3
EITE, change in imports as % of actual	-4.6	-5.0	-6.8	-7.4	-4.4	-13.8	-14.9	-20.0	-21.2	-13.5

(Table 4.12 continued)

Industry group	Scenario F					Scenario G				
	China	India	Brazil	South Africa	10 other selected developing countries	China	India	Brazil	South Africa	10 other selected developing countries
Food products, textiles, leather products and apparel	-3929.5	-1016.8	-623.8	-44.7	-3947.5	-2362.1	-545.2	-328.9	-23.6	-2060.2
Wood, furniture, pulp, paper and printing	-6336.1	-105.3	-979.5	-45.2	-3090.6	-3959.8	-58.2	-555.1	-26.1	-1707.9
Refinery products and petrochemical manufacturing	-56.2	-21.3	-281.5	-3.3	-7912.7	-36.5	-13.0	-159.5	-1.9	-4443.4
Plastics, synthetic fiber etc	-956.3	-102.8	-35.5	-1.9	-820.1	-610.5	-58.2	-20.0	-1.1	-465.5
Chemicals and products	-4045.0	-643.5	-377.2	-158.6	-3269.3	-2512.7	-357.6	-208.1	-91.5	-1794.7
Cement and other non-metallic mineral products	-1107.3	-72.4	-285.9	-185.2	-824.3	-783.2	-39.3	-157.9	-99.2	-500.9
Basic Metals	-4820.5	-888.5	-2506.9	-849.0	-4567.7	-3396.7	-565.1	-1650.9	-573.9	-2947.0
Fabricated Metals	-1361.9	-60.4	-37.5	-3.8	-1528.9	-795.9	-31.1	-19.4	-2.0	-788.4
Machinery and transport equipment	-8343.4	-197.1	-655.2	-86.5	-10973.6	-4811.4	-100.4	-334.7	-44.3	-5595.2
Miscellaneous Manufacturing	-1065.9	-93.2	-7.0	-3.5	-346.9	-610.3	-47.1	-3.5	-1.8	-175.2
<b>All industries</b>	<b>-32022.1</b>	<b>-3201.4</b>	<b>-5790.1</b>	<b>-1381.7</b>	<b>-37281.6</b>	<b>-19879.2</b>	<b>-1815.2</b>	<b>-3438.0</b>	<b>-865.2</b>	<b>-20478.6</b>
Energy intensive trade exposed	-13651.7	-1775.3	-4170.7	-1237.7	-18761.2	-9102.8	-1060.4	-2595.2	-790.7	-10949.1
All industries, change in imports as % of actual	-10.3	-14.5	-22.5	-31.2	-11.3	-6.4	-8.2	-13.3	-19.5	-6.2
EITE, change in imports as % of actual	-33.0	-35.1	-44.5	-45.3	-32.6	-22.0	-21.0	-27.7	-28.9	-19.0

Estimates of loss in manufacturing sector value added due to reduced exports of manufactured products to the US (cause by carbon pricing in the US along with BTA) are presented in Table 4.13 for all seven scenarios. The loss is found to be greater for Brazil than that for India, whenever exports from both countries are subject to carbon border tax at the US. In scenario D, when the carbon border tax is based on US domestic industry carbon intensities, India's loss in manufacturing value added is US\$ 0.5 billion, whereas Brazil's loss in manufacturing value added about US\$ 1.1 billion. In scenario F, when the carbon border tax is based on carbon content in imports, the value added loss in India is US\$ 1.2 billion, while the value added loss in Brazil is about US\$ 2.6 billion. The loss in manufacturing value added in China far exceeds that in both India and Brazil. On the other hand, the manufacturing value added loss in South Africa is small in relation to the manufacturing value added loss suffered by China, India and Brazil.

**Table 4.13: Estimated Value Added Loss due to Reduced Manufactured Exports to the US, in Different Scenarios, China, India, Brazil and South Africa**

Countries	Change in Value added in different scenarios, in Billion US\$						
	A	B	C	D	E	F	G
China	-1.36	-1.15	-4.25	-3.62	-11.00	-9.46	-5.92
India	-0.18	-0.16	-0.57	-0.49	-1.39	-1.24	-0.71
Brazil	0.04	-0.36	0.13	-1.08	0.40	-2.56	-1.51
South Africa	0.01	-0.06	0.02	-0.17	0.06	-0.38	-0.24
10 other developing countries	0.24	-1.54	0.79	-4.84	2.36	-12.59	-6.98
All	-1.26	-3.27	-3.88	-10.20	-9.58	-26.21	-15.36
	Change in Gross value added in different scenarios, in %						
	A	B	C	D	E	F	G
China	-0.135	-0.115	-0.423	-0.360	-1.095	-0.941	-0.590
India	-0.186	-0.161	-0.573	-0.500	-1.408	-1.253	-0.715
Brazil	0.017	-0.154	0.057	-0.463	0.171	-1.101	-0.651
South Africa	0.013	-0.144	0.044	-0.416	0.132	-0.901	-0.569
10 other developing countries	0.038	-0.247	0.126	-0.776	0.379	-2.020	-1.120
All	-0.063	-0.164	-0.194	-0.510	-0.479	-1.310	-0.768

Note: For description of Scenarios, see Table 4.1

In percentage terms, the loss in manufacturing value added is not much different among the four countries, China, India, Brazil and South Africa. In scenario D, the percentage fall in value added ranges from 0.36 to 0.50, and in scenario F, the range is from 0.90 to 1.25 percent.

Estimates of employment loss due to reduced manufactured exports to the US are shown in Table 4.14. The employment loss in number of persons in Brazil and South Africa is relatively

smaller than that for China and India, particularly in the case of South Africa. In scenario F which has the largest adverse impact on the developing countries, the loss in employment in South Africa due to reduced exports of manufactured products to the US is only about 8,000 persons whereas the employment loss in China is about 671 thousand persons and that in India is about 91 thousand persons. Employment loss in Brazil is higher than that of South Africa, but less than that in China and India.

**Table 4.14: Change in Employment due to Reduced Manufactured Exports to US, in Different Scenarios, China, India, Brazil and South Africa**

Countries	Change in employment in different scenarios, in 000 no.						
	A	B	C	D	E	F	G
China	-91.9	-77.9	-291.8	-248.1	-785.2	-670.5	-409.7
India	-12.5	-10.6	-39.8	-33.9	-106.4	-91.1	-49.4
Brazil	1.2	-6.5	3.9	-20.3	11.7	-52.2	-29.2
South Africa	0.1	-1.1	0.4	-3.3	1.3	-7.9	-4.7
10 other developing countries	21.1	-69.9	70.2	-226.0	210.7	-631.2	-332.5
All	-82.0	-166.0	-257.1	-531.7	-667.9	-1452.8	-825.4
	Change in employment in different scenarios, in %						
	A	B	C	D	E	F	G
China	-0.16	-0.13	-0.50	-0.43	-1.35	-1.15	-0.70
India	-0.17	-0.14	-0.54	-0.46	-1.45	-1.24	-0.67
Brazil	0.02	-0.09	0.05	-0.28	0.16	-0.71	-0.40
South Africa	0.01	-0.08	0.03	-0.23	0.09	-0.54	-0.32
10 other developing countries	0.07	-0.22	0.22	-0.71	0.66	-1.99	-1.05
All	-0.08	-0.16	-0.24	-0.50	-0.63	-1.37	-0.78

Note: For description of Scenarios, see Table 4.1

In percentage terms too, the employment loss in Brazil and South Africa is lower than that in China and India. In Scenario F, China and India lose over one percent of their manufacturing employment. The corresponding figures for Brazil and South Africa are 0.7 and 0.5 percent respectively.

#### 4.4 Indirect Effects on the Indian Economy

An attempt has been made to assess for India the indirect effect of the loss of exports to the US on the rest of the Indian economy. This analysis is based on an input-output table for 2006-07 prepared by the Central Statistical Office (CSO), Government of India.<sup>15</sup> The loss of exports to

<sup>15</sup> At the time this analysis was done, the table was available at the website of CSO. It is not available now.

the US is converted into the change in the export vector of the input-output table. The change in the export vector is then multiplied by the Leontief inverse matrix to obtain changes in the output in different sectors of the economy. The changes in output of the different sectors of the economy are multiplied by the value added to output ratio computed for different input-output sector to derive the loss in aggregate value added in the economy. In a similar manner, the aggregate loss in employment is computed. This requires estimates of employment output ratio for different sectors of the economy. This has been done using employment estimates drawn from NSS (Nation Sample Survey) data<sup>16</sup> and value of output of different sectors of the economy as provided in the input-output table.

