Modelling the Impact of the Clean Environment Cess: A Hybrid Energy Input–Output Approach[1]

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Abstract

The Government of India introduced the Clean Environment Cess (CEC), to be levied on the total sales (including imports and exports) of all types of coal in India, in 2010 to reduce emissions and tackle climate change. This paper seeks to measure the impact of this cess on greenhouse gas (GHG) emissions and the gross domestic product (GDP) at both the sectoral and national levels. It examines these questions by modelling the impact of the CEC using a hybrid Energy Input–Output (EIO) framework. The EIO for India for 2015–16, published by the Centre for Social and Economic Progress (CSEP), is the major data source for this study. The rate of the CEC was Rs 200/tonne in 2015–16. It was increased to Rs 400/tonne in 2016–17. However, the actual collection rate of this levy was Rs 144/tonne and Rs 324/tonne, respectively. This increase of Rs 180/tonne in the actual tax levied resulted in around 0.09% reduction in the GDP, while emissions from coal and petroleum products reduced by only 0.96% and 0.13%, respectively. The sector most affected by this cess was the coal electricity sector, with a potential reduction of around 1.5% in its proportion of gross value added. This was followed by a 0.47–1.2% reduction in the proportion of gross value added of the coal and lignite, cement, crude petroleum, and iron and steel sectors. The reduction in emissions across sectors also followed the same order, as the decrease in output led to lesser emissions. Thus, the CEC alone is not a useful tool for meeting India's climate change targets. However, a similar cess on the production of other high-emitting sectors—such as fertilisers, iron and steel, non-ferrous basic metals, paper and paper products, and textile and leather—may help.

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Modelling the Impact of the Clean Environment Cess: A Hybrid Energy Input–Output Approach

India was ranked among the most climate change–affected countries in 2019 (Germanwatch, 2021), due to a longer-than-expected monsoon and six “very severe” cyclones—both of these climate events caused severe hardship among vulnerable communities and extensive economic damage. The Indian government is implementing various strategies to mitigate the impace of climate change and help communities adapt to it. One of the many tools in its arsenal is the Clean Environment Cess[3] (CEC) levied on the total sales (including imports and exports) of all types of coal in India. This cess was implemented in 2010.[4] This was the first fiscal tool employed by the union government to reduce emissions and combat climate change. Now, over a decade since it was introduced, it is important to understand the implications of this cess for the Indian economy and, more importantly, its impact on national greenhouse gas (GHG) emissions. Several questions need to be answered in this context. What is the impact of the CEC on the gross domestic product (GDP) and emissions? Is CEC an effective fiscal tool for combating climate change? What are the reasons for its effectiveness/ineffectiveness?[5] In this paper, we examine these fundamental questions relating to this pioneering (and only) fiscal[6] tool designed by the Government of India.

Historical foundations of the CEC

One of the first, comprehensive climate change mitigation measures undertaken by the Indian government was the adoption of the National Action Plan on Climate Change (NAPCC) in 2008. The plan consisted of eight national missions: solar, enhanced energy efficiency, sustainable habitats, water, sustainable Himalayan ecosystems, green India, sustainable agriculture, and strategic knowledge on climate change. On the international stage, India is party to the Paris Agreement and pledged to eight Nationally Determined Contributions (NDCs) in 2015; the NDCs were subsequently updated in 2022 and, of them, three are quantifiable (Government of India, 2022):

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[3] A cess is a tax levied by the government that is earmarked for a particular purpose.

[4] Since implementing the cess, the Government of India has changed its rate, name, and purpose. More on this in the subsequent paragraphs.

[5] There are other interesting questions that can be analysed in the context of the CEC. For example, how is the revenue from the CEC utilised? What are the issues associated with its revenue utilisation, if any? Does the CEC need restructuring? Can the CEC provoke dynamic efficiency by shifting away from polluting forms of energy production? What are the price effects of levying the CEC? Of course, these questions are important, but the scope of the present study is limited to analysing the research questions posed in the main text. These other questions could be analysed in other studies.

[6] This is a pioneering fiscal tool for combating climate change because other forms of taxes, such as the tax on petroleum and diesel etc., do not have a similar intent as that of the CEC. The CEC clearly follows the “polluter pays” principle, which is not true of other forms of taxation (Department of Expenditure, 2017). These other taxes are also referred as environmentally-*related* taxes by the OECD/EEA database https://data.oecd.org/envpolicy/environmental-tax.htm

1. Reduce the emissions intensity of the country's GDP by 45% by 2030, from 2005 levels.
2. Achieve about 50% cumulative electric power installed capacity from non-fossil fuel energy sources by 2030.
3. Create an additional carbon sink of 2.5–3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030.

During the 26th Conference of the Parties summit held in November 2021, the Indian government extended its climate change mitigation commitments further with five pledges (PIB Delhi, 2021):

1. Reach 500 GW of non-fossil fuel capacity by 2030.
2. Meet 50% of India's energy requirements using renewable energy by 2030.
3. Reduce total projected carbon emissions by 1 billion tonnes from now [2021] till 2030.
4. Reduce the carbon intensity of the economy to less than 45% by 2030.
5. Achieve a net-zero target by 2070.

To realise its emissions reduction targets, the Indian economy would need to transition from fossil fuels to renewable energy sources. Coal-powered electricity generation plays an important role in the Indian economy, and, as of February 2022, it accounted for 53.2% of the total installed power generation capacity (Central Electricity Authority, Government of India, 2022). Renewable sources (excluding large hydro), of which solar and wind form the majority, make up 28.2% of the total capacity, at 114 GW; the government aims to raise this to 175 GW in 2022 (Press Trust of India, 2021).

Given this context, the Government of India introduced the CEC, which came into effect with the Finance Act, 2010 (Ministry of Finance, 2010a). Unlike other taxes on carbon emissions across the globe, the CEC is an excise duty levied on the the total sales (including imports and exports) of coal, lignite, and peat in India. The union government has the power to make rules governing its assessment, collection, and utilisation. The purpose of the cess is "financing and promoting clean energy initiatives, funding research in the area of clean energy or for any other related purpose". This cess follows the "polluter pays" principle—those who produce the pollution should bear the cost of managing the impacts of the pollution on the environment and human health.

