Analysis of Carbon Pricing in India: Synthetic Control Method for Coal Cess and CCTS Design Assessment

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MASTER THESIS:

Analysis of Carbon Pricing in India: Synthetic Control Method for Coal Cess and CCTS Design Assessment

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Abstract

India is the third-largest greenhouse gas (GHG) emitters in the world while further economic growth is expected to drive an increase in energy demand. Balancing rising energy demand with energy security and affordability while simultaneously fostering economic growth and lifting people out of poverty presents a stark challenge to the country. Carbon pricing is a market-based mechanism to reduce GHG emissions cost-effectively, and India is among many countries that have deployed carbon pricing. India implemented the Clean Energy Cess in 2010 to finance and promote clean energy initiatives. It also introduced the Perform, Achieve and Trade (PAT) scheme to improve energy efficiency in energy-intensive sectors. Currently, the country is designing a domestic carbon market, known as the Carbon Credit Trading Scheme (CCTS). This study first gives an overview of these policies and utilizes the synthetic control method (SCM) to analyze the impact of the coal cess on CO_2 emissions. Furthermore, it examines the current development of CCTS. Through SCM analysis, this study provides implications that the increases in the tax rate of the coal cess might have an effect on CO_2 emissions while the results are not statistically significant. Furthermore, by examining the current CCTS development, this study identifies key elements such as emissions targets, penalties and institutional structures.

Keywords

Clean Energy Cess; Clean Environment Cess; GST Compensation Cess; Perform, Achieve and Trade (PAT); Carbon Credit Trading Scheme (CCTS); synthetic control method (SCM); carbon pricing; coal tax; emissions trading system (ETS)

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List of acronyms

ATT	Average treatment effect on the treated
BEE	Bureau of Energy Efficiency
CCC	Carbon Credit Certificate
CCTS	Carbon Credit Trading Scheme
CEEW	Council on Energy, Environment and Water
CH_4	Methane
CO_2	Carbon Dioxide
DC	Designated Consumer
DiD	Difference-in-differences
DISCOM	Distribution Company
EDGAR	Emissions Database for Global Atmospheric Research
ESCert	Energy Saving Certificate
ETS	Emissions Trading System
EU	European Union
GDP	Gross Domestic Product
GEI	Greenhouse gas Emission Intensity
GenAI	Generative Artificial Intelligence
GHG	Greenhouse Gas
GST	Goods and Service Tax
GW	Gigawatt
ICAP	International Carbon Action Partnership
IEA	International Energy Agency
IMG	Inter-Ministerial Group
INR	Indian Rupee
IPCC	Intergovernmental Panel on Climate Change
KRW	Korean Won
kWh	Kilo Watt Hours
MoP	Ministry of Power
MoEFCC	Ministry of Environment, Forest and Climate Change
MRV	Monitoring, Reporting and Verification
MSPE	Mean Squared Prediction Error
Mtoe	Million Tonne of Oil Equivalent
NAPCC	National Action Plan on Climate Change
NCEEF	National Clean Energy and Environment Fund
NDCs	Nationally Determined Contributions
NMEEE	National Mission for Enhanced Energy Efficiency
NSC-ICM	National Steering Committee for Indian Carbon Market
N_2O	Nitrous Oxide
PAT	Perform, Achieve and Trade
PFC	Perfluorocarbon
PPA	Power purchase agreement
REC	Renewable Energy Certificate
RGGI	Regional Greenhouse Gas Initiative
SCM	Synthetic Control Method
SCC	Social Cost of Carbon
SEC	Specific Energy Consumption
tCO_2	Tonne CO_2
tCO_2e	Tonne CO_2 -equivalent
TJ	Terajoule

1 Introduction

1.1 Problem description

To achieve the global goal of limiting temperature rise to less than 2.0 degrees Celsius while pursuing efforts to 1.5 degrees as set in the Paris Agreement, the world needs to accelerate its efforts to reduce greenhouse gas (GHG) emissions. In 2022, China, the United States and India were identified as the top three GHG emitters (Crippa et al., 2024). Among them, India is expected to undergo further population growth and economic growth, which will lead to further increase in energy consumption. As a result, India is projected to become the second largest emitter around the world by 2050 (Deb & Kohli, 2022).

Despite being a leading GHG emitter, India is also expected to face negative impacts from climate change. Social cost of carbon (SCC) is an indicator to estimate economic damage caused by one additional tonne of carbon emissions, and it is highest for India at $86 per tonne CO_2 (Ricke et al., 2018). Among the negative impacts India is expected to confront, temperature rise is one of the top concerns. The temperature in India is calculated to increase by 4.4°C from the average between 1976 and 2005 by 2100 in the high-emission scenario (RCP8.5 scenario), and heat stress associated with the temperature rise is also expected to be amplified. Change in rainfall patterns, droughts, sea level rise are also major challenges India will face (Krishnan et al., 2020). To counter these negative impacts, India aims to achieve net-zero emissions by 2070. Furthermore, the country's Nationally Determined Contributions (NDCs) include goals of reducing emissions intensity of its GDP by 45% by 2030 relative to 2005 levels and increasing renewable energy capacity by 2030 (Government of India, 2022). Achieving these goals necessitates the use of multiple policy tools that are well-designed to be aligned with the goals.

Carbon pricing is seen as an effective policy instrument using market mechanisms to reduce carbon emissions. The major two instruments are carbon tax and emissions trading system (ETS). India has also used some market mechanisms to address negative environmental impacts. The first example is the tax originally called the Clean Energy Cess and later renamed the Clean Environment Cess. It has levied a cess on coal production and imported coal since 2010. However, in 2017 the Goods and Service Tax (GST) was introduced, and the Clean Environment Cess was subsumed under the GST. Under this new tax scheme, the cess was renamed as the GST Compensation Cess (Gerasimchuk, Whitley, et al., 2018).

Another policy using market mechanisms is the Perform, Achieve and Trade (PAT) scheme. The PAT scheme was implemented to reduce energy consumption in energy-intensive sectors. Specific energy-intensive industries, such as aluminum, fertilizer, and iron & steel, are identified as Designated Consumers (DCs), and DCs are obliged to report energy consumption and conduct energy audits regularly. The Bureau of Energy Efficiency (BEE), a governmental agency under the Ministry of Power, sets energy saving standards. When DCs exceed the energy saving standards, they are allowed to trade their excess saving by issuing Energy Savings Certificates (ESCerts) on the market, and other DCs which fail to meet the standard are able to buy ESCerts from the market (Bureau of Energy Efficiency, n.d.-b).

In addition to these policies, another notable policy initiative is taking place in India. Amid India's challenge of reducing GHG emissions, it passed legislation to set up a carbon crediting system called the Carbon Credit Trading Scheme (CCTS) (World Bank, 2023). This policy development is a positive move toward curbing GHG emissions.

To further accelerate India's emission reduction efforts, it is crucial to effectively design and employ carbon pricing. The coal cess should have ideally led to a decrease in coal production, there has been no thorough analysis of the causal effect of the coal cess on CO_2 emissions. Thus, this paper first examines the features and roles of India's existing policies that utilize market mechanisms. Then it will analyze the impact of the coal cess on CO_2 emissions. Lastly this paper explores the current design of the CCTS and key elements for an effective CCTS to drive emissions reductions.

1.2 Objective

This research aims to help accelerate GHG emission reductions in India by analyzing existing policy measures that utilize market mechanisms and by exploring the current development and key design elements of the CCTS.

1.3 Research questions

Given the objective of this research, the main research question is formulated as: *What are the effects of carbon pricing on GHG emission reductions in India in the past, present and future?*

To address this main research question, the following sub-research questions are formulated:

1. *How have India's climate policies, using market mechanisms, been implemented and what is their future prospect?*
2. *What is the effect of the Clean Energy (Environment) Cess and the following GST Compensation Cess on CO_2 emissions?*
3. *What characteristics will be key in the design of an effective CCTS to drive emissions reductions?*

1.4 Methodology

The first sub-research question is conducted by literature review. India's existing climate policies using market mechanisms include the Clean Energy (Environment) Cess and the PAT scheme. Furthermore, India has been developing the CCTS. The features of those policies will be elaborated through literature review to answer the first sub-research question.

The second sub-research question on how the Clean Energy (Environment) Cess and the GST Compensation Cess had an impact on CO_2 emissions will be addressed using the synthetic control method (SCM). The SCM, proposed by Abadie et al. (2010) and Abadie & Gardeazabal (2003), is a statistical analysis tool for causal inference. In the SCM, the subject of interest serves as the treatment group, and the control group is constructed using other groups to closely resemble the treatment group based on certain characteristics. This research aims to analyze the effect of the Clean Energy (Environment) Cess and the GST Compensation Cess using SCM to assess their effectiveness. Synthetic India will be created as close to India as possible by using data from other countries. Then the policy effect on emissions will be analyzed. Further details will be provided in the methodology section.

The last sub-research question will be addressed by examining official documents and other relevant papers. Literature reviews will be conducted to explore past and present success stories and challenges that different countries have encountered when implementing ETS. This knowledge will be extended to analyze the implementation of carbon pricing in India.

1.5 Outline of report

The structure of this thesis is as follows: Chapter 2 provides a comprehensive view on topics regarding India's carbon pricing. It provides a detailed picture of India's energy situations leading to GHG emissions. Chapter 3 discusses detailed methodologies taken to conduct the analyses. It includes details in steps and datasets for the SCM analysis. Chapter 4 answers the first sub-research question by providing thorough descriptions of India's policies that utilize market mechanisms. Chapter 5 shows the results from the SCM analysis to assess the impact of the coal cess on CO_2 emissions. Chapter 6 is on the analysis of the CCTS development. Chapter 7 discusses key findings from the analyses, limitations of the research, and further research, followed by conclusions in Chapter 8.

2 Thematic background

2.1 Carbon pricing

General idea

Carbon pricing is often hailed as an effective climate policy to reduce emissions. By providing a price signal, it uses market mechanisms that help governments and businesses invest in cleaner alternatives and shift away from fossil fuel dependance. Many countries, regions, and cities have introduced carbon pricing. In 2024, 75 carbon pricing policies are in operation, spanning from the European Union (EU) and Canada to Chile, South Africa and Taiwan, and those in operation cover 24% of GHG emissions around the world (World Bank, 2024). Each country applies carbon pricing differently in their policy design. Explicit carbon pricing puts a price on GHG emissions. On the other hand, implicit carbon pricing does not directly impose a price on emissions but provides a price signal through policies such as fossil fuel taxes and removal of subsidies for fossil fuels (Hingne et al., 2023). However, the major instruments deployed by countries are two explicit carbon pricing: carbon tax and emissions trading system (ETS). Carbon credits have also started to gain momentum in the face of challenges arising from climate change. A later section describes each instrument further in detail.

From an economic perspective, carbon pricing offers two key characteristics. First, carbon pricing helps incorporate external costs into decision-making (Aldy & Stavins, 2012). Climate change is sometimes referred to as the biggest market failure (Rathi, 2023). Negative environmental effects such as GHG emissions have frequently been ignored and not incorporated into decision-making as a cost. This issue called externalities has often led to businesses taking advantage of cheaper fossil-based electricity to produce their products in the sacrifice of negative environmental impacts. Carbon pricing internalizes those externalities in a cost-effective way; therefore, it is expected that decisions will be made by factoring in those external costs. Another attribute carbon pricing holds is a concept called the double dividend. Not only can carbon pricing help reduce emissions by internalizing negative externalities, but it also generates revenues. Since revenues can be used for various purposes, such as deploying renewable energy and reducing other taxes, they can either accelerate climate measures or help mitigate negative economic impacts.

Carbon tax

One of the major instruments is carbon tax that puts a price on carbon by setting a tax rate on GHG emissions (World Bank, n.d.-a). Due to the existence of carbon tax, fuel suppliers are expected to pass the new cost onto downstream players, incentivizing switching fuels to cleaner alternatives and investing in cleaner technologies, thereby leading to reducing GHG emissions (Aldy & Stavins, 2012). To effectively reduce emissions, the price should be put on the same level as the social cost of carbon (SCC) (Aldy & Stavins, 2012). According to the analysis of the World Bank (2024), it is estimated that the price on carbon should be at between \$63 and \$127 per tonne of CO_2e to achieve the goal of limiting temperature rise to well below 2°C; however, carbon tax rates deployed in many countries are significantly lower than the proposed price level. While Uruguay has the highest rate of carbon tax (\$167.17/tCO_2e), followed by Switzerland and Liechtenstein (\$132.12), countries like Argentina (\$0.81), Japan (\$1.90) and Estonia (\$2.14) have the lowest carbon tax rates (World Bank, n.d.-b). Carbon tax has its advantage in administrative ease over ETS, allowing governments to utilize their existing taxation schemes (Aldy & Stavins, 2012). Another attribute comes from its certainty of prices, as governments set the tax rate at a certain emission level, expected revenues are relatively easy to predict while a level of emissions is hard to estimate beforehand (Green, 2021).

Emissions trading system

In the ETS, on the other hand, a government sets a cap on the maximum level of emissions. Emitting companies must obtain a permit for each unit of their emissions from the government or through trading with other companies. Companies that expect not to have enough permits must either cut their emissions or buy permits from another company (World Bank, n.d.-a). Launched in 2005, the EU-ETS is one of the longest and largest carbon markets in operation. Its coverage accounts for 40% of the EU's

GHG emissions including electricity, heat generation and manufacturing sectors. The cap decreases every year to make sure emissions decrease. Permits are sold in auctions and can be traded under the EU-ETS, and countries are obliged to report every year (European Commission, n.d.-b). ETSs also exist at national and subnational levels such as the Indonesia ETS, the Regional Greenhouse Gas Initiative (RGGI) by a few states in the US, and Tokyo's cap and trade program. In contrast with carbon tax, ETS can be a complex system. Governments need to set an emission cap and decide whether to distribute permits for free or set a price through auctions. This might be a challenge for some countries with limited institutional capacity (Parry et al., 2022). However, governments can collect revenue from auctions just like from a carbon tax (Aldy & Stavins, 2012). Another contrast is that while an ETS provides certainty in emission levels, prices can be volatile (Green, 2021).

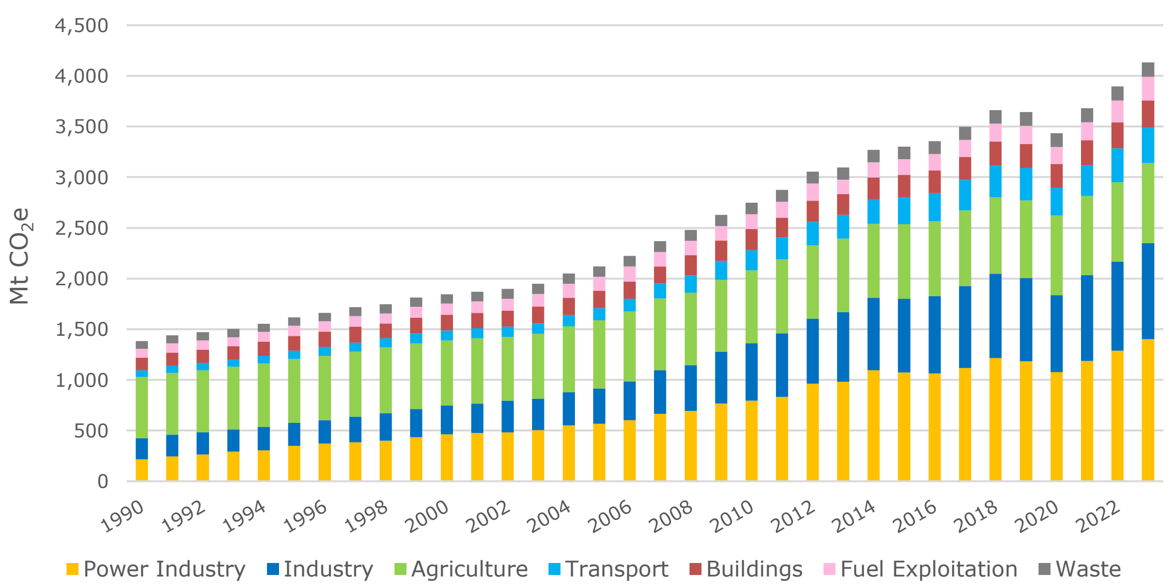
2.2 India's emissions and energy system

Emissions in India

According to data from the European Commission's emission inventory, the Emissions Database for Global Atmospheric Research (EDGAR), India's GHG emissions in 2023 are 4,134 Mt CO_2e, making up 7.8% of the world's GHG emissions for the year. These emissions have tripled since 1990. The country's emissions are the third largest around the world, following China (15,944 Mt CO_2e) and the US (5,961 Mt CO_2e), each country representing 30.1% and 11.3% in the global GHG emissions in 2023 respectively. While the absolute level of emissions is significant, India's GHG emissions per capita (2.9 t CO_2e) are considerably lower than those of major economies. Examining the contributions by type of GHG, India's emissions are composed of CO_2 (71.5%), CH_4 (20.3%), N_2O (6.5%) and fluorinated gases (1.7%). Furthermore, emissions data by sector provides additional insight into the country's emissions. Figure 2-1 illustrates the historical trend of India's emissions by sector.

Figure 2-1

Trends in GHG Emissions by Sector (1990–2023)



Note. Data retrieved from *GHG emissions of all world countries*, published in 2024 by the Emissions Database for Global Atmospheric Research (EDGAR). Available at https://publications.jrc.ec.europa.eu/repository/handle/JRC138862.

