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Impact of Energy Subsidy Removal on Climate Change: A CGE Modelling Approach for India

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Abstract

There is a negative relationship between prices of energy products and pollution content of export as well as the Pollution Terms of Trade (PTOT) in India. However the pollution content of domestic consumption has a marginally stronger positive effect than the negative effect on export. This indicates that, for instance when prices of energy products rise in India either due to removal of fuel subsidy or rise in international crude prices, some of the manufacturers who were previously exporting pollution intensive goods lose their competitiveness in the international market due to increase in fuel prices and start selling their product to the domestic market. Thus clearly a rise/fall in prices of energy goods does not significantly contribute to climate change in India.

Keywords: CGE, Climate Change, SAM, Energy Subsidy, Pollution Terms of Trade.

1. Introduction

One of the most important environmental changes, which have come into foray in the current times, is the build-up of atmospheric pollutants like Carbon Dioxide, Sulphur Dioxide and Oxides of Nitrogen. Undoubtedly, most of the

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added pollutants in the atmosphere is coming from anthropogenic activities like the burning of fossil fuels coupled with simultaneous cutting of forests etc. The main outcome of this build up is the dramatic rise in the temperature of the surrounding atmosphere. To combat climate change and subsequently build-up of CO_2 and other greenhouse gases (GHGs) and pollutants in the atmosphere, international efforts and collaboration are on the rise. Developing nations like India would be looking forward to an ambitious but equitable outcome which would curb global GHG emissions as well as be in agreement with the current growth prospects of the country. A great concern in this regard is that with liberalization in trade regimes and increase in export incentives, there could be greater exploitation of natural resources leading to increase in pollution. Pollution Terms of Trade (PTOT) is the term used to denote the pollution embodied in import from Rest of the World[3]. A greater than unity value of PTOT indicates the presence of dirty industry migration as the domestic economy exporting higher pollution than it imports from Rest of the World.

Presently, the per capita emission of India is 1.4 tCO_2/person (as of 2010) which is less than one third of world average of 4.5 tCO_2/person[4]. This per capital emission figure is projected to increase to 2.67 tCO_2/person in 2020, which is almost 90% increase over 2010 number. Total GHG emissions of India stood at 1,570 million tCO2 which is projected to increase to 3,537 tCO_2 in 2020 (assuming 8% GDP growth). This emission inventory is the result of a highly coal dominated energy mix of India. Of the primary energy mix, coal is the dominant energy source at almost 50% followed by crude oil (petroleum products such as diesel and petrol) at 25%, natural gas at 15% and renewable energy at 8%. For the purpose of this research, coal, crude oil, LPG, petrol and diesel have been considered for further analysis[5] .

In India, in recent years the government has taken several steps to reduce subsidies on fossil fuels like LPG, petrol and diesel, which has resulted in increase of price of these fuels in India. The Government of India took advantage of the fall in global crude oil prices to reduce subsidies on fossil fuels significantly. The effect of this subsidy reduction along with fall in global crude oil prices on trade and pollution content of trade needs to be evaluated and understood. The

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[3] Antweiler (1996).

[4] The Final Report of the Expert Group on Low Carbon Strategies for Inclusive Growth, Planning Commission, Government of India, April 2014.

[5] The Final Report of the Expert Group on Low Carbon Strategies for Inclusive Growth, Planning Commission, Government of India, April 2014.

chief purpose of the present paper is to comprehend general equilibrium impacts of the variation in international crude oil prices and removal of domestic energy subsidies on the pollution content of Indian trade.

In this paper we use the Computable General Equilibrium (CGE) framework to conduct three such experiments: how PTOT is impacted with:

(i) The changes in taxes and subsidies on LPG, petrol and diesel on the Indian economy had crude oil prices remained constant at 2007-8 level. Between 2007 and 2015, LPG subsidies decreased from 72% to 25% while petrol and diesel subsidies reduced from 3% and 18% to no subsidy respectively. Hence the impact of year-on-year average subsidy levels (varying within the range of subsidy mentioned before) has been simulated.

(ii) The fall in international prices of crude had taxes and subsidies on LPG, petrol and diesel remained constant at the 2007-08 level. Crude oil prices fluctuated between USD 52/bbl and USD 109.45/bbl between 2007 and 2015 with the 2007 crude price being USD 69/bbl. Hence the impact of year-on-year fluctuation of crude oil price has been analysed.