While the Finance Act, 2010, initially set the rate of the cess at Rs 100/tonne, a subsequent notification in June 2010 reduced the cess to Rs 50/tonne. With the Finance Act, 2014, the purpose of the cess was extended to also include clean environment initiatives in addition to clean energy initiatives (Ministry of Finance, 2014). Additionally, the effective rate of the cess[7] was increased back up to Rs 100/tonne. The effective rate of the cess was further increased

[7] The effective rate of cess refers to the rate of Clean Environment Cess accounting for the exemptions from other cesses

twice: in 2015–16 to Rs 200/tonne, and in 2016–17, to Rs 400/tonne. In the Finance Act, 2016, the tax was renamed “Clean Environment Cess” to reflect its broader purpose.

To manage the collection and allocation of funds accrued under the CEC, the National Clean Energy & Environment Fund (NCEEF) was created in 2010 (Department of Expenditure, Government of India, 2017). Data on fund collection and utilisation is available up to 2017–18.

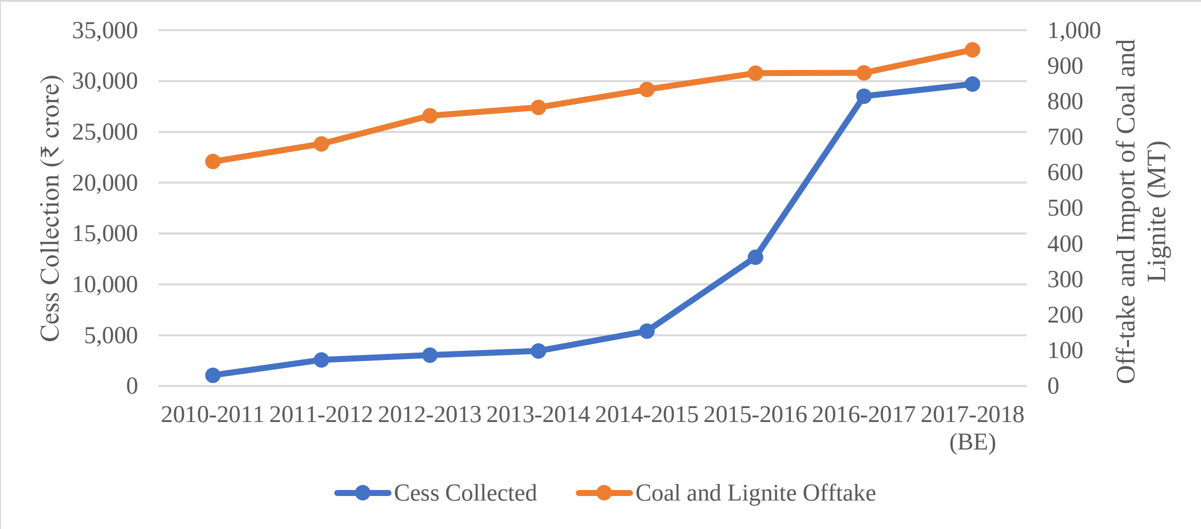
Figure 1 shows the collection of CEC funds alongside the growth of coal and lignite production and imports. There were sharp rises in cess collection in the three years in which the rates were increased. Figure 2 compares the CEC rate as prescribed by the CEC rules against the actual collection rate. Data on the coal and lignite offtake were taken from the Coal Directory of India 2019-20 (Ministry of Coal, 2021). The offtake quantity refers to the quantity of coal leaving the mines for consumption, on which the cess is applied. Since 2013–14, there has been a widening difference between prescribed and actual CEC rates. Clearly, there may be inefficiencies in the tax collection process.

Table 1: Evolution of the rates of the CEC

Legislation	**Year**	**Cess on coal, lignite, and peat (Rs/tonne)**	**Cess (US$/tonne)**
Finance Act, 2010	2010	100	2.19
Notification 03/2010	2010	50	1.10
Finance Act, 2014	2014	100	1.63
Finance Act, 2015	2015	200	3.05
Finance Act, 2016	2016	400	5.96

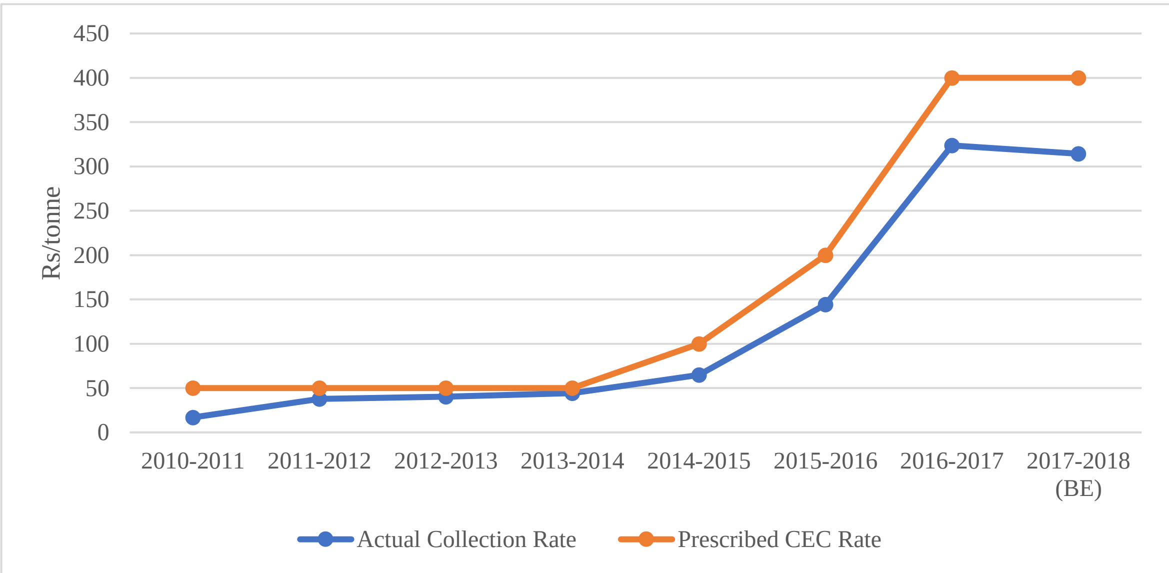
Source: Authors' compilation from Ministry of Finance (2010a), Ministry of Finance (2010b), Ministry of Finance (2014b), Ministry of Finance (2015), Ministry of Finance (2016), Reserve Bank of India (2017)