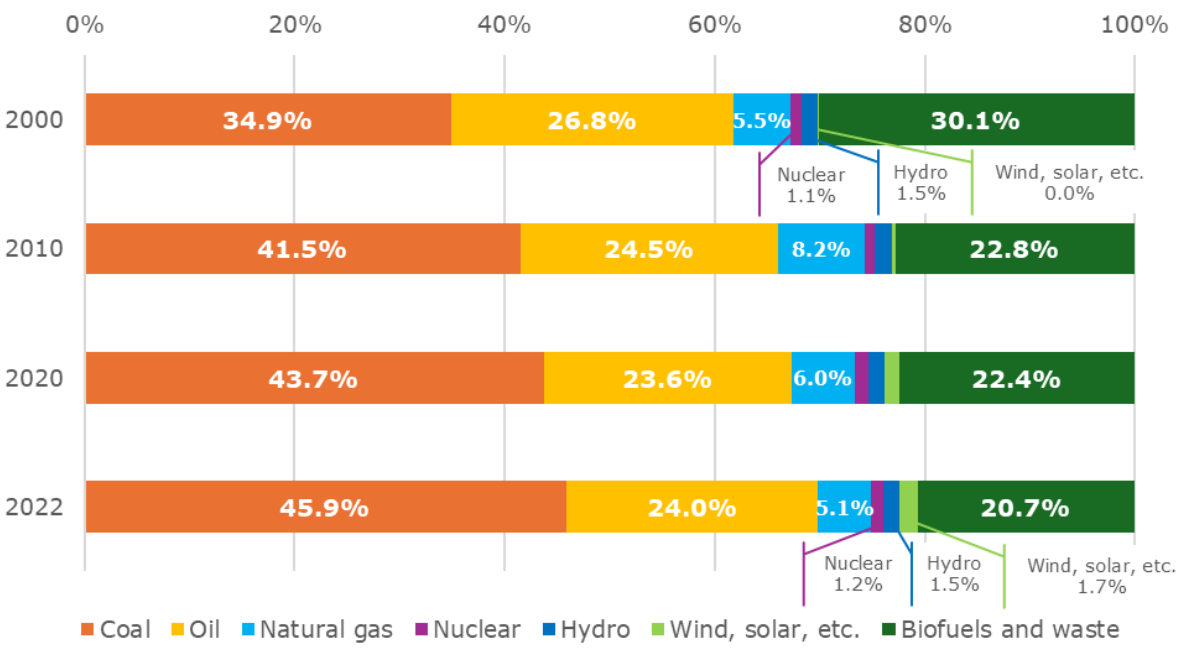
The power industry[1] sector is responsible for the largest emissions, totaling 1,401 Mt CO_2e, which accounts for 34% of its total GHG emissions in 2023, followed by the industry[1] (948 Mt CO_2e) and agriculture[1] (791 Mt CO_2e) sectors. The power industry sector emitted more than six times the amount of emissions compared to the level in 1990. When considering only CO_2, the power industry sector accounts for 47% of the country's total CO_2 emissions. The industry sector also contributes nearly 30% of these emissions. Additionally, the agricultural sector is responsible for nearly 70% of the country's methane emissions (Crippa et al., 2024).

Energy system in India

As shown in the previous section, the power sector is highly responsible for India's emissions. To provide further background on the emissions data, this section examines India's energy system. According to data from the International Energy Agency (n.d.), in 2022, the total energy supply[2] in India was 42,515,035 TJ, and the energy mix is shown in Figure 2-2. Coal holds the largest share in 2022, representing 45.9%, followed by oil (24.0%) and biofuels and waste (20.7%). The share of coal has increased by more than 10 percentage points since 2000.

Figure 2-2

Trends in Shares of Total Energy Supply



Note. Data retrieved from *Energy system in India* by the International Energy Agency (IEA). Available at https://www.iea.org/countries/india.

[1] Crippa et al. (2024) explains sectors as "Power industry includes power and heat generation plants (public and auto-producers)," "[Industry] includes combustion for industrial manufacturing and industrial process emissions" and "Agriculture includes agriculture livestock (enteric fermentation, manure management), agriculture soils (fertilisers, lime application, rice cultivation, direct soil emissions, indirect N_2O emissions from agriculture), field burning of agricultural residues."

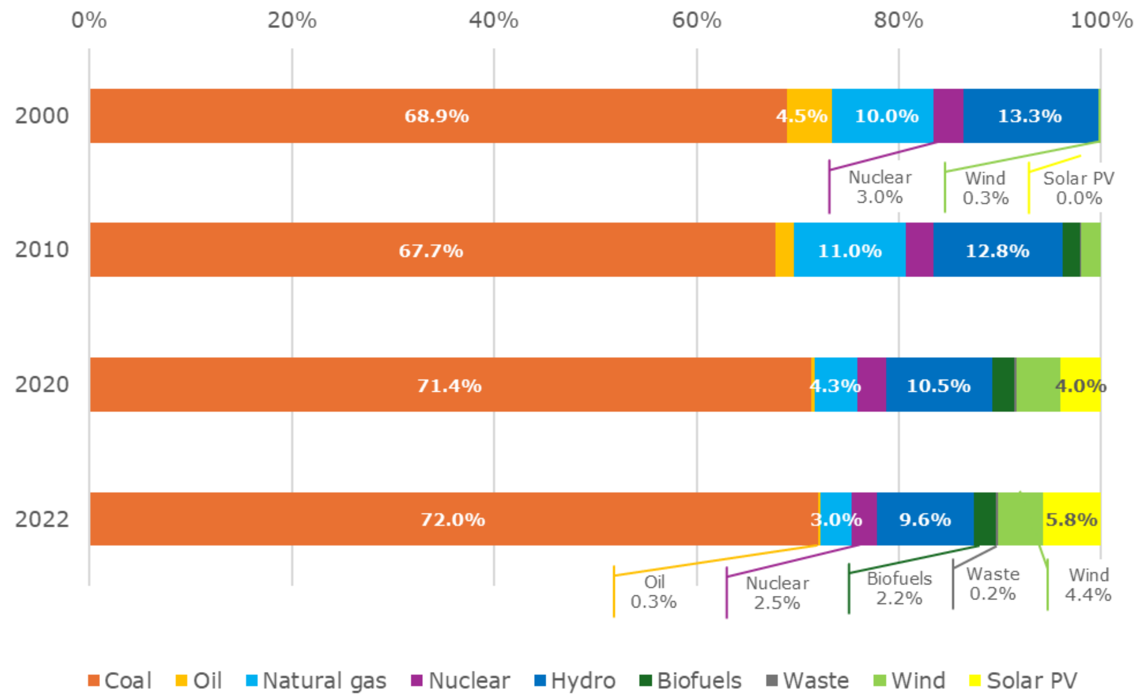
[2] According to the definition of the International Energy Agency (n.d.), total energy supply "includes all the energy produced in or imported to a country, minus that which is exported or stored."

Of all the total energy supply, India supports itself by producing 64% of its total energy supply domestically. Coal also plays a crucial role in its domestic energy production, making up 52.4% of its domestic energy production. As the demand for energy grows in India, it has increased energy imports from abroad. In 2022, nearly 42% of India's total energy supply is covered by imports. This share has grown significantly since 2000, when the share of imports only accounted for about 24% of its total energy supply. Oil holds the largest share in imports while it imports a notable amount of coal (top import counterparts include Australia and Indonesia) as well as gas (International Energy Agency, n.d.; NITI Aayog, n.d.).

To further examine the impact of the power sector, the energy mix of power generation is shown in Figure 2-3. While renewable energy such as wind and solar has increased in the past 20 years, coal has maintained the largest share of the country's electricity generation by a significant margin. Furthermore, sector-wise electricity consumption data reveals that the industry sector accounts for 42.2% of the electricity consumption while the residential and agricultural/forestry sectors make up 25.9% and 17.2% respectively.

Figure 2-3

Trends in Shares of Electricity Generation Source



Note. Data retrieved from *Energy system in India* by the International Energy Agency (IEA). Available at

https://www.iea.org/countries/india.

As shown above, coal has a predominant role in India's energy system, particularly in electricity generation. As India's economy grows, its energy demand is expected to rise substantially. The demand for electricity increased 7% in 2023, and its annual growth until 2026 is expected to be over 6% (International Energy Agency, 2024b). To meet the growing demand, India is anticipated to keep turning to coal. In 2023, India's demand growth for coal (+105 million tonnes) offset the EU's demand decline (-103 million tonnes) (International Energy Agency, 2024a). While renewable energy is growing rapidly, it cannot support the country's overall energy demand, leading to continuous reliance on coal. Additionally, despite being the second largest coal importer, India aims to reduce imports, and in 2020, Prime Minister Narendra Modi announced the goal of self-reliant India by 2047.

In contrast, the country also tries to accelerate renewable energy. International Energy Agency (2024c) expects that India's renewable energy market has been and continues to be the fastest growing. It also analyzed, on the other hand, that weak financial performance of distribution companies (DISCOMs) and slow expansion of solar photovoltaics manufacturing can hinder further acceleration of renewable energy capacity (International Energy Agency, 2024c). In terms of installed capacity, India is already well on track to achieving its climate goals. One of India's nationally determined contributions (NDCs) is "to achieve about 50 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030" (Government of India, 2022). Out of the total installed capacity of 451GW as of 31st August 2024, while 48.3% (218GW) came from coal, non-fossil fuel-based sources made up 46.1% with solar and wind accounting for 19.84% (89GW) and 10.47% (47GW) respectively (NITI Aayog, n.d.). India aims to increase its renewable capacity to 500GW by 2030 from the current level of 191GW in 2023 (International Trade Administration, 2024; NITI Aayog, n.d.).

3 Methodology

3.1 Sub research question 1

The first sub-research question will be addressed by reviewing governmental documents, bills and existing literature on India's carbon pricing policies, namely the Clean Energy (Environment) Cess and the Perform, Achieve and Trade (PAT) scheme. The fundamentals of these policies will be elaborated upon, along with some criticisms of them. Furthermore, the dynamics of the power market are both very important and highly relevant to these policies; therefore, they are also discussed in this section.

3.2 Sub research question 2

The second sub-research question on how the past Clean Energy (Environment) Cess and the GST Compensation Cess have had an impact on CO_2 emissions will be addressed using the synthetic control method (SCM). The SCM, proposed by Abadie et al. (2010) and Abadie & Gardeazabal (2003), is a statistical analysis tool for causal inference and demonstrates value in the absence of untreated control groups. In the SCM, the subject of interest serves as the treatment group, and the control group is constructed using other groups to closely resemble the treatment group based on certain characteristics. To analyze the causal effects of a certain policy, one can use another statistical method called difference-in-differences (DiD). However, DiD requires an assumption of a strict parallel trend assumption. Besides, DiD assigns equal weights to all the control subjects, which can lead to creating a less optimal synthetic group. Furthermore, it is often difficult to find a counterpart that functions as a counterfactual with a similar characteristic. In this regard, the SCM offers advantages over DiD as it allows us to create a better representative with the consideration of varied weights in the donor pool as well as covariates with differentiated weights (Abadie et al., 2010).

The SCM has been widely applied in various fields. Abadie et al. (2010) analyzed California's tobacco control program by creating synthetic California with differentiated state weights and showed that the policy led to tobacco consumption reduction. Bohn et al. (2014) analyzed Arizona's unauthorized immigration policy where a few states received varied weights to create synthetic Arizona, and Kleven et al. (2013) explored the effect of taxation on migration of football players using the SCM. In the context of carbon pricing, existing research has already used the SCM to analyze the effects of carbon tax on emissions, focusing on countries and regions such as Sweden and British Columbia (Andersson, 2019; Arcila & Baker, 2022; Pretis, 2022). Andersson (2019) found a significant effect of carbon tax on CO_2 emission reduction. The author used OECD countries to create synthetic Sweden, where Denmark received the highest weight (0.384), and other countries included Belgium and New Zealand. Moreover, GDP per capita and number of vehicles were selected as variables in the analysis, alongside several other variables. Pretis (2022) and Arcila & Baker (2022) both worked on the effect of carbon tax on emissions in British Columbia. Both attributed certain weights to provinces in Canada aside from British Columbia. Pretis (2022) showed that the carbon tax is only marginally effective in reducing emissions in the province. Arcila & Baker (2022), on the other hand, found that CO_2 emissions and fossil fuel consumption have risen in British Columbia after the tax implementation. These existing studies demonstrate the value of SCM in analyzing the effect of carbon tax on GHG emission reductions.

While there has been a wide range of SCM application in the field of carbon pricing, there has been no application in India's context to the best of my knowledge. Thus, this research aims to analyze the effect of the Clean Energy (Environment) Cess and the GST Compensation Cess using SCM to give an overview of the policy's effectiveness. Synthetic India will be constructed to closely resemble India by using data from countries that rely on coal in their energy mix and have available data but lack policy instruments such as a coal tax, carbon tax, or ETS that could reduce coal production or consumption. Then the effect on emissions reductions will be analyzed. The steps involved in the analysis will be outlined in the following sections.

3.2.1 Data requirements

Treatment: Implementation of coal cess in India in July 2010

Coal cess has been renamed a few times: The Clean Energy Cess (2010–2016), The Clean Environment Cess (2016–2017), The GST Compensation Cess (2017–).

Treatment group: India

Control group:

Bangladesh	Belarus	Brazil	China	Egypt	Hong Kong
Indonesia	Iran	Israel	Japan	Malaysia	Morocco
Pakistan	Peru	Philippines	Russia	South Africa	Taiwan
Thailand	Türkiye	United States	Uzbekistan	Vietnam	

To the best of my knowledge, those countries in the control group rely on coal in their energy mix and have available data but lack policy instruments such as a coal tax, carbon tax, or ETS that could reduce coal production or consumption. Note that Japan implemented carbon tax in 2012, but the tax rate was very low, and some regions in the United States and China implemented emissions trading systems but not on a national level, thus those countries were included in the control group.

Timeline: 2000–2018 (Pre-treatment: 2000-2009; Post-treatment: 2011-2018)

Some data is only available from 2000. Additionally, emissions level after 2020 may have been impacted by COVID-19, and one of the countries in the donor pool, South Africa, introduced a carbon tax in 2019.

Outcome variable:

Variable	Source
Indexed annual CO_2 emissions from coal (2000 = 100)	Annual CO_2 emissions from coal by Our World in Data

Covariates:

Variable	Source
Indexed population (2000 = 100)	World Economic Outlook (October 2024) by the International Monetary Fund
Indexed GDP (2000 = 100)	World Economic Outlook (October 2024) by the International Monetary Fund
Indexed coal consumption (2000 = 100)	Statistical Review of World Energy 2024 by the Energy Institute
Indexed annual CO_2 emissions from coal (2000 = 100)	Annual CO_2 emissions from coal by Our World in Data

The outcome variable and covariates were prepared on a country-wise basis for the years from 2000 to 2018. Those covariates were selected based on the Kaya Identity identified by Kaya & Yokobori (1997), as shown below:

$$CO_2\ emissions = Population \times \frac{GDP}{Population} \times \frac{Energy\ consumption}{GDP} \times \frac{CO_2\ emissions}{Energy\ consumption}$$

The components of the Kaya identity, namely population, gross domestic product (GDP) and energy consumption, were used; however, energy consumption was replaced with coal consumption as this study focuses on coal. Furthermore, due to the variation in the scale of the data across countries, I used an index for the variables, setting it to 100 for the year 2000, to enable direct comparisons between countries.

3.2.2 Procedure to determine the weights of countries in the donor pool

The first step in conducting the SCM is to determine the weights given to countries in the donor pool. Based on Abadie (2021) and Abadie et al. (2015), this step will be conducted in the following way:

A) Obtain data from $J+1$ countries, $j = 1, 2, \ldots, J+1$, where $j = 1$ is the treatment group (India) and from $j = 2$ to $j = J + 1$ are the countries in the donor pool.
B) Obtain the data for the time periods $t = 1, 2, \ldots, T$. Since there is a point of intervention, the pre-treatment period will be denoted as T_0, and the post-treatment period will be expressed as T_1. Thus, $T = T_0 + T_1$.
C) The synthetic control group can be denoted in a $(J \times 1)$ vector of weights $W = \left(w_2, \ldots, w_{J+1}\right)'$, where $0 \leq w_j \leq 1$ and $w_2 + \cdots + w_{J+1} = 1$ for $j = 2, \ldots, J$.
D) To select W to create the synthetic control group as close as possible to the treatment group, other notations are introduced. X_1 is a $(k \times 1)$ vector consisting of covariates representing the treatment group during the pre-treatment period. X_0 is a $(k \times J)$ matrix showing the value of the covariates (k) for different units in the donor pool (J). Then the difference between the treatment and control groups during the pre-treatment period will be denoted as a vector $X_1 - X_0 W$. We can select the optimal weights, W^*, by minimizing the difference of the equation. When we define X_{1m} as m-th covariate for the treated and X_{0m} as m-th covariate for the donor pool, W^* will be the value of W that minimizes the following equation:

$$\sum_{m=1}^{k} v_m (X_{1m} - X_{0m} W)^2$$

Minimizing the above can be done using constrained quadratic optimization. v is the weight given to the covariate relative to the importance of creating the synthetic group as close to the treatment group as possible.

3.2.3 Procedure to construct synthetic India

A) When $\boldsymbol{V} = (v_1, \ldots, v_k)$ and $\boldsymbol{W}(\boldsymbol{V}) = \left(w_2(\boldsymbol{V}), \ldots, w_{J+1}(\boldsymbol{V})\right)'$, V can be selected to let $W(V)$ minimize the mean squared prediction error (MSPE). By computing from the pre-treatment period data, $\widetilde{w_2}(\boldsymbol{V}), \ldots, \widetilde{w_{J+1}}(\boldsymbol{V})$ will be the synthetic control weights. The MSPE can be calculated as following and V^* that will minimize the MSPE will be selected:

$$\sum_{t=1}^{T_0} \left(Y_{1t} - \widetilde{w_2}(\boldsymbol{V}) Y_{2t} - \cdots - \widetilde{w_{J+1}}(\boldsymbol{V}) Y_{J+1t}\right)^2$$

B) Finding the optimal w and v will lead to estimating the Average Treatment Effect on the Treated (ATT). The treatment effect on period t will be denoted as $\tau_1 = Y_{1t}^I - Y_{1t}^N$. This will be the indicator for the causal effect of the coal cess on CO2 emission reductions.

3.2.4 Robustness check

To assess the robustness of the results, I will conduct an in-place placebo test, an in-time placebo test, and a leave-one-out test. An in-place placebo test involves iteratively giving treatment to a country in the control group, meaning that the treatment is randomly assigned to each country that did not receive it in reality. This allows for the calculation of the p-value, which helps determine if the average treatment effect on the treated (ATT) is statistically significant. The ratio of post-MSPE to pre-MSPE is calculated to evaluate the impact of the intervention (Yan & Chen, 2023).

An in-time placebo test is used to assign a fake implementation year, shifting the actual implementation year to another year in the pre-treatment period. In this study, the actual policy implementation took place in 2010; however, the year was shifted to 2005. As a result, the treatment was given for the years 2006–2010, a period when it was not actually implemented. If the treatment effect during this period

(2006–2010) turns out to be significant, it raises uncertainty about the actual treatment effect (Yan & Chen, 2023).

In a leave-one-out test, each country is removed from the control group, and the SCM is run iteratively. This allows to assess whether the removal of a country impacts the main result. If any iteration of removing one country shows no substantial change from the main result, it suggests that the estimate of the treatment effect is robust and not driven by any particular country (Yan & Chen, 2023).

