# India’s CEC: A story of Double Dividends or a Double-Edged Sword?

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# Abstract

The research paper assesses India's Clean Environment Cess' (CEC) ability to achieve double dividends. Double dividends refer to an environmental tax's ability to achieve environmental improvement and economic efficiency simultaneously. Therefore, using the Prowess data set, the study uses changes in the level of coal consumption and net profits for heavy industry firms to model the CEC's impact on environmental improvement and economic welfare, respectively. Using Two-Way Fixed Effects Difference-in-Differences (TWFE DID) estimation, with controls for operational capacity and operational efficiency, the study finds that the CEC resulted in a reduction in coal consumption and net profits for firms in non-mining states relative to firms in mining states. This finding concludes that the CEC was unable to achieve double dividends since firms experienced lower profitability. However, CEC may facilitate better economic efficiency and renewable energy security in the future through its revenue recycling policy of financing sustainability projects.

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## 1. Introduction

The Clean Environment Cess (CEC) is India's first fiscal tool aimed at reducing carbon intensity of energy and improving its sustainable energy capacity.[1] The CEC came into effect with The Finance Act, 2010 with an initial rate of Rs 50/tonne, levied on the total sales of coal and its derivatives. The rate was increased to Rs 400/tonne by 2016 and eventually replaced with the Goods and Service Tax (GST) on July 1, 2017. During its period of implementation, the resulting tax revenue was recycled into the economy by financing sustainable energy projects through the National Clean Energy Fund (NCEF), with a focus on tapping into India's massive solar energy potential as per the National Solar Mission. In fact, in 2016, the NCEF contributed the entire budgetary allocation of Rs. 50 billion to the Ministry of New and Renewable Energy (Chaturvedi, 2017). By reducing coal consumption and redistributing the tax revenue in sustainability projects, the CEC aimed at achieving double dividends, i.e. a simultaneous improvement in the environment and the economy.

However, successfully achieving the double dividends requires a careful balance between the revenue recycling effect and the tax interaction effect.[2] Till now, only British Columbia, Canada, has been able to claim the double dividends with an effective revenue recycling policy which has used tax cuts and rebates to reduce inefficiencies associated with a Pigouvian tax. On the contrary, India's decision to create the NCEF and promote renewable energy sources highlights its ambitious, yet risky, plan to invest in the future instead of reaping short-term benefits. Such a long-term strategy aligns with India's goal of achieving a net-zero target by 2070, but it questions India's ability to ensure economic welfare for the economically weaker

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[1] A Cess is a specific type of tax that is levied for a particular purpose. Unlike general taxes, which contribute to the overall revenue of the government, a Cess is earmarked for a specific fund or project.

[2] The Revenue Recycling Effect and Tax Interaction Effect have been explained in detail in section 2.

sections of the society, who are also the worst affected by climate change. Therefore, this research paper aims to delve deeper into assessing the CEC's impact, while addressing the essential question – Did the CEC achieve double dividends?

For this purpose, I have used the Prowess dataset which contains firm-level data on energy consumption, income, and expenses for Indian firms across various districts. Using a Two-Way Fixed Effects Difference-in-Differences (TWFE DID) framework, I assess the CEC's impact on two outcomes of interest – i) coal consumption (first dividend) and ii) net profits (second dividend) for heavy industry firms. Leveraging the fact that transportation cost for coal constitutes a major portion of the total supply chain cost for heavy industry firms, firms in coal mining states are considered the control group, and firms in non-mining states are the treatment group.[3] I find that the CEC resulted in a reduction in coal consumption levels and net profits in 2010. However, there's no evidence that the effect lasted in the subsequent years of the CEC's implementation.

The rest of the paper is structured as follows: Section 2 discusses the double dividend hypothesis in detail and existing literature on assessing CEC's impact on the double dividends, Section 3 reports the data and methodology used, Section 4 provides the results and a subsequent discussion of the results in context, and finally, Section 5 concludes the paper along with providing its implications.

[3] The methodology behind choosing the treatment and control groups has been explained in detail in section 3.

# 2. The Double Dividend Hypothesis

## 2.1 Double Dividends – Balancing Two Effects

The double dividend hypothesis states that an environmental tax can achieve two positive outcomes or "dividends" if it is implemented under the ideal policy framework. The first dividend is in the form of direct environmental benefits as a result of the tax such as reduced GHG emission levels or mitigated climate change. On the other hand, the second dividend focuses on improvement in economic welfare caused by effective redistribution of tax revenue. However, achieving double dividends through an environmental tax requires careful implementation, especially due to inherent inefficiencies associated with the Pigouvian Tax.[4] Moreover, even in cases where a tax is considered to have achieved double dividends, such as in the case of British Columbia, it is subject to many socio-political challenges which question the tax's viability in achieving its desired objectives.