(iii) Both the change in crude oil prices and subsidy reduction of fossil fuel.

The paper also analyses the effect of all the above scenarios on the pollution content of domestic consumption[6].

Since environmental concerns have increasingly become important for India and globally, there is some literature available on pollution haven analysis. The concept of pollution terms of trade' index was introduced by Werner Antweiler (1996) - it measured the environmental gains or losses that a country sustains from engaging in international trade and distinguished between the trade composition effect and the environmental technology effect. PTOT of India with EU and with rest of the world for CO_2 varied between 0.71-0.73 and 0.49 - 0.53 respectively in the 1990s (Mukhopadhyay and Chakraborty, 2005). Dietzenbacher

[6] The year 2007-08 has been denoted as year 1 and subsequent years (till 2015) as year 2, 3 and so on. This is because the Social Accounting Matrix which has been used is of 2007-08 and we have tried to see how the pollution content changes with various factors such as subsidy reduction and international crude oil price fluctuations.

and Mukhopadhyay (2007) obtained PTOT value for India in 1991-92 to be 0.75 and that for 1996-97 as 0.72 i.e. PTOT value is less than unity in 1990's and thus they concluded that Pollution Haven Hypothesis should be rejected for India. Dietzenbacher and Mukhopadhyay (2007) computed PTOT for 1990's and simulated corresponding value for the year 2006-7 as 0.97 i.e. very close to the border line of unity. The latest computed value of PTOT for India is 0.902 for 2003-04 (Das and Chakraborti, 2013). All the available literature for India is based on the SAM of 2003-04 or earlier. There is no available literature on estimation of PTOT on the SAM of 2007-08 which focuses on the impact on PTOT of India due to international crude oil price variation and reduction of energy subsidy. This has been the main motivation of this research.

The rest of the paper is arranged as follows: Section 2 highlights how emission factors of different fossil fuels are computed. Section 3 provides the methodology of construction of SAM. Section 4 provides the structure of benchmark CGE model. Section 5 describes how modelling "Pollution Haven" is done in CGE. Section 6 highlights the results of the research experiments. Finally Section 7 concludes the paper.

2. Derivation of Emission Factors

Greenhouse gases are generated due to the consumption of fossil fuels as inputs in production of output of the industries. Following Mukhopadhyay and Foessell(2005), we can calculate emission as follows:

$F_{GHG} = C^* L1^* Z$

Here F_{GHG} is a scalar representing total quantity of emission (of CO_2) from fossil fuelcombustion.

C is a vector of dimension (1xm), representing emission coefficients for a particular type of GHG from m[5] different types of primary fuels. L1 represents amatrix ($m.\ n$) of energy consumption coefficients for different sectors. Z is a vectorof dimension (n .1) representing output of n different sectors.

Different Emission coefficients correspond to various fossil fuels and are computed following IPCC (Inter Governmental Panel on Climate Change) guideline. IPCC provides the emission factor (in tCO_2/TJ) and calorific value (in TJ/Gg). The product of these two parameters is multiplied with price of the particular fuel to arrive at the emission coefficient.

3. Construction of the Social Accounting Matrix

We base our calculations on the Social accounting Matrix (SAM) for India for the year 2007-08 following Pradhan, Saluja and Sharma (2013)[7]. This SAM consists of 78 sectors and nine categories of households which are based on occupation and location (i.e. rural and urban). The gross value added has been divided into three factors of production, i.e. labour, capital, and land. Further, labour has been divided into three types, i.e. unskilled, semi-skilled, and skilled.