Figure 1: CEC collection vs coal production and imports



Source: Authors' computations using data from Department of Expenditure (2017) and Ministry of Coal (2021)

Figure 2: Prescribed vs actual CEC rate

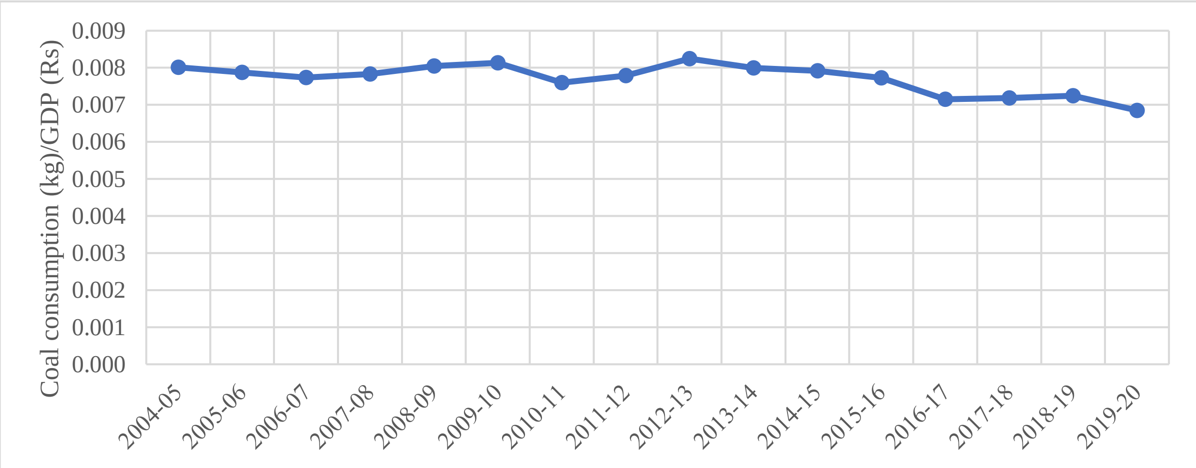


Source: Authors' computations using data from the Department of Expenditure (2017)

The CEC was abolished in 2017 (Central Electricity Regulatory Commission, Government of India, 2018). In its place, a Goods and Services Tax (GST) compensation cess was levied on products at the erstwhile rate of Rs 400/tonne. The funds accrued under the cess on coal were used to compensate Indian states for tax revenue deficits that had resulted from the introduction of GST in 2016. Though the goal of using the funds generated by the CEC for clean environment purposes was suspended, the tax on coal still has implications for the utilisation of coal, and hence on greenhouse gas emissions.

Figure **3** shows the consumption (which includes domestic consumption, exports, and imports) of coal and lignite in relation to India's GDP from 2004–05 to 2019–20, estimated at constant 2011–12 prices (Ministry of Coal, Government of India, 2021). In 2010–11, when the cess was introduced, consumption decreased by 6.6% from the previous financial year.[8] In the three years when the CEC rate was increased (2014–15, 2015–16, and 2016–17), the ratio of coal consumption to GDP decreased by 0.9%, 2.4%, and 7.5%, respectively. Overall, from 2004–05 to 2009–10, there was a compound annual growth rate (CAGR) of 0.3%. Meanwhile, from 2010–11 to 2019–20, the CAGR dropped to –1.1%. Thus, the cess seems to have influenced coal use with respect to the national GDP.

Figure 3: Share of Coal and lignite consumption in GDP[9]

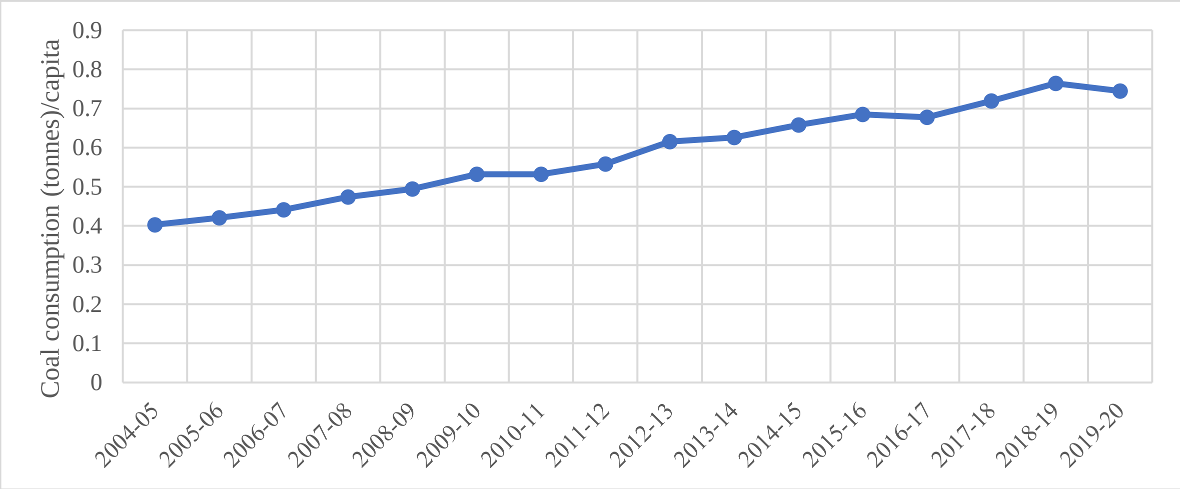


Source: Authors' computations; Coal Directory of India 2019-20; National Accounts Statistics 2021

[8] The financial year in India runs from April 1 to March 31.
[9] The absolute values of the consumption of coal in India are mentioned in Annexure A.