3.3 Sub research question 3

The last sub-research question will be addressed qualitatively, aiming to identify how India has approached the design of its carbon credit trading scheme (CCTS) and to examine key elements the country needs to address to effectively operationalize the CCTS. The International Carbon Action Partnership (ICAP) published a document *Emissions Trading in Practice: A Handbook on Design and Implementation* in 2021. It outlines 10 steps for designing and implementing an emissions trading system. The 10 steps provided in the ICAP document are:

- Step 1: Prepare
- Step 2: Engage stakeholders, communicate, and build capacity
- Step 3: Decide the scope
- Step 4: Set the cap
- Step 5: Distribute allowances
- Step 6: Promote a well-functioning market
- Step 7: Ensure compliance and oversight
- Step 8: Consider the use of offsets
- Step 9: Consider linking
- Step 10: Implement, evaluate, and improve

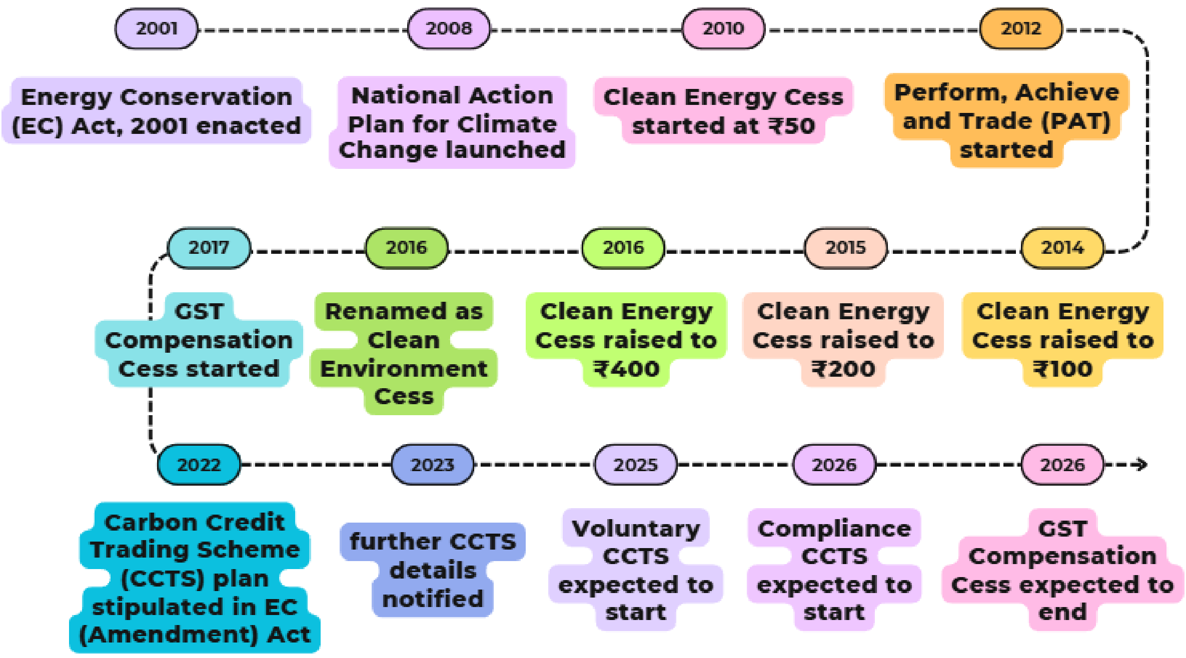
To examine India’s approach to developing the CCTS, I will investigate its progress and potential future developments at each step. The holistic steps provided in the ICAP document offer a comprehensive framework for analyzing India’s challenges and identifying the necessary actions and components for moving forward.

4 Results – India's carbon pricing (Research question 1)

This chapter elaborates on existing policies which utilize market mechanisms to tackle climate change, namely the Clean Energy (Environment) Cess, Perform, Achieve and Trade (PAT) scheme and the Carbon Credit Trading Scheme (CCTS). Figure 4-1 illustrates the major events over the years related to those policies.

Figure 4-1

Timeline of Climate Policies that Use Market Mechanisms in India



4.1 Coal cess

Clean Energy (Environment) Cess

India has not been an exception in adopting market mechanisms to tackle negative environmental impacts. The first example is the tax originally called the Clean Energy Cess and later renamed as the Clean Environment Cess. The Government of India has levied a cess on coal production and imported coal since 2010 under Section 83, Chapter VII of the Finance Act, 2010. The Clean Energy Cess was aimed at "financing and promoting clean energy initiatives, funding research in the area of clean energy or for any other purpose relating thereto" (The Finance Act, 2010, 2010). While excise taxes have been levied on other fossil fuels such as petrol and diesel, those are not intended to mitigate climate change but instead to generate general revenues for the government (Ojha et al., 2020). The Clean Energy Cess Rules, 2010 stipulate that the cess is applicable to the whole of India, and raw coal, raw lignite and raw peat are subject to the cess (Government of India, 2010). The Rules also mandate that coal, lignite and peat producers register with central excise authorities and assess the cess payable by themselves. The Cess will be payable at the time of removal of those products from a mine. Additionally, any violation of tax liability is subject to a maximum penalty of 10,000 rupees (Government of India, 2010). Under India's taxation system, the government imposes a cess to generate funds for a particular purpose (Comptroller and Auditor General of India, 2017). The Clean Energy Cess was levied at a rate of INR 50

($0.57[3]) per tonne of coal at the onset of the cess in 2010. The tax rate was raised to INR 100 ($1.14) in July 2014, then to INR 200 ($2.29) in March 2015, and finally reached INR 400 ($4.57) in March 2016.

National Clean Energy and Environment Fund

Revenues collected from the Clean Energy Cess are not distributed to states. Instead, the National Clean Energy and Environment Fund (NCEEF), which was initially named the National Clean Energy Fund, was founded to earmark the revenue from the cess. An Inter-Ministerial Group (IMG) was formed to make a decision on approval of projects financed under the NCEEF. The Finance Secretary was appointed as the chair, with the Expenditure Secretary and the Revenue Secretary as members. The IMG also comprised representatives from the Ministries of Power, Coal, Environment and Forests, New and Renewable Energy, Petroleum and Natural Gas, and Chemicals and Fertilizers (International Forum for Environment, Sustainability & Technology, 2024).

Despite its objective, the NCEEF has met with a variety of criticism across different phases of its implementation. The first criticism comes from its use of revenues from the Clean Energy (Environment) Cess. From the fiscal year 2010 to 2017, during the implementation of the Clean Energy (Environment) Cess, INR 654,307 million was collected (Controller General of Accounts, Department of Expenditure, Ministry of Finance, 2024). However, of the total cess collected, only 45% (INR 296,453 million) was transferred to the NCEEF. Furthermore, even out of the amount transferred to NCEEF, only about 50% was ultimately used to fund projects, meaning that only 24% of the total cess was utilized for its original objective (Department of Expenditure, Ministry of Finance, 2017). Additionally, while the NCEEF's initial objective was to promote clean energy and indeed a significant portion of the cess was directed to finance renewable energy technologies, some projects are targeted at more widely environmental related projects such as restoration of hazardous waste and clean Ganga River or the conservation of ecosystems (Department of Expenditure, Ministry of Finance, 2017). This led to the renaming of the Clean Energy Fund to the Clean Energy and Environment Fund. Additionally, the funding for some projects is considered as an extension of supporting budgetary purposes rather than promoting innovative clean energy technologies. Another critique comes from its operation. To finance projects from the NCEEF, a relevant ministry reviews a project first, followed by a review from the Ministry of Finance, and finally by the IMG, which consists of bureaucrats. While research and development of innovative technologies require long-term financial support and involve high risks, decision-makers in the funding process typically prefer low risk. Moreover, there is a clause stating that the NCEEF can fund a maximum of 40% of a certain project. However, this percentage is arbitrary, and in some cases, it funds projects with more than 40% of the total cost. Lastly, one of the biggest flaws lies in the absence of a proper monitoring system, which leads to issues with accountability and transparency. A proper monitoring and evaluation scheme, one that would have tracked and reviewed projects, should have been established to ensure the fund was more effectively allocated to promote clean energy technologies (Panda & Jena, 2012).

GST Compensation Cess

In 2017, the Goods and Service Tax (GST) was introduced to streamline existing indirect taxes levied on goods and services, with the aim of ultimately increasing economic efficiency. Under this new tax system, the GST Compensation Cess was introduced to help states fill their budget deficits caused by the introduction of the GST. The Clean Environment Cess was subsumed under the GST, and the NCEEF was abolished accordingly. However, coal production remained subject to the GST Compensation Cess, with the tax rate maintained at the same rate of INR 400 per tonne, the same rate as the Clean Energy (Environment) Cess (Gerasimchuk, Whitley, et al., 2018). Initially, a five-year transition period was set up for the Compensation Cess until 2022 (The Goods and Services Tax (Compensation to States) Act, 2017, 2017). Later in 2022 it was extended until March 2026, with a final decision that no further

[3] When converting INR into USD, USD 1 = INR 87.50 was used. Exchange rate at the end of February 2025 retrieved from *Foreign Exchange Rates* by the Board of Governors of the Federal Reserve System (Board of Governors of the Federal Reserve System, 2025).

extensions will be made (Goods and Services Tax (Period of Levy and Collection of Cess) Rules, 2022, 2022).

It is worth noting that the Inter-Ministerial Committee, which included representatives from multiple ministries, such as the Ministry of Coal, as well as Coal India Limited, the largest coal producer in India, highlighted a flaw in the cess in its report. Since the inception of the Clean Energy Cess until the GST Compensation Cess, the levy on coal production has been based on weight irrespective of its quality, currently set at INR 400 per tonne. As imported coal often has a higher gross calorific value (GCV) of 5000–6000 kcal/kg compared to domestic coal (3000–3500 kcal/kg), imported coal tends to be subject to a lower cess in terms of quality. Thus, the Inter-Ministerial Committee argued that the cess should be priced on an ad-valorem basis. India is now the second-largest coal importer, despite being the second-largest coal producer, due to factors such as the low value of domestic coal and difficulties in developing new coal mines (Ministry of Coal, 2024).

4.2 Perform, Achieve and Trade (PAT)

Perform, Achieve and Trade (PAT) is another policy instrument using a market mechanism. Acknowledging the adverse effects of climate change on the country's natural resources and the livelihoods of its people, and recognizing the need for adaptation, the Government of India launched the National Action Plan on Climate Change (NAPCC) in 2008. It aimed to achieve sustainable development by allowing economic growth while also reducing the environmental impacts of climate change. It outlined eight core missions such as the National Solar Mission and National Mission on Sustainable Habitat. PAT was launched as part of the National Mission for Enhanced Energy Efficiency (NMEEE), one of the core missions. PAT was implemented to "enhance cost effectiveness of improvements in energy efficiency in energy-intensive large industries and facilities, through certification of energy savings that could be traded" (Government of India, 2008). This scheme leverages market forces to improve energy efficiency in a cost-effective manner.

The Energy Conservation Act, 2001 defines designated consumers as those specified by the central government based on the intensity or quantity of energy consumption. The Act delegates the right to establish "energy consumption norms and standards for designated consumers" to the central government (The Energy Conservation Act, 2001, 2001). In the PAT scheme, specific energy-intensive industries in selected sectors are identified as Designated Consumers (DCs). These DCs are obliged to appoint an energy manager, report their energy consumption, and conduct energy audits regularly (Bureau of Energy Efficiency, n.d.-b).

To measure energy efficiency improvements, a specific energy consumption (SEC) reduction target is determined for each individual plant, considering "the trend of energy consumption and energy-savings potential of the plants" (Ministry of Power, 2012). SEC is calculated by dividing the net energy input, such as electricity, coal and natural gas by the total quantity of output within the plant's boundary (Bureau of Energy Efficiency, n.d.-b). Alternatively, for the thermal power sector, the SEC is determined using heat rates, which are calculated based on the amount of energy (kcal) consumed to produce 1 kWh of electricity (Yadav et al., 2021). The Bureau of Energy Efficiency (BEE), a governmental agency established by the Energy Conservation Act, 2001, under the Ministry of Power (MoP), sets energy saving targets through the PAT scheme. The PAT scheme runs in cycles, with DCs given three years to achieve their energy saving target. To calculate the targets that DCs must meet, a certain baseline year is used, and DCs are required to improve energy efficiency to achieve the designated target by the target year. Once DCs achieve the target in a cycle, they are not included in the next cycle. Only those who fail to achieve the target are selected as DCs again in the next cycle. Additionally, DCs have to appoint an energy auditor from the list created by the BEE, and the auditor will certify the actual energy saving reported by DCs (Ministry of Power, 2012).

A key feature of the PAT scheme that makes it a market-based policy is the issuance of Energy Saving Certificates (ESCerts). This certification allows DCs to sell or buy their energy saving excess or shortage.

ESCerts are issued by the BEE, with each certificate equivalent to one tonne of oil equivalent of energy saved by a DC (Ministry of Power, 2012). ESCerts are traded in two exchanges: Indian Energy Exchange and Power Exchange of India. The Central Electricity Regulatory Commission serves as the market regulator for ESCert trading. DCs are allowed to trade their excess saving on the market when they exceed the energy saving standards. However, if they fail to meet the standard, they need to buy ESCerts from the market (Bureau of Energy Efficiency, n.d.-b). If DCs fail to comply with the saving standards or purchase certificates, they are subject to a financial penalty of up to INR 1 million. Additionally, in the case of continuous noncompliance, DCs will incur an additional daily charge of INR 10,000 (Bhandari & Shrimali, 2018).

In 2012, the MoP notified the PAT rules as well as the targets for each DC in the eight sectors. Cycle I started in 2012 and ran between FY2012–13 and FY2014–15. 478 industrial units are selected as DCs from eight sectors. Those sectors are aluminum, cement, chlor-alkali, fertilizer, iron and steel, pulp and paper, textile, and thermal power plant. The goal for reducing total energy consumption among DCs was 4.05%, which is equivalent to 6.69 million tonnes of oil equivalent (Mtoe). According to BEE's analysis after the cycle, Cycle I achieved a reduction of 8.67 Mtoe, surpassing the goal. Furthermore, 306 DCs achieved the targets, and 3.83 million ESCerts were issued. Subsequently, Cycle II ran between FY2016–17 and FY 2018–19. To deepen and widen the scope, the BEE added a refinery, railway and distribution companies (DISCOMs) sectors. This cycle resulted in energy savings of 14.08 Mtoe. From Cycle III onwards, new DCs and targets are notified annually. Cycle IV added two new sectors of petrochemical and buildings. The Ministry announced the most recent notification of Cycle VIII in 2023 (Bureau of Energy Efficiency, n.d.-b).

However, the PAT scheme has faced some criticism concerning its effectiveness. The main critique is that the targets set for the DCs are not strict enough to induce energy efficiency improvement measures among DCs, and major improvement is due to increased energy costs instead of the PAT scheme. Additionally, they point out the lack of clear rules and long-term goals in the scheme. Moreover, the penalties are set too low for the DCs to give enough compliance motivation (Bhandari & Shrimali, 2018; Sahoo et al., 2017).

Among the sectors covered in the PAT scheme, the thermal power plant sector is one of the participants. It holds the largest share of DCs and was assigned the biggest target during the early years of PAT implementation. In the first cycle, the reduction target for the sector was 3.211 Mtoe while the reduction achieved was 3.06 Mtoe. However, this is partly due to the delay of monitoring and verification in a certain number of DCs as 13 DCs among 144 DCs had not completed MRV. If only DCs that had conducted MRV were considered, the thermal power plant sector exceeded its target by 19%. This suggests that the BEE was not strict about the MRV process and that the target was too lenient for the sector (Yadav et al., 2021). Yadav et al. (2021) also denounce that the target for the sector was too lenient meanwhile the sector underperformed to achieve the target compared to other covered sectors. They argue that the reduction achieved by the sector during the first cycle was only 1.57% of the total emissions from the country's electricity generation, which is very marginal.

4.3 Carbon credit trading scheme

Building on the experience of the PAT scheme, India is further developing its carbon market. As the country faces the need to accelerate GHG emission reductions, it has passed legislation to set up a carbon crediting system (World Bank, 2023). In 2022, an amendment to the Energy Conservation Act was passed into law in India. The Act was originally established in 2001 aimed at reducing energy intensity in India (International Energy Agency, 2023). The 2022 amendments include the expansion of issuers and buyers of ESCerts (Malhotra & Aggarwal, 2022). A key decision made in the amendment bill is the creation of the Carbon Credit Trading Scheme (CCTS). India has also started to work on creating institutional and regulatory frameworks for the scheme. Alongside this compliance mechanism, the country is also working on offset mechanisms (International Carbon Action Partnership, 2024). Furthermore, the BEE has proposed a phased introduction, starting with a voluntary market and culminating in a mandatory system (International Carbon Action Partnership, 2022). Chapter 6 will elaborate on the development and design of the CCTS, particularly focusing on the CCTS compliance mechanism.

4.4 Power market dynamics in India

In the final section of this chapter, it is worth noting that India's power market is highly regulated, which influences the original intent of policies targeting at reducing GHG emissions. India's energy policies are driven by multiple objectives including energy security, independence, and affordability (Gerasimchuk, Beaton, et al., 2018). Considering the country's rapid economic growth and soaring energy demand, it is crucial for the country to secure stable and affordable electricity domestically. This has led to some practices in the power market in India, which could influence the effectiveness of some climate policies.

A key example is long-term power purchase agreements (PPAs) between electricity generators and DISCOMs. In India, DISCOMs typically sign long-term PPAs with electricity generators, often spanning 20 to 25 years (Montrone et al., 2021). Since DISCOMs are obliged to fulfil the contract, and power generators cannot adjust prices in response to policies affecting the cost of power generation, the tax levied on coal is unlikely to be passed through. Unless the PPA is flexible enough to reflect the impact of the cess, this could place financial strain on power generators (Garg, 2016). Meanwhile, for DISCOMs, it may prevent them from purchasing renewable energy even if it is cheaper than coal-sourced electricity (Srivastava & Shah, 2021)

Additionally, DISCOMs receive substantial subsidies from state governments. Ensuring energy security and affordability is crucial for India's development. To achieve this, state governments provide subsidies at varying rates based on consumption categories, enabling DISCOMs to distribute electricity at lower prices. These subsidies primarily benefit agricultural or residential consumers, ensuring stable and affordable energy access (Aggarwal et al., 2020; Mishra, 2019). It has been observed that DISCOMs do not set prices based on the cost of electricity supply. In the context of the cess levied on coal production, this also prevents cost pass-through. Even if the cost of supply rises due to the cess, DISCOMs are unable to transfer the increased costs to consumers, further exacerbating their financial situation (Aggarwal et al., 2020; Mishra, 2019).

Those could work as a hinderance to policies which aim to increase renewable energy or use market mechanisms to reduce GHG emissions in India.

5 Results – Impact of the coal cess on emissions (Research question 2)

5.1 Setup to create synthetic India

To examine whether the Clean Energy (Environment) Cess had an impact on reducing CO_2 emissions from coal, I used the synthetic control method (SCM). First, countries were selected to construct synthetic India that closely resembles the actual India. The selection criteria was the absence of market-based policies such as carbon tax, emissions trading system, or fuel tax. Furthermore, those countries rely on coal in their energy mix, and data availability was another key factor. Second, since the outcome variable in this SCM is CO_2 emissions from coal, variables that effectively predict the outcome variable were selected. The Kaya identity is an equation formulated by Kaya & Yokobori (1997), and it is used in Intergovernmental Panel on Climate Change (IPCC) reports. The formula is given below:

$$CO_2\ emissions = Population \times \frac{GDP}{Population} \times \frac{Energy\ consumption}{GDP} \times \frac{CO_2\ emissions}{Energy\ consumption}$$

The components of CO_2 emissions in Kaya identity, namely population, gross domestic product (GDP) and energy consumption, were used. However, energy consumption was replaced with coal consumption since this study focuses on coal. Since the levels of these variables vary significantly depending on the size of the countries in the control group, the first year of the study's timeframe, 2000, was chosen as the base year, and the variables were recalculated as indices. These indexed variables were then averaged over the pre-treatment period from 2000 to 2009. In addition to these components, the outcome variable, CO_2 emissions from coal, was also indexed and used to construct synthetic India. However, rather than taking the average before the treatment, lagged CO_2 emissions from coal were selected from specific years, 2002, 2004, 2006 and 2008 with the aim of creating synthetic India as close as possible to the real India while minimizing the risk of overfitting.