To construct our Energy SAM, relevant sectors from the above SAM were aggregated into primary (agriculture sector consists of all agricultural products, minerals, primary products such as iron ores, crude petroleum and agro process activities), secondary (Manufacturing sector comprised mainly of all manufacturing activities such as cotton and textile, plastic, rubber and leather products, cement, different chemical products, etc. without crude oil, LPG, petrol and diesel) and tertiary (Service sectors such as education, health care services, public administration, bank and insurance, postal services etc.) sectors. Coal and crude oilhave been taken as separate sectors. LPG, petrol and diesel have been proportionately taken out from the sector – petroleum products. Thus, the SAM that we work with has three energy sectors (LPG, petrol and diesel) where subsidies have varied over the years, two energy sectors (crude oil and coal) where there is no subsidy and two non-energy sectors (agriculture; manufacturing and services) where there is no subsidy as well. Four types of agents in the economy have been considered, namely, (a) household, (b) firm, (c) government and (d) Rest of World (ROW). The three types of labour (unskilled, semi-skilled and skilled) were aggregated into one sector – labour. Households have been aggregated into two types – urban and rural household. Table 1 shows the ESAM of India developed for this study.

In our ESAM we have a total of seven sectors. The conventional sectors are 1) Primary sector 2) Secondary sector and Tertiary service sector and the energy sectors i.e. 3) Crude oil 4) LPG 5) Petrol 6) Diesel and 7) Coal sectors.

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[7] In Indian context I/O table is published by the Central Statistical Office in every five years gap. Pradhan, Saluja and Sharma (2013) constructed SAM for India using the I/O matrix for the year 2007-08. The main data sources used in the construction of this SAM are CSO's I-O table 2007-08, NSSO's 66th round survey on consumer expenditure, and NCAER's Income-Expenditure Survey 2004-05.

We have constructed SAM of India for the year 2007-08 based on the SAM constructed by Pradhan, Saluja and Sharma (2013). This research work tries to analyse the impact of policy level changes in the LPG, petrol and diesel sectors and the impact of international crude oil prices. Hence these energy sectors are disaggregated from the three main sectors (primary, secondary and tertiary) and the impact on energy sector is analysed. These three main sectors are also included with the energy sectors, since it is a general equilibrium framework, and it has the inter-linkages among the sectors. Hence changes in the separate energy sectors will affect the other sectors as well, through the linkage effects and to obtain this general equilibrium implications of changes in energy sector- the different energy sectors have been disaggregated as separate sectors.

4. Structure of the Benchmark CGE Model Under Perfect Competition

The ESAM was used for the calibration of the CGE model and considering an open economy and perfect competition. Subsidy rates are supplied exogenously. Our benchmark CGE model is based on perfect competition and constant returns to scale assumption both in commodity market and factor market[8] [9].

The base year of this study has been taken as 2007-08.

5. Modelling "Pollution Haven" in CGE

To make an exact link between trade and environment we modelled "Pollution Haven" by computing Pollution Terms of Trade (PTOT) proposed by Antweiler, W(1996). PTOT is computed taking the ratio of pollution content of export and pollution content of import. Pollution content of export and import can be given by:

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[8] For a reference CGE model, please refer to Das & Chakraborti (2013).

[9] We have assumed over here that zero profit condition actually holds in the minimum point of average cost curve. This also indicates there is constant returns to scale in the long run and there is no excess capacity present in the market. In the energy sector, there are many buyers and in this era of liberalization and globalization, quite handsome number of firms actually produce almost homogenous products. Hence perfect competition assumption maybe a very close approximation to the reality when there is no presence of increasing returns to scale, and zero profit condition holds at the minimum point of the long run average cost curve.

$$F_{GHG\ (EXPORT)} = C^* \ L^* \ (I - A_d)^{-1} {}^*E$$

$$F_{GHG\ (IMPORT)} = C^* L^* (I - A_d)^{-1} {}^*M$$

Here E and M are (nx1) vectors representing export and import of the domestic economy in different sectors. Here Ad is the matrix domestic input/output coefficient. Hence $(I\text{-}Ad)^{-1}$ is the Lieontief domestic inverse matrix. Here we assume identical technology as of domestic production for the import from ROW (Rest of the World). Here $C^* L1^*(I- A_d)^{-1}$represents both direct and indirect requirements of pollutionintensities within Export and Import. Pollution Terms of Trade for India with rest ofthe World can be given by:

$$PTOT= F_{GHG\ (EXPORT)} / F_{GHG\ (EXPORT)} =C^* L^*(I- A_d)^{-1} {}^*E /C^* L^*(I- A_d)^{-1*}M$$

A country gains environmentally from trade in relative terms whenever pollution content of its imported good is higher than that of its exported good. Whenever PTOT value is greater than unity, it indicates country's export contains higher pollution than it is receiving through import. PTOT is an indicator to reflect pollution haven effect.