To achieve double dividends, policy makers must find the right balance between two counteracting effects – i) revenue recycling effect and ii) tax interaction effect. An interaction of these effects determines the direction and magnitude of the dividends (Goulder, 2013). Fig. 1 shows a simple analysis of the benefits and costs of a Pigouvian Tax policy. Firstly, let's consider a situation with no taxes – in such a scenario, the marginal social cost ($MC_{SOC}$) will exceed the private marginal cost (MC) by the amount of marginal external cost or damage (MED). As a result, the marginal social cost from production would exceed the marginal benefit (MB) from the use of fossil fuels such as coal, thereby causing market distortions such that $Q_0$ amount of goods and services are produced in the economy. Now, to bring the economy back into a state of

[4] According to the Pigouvian Tax, to achieve the market equilibrium in the presence of environmental costs like GHG emissions, government interventions in the form of taxes which internalize the societal cost are a necessity. However, it is an inefficient tax since estimation of external costs can be challenging, leading to overcorrection or undercorrection of the externality.

equilibrium, with $Q_1$ amount of production, an environmental tax can be implemented to increase the private marginal cost (MC) and ensure that it equals the marginal social cost and the marginal benefit (MB) (Goulder, 2013).

Fig. 1: Simple Analysis of Benefits and Costs

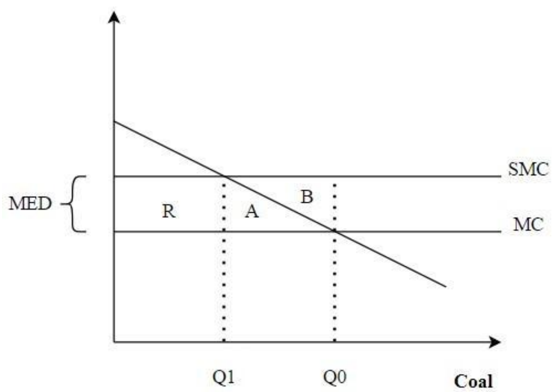
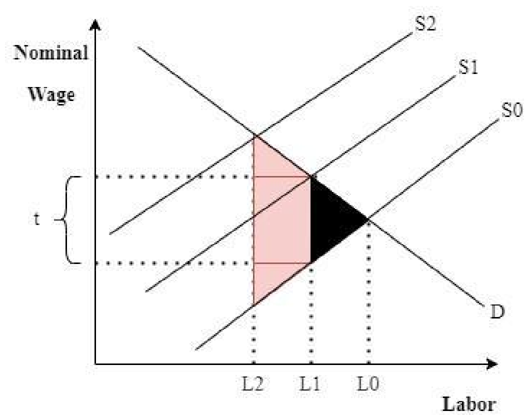



Fig. 1 also illustrates that at the new equilibrium point of $Q_1$ achieved under the Pigouvian principle, the economy experiences an environmental benefit in the form of A+B i.e., the avoided environmental damage. However, it also bears an additional cost in the form of reduced consumer surplus since, now, consumers will have to pay more for procuring the same quantity of coal – the reduction in consumer surplus is represented by the area A + R, where R is the tax revenue. In an effort to reduce this additional cost borne on the society, governments recycle the tax revenue (R) back into the economy by either following a tax revenue neutral or a non-tax revenue neutral policy. For example, one on one hand, where British Columbia implements a tax revenue neutral policy in the form of tax cuts and tax rebates, India uses a non-tax revenue neutral policy by reinvesting its tax revenue (R) in sustainability projects such as solar and wind power plants. Such a recycling process results in the revenue recycling effect, thereby reducing the total deadweight loss from A+R to A. This analysis implies that as a result of the revenue recycling effect, the tax's environmental benefit (A+B) exceeds the deadweight loss (A), and the net benefit of such a tax would be the area represented by B. In fact, some economists argue that effective revenue recycling which can finance cuts on existing taxes such as income or sales tax can reduce existing market distortions resulting from these taxes. Consequently, such an efficiency improvement would exceed the net benefit represented by B, implying that achieving double dividends is a simple consequence of any environmental tax policy which effectively recycles its tax revenue (Goulder, 2013).

