



The impacts and incentives inherent in
destination-based carbon pricing
- An Indian Case study

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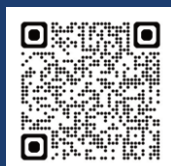
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Citation:

Please cite this publication as follows: UNFCCC-KCI. 2026. The impacts and incentives inherent in destination-based carbon pricing: An Indian case study. Bonn: UNFCCC. Available at <https://unfccc.int/documents/656965>.

This publication is also available in digital format:





United Nations Climate Change
Katowice Committee on Impacts

The impacts and incentives inherent in destination-based carbon pricing

An Indian case study

Mandate description

This work is an output of the implementation of activity 12 of the workplan of the forum on the impact of the implementation of response measures and its Katowice Committee of Experts on the Impacts of the Implementation of Response Measures.¹

Activity 12: Develop a case study in each of the five United Nations regions in accordance with activity 7 of the workplan.

Acknowledgement

The Katowice Committee of Experts on the Impacts of the Implementation of Response Measures extends its appreciation to stakeholders who provided inputs for preparing this report. The individuals below contributed in their expert capacities and their affiliations are only mentioned for identification purposes.

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¹ Activity 12 arose from the outcomes of the midterm review of the workplan of the forum on the impact of the implementation of response measures and its Katowice Committee of Experts on the Impacts of the Implementation of Response Measures, contained in annex II of decisions 4/CP.25, 4/CP.15 and 4/CMA.2.

Preface

By the Co-chairs of the Katowice Committee of Experts on the Impacts of the Implementation of Response Measures

As climate ambition accelerates globally, response measures adopted in one set of countries are increasingly shaping production structures, competitiveness and development prospects elsewhere. At the same time, the impacts experienced by any one country are shaped not only by external policies, but also by how that country and other affected countries respond over time. Understanding these dynamics is therefore essential for designing policy responses that minimize risks and maximize potential opportunities.

This India case study explores a hypothetical situation in which India's major export destinations—Canada, the European Union, Japan, Oceania (including Australia), the United Kingdom and the United States—introduce destination-based carbon pricing, together with the responses of other affected countries, can influence national outcomes in India. For a large and diverse developing economy such as India, these interactions can generate both challenges and incentives that shape employment outcomes, industrial transformation and long-term development trajectories. Using a quantitative analytical approach based on a global computable general equilibrium (CGE) model, the case study assesses the resulting economic and social impacts on India, focusing on key transmission channels such as production, trade and employment.

The analysis demonstrates that outcomes are shaped not only by the design of external response measures themselves, but also by the timing and ambition of domestic climate action. In this context, proactive mitigation efforts can play an important role in reducing adverse impacts while strengthening longer-term competitiveness and resilience.

This country-specific case study contributes to the work of the Katowice Committee of Experts on the Impacts of the Implementation of Response Measures by providing an assessment of cross-border impacts from the implementation of external response measures in the context of India. While grounded in national circumstances, the analytical approach and insights presented may be relevant for other developing countries facing similar impacts. By presenting policy-relevant insights, the case study support informed decision-making and the exchange of experiences on assessing impacts of response measures under the Convention, the Kyoto Protocol and the Paris Agreement.



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Contents

1	Introduction	1
2	Data	3
2.1	Model database	3
2.2	Base data: carbon content by sector and region	5
2.3	Carbon pricing	8
3	Model and scenario	11
3.1	Model description	11
3.2	Scenarios	16
3.2.1	Reference scenarios	17
3.2.2	Policy scenario - BCA	21
3.2.3	Closures	23
4	Results	25
4.1	Global macro effects	25
4.2	Effect on production in India	28
4.3	Effect on households in India	32
5	Conclusions	35
	References	37

Abbreviations and acronyms

BCA	border carbon adjustment
CES	constant elasticity of substitution
CET	constant elasticity of transformation
CGE	computable general equilibrium
CO₂	carbon dioxide
CO₂ eq	carbon dioxide equivalent
EU	European Union
GDP	gross domestic product
GHG	greenhouse gas
GTAP	Global Trade Analysis Project
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
OECD	Organisation for Economic Co-operation and Development
RS	reference scenario
SAM	social accounting matrix
SSP	shared socioeconomic pathway



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Introduction

1

The issue of quantifying the impacts of the implementation of response measures has been well studied. However, there has been relatively little dynamic analysis that takes into account the adaptive response of the impacted countries.