6. Analysis of Policy Simulation Experiments

Experiment 1: Impact of Reduction of Energy Subsidies Only

With reduction in energy subsidies, it is seen that pollution embodied in both exports and imports decreases. However the decrease in pollution content of exports is higher than the decrease in pollution content of imports. On an average, pollution contents of exports decrease by 0.23% over the study period while pollution content of imports decrease by 0.20% for the same period. With reduction in energy subsidies, price of fossil fuels increase and hence many exporters stop exporting energy intensive goods. This reduces the pollution content of exports.

The PTOT decreases i.e. pollution content of export decreases implying there is a reduction in export of pollution intensive manufacturing/industries – reducing pollution embodied in exports. Between year 1 and 9, PTOT decreases by 0.16%. In the year 1, when subsidy is the highest, it is seen that PTOT increases by 0.15% over the benchmark PTOT of 0.839. As the subsidy rates are reduced, the

PTOT also decreases. Moreover it is seen that pollution content of domestic consumption increases with reduction in energy subsidies. This is logical since with reduction of subsidies, the prices of fossil fuels increase in domestic markets increase and hence more energy intensive industries who were previously exporting have lost their competitiveness due to increase in fuel prices and have started supplying to the domestic market. Pollution content of domestic consumption increases by 0.4% between year 1 and year 9.

Experiment 2: Impact of Variation of Crude Oil Prices Only

With increase in crude price, the pollution content of import decreases and vice versa. This is mainly because crude oil import decreases due to price increase. Pollution content of export also decreases with increase in crude oil prices, however the decrease in case of imports is higher. Between year 1 and year 9, when crude oil prices decrease by 25%, pollution content of export increases by 0.33% while that of import increases by 0.6%. Hence there is a net decrease in the ratio of pollution content of export and import.

With variation in crude oil price, it is seen that the PTOT in increases in the years that crude oil price increases and vice versa over the benchmark PTOT of 0.839. In the years 2, 4, 5 and 6, when the crude oil price rises, PTOT also increases implying that with increase in crude oil price, import of crude oil decreases. Between year 1 and year 9, PTOT reduced by 0.21% for a 25% reduction in crude oil price in year 9 over year 1. The pollution content of domestic consumption increases with increase in crude oil price and decreases with decrease in crude oil price. This is because with increase in crude oil price (assuming no energy subsidies), prices of fossil fuels also increase in domestic market. Players who were so far exporting energy intensive goods lose their competitive edge and are forced to supply goods in the domestic market, thus increasing pollution content of domestic consumption. Pollution content of domestic consumption reduces by 0.9% between year 1 and year 9 due to 25% reduction in crude oil price in year 9 over year 1.

Experiment 3: Impact of Variation of International Crude Oil Prices and Reduction of Energy Subsidies

When the net impact of variation of crude oil prices and reduction of energy subsidies is simulated on pollution content of exports and imports, it is seen that the effect of international crude oil prices dictates the net effect. In the years that crude oil prices decrease, it is seen that pollution content of both exports and imports increases and vice versa. Between year 1 and year 9, pollution content of export and pollution content of import increases by 0.32% and 0.26% respectively. The increase in this case is however less that in the case where only the effect of international crude oil price variation was observed. This is because the effect of subsidy removal reduces the magnitude of the effect (impact of subsidy removal and impact of crude oil price decrease have opposite impacts).

It is seen that international crude oil price variation has a more dominating impact on PTOT than reduction of energy subsidies. In the years that crude oil price increases, PTOT increases inspite of the fact that energy subsidy decreases. The import of crude oil decreases due to increase in crude oil price which leads to increase in PTOT. However, PTOT is always less than unity indicating that Indian exports have always been less pollution intensive than Indian imports. PTOT decreases by 0.1% between year 1 and year 9 for the net effect of crude oil variation and energy subsidy reduction as compared to a reduction of 0.16% for only subsidy reduction and decrease of 0.21% for only crude oil variation. Crude oil price variation also has a more dominating effect on pollution content of domestic consumption as compared to energy subsidy reduction. Pollution content of domestic consumption decreases in the years that crude oil price decreases (although the value is less than in Experiment 2 due to the increasing effect of subsidy). Pollution content of domestic consumption decreases by 0.02% between year 1 and year 9 as compared to 0.4% increase for subsidy reduction only and 0.9% reduction for crude oil price variation only.