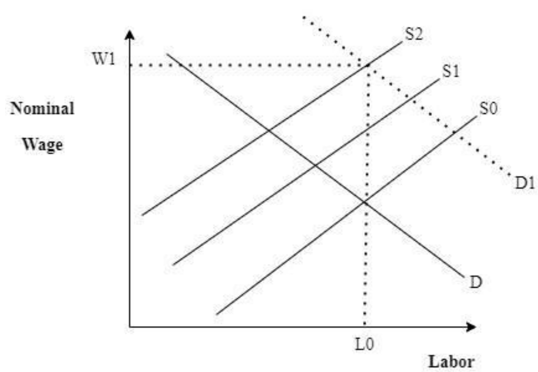
However, as indicated by existing literature, achieving double dividends isn't as easy as it is made to sound by the revenue recycling effect – due to the presence of a counteracting force, the tax interaction effect (Fig. 2). The tax interaction effect results from the fact that like any other tax, an environmental tax is also an implicit tax on factors of production. For instance, a coal tax is an implicit tax on labor since for a given nominal wage, an increase in the price of coal implies a reduction in real wage, which reduces labor supply and introduces an inefficient labor market. The inefficiencies are further magnified due to the presence of existing labor taxes such as income, payroll, and sales tax. As a result, as suggested by Fig. 2, the labor supply first reduces from $L_0$ to $L_1$ due to existing taxes, and the coal tax further reduces supply from $L_1$ to $L_2$, thereby increasing the inefficiency even further (Goulder, 2013).

Fig. 2: The Tax-Interaction Effect



In fact, unemployment as a direct result of an environmental tax policy is posed as one of the biggest threats by its opponents, especially in the Canadian province of Alberta. However, a forward-looking approach of redistributing tax revenue for the purpose of investing in sustainability projects, as adopted by India, can help overcome/offset the tax interaction effect through job creation, i.e. an increase in labor demand. Depending on the magnitude of increase in labor demand, the level of unemployment in the energy intensive industries decreases and nominal wage increases. For instance, Fig. 3 illustrates a hypothetical situation where the decrease in labor supply caused by the coal tax is exactly equal to the increase in labor demand created through investments in sustainability projects, thereby resulting in no change in employment levels and increasing nominal wage.[5] Taking note of the above analysis, this section has highlighted the underlying forces behind the creation of double dividends. Various studies have tried to assess and measure these dividends created by the CEC, and some of these frameworks have been mentioned in the following section.

Fig. 3: Increased Labor Demand from Sustainability Projects




[5] The paper doesn't focus on the impact of coal tax on labor demand/supply but rather its impact on firm-level coal consumption levels and profitability as measures for the double dividends.

**2.2 Literature Review**

Existing literature on India's CEC and its impact on the double dividends is sparse, and it's mostly restricted to non-empirical discussion of the history, mechanisms, and implications of the CEC. Among the empirical studies examining the double dividend hypothesis, most have concluded that the CEC wasn't successful in achieving its desired objectives since it contributed to a marginal reduction in carbon emissions and no improvement in economic welfare. For instance, Parry et al. (2017) and Pradhan and Ghosh (2022) analyze the impact of the CEC on the Indian economy by using spreadsheet modelling and recursive dynamic computable general equilibrium (CGE) model. Both these studies are dynamic analysis and show that carbon emissions reduced by $\leq 1\%$ with the CEC. These results align with Verma and Sivamani's (2022) findings from their comprehensive report on CEC. The report uses a hybrid energy input-output (EIO) framework to explore the CEC's impact on GHG emissions and GDP at the national and sectoral levels. Since this study focuses on providing sector-wise impacts of the CEC, it highlights the importance of studying the interlinkages between the various sectors and agents in the economy which were affected by the regulation, i.e. how does the change in one sector impact the other. This sectoral-level analysis is made possible by the EIO framework which explores the flow of goods, services, transactions, and emissions between sectors. Moreover, their study acts as an improvement over the previous I-O framework of Social Accounting Matrix (SAM) used by Groterra et al. (2015) by equally distributing the impact of the CEC across all coal consuming sectors.[6]

[6] While both SAMs and traditional I-O tables capture the interindustry transactions and relationships within an economy, SAMs provide a more comprehensive representation by including additional information on factors such as income distribution, savings, and taxes.

However, the hybrid EIO framework's robustness in modelling the impact of the CEC on double dividends is subject to concerns. Firstly, I-O makes assumptions on the Leontief Coefficients (technology coefficients) to represent the input-output relationships between different sectors. Changes induced by the CEC in technology adoption, production processes, or energy intensities may not be accurately captured by the assumed coefficients, potentially leading to biased results. Secondly, the CEC could influence energy intensities across sectors, i.e. the amount of energy required to produce a unit of output in each sector. If the I-O model assumes constant energy intensities and does not account for changes due to the policy, the results may be inaccurate. Thirdly, I-O models may struggle with capturing unobservable factors that can affect the relationship between sectors. These unobservables, such as changes in consumer preferences, technological innovations, or external shocks, may introduce biases into the model if not properly controlled for.