This study uses computable general equilibrium (CGE) models to assess the impacts or incentives a large, complex developing economy (India) faces in relation to destination-based carbon pricing from key developed country markets.

The case study will analyse the impact of destination-based carbon pricing implemented in Canada, EU, Japan, Oceania, UK and USA in four different reference scenarios (RS for specific scenarios such as RS1). The scenarios assume early decarbonization for developed economies that implement destination-based carbon pricing.

The hypothesis is that, while response measures such as destination-based carbon pricing would have significant economic and social impacts for developing country exporters such as India, there are important incentives for those exporters to achieve decarbonization in a world where such response measures are more widespread.

Section 2 describes the data used in this study and details carbon content by sector and region. Section 3 describes the employed model and scenarios. Modelling results are presented in section 4 and the conclusions of the study in section 5.



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Data

2

2.1 Model database

The model uses data from the Global Trade Analysis Project (GTAP) circular economy v11 database (Aguar et al., 2023) for the year 2017. The data is organized in a social accounting matrix format and aggregated to reflect 24 regions and 43 sectors, detailing eight power generation activities, as shown in table 1.

Emission data are sourced from GTAP 11 satellite data. Emissions are distinguished by fuel and by user for the regions in the GTAP 11 circular economy database. Data on CO₂ emissions from fossil fuel combustion are based on extended energy balances compiled by the International Energy Agency. In GTAP 11, emissions accounting is based on the tier 1 methodology from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IEA 2019).²

² Please refer to Chepeliev (2024) for a detailed documentation on the emission accounting applied in the GTAP database.

Table 1. Model aggregation

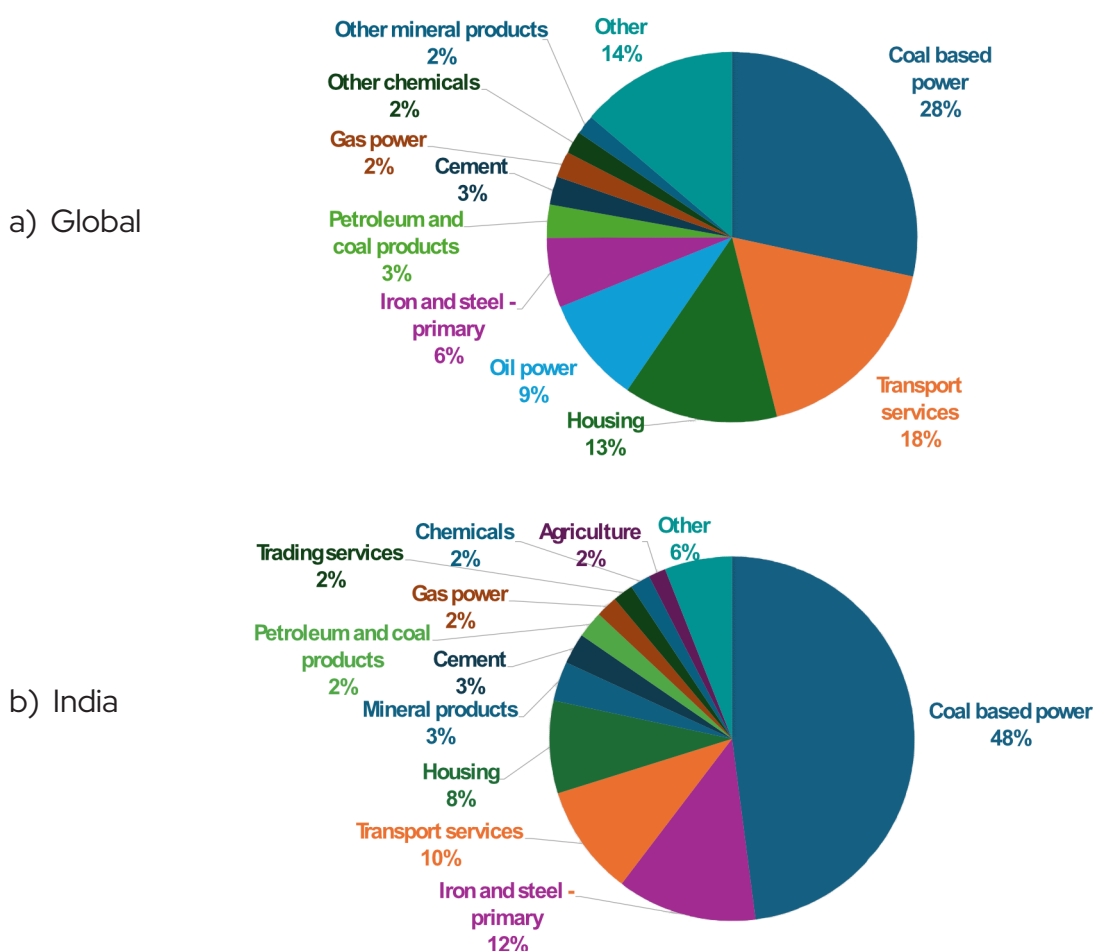
Regions:	
India	Rest of South America
China	Rest of Central America
Japan	European Union
Other High Income Asia	United Kingdom
South-East Asia	Rest of EFTA*
Rest of South Asia	Russia
Oceania	Rest of Eastern Europe
Canada	High Income Middle East
United States of America	North Africa
Mexico	Rest of Africa
Brazil	South Africa
High Income South and Central America	Rest of the World
Sectors:	
Agriculture	Computer, electronics and equipment
Coal	Other machinery and equipment
Oil	Motor and transport vehicles
Gas	Other manufacturing
Mining of minerals	Electricity transmission and distribution
Food processing	Nuclear power
Textiles	Coal power
Wood and paper products	Gas power
Petroleum and coal products	Oil power
Fertiliser	Wind power
Other chemicals	Hydroelectric power
Basic pharmaceutical products	Solar power
Rubber and plastics	Other power
Cement	Gas manufacturing and distribution
Other mineral products	Water
Iron and steel - primary	Construction
Iron and steel - secondary	Trading services
Recycling - iron and steel	Transport services
Iron and steel casting	Business services
Aluminium	Public services
Other metals	Other services
Metal products	