Figure *4* shows the per-capita consumption of coal and lignite. This value had a CAGR of 5.7% from 2004–05 till 2009–10, and 3.8% from 2010–11 to 2019–20; clearly, there was a drop in growth after the introduction of the cess. In 2015–16, India consumed approximately 0.69 tonnes of coal and lignite per capita, compared to the world average of 0.74 tonnes per capita (Statista Research Department, 2016). China and South Africa, two comparable developing economies, consumed 2.03 and 2.39 tonnes per capita, respectively. Australia, the United States of America (USA), and Germany also had much higher per-capita consumption rates of coal—2.77, 1.63, and 1.38 tonnes, respectively.

Figure 4: Per-capita coal and lignite consumption

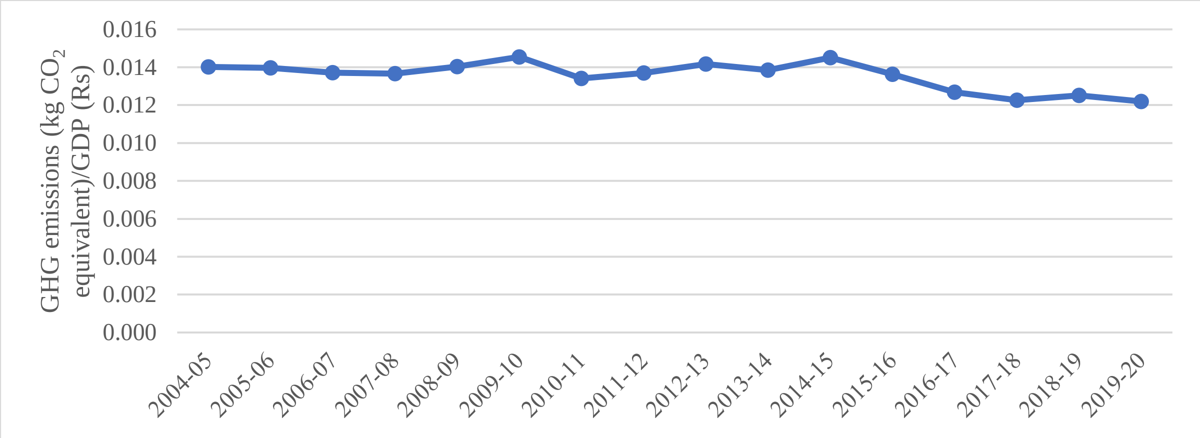


Source: Authors' computations; Coal Directory of India 2019-20; National Accounts Statistics 2021

Figure **5** shows the greenhouse gas emissions[10] (i.e., carbon dioxide, methane, and nitrous oxide) from burning coal and lignite per GDP from 2004–05 to 2019–20. Emissions estimates were computed using the data on the net calorific value and emissions factor of coal and lignite from the Ministry of Environment, Forest and Climate Change, Government of India (2021). In the five years preceding the introduction of the cess, the coal emissions to GDP ratio rose by 0.7% CAGR. Since the introduction, there has been a decrease of 1% in the CAGR.

Figure 5: Emissions intensity from the burning of coal and lignite

[10] This has been estimated using the net calorific values and emissions factors for coal and lignite products reported in India's Third Biennial Update Report to the United Nations (Ministry of Environment, Forest and Climate Change, Government of India, 2021). available at https://unfccc.int/sites/default/files/resource/INDIA_%20BUR-3_20.02.2021_High.pdf



Source: Authors' computations; Coal Directory of India 2019-20; National Accounts Statistics 2021

The data analysed so far shows that with the introduction of the CEC, and with each of its rate hikes, coal consumption in India, in both GDP and per-capita terms, has decreased. This has subsequently led to a decrease in emissions intensity from burning coal and lignite products. However, this decrease is not substantial when compared to the present cess rate, which stands at around 20% of the value of the output/import of coal.

Data and method

The major data source used in this study is CSEP's hybrid energy input–output (EIO) table, which gives the sectoral monetary transactions of 34 sectors in India for 2015–16 (Chadha & Sivamani, 2022). The EIO table is based on an aggregated 131-sector input–output table. The resulting hybrid input–output table extends the monetary flows table by including two additional datasets: energy flows and greenhouse gas emissions. Ten of the sectors pertain to energy:

- Biomass, coal, and lignite
- Crude petroleum
- Natural gas
- Combustible petroleum products
- Non-combustible petroleum products
- Coal electricity
- Other thermal electricity
- Large hydroelectricity
- Renewable energy sources (RES) of electricity
- Nuclear electricity

The energy-extended table provides data on the sectoral energy use in each of the 10 sectors. It also reports two sources of carbon dioxide–equivalent greenhouse gas emissions generated by each sector—i.e., the burning of coal and lignite and combustible petroleum products. We examine these sources to understand the impact of the coal cess on emissions in India. For this paper, we aggregate 131 sectors into 34 sectors of interest to fulfil the objectives of the study (see Annexure B for details on these 34 sectors).

We are modelling the CEC using a hybrid I–O approach to reveal the interlinkages between the various production sectors of the entire economy. A fiscal tool such as a tax has wide-ranging effects on various industries and other agents in the economy—for instance, the government and consolidated consumer demand. This affects macroeconomic parameters such as the GDP, emissions, and prices. Therefore, the hybrid I–O approach, which accounts for changes to the tax rate, is more appropriate for this study than other methodologies such as regressions or correlations.

Modelling the impact of the CEC on GDP

The CEC is a specific tax (also known as a per-unit tax) that was levied at the fixed rate of Rs 400/tonne in 2016–17. However, our preceding analysis shows the difference between the actual and prescribed rates of CEC for all the years since its introduction in 2010, except from 2011–12 to 2013–14, when the differences were minimal. The rate of Rs 400/tonne was actually equivalent to only Rs 324 in 2015-16 (see Figure 2). The EIO table for 2015–16 incorporates the impact of the actual collection rate of Rs 144/tonne, not the prescribed rate of Rs 200/tonne,[11] on the Indian economy. In this study, we compute the effects of the additional Rs 180/tonne tax rate[12] in 2016–17 on emissions and the GDP by providing for the influx of this amount through corresponding changes in the input coefficients of all sectors that consume coal.[13]

We model the impact of the CEC on the economy and emissions by modifying the methodology used by Grottera et al. (2015). In their paper, the impact on GDP, employment, and emissions of a tax on greenhouse gases, and its revenue recycling in the economy, were analysed using a social accounting matrix. The present study allocates the burden of the CEC to all sectors that consume coal. This is unlike the approach of Grottera et al. (2015), who did not distribute the burden of the proposed carbon tax among sectors producing emissions.