To overcome these issues, this research paper uses a Difference-in-Differences model (DID) to assess the double dividend hypothesis. DID models do not rely on assumptions about the underlying technology coefficients or input-output relationships. The DID approach focuses on estimating treatment effects by comparing changes over time between a treatment group (affected by the policy change) and a control group (not affected). This makes DID less sensitive to assumptions about the technical details of production processes. DID only relies on the assumption that, in the absence of treatment, the treatment and control groups would follow parallel trends. By focusing on the difference in trends before and after the treatment, DID mitigates the need to explicitly model or control for all unobservable factors. Moreover, the use of DID, in the context of CEC, has already been validated by Bhat and Mishra (2019) in their study of modelling the CEC's impact on R&D in energy efficient technologies. This paper aims to build on the work by Bhat and Mishra (2019) with a focus on change in coal consumption levels and net profitability for heavy industry firms in response to the CEC. The next section provides further details about the data and methodology used in this analysis.

## 3. Data and Methodology

### 3.1 Data Summary and Findings

The paper uses firms level data which has been obtained from the Prowess Data of the Centre for Monitoring of the Indian Economy (CMIE). The data set covers key performance indicators for over 40,000 firms, including firms listed on the National Stock Exchange (NSE) and the Bombay Stock Exchange (BSE) as well as several unlisted Public and Private Limited Companies. Moreover, it is a comprehensive panel data covering the years of 1989 – 2021 even though data after 2016 hasn't been accounted for by the study since the Cess was replaced with the Goods and Service Tax (GST) on July 1, 2017. The dataset includes firm-level data on energy consumption levels across various Indian districts. For instance, it covers data on coal, biomass, natural gas, solar energy, wind energy and various other forms of energy such as firewood, husk, and kerosene, which continue to be used in large quantities in rural India. Moreover, firms are distributed across a wide range of industries such as cement, steel, financial services, and more. However, the paper focuses on a smaller subset of heavy industries such as cement, steel, fertilizers, etc. since these industries are the most heavily reliant on coal and find it extremely difficult to decarbonize their supply chains due to various reasons. For instance, these industries involve process emissions of $CO_2$ and require very high sources of heat in their production stages. Economics factors such as a high dependency of the workforce on heavy industries, low profit margins, and capital intensity make the industry even more inflexible to the adoption of cleaner sources of energy (Gross, 2021). Therefore, any impact of a coal tax would be the most visible on coal consumption levels of heavy industries. Table 1 further strengthens the fact that coal is the major energy source for heavy industries by comparing coal consumption levels with those of biomass and renewable energy. In fact, it shows that coal consumption levels for heavy industries are about 100 times higher than renewable energy sources such as solar and wind energy.

Table 1: Comparison of Fuel Consumption

| Fuel Type | Consumption | Units |
|---|---|---|
| Coal | 261,666.5 (1,312,753) | Tonnes |
| Biomass | 176,525.5 (980,837.3) | Tonnes |
| Renewable (Solar + Wind) | 6,671, 563 (5,430,201) | kWh |

*Note: 1 tonne = 1000kg or 2,204.6 lbs. 1 tonne = 2,500 kWh. All values are mean consumption and standard errors are given in parenthesis. This implies that coal produces 654,166,250 kWh.*

**3.2 Identification Strategy**

Another important characteristic of heavy industry firms ("sinks") is their choice of location relative to the coal mines ("sources"). Firms are more likely to be located near coal mines to achieve supply chain efficiencies through reduced transportation and storage costs. For instance, some of the prominent coal mining districts in India such as Jharia, Dhanbad, and Bokaro are also important industrial hubs for steelmaking, cement, etc. In fact, transportation cost is the major cost in the coal supply chain due to various reasons. Firstly, domestic coal in India is characterized as low-grade bituminous coal which has a relatively low moisture content but a high ash content. For instance, ash content in domestically produced coal varies between 30%-50% as compared to the high grade imported coal which has an ash content of less than

15%. Since ash is a non-combustible material, low grade coal has a lower Gross Calorific Value (GCV), i.e. the amount of heat released by the complete combustion of a unit of natural gas. As a result, more tonnes of coal must be transported to produce the same unit of output as compared to high-grade coal with a lower ash content. This lower energy efficiency directly implies a higher transportation cost, with the cost depending on the distance between the sources and the sinks. Secondly, coal transportation in India is achieved through its extensive railway system which costs between Rs 700 – 1,000 / tonne for 200 – 1,000 km, thereby accounting for most of a firm's variable cost (Kalyanaraman, 2017).

Since coal transportation accounts for a significant portion of cost for heavy industry firms, it is rational for firms to locate their operations closer to the mines to gain a competitive advantage in supply chain efficiency. Such firms are also characterized by an inelastic demand and higher consumption levels for coal as compared to other sources of energy such as biomass, natural gas, and renewable energy as also shown by Table 1. Table 2 further illustrates this point by reporting the top 5 Indian states with the highest coal consumption levels and whether these states are considered coal mining states or not.[7] It can be inferred that each of the top 5 states are mining states, with Gujarat being the highest coal producer. This result isn't surprising since Gujarat has one of India's largest lignite reserves and is also home to a thriving cement industry.[8]

[7] A coal mining state is defined as one with a significant presence of coal mines.
[8] Lignite is a coal derivative. Gujarat is also home to several ports, thereby making it the major entry point of imported coal into India. However, this paper focuses on domestically produced low-grade coal.