The estimates of direct and indirect loss in value added and in employment are reported in Table 4.15. This is shown for different scenarios. The estimates of direct loss are taken from Tables 4.9 and 4.10 above. The estimates of total loss, direct and indirect loss combined, have been made using the method explained above. In the worst scenario, the loss in GDP is about US\$ 3.2 billion. India's aggregate GDP in 2006-07 was about US\$ 1016 billion. Thus, the loss in GDP in the worst scenario comes to about 0.3 percent. The loss in employment in the worst scenario is about 1.5 million. This comes to about 0.3 percent of the aggregate employment in the Indian economy in 2006 (about 480 million).

**Table 4.15: Impact of Reduced Manufactured Exports to the US on GDP and Employment in the Indian Economy**

Scenario	Impact on GDP (billion US\$)		Impact on employment (000 persons)	
	Direct	Direct and indirect	Direct	Direct and indirect
A	-0.2	-0.4	-13	-183
B	-0.2	-0.4	-11	-156
C	-0.6	-1.3	-40	-579
D	-0.5	-1.1	-34	-496
E	-1.4	-3.2	-106	-1530
F	-1.2	-2.9	-91	-1319
G	-0.7	-1.6	-49	-720

Note: For description of Scenarios, see Table 4.1

While the US carbon price policy when accompanied with border tax adjustment is expected to have an adverse effect on the India economy because of the loss in exports to the US market, an indirect benefit is expected to be reaped by the Indian economy through the downward pressure that the US policy will have on the global oil prices. The studies on the US carbon price policy do not provide a clear indication of the magnitude of the likely fall in global oil prices that will take place due to these policies. Assessing the benefits that India will draw from the reduction in global oil prices is therefore difficult. Nonetheless, the benefits could be large enough to compensate at least partly for the loss of output and employed caused by reduction in exports to the US.

<sup>16</sup> The employment estimates are for 2004-05. These have been extrapolated to 2006-07.

## **5. Energy and Carbon Intensity, Comparing India with Other Countries**

This section supplements the analysis presented in the previous two sections. It deals with inter-country differences in energy intensity and carbon emission intensity. How India compares with the US in this regard is of particular interest. This analysis of differences in energy intensity and carbon emission intensity between India and the US is important for understanding how big a gap is there between emission intensities of manufacturing industries of India and the US, and how large an impact will be there on the Indian exports of manufactures to the US if the carbon border tax in the US is imposed on the basis of carbon content of imports rather than carbon content of similar domestically produced goods.

### **5.1 Basis for the Rate of Carbon Border Tax**

The Waxman-Markey bill contains two kinds of provisions with potential trade impact. The first one is the grant of free emission allowances to certain energy intensive or trade intensive industries. But, whether these allowances will be given as subsidies or lump sum transfers is not clear yet. Another provision is about imposition of border tax on the imports. The main questions which remain unanswered in this regard are:

1. Whether this tax will be imposed on all the products or only on energy intensive products?
2. Whether the tax rate will be based on the carbon content of the imports or that of the comparable domestic products?

It needs to be emphasized here that the imposition of carbon border tax on the basis of carbon content of imports rather than carbon content of comparable domestic products will have far greater impact on US imports from developing countries. The basis for this argument is not hard to appreciate. It has already been shown in Section 3 that the impact of carbon tax on imports depends on the magnitude of certain price elasticities and the level of carbon taxes, and clearly the rate of tax when it is imposed on imports from a developing country on the basis of carbon content of imports will almost invariably be higher than when it is based on carbon content of similar domestic products. A higher tax on imports will obviously have greater impact on imports. It should be noted further that the estimates of impact of carbon tax presented in the previous section corroborates the argument that the imposition of carbon border tax on the basis of carbon content of imports instead of carbon content of comparable domestic products will have far greater impact on US imports from developing countries.

From the above, it follows that if the US imposes the carbon border tax on the basis of comparable domestic production rather than carbon content of imports, this will be advantageous for developing countries, as it will give them a level playing field with domestic US industries, while addressing the problem of loss of competitiveness of US industries and carbon leakages at the same time. One disadvantage of basing the carbon tax on emission intensity of comparable domestic products is that it does not create sufficient incentive for foreign (developing country) producers to become more energy efficient and reduce their level of emissions, as they will continue to pay the same tax even if they become more energy efficient.

To put the issues raised above in a broader perspective, it may be pointed out that the application of border tax adjustment has been advised by economists as an instrument to reduce the gap in the environmental related policies and measures among different countries, especially Annex I and II countries. It needs to be realized in this context that unless the developing countries which are significant sources of carbon emission take steps for containing the growth in their level of carbon emission, the rate of emission at the global level may continue to rise. It needs to be underscored that energy use in certain developing countries like China and India is growing rapidly. Between 1990-2005, China's manufacturing energy demand more than doubled, transport energy use almost tripled and the service sector increased its consumption of energy by three and a half times. China's final energy use increased by 69% over this period (IEA, *World Energy Outlook*, 2007). If the governments around the world continue with current policies, the world's energy needs would be well over 50 percent higher in 2030 than today. China and India would together account for about 45 percent of the increase in demand in this scenario. Globally, fossil fuels continue to dominate the fuel mix. These trends lead to continued growth in energy related emissions of carbon-dioxide (CO<sub>2</sub>) and to increased reliance of consuming countries on imports of oil and gas – much of these from the Middle East and Russia. Both developments would heighten concerns about climate change and energy security (IEA, *World Energy Outlook*, 2007).

Rising CO<sub>2</sub> and other greenhouse-gas concentrations in the atmosphere, resulting largely from fossil-fuel combustion, are contributing to higher global temperatures and to changes in the climate. This has already been noted in the introductory section of the Report. Growing fossil-fuel use will continue to drive up global energy-related CO<sub>2</sub> emissions in the years to come. The United States, China, Russia and India contribute about two-thirds of this increase. China is by far the biggest contributor to incremental emissions, overtaking the United States as the world's biggest emitter in 2007. India will become the third-largest emitter by around 2015.

Given the current trends in energy consumption and CO<sub>2</sub> emissions in China, India and other major developing countries, raising serious concerns about the increasing CO<sub>2</sub> and other greenhouse-gas concentrations in the atmosphere, some of the industrialized may respond to the situation by combing their carbon pricing policy with border tax adjustment to address the problems of carbon leakage and loss of competitiveness. While there are issue of WTO compatibility, one cannot ruled out the possibility that such countries fix the rate of the carbon border tax on imports from developing countries on the basis of carbon content of imports rather than on carbon content of comparable domestic products. Hence, it is important to study how much difference is there in energy intensity and carbon intensity between the US and the developing countries. This is attempted in the following sub-sections.

## **5.2 Energy Intensity at the Aggregate Economy Level**

To compute energy intensity (or emission intensity) for international comparison, it becomes necessary to express the value of output of different countries in some common currency, often in US\$. The conversion of the value of output of a country from its local currency to US\$ can be done at market exchange rate (MER) or at Purchasing Power Parity (PPP) exchange rate.



Whether the market exchange rate is used for the purpose, or the PPP exchange rate is used, makes a lot of difference.

Both market exchange rate and PPP exchange rate are legitimate ways to convert the values expressed in the currencies of different countries into values expressed in a common currency, in practice in US\$. Market exchange rates are influenced by short-term factors and are subject to substantial distortions caused by speculative movements and government interventions, and therefore comparisons based on exchange rates, even when averaged over a period of time such as a year, may yield unreliable and misleading results. By contrast, PPP conversions allow cross-country comparisons of economic aggregates on the basis of physical levels of output, free of price and exchange rate distortions. But PPP has its own limitations; a prominent one is that it does not include non-tradable goods.

There is a large gap between market and PPP-based exchange rates in emerging market and developing countries, for most of which the ratio of the market to PPP U.S. dollar exchange rate is between 2 and 4. But, for advanced countries, the market and PPP rates tend to be much closer. As a result, developing countries get a much higher weight in aggregations that use PPP exchange rates than those that use market exchange rates. China's weight in the global economy is more than 15 percent using PPP exchange rates, but less than 5 percent with market-based exchange rate. For India, the corresponding figures are 6 percent and 1.5 percent, respectively.

In Tables 5.1 and 5.2, a comparison of the energy intensity of the US is made with that of a number of developing countries for the years 2004 to 2009. The comparison in Table 5.1 is based on MER while that in Table 5.2 is based on PPP. When the comparison is made on the basis of market exchange rate, energy intensity of all the five developing countries under consideration is found to be higher than that of the US (in the case of Mexico, this holds for 2006 and later years). But, in PPP exchange rate, the relative positions of different countries in energy intensity change. The relative position (vis-à-vis US) reverses for Brazil, Mexico and India, whereas for China and South Africa, the gap in energy intensity reduces significantly. Table 5.1 which is based on MER gives the impression that India's efficiency in energy use is much less than that of the US. But, a more correct comparison based on PPP presented in Table 5.2 which implicitly makes corrections for difference in price levels of commodities in the two countries indicates that the gap in energy efficiency level may not be large.

