Towards inverting environmental injustice in Delhi

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Online Supplemental Files

Contours of the proposed fiscal policy

The fiscal policy we have proposed above is revenue-neutral, which means the carbon taxes are calculated endogenously. Let us look at the steps of arriving at the appropriate tax rate. There are four categories of expenditure — changing the energy mix G_f, free rations (in nominal terms) F, free electricity up to a certain unit (in real terms) $\bar{e}$, and travel passes (in nominal terms) T. We propose, like (Boyce and Riddle, 2007; Boyce and Riddle, 2011), that the tax is collected 'upstream' instead of the messy commodity wise carbon taxes, because the former has lower administrative costs while preventing leakage on account of caused by multiple layers of administration. These taxes will get passed on to the consumers by the producers in tandem with the rise in the cost of production as a result of these taxes. The administrative cost of this collection has been assumed to be 1% of the tax revenue in the literature, so, we make the same assumption. Let us call this total net revenue R, which, with $\bar{C}$ as the total carbon emissions in Delhi and t as the carbon tax, is given by:

$$R = t\bar{C} - 0.01t\bar{C} = 0.99t\bar{C} \qquad (1)$$

For the supply side measures, we take the expenditure required to change the energy mix in Delhi to be 1.5% of the GSDP. So, the total expenditure on this count would be $G_f = 0.015 \cdot Y$, where Y is Delhi's GSDP. For the demand-side measures, if the tax rate is t per unit of carbon, the prices of each of these three entitlements increase according to their respective carbon content. Denoting the new carbon content (resulting from the implementation of the policy) as c_f, c_e, c_t (the figures for each are given in the last column of table A2), the price rise, assuming the old price of electricity to be p_e, will be $1 + c_f \cdot t, p_e + c_e \cdot t, 1 + c_t \cdot t$ for food, electricity and transport respectively. We can now calculate the total costs that the Delhi government has to bear for the proposed policy. The carbon tax rate t is, therefore, calculated endogenously in the following manner.

$$\begin{aligned} 0.99t\bar{C} &= 0.015Y + \left(1 + tc_f\right)F + (p_e + tc_e)\bar{e} + (1 + tc_t)T \\ t &= \frac{0.015Y + F + p_e\bar{e} + T}{0.99\bar{C} - c_f F - c_e\bar{e} - c_t T} \end{aligned} \qquad (2)$$

Methodology and data

Methodology

The methodology used in the paper is similar to the existing literature (Fremstad and Paul, 2019). To calculate the carbon content in individual commodities, as well as the employment potential of a given sector in the economy, the input-output tables for India, have been used. The Right to Energy programme requires two steps: calculating the carbon content and determining its impact on the household budget. For the former, IO data is used. And for the latter, the national sample survey (NSS) data is used to estimate the consumption of different deciles of the households. Commodities of consumption in the NSS have been recategorised to match the IO specification available for India.

Step 1:

To calculate the effect of a carbon tax on the price of a commodity, we use the same methodology as used in (Azad and Chakraborty, 2020) and, and we use (Fremstad and Paul, 2019) to estimate the carbon content. The *direct* content dc_{ej} is simply the amount of the energy sector going into producing one unit of that commodity (e and j in dc_{ej} represent the energy sector and the sector that produces the commodity under consideration, respectively). There is an *indirect* carbon content too, which enters a commodity through the other commodities that have gone into its production. The sum of these gives us the total content (tc_{ej}) of carbon of a commodity, which can be calculated from the Leontief inverse matrix in the following manner, where **DC** and **TC** are respectively the matrices of the direct and total content of commodities as inputs to commodities as outputs and, **I** is the identity matrix.

$$\mathbf{TC} = (\mathbf{I} - \mathbf{DC})^{-1} \qquad (3)$$

Each of the elements tc_{ij} in $\mathbf{TC}$ represents the amount of commodity i entering as an input for producing a unit of commodity j. By implication, the tc_{ej} represents the amount of energy embodied in each commodity j, so, the energy row of the $\mathbf{TC}$ matrix gives us the total content of energy in each of the commodities. To find out the carbon content in commodity j, we multiply it by the amount of carbon (c_e) emitted by a unit of energy,

$$c_j = tc_{ej} \cdot c_e \qquad (4)$$

The increase in price of a commodity j as a result of a tax t imposed on carbon can then be calculated by multiplying this tax rate with the total carbon embodied in a commodity,

$$p_j^{new} = p_j^{old} + c_j \cdot t \qquad (5\%$$

This increase in prices can then be used to calculate its adverse impact on the budget of a household.

Step 2:

The budget of the household is derived from the NSS survey. The NSS survey gives details of expenditures for a household across a whole range of commodities defined at a very detailed level. Because our intention is to find the carbon content of these commodities, we have re-categorised them in a way that is commensurate with the IO level of disaggregation. We have divided the commodities into eight categories and found the respective industries in the IO table and the commodities in the NSS survey to match that. The exact codes used for this match from the respective sources is provided in table A1 of the appendix.

With this match, the carbon content and the price rise can now be calculated across these eight consumption categories based on the equations on carbon content and price. The total carbon content of these eight categories of commodities has been reported in table A2.