Table 2: Top 5 States with highest Coal Consumption

| State | Mining State | Total Coal Consumption (tonnes) |
|---|---|---|
| Gujarat (n=195) | Yes | 186,370,665 |
| Maharashtra (n=468) | Yes | 142,043,054 |
| Telangana (n=331) | Yes | 92,575,901 |
| Tamil Nadu (n=163) | Yes | 37,541,704 |
| Haryana (n=69) | Yes | 35,212,846 |

*Note: Number of heavy industry firms in a state are given in paranthesis.*

Based on the above inference of an inelastic demand and higher coal consumption levels for firms located in mining states, the paper assumes that firms located in non-mining states (treatment group) are bound to be more sensitive to any changes in coal price caused by the coal tax. As a result, in response to the CEC, such firms' coal consumption levels will experience a larger decline as compared to firms located in mining states (control group). The choice of state as a determinant of treatment groups highlights an important limitation of the data set. The Prowess dataset doesn't provide district level data on the location of the firm's plant of operation and instead provides the registered office district. Since there could be a difference in location between a firm's registered office district and its plant district, the paper uses a broader measure of the state to determine a firm's proximity to coal mines.[9]

In addition to finding the CEC's impact on coal consumption, the paper also focuses on the economic welfare aspect of the tax, i.e. the second dividend. The Prowess dataset also includes a measure of each firm's income and expense characteristics which are leveraged to examine the second dividend in the form of Net Profits for each firm.[10] Furthermore, Table 3 provides a comparison of important firm characteristics across the treatment groups. It can be

[9] Plant location would have been preferred since it provides a more accurate estimate of distance between the coal mine and the firms' place of operation.
[10] Net Profit = Total Revenue – Total Expenses

inferred that control group firms which are located in mining states exhibit a higher magnitude of operational capacity (net fixed assets) and operational efficiency (net profits, sales, operating expenses, and taxes paid).

Table 3: Characteristics of firms by Treatment Group

| Characteristics (million $) | Control (1) | Treated (2) |
|---|---|---|
| Net Fixed Assets | 1.0913<br>(3.3887) | 1.0232<br>(4.0722) |
| Net Profit | 13.6375<br>(95.1970) | 3.6499<br>(42.8744) |
| Total Sales | 193.9537<br>(611.7591) | 145.0002<br>(373.0265) |
| Operating Expense | 160.4872<br>(456.5819) | 125.1312<br>(326.2107) |
| Indirect Tax | 20.5504<br>(65.5751) | 13.8290<br>(34.0773) |
| Direct Tax | 643.425<br>(4485.036) | 249.4523<br>(1217.369) |

*Note: All values are mean. Standard Error given in paranthesis.*

To examine how the outcomes of interest, i.e. coal consumption and net profits changed on average between 1990 and 2016, Table 4 provides the relevant summary statistics across the treatment groups. It can be inferred that average coal consumption increased and net profits decreased for both the treatment groups. The rise in average coal consumption was expected given the growing industrial sector and greater energy demands. However, mining state firms had a lower coal consumption level in 2016 as compared to non-mining state firms. This result could be influenced by multiple factors such as a growing industry farther away from the mines as a result of better transportation efficiency or technological improvements which allow the firms to reduce their energy demand. Similarly, the fall in net profits for both the groups could be caused by confounding factors such as economic downturns and changing government regulations.

Table 4: Summary Statistics for outcomes of interest by Treatment Group

| Treatment Group | Year | Coal Consumption (Tonnes) | Net Profit (million $) |
|---|---|---|---|
| Treated | 1990 | 45,917.55 | -2.1790 |
| | | (62,961.14) | (3.7169) |
| N = 1,149 | 2016 | 324,123.3 | -20.7964 |
| | | (1,316,693) | (124.1107) |
| | Difference | 278,205.8 | -18.6174 |
| Control | 1990 | 57,170.67 | 1.8799 |
| | | (69,702.75) | (4.7512) |
| N = 1,484 | 2016 | 287,455.3 | -0.0409 |
| | | (738,164.7) | (16.1435) |
| | Difference | 230,284.63 | -1.9208 |
| | Difference between groups | 47,921.17 | -16.6966 |

*Note: All values are mean of coal consumption and net profit. Standard error is given in paranthesis.*

### 3.3 Two-Way Fixed Effects Difference-in-Differences Model

To assess the CEC's impact on coal consumption and net profits pre and post the treatment period of 2010, the paper uses a Two-Way Fixed Effects Difference-in-Differences (TWFE DID) model. Using the treatment groups outlined in section 3.2, the following model is used (Eq. 1) -

$$y_{it} = \alpha_i + \gamma_i + \lambda_t + \beta^{DD} D_{it} + \Omega X_{it} + \varepsilon_i \qquad (1)$$