One difficulty with the comparisons made in Tables 5.1 and 5.2 is that energy intensity at the aggregate economy may not correctly portray the true differences in energy efficiency levels because the industry compositions of the countries differ. Thus, a relatively higher share of services in an economy may reduce the energy intensity, without the country actually being relatively more efficient in the use of energy as compared to others. Clearly, to assess properly the inter-country differences in energy use efficiency, comparisons of energy intensity need to be made at sector or industry level. This is attempted in the next sub-section.

**Table 5.1: Energy Intensity - Total Primary Energy Consumption per Dollar of GDP (Btu / Year 2005 U.S. Dollars (Market Exchange Rate))**

Countries	2004	2005	2006	2007	2008	2009
United States	8,234	7,935	7,679	7,659	7,505	7,340
Mexico	7,890	7,924	8,187	7,818	7,754	7,958
Brazil	10,524	10,601	10,567	10,391	10,087	10,081
South Africa	22,231	20,742	20,289	20,056	20,013	19,506
China	31,026	30,236	28,656	26,607	26,596	25,982
India	20,006	19,468	19,204	18,691	18,860	19,166

Source: US Energy Information Authority, available at <http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=90&pid=44&aid=8> (accessed on 10 November 2011 and 17 May 2012)

**Table 5.2: Energy Intensity - Total Primary Energy Consumption per Dollar of GDP (Btu/ Year 2005 U.S. Dollars (PPP exchange rate))**

Countries	2004	2005	2006	2007	2008	2009
United States	8,234	7,935	7,679	7,659	7,505	7,340
Mexico	4,965	4,986	5,152	4,920	4,880	5,008
Brazil	6,050	6,094	6,075	5,974	5,799	5,796
South Africa	13,628	12,715	12,438	12,295	12,269	11,958
China	12,875	12,547	11,891	11,041	11,036	10,782
India	6,669	6,489	6,401	6,230	6,287	6,389

Source: US Energy Information Authority, available at <http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=90&pid=44&aid=8> (accessed on 10 November 2011 and 17 May 2012)

### 5.3 Sector- wise energy intensity

The analysis of inter-country differences in energy intensity is taken a step further by making such a comparison at a disaggregated level. A comparison of energy intensity has been done for 10 broad industrial groups or sectors for Brazil, China, Mexico, India, South Africa and the US for the year 2006. The data on output have taken from the *Year Book of Industrial Statistics*, 2010 and 2011. The source of data on energy consumption is the International Energy Agency (IEA). There are difficulties in matching energy use and production data for individual industries obtained from two data source. Whatever best is possible has been attempted in Table 5.3.

Table 5.3 shows, for the ten sectors, the energy intensity of different countries at the market exchange rate and PPP exchange rate for the year 2006. The main findings from the comparison of energy intensity at Market exchange rate (MER) are as follows:

1. China has relatively higher energy intensity in almost every product group except paper and pulp.
2. Brazil has higher energy intensity than US for all the product groups, except Chemicals, Petroleum products and Textiles.
3. India has lesser energy intensity than the US in four product groups and higher energy intensity in three product groups. But, on average, energy intensity in India is higher than that in the US, which can be traced to a huge gap in energy intensity in Non-metallic mineral products.
4. Mexico has by and large the same pattern as India (except for Food) and its average energy intensity is also higher than that of US. The relatively higher average energy intensity of Mexico compared to the US is because of the huge difference in energy intensity in transport equipment.
5. South Africa is the only country showing lesser energy intensity than US in most product groups.

When comparison of energy efficiency is made on the basis of PPP exchange rate, radical changes are observed. Some key points that may be noted are:

1. Except for Iron and Steel, the pattern has reversed for all the products under PPP. Under PPP, all the countries except Brazil are showing lesser energy intensity than the US.
2. Only for Iron and Steel, the energy intensity of China is higher than US in both the cases. But, for other products, China's energy intensity has become lesser under PPP. The average has also reduced under PPP.
3. Brazil is the only country which is showing higher average energy intensity than the US in both the cases, MER and PPP. In fact, except for Chemicals and petrochemicals, and Textile products, all the products are showing higher energy intensity in both the cases.
4. Indian energy intensity has also reduced under PPP. Under PPP all the products except non-metallic mineral products are showing lesser energy intensity than the US.

The overall conclusion that one may draw on the basis of comparison of energy intensity of manufacturing industries using PPP exchange rates presented in Table 5.3 is that the energy intensity of manufacturing industries of major developing countries at PPP exchange rate is commonly lesser than that of the US (except for Brazil).

**Table 5.3: Energy Intensity, 2006 (tones oil equivalent /million \$ output)**

ISCI code	Description	Product code	Products	Mexico PPP	Mexico MER	Brazil PPP	Brazil MER	South Africa PPP	South Africa MER	China PPP	China MER	India PPP	India MER	US	PPP based average	MER based average	
2710 2731	Iron and steel	19	Iron, Steel and Ferroalloy	244.45	351.58	283.2	440.98	286.83	485.19	198.04	430.02	96.9	292.65	148.12	312.15	400.08	
	basic iron and steel			65%a	137%a	91% a	198% a	94% a	228% a	34% a	190% a	-35% a	98% a		111% a	170% a	
	casting of iron and steel	21	Ferrous Metal foundries		72%b		107% b		134% b		157% b		132% b			59% b	
2413 2411 2411 2413 2430 2412 242	chemical and petrochemical plastic in primary forms	7	Petrochemical manufacturing Basic Inorganic Chemical Manufacturing Other basic organic chemicals Mfg Plastic and Material Resins Artificial & synthetic fibers, Filaments Fertilizers Other chemical and plastics	47.02	67.62	66.89	104.16	57.12	96.62	98.99	214.94	28.24	85.28	122.12	88.23	113.72	
				-61% a	-45% a	-45% a	-15% a	-53% a	-21% a	-19% a	76% a	-77% a	-30% a		-28% a	-7% a	
	basic chemicals	8				17% b		31% b		32% b		95% b		47% b			21% b
	basic chemicals	9															
	plastic in primary forms	10															
	Man-made fibers	11															
	Fertilizers	12															
other chemicals	13																
2720	Non-ferrous metals	20	Alumina refining, primary and secondary Aluminum, non-Ferrous Metal foundries	8.02	11.53	247.01	384.64	124.58	210.74	78.27	169.96	7.85	23.72	133.47	136.42	160.112	
	basic non-ferrous metals			-94% a	-91% a	85% a	188% a	-7% a	58% a	-41% a	27% a	-94% a	-82% a		2% a	20% a	
					3% b		103% b		65% b		69% b		12% b			18% b	

2610 2694 2694 2699 2699	Non-metallic mineral products glass and glass products	14	Glass Containers	126.71	182.24	256.23	398.99	107.49	181.82	328.94	714.27	201.21	607.66	172.47	293.41	416.99	
	cement , lime n plaster	15	Cement	-27% a	6% a	49% a	131% a	-38% a	5% a	91% a	314% a	17% a	252% a		70% a	142% a	
	cement , lime n plaster	16	Lime and Gypsum														
	Non-metallic mineral products	17	Mineral Wool														
	No- metallic mineral products	18	Other Nonmetallic minerals														
331	Transport equipment	28	Other Transportation Equipment Manufacturing	294.64	423.77	--	--	3.92	6.63	57.46	124.77	--	--	50.37	118.67	185.06	
	Transport equipment			485% a	741% a			-92% a	-87% a	14% a	148% a					136% a	267% a
					256% b				5% b		134% b						
291	Machinery	25	Machinery	0.73	1.05	--	--	4.49	7.6	32.63	70.85	7.8	23.55	45.68	11.41	25.76	
	Machinery			-98% a	-98% a			-90% a	-83% a	-29% a	55% a	-83% a	-48% a		-75% a	-44% a	
					1% b				7% b		84% b		34% b				31% b
15	Food and tobacco manufacturing of food products and beverages	1	Food	23.69	34.07	112.65	175.42	1.94	3.29	28.34	61.54	42.5	128.35	44.98	60.689	80.53	
					-47% a	-24% a	150% a	290% a	-96% a	-93% a	-37% a	37% a	-6% a	185% a	0% a	35% a	79% a
						23% b		140% b		3% b		74% b		191% b			
21	Paper , pulp and printing	5	Pulp and Paper Mills	60.23	86.63	174.39	271.55	12.56	21.24	59.66	129.54	41.55	125.49	214.6	106.05	126.89	
	paper and pulp			-72% a	-60% a	-19% a	27% a	-94% a	-90% a	-72% a	-40% a	-81% a	-42% a		-51% a	-41% a	
							45% b		4% b		33% b		39% b				10% b