The effect of a carbon tax varies across income categories of households, so, we divide the NSS population in deciles and study the effect of this tax on their budget and then compensate both for free energy and travel passes to see the net impact of our programme on these deciles. We also report the overlap between class and caste to show the progressive effects of our policy on the socio-economic fabric of India.

Data Sources

We use the latest NSS 68th-round unit-level data (survey done in 2011-12), and the corresponding source for the Input-Output table is OECD database. NSS schedule 1.0 has been used for consumption related data. For carbon consumption of Delhi, we use the estimates from the web resource (http://citycarbonfootprints.info/) and extrapolate it using the World Development Indicators, World Bank database.

Appendix

While we use Delhi specific consumption data, the underlying production structure is taken at a country level. One of the reasons to do so is that there is no state-specific IO matrix and the other reason is that the production of commodities can be broadly assumed to have a similar process across the country. In most commodities, such as cars, clothing and other industrial goods, fuel, medical, this is most likely to be the case. In some others, which are not standardised across the country, such as food, the production processes could vary. Notwithstanding, these differences, given the paucity of data at the state level, we believe taking the IO matrix of India as representative of Delhi is a close approximation to reality.

Table A1: *Code Matching from Input Output Tables to NSS Categories*

Consumption Categories	**IO Codes***	**NSS Codes****
Food	C01T05+C15T16	1 to 17
Clothing and Footwear	C17t19	29+30+31
Manufactured Goods	C20+C21T22+C24+C25+ +C26+C27+C28+C29+ +C30T33X+C31+C34+C35+C36T37	21+22+23+34
Housing	C45+C70+C71	26
Fuel and Electricity	C10T14+C23+C40T41	18
Transport	C60T63	25
Health and Education	C80+C85	19+32+33
Misc Services	C50T52+C55+C64+C65T67 +C72+C73T74+C75+C90T93	20+24+27

*Codes are taken from OECD Input-Output Tables (IOT), 2015
**Codes are serial numbers of items in the Summary of Consumer Expenditure (Level 12) of Schedule 1.0 (NSS 68th round)
Source: Compiled by authors from IO, NSS
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Table A2: *Macro Level Estimations*

2011-12 (actual)	
Average Carbon content	
GDP (US$) [a]	1827637859135.7
Carbon emissions (mmt CO2) [b]	2018.503
Carbon intensity (mtco2/USD [b/a]	0.0011044327
2035-36 (estimated)	
Average Carbon content	
GDP estimated (US$) [c]	6100000000000
Carbon emissions (mmt CO2) [d]	2200
Carbon intensity (mtco2/USD) [d/c]	0.000360655737704918
Midrange of carbon content	0.663276468
Reduction in carbon content	0.336723532
Source: Authors' Calculation (see text for details)	

Table A3: *Mimimum Per Capita Distributional Incidence of Delhi's Green Energy Program (in USD)*

				CarbonDividend						Percentage of Expenditures		
Decile	Total Expenses	HH Size	Carbon Charge	Energy	Transport	Food	Total Benefit	Net Benefit	Net Benefit per Household	Charge (in %)	Benefit (in %)	Net Benefit (in %)
	[a]	[b]	[c]	[d]	[e]	[f]	[g=d+e+f]	[h=g-c]	[i=h x b]	[c/a]	[g/a]	[h/a]
1	234.4	6.9	39.9	8.14	17.3	148.0	173.47	133.60	921.8	17.0	74.0	57.0
2	310.1	6.0	52.0	11.86	22.1	180.4	214.40	162.40	974.4	16.8	69.1	52.4
3	375.7	6.2	59.0	12.19	28.5	204.6	245.30	186.31	1155.1	15.7	65.3	49.6
4	442.5	5.4	69.8	16.45	42.2	204.6	263.26	193.47	1044.7	15.8	59.5	43.7
5	514.4	5.6	83.0	18.11	50.7	204.6	273.42	190.38	1066.1	16.1	53.2	37.0
6	597.7	4.7	92.2	22.91	66.2	204.6	293.72	201.53	947.2	15.4	49.1	33.7
7	724.2	4.2	115.0	32.28	75.1	204.6	312.04	197.01	827.4	15.9	43.1	27.2
8	906.9	3.8	139.4	0.00	75.1	204.6	279.76	140.32	533.2	15.4	30.8	15.5
9	1140.2	4.4	163.7	0.00	75.1	204.6	279.76	116.04	510.6	14.4	24.5	10.2
10	2151.9	3.8	299.9	0.00	75.1	204.6	279.76	-20.18	-76.7	13.9	13.0	-0.9

Sources

Azad R and Chakraborty S (2020) Green growth and the right to energy in india. *Energy Policy* 141. Elsevier.

Boyce J and Riddle M (2007) *Cap and dividend: How to curb global warming while protecting the incomes of american families*. Political Economy Research Institute, University of Massachusetts at Amherst.

Boyce JK and Riddle M (2011) *Clear economics: State-level impacts of the carbon limits and energy for america's renewal act on family incomes and jobs*. Report. Amherst,MA: Political Economy Research Institute.

Fremstad A and Paul M (2019) The impact of a carbon tax on inequality. *Ecological Economics* 63: 88–97.