To model the CEC using the EIO framework, we must compute the quantity of coal utilised by all 34 sectors. The data on the quantity of coal used by each of the 34 sectors is easily obtained from the EIO. The cess is levied on the total sales (including imports and exports) of all types of coal in India. Therefore, to compute actual vs prescribed rates, we consider the total offtake[14] value of the coal produced and imported by India. The actual rate of Rs 180/tonne was then proportionately levied on 25[15] of the 34 sectors that consumed coal in 2015–16. Also, as the private final consumption expenditure (PFCE) and exports sector consume coal, their values have been adjusted in the final demand matrix (X). This is how we modified the method detailed by Grottera et al. (2015) and further developed it for use in the I–O framework, as Grottera et al. utilised a SAM framework. Since the CEC is a per-unit tax, Equation 1 has been used to compute the total tax revenue (*T*) generated from the additional levy of Rs 180/tonne.

$$T = t.Q \quad \text{(1)}$$

t –Tax rate of the CEC

Q – Quantity of coal used by all the sectors

T – Tax revenue

This additional tax revenue, generated through the increase in the actual rate of the CEC, needs to be factored out of the total value of the output of the 25 sectors to find their new effective output. The new effective outputs then have to be divided by the original outputs to get the

[11] The tax rate in 2015–16 was Rs 200/tonne.

[12] Rs 180 is the difference between the actual rate of Rs 324 in 2016–17 and Rs 144 in 2015–16.

[13] A detailed explanation of this method is provided in the subsequent paragraphs. The assumption made for this influx is that the structure of the Indian economy did not change in 2016–17 from 2015–16. Therefore, it is a reasonable assumption to make.

[14] Coal offtake is the quantity of coal supplied from the coal pitheads.

[15] These sectors are highlighted in Annexure B.

change in their share of output of the coal sector due to the cess. This is represented by Equation 2. For the remaining nine sectors, the diagonal matrix (O) shows a value of 1 since these sectors do not consume coal.

$$O_{34\times34} = \left[1 - \frac{T}{Y}\right] \ldots\ldots (2)$$

$O_{34\times34}$ – Proportion of effective output due to the levy of tax, represented in the diagonal elements of the O matrix

Y – Total initial output of all sectors

$$[O]_{34\times34} \,.\, [A]_{34\times34} = \left[A_{eff}\right]_{34\times34} \ldots\ldots (3)$$

A – Coefficient matrix pre ecotax

A_{eff} – Coefficient matrix post ecotax

$$\left[Y_{eff}\right]_{34\times1} = \left[I - A_{eff}\right]^{-1}_{34\times34} \,.\, \Delta[X]_{34\times1} \ldots\ldots (4)$$

ΔX – Change in the exogenous demand vector due to the tax levied on PFCE and exports using coal

Y_{eff} – Total output post ecotax

Levying the additional CEC changes the effective output of the 25 sectors ($Y_i - T_i$), which must therefore be reflected in their respective coefficient matrix. The updated effective coefficient matrix (A_{eff}) is obtained by multiplying matrix O with matrix A, as shown in Equation 3. This will further change the multiplier and eventually affect the output of the sector, which can be obtained using the conventional matrix formula depicted in Equation 4. The effect of the CEC on the PFCE and exports is reflected in the change to their entries for the coal consumption in the exogenous demand vector (ΔX). Therefore, an exogenous policy shock, such as the levy of CEC, impacts the output of every sector in the economy even if a particular sector is not directly taxed. The interactive effect, which is depicted by the new multiplier matrix $(I - A_{eff})^{-1}$, is the cause for such an effect, as shown by Equation 4. This is the fundamental notion which has been used in this study.

It is important to understant why we updated the coefficient matrix. In Equation 2, we removed the additional tax revenue that would be generated because of the Rs 180/tonne increase in the tax rateThis can be justified because the industries did not pay this amount prior to the increase in the tax rate. Further, since the increase, the amount has been directly transferred to the government, and has not benefitted the industries. Therefore, this tax revenue has been removed from the I–O system by computing the effective value of the output (O matrix) of these sectors, which has been used to calculate the effective coefficient matrix due to the change in the CEC rate.

The coefficients of value added have been computed for every sector from the EIO table and these have been multiplied by the new output of every sector which was obtained from the

Equation 4. This gives us the post-tax value added for each sector, which can then be compared with the original value added to obtain the impact on the GDP.

Modelling the impact on greenhouse gas emissions

Next, we need to comprehend the effect of the change in the output of the 34 sectors of the economy using the method detailed by Kohn (1975), as cited in Pal et al. (2015).

$$E_{2\times1} = P_{2\times34} \,.\, Y_{34\times1} \quad \ldots\ldots \quad (5)$$

E – Total emissions from the two sources of pollution[16]

P – Pollution coefficient matrix

Y – Total output of core sectors

$$E_{2\times1} = P_{2\times34} \,.\, (I - A)^{-1}_{34\times34} \,.\, X_{34\times1} \quad \ldots\ldots \quad (6)$$

The premise of this methodology is that emissions are directly proportional to the output of the sector. This is a reasonable assumption as the quantity of coal consumed increases with output and, hence, pollution generated, assuming the technology used for production remains fixed (Equation 5). This constancy in the technology can be represented by the pollution coefficients (*P*), which could be interpreted as the amount of pollution generated per unit of utilisation of output from a sector. In the present study, this data has been computed using the EIO for the coal and combustible petroleum products sectors.