20 3610	Wood and wood products	4	Wood and furniture	--	--	--	--	4.73	8	27.83	60.43	--	--	57.2	16.28	34.21	
	wood products							-92% a	-86% a	-51% a	6% a					-72% a	-40% a
	Furniture								6% b		57% b						
17	Textile and leather manufacturing of textile	2	Textile	--	--	34.28	53.38	7.21	12.19	44.81	97.3	10.61	32.04	76.02	39.84	48.73	
						-55% a	-30% a	-91% a	-84% a	-41% a	28% a	-86% a	-58% a		-48% a	-36% a	
							25% b		7% b		69% b		28% b			12% b	
Average				100.69	144.81	167.81	261.3	61.09	103.33	99.48	207.36	54.58	164.84	106.5	118.32	159.21	

*Yearbook of Industrial statistics (UNIDO), 2010 and 2011, and International Energy Agency. a – percentage higher or lower than US b- percentage difference between intensity computed on the basis of PPP and market exchange rate*

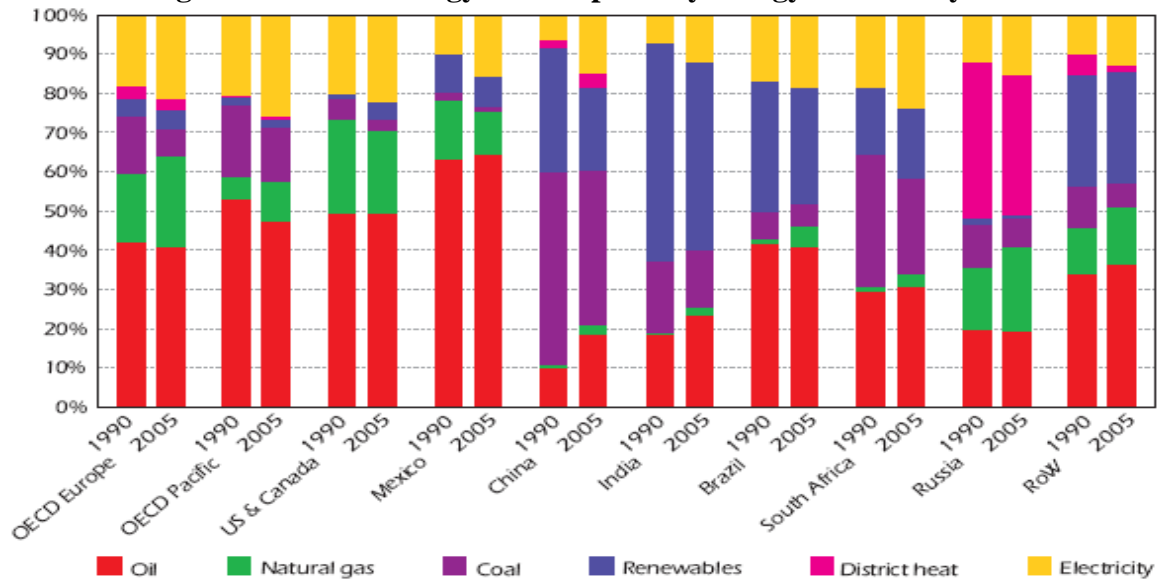
Attention may be drawn here to the fact that while PPP exchange rates are meaningful when comparisons are made at the economy level, the PPP exchange rates may not show correctly the price differences for individual sectors. Ideally, for comparisons of energy intensity and emission intensity across countries at the industry or sector level, the sectoral PPP should be used. But as the data on sectoral PPP are not available, the country level PPP had to be used. This introduces a distortion in the comparison. But, it seems, the broad conclusion drawn from Table 5.3 will stand even if sectoral PPP exchange rates are used.

## 5.4 Carbon Intensity

Two factors determine the carbon intensity of industrial production: the source of energy used to manufacture the good and the efficiency with which it is produced. These two factors can differ greatly between firms and between countries.

Analysis of the energy mix of India for 2005 (Figure 5.1) reveals that the type of energy with highest share in energy use is renewable energy, followed by coal and oil. By contrast, China uses coal heavily to meet its energy requirements followed by oil and renewables. US energy mix is different from that of India and China; the US heavily depends on Oil and natural gas, and the share of renewables is negligible.

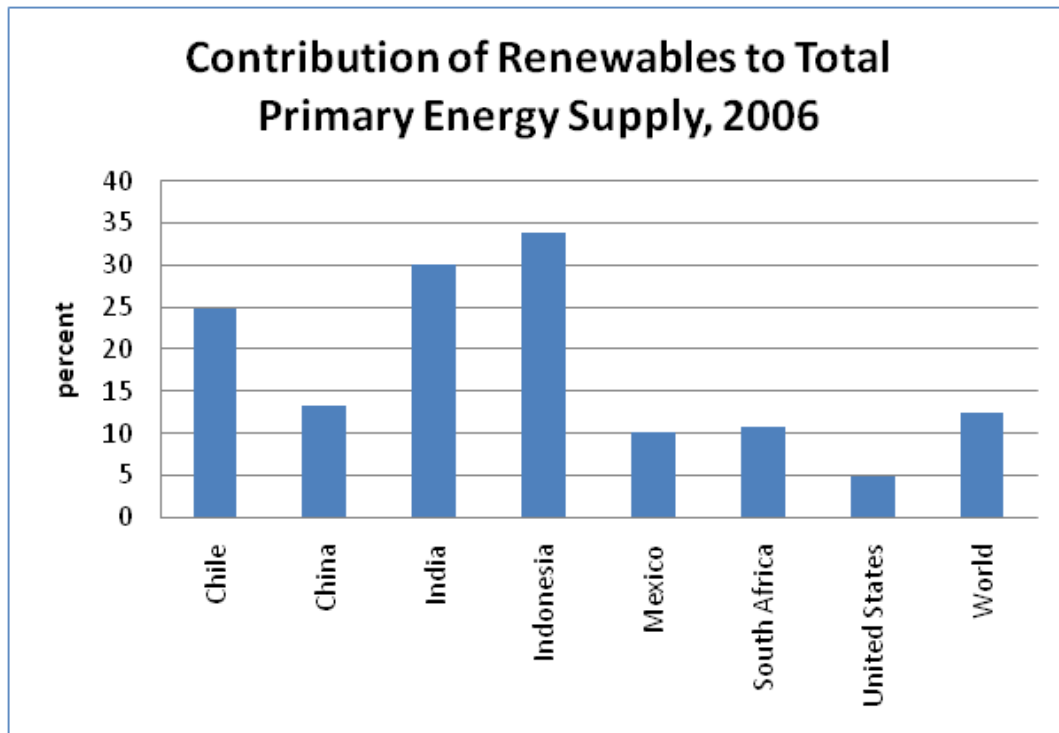
**Figure 5.1: Total energy consumption by energy commodity in 2005**



Sources: IEA, 2007 c; IEA, 2007 d; IEA estimates.  
 Note: Excludes fuel use in electricity and heat production.

Figure 5.2 compares India with the US and a number of other developing countries in terms of the share of renewables in total primary energy. Contribution of renewables to total primary energy is shown for the year 2006. It is evident from the graph that the use of renewable energy is relatively high in India. Prima facie, this may appear surprising. However, this is a fact and the explanation lies in the extensive use of bio-mass (e.g., crop residue and animal dung) for cooking in rural areas in India, which is included among the renewable sources of energy.

**Figure 5.2: Contributions of Renewables to Primary Energy Supply, 2006**



Examination of the carbon intensity of different countries is revealing. A comparison at the aggregate economy level across countries is presented in Tables 5.4 and 5.5 for the years 2005 to 2009. Carbon intensity at market exchange rate is relatively high for China, India and South Africa in relation to the US. But, at PPP, India's carbon intensity is almost equal to that of the US, or only marginally higher. Carbon intensity of Brazil and Mexico is significantly lesser than that of the US at PPP exchange rate. The large gap between China and the US in terms of carbon intensity narrows down substantially when measurement is done at the PPP exchange rate rather than at market exchange rate.