5.2 Weight selection

To assess the impact of the cess, weights for covariates and for countries in the control group were first determined. I used the R package, *tidysynth*, which allows for determining weights for both the control group and the variables, thereby enabling me to construct a synthetic control group. To create the best possible synthetic India, I first calculated the pre-treatment mean squared prediction error (MSPE) for each combination of variables. The MSPE represents the gap between the actual value for India's outcome variable and the values predicted by the synthetic model. Since a smaller gap between India and synthetic India indicates a better fit, the combination of variables that realized the smallest MSPE was selected. As Table 5-1 below shows, using lagged CO_2 emissions from coal and GDP will create the best possible synthetic India with an MSPE of 1.06. This means that data for population and coal consumption were excluded when creating synthetic India.

Table 5-1

MSPE for Each Covariate Combination

No.	Covariate (indexed)	MSPE
1	Emissions from coal (2002/2004/2006/2008)	2.85
2	+ population	5.64
3	+ GDP	1.06
4	+ coal consumption	16.75
5	+ population + GDP	5.43
6	+ population + coal consumption	7.16
7	+ GDP + coal consumption	1.54
8	+ population + GDP + coal consumption	37.97

Using the selected variables, CO_2 emissions from coal and GDP, their weights were determined as Table 5-2 shows. CO_2 emissions from coal in 2002 received the highest weight (47.0%), followed by the same metric for 2004 (26.7%) and 2006 (24.7%) while CO_2 emissions from coal in 2008 and GDP were assigned very small weights.

Table 5-2

Weights for Each Covariate

No.	Variable	Weight
1	emissions from coal index 2002	47.00 %
2	emissions from coal index 2004	26.70 %
3	emissions from coal index 2006	24.70 %
4	emissions from coal index 2008	0.98 %
5	GDP index	0.56 %

Furthermore, Table 5-3 shows the weights assigned to each country in the control group. Bangladesh was given the highest weight (29%) to construct synthetic India, and China (18%), Belarus (12%), and Russia (6%) follow.

Table 5-3

Weights for Each Country in the Control Group

No.	Country	Weight	No.	Country	Weight
1	Bangladesh	29 %	13	Taiwan	2 %
2	China	18 %	14	Brazil	2 %
3	Belarus	12 %	15	Egypt	2 %
4	Russia	6 %	16	South Africa	2 %
5	Uzbekistan	3 %	17	Vietnam	2 %
6	Iran	3 %	18	Hong Kong	2 %
7	Thailand	3 %	19	Peru	1 %
8	Philippines	2 %	20	Türkiye	1 %
9	United States	2 %	21	Pakistan	1 %
10	Israel	2 %	22	Malaysia	0 %
11	Japan	2 %	23	Indonesia	0 %
12	Morocco	2 %			

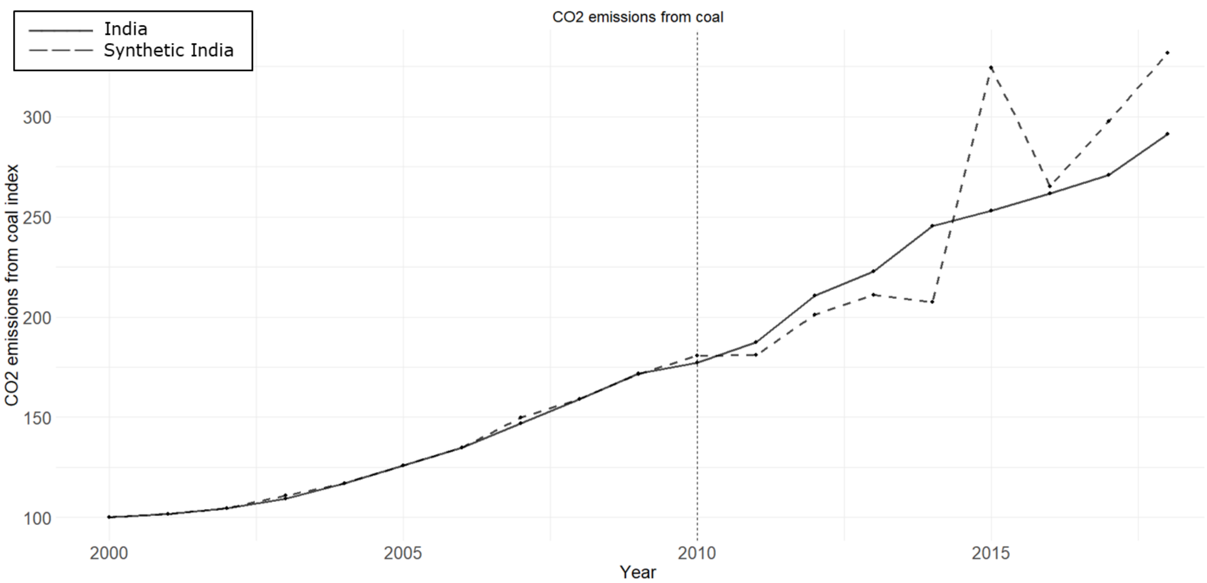
5.3 Results

5.3.1 Main result

Figure 5-1 shows the result of the synthetic control method. Since synthetic India was created to match the emission trajectory as close as possible to India before the intervention, the trajectories of India and synthetic India are very similar before 2010. After the implementation of the Clean Energy Cess in 2010, India's CO_2 emissions are higher than that of synthetic India. Then, synthetic India showed a significant hike in emissions in 2015 and reversed the trajectories of the two groups. While the emissions from synthetic India declined sharply in 2016, it continued to exceed that of India. The emissions hike and decline observed between 2015 and 2016 are attributable to data of the actual emissions from Bangladesh, which received the highest weight in the control group. As it appears that the data from Bangladesh highly influences the outcome of this analysis, this effect will be further discussed in the later section.

Figure 5-1

CO_2 Emissions Trajectories for India and Synthetic India



To estimate the impact of the Clean Energy (Environment) Cess, the average treatment effect on the treated (ATT) is also calculated. As shown in Table 5-4, the ATT is -9.55, indicating that India's emissions index (India's emissions in 2000 are set to an index value of 100) is 9.55 points lower than that of synthetic India after the treatment until 2018. Figure 5-2 illustrates the gap between India's actual values and those of synthetic India.

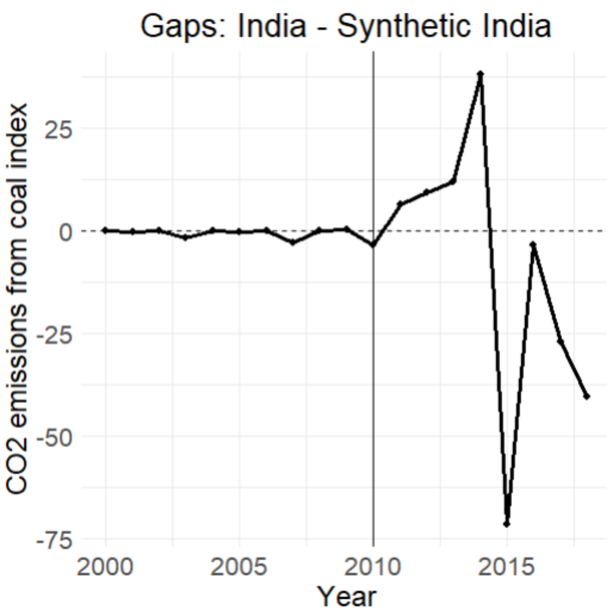
Table 5-4

Post-Treatment Estimates for India and Synthetic India

Year	India	Synthetic India	Treatment effect
	CO2 emissions from coal index	CO2 emissions from coal index	CO2 emissions from coal index
	a	b	c = a - b
2011	187.50	181.00	6.50
2012	210.60	201.10	9.50
2013	222.80	210.93	11.87
2014	245.60	207.37	38.23
2015	253.00	324.53	-71.53
2016	261.70	265.15	-3.45
2017	270.80	297.83	-27.03
2018	291.20	331.72	-40.52
Total			-76.43
ATT			**-9.55**

Figure 5-2

Gap Between India and Synthetic India

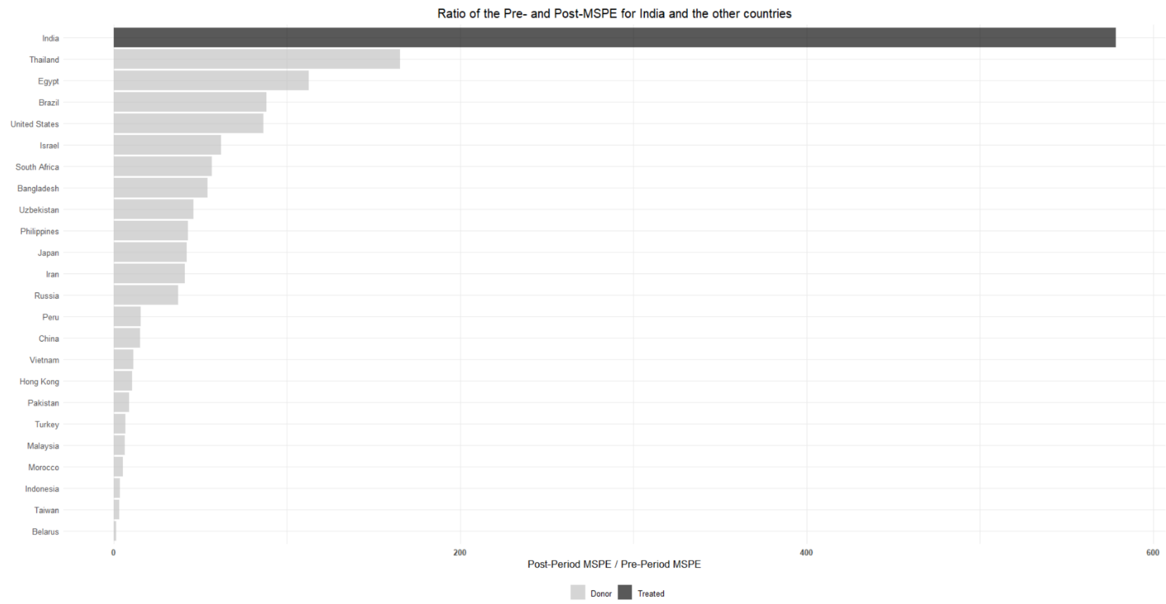


5.3.2 In-place placebo

To assess the significance of this result, an in-place placebo test was conducted. This test iteratively assigns the treatment to a country in the control group, meaning that the treatment is randomly assigned to each country that did not receive it in reality. This allows for the calculation of a p-value, which helps determine whether the ATT is statistically significant. The ratio of post-MSPE to pre-MSPE is calculated to evaluate the impact of the intervention. As Figure 5-3 shows, after each iteration of giving the treatment to all 23 countries in the control group, India's ratio of post-MSPE to pre-MSPE turned out to be the highest, and the p-value provided is 0.04. This indicates that the probability of obtaining an ATT of -9.55 purely by chance is very low. Since 0.05 is often used as a significance level by convention, the null hypothesis in this context, the observed ATT is due to random variation, is rejected.

Figure 5-3

Ratio of Pre- and Post-Treatment MSPE



5.3.3 Interpretation of the result

While the Clean Energy Cess started in 2010 at a tax rate of INR 50 per tonne of coal production, the tax rate subsequently increased to INR 100 in 2014, INR 200 in 2015, and INR 400 in 2016. Given these price hikes and the results of the synthetic control analysis, one might argue that India's higher trajectory between 2010 and 2014 could be attributed to the initial low tax rate, which failed to provide a sufficient price signal to reduce CO_2 emissions. In contrast, the subsequent tax increases may have contributed to reversing the trajectories of India and synthetic India. International experiences have also shown that carbon pricing can be ineffective due to low price levels. In the case of British Columbia's carbon tax, Pretis (2022) applied the difference-in-differences and synthetic control methods and found that the tax in the jurisdiction did not have a statistically significant effect on overall emissions. The study suggested that this lack of impact could be due to the price level being too low. Similarly, another study pointed out that Chile's carbon tax, set at $5 per tonne of CO_2 emissions, was insufficient to provide a strong incentive for emissions reductions (Amigo et al., 2020).

To assess the impact of the tax rate increases, a brief overview of financial figures from Coal India Limited is provided below. As this state-owned coal producing company holds an 83% share in India's domestic coal production, this overview offers insights into the impact of the cess on coal producers (Coal India Limited, n.d.). At the onset of the cess and until 2013 when the tax rate was low at INR 50, the share of the Clean Energy Cess paid by the company relative to its gross sales ranged from 2.1 to 2.7%, which represented a small fraction of its total annual revenues. However, this share increased in subsequent years, reaching 4.4% in 2014 and 9.2% in 2015 (Coal India Limited, 2011, 2013, 2015, 2017). After the Clean Environment Cess rose to INR 400 in 2016 and remained at that level until 2018, the share of the cess relative to its gross sales increased further, reaching 17.2 to 18.8% (Coal India Limited, 2019). This suggests that the tax rate hikes have had a financial impact on the coal producer.

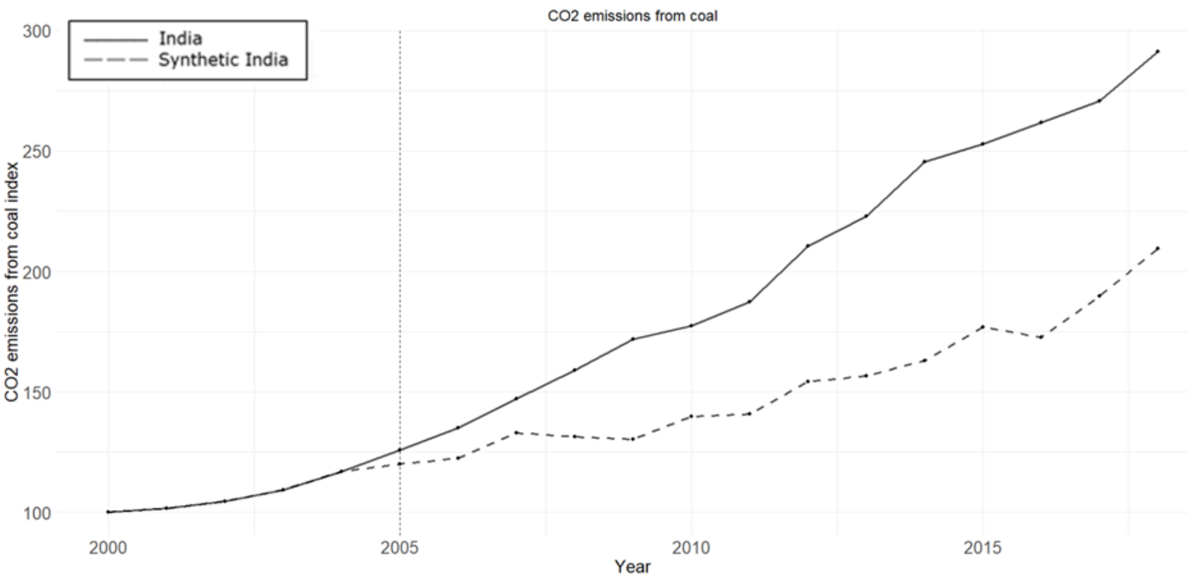
5.4 Robustness test

5.4.1 In-time placebo test

An in-time placebo test is used to assign a fake implementation year, shifting the actual implementation year to another year in the pre-treatment period. In this study, the actual policy implementation took place in 2010; however, the year was shifted to 2005. As a result, the treatment was given for the years 2006–2010, a period when it was not actually implemented. If the treatment effect during this period (2006–2010) turns out to be significant, it raises uncertainty about the actual treatment effect (Yan & Chen, 2023). As shown in Figure 5-4, when the implementation of the policy is shifted from 2010 to 2005, the emissions trajectory of the synthetic control group changed significantly. This result suggests that synthetic control is sensitive to the choice of pre-treatment period, which affects the robustness of the main analysis.

Figure 5-4

CO_2 Emissions Trajectories for India and Synthetic India in the In-Time Placebo Test

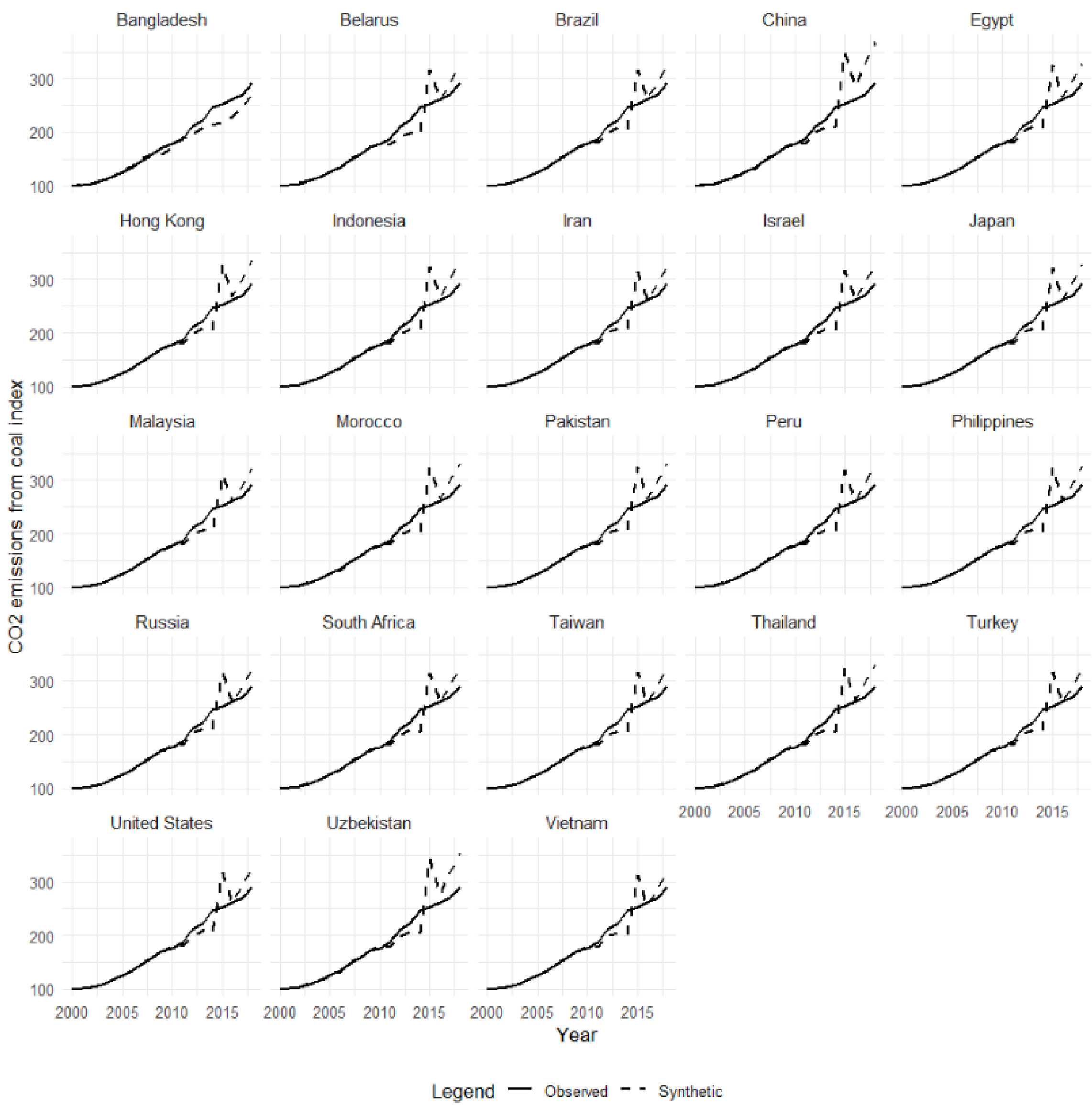


5.4.2 Leave-one-out test

A leave-one-out test was also conducted to see if any single country had a substantial impact on the main result. In this test, each country is removed from the control group, and the SCM is run iteratively. This allows for assessing whether the removal of a country impacts the main result. If any iteration of removing one country shows no substantial change from the main result, it suggests that the estimate of the treatment effect is robust and not driven by any particular country (Yan & Chen, 2023). Figure 5-5 presents the results of the leave-one-out test. The results show that removing Bangladesh significantly alters the CO_2 emissions trajectory of synthetic India. Without Bangladesh in the control group, the trajectory suggests that India's emissions continued to grow despite the presence of the coal tax. On the other hand, removing another country from the control group does not lead to significant changes while there is some slight variation depending on which country is excluded. This suggests that having Bangladesh in the control group affects the estimated impact of the coal cess.