Equation 6 is derived by replacing output ($Y_{34\times1}$) in Equation 5 with the product of the multiplier matrix and the change in the exogenous demand vector (*X*), which comes directly from the I–O's fundamental methodology. Now, the effect of the CEC on total emissions can be calculated by plugging in the value of the new output, obtained using the methodology of Grottera et al. (2015). We give a hypothetical example of how a change in the cess rate operates in a 3×3 hypothetical I–O framework in Annexure C.

Any I–O/SAM analysis is a "what if" analysis, i.e., what will be the impact on the economy if, for instance, we introduce an exogenous shock (change) into the I–O system by imposing a new tax or changing the tax rate. Therefore, the analysis models the impact of such exogenous changes given constant technological parameters (Leontief coefficients). The analysis conducted in this study does not consider changes in technology (moving away from coal-based electricity generation because of the CEC), the use of CEC revenue for environmental objectives, or the price effect of the levy. These questions could be answered in separate modelling exercises. Also, the non-linear effects of such a tax cannot be modelled using an I–O analysis.

[16] The two sources of pollution used in this study are the burning of coal and lignite and combustible petroleum products in the 34 sectors of the EIO (Chadha and Sivamani, 2022).

Simulating the impact of the CEC

The cess has been modelled as a per-unit tax on the coal consumed by 34 sectors of the Indian economy at a rate of Rs. 180/tonne. The impact of this additional cess on emissions from the coal and lignite sector and combustible petroleum products is summarised in Table 2. The emissions from both these sectors declined due to the levy of this cess, as this reduces the value of the output of all the 34 sectors, as all of these sectors are interlinked. For instance, the coal and lignite sector's output is used by other sectors, and other sectors' outputs are used by the coal and lignite sector; hence, a tax on the coal sector affects the entire economy. Table 2 clearly shows that due to the additional Rs 180/tonne cess (equivalent to around an additional 13% actual tax rate on the value of India's coal output and imports in 2015–16), the overall GDP of the Indian economy in 2015–16 reduced by 0.093%, and the overall emissions from the coal and lignite sector and the petroleum combustible products sector also declined by 1.059% and 0.225%, respectively.[17]

Table 2: Immediate computed effect of the additional CEC on emissions and the GDP in 2015–16

Sectors from which emissions data is available	**Change in emissions (%)**	**Change in GDP (%)**	**Change in emissions to change in GDP (%)**
Coal and lignite	–1.059		–0.967
Combustible petroleum products	–0.225	–0.093	–0.133
Total	**–0.898**		**–0.806**

Note: The impact depicted is for Rs 180/tonne, which is equivalent to the actual collection rate of the Government of India.
Source: Authors' computations

It is interesting to note that the emissions to GDP ratio for these two sectors was marginally impacted. For the coal and lignite sector, the emissions to GDP ratio decreased to 0.967%, and there was a small drop in the emissions to GDP ratio of the combustible petroleum production sector, by 0.133%. The reason for this marginal change could be attributed to the meagre impact of this cess on the GDP and emissions (

Table **2**).

To understand the disaggregated effect of the CEC on the Indian GDP, the change in each sector's value added as a result of the additional CEC was computed. Since the output of every sector was impacted, this reduced the value added by these sectors. Tables 3 and 4 show the percentage change in the five most and least affected sectors' value added, respectively, before and after the increased CEC. Apparently, the coal electricity sector was most impacted, with a decline of around 1.5% in its value addition. The average reduction in the other four most

[17] The impacts of the cess on the economy and emissions were additionally computed by attributing the entire burden of the cess to the coal and lignite sector, rather than distributing it proportionally among coal-consuming sectors. The results of this exercise are provided in Annexure D.

impacted sectors was only around 0.97%. The five sectors that were least affected saw an average reduction of only 0.01% in their respective value added, ranging from –0.006% to –0.018% for the food and tobacco and transport sectors, respectively.

Table 3: Five sectors most affected by the CEC, according to the change in the value added and emissions

Sectors	**Change in the sector's own value added and emissions (%)**
Coal electricity	–1.49
Coal and lignite	–1.16
Cement	–1.12
Crude petroleum	–0.63
Iron and steel	–0.47

Source: Authors' computations

Table 4: Five *least* affected sectors by the CEC, according to the change in the value added and emissions

Sectors	**Change in the sector's own value added and emissions (%)**
Transport equipment	–0.018
Agriculture	–0.017
Biomass (energy)	–0.012
Fishing and aquaculture	–0.009
Food and tobacco	–0.006

Source: Authors' computations

The values depicted in Tables

Table *3* and

Table *4* represent the reduction in emissions due to the drop in output. This is because Equation 5 states that the impact on emissions can be explained through the impact on output, as pollution coefficients do not change in a year. Thus, the percentage change in emissions follow the same order as that of the change in the GDP or value added.

Comparing the results of this study with the existing literature on the CEC

Not many studies in the literature have analysed the impact of the CEC on sectoral emissions and value added. Most research on the CEC is descriptive in nature, either examining the history of this levy or commenting on the utilisation of the funds generated by the levy (Panda & Jena, 2012; Sarangi, 2018; Verma, 2021; Singh, 2017 etc.). Others, for instance, Bhat & Mishra (2020), examine the incidence of the CEC and other levies, such as petrol/diesel taxes. The study by Mukherjee (2022) attempts to compute the revenue neutral rate of a proposed carbon tax on thermal electricity generation by replacing the CEC. We could find only two studies—one by Parry et al. (2017) and the other by Pradhan and Ghosh (2022)—which attempt to analyse the impact of the CEC on the Indian economy. The former examines several policy scenarios such as the CEC and other forms of levies (a carbon tax, an emissions trading system, etc.) using speadsheet modelling and then compares their effects. The latter explores the relationship betweeen the CEC and technological improvements in the clean energy generation sectors and carbon capture and storage mechanisms. This study uses a recursive dynamic computable general equilibrium (CGE) model to analyse these effects. Both these studies are dynamic analyses (the former a13-year analysis and the latter a 33-year one). They show a similar average reduction in emissions—less than 1%—due to the implementation of the CEC, even when the rate of the CEC was gradually increased. These trends mirror the results of our study, confirming that the total reduction in emissions due to the increase in the tax rate of the CEC is around 0.89%, which is minimal. Our study analyses the changes in emission levels and value added at the sectoral level. It also details a methodological framework for examining these impacts in the I–O framework by improving on the work provided by Grottera et al. (2015). The present study's methodology can be used to examine the impact of any tax on the Indian economy.