**Table 5.4: Carbon Intensity using Market Exchange Rates (Metric Tons of Carbon Dioxide per Thousand Year 2005 U.S. Dollars)**

Countries	2005	2006	2007	2008	2009
<b>United States</b>	0.474	0.456	0.455	0.441	0.421
<b>Mexico</b>	0.469	0.491	0.483	0.483	0.505
<b>Brazil</b>	0.419	0.418	0.412	0.417	0.417
<b>South Africa</b>	1.751	1.705	1.684	1.696	1.609
<b>China</b>	2.442	2.287	2.154	2.136	2.219
<b>India</b>	1.408	1.395	1.357	1.380	1.406

Source: US Energy Information Authority, available on <http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=90&pid=44&aid=8> (accessed on 10<sup>th</sup> November 2011 and 17<sup>th</sup> May, 2012)

**Table 5.5: Carbon Intensity using Purchasing Power Parities (Metric Tons of Carbon Dioxide per Thousand Year 2005 U.S. Dollars)**

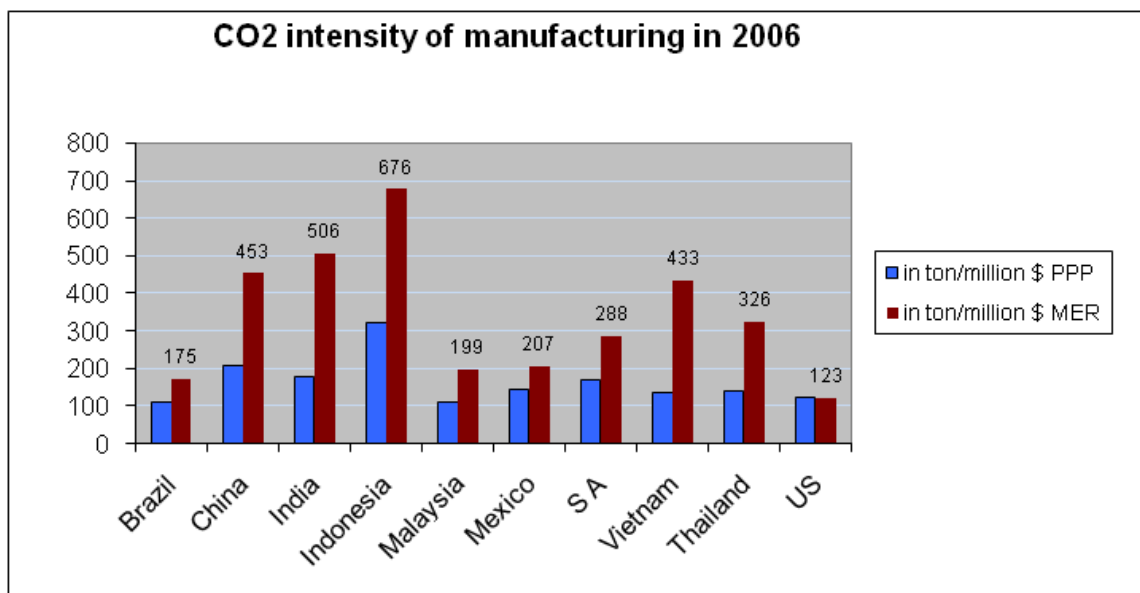
Countries	2005	2006	2007	2008	2009
<b>United States</b>	0.474	0.456	0.455	0.441	0.421
<b>Mexico</b>	0.295	0.309	0.304	0.304	0.318
<b>Brazil</b>	0.241	0.240	0.237	0.240	0.240
<b>South Africa</b>	1.074	1.045	1.033	1.040	0.987
<b>China</b>	1.013	0.949	0.894	0.886	0.921
<b>India</b>	0.469	0.465	0.452	0.460	0.469

Source: US Energy Information Authority, available on <http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=90&pid=44&aid=8> (accessed on 10<sup>th</sup> November 2011 and 17<sup>th</sup> May, 2012)

Since the focus of the study is on the manufacturing sector, it is important to make an inter-country comparison of carbon intensity of the manufacturing sector. The estimate of carbon intensity of manufacturing for different countries has been made using data on CO<sub>2</sub> emission taken from IEA (2008b) and data on manufacturing sector output taken from the *Yearbook of Industrial Statistics* (UNIDO). In the IEA estimates of CO<sub>2</sub> emissions, manufacturing and construction is combined. This has been separated into estimates of emissions for manufacturing and that for construction using data on energy consumption in manufacturing and construction. The estimates of carbon intensity in manufacturing are shown in Figure 5.3.<sup>17</sup>

<sup>17</sup> Certain limitations of the estimates need to be pointed out. Since data on CO<sub>2</sub> emissions and manufacturing sector output have been obtained from two different sources, there is a problem of data comparability. Also, due to gaps in available data on energy consumption in construction, considerable difficulties have been faced in splitting the estimated CO<sub>2</sub> emissions for manufacturing and construction available in the publication of IEA into the amount of emissions attributable to the two sectors. Therefore, the estimates shown in Figure 5.3 should be treated as rough estimates which need to be refined as more data become available.

**Figure 5.3: CO<sub>2</sub> emission ton/million US\$ output for Manufacturing, 2006**



Source: Data on CO<sub>2</sub> Emissions from fuel combustion taken from IEA (2008b) and value of output from *Yearbook of industrial statistics* 2010 and 2011. Carbon intensity of manufacturing calculated by authors.

It is seen from the Figure 5.3, that the CO<sub>2</sub> intensity of manufacturing sector of all the nine developing countries considered for the analysis are higher than that of the US when measurement of intensity is done at the market exchange rates. But, the gap reduces significantly when emission intensity is computed at PPP exchange rate. In particular, it may be noted that at market exchange rate, the carbon intensity of Indian manufacturing is over four times that of the US manufacturing. But, at PPP, the carbon intensity of Indian manufacturing is only about 50 percent higher than that of the US manufacturing.

#### ***Comparison with Estimates in the Mattoo et al. paper***

Aaditya Mattoo and associates (Mattoo et al., 2009) have given estimates of direct and indirect emission intensity for the manufacturing sectors of the US, China and India for 2004. In terms of total (direct + indirect) emissions, the carbon intensities of manufacturing of India and China at 518 and 681 tons per million US dollars of output respectively are very high as compared to that of the US (226% and 328% higher than the US). But, this gap reduces somewhat when the direct emission level is only considered; the gap reduces to 208% and 253% respectively for India and China. The estimates of emission intensity of manufacturing sector obtained in this study (Figure 5.3) also show a large difference between carbon intensity of manufacturing of India and China and that of the US. The gap in carbon intensity from the US level is 311% and 269% for India and China respectively for 2006. Thus, the estimates obtained in this study are broadly consistent with those of Mattoo and associates.

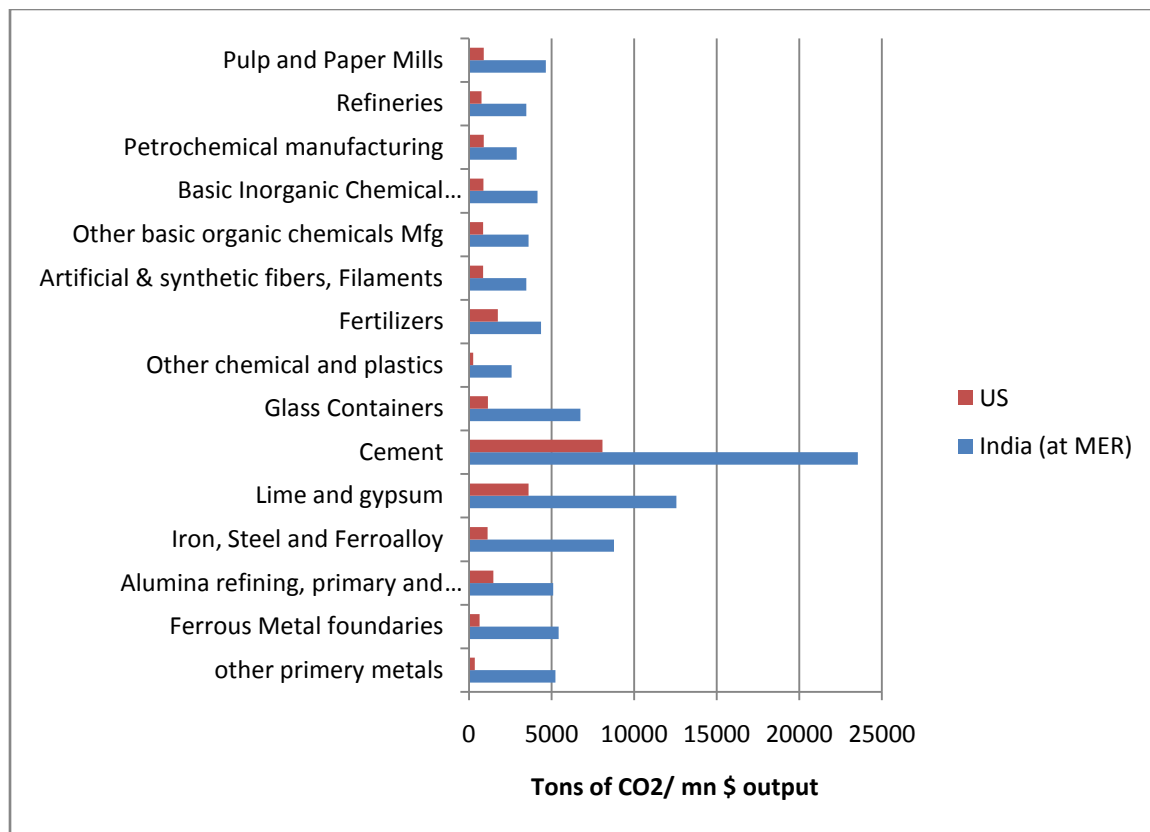
The estimates of carbon intensity of manufacturing mentioned above are at market exchange rate. In the computations of the carbon intensity of manufacturing made at PPP exchange rate, the difference reduces drastically to about 50% and 70% for India and China respectively (shown in Figure 5.3). Evidently, at PPP, the carbon intensity of manufacturing of India and China is not much higher than that of the US. This is basically a reiteration of the argument made above that carbon intensity at MER tends to exaggerate the carbon intensity of developing countries.