Figure 5-5

CO_2 Emissions Trajectories for India and Synthetic India in the Leave-One-Out Test



5.4.3 Reliability of Bangladesh data

The previous robustness tests suggest that the finding of a statistically significant impact of the Clean Energy (Environment) Cess on CO_2 emissions from coal is questionable. The result is highly influenced by the emissions trajectory of Bangladesh, and concerns about the accuracy of the country's data arose when closely looking at Bangladesh's data. As shown in Table 5-5, CO_2 emissions from coal in Bangladesh surged in 2015 but declined sharply in 2016 based on the data provided by Our World in Data. While the spike in 2015 could be attributed to the Bangladeshi government's intention to transition from natural gas to coal as stipulated in the Power Sector Master Plan (Mahbub, 2024), there are no clear events that could explain the sharp decline in 2016. Although sudden changes in emissions data can occur when a responsible reporting body modifies its methodologies or alters key metrics such as calorific values, this raises doubts about the reliability of Bangladesh's data. Furthermore, while the International Energy Agency is considered a reliable source of CO_2 emissions data, its dataset also shows an unexplained spike between 2000 and 2001 (see Table 5-5). This would affect the SCM analysis if it were used in this study, as CO_2 emissions from coal in 2000 are set to an index value of 100. Due to the lack of reliable data for Bangladesh, I decided to remove the country from the control group for the following robustness check.

Table 5-5

CO_2 Emissions Data for Bangladesh

Year		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Our World in Data	Mt	1.25	1.33	1.33	1.37	1.45	1.60	1.81	2.21	2.47	3.02
	index	100	106	106	109	116	128	144	176	197	241
IEA	Mt	0.34	1.24	1.29	1.38	1.39	1.90	1.87	2.45	2.54	3.07
	index	100	363	377	404	405	557	546	716	742	896
Year		2010	2011	2012	2013	2014	2015	2016	2017	2018	
Our World in Data	Mt	3.07	2.84	3.42	3.75	3.51	8.61	6.07	7.15	8.18	
	index	245	226	273	299	280	687	485	571	653	
IEA	Mt	3.20	2.88	3.57	3.92	3.38	5.53	6.98	8.93	8.00	
	index	936	843	1,045	1,145	989	1,617	2,042	2,610	2,340	

Note. Data from *CO_2 emissions by fuel* by Our World in Data was used in the main analysis. Available at https://ourworldindata.org/emissions-by-fuel. In the attempt to address concerns about data accuracy, data from International Energy Agency (IEA) was checked, which was retrieved from *Energy system in India* by IEA. Available at https://www.iea.org/countries/india.

5.4.4 Chow test

Bangladesh's case sheds light on the SCM reliability when there is a significant change in variables before and after the policy implementation of interest. Thus, I conducted a Chow test to assess whether there was any substantial change in CO_2 emissions from coal in other countries. The Chow test is often used to assess whether two sets of observations belong to the same regression model (Lee, 2008). This test can also be used to detect structural breaks in the data (Upendra et al., 2023). Table 5-6 shows the results of the Chow test. They highlight that emissions trajectories in China, Egypt and Vietnam differ significantly before and after 2010. Figure 5-6 illustrates the emissions trajectories of Bangladesh, China, Egypt and Vietnam. After this result, further analysis revealed that China's CO_2 emissions from coal reached a plateau due to slow economic growth and policies aimed at limiting coal consumption in the 2010s (Sandalow et al., n.d.). Egypt experienced electricity shortages in 2014, which led to an increased share of coal in the country's energy mix (International Renewable Energy Agency, 2018). In Vietnam, coal consumption rose as the country sought to meet growing energy demands driven by economy growth (Johnson & Slater-Thompson, 2015). Thus, I will proceed with a further robustness check by removing those four countries.

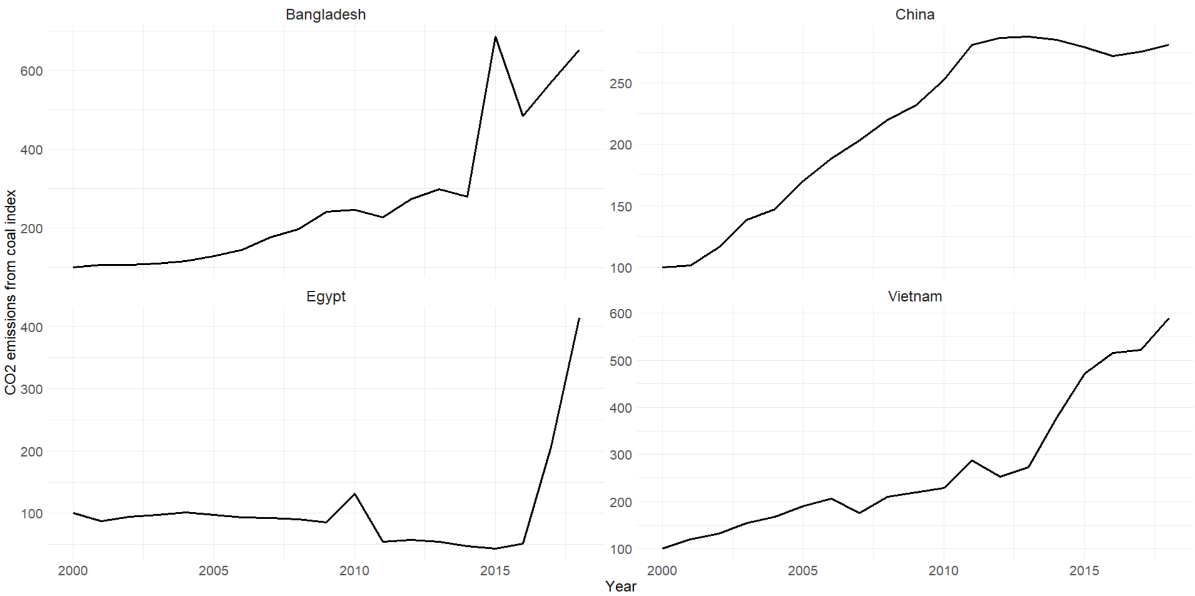
Table 5-6

P-Values for All Countries from the Chow Test

No.	Country	p-value	No.	Country	p-value
1	Bangladesh	0.0691	13	Morocco	0.6550
2	Belarus	0.3480	14	Pakistan	0.1090
3	Brazil	0.3270	15	Peru	0.4500
4	China	0.0319	16	Philippines	0.2930
5	Egypt	0.0184	17	Russia	0.5740
6	Hong Kong	0.1990	18	South Africa	0.2460
7	India	0.1040	19	Taiwan	0.1160
8	Indonesia	0.9660	20	Thailand	0.1060
9	Iran	0.4420	21	Türkiye	0.9240
10	Israel	0.1330	22	United States	0.1230
11	Japan	0.4400	23	Uzbekistan	0.1770
12	Malaysia	0.9910	24	Vietnam	0.0226

Figure 5-6

CO_2 Emissions Trajectories for Selected Countries



Note. Data retrieved from *CO_2 emissions by fuel* by Our World in Data. Available at https://ourworldindata.org/emissions-by-fuel.

5.4.5 Alternative test – removing selected countries and using the same predictors

Given the results of the Chow Test, by excluding Bangladesh, China, Egypt and Vietnam, I first conducted the SCM using the same predictors as in the main analysis, which is GDP index and CO_2 emissions from coal index. The MSPE of this analysis is 37.13, with Philippines receiving the highest weight (33%), followed by Indonesia (21%), Russia (14%) and Uzbekistan (9%). Additionally, Table 5-7 presents the weights for each covariate.

Table 5-7

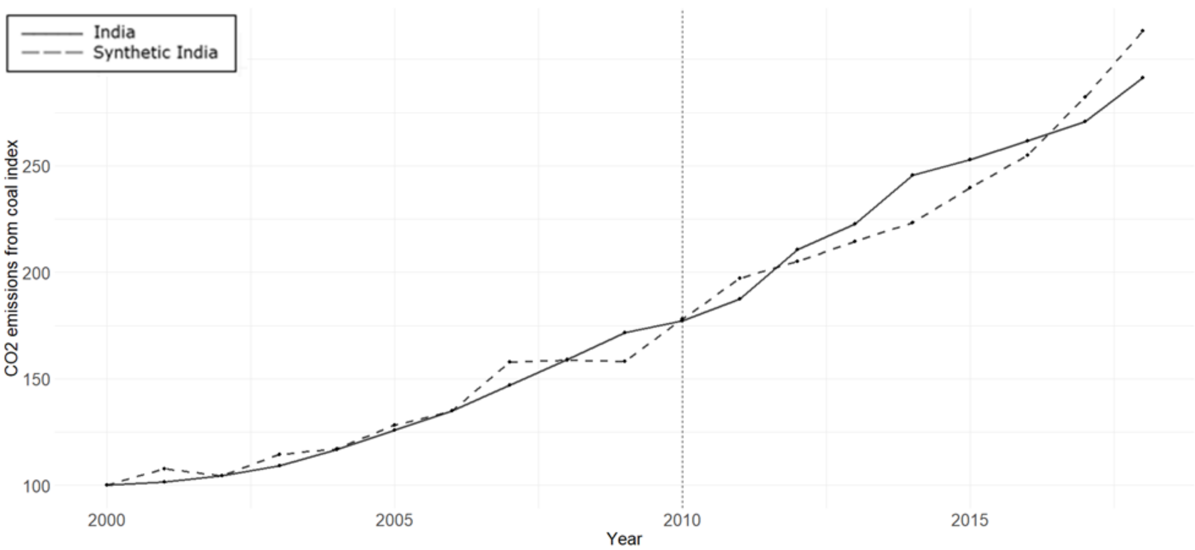
Weights for Each Covariate After Excluding Selected Countries

No.	Variable	Weight
1	emissions from coal index 2002	24.00 %
2	emissions from coal index 2004	19.70 %
3	emissions from coal index 2006	11.50 %
4	emissions from coal index 2008	24.5 %
5	GDP index	20.3 %

Figure 5-7 illustrates the trajectories from India and synthetic India using the weights. The results indicate that India's emissions trajectory is slightly higher in most years, with synthetic India's emissions surpassing India only in the last two years, resulting in an ATT of 1.61. The in-place placebo test revealed that this result is not statistically significant with a p-value of 0.85.

Figure 5-7

CO_2 Emissions Trajectories for India and Synthetic India After Excluding Selected Countries



5.4.6 Alternative test – removing selected countries and using all predictors from Kaya identity

Although it makes sense to construct a synthetic control group by minimizing the MSPE as much as possible to create one that closely resembles the treatment group, it is critical to include all relevant predictors to ensure accurate prediction of the outcome variable. Therefore, I included all the variables derived from the Kaya identity (population index, GDP index, coal consumption index and CO_2 emissions from coal index) and ran the SCM without the four excluded countries. The MSPE of this analysis is 40.28, with Philippines receiving the highest weight of 58%, followed by Indonesia (13%), Morocco (11%) and Russia (9%). Additionally, Table 5-8 presents the weights for each covariate.

Table 5-8

Weights for Each Covariate After Excluding Selected Countries While Including All Predictors

No.	Variable	Weight
1	emissions from coal index 2002	2.92 %
2	emissions from coal index 2004	75.80 %
3	emissions from coal index 2006	0.46 %
4	emissions from coal index 2008	5.51 %
5	GDP index	3.42 %
6	population index	11.80 %
7	coal consumption index	0.10 %

Figure 5-8 illustrates the trajectories from India and synthetic India when using all the predictors. This result shows that India’s trajectory reversed after 2015, and emissions of synthetic India surpassed India’s emissions, and the gap continued to grow over time. This results in an ATT of -17.65. However, the in-place placebo test indicated that this result is not statistically significant with a p-value of 0.35.

Figure 5-8

CO_2 Emissions Trajectories for India and Synthetic India After Excluding Selected Countries While Including All Predictors

5.4.7 Alternative test – removing selected countries and using additional predictors

Lastly, in an attempt to create a more accurate synthetic India, I included additional variables. Although the previous robustness test relied on variables derived from the Kaya identity, all were still indexed. To reflect the scale of the economy and emissions in weight allocation, I added average CO_2 emissions from coal, population, GDP per capita, coal consumption per GDP, and emissions from coal per coal consumption. Those variables correspond exactly to the components of the Kaya identity equation. In addition, using absolute values should allow for capturing the magnitude of those variables more effectively. Lastly, while coal constitutes a significant share of India's energy mix, some countries in the control group rely on it for less than 5%. To ensure that countries with similar energy structures receive higher weights, I also added the share of coal in the energy mix.

The MSPE of this analysis is 23.05. By adding further variables, the smaller MSPE was achieved compared to the previous robustness checks. In this iteration, Philippines was again assigned the highest weight of 56%, followed by South Africa (29%), Indonesia (7%), and Hong Kong (5%). Additionally, Table 5-9 presents the weights for each covariate.

Table 5-9

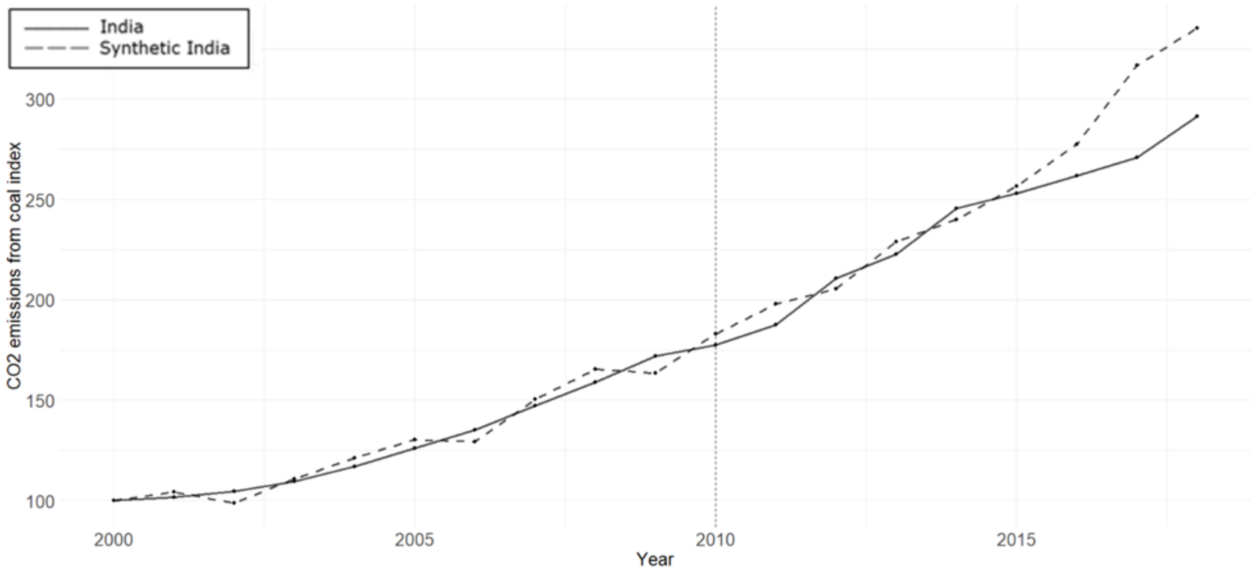
Weights for Each Covariate After Excluding Selected Countries and Adding Additional Predictors

No.	Variable	Weight
1	emissions from coal index 2002	0.07 %
2	emissions from coal index 2004	2.40 %
3	emissions from coal index 2006	13.90 %
4	emissions from coal index 2008	1.20 %
5	GDP index	5.75 %
6	population index	9.38 %
7	coal consumption index	12.7 %
8	population	0.95 %
9	GDP per capita	13.00 %
10	coal consumption per GDP	7.13 %
11	emissions from coal per coal consumption	29.10 %
12	emissions from coal	0.25 %
13	share of coal index	4.09 %

Figure 5-9 shows the trajectories of emissions and presents that India's trajectory again reversed after 2015, and emissions of synthetic India surpassed India's emissions, and the gap continued to grow over time. This results in an ATT of -14.40. However, the in-place placebo test indicated that this result is not statistically significant with a p-value of 0.30.

Figure 5-9

CO_2 Emissions Trajectories for India and Synthetic India After Excluding Selected Countries and Adding Additional Predictors



5.4.8 Discussions and limitations

Although none of the robustness tests yield statistically significant results, they imply that India's emissions lost momentum after 2015. This coincides with the period when the government raised the tax rate to INR 100 in 2014, INR 200 in 2015 and INR 400 in 2016. While the rise in the tax rate may have contributed to slowing the rise in emissions, this study does not provide sufficient evidence to support this argument.