Analysing the impact of the CEC on the Indian economy

First, the effect on the GDP can be explained using the change in value added for the sectors that were most affected, utilising the coefficients computed from the EIO table. The validity of the CEC's minimal impact on the GDP could then be easily comprehended as, the share of value addition of the coal and lignite sector in the overall GDP of the Indian economy is only 0.33%. Therefore, if a sector such as coal is taxed, the impact of the tax on the GDP of the Indian economy cannot be more than the sector's overall contribution to the GDP Further, the output of the coal electricity sector is most impacted, as this sector consumes considerable amounts of coal; thus, the price effect for this sector will be the highest. This is why the output of the coal electricity sector gets reduced by around 1.5%. The second-most affected sector is the coal sector itself, whose output reduced by about 1.2%. The coal sector's output reduces by less than the coal electricity sector's output as the coal consumption for every Rs 1 lakh of output produced in the former sector is just Rs 130, while for the latter it is around Rs 6,600. The amount of tax burden on the 34 sectors is proportionate to the coal consumption of each sector. The third-most impacted sector is the cement sector, whose output reduces by around 1.1%. This is close to the output reduction for the coal sector.

The effect on the crude petroleum sector was initially puzzling, as this sector does not demand from or supply to the coal sector. However, its reliance on the coal sector is more indirect, through the chemicals, iron and steel, land transport, and railway transport sectors, which are among the top five sectors that supplies inputs to the crude petroleum sector. The chemicals sector supplies 9.3%,[18] iron and steel contributes 4.4%, land transport provides 3.4%, and railway transport contributes 2.2% to the overall input requirements of the crude petroleum sector. The average reduction in output due to the CEC for all these four sectors is around 0.23%. This explains the indirect impact on the crude petroleum sector, amounting to 0.63%, even though there is no direct relation with the coal sector. The effect on the iron and steel sector, which ranks fifth in terms of impact on output, could easily be explained by its input coefficient requirement of around 8% from the coal sector alone.

The emissions to GDP ratio being small for the coal sector and even smaller for the combustible petroleum products sector could be linked to the low share of the coal sector in the total value added to the economy, leading to small changes in output. In the case of the combustible petroleum products sector, the reduction in the output value is only 0.16%, which results in a minimal impact on the emissions from this sector.

The sectoral emissions follow the same decreasing trend as that of the sectoral output. This is easily explained by the fact that emissions would increase or decrease in proportion to the output of a sector. The CEC levy reduced the output of all 34 sectors and, therefore, had a proportional impact on the emissions of these sectors, as explained by Equations 5 and 6, which were used to simulate these impacts. Thus, the reasoning for the change in value added and GDP is also applicable to the change in emissions. In fact, the change in emissions for all sectors will precisely match the change in output due to the increased CEC, as the pollution coefficients, which represent the production technology used in any sector, do not change.

Concluding remarks

The CEC was the first-ever fiscal policy tool imposed at the union level with the objective of mitigating emissions from the use/misuse of coal in all its forms in India. It has been more than a decade since its inception, and its impacts on the Indian economy and its fossil fuel emissions have not yet been examined in a systemic manner, to the best of our knowledge. We found that its effects are *not* substantial, given that the increase in actual cess collection was equivalent to around 13% of the tax rate on coal products in 2016. Moreover, the additional CEC imposed resulted in a reduction of *only* 1.06% and 0.23% of carbon dioxide–equivalent emissions in the coal and combustible petroleum products sectors, respectively. Further, it had a minimal impact on the GDP of the country—around a 0.09% reduction. This implies that the emissions to GDP ratio slightly decreased for both the coal and petroleum sectors. Along with the limited reduction in emissions and emissions intensity, the funds generated from this levy were not adequately utilised and tax revenue was not collected to its full potential. Only around 18% of the cess collected was utilised for its intended purposes (Verma, 2021, p. 97). Further, the coal cess is not designed to account for the pollution generated by different varieties of coal. This is a major shortcoming of the present design of the coal cess.

[18] The highest input coefficient requirement (except for its value-added coefficient, which is 60%) for the crude petroleum sector comes from commerce and public services, which supplies 11.1% of the inputs/value added required. This underscores the importance of the chemicals sector.

One of the major outcomes of this study is the conclusion that the tax base of the CEC, i.e., the production and import of coal and lignite products, is ill defined. This is because it does not have substantial forward and backward linkages. Therefore, its impact on emissions, including those from its own usage in 33 other productive sectors of the economy, is insignificant. Thus, the Government of India must broaden the tax base to include other polluting sectors, such as the coal electricity,[19] fertilisers, iron and steel, non-ferrous basic metals, paper and paper products, and textile and leather industries. These sectors are regarded as more polluting than the mining and coal import sectors in India (Pandey, 2005; Gupta, 2002; Verma, 2021). They are responsible for other forms of pollution, such as wastewater generation and land degradation, etc., besides from the burning of coal. The present study's recommendation to move away from the coal cess, as a fiscal policy to control pollution, differs from earlier studies on the impact of the CEC, such as Parry et al. (2017) and Pradhan and Ghosh (2022), which proposes sequentially increasing coal cess rates. This is despite the fact that the impact on emissions as a result of the CEC is minimal, as confirmed by our study.

[19] The coal electricity sector consumes only 6.6% of the inputs from the coal and lignite sector. This is abysmally low considering that around 26% of its inputs/value added come from the commerce and public services sector. Therefore, the impact in terms of reduction of output from the most polluting sector in India (as per Verma, 2021) is extremely limited; the reduction would be only 1.5%.