### ***India-US comparison of carbon intensity***

Figure 5.4 presents a comparison of carbon intensity of a number of industries in India with their counterpart in the US. The estimates for India have been taken from Amrita Goldar et al. (2011) while those for the US are taken from Adkins et al. (2010; Table A8). These estimates represent total emissions of an industry, combining direct and indirect. There is, however, some difference in the methodology adopted in the two studies (on which the graph is based), and for this reason the estimates are not exactly comparable. The estimates for India take into account the direct emissions of an industry as well as carbon emissions attributable to materials and service (e.g. transport services) used. The estimates for US do not include the indirect emissions of materials suppliers and service providers. As a result, the estimates for the US understate somewhat the total emissions caused by a particular manufacturing industry. Another incomparability, a minor one, is that while the estimates for India are for 2003, those for the US are for 2006.

Despite the incomparability of the estimates of carbon intensity for India and the US shown in Figure 5.4, it seems safe to conclude on the basis of the graph that CO<sub>2</sub> emission intensity of Indian industries far exceeds that of the corresponding US industries. This is in agreement with the estimates of Mattoo and associates mentioned above as well as with the estimates shown in Figure 5.3. However, these estimates are at market exchange rate, and as noted earlier, the gap between the emission intensity of Indian industries and that of the US industries would narrow substantially when the output of Indian industries are converted into US\$ using PPP exchange rate.

**Figure 5.4: CO<sub>2</sub> Emission Intensity of Select Indian and US Industries**



Note: The emission intensities shown in the graph are total emission intensity combining direct and indirect emissions. The estimates for India are for 2003, and those for the US are for 2006. Source: Estimates for India have been computed from Goldar et al. (2011), and those for the US have been taken from Adkins et al. (2010).

### 5.5 Carbon Intensity of Some Select Industries

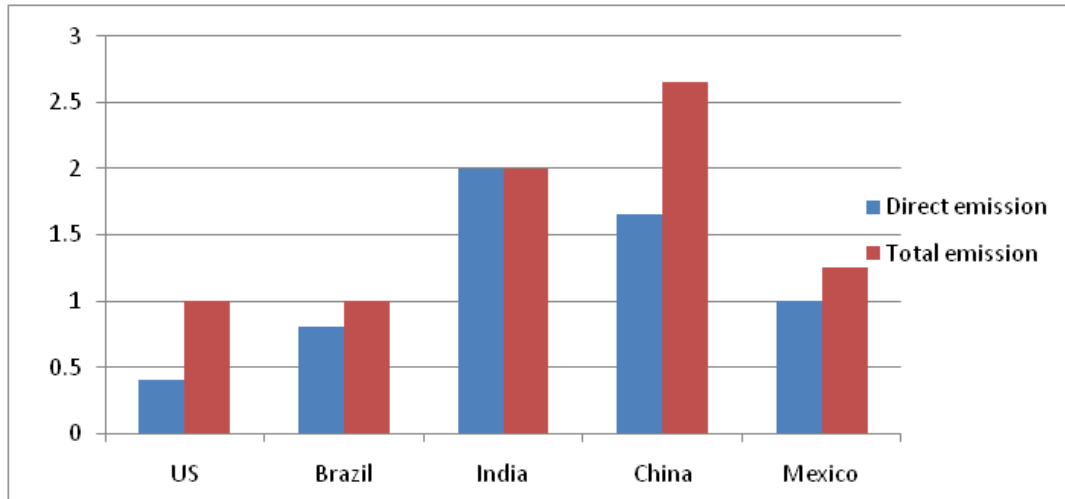
Before concluding this section on inter-country differences in energy and carbon intensity, it would be useful to present some estimates of carbon intensity in physical units for a few carbon emission intensive manufacturing industries.

#### Steel

US steel production is among the least carbon-intensive in the world. This is primarily the result of the type of production process the industry employs. Figure 5.5 compares CO<sub>2</sub> emission intensity of US steel industry with that of steel industries of Brazil, India,

China and Mexico. It is evident from the graph that the emission intensity level of steel industries in China and India is far higher than that in the US.

**Figure 5.5: Carbon intensity of Steel in 2005, tons of CO<sub>2</sub> per ton of steel, by country**



Source : *Steel Statistical Yearbook 2007*, as given in Houser et al. (2008).

### Aluminum

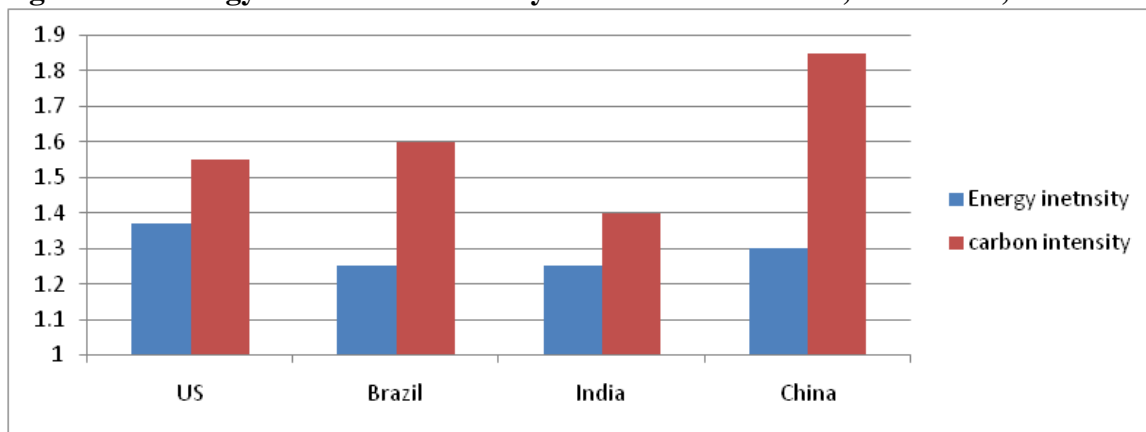
The bulk of the energy consumed in manufacturing of primary aluminum is in the form of electricity. Thus, the carbon intensity of a ton of aluminum is largely determined by the source of electricity used to produce it. In the US, roughly half of the electricity used in primary aluminum production comes from hydropower, with the remainder coming from coal. That makes US smelters less carbon intensive than the average Asian or African smelter.

Indian electricity generation is dominated by inefficient coal which constitutes about 53% of the generation capacity. This causes aluminum production in India to be more CO<sub>2</sub> intensive than that in the US. An estimate of carbon intensity of aluminum production in India and the US has been made using data on emissions available from the IEA along with data on aluminum production. According to this estimate, CO<sub>2</sub> emission intensity of aluminum production in the US is 1.46 tons of CO<sub>2</sub> per ton of aluminum, whereas the corresponding figure for India is 3.33 tons of CO<sub>2</sub> per ton of aluminum. From these estimates of carbon intensity of aluminum production in India and the US, which represent average across firms in each country, it appears that the CO<sub>2</sub> emission intensity of aluminum production in India is about twice that of aluminum production in the US.

## Chemicals

The US chemical industry, with some of the oldest capital stock in the world, is fairly energy inefficient in the production of chemicals. New ethylene crackers in China and the Middle East are all more energy efficient than the average facility in the US. At the same time, it may be noted that the US chemical industry is more dependent on natural gas for feedstock than its competitors in Asia, which rely primarily on naphtha as feedstock. As a result, the US chemical industry is less carbon intensive than China and Taiwan. Interestingly, Indian chemical industry is superior to the US chemical industry both in terms of energy efficiency and CO<sub>2</sub> emission intensity (Figure 5.6).

**Figure 5.6: Energy and carbon intensity of different countries, Chemicals, 2005**



Source : IEA 2007, given in Houser et al. (2008).

Note: An energy and carbon intensity index value of 1.00 equals best available technology and feedstock.

## Cement

For cement production, the most important factor in determining carbon intensity is the type of kiln used. Coal accounts for less than two third of the fuel used in kilns in the US, and this proportion is less than that in China and India. Therefore, on an average, the US cement industry is less carbon intensive than most Asian producers.