Although the price hike in the coal cess might have influenced emissions from coal, multiple potential confounders must also be considered. One such factor is the PAT scheme, a policy that India implemented in 2012 to improve energy efficiency in energy-intensive sectors. Among the sectors covered by this scheme is the thermal power plant sector. While some studies point out that the policy did not provide sufficient incentives for the sector to accelerate energy efficiency improvements, it might still have had some impact on CO_2 emissions from coal. Additionally, since 2014, India has introduced policies to promote renewable energy deployment. The growing share of renewable energy could have contributed to reducing reliance on coal. Thus, the observed slowdown in emissions might, at least in part, be attributed to the expansion of renewable energy.

It is also worth noting that several factors may have counteracted the intended effects of the coal cess. As discussed in the previous chapter, the dynamics of the country's power market play a crucial role in the effectiveness of the coal cess. Due to certain power market regulations, cost-passthrough is often challenging to achieve. Similar difficulty in passing through cost in highly regulated power markets have also been observed in China (Maosheng, 2023). Furthermore, the government still provides subsidies for fossil fuels including coal. Coal subsidies amounted to INR 150 billion in the form of concessional excise duty, a figure comparable to the revenue collected from the coal cess (Gerasimchuk, Beaton, et al., 2018).

Furthermore, it appears that the synthetic control method has inherent limitations when analyzing the impact of a certain policy. In the context of climate policy, each country has unique characteristics that could affect emissions. Additionally, during the 2010s, many countries implemented policies to reduce fossil fuel use and promote renewable energy while some countries expanded coal consumption to meet growing energy demands or reduce reliance on other fossil fuels. Given those unique variations among countries, constructing a suitable synthetic control group using other countries can be particularly challenging.

Meanwhile, since this study does not disentangle the aforementioned confounding factors, attributing changes in CO_2 emissions from coal solely to the coal cess remains uncertain. However, it is worth noting that the main analysis and subsequent robustness tests imply a potential effect of the tax rate increase on CO_2 emissions from coal.

6 Results – CCTS design (Research question 3)

India updated its Nationally Determined Contributions (NDCs) in 2022. To accelerate its climate goals, the government outlined the development of the Carbon Credit Trading Scheme (CCTS). To address the main research question of the effects of carbon pricing on emissions reductions in future, it is critical to examine India's CCTS progress and potential future developments. In line with this, the 10 steps outlined in a document published by the International Carbon Action Partnership (ICAP), *Emissions Trading in Practice: A Handbook on Design and Implementation*, will serve as the framework for this purpose (Partnership for Market Readiness & International Carbon Action Partnership, 2021). The handbook offers 10 steps to design and implement emissions trading systems. India's CCTS will be elaborated following each of those 10 steps.

6.1 ETS design and implementation: Steps and India's CCTS progress

6.1.1 Step 1: Prepare

The first step identified is to prepare for setting up an ETS. This includes understanding why an ETS is needed, its objectives within the jurisdiction, and its interaction with other climate policies. The major objectives of an ETS are to limit emissions to a certain level and to provide incentives to invest in cleaner technologies in the long term. As an ETS can give a price signal to reduce emissions and make low-carbon technologies more competitive, it can accelerate emissions reductions in a cost-effective manner. Moreover, the ICAP handbook mentions the importance of considering the interaction of ETS with other climate policies. Other policies can either complement, overlap with or run counter to ETS in jurisdictions. Policies that have opposite effects include subsidies for fossil fuels and policymakers need to assess the impact of those policies on another policy objective. On the contrary, an ETS could also have effects on other policies. It might facilitate the achievement of other policies, or it might negatively affect society by raising the energy price, thereby making energy less affordable. Furthermore, policymakers may need to consider additional complementary policies so that they can enhance the effectiveness of the ETS (Partnership for Market Readiness & International Carbon Action Partnership, 2021).

As elaborated in the previous sections, India already has experience in using some forms of carbon pricing to tackle climate change, namely the Clean Energy (Environment) Cess or the Perform, Achieve and Trade (PAT) scheme. Those policies aimed to levy a tax on coal production and incorporate market mechanisms to reduce energy intensity in energy-intensive sectors. In addition to those policies, India has started developing its own carbon market, aimed at supporting achievement of the country's NDCs and mobilizing investment in low-carbon technologies for the transition to a low-carbon economy. The CCTS will also play a role in interacting with other climate policies. It is expected to build upon the existing PAT and evolve from it (Bureau of Energy Efficiency, n.d.-a). While it is not clear how the GST Compensation Cess will continue or cease beyond 2026, the tax on coal production could help accelerate the reduction of dependence on fossil fuels in India's energy mix. Another notable policy, Renewable Energy Certificates (RECs) may also complement the CCTS to achieve India's NDCs. Furthermore, India has policies that have opposite effects to the CCTS such as oil and gas subsidies (Raizada et al., 2023). More importantly, despite the coal cess, India has also provided subsidies to coal producers through concessional tax rates (Aggarwal et al., 2022). Lastly, given that the largest share of India's emissions comes from the electricity generation, the power sector plays a pivotal role in India's decarbonization path. However, the power sector in India is highly regulated, making it essential to reconsider existing regulations alongside the development of the CCTS. Moreover, as discussed in the following section, it is crucial to consider incorporating the power sector into the CCTS, given that it is currently not included as a covered sector.

6.1.2 Step 2: Engage stakeholders, communicate, and build capacity

This step entails communicating with stakeholders and providing capacity building for those affected by the implementation of the ETS. Stakeholder engagement is essential as it may be mandated by legal requirements, can leverage stakeholder knowledge to design a better ETS, and build trust among stakeholders and the broader public. Engaging with stakeholders and understanding them help design and implement an ETS that accommodate their circumstances, thereby enhancing the effectiveness of the ETS. The stakeholders that should be considered include both regulated and non-regulated industries, governmental bodies, market service providers, NGOs, media, and academic and research institutions. Once stakeholders are identified, it is imperative to understand each stakeholder's interests and concerns regarding the ETS as well as how they are affected. For stakeholder engagement to achieve its goals and foster meaningful outcomes, it should be conducted in a timely, transparent and inclusive manner (Partnership for Market Readiness & International Carbon Action Partnership, 2021).

In India's context, as the Government of India delegates the task of the CCTS development to the Bureau of Energy Efficiency (BEE), the BEE works as the main actor to work on stakeholders. They conducted stakeholder consultation workshops in multiple locations such as New Delhi, Mumbai and Bengaluru in 2023 (Bureau of Energy Efficiency, 2023). Stakeholders had the opportunity to convey their comments and suggestions on the draft procedures for the compliance mechanism. Non-governmental organizations have also taken a lead to building capacity among stakeholders. The Council on Energy, Environment and Water (CEEW) conducted workshops with other research and academic institutions in multiple locations in 2023. As building knowledge and capacity among stakeholders about ETS is critical to a well-functioning system, the organizers aimed to provide understanding of how ETS functions and its possible impacts through simulation sessions. Through the workshops, stakeholders' widespread concerns about the price level and trajectory of the CCTS were observed (Singh et al., 2023).

6.1.3 Step 3: Decide the scope

After identifying the motivations to implement an ETS and engaging with stakeholders, it is imperative to decide which sectors to be included and which gases to be covered in the ETS. Including a broad range of sectors and gases has both advantages and disadvantages. A broader scope allows policymakers to be more certain about meeting climate goals. Additionally, economies of scale may help reduce the administrative costs of the ETS. Expanding coverage could also lower the risk of carbon leakage as a narrower scope might lead to emissions shifting from regulated sectors to those outside the ETS. Meanwhile, a broader scope could lead to higher monitoring costs and increased complexity, which may negatively impact the functioning of the ETS. Additionally, data availability of emissions within a sector could also play a role in facilitating the ease of implementation. Furthermore, an ETS might produce co-benefits in other areas by incorporating sectors with significant environmental or societal impacts. For instance, bringing a power sector which heavily relies on coal under the ETS could improve air quality, which could further lead to better public health. Thus, when determining the scope of a jurisdiction's ETS, it is imperative that policymakers carefully weigh the advantages and disadvantages in relation to their climate goals, administrative capacity, and the role of the ETS in their broader climate policy mix. In terms of the types of GHGs to be covered in the ETS, they vary among jurisdictions. All the existing ETSs around the world cover carbon dioxide (CO_2) to be regulated under the ETSs. While the ETSs in California, New Zealand and South Korea include methane (CH_4), some ETSs such as the EU-ETS or Switzerland do not include the gas. The selection of gases corresponds to which sector is included in the ETS (Partnership for Market Readiness & International Carbon Action Partnership, 2021).

At the beginning phase of India's CCTS, nine sectors are brought under the covered sectors: aluminium, cement, chlor-alkali, fertilizer, iron and steel, pulp and paper, textile, petro-chemical, and petro-refinery. All of those sectors have been covered under the PAT scheme. The most contested argument regarding sector coverage in India's CCTS is the exclusion of the power sector. While electricity generation holds the largest share of CO_2 emissions (52.7%) according to the International Energy Agency (n.d.), the government decided to exclude the power sector from the covered sectors under the CCTS. The exclusion of the sector could potentially result from current regulations in the power market, financial strains among DISCOMs, or concerns over energy security (Kumar & Agrawal, 2024). However, to drastically reduce emissions in India, serious consideration must be given to reforming existing power market regulations and bringing the sector under the CCTS.

With regard to covered gases, only carbon dioxide (CO_2) and perfluorocarbon (PFCs) gases will be regulated under the CCTS, while the government has left the door open to expanding coverage to other GHGs. Perfluorocarbons are a type of fluorinated gases, which are made of man-made substances. These fluorinated gases, including PFCs, have a significantly high global warming potential, which are often thousands of times greater than that of CO_2. They are commonly emitted during the production of aluminium (International Aluminium Institute, 2024). Jurisdictions such as California, the EU, New Zealand, South Korea and Switzerland also include PFCs as one of the covered GHGs.

6.1.4 Step 4: Set the cap

The fourth step that policymakers need to take is cap-setting. Policymakers can set the cap either on an absolute basis or on an emission intensity basis. The cap should be aligned with the jurisdiction's climate goals, and while it is imperative to have an ambitious goal, it is also important to set a cap at the level where stakeholders consider it fair. At an early stage, starting at a loose cap will facilitate a smooth start of an ETS in a jurisdiction. Prioritizing the establishment of an ETS will help stakeholders learn through practice, build trust in the system, and reduce negative impacts on participants or the economy. Meanwhile, it is also important to prevent embedding a low cap in the system in the long run. Thus, setting a timeline to tighten the cap later, even in the early phase, will help. Caps can be set either a top-down or bottom-up approach. In a top-down approach, policymakers weigh the reduction potential and costs of covered sectors and set the cap in alignment with the jurisdiction's climate goals. In a bottom-up approach, the cap is determined by summing up each sector or ETS participants' potential. For cap setting, policymakers can base the target on historical emissions and economic data such as GDP in case a jurisdiction decides to use an intensity-based cap. Other existing policies may also accelerate or negatively affect the impact of the ETS, thus assessing their potential impact on the ETS will be an imperative part of the cap-setting process (Partnership for Market Readiness & International Carbon Action Partnership, 2021).

In cap-setting, the next step will be to implement the cap calculated based on the aforementioned factors. Entrusting the responsibility of setting and overseeing the ETS to an appropriate body is a crucial aspect. It may also be advantageous to set up an independent body consisting of stakeholders and technical experts to give insights into cap-setting. Legalizing the necessary process or cap level can provide certainty, which helps stakeholders make decisions regarding the deployment of low-carbon technologies, although the process of creating legislation may involve complicated and lengthy procedures. Lastly, cap-setting also involves establishing compliance periods, which are specific timeframes for covered sectors to comply with the cap, as well as phases, which are long-term periods during which the cap is fixed (Partnership for Market Readiness & International Carbon Action Partnership, 2021).

In India's case, the CCTS is designed to be a baseline-and-credit system, which is a different form of ETS from the cap-and-trade system. Under a cap-and trade system, a total cap is set on emissions from covered sectors, and entities must have emissions allowances for their emissions. These allowances can be traded, resulting in limiting emissions (Carbon Market Institute, 2019; Center for Climate and Energy Solutions, 2024). On the other hand, under a baseline-and-credit system, covered sectors receive emissions baselines, which represents the amount of emissions they are allowed to emit. If their emissions fall below the baseline, the difference can be converted into credits (Carbon Market Institute, 2019; Climate Change Authority, 2014).

Regarding the functions of relevant stakeholders, the Ministry of Power (MoP) has the responsibility to set GHG emission intensity reduction targets, taking into account the recommendations from the BEE and the National Steering Committee for Indian Carbon Market (NSC-ICM). Meanwhile the technical committee constituted by the BEE will evaluate the emissions intensity in the baseline year and the reduction targets for respective sectors. The technical committee will report the emissions intensity targets to the BEE. The MoP recommends the targets to the Ministry of Environment, Forest and Climate Change (MoEFCC), which will then notify the obligated entities of the targets. The obligated entities will be assessed based on their performance. If their actual emissions are below the target, they can sell the reduced amount as Carbon Credit Certificates (CCCs). In case entities exceed the target, they will need to buy CCCs or use CCCs banked from previous years. While the exact targets for the obligated entities have not been announced yet, the targets in the CCTS will be intensity-based, calculated by total GHG emissions (tCO_2e) divided by total equivalent output (tonne or MWh). The predecessor policy, the PAT scheme, used Specific Energy Consumption (SEC) as a target set for each designated consumer (Bureau of Energy Efficiency, 2024).

6.1.5 Step 5: Distribute allowances

Regarding the allocation of emission allowances in a cap-and-trade system, the two major ways are selling allowances at auction and allocating them for free. While which approach suits local conditions depends on each jurisdiction’s circumstance and experience, ETS can mix both auctioning and free allocation, as well as use a mix of these methods for different sectors or entities covered under the system. The most prominent advantage of auctioning is that it can generate revenue for the government. The revenue collected from allowance auctions can be used to invest in cleaner technologies or mitigate the negative economic impacts arising from ETS implementation. It also fosters price discovery, which is one of the main characteristics of ETS. Furthermore, while free allocation may skew the incentives to realize cost-effective emission reduction measures, auctioning helps prevent the problem through price discovery in the market. In addition, as entities which have already implemented low carbon technologies will need to buy fewer allowances, auctioning can reward early adopters toward climate change. Despite those advantages, a disadvantage includes financial burdens to join the market for obligated entities, especially small firms which tend to have less capacity. Free allocation can help jurisdictions, especially in the early stages, and gradual transition along with their experiences will help overarching ETS objectives. In comparison to auctioning, covered firms are expected to be less reluctant to accept the policy when they can receive allowances for free. Additionally, if they reduce emissions, they can sell their allowances, which can incentivize them to drive emissions reductions. Generally, it is reasonable to begin with free allocation and gradually advance to auctioning as the jurisdiction builds experience (Partnership for Market Readiness & International Carbon Action Partnership, 2021).

In this step, revenue generation holds significant potential for India to ratchet up its climate actions. India’s CCTS is expected to be a baseline-and-credit system, thus this step is of limited relevance at this moment. However, it will be important to consider revenue generation during the further development stage of the CCTS. It is worth noting that the Australian Safeguard Mechanism uses a baseline-and-credit system while covered entities which fail to achieve their targets need to buy Australian Carbon Credit Units from the government (Ritchie et al., 2024).

6.1.6 Step 6: Promote a well-functioning market

In ETS markets, price fluctuations are a key factor to consider. The price is determined by supply and demand, where supply depends on the cap level, available allowances such as those carried over or from linked systems, and available offset programs. Demand is influenced by multiple factors such as emissions levels, the cost of compliance, and the availability of technology to achieve the cap. While price changes are not inherently harmful, they are rather a key element of its efficient operation. Allowing the financial sector to enter the market can help manage volatility. Jurisdictions may also want to address extreme price volatility, but any intervention should be conducted in a transparent and guided by a long-term perspective, to prevent further distorting the market.

Three elements are key to well-functioning ETS markets: banking, borrowing and the length of compliance periods. Banking allows covered entities to carry allowances from one compliance period to another, providing flexibility to prepare for stricter future caps. While it enhances the efficiency of ETS markets, policymakers should be aware of potential risks such as unlimited banking leading to oversupply, banking from a trial phase, and excessive banking within a single firm. Borrowing, on the other hand, allows firms to use allowances from a future period in the current one. However, as this may provide incentives for firms to deter their emission reduction efforts, ETSs generally do not allow or limit the use of borrowing. Regarding compliance periods, longer periods can provide firms with sufficient time to adopt reduction measures and flexibility to react to unexpected events.

In contrast to the primary market where auctioning or free allocation takes place, the secondary market also plays a key role by enabling firms to trade allowances. Policymakers play an important role in establishing rules and determining which actors join the secondary market. Trading generally occurs via brokers as they can operate trading more efficiently than individual buyers or sellers. The market is supplemented by financial products that will help participants reduce risks associated with market transactions (Partnership for Market Readiness & International Carbon Action Partnership, 2021).

India's CCTS has made it clear that banking of CCCs is allowed "for use in subsequent compliance years" (Bureau of Energy Efficiency, 2024). However, it is also important to establish a timeline for how long entities may bank their remaining CCCs to avoid oversupply in later phases. Furthermore, there is currently no limit on the number of certificates entities can bank. Regarding the length of compliance periods, India defines a "Compliance Year" as "the specific financial year by which obligated entities shall meet their Greenhouse gas Emission Intensity (GEI) targets" and a "Trajectory period" as "three consecutive compliance years or as specified by the Central Government for the greenhouse gas (GHG) emission intensity targets" (Bureau of Energy Efficiency, 2024).

International experiences can serve as a reference for designing rules on banking for India. Tokyo's cap-and-trade system allows banking only within consecutive compliance periods. The Australian Safeguard Mechanism allows unlimited banking until 2030, but it is estimated to review the use of banked credits in 2026 and 2027, regarding the period after 2030. The Korea ETS sets a limit on the amount of allowances that can be banked. In Phase One, it allowed up to 20% of a covered sector's obligation, which was reduced to 15% in Phase Three (International Carbon Action Partnership, n.d.)

Singh et al. (2024) argue that financial players can play an important role in establishing a well-functioning market in India. They would contribute to enhancing capital allocation efficiency, helping price discovery, and creating financial products. On the other hand, the participation of financial players could also pose some challenges, including further price volatility caused by speculative trading. They recommend that it will be beneficial to allow financial players to participate in the system from the beginning so that entities can learn from financial actors' actions and understand how they affect the markets.

6.1.7 Step 7: Ensure compliance and oversight

To make ETS effective, it is essential to make sure that covered entities comply with the rules and that regulators oversee their compliance. Lack of these elements may ultimately hinder the achievement of the environmental objectives intended by the ETS. As implementing an ETS in a jurisdiction could constrain the activities of entities covered under the system, institutionalizing it within the legal system is a fundamental part of ETS design. Policymakers can enshrine core elements in law to safeguard the ETS from political changes. Conversely, technical aspects can be addressed in less stringent legal instruments such as regulations and guidelines to allow for necessary adjustments in line with the jurisdiction's ETS development. Core elements to be enshrined in law may include ETS objectives, covered entities' rights and obligations, revenue recycling, emission reduction targets and sector coverage. Technical aspects may include caps, benchmarks, and allowance registry systems. While embedding certain elements in law supports the durability of ETS, it would entail a complex process. Thus, balancing durability and flexibility is crucial.