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Annexure A: Production and import of coal in India

Year	Consumption of all types of coal (million tonnes) in India (including imports and exports)
2004–05	441.98
2005–06	475.69
2006–07	505.20
2007–08	540.86
2008–09	574.18
2009–10	639.37
2010–11	639.34
2011–12	685.13
2012–13	748.64
2013–14	776.89
2014–15	875.23
2015–16	887.02
2016–17	894.20
2017–18	930.30
2018–19	1,010.73
2019–20	1,021.56

Source: Coal India Limited (2016)

Annexure B: List of 34 sectors in the EIO

No.	Sectors
1	Agriculture
2	Forestry and logging
3	Biomass (energy)
4	Fishing and aquaculture
5	Coal and lignite
6	Crude petroleum
7	Natural gas
8	Mining
9	Food and tobacco
10	Textiles and leather
11	Wood and wood products except furniture
12	Paper, pulp, and print
13	Petroleum products combustible
14	Petroleum products non-combustible
15	Chemicals
16	Cement
17	Non-metallic mineral products
18	Iron and steel
19	Aluminium
20	Non-ferrous basic metals (including alloys)
21	Machinery
22	Transport equipment
23	Industry NEC
24	Construction and construction services
25	Coal electricity
26	Other thermal electricity
27	Large hydro electricity
28	Renewable Energy Sources and nuclear electricity
29	Railway transport

30	Land transport
31	Water transport
32	Air transport
33	Transport NEC
34	Commerce and public services

Source: Chadha and Sivamani (2022)

Annexure C: A 3×3 hypothetical example of CEC computations

Let us assume a 3×3 matrix of the Indian economy, which has three sectors: coal, electricity, and others. Say there is an additional CEC of 10%, which we are attempting to model in this 3×3 sector. Now, the value of the output of coal is Rs 300 (assuming that everything produced is sold in the economy and, therefore, the production and offtake values are equal). Therefore, the tax rate of 10% would yield a tax revenue of Rs 30, which would have to be taken out of the system as it is a transfer to the government. This tax is proportionately distributed between all three sectors as they all take some inputs from the coal sector. The effective proportion of output (O) for coal, electricity, and other sectors is 0.997, 0.998, and 0.97, respectively, after tax, as all these sectors use coal and, therefore, will pay the tax. Now, this effective output can be represented in the form of a diagonal matrix. This matrix can then be multiplied by the input coefficient matrix (A) to obtain the effective coefficient matrix (A_{eff}), due to the additional 10% tax rate. Thereafter, we use the conventional I–O analysis to understand the impact of this effective coefficient matrix on the outputs. Evidently, the effective value of the output for coal, electricity, and others is Rs 288.02, Rs 394.51, and Rs 496, respectively. Therefore, a tax of 10% would reduce the GDP by 2.43%. Emissions would be impacted at the same level as that of the outputs of these three sectors because of the assumption of a one-to-one relationship between outputs and emissions.

A hypothetical 3×3 model of the Indian economy

	Coal	**Electricity**	**Others**	**Intermediate Use**	**Total Final Use**	**Output**	**New (ΔX)**	**TFU**
Coal	10	50	150	210	90	300		
Electricity	5	5	250	260	140	400		1
Others	15	25	50	90	410	500		4
Total inputs	30	80	450					
GVA+NIT	270	320	50					
Output	300	400	500					
Tax revenue	1	5	15	21	9			
Effective output matrix	0.997	0.988	0.970					

Tax rate = 10%

Tax revenue	30

A matrix: Computing the Leontief coefficient matrix

	Coal	Electricity	Others
Coal	0.033	0.125	0.300
Electricity	0.017	0.013	0.500
Others	0.050	0.063	0.100
GVA+NIT	0.900	0.800	0.100

O matrix: Effective output matrix

	Coal	Electricity	Others
Coal	0.997	0.000	0.000
Electricity	0.000	0.988	0.000
Others	0.000	0.000	0.970

A_{eff}: Effective coefficient matrix

	Coal	Electricity	Others
Coal	0.033	0.125	0.299
Electricity	0.016	0.012	0.494
Others	0.049	0.061	0.097
GVA+NIT	0.902	0.802	0.110

Inverse of $I – A_{eff}$

	Coal	Electricity	Others
Coal	1.06	0.16	0.44
Electricity	0.05	1.05	0.59
Others	0.06	0.08	1.17

Final output due for a tax of 10%

	Effective output (Y_{eff})	Old output (Y)
Coal	288.02	300
Electricity	394.51	400
Others	496.00	500
Total	1178.53	1200

Impact on GDP

Original GDP	640.00
New GDP	624.43
Decrease in GDP	15.57
% decrease in GDP	2.43

Impact of tax on sectoral output

Coal	–11.98
Electricity	–5.49
Others	–4.00

Annexure D: Comparing the results from differing methodologies for modelling CEC

In this paper, the impact of the additional cess was modelled by attributing the additional cess to each of the sectors consuming coal, in proportion to the quantity of coal the sector consumed. Alternatively, it is possible to allocate the total additional cess burden to just the coal and lignite sector and similarly compute the effects on emissions and GDP.

Table ***5*** shows the differences in the results between Methodology 1 (as presented in the paper) and Methodology 2 (similar to that used by Grottera et al., 2015).

Table 5: Comparing the results of different methodologies

Result	**Methodology 1** **(Used in this paper)**	**Methodology 2** **(Grottera et al., 2015)**
Change in coal and lignite sector's output (%)	–1.16	–17.44
Change in GDP (%)	–0.093	–0.150
Change in emissions from coal and lignite (%)	–1.059	–0.070
Change in emissions from combustible petroleum products (%)	–0.225	–0.172

Methodology 1 is superior as the impact on the output of the coal sector, as obtained from the Methodology 2, is unjustifiably large. This does not conform with the actual change in coal production in 2016–17. Additionally, since thermal electricity accounts for the largest share in the electricity mix in India, the substitution of coal did not take place. Hence, the tax on the coal sector would have been passed on to consuming sectors in proportion to the quantity of coal they consumed, this is, what we modelled in the revised methodology for this study. This paper, therefore, provides a practical methodology for modelling any form of tax in an I–O framework and, thus, advances the methodology proposed by Grottera et al. (2015).