In this model, $y_{it}$ is the outcome of interest, $\alpha_i$ is the industry fixed effects, $\gamma_i$ is the district fixed effects, $\lambda_t$ is the year fixed effects, $D_{it}$ is a dummy variable equal to 1 if the firm is located in a mining state in year t, and $X_{it}$ is a vector of control variables. When $y_{it}$ is coal consumption, then the controls include direct tax payments and net fixed assets. On the other hand, when $y_{it}$ is net profits, then the controls include indirect tax payments and net fixed assets.[11] Lastly, the coefficient $\beta^{DD}$ is the post-treatment TWFE DID estimator for the effect of the CEC on the

[11] Measures of income, expense, and profitability are given on an annual basis.

outcome of interest $y_{it}$.[12] $\beta^{DD}$ is equal to the difference of conditional means of $y_{it}$ in the post-policy periods (2010 – 2016) and pre-policy periods (1990 – 2009) as given in Eq. 2.

$$\beta^{DD} = (\overline{y}_{1,\mathrm{Post}} - \overline{y}_{1,\mathrm{Pre}}) - (\overline{y}_{0,\mathrm{Post}} - \overline{y}_{0,\mathrm{Pre}}) \qquad (2)$$

Here, fixed effects for districts control for all unobservable, time invariant district-specific effects, and time dummies control for period-specific effects shared by all districts. The choice of including time fixed effects was particularly important in this paper since coal consumption and profitability has been affected by several economic, political, and social events during 1990 – 2016. For instance, during the 1990s, the Indian government announced its first environmental regulations called the Supreme Court Action Plans (SCAP) and Mandated Catalytic Converters with the aim of reducing carbon emissions. Similarly, The Great Recession (2007 – 2009) and the Coalgate scam negatively affected coal mining activities and industry profitability.[13] Also, data on district-specific industry control for the effects of industry type since even within the broader umbrella term of "heavy industries", certain industries like cement and steel are expected to be more reliant on coal as an essential input as compared to others such as the fertilizer industry.

Nonetheless, despite controlling for industry fixed effects, it is also important to note that within-industry firm differences can occur, which can possibly bias the estimates and cause the parallel trends assumption to fail. Therefore, in the case of measuring coal consumption levels, controls for direct tax payments and net fixed assets have been included. Direct tax payments control for firms' operational efficiency and net fixed assets control for the firms' operational capacity. The reason for choosing direct tax payments as a proxy for a firm's operational

[12] Outcomes of interest, $y_{it}$, have been log transformed due to the data's skewed nature.
[13] The "Coalgate" scam, officially known as the coal allocation scam, was a major political and financial scandal in India related to the allocation of coal blocks to private companies for captive use.

efficiency lay in the fact that direct taxes such as corporate tax are levied on a firm's profitability, implying that higher direct tax payments are indicative of higher profitability and therefore higher operational efficiency. Moreover, direct taxes are preferred as a proxy for operational efficiency over net profits, operating expenses, or indirect taxes since they ensure that there's no simultaneity relationship between the response variable (coal consumption) and the covariate. This is due to the fact that higher direct taxes, and therefore greater operational efficiency, might result in lesser coal consumption, but coal consumption levels don't directly influence the amount of direct tax payments, as taxes paid on the purchase of raw materials such as coal are a form of indirect tax payment. On the other hand, other performance indicators such as net profits and operating expenses introduce endogeneity through their simultaneity relationship with coal consumption. Similarly, for measuring the second dividend of net profits, the model includes controls for net fixed assets and indirect tax payments. Indirect tax payments control for operational efficiency without introducing endogeneity since they aren't directly levied on a firm's net profits. Also, Table 3 further strengthens the validity of these controls since distribution of controls varies across the treatment groups, highlighting the necessity to add these controls to satisfy the parallel trends assumption.

## 4. Results and Discussion

### 4.1 TWFE Results and Event Study

Table 5 reports the TWFE DID estimates for the impact of the CEC on coal consumption and net profits after its introduction in 2010. It includes a comparison of results under an unconditional model (columns 1 and 3) and conditional model (columns 2 and 4).[14] The results show a significant decrease in coal consumption for the unconditional and the conditional models. The unconditional model indicates that the tax resulted in a 36.9% decrease in coal

[14] The covariates included in each model have been reported in the previous section.

consumption for the treatment group relative to the control group in 2010.[15] Moreover, this result is statistically significant at a 5% significance level. Similarly, the conditional model indicates a significant 28.9% decrease in the treatment group relative to the control group.[16]