To ensure compliance, Monitoring, Reporting and Verification (MRV) plays a key role. MRV entails calculating the emissions of covered gases from entities, reporting them to a responsible authority, and verifying the calculated figures by verifiers. Policymakers are encouraged to provide key elements such as methodologies for emissions calculation, reporting templates, and verification guidelines. Verification serves to make sure that the emissions data submitted by entities is accurate and reliable. Additionally, policymakers need to ensure verification processes remain impartial. These measures can be reinforced by multiple factors including capacity building and penalties. Appropriate penalties should outweigh the expected benefits that regulated entities expect from non-compliance and may take the form of fines or public disclosure of non-compliant entities (Partnership for Market Readiness & International Carbon Action Partnership, 2021).

In India's CCTS, obligated entities are required to create and submit a monitoring plan within three months of the start of each compliance year. This plan should include a description of their activities, emission sources, monitoring methodology, and energy consumption data, among other elements. Entities must submit a monitoring plan annually, which will be reviewed and approved by the BEE. After one compliance year, obligated entities must submit a performance assessment document along with verification to the BEE. In the performance assessment document, obligated entities are required to fill in relevant information such as the achieved GHG emissions intensity, the number of CCCs issued or surrendered, and measures taken to reduce emissions. The verification must be conducted by one of the carbon verification agencies accredited by the BEE (Bureau of Energy Efficiency, 2024).

6.1.8 Step 8: Consider the use of offsets

When jurisdictions implement a compliance ETS, they may also consider integrating offset mechanisms. These mechanisms involve the trading of carbon credits generated from activities that either reduce emissions or remove GHGs from the atmosphere. A key aspect of offset mechanisms is additionality, which ensures that the reduction or removal takes place as a direct result of the carbon credit mechanisms. Offsets can come from uncovered sectors within the jurisdiction or from outside. There are various advantages and disadvantages to using offsetting in an ETS. One advantage is that it can provide price signals for uncovered sectors, leading to more cost-effective emissions reductions and incentivizing the development of removal technologies. On the other hand, ensuring additionality is generally challenging, and removal activities might have potential negative consequences in the future. Furthermore, including offset mechanisms may decrease entities' incentives to reduce their own emissions. To effectively manage offset mechanisms and help achieve overarching objectives, it is important to set criteria such as limiting the amount of offsets that entities can use to meet their emissions obligations and restricting offsetting activities to certain projects that ensure mitigation, additionality, and environmental integrity (Partnership for Market Readiness & International Carbon Action Partnership, 2021).

India's CCTS will start as a voluntary mechanism first in April 2025. This will provide relevant sectors with time to learn and adapt to the system. Non-obligated entities can register projects that reduce, remove or avoid emissions to issue CCCs. This voluntary mechanism is aimed at incentivizing emissions reductions in sectors not covered by the compliance CCTS. The BEE has notified the approved sectors for participation in the voluntary mechanism including energy, agriculture, forestry, transport, and CCUS, among others (Bureau of Energy Efficiency, n.d.-a).

6.1.9 Step 9: Consider linking

An ETS in one jurisdiction may link with other jurisdictions' ETSs. This offers advantages such as reducing compliance costs and potential carbon leakage, while increasing the number of players and allowances. However, linking ETSs may also present challenges, including disincentivizing participants to reduce their own emissions and potentially reducing revenues generated from auctions. Furthermore, if there are significant differences in economic, political and environmental situations between the linked jurisdictions, a shock in one jurisdiction may affect the others. Lastly, linking systems may undermine a jurisdiction's control over its own system design. To mitigate those challenges, policymakers can weigh the benefits and costs of structural similarities with the linked bodies (Partnership for Market Readiness & International Carbon Action Partnership, 2021).

In India's case, it is currently not at the stage of considering linkages with other jurisdictions. However, the CCTS notification published in June 2023 has already assign the task of "establish linkages with other National or International registries" to the Grid Controller of India Limited (Ministry of Power, 2023).

6.1.10 Step 10: Implement, evaluate, and improve

The last step in ETS design and implementation is to implement, evaluate and improve the system. When considering implementation, jurisdictions can decide whether to start with a pilot phase or gradual implementation. The main objectives of a pilot phase include collecting data, testing the system, and providing learning experiences for both participants and regulators. Nevertheless, it is important to decide and explicitly communicate when the pilot phase will end. In addition to the pilot phase's focus, gradual implementation aims to further foster learning through experience. The procedures should be an iterative process, with regular reviews and improvements playing a crucial role in attaining the system's overarching objectives. In line with the experiences of regulators and regulated entities in ETS, policymakers need to assess whether the system effectively contributes to reducing negative environmental impacts, attains cost-effectiveness and promotes fairness among participants. Those review processes should involve a variety of stakeholders and be conducted impartially (Partnership for Market Readiness & International Carbon Action Partnership, 2021).

India's CCTS experience could be a gradual and iterative learning process. It has been made clear that the sectoral or GHG coverage is open to expansion. Some sectors are not currently covered, most importantly the highest-emitting sector, the power sector. Other potent GHGs like methane (CH_4) or nitrous oxide (N_2O) are also not covered in the current design. It is important to regularly review its progress and impacts. Furthermore, after accumulating experience among both participants and regulators, it would be worth considering transitioning to a cap-and-trade system or setting absolute emission reduction targets to further accelerate emissions reductions. Additionally, drawing lessons from the Clean Energy (Environment) Cess, it is crucial to ensure that the MRV systems work coherently. This process will entail consultation with multiple experts from the sector, academics and researchers, financial institutions, and private sector companies. India could also leverage various actors such as non-governmental organizations to gain insights and provide capacity building to new actors in the system.

6.2 Analysis of Indian carbon market – Key elements

Since the development of the Indian Carbon Market is an ongoing process and many aspects remain unknown, a number of elements need to be considered. The following is not an exhaustive list of key elements for the compliance CCTS, but rather those are identified from India's own experience and international insights.

6.2.1 Intensity-based cap

India's target setting in the compliance CCTS will be an intensity-based one. Compared to absolute targets, intensity-based targets are more appealing to developing countries. While absolute emissions caps are often considered as a constraint on economic growth, intensity-based targets allow for economic growth as long as emissions intensity improves, which makes the policy more acceptable (Jotzo & Pezzey, 2007; Pizer, 2005). While the EU-ETS or California's cap-and-trade system use absolute emissions targets, China's ETS uses intensity-based targets. Critics argue that China's intensity-based targets undermine the effectiveness of the ETS (Busch et al., 2022; Ewing, 2024; Nakano & Kennedy, 2021; Nogrady, 2021). There are multiple aspects regarding those negative views toward the target setting. Ewing (2024) argues that intensity-based targets have only limited ability to reduce absolute emissions. China's case has shown that such targets combined with lenient benchmarks undermine the effectiveness of the country's ETS in reducing absolute emissions. They recommend that policymakers set a clear timeline at an early stage of ETS development and consider moving forward to absolute targets. Moreover, while intensity-based targets allow for marginal efficiency improvements, they do not accelerate adopting cleaner technologies. Predictability of emissions reductions will also be compromised. If actual economic growth deviates from projections, intensity targets will need to be adjusted accordingly (Ewing, 2024; Zeng et al., 2016). Additionally, MRV becomes more complex as both emissions and actual outputs need to be accurately reported and verified, thus adding administrative complexity (Ewing, 2024; Jotzo & Pezzey, 2007).

Given India's need for economic growth and its growing energy demand, the decision to use intensity-based targets reflects a balance between meeting energy needs and reducing emissions. This approach also aligns with India's NDCs updated in 2022, which includes a target to reduce emissions intensity per unit of GDP by 45% by 2030, compared to 2005 levels (Government of India, 2022). Additionally, a gradual implementation that allows entities to gain experience is a sound approach for initiating the CCTS. However, obligated entities can increase their production levels as long as their emissions intensities are lower than the target. As a result, while energy efficiency may improve and the target may be achieved, the overall reduction in emissions may remain uncertain (Nakano & Kennedy, 2021). In China's case, the targets were set at a level where entities could easily achieve, which has also been observed in India's PAT scheme. While India has not clarified its potential transition to absolute targets, it would be advantageous for the country to consider such a shift. Given that absolute targets are generally more efficient and less resource-intensive compared to intensity-based targets, once the covered sectors gain experience in the CCTS and compliance is ensured, moving towards absolute targets could facilitate the achievement of India's climate targets. Furthermore, to enhance emissions reductions among entities, it is also essential that targets be progressively tightened.

6.2.2 Penalty

Carbon pricing functions to provide appropriate price signals to compel emitting entities to reduce emissions in a cost-effective manner. When entities covered under ETSs consider emission reduction measures, they also take potential penalties for non-compliance into account. Thus, they calculate the sum of abatement costs and potential penalties and make decisions by minimizing the total cost (Kim & Yu, 2018). If the estimated penalties are too low, covered entities are likely to just continue emitting and simply pay the penalty as it would be the most cost-effective option for them. This undermines the ETS effectiveness, so implementing an appropriate level of penalties is integral to the proper functioning of ETSs. The EU-ETS imposes a penalty of EUR 100 per tonne of CO_2 for non-compliance and the Korea ETS imposes KRW 100,000 ($68.54[4]) per tonne of CO_2 or an amount "not exceed either three times the average market price of allowances of the given compliance year" (International Carbon Action Partnership, n.d.). Gupta et al. (2024) point out that the Kazak ETS has experienced low accountability partly due to low penalties of about $40 per tonne of CO_2. Some ETSs publicly disclose the names of entities that fail to meet their target, as is the case in the EU-ETS (European Commission, n.d.-a).

While the exact amount of penalties for the compliance CCTS has not yet been determined, India's own experience with the Clean Energy (Environment) Cess, where critics point out that low penalties were a design flaw, along with international experiences, highlights the importance of setting appropriate penalties to motivate obligated entities to comply with the emission reduction targets.

6.2.3 Institutional structure

There are multiple key stakeholders in the decision-making process of the CCTS including the Government of India, the Ministry of Power (MoP), the Bureau of Energy Efficiency (BEE), the Ministry of Environment, Forest and Climate Change (MoEFCC), and the National Steering Committee for Indian Carbon Market (NSC-ICM). Additionally, the technical committee, the Grid Controller of India Limited, accredited carbon verification agencies, and the Central Electricity Regulation Commission also play key roles. The Notification published in June 2023 by the Ministry of Power defines terms, relevant actors and their responsibilities in detail.

[4] USD 1 = KRW 1453.86, exchange rate at the end of February 2025 retrieved from *Foreign Exchange Rates* by the Board of Governors of the Federal Reserve System (Board of Governors of the Federal Reserve System, 2025).

The Government of India constitutes the NSC-ICM, which will be co-chaired by secretaries from the Ministry of Power and the Ministry of Environment, Forest and Climate Change. The committee consists of members from various ministries, such as the Ministry of Coal and the Ministry of New and Renewable Energy, among others. The NSC-ICM will meet at least once every three months and will assume responsibilities for various areas to govern and oversee the functioning of the CCTS. The following are the responsibilities conferred on the NSC-ICM as listed in the Notification from June 2023 (Ministry of Power, 2023):

- Recommend to Bureau for the formulation and finalisation of procedures for institutionalizing the Indian carbon market;
- recommend to Bureau for the formulation and finalisation of the rules and regulations for the functions of Indian carbon market;
- recommend to Bureau for the formulation of specific greenhouse gases emission targets for the obligated entities;
- recommend to Bureau for the formulation and finalisation of guidelines regarding trading of carbon credit certificates outside India;
- recommend to Bureau to issue carbon credit certificate;
- recommend to Bureau for the development of the process or conditions for crediting period or renewal or expiry of carbon credit certificate;
- to monitor the functions of Indian carbon market;
- recommend to Bureau to constitute any Committee or Working group as required in connection with Indian carbon market; and
- any other functions assigned to it by the Central Government.

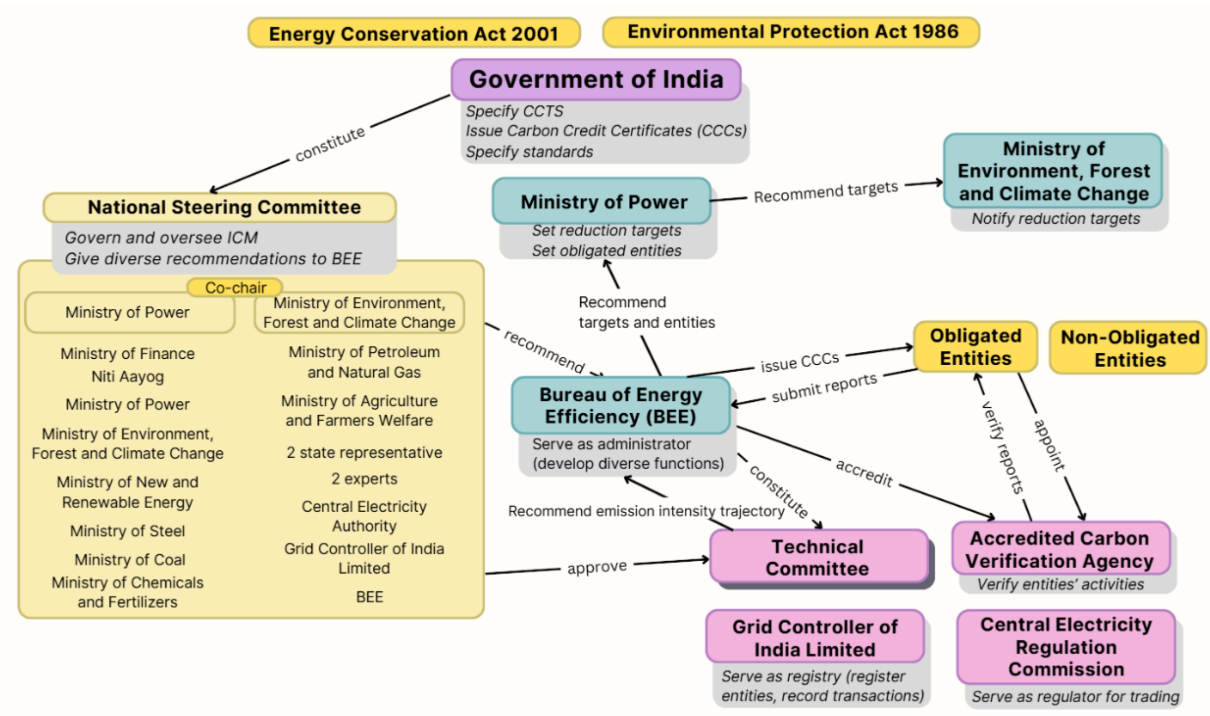
The BEE will assume various important responsibilities in the CCTS as an administrator. The following are the responsibilities conferred on the BEE (Ministry of Power, 2023):

- identify sectors and potential for reduction of greenhouse gases emissions in such sectors and recommend to the Ministry of Power to include such sectors in Indian carbon market;
- develop trajectory and targets for the entities under compliance mechanism;
- issue the carbon credits certificate based on the recommendation of the National Steering Committee for Indian carbon market and subsequent approval of the Central Government;
- develop market stability mechanism for carbon credits
- develop the procedure for accreditation and functions of accredited carbon verification agency;
- accredit the agencies in accordance with the approved procedure for accredited carbon verification agency;
- determine, the fees and charges payable by the registered entities with the approval of Central Government, for the purposes of meeting the cost and expense towards the implementation of this Scheme;
- develop the process or conditions for crediting period or renewal or expiry of carbon credit certificates;
- develop data submission formats, forms for effective functioning of Indian carbon market;
- undertake capacity building activities for the stakeholders;
- develop and maintain the information technology infrastructure including the user guidance platform required for Indian carbon market;
- maintain secure database with all security protocols as approved by the Central Government;
- constitute any Committee or working group as recommended by the National Steering Committee for Indian carbon market; and
- any other functions assigned to it by the Central Government.

Figure 6-1 depicts the relevant stakeholders and their relationships in the operation of the CCTS compliance mechanism. The administrator will be the BEE, and the NSC-ICM, constituted by the Government of India, will give recommendations on multiple aspects including regulations, GHG reduction targets, and the issuance of CCCs. However, the NSC-ICM comprises various ministries that have diverse and often competing interests, including the Ministry of Power, the Ministry of Environment, Forest and Climate Change, the Ministry of Coal and the Ministry of Petroleum and Natural Gas. This complexity in the institutional structure could hinder the effective functioning of the Indian Carbon Market.

Figure 6-1

Institutional Structure of CCTS



Note. Data retrieved from Notification by the Ministry of Power announced on 28th June 2023.

The Korean ETS experienced bureaucratic conflicts before its operation. The Ministry of Environment assumed responsibility for overseeing the ETS while the then-Ministry of Knowledge Economy (later restructured into the Ministry of Trade, Industry and Energy in 2013) also regarded the ETS as falling within its purview (O'Donnell, 2012). After the ETS implementation in 2015, its institutional framework underwent restructuring in 2016. As a result, the Ministry of Finance and Strategy became responsible for the overall system operation. In addition, four ministries became responsible for the allocation of allowances and communication with stakeholders based on their sectoral scopes. Those ministries were the Ministry of Trade, Industry and Energy, the Ministry of Land and Infrastructure Transport, the Ministry of Environment, and the Ministry of Agriculture, Food and Rural Affairs. The Korean ETS experienced further restructuring in 2018. The Ministry of Environment held the overall responsibilities including overall ETS development, the allocation plan, and ETS operation (Asian Development Bank, 2018).

The choice of the BEE as a key administrator appears to stem from India's past experience with energy efficiency measures. As the CCTS is expected to evolve from the PAT scheme, which is an energy efficiency improvement policy, the BEE's assumption of responsibility may allow for a smooth transition. Additionally, the BEE likely has better experience in specifying targets and communicating with stakeholders based on these past experiences. However, given that the CCTS should be a policy supporting the country's climate objectives, it must function as more than just an energy efficiency program. Thus, doubts arise regarding BEE's roles, particularly in the long term. Furthermore, since the NSC-ICM, which recommends a variety of critical elements of the CCTS, comprises very diverse stakeholders, it is uncertain whether the CCTS can implement ambitious targets and effectively contribute to achieving climate goals. Frequent changes in responsibilities, as seen in the case of the Korean ETS, might hinder the effectiveness of the ETS or confuse stakeholders. Therefore, it is essential to streamline the institutional structure to enhance clarity and efficiency.