*EFTA: European Free Trade Association

2.2 Base data: carbon content by sector and region

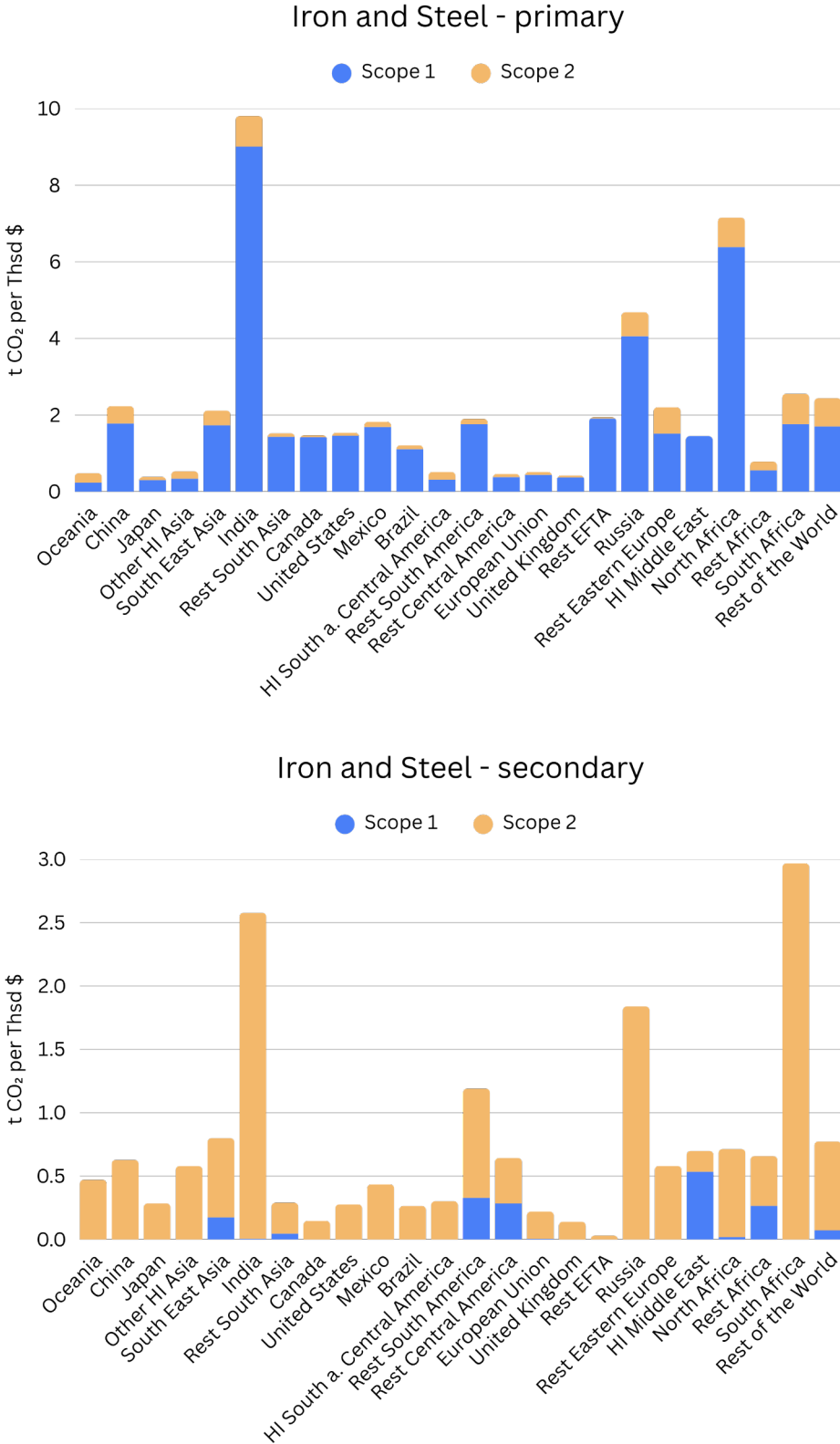
The GTAP database reports CO₂ emissions by region and sector. Figure 1 depicts the distribution of emissions across sectors on a global level and for India. Coal-based power generation is responsible for the biggest share of emissions: 28% of global and 48% of India's CO₂ emissions in 2017. Primary iron and steel production accounts for 12% of India's emissions, which is more than the global average of 6%. Transport services (air, water and land) are responsible for another 10% and housing for 8% of India's emissions.

Figure 1. CO₂ emissions by sector in 2017



Steel is an important export commodity for India: in 2017, 22% from primary and 35% from secondary production were exported. As a result, Indian steel production is highly vulnerable to trade policies. The emission intensity of primary and secondary steel production, that is, CO₂ emissions per unit of output, is high for India compared with other regions (figure 2). While the emission intensity of secondary steel production is considerably lower than that of primary steel production, scope 2 emissions, meaning emissions from electricity use in the production, are high in India compared with other regions.