Estimates of CO<sub>2</sub> emission intensity of cement production has been made for India and the US in this study. The estimates are for 2005. These are crude estimates as detailed data are not available. The estimates indicate that CO<sub>2</sub> intensity of cement production in the US is about 0.52 tons of CO<sub>2</sub> per ton of cement production. The corresponding estimate for India is 0.58 tons of CO<sub>2</sub> per ton of cement. Thus, CO<sub>2</sub> emission intensity of cement production in India is higher, but the difference is probably not large. The low gap between India and the US in regard to CO<sub>2</sub> emission intensity of cement production is probably attributable to the fact that the PPC (Portland pozzalona cement) has a dominant share in the Indian market and this type of cement is produced in India with a blending of fly-ash up to 30 percent, which helps in cutting down emissions in cement production.

## 6. Initiative taken in India for Low Carbon Growth

This section discusses certain initiatives taken by the Indian government for enhancing efficiency in the use of energy and thereby containing CO<sub>2</sub> emissions. The focus of the discussion is on the Perform, Achieve and Trade (PAT) scheme which has been launched recently.

### 6.1 National Action Plan on Climate Change (NAPCC)

As a part of domestic actions by India to tackle, mitigate and adapt to climate change, the National Action Plan on Climate Change (NAPCC) was launched by the Prime Minister of India in June 2008. NAPCC contains eight missions – one of them is the National Mission on Enhanced Energy Efficiency (NMEEE). NMEEE operates under the Bureau of Energy Efficiency (BEE), a statutory body constituted under the Ministry of Power, Government of India.

At the time of launching of the NAPCC, it was envisaged that NMEEE will by the end of 5 years save 23 million ton of oil equivalent (MTOE) of fuel, avoid thereby 19,000 MW power capacity addition and will reduce CO<sub>2</sub> emission by 98.55 million ton annually. Since India's CO<sub>2</sub> emission was about 1450 million tons in 2008 (IEA, 2011a), the annual reduction in CO<sub>2</sub> emissions envisaged through the mission is substantial. Four initiatives are to be taken under NMEEE. These are:

- **Perform, Achieve and Trade Scheme:** A market based mechanism to enhance cost effectiveness of improvements in energy efficiency in energy-intensive large industries and facilities, through certification of energy savings that could be traded.
- **Market Transformation for Energy Efficiency:** Accelerating the shift to energy efficient appliances in designated sectors through innovative measures to make the products more affordable.
- **Energy Efficiency Financing Platform:** Creation of mechanisms that would help finance demand-side management programs in all sectors by capturing future energy savings.
- **Framework for Energy Efficient Economic Development:** Developing fiscal instruments to promote energy efficiency.

Of the four abovementioned initiatives of the NMEEE, the Perform, Achieve and Trade (PAT) Scheme is of particular significance for this study, as it is in certain ways similar to the cap and trade scheme envisaged in the Waxman-Markey bill. It is interesting therefore to compare the provisions of the Waxman-Markey bill with the expected outcomes of the National Action Plan on Climate Change, particularly with regard to the PAT scheme. The comparison is shown below. Besides the PAT scheme, certain other schemes are also taken into account in the comparison.

Waxman-Markey bill (US)	National Action Plan on Climate Change (India)
Requirement to meet 20% of its electricity demand by renewable energy by 2020.	NAPCC requires 15% electricity by renewable by 2020 and has introduced Renewable Energy Certificate (REC) for enabling large numbers of stockholders to meet their targets. Thus, a market based system has been introduced to increase the use of renewable sources for electricity generation.
Improving energy productivity by at least 2.5% per year by 2012 and maintain that improvement through 2030	NEMEE will by the end of 5 Years save 23 million ton of oil equivalent (MTOE) of fuel, and thereby avoid 19,000 MW power capacity additions. The improvement in energy efficiency under the PAT scheme in the first round of three years will be by 4.32%. This comes to about 1.5% improvement per year.
Setting a cap and trade system for GHGs for reducing emissions by 83% of 2005 level by 2050.	PAT, a market based system is targeted at saving 9.78 million metric tons of oil equivalent, which amounts to an avoided capacity of 5623 MW over a period of 3 year from the start of the scheme. Annual reduction in CO <sub>2</sub> emissions is about 100 million tons. This is substantial given that India's annual CO <sub>2</sub> emissions were about 1450 million tons in 2008.

According to Waxman-Markey Bill, the imports in the listed sectors will be subjected to the allowance program, unless the importing country has laws imposing requirements “as stringent as” that of the US. And, specifically India and China are mentioned in the bill for checking the strictness of the laws for containing emissions.

Given that the PAT scheme is being implemented for certain energy intensive industries in India, one may possibly argue that India is also adopting significant energy saving policies, and therefore India's exports should not be subjected to any kind of border tax restrictions in the US, at least in respect of the industries that are covered under PAT. The acceptability of this argument obviously depends on the nature of the scheme and how much energy saving incentive it will create for Indian firms. This aspect is discussed further below.

## 6.2 Perform, Achieve and Trade Scheme of India

As mentioned above, the Perform Achieve and Trade scheme is a market-based mechanism to enhance energy efficiency in the large-scale energy-intensive industries. The facilities that come under the category of energy-intensive, large scale industrial units are known as ‘Designated Consumers’ (DCs).

DCs has been selected on the basis of their energy intensity, amount of investment required for switching over to energy efficient equipments, capacity of industries to invest in it and the availability of energy efficient machinery and equipments. According



to some official documents on the PAT, DCs account for 25% of the national gross domestic product (GDP) and about 45% of commercial energy use in India.

It has been observed that in recent years, Indian industry has been choosing state-of-the-art technologies, which are more energy-efficient. Also, there have been many in-house efforts made by the industry to become more energy-efficient. Thus, for the DCs, the PAT scheme creates financial incentives to undertake such energy saving efforts.

PAT scheme creates energy efficiency targets to be met and incentivizes businesses achieving higher energy efficiency with tradable energy saving certificates (ESCerts). The market for these ESCerts will be the entities that will not meet their energy efficiency targets and will need to buy these ESCerts to meet the energy efficiency norms. Some further details are provided below.

### ***Energy Savings Certificates (ESCerts) – How will it work?***

- Designated consumers will be given Specific Energy Consumption (SEC) targets to meet over a period of three years.
- If they succeed in meeting the threshold for the energy saving, they will have no obligation to buy ESCerts from others through the PAT mechanism.
- Those who have surpassed the target (i.e. achieved additional savings above the benchmark) will qualify for earning Energy Saving Certificates (ESCerts) (which would be equivalent to one ton of Oil Equivalent, which could be traded with DCs falling short of their targets.
- A penalty of Rs one million has been fixed for non-compliance.

### ***Bandwidth of specific energy consumption (SEC)***

As per the several studies done by the BEE, the wide bandwidth of specific energy consumption (SEC) within an industrial sector is indicative of the large energy-savings potential in the sector. The wide bandwidth is also a reflection of the differences in the energy-saving possibilities amongst plants because of their varying vintage, production capacity, raw material quality, and product-mix. Thus, it is felt that setting the same target for all firms in an industrial sector will not be a feasible option. Rather, the target has to be unit specific. Each DC is mandated to reduce its SEC by a fixed percentage, based on its current SEC (or baseline SEC) within the sectoral bandwidth. The typical SEC bandwidth in each of the sectors selected for the PAT scheme is shown below:

SEC bandwidth in Different Sectors	
Sector	Range of SEC
a) Power Plant	2300 – 3400 kcal/kwh
b) Fertilizers	5.86 – 9.11 Gcal/T of Urea
c) Cement	665-900 Kcal/Kg of clinker (Thermal), 66-127 KWH/T (Elect)
d) Integrated Steel	6.15 – 8.18 Gcal/tcs
e) Sponge Iron	4.4 – 7.6 Gcal/T (Thermal) 72-135 KWH/T (Elect)
f) Aluminium(smelter)	15875 – 17083 KWH/T
Aluminium (Refinery)	3.28 – 4.12 Mkcal/T of Alumina
g) Pulp and Paper	23.3 -121 GJ/T
h) Textile	3000 – 16100 Kcal/kg (Thermal) 0.25-10 KWH/Kg (Elect)
i) Chlor-Alkali	2300 – 2600 kwh/T of caustic soda

Source: PAT consultation Document, December 2010, Bureau of Energy Efficiency, Government of India.

$$\text{SEC} = \frac{\text{Total energy input to the plant boundary}}{\text{Quantity of the product}}$$

Because of this wide bandwidth, some plants especially old ones would find it difficult to achieve the set target at the industry level. Therefore, the sectoral targets would have to be distributed among the DCs in a logical manner keeping in view of historical energy consumption scenario, potential availability in the DC, sustainability of trading market and other related issue. The lowest % target would be given to the best performing plant where as others will be assigned as per a ‘relative increment’ based on the concept of relative SEC.