7. Conclusion

With reduction in energy subsidies, India does not become a pollution haven and pollution intensiveness of exports decrease. However, pollution content of domestic consumption increases with reduction in subsidies, implying that prices of fossil fuels increase in domestic markets with reduction in subsidies and more energy intensive industries who were previously exporting have lost their competitiveness due to increase in fuel prices and have started supplying to the domestic market. Hence fossil fuel subsidy reduction is beneficial as India gains environmentally from trade in relative terms as pollution content of its imported good is higher than that of its exported good. However with increase in crude oil price, India‘s pollution intensiveness of imports decrease, thereby increasing the PTOT. Hence, an increase in international crude oil price is not desirable in India from the environmental front also. The pollution content of domestic consumption increases with increase in crude oil price and vice versa. This is because when international crude oil price increases, fossil fuel prices in local markets also increase (assuming there is no subsidy effect), thus making many exporters lose their competitive edge in foreign markets. These exporters then supply their goods in domestic markets and increase the pollution content of domestic consumption. Effect of crude oil price variation is more dominant on PTOT when the net effect of crude oil price variation and subsidy reduction is being considered. Comprehensively, Indian economy has not been "Pollution Haven" in 2007-08 and Indian imports have been 16% more pollution intensive than Indian exports. These results also corroborate with previous works of Mukhopadhyay and Chakraborty (2005), Dietzenbacher and Mukhopadhyay (2007) and Das and Chakraborti (2013) who concluded that Pollution Haven Hypothesis should be rejected for India in earlier years.

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Table 1: ESAM of India 2007-08 (in INR billion)

Sector	Primary sector	Secondary + tertiary Sector	LPG	Petrol	Diesel	Coal	Crude oil	Labour	Capital + Land	Rural Household	Urban Household	Pvt. Corp.	Pub. Enter.	Govt.	Ind. Taxes	Capital a/c	ROW	Row Total
Primary sector	2388	3443	1	1	1	1	1	1	1	4388	2077	1	1	100	1	-6	280	12680
Secondary + tertiary Sector	1821	33126	60	71	806	97	83	1	1	8797	11358	1	1	4859	1	18071	8767	87922
LPG	1	41	1	1	1	1	1	1	1	5	8	1	1	1	1	4	9	79
Petrol	1	120	1	1	1	1	1	1	1	12	17	1	1	2	1	9	21	193
Diesel	120	1283	1	1	1	9	1	1	1	269	380	1	1	51	1	205	461	2787
Coal	1	678	1	1	1	11	12	1	1	3	2	1	1	1	1	2.4253	1.796	719
Crude oil	1	2951	1	1	1	5	1	1	1	1	1	1	1	1	1	-0.4	43	3011
Labour	4720	17624	1	1	17	114	98	1	1	1	1	1	1	1	1	1	-25	22559
Capital+ Land	3749	18631	8	17	374	249	213	1	1	1	1	1	1	1	1	1	-180	23069
Rural Household	1	1	1	1	1	1	1	9989	8033	1	1	1	1	2189	1	1	378	20602
Urban Household	1	1	1	1	1	1	1	12560	5125	1	1	1	1	1502	1	1	1297	20497
Pvt. Corp.	1	1	1	1	1	1	1	1	2928	1	1	1	1	1921	1	1	1	4864
Pub. Enter.	1	1	1	1	1	1	1	1	1142	1	1	1	1	1	1	1	1	1158
Govt.	1	1	1	1	1	1	1	1	987	820	982	1921	1	1	4050	1	1	8772
Ind. Taxes	-326	2150	2	5	112	8	11	1	1	247	263	1	1	114	1	735	728	4055
Capital a/c	1	1	1	1	1	1	1	1	4846	6045	5396	2928	1142	-1982	1	1	644	19029
ROW	198	9158	6	13	293	208.3253	2550	1	1	1	1	1	1	1	1	1	1	12436
Column Total	12680	89211	89	119	1613	711	2978	22564	23072	20594	20491	4864	1158	8765	4066	19029	12429	

Source: Prepared by the authors.