7 Discussions of results

7.1 Key findings

The objective of this study is to help accelerate GHG emission reductions in India by analyzing the existing policy measures using market mechanisms and by exploring the conditions underpinning India's CCTS effectiveness. To achieve this, the main research question is formulated as: *What are the effects of carbon pricing on GHG emission reductions in India in the past, present and future?* To solve this main research question, there are three sub-research questions. Key findings for each sub-research question are listed below:

Research Question 1

- How have India's climate policies, using market mechanisms, been implemented and what is their future prospect?

- **Clean Energy (Environment) Cess and GST Compensation Cess**

In 2010, the Clean Energy Cess was implemented to levy a tax on domestic coal production and imported coal with the aim of financing and promoting clean energy initiatives. It was levied at a rate of INR 50 per tonne of coal at the onset of the cess in 2010. Subsequently, the tax rate was raised to INR 100 in 2014, then to INR 200 in 2015, and finally reached INR 400 in 2016. Although the National Clean Energy and Environment Fund (NCEEF) was founded to earmark revenue from the cess, only 45% of the cess collected was transferred to the NCEEF. Furthermore, even out of the amount transferred to the NCEEF, only about 50% was ultimately used to fund projects, meaning that only 24% of the total cess was utilized for its original objective. In 2017, alongside the introduction of the Goods and Service Tax (GST), the GST Compensation Cess was introduced, and the Clean Environment Cess was subsumed under the GST, and the NCEEF was abolished accordingly. However, coal production remained subject to the GST Compensation Cess, with the tax rate maintained at the same rate of INR 400 per tonne.

- **Perform, Achieve and Trade**

Perform, Achieve and Trade (PAT) was implemented to enhance cost effectiveness of improvements in energy efficiency in energy-intensive industries through certification of energy savings that could be traded. In the PAT scheme, specific energy-intensive industries in selected sectors are identified as Designated Consumers (DCs). These DCs are obliged to achieve energy efficiency targets set by the Bureau of Energy Efficiency. A key feature of the PAT scheme is the issuance of Energy Saving Certificates (ESCerts). This certification allows DCs to sell or buy their energy saving excess or shortage. However, the PAT scheme has faced some criticism concerning its effectiveness. The main critique is that the targets set for the DCs are not strict enough to induce energy efficiency improvement measures among DCs, and major improvement is due to increased energy costs instead of the PAT scheme. Additionally, the lack of clear rules and long-term goals in the scheme has been pointed out. Moreover, the penalties are set too low for the DCs to give enough compliance motivation.

- **Carbon Credit Trading Scheme**

In 2022, an amendment to the Energy Conservation Act was passed into law in India. A key decision made in the amendment bill is the creation of the Carbon Credit Trading Scheme (CCTS). India has also started to work on creating institutional and regulatory frameworks for the scheme. Alongside this compliance mechanism, the country is also working on offset mechanisms. The sub-research question 3 elaborates on the development and design of the CCTS.

- **Power market dynamics**

India's power market is highly regulated, which influences the original intent of policies targeting at reducing GHG emissions. Considering the country's rapid economic growth and soaring energy demand, it is crucial for the country to secure stable and affordable electricity domestically. This has triggered some policy reactions in the power market in India. A key example is long-term power purchase agreements (PPAs) between electricity generators and distribution companies (DISCOMs). In India, DISCOMs typically sign long-term PPAs with electricity generators. Since DISCOMs are obliged to fulfil the contract, and power generators cannot adjust prices in response to policies affecting the cost of power generation. Additionally, to ensure energy security and affordability, state governments provide DISCOMs with subsidies at varying rates based on consumption categories, enabling DISCOMs to distribute electricity at lower prices.

Research Question 2	• What is the effect of the Clean Energy (Environment) Cess and the following GST Compensation Cess on CO_2 emissions?

- **Main analysis**

To analyze the impact of the Clean Energy (Environment) Cess on emissions, the synthetic control method (SCM) was employed. Synthetic India was constructed using relevant predictors from 23 countries to estimate the impact of the cess. The smallest mean squared prediction error (MSPE) allowed for creating the best possible synthetic India, with CO_2 emissions from coal index and GDP index selected as predictors. In this analysis, Bangladesh received the highest weight of 29%. The SCM results suggested that India's emissions exceeded those of synthetic India until 2014, but the trajectories reversed in 2015. The average treatment effect on the treated (ATT) was -9.55, with an in-place placebo test providing a p-value of 0.04. However, both the in-time placebo test and the leave-one-out test indicated that the main result is not sufficiently robust. This prompted further robustness checks.

- **Robustness**

To further assess the robustness of the main result, the selection of countries in the control group was reexamined. One major issue was the unexplained sharp decline in emissions in 2016, which was attributed to Bangladesh's data. Due to the absence of reliable data, the country was excluded from the control group. Subsequently, the Chow test revealed that China, Egypt and Vietnam also experienced significant changes in emissions trajectories before and after 2010. As a result, those countries were also removed from the control group. After the removal of four countries, the SCM was conducted using different sets of predictors. While none of the iterations produced statistically significant results, the overall findings implied that the rise in the tax rate might have an effect on CO_2 emissions from coal. However, multiple confounders such as the PAT scheme and power market dynamics might have also impacted emissions. Ultimately, the analysis did not yield sufficient evidence to support the effect of the tax rate increase.

Research Question 3	• What characteristics will be key in the design of an effective CCTS to drive emissions reductions?

- **Current CCTS design**

The Government of India delegates the task of the CCTS development to the Bureau of Energy Efficiency (BEE). At the beginning phase of India's CCTS, nine sectors are brought under the covered sectors: aluminium, cement, chlor-alkali, fertilizer, iron and steel, pulp and paper, textile, petro-chemical, and petro-refinery. All of those sectors have been covered under the PAT scheme. However, the highest-emitting power sector is excluded from the covered sectors. India's compliance CCTS is designed to be a baseline-and-credit system where covered sectors receive emissions baselines, which represents the amount of emissions they are allowed to emit. If their emissions fall below the baseline, the difference can be converted into credits. If obligated entities' actual emissions are below the target, they can sell the reduced amount as Carbon Credit Certificates (CCCs). In case entities exceed the target, they will need to buy CCCs or use CCCs banked from previous years. While the exact targets for the obligated entities have not been announced yet, the targets in the CCTS will be intensity-based, calculated by total GHG emissions divided by total equivalent output. As part of Monitoring, Reporting and Verification (MRV), obligated entities are required to create and submit a monitoring plan and a performance assessment document with verification to the BEE. Those documents include information such as monitoring methodology and energy consumption data as well as the achieved GHG emissions intensity and the number of CCCs issued or surrendered. India's CCTS will start as a voluntary mechanism first in April 2025. This will provide relevant sectors with time to learn and adapt to the system. Non-obligated entities can register projects that reduce, remove or avoid emissions to issue CCCs. This voluntary mechanism is aimed at incentivizing emissions reductions in sectors not covered by the compliance CCTS. The BEE has notified the approved sectors for participation in the voluntary mechanism including energy, agriculture, forestry, transport, and CCUS, among others.

- **Key elements**

Intensity-based cap, penalty and institutional structure were identified as key elements. India's target setting in the compliance CCTS will be an intensity-based one. Given India's need for economic growth and its growing energy demand, the decision to use intensity-based targets reflects a balance between meeting energy needs and reducing emissions. This approach also aligns with India's NDCs updated in 2022, which includes a target to reduce emissions intensity per unit of GDP by 45% by 2030, compared to 2005 levels. Additionally, a gradual implementation that allows entities to gain experience is a sound approach for initiating the CCTS. However, obligated entities can increase their production levels as long as their emissions intensities are lower than the target. As a result, while energy efficiency may improve and the target may be achieved, the overall reduction in emissions may remain uncertain. While India has not clarified its potential transition to absolute targets, it would be advantageous for the country to consider such a shift. Given that absolute targets are generally more efficient and less resource-intensive compared to intensity-based targets, once the covered sectors gain experience in the CCTS and compliance is ensured, moving towards absolute targets could facilitate the achievement of India's climate targets. Furthermore, to enhance emissions reductions among entities, it is also essential that targets be progressively tightened.

When entities covered under ETSs consider emission reduction measures, they also take potential penalties for non-compliance into account. Thus, they calculate the sum of abatement costs and potential penalties and make decisions by minimizing the total cost. If the estimated penalties are too low, covered entities are likely to just continue emitting and simply pay the penalty as it would be the most cost-effective option for them. This undermines the ETS effectiveness, so implementing an appropriate level of penalties is integral to the proper functioning of ETSs. While the exact amount of penalties for the compliance CCTS has not yet been determined, it is important to set appropriate penalties to motivate obligated entities to comply with the emission reduction targets.

There are multiple key stakeholders in the decision-making process of the CCTS. The administrator will be the BEE, and the Ministry of Power has the responsibility to set GHG emission intensity reduction targets, taking into account the recommendations from the BEE and the National Sterring Committee for Indian Carbon Market (NSC-ICM), which comprises various ministries that have diverse and often competing interests. This complexity in the institutional structure could hinder the effective functioning of the Indian Carbon Market. The choice of the BEE as a key administrator appears to stem from India's past experience with energy efficiency measures. However, given that the CCTS should be a policy supporting the country's climate objectives, it must function as more than just an energy efficiency program. Thus, doubts arise regarding the BEE's role, particularly in the long term.

Lastly, while the inclusion of the power sector is critically important, the discussion was not provided as it is beyond the scope of this study.

7.2 Limitations

Analysis of the impact of the Clean Energy (Environment) Cess using the synthetic control method has critical limitations. The main analysis suggested that the policy had an impact on CO_2 emissions from coal. However, the following robustness tests revealed that this result is not robust enough to be supported, and the results turned out to be sensitive to a change in country selection and predictor choice. As discussed in Chapter 5, although the price hike in the coal cess might have influenced emissions from coal, multiple potential confounders must be considered. One such factor is the PAT scheme, a policy that India implemented in 2012 to improve energy efficiency in energy-intensive sectors. Among the sectors covered by this scheme is the thermal power plant sector. While some studies point out that the policy did not provide sufficient incentives for the sector to accelerate energy efficiency improvements, it may still have had some impact on CO_2 emissions from coal. Additionally, since 2014, India has introduced policies to promote renewable energy deployment. The growing share of renewable energy could have contributed to reducing reliance on coal. Thus, the observed slowdown in emission growth might, at least in part, be attributed to the expansion of renewable energy.

It is also worth noting that several factors counteract the intended effects of the coal cess. As discussed in Chapter 4, the dynamics of the country's power market play a crucial role. Due to certain power market regulations, cost-passthrough is often challenging to achieve. Furthermore, the government still provides subsidies for fossil fuels including coal. Coal subsidies amounted to INR 150 billion in the form of concessional excise duty, a figure comparable to the revenue collected from the coal cess.

Furthermore, the synthetic control method has inherent limitations when analyzing the impact of a certain policy. In the context of climate policy, each country has unique characteristics that could affect emissions. Additionally, during the 2010s, many countries implemented policies to reduce fossil fuel use and promote renewable energy while some countries expanded coal consumption to meet growing energy demands or reduce reliance on other fossil fuels. Given those unique variations among countries, constructing a suitable synthetic control group using other countries can be particularly challenging.

Regarding analysis of the development of the carbon credit trading scheme (CCTS) discussed in Chapter 6, the ongoing nature of the policy made analysis challenging. The Indian government and relevant bodies, namely the Ministry of Power and the Bureau of Energy Efficiency, are in the process of drafting and finalizing the policy design, thus it is often challenging to follow the latest discussions and decisions. While I tried my best to stay updated, it is important to acknowledge that some information outlined in this study may not reflect the most recent developments.

Furthermore, one of the most critical discussions of the current development of CCTS is the inclusion of the power sector. As the power sector accounts for the largest share of emissions in India, including the sector in the new scheme is crucial. However, the government's current design does not incorporate the sector in the CCTS. Thus, the discussion of the inclusion of the power sector is of critical importance to secure policy effectiveness and harness emissions reductions. However, since the discussion consists of diverse backgrounds and arguments, including the discussion in this study is outside the scope of this study.

7.3 Further research

There is significant room for improving the synthetic control method, which could not be fully explored within the time constraints of this study. Firstly, the selection of covariates for constructing Synthetic India can be refined. Although relevant predictors were chosen using the established Kaya identity, alternative covariates may better predict emissions from coal. As the main analysis and subsequent robustness checks indicated, adding absolute values alongside indexed values alters the emissions trajectory. Since both the choice of predictors and their treatment (e.g., using absolute vs. indexed values, taking the average or selecting specific years) greatly influence the results, exploring further approaches could enhance the quality of the analysis.

Furthermore, extending the pre-treatment period could help construct a better synthetic control group. As the policy of interest was implemented in 2010, and the pre-treatment period starts in 2000, only ten years (2000–2009) are available for constructing the synthetic control model. A longer pre-treatment period would allow for the effective use of cross-validation. Cross-validation is a method that divides the pre-treatment period into two (a training period and a validation period), and computes weights for the control group and covariates using only the training period, and selects the combination that minimize the MSPE in the validation period (Abadie, 2021). Furthermore, a longer pre-treatment period allows for conducting a t-test to examine the significance of the ATT. Chernozhukov et al. (2018) proposed a K-fold cross-fitting procedure to make inferences on ATT using a t-test. This procedure involves dividing the pre-treatment period into K folds. K=3 is generally recommended when the pre-treatment period is small. When applied to this study, the pre-treatment period is divided into three folds. For each fold, synthetic controls are constructed by taking one fold as the training set and the remaining folds as the validation set. When K=3, three ATT estimates are obtained, and their average is calculated. The averaged ATT obtained from this procedure yields a p-value, which allows for determining statistical significance.

A broader consideration of the impact of transitioning away from coal is also crucial. While it is critically important for the country to drastically curb emissions, it remains a significant challenge. India still heavily relies on fossil fuels, particularly coal, which accounted for 45.9% of its total energy supply and 72.0% of its electricity generation in 2022 (International Energy Agency, n.d.). It is worth noting that a large portion of the population relies on coal production for their livelihoods. Therefore, a thorough analysis of both the potential benefits and the costs of transitioning away from fossil fuels will be essential for the country.

As discussed in the limitations section, the inclusion of the power sector in the CCTS is a critically important issue. The government’s current plan is to exclude the sector from the new scheme. However, since the power sector accounts for the largest share of the country’s GHG emissions, its inclusion in the CCTS would significantly influence the policy’s effectiveness. To strengthen the policy, it is crucial to examine the benefits and challenges of bringing the sector under the CCTS. Given the highly regulated and subsidized nature of the power sector, this discussion would inevitably involve complex power market reforms.

Lastly, the Indian government should consider generating revenue from the CCTS and designing elements to ensure that these funds are utilized to invest in low-carbon technologies. Allowing the CCTS to generate revenue would help the government accelerate investments in low- carbon projects. A key lesson learnt from the Clean Energy (Environment) Cess was that while the National Clean Energy and Environment Fund was created, the revenue collected from the cess was not sufficiently directed to the fund, and the fund itself did not adequately invest in clean energy projects. To avoid repeating this issue, it is crucial to recommend key design elements that ensure the proper utilization of revenue.

8 Conclusion

This study attempted to answer the research question: *What are the effects of carbon pricing on GHG emission reductions in India in the past, present and future?* India has experienced rapid economic growth and is expected to continue on this trajectory. Its rising population and fast-paced economic growth present the challenge of balancing rising energy demand with energy security and affordability while simultaneously fostering economic growth and lifting people out of poverty. In the midst of these challenges, India's climate goals play a critical role.

To address the main research question, this study examined three key policies: the Clean Energy (Environment) Cess, the Perform, Achieve and Trade (PAT) scheme, and the Carbon Credit Trading Scheme (CCTS). The first two policies were implemented in the early 2010s to curb emissions from coal and energy-intensive industries. Since then, coupled with renewable energy policies, particularly solar power, renewable energy capacity has grown exponentially. Yet, coal remains dominant, accounting for the largest share of the country's energy mix. Even though the Clean Energy (Environment) Cess aimed to channel revenue from the cess toward clean technology investments, the National Clean Energy and Environment Fund, which was established to earmark revenue, was not leveraged to its full potential. The PAT scheme deployed market mechanisms by allowing the trading of credits earned through energy efficiency improvements. However, critics argue that its targets were too lenient to foster further improvement in energy efficiency.

To assess whether the coal cess had an effect on CO_2 emissions, a topic rarely explored, I applied the synthetic control method to test the causal relationship between the cess and CO_2 emissions. This analysis involved constructing synthetic India and comparing its emissions with actual emissions from India between 2000 and 2018. However, this study did not find clear evidence that the policy had an effect on reducing CO_2 emissions. Yet, the main result and subsequent robustness checks could imply that the increases in the tax rate after 2014 might have had an impact on CO_2 emissions from coal.

Furthermore, this study examined the current development of the compliance CCTS in the Indian Carbon Market. Although the development is an ongoing process, India is on a path to accelerating emissions reductions in a cost-effective manner. The compliance CCTS is designed as a baseline-and-credit system with intensity-based targets for the obligated entities. It is expected to cover nine energy-intensive sectors covered in the PAT scheme. However, its effectiveness is already in question as the high-emitting power sector is excluded from the covered sectors. Alongside the compliance CCTS, India will initially introduce a voluntary mechanism in April 2025. This will provide relevant sectors with time to learn and adapt to the system.

The findings of this study have implications for policymakers in India as well as other emerging economies: price levels of carbon pricing, revenue utilization, and strong enforcement mechanisms such as proper penalties and institutional structure. As the SCM analysis implied, the price level of carbon pricing influences its effectiveness in driving emissions reductions. If the price is set too low, it fails to provide sufficient incentives for participants. Revenue utilization is another key factor. Among the benefits of carbon pricing, it can not only foster emissions reductions but also raise revenue, a concept known as the double dividend. Revenue collected from the policy can be utilized either for investing in clean technologies or for compensating communities negatively affected by the policy. However, as seen in India's coal cess experience, poor design in revenue collection, earmarking, and allocation can limit these potential benefits. Lastly, strong enforcement mechanisms are essential to ensuring carbon pricing achieves its intended goals. A lack of proper penalty systems may discourage participants from complying with the policy. An overly complex institutional structure may hinder the proper functioning of the policy at the administrative level.

Carbon pricing is either in force, under development or under consideration in a growing number of countries and jurisdictions. Policymakers must learn from international experiences gained over the past decades and collaborate with stakeholders to design and implement effective carbon pricing that drives emissions reductions. This effort will be a critical component of achieving the global goal of limiting temperature rise to less than 2.0 degrees Celsius while pursuing efforts to 1.5 degrees as set in Paris Agreement.

9 Use of generative artificial intelligence (GenAI)

During this study, I used generative artificial intelligence (GenAI) tools. GenAI tools used in this study are ChatGPT, Copilot, and NotebookLM. ChatGPT and Copilot were used to check grammar and improve the natural flow of English, identify relevant literature and data sources and generate ideas for coding scripts in R for the synthetic control analysis. NotebookLM was employed to summarize documents and extract key points efficiently.

10 References

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