Table 5: Two-Way Fixed Effects DID

| | Coal Consumption | | Net Profit | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| TWFE Estimate | -0.46** (0.2094) | -0.34** (0.1927) | -0.64*** (0.2237) | -0.44** (0.1788) |
| N | 2,633 | 2,619 | 1,584 | 1,589 |
| Controls | No | Yes | No | Yes |

*Note: Standard Errors are given in paranthesis. Quantities for coal consumption and net profit have been log transformed. Columns (1) and (3) and unconditional models, and columns (2) and (4) are conditional models. * $p<0.10$, ** $p<0.05$, and *** $p<0.01$.*

Followingly, event study graphs for the unconditional and conditional models are presented by Fig. 4 to test for the parallel trends assumption. Since, for the unconditional model, the estimates aren't centered around 0, and I get a statistically significant result for 1996, it can be concluded that pre-treatment trends exist, thereby invalidating the causal effect of the tax on coal consumption. However, the event study graph for the conditional model shows that the estimates are smoothly centered around 0 with slight yet statistically insignificant deviations at the 5% significance level, thereby satisfying the parallel trends assumptions and providing evidence for a causal relationship.

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[15] Since the outcomes of interest have been log transformed, the estimates are interpreted as $e^{\beta DD}$.

[16] To interpret the coefficients in percentage term, they are interpreted as $(1 - e^{\beta DD}) * 100$

Fig. 4: Event Study Graphs for Coal Consumption

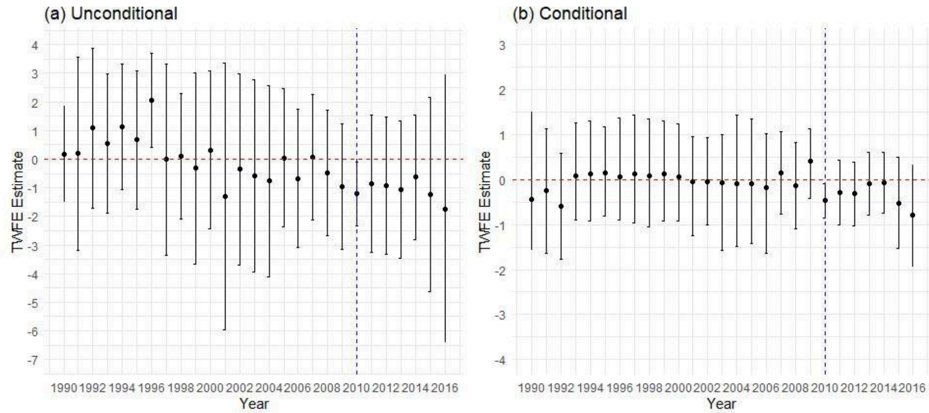
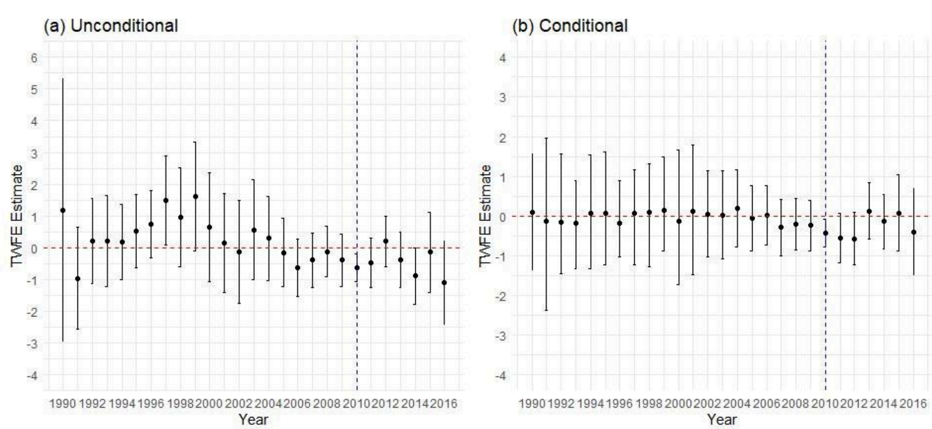



Table 5 also indicates a statistically significant result for a post-treatment decrease in net profits for the conditional as well as the unconditional model. In the unconditional model, the treatment group's net profits fall by 47.3% relative to the control group, and the fall reduces to 35.6% in the conditional model. However, just as in the case of measuring coal consumption levels, Fig. 5 shows that the parallel trends assumption gets violated in the unconditional model, but it is satisfied when the model controls for key covariates in the conditional model. Lastly, even though Fig. 4 and Fig. 5 indicate a significant effect of the tax on coal consumption and net profits in the year the CEC is introduced (2010), the results are found to be insignificant in the post-2010 period, thereby highlighting a decreasing impact of the CEC in reducing coal consumption.