Figure 2. Emission intensity of primary and secondary steel production by region



Source: GTAPv11 database



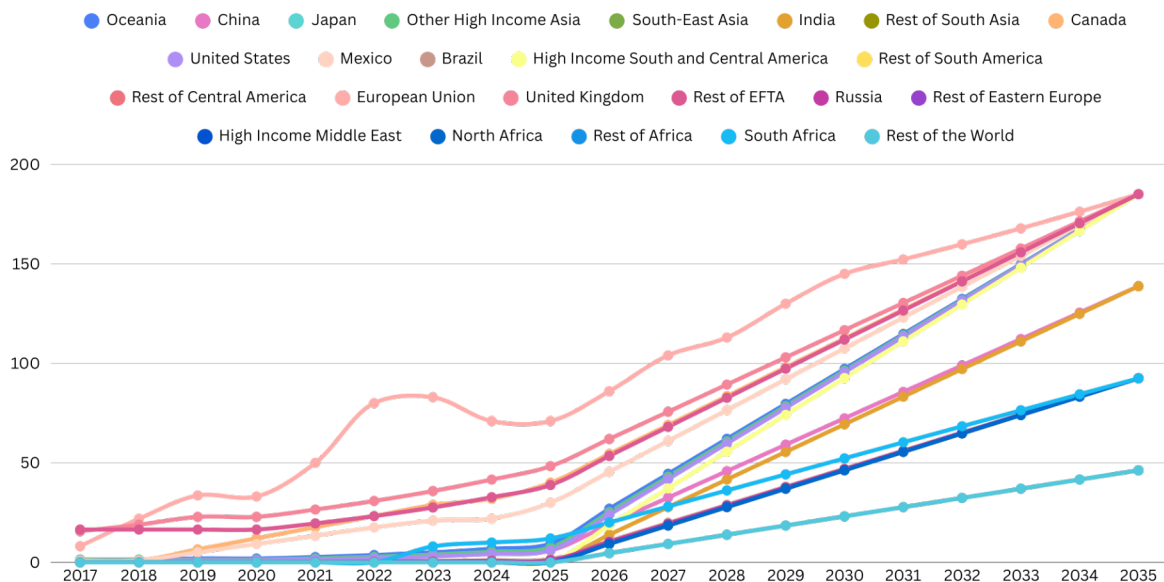
2.3 Carbon pricing

Data on emission pricing in the base year are sourced from the World Bank carbon pricing dashboard,³ which reports carbon prices and associated government revenue. These data are combined with price forecasts for EU allowances from Carbon Pulse as of January 2025, which provides a forecast until 2030. This study assumes yearly growth of EU carbon prices of 5% between 2030 and 2035.

Average carbon prices in 2017 were calculated using the revenue for model regions by mapping reported revenue from World Bank data to the appropriate model region. This revenue is divided by carbon emissions reported in the GTAP database in the sectors targeted by the respective policy scheme. For 2017–2035, the EU price forecast (Carbon Pulse) served as a target. This study assumes a graded convergence of carbon prices as follows (figure 3):

- Organisation for Economic Co-operation and Development (OECD): full convergence to EU prices until 2035;
- China: 75% convergence until 2035;
- Middle-income and Middle East: 50% convergence until 2035;
- Low-income countries: 15% convergence until 2035.

Figure 3. Carbon prices in the business-as-usual scenario in euros per tonne of CO₂



Source: Carbon Pulse (2025) and expert assumptions

³ <https://carbonpricingdashboard.worldbank.org> data retrieved in May 2022.

Prices for 2020 are based on price changes reported in World Bank data. Regions with existing carbon prices in 2020 start to catch up from 2020 onwards, while those without existing carbon pricing schemes start catching up in 2025, just before the Carbon Border Adjustment Mechanism is simulated to enter into force (2026).



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Model and Scenario

3

3.1 Model description

The study uses a global CGE model (GLOBE, Thierfelder 2024), calibrated with an augmented version of the GTAP circular economy database.⁴ The model links regions through bilateral trade relationships and current account transactions. The model allows for substituting between different energy inputs in production, such as fossil fuels and electricity. The production of commodities involves CO₂ emissions (GTAP satellite data) which can be subject to emission taxes. The recursive dynamic mode of the model is used, which includes endogenous updating of physical capital stocks with partial adjustment to returns by activity and region on capital between solutions.

CGE models are well suited to analysing ‘what if?’ questions, that is, the scenario-based approach allows for ex ante analysis. This type of model highlights the importance of linkages between sectors and agents (producers, workers, consumers, government, trade partners) and incorporates unique features of an economic system. CGE models are constructed for policy impact analysis and are especially useful for analysing the effects of policies, particularly those that affect multiple sectors or regions or result in behaviour changes.

The model consists of a series of single-country CGE models, linked through trade relationships. The model is linear, homogeneous of degree zero in prices, and each region has its numeraire and an effective exchange rate that is defined relative to an exchange rate index of reference regions.⁵

⁴ Please refer to the technical model documentation for a full genealogy and detailed description of the underlying model.

⁵ Please refer to Robinson (2004) and Lemelin (2017) for a detailed explanation of implications.

Production is depicted by nested constant elasticity of substitution (CES) and/or Leontief production functions, assuming profit maximization. Leontief technology is used between aggregate primary inputs and aggregate intermediate inputs, with CES production functions over primary inputs and Leontief technology across intermediate inputs. Aggregate primary inputs are formed by labour (composite of skilled and unskilled), land, a capital–energy composite and a steel composite. The capital–energy composite is a composite of formed capital and energy, and is depicted by nested CES functions. The steel composite accommodates a high level of substitution between different types of steel in demand.