### ***Coverage of PAT***

The Energy Conservation Act, 2001 provides the framework for efficient use of energy and its conservation in India. There are 15 industries which are energy intensive and large in scale, of which nine have been covered by the PAT scheme.

It was envisaged initially that PAT will cover 714 industrial units across the country in nine sectors – cement, thermal power plants, fertilizers, aluminum, iron and steel, chlor-alkali, pulp and paper, textiles, and railways. The Indian government notified the launch of the scheme on 30 March 2012. In the notification, 478 designated consumers are listed belonging to eight industrial sectors (railways not included). The largest number of DCs are in thermal power (144) followed by textiles (90) and cement (85).

### ***Energy Saving Target and Potential***

According to several write-ups available on the Internet, PAT has been rolled out from April 2011 (actual notification has come in March 2012) and is targeted at savings 9.78 million metric tons of oil equivalent (MTOE), which amounts to an avoided capacity of 5623 MW over a period of three years. In the first round of three years, the average energy saving of the chosen designated consumers is about 4.3 percent. According to an assessment made by the Confederation of Indian Industry (CII, undated), the energy saving potential of all DCs under the PAT scheme is 22.6 MTOE of which the PAT is targeted to save in the first phase of three years about 10 MTOE.

It should be noted that the focus of the PAT scheme is on energy consumption, and not on CO<sub>2</sub> emissions. Thus, it does not create incentive for using low-carbon but more expensive fuel such as natural gas. Nor does it create incentive for using renewable biomass as a source of energy in manufacturing industries.

A moot question is whether the PAT scheme can be regarded as a strong enough initiative for energy conservation in industries so as to enable India claim exemption to the carbon border tax if imposed by the US. The targeted reduction in energy use in the selected sectors is lower than what is being targeted in the US. In the first phase of three years, the targeted reduction under the PAT scheme is 4.3 percent. This comes to about 1.5 percent per year. On the other hand, according to Waxman-Markey Bill, the targeted improvement in energy efficiency in the US is 2.5 percent per year.

It has been mentioned earlier, that according to Waxman-Markey Bill, the imports in the listed sectors will be subjected to the allowance program, unless the importing country has laws imposing requirements “as stringent as” that of the US. A question that presents itself here is: will a scheme yielding a rate of improvement of energy efficiency in select Indian industries of about 1.5 percent per annum be regarded as sufficient to meet this condition? This question is difficult to answer. Perhaps, the target rate of improvement in energy efficiency will have to be enhanced to some extent for the scheme to qualify as being regarded “as stringent as” the proposed program of the US. Alternatively, one may argue that the scheme aims at a large annual reduction in CO<sub>2</sub> emissions from Indian industries, and therefore there is a case for seeking exemption from US carbon border tax.

Given the wide dispersion in SEC in the industries covered under PAT, it seems that by replacing highly inefficient plants and machinery by new, energy efficient ones, it should be possible to make substantial reduction in energy use. At present, the PAT scheme does not create a strong force for resource reallocation within an industry. Rather, the overall industry target is sought to be achieved by each unit making small improvements, and some trading taking place at the margin. Some change in the design of PAT may help to achieve larger reductions in industrial energy use than what is being targeted now.<sup>18</sup>

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<sup>18</sup> Dube et al. (2011) come up with recommendations for making the PAT scheme more effective.

## 6. Conclusion

The review of the literature and the analysis presented above show that carbon price policy of the US will not have much impact on exports, output and employment in India unless the US applies carbon border tax on developing country imports into the US on grounds of competitiveness and carbon leakage. Even in this case, the seriousness of the impact will depend on the level at which the price of carbon is set (or gets set, in case this is market determined) and the basis adopted for the imposition of carbon tax on imports. If the price of carbon is set at US\$ 50 per ton of CO<sub>2</sub> and carbon tax on imports are based on the emission intensity of domestic producers, the loss manufacturing value added in India will be about 0.5 percent and loss of manufacturing employment will also be about 0.5 percent. This corresponds to reduction in India's exports of manufactured products to the US by about 5 percent (for products of energy intensive industries, about 15 percent). If the carbon tax on imports is imposed on the basis of carbon embodied in imports, India's losses will be greater. The loss in value added in manufacturing will be about 1.3 percent and that in manufacturing employment about 1.2 percent. In this case, India's exports of manufactured products to the US will go down by about 15 percent and energy intensive manufactured products by about 35 percent. This will be the expected loss if emission intensity is measured using the market exchange rate. One can make a case for basing the assessment of emission intensity on PPP exchange rates rather than market exchange rates. If the PPP based emission intensities are used for ascertaining the tax rates applicable to imports from different source countries, the adverse effects on India will be much smaller since the emission rates in Indian manufacturing industries are relatively low in PPP exchange rates. The reduction in manufactured exports to the US will be about 8 percent. The value added loss to manufacturing will be about 0.7 percent and employment loss will also be about 0.7 percent.

There would also be indirect losses to other sectors of the Indian economy through inter-industry linkages. While in the scenario based on PPP exchange rate mentioned above, the direct loss in value added due to reduced exports to the US will be about 0.7 billion US dollars, the total impact (direct plus indirect) will be a loss of about 1.6 billion US dollars. Similarly, while the direct employment loss will be about 49 thousand persons, the total employment loss will be about 720 thousand persons. If market exchange rate becomes the basis for ascertaining carbon intensity of imports, rather than PPP, then the total loss of employment will be 1.3 billion persons and value added loss will be US\$ 2.9 billion.

Though not as large as the estimates of Mattoo et al. (2009), the estimated effects of US carbon price policy on exports, production and employment in Indian manufacturing obtained in this study are significant. If the use of unilateral measures by the developed countries cannot be prevented, India should strive for making the border tax based on the domestic emission intensity of developed countries rather than being based on carbon embodied in imports. If the latter form of carbon tax becomes inevitable, India's interest lies in ensuring that the tax should be based on emission intensity computed on the basis of PPP exchange rates rather than the market exchange rate. Emission intensity computed

on the basis of PPP exchange rate has a stronger justification for being used in inter-country comparison of emission intensity than the estimates of emission intensity based on market exchange rate.

The analysis presented in the Report reveals that the carbon pricing policy in the US if accompanied by border tax adjustment will have an adverse effect (in terms of the loss of manufactured exports to the US and the consequent loss in value added and employment in manufacturing) not only on India but also on other major developing countries such as China, Brazil and South Africa. The adverse effect on China will probably be much greater than that on India, Brazil and South Africa.

In the last four years, India has taken several initiatives for improving energy use efficiency in industries and cutting down CO<sub>2</sub> emissions. The Perform, Achieve and Trade (PAT) Scheme launched recently in India is in certain ways similar to the cap and trade scheme envisaged in the Waxman-Markey bill of the US. The PAT scheme is expected to reduce energy use in industries by about 1.5 percent each year and substantially reduce CO<sub>2</sub> emissions over time. The Waxman-Markey Bill has the provision that if goods in the listed sectors are imported from a country that has laws for containment of CO<sub>2</sub> emissions “as stringent as” that of the US, then the imported goods will not be subjected to the allowance program. Given the high level of reduction in CO<sub>2</sub> emissions targeted by the PAT scheme, it might be possible to build a good case for seeking exemption for India from US carbon border tax, in case that becomes a reality in the near future.

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**Annex-A: Elasticity of substitution taken from GTAP database**

<b>Code</b>	<b>Description</b>	<b>ESUBD <math>\sigma^m</math></b>	<b>ESUBM <math>\sigma^w</math></b>
19 cmt	Meat: cattle,sheep,goats,horse	3.9	7.7
20 omt	Meat products nec	4.4	8.8
21 vol	Vegetable oils and fats	3.3	6.6
22 mil	Dairy products	3.7	7.3
23 pcr	Processed rice	2.6	5.2
24 sgr	Sugar	2.7	5.4
25 ofd	Food products nec	2.0	4.0
26 b_t	Beverages and tobacco products	1.2	2.3
27 tex	Textiles	3.8	7.5
28 wap	Wearing apparel	3.7	7.4
29 lea	Leather products	4.1	8.1
30 lum	Wood products	3.4	6.8
31 ppp	Paper products, publishing	3.0	5.9
32 p_c	Petroleum, coal products	2.1	4.2
33 crp	Chemical, rubber, plastic prods	3.3	6.6
34 nmm	Mineral products nec	2.9	5.8
35 i_s	Ferrous metals	3.0	5.9
36 nfm	Metals nec	4.2	8.4
37 fmp	Metal products	3.8	7.5
38 mvh	Motor vehicles and parts	2.8	5.6
39 otn	Transport equipment nec	4.3	8.6
40 ele	Electronic equipment	4.4	8.8
41 ome	Machinery and equipment nec	4.1	8.1
42 omf	Manufactures nec	3.8	7.5