Fig. 5: Event Study Graphs for Net Profits



**4.2 Discussion**

The paper finds that the CEC resulted in a short lived fall in coal consumption and net profits. The fall in coal consumption for firms in non-mining states as compared to those located in mining states indicates that the tax was successful in achieving its primary objective of reducing coal consumption among firms with an elastic demand. Moreover, it is intuitive to draw the conclusion that a fall in coal consumption further leads to a fall in carbon emissions since coal is the primary source of energy in India and has the highest carbon content among all fossil fuels. Nonetheless, the fall in coal consumption cannot directly be interpreted as the successful achievement of the first dividend, i.e. a reduction in carbon emissions. In fact, a reduction in coal consumption may have little to no impact on emissions due to the resulting substitution effect caused by the tax. In response to the higher coal prices, firms which are distant from coal mines and already face a high transportation cost, may find it more cost efficient to replace coal with cheaper yet unclean sources of energy. For example, natural gas and biomass, which are often considered cleaner sources of energy, can cause additional concerns such as methane leakage and deforestation, respectively. Therefore, such alternatives aren't suitable, especially in the long term, if India must achieve its aggressive goal of reducing emissions intensity of its GDP by 45% by 2030 from 2005 levels.

Moreover, an inability to measure firm-level carbon emission levels adds to the challenge of measuring the direct impact of CEC on carbon emissions. In response to this challenge of measuring the substitution effect, further studies must be conducted to explore if the CEC resulted in substitution towards renewable sources of energy, with a focus on solar energy, given India's abundant sunlight availability, especially in the states of Rajasthan, Gujarat, and Maharashtra. Assessing the impact of CEC on solar energy consumption levels is particularly relevant since the Indian government recycles the coal tax revenue through its National Clean Energy Fund (NCEF) to invest in sustainability projects.[17] In fact, during 2016, the hike in CEC rate from Rs 50 per tonne of carbon to Rs 400 per tonne of carbon allowed CEC to contribute towards the entire budgetary allocation for the Ministry of New and Renewable Energy with Rs 50 billion in 2016 (Chaturvedi, 2017). Additional initiatives such as R&D and greater subsidies through the NCEF also allow for improving India's ability to adapt to renewable energy sources and meet their high fixed costs.

On the other hand, the fall in net profits for the treatment firms indicates an inability of CEC to achieve the second dividend, i.e. higher economic welfare. This result isn't surprising given the fact that the highly coal reliant Indian firms couldn't find viable substitutes to coal in response to the tax, thereby increasing their indirect tax expenses and reducing their profitability. This result differs from British Columbia's textbook model for the coal tax which successfully achieved the second dividend of higher economic welfare by recycling the tax revenue in the form of tax cuts and rebates. However, India has implemented a revenue recycling scheme of investing in sustainability projects, which will reap benefits only in the long term through technology improvements and higher operational capacity.

## 5. Conclusion

The paper contributes to the existing literature on assessing India's CEC in context of the double dividend hypothesis. The analysis is performed using a TWFE DID framework to find the CEC's impact on coal consumption (first dividend) and net profits (second dividend) on heavy industry firms. Using firms in mining states as the control group and firms in non-mining states as the treatment group, the study finds that the CEC resulted in a fall in coal consumption levels

[17] Investments in sustainability projects through the NCEF generates the revenue recycling effect.

and net profits, thereby indicating that the CEC failed to achieve the double dividends of environmental and economic improvement. However, the parallel trends assumption while measuring both the outcomes of interest was satisfied only after controlling for important factors such as the firms' operational capacity and operational efficiency. Including these covariates ensured that the causal relationship between CEC and the double dividends was valid.

The paper's results align with results from previous studies which suggest that CEC was able to bring a marginal environmental improvement as emissions decreased by $\leq 1\%$ but no improvement in economic welfare. However, these studies, such as the one by Verma and Sivamani (2022) don't account for the differences between mining and non-mining states as a result of the high transportation cost associated with coal. The paper demonstrates that a firm's location relative to a coal mine is an important determinant of the coal tax's effectiveness. For instance, in 2010, firms in non-mining states experienced a 28.9% decrease in coal consumption relative to the mining state firms. This implies that implementing a differential tax system based on regional characteristics could be an effective strategy in improving the tax's effectiveness in reducing emissions and increasing tax revenue collection. However, such a policy may be considered unfair, especially if those regions heavily rely on the coal industry for employment and economic activity. Moreover, it may result in cross-border shopping in states with lower taxes, thereby resulting in economic distortions.

Lastly, the use of net profits for measuring the second dividend is also unique to this paper since other studies have focused on measuring this dividend through macroeconomic indicators such as GDP and GVA. The fall in net profits with the CEC's introduction isn't surprising since India is following a long-term strategy of recycling its tax revenue in sustainability projects instead of providing tax cuts and rebates. Such a strategy will improve

India’s economic efficiency in the future while also ensuring that it achieves its net-zero target by 2070.

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