Emission intensity and export shares of steel are relatively high in India, making the iron and steel sector vulnerable to emission taxation at the border. The study therefore includes a specific focus on the iron and steel sector, detailing different types of steel production.

Households receive income from factor (labour land and capital) ownership and spend their income on consumption, having first paid income taxes and saved a fixed proportion of net income. Households maximize utility subject to preferences represented by a nested linear expenditure system, where subsistence consumption of households is selected from aggregate commodity groups (i.e. food, manufacturing, energy, construction and services). Inside these groups, commodities can be substituted depending on relative price changes.

The Armington assumption is used for trade. Exports are depicted in a two-level constant elasticity of transformation (CET) structure where the composite export commodity is a CET aggregate of exports to different regions, and aggregate export supply is a CET aggregate of regions. The distribution of exports between regions is, therefore, determined by the relative export prices. Consequently, domestic producers respond to prices in different markets.

Domestic final demand is composed of aggregate imports and domestic supply, the composition is based on relative prices using CES technology. CES technology is also used to form aggregate imports from different regions. A special feature allows for applying Leontief technology to prevent disproportionate effects of small trade flows.

Government receives income from taxes that are mostly expressed as ad valorem taxes, while income taxes are defined as fixed proportions of household incomes. Government expenditure consists of commodity demand, which is assumed to be in fixed proportions, and government saving is defined as a residual.

Total savings come from households, the internal balance on the government account, and the external balance on the trade account. The external balance is defined as the difference between the value of total exports and total imports, converted into domestic currency. Expenditures from the capital account consist solely of commodity demand for investment.

The model includes a regional carbon tax and related emissions. This carbon tax is levied on the CO₂ emissions associated with inputs in the production process and those associated with household consumption.

Border carbon adjustment instrument

The model includes a border carbon adjustment (BCA) as a policy instrument, allowing for choices between characteristics such as sector coverage, scope of emissions included and revenue transfers. The BCA is implemented as a specific import tariff depending on the embedded CO₂ content of imported goods.

The import carbon tax rate $TMCARBA_{w,c,r}$ enters the import price equation as a specific tax.

$$PMR_{w,c,r} = [PWM_{w,c,r} * (1 + TM_{w,c,r}) + TMCARB_{w,c,r}] * ER_r \quad (1)$$

Where $PMR_{w,c,r}$ is the bilateral domestic import price of commodity c imported by region r from region w , $PWM_{w,c,r}$ the import price free on board (fob), $TM_{w,c,r}$ an ad-valorem import tariff and ER_r the exchange rate.

The BCA rate depends on the carbon content embodied in imported products ($EEmit_{w,c,r}$) and the carbon price levied on imports ($TMC_{w,c,r}$) that equals the domestic carbon price in region r and commodity c ($Tcarb_{c,r}$), accounting for existing carbon prices in the exporting region w ($Tcarb_{w,c}$).

$$TMCARB_{w,c,r} = TMC_{w,c,r} * EEmit_{w,c,r} \quad (2)$$

$$\text{Where } TMC_{w,c,r} = Tcarb_{c,r} - Tcarb_{w,c}$$

Emission scope

The BCA instrument enables the inclusion of direct and indirect emissions. The carbon content embodied in imported products c from region w in region r ($EEmit_{w,c,r}$) is determined as the sum of selected direct emissions ($CO2SCP1_{w,c}$, eq. 3) and indirect emissions ($CO2SCP2_{w,c}$, eq. 4) embedded in commodity c from region w .

Direct emissions from fossil fuel combustion embedded in commodity c are determined by CO₂ emissions ($CO2Emit_{cp,a,w}$) associated with the use of energy commodity cp employed in the production of sector a , per unit of output ($QXC_{c,w}$). The model features multiple activity commodities; thus energy is produced through a mix of power-generating activities. Carbon content embedded in electricity is represented as

average for the energy mix in a region, where variable $IOQXACQXV_{a,c,w}$ applies activities to commodities.

$$CO2SCP1_{c,w} = \sum_a (IOQXACQXV_{a,c,w} * \sum_{cp} CO2Emit_{cp,a,w}) / QXC_{c,w} \quad (3)$$

Indirect emissions include direct emissions embedded in products cp used in the production process of activity a , per unit of output ($QXC_{c,w}$). The intermediate products included in the calculation are determined by the binary parameter $scp01_ind_c(cp)$. Emissions embedded in inputs are capturing the emission mix of imported $\sum_{r2} (CO2SCP1_{c,r2} * QMR_{r2,c,w} / QQ_{cp,w})$ and domestic $CO2SCP1_{c,w} * QD_{c,w} / QQ_{cp,w}$ goods used as inputs in production $QINTD_{cp,a,w}$.

Production activities are transferred to output commodities by applying weighted averages for commodities produced through multiple activities.

$$CO2SCP2_{c,w} = \frac{\sum_a \left[IOQXACQXV_{a,c,w} * \sum_{cp} \left\{ scp01_ind_c_{cp} * \frac{\sum_{r2} (CO2SCP1_{c,r2} * QMR_{r2,c,w}) + CO2SCP1_{c,w} * QD_{c,w}}{QQ_{cp,w}} * QINTD_{cp,a,w} \right\} \right]}{QXC_{c,w}} \quad (4)$$



Dynamics

This study uses GLOBE in its recursive dynamic mode. Recursive dynamic CGE models are backward-looking, that is, decisions relating to period $t+1$ are based on the outcomes in period t . The model is solved for annual steps under the maintained assumption that agents make decisions about resource allocations at the start of the given period. These decisions are then revised on the basis of the outcomes, primarily prices, during the period to make decisions about resource allocation at the start of the next period.

Growth of the labour force and population are exogenous in the baseline. The quality of the labour supplied by each household can change. The underlying rates of growth of human capital for each household and labour type are set exogenously in the baseline scenarios.

The factor capital is assumed to be fixed within each time period; once capital stocks are committed to an activity, they can only exit that activity by depreciation and/or premature retirement. New capital stocks are allocated to each activity for period $t+1$ in shares that reflect the rates of return to capital in period t and the capital stock shares in period t . In other words, the allocation principle is one of partial adjustment.

Model strength and limitations

The strength of CGE models lies in their ability to link various markets, sectors and economies. They show how policy changes, or changes in general, affect other areas of the economic system, beyond the sector or country where the change occurs, highlighting the importance of linkages between sectors and countries. CGE models are theoretically consistent and, being based on empirical data, incorporate unique features of an economic system. CGE models are therefore suited to analysing the effects of policies that affect multiple sectors or countries or result in changes in behaviour. They are also useful for 'what if' questions in ex ante scenarios. They are used widely in international trade, public finance, regional economics and environmental economics.

CGE models have substantial data requirements, which is reflected in the database and parameters used in the model. The models require a complete and consistent database; for example, imports from country A to B need to be equal to exports from country B to A. Transactions must be reconciled as the global social accounting matrix database will deviate from national account data published by statistical offices. Global CGE models cover all sectors in all countries; hence, sector detail is limited. By covering all sectors in an economy, a CGE model may miss key features of critical sectors in a specific country.

All recursive dynamic CGE model simulations are constrained by the absence of intertemporal optimizing behaviours. It is therefore critical for users to understand the limitations of recursive dynamic CGE models despite their appeal to policymakers. CGE

models are not forecasting models and should not be interpreted as such, that is, the models cannot tell what the state of an economy will be in the future. Rather, CGE models are analytical models that provide insights into changes in economic incentives and responses by economic agents.

Underlying this argument are four points. First, whole-economy CGE models are Walrasian and hence exclude macroeconomic features such as assets and financial markets. Second, recursive dynamic CGE models explicitly adopt the principles underlying models of economic growth and implicitly assume that economies are in some form of steady state and follow some form of optimal growth path. Third, all changes in gross domestic product (GDP) and other macroeconomic aggregates not explained by changes in inputs are assumed to result from an unexplained form of productivity growth. Fourth, real-world features of economies, such as uncertainty, risk and the interplay between emotions and human economic behaviour are unknowns that cannot be identified or quantified.

While CGE models are not forecasting models, they can provide insights into forces generated by economic shocks and policy changes. Assuming there are no changes in the macroeconomy, for example in asset and finance markets, models can carve out related adjustment processes.

3.2 Scenarios

A single policy scenario, where a group of high-income regions are introducing a BCA measure, is implemented. This scenario is implemented for four different reference scenarios, as detailed in table 2.

Table 2. Matrix of reference scenarios

		Other emerging or developing countries	
		No/delayed decarbonization	Early decarbonization
India	No/delayed decarbonization	RS1: Status quo (SSP4)	RS3: Late comer (SSP1)
	Early decarbonization	RS2: First mover (SSP4)	RS4: Global action (SSP1)

3.2.1 Reference scenarios

Shared socioeconomic pathways

The reference scenarios are based on the shared socioeconomic pathways (SSPs). The SSPs are part of a framework that the climate change research community has adopted to facilitate the integrated analysis of future climate impacts, vulnerabilities, adaptation and mitigation (O'Neill et al., 2017; and Riahi et al. 2017). SSPs comprise five pathways that represent different mitigation and adaptation challenges (figure 4). The resulting impact on future development of economic variables is detailed in table 3.

This study employs two SSPs to reflect the mitigation efforts embodied in the four reference scenarios. SSP4 is used in the reference scenarios where mitigation efforts are assumed for high-income countries only, and the majority of other regions and countries are assumed as 'late comers' (RS1 and RS2):

- SSP4: Inequality – A Road Divided (low challenges to mitigation, high challenges to adaptation, O'Neill et al., 2017):

Highly unequal investments in human capital are combined with increasing disparities in economic opportunity and political power, lead to increasing inequalities and stratification both across and within countries. Over time, a gap widens between an internationally-connected society that contributes to knowledge- and capital-intensive sectors of the global economy, and a fragmented collection of lower-income, poorly educated societies that work in a labour-intensive, low-tech economy. Technology development is high in the high-tech economy and sectors. The globally connected energy sector diversifies, with investments in both carbon-intensive fuels like coal and unconventional oil, but also low-carbon energy sources. Environmental policies focus on local issues around middle- and high-income areas. Little attention is paid to vulnerable areas or global issues.

SSP1 is used to construct the reference scenarios that embody global action (RS3 and RS4):

- SSP1: Sustainability – Taking the Green Road (low challenges to mitigation and adaptation):

The world shifts gradually but pervasively towards a more sustainable path, emphasizing more inclusive development that respects perceived environmental boundaries. Management of the global commons slowly improves, educational and health investments accelerate the demographic transition, and the emphasis on economic growth shifts towards a broader emphasis on human well-being. Driven by an increasing commitment to achieving development goals, inequality is reduced both across and within countries. Consumption is oriented towards low material growth and lower resource and energy intensity. Environmental policy is

characterized by improved management of local and global issues and tighter regulation of pollutants. International cooperation is effective and institutions are effective at national and international levels.

Figure 4. The five shared socioeconomic pathways



Source: O'Neill et al. (2017)



Table 3. Economic features for different pathways

Source: O'Neill et al. (2017)

SSP element	SSP1	SSP2	SSP3	SSP4	SSP5
Growth (per capita)	High in low- and medium-income countries; medium in high-income countries	Medium, uneven	Slow	Low in low-income countries, medium in other countries	High
Inequality	Reduced across and within countries	Uneven, moderate reductions across and within countries	High, especially across countries	High, especially within countries	Strongly reduced, especially across countries
Globalization	Connected markets, regional production	Semi-open globalized economy	Deglobalizing, regional security	Globally connected elites	Strongly globalized, increasingly connected
Consumption and diet	Low growth in material consumption, low-meat diets, first in high-income countries	Material-intensive consumption, medium meat consumption	Material-intensive consumption	Elites: high consumption lifestyles; Rest: low consumption, low mobility	Materialism, status consumption, tourism, mobility, meat-rich diets



Different growth assumptions are reflected in different emission pathways (figure 5). International cooperation towards a more sustainable path, as reflected in SSP1 and embedded in RS3 and RS4, implicates higher GDP growth in India. Most importantly, in RS2, where India takes early action, the model returns quasi-constant emissions. The modelled action, however, is not strong enough to stabilize emissions in RS4, where all regions are taking coordinated measures to limit emissions. This is because this reference scenario assumes higher GDP growth rates in India. Higher GDP growth rates require more stringent climate action.

Figure 5. Emission pathways for India in million tonnes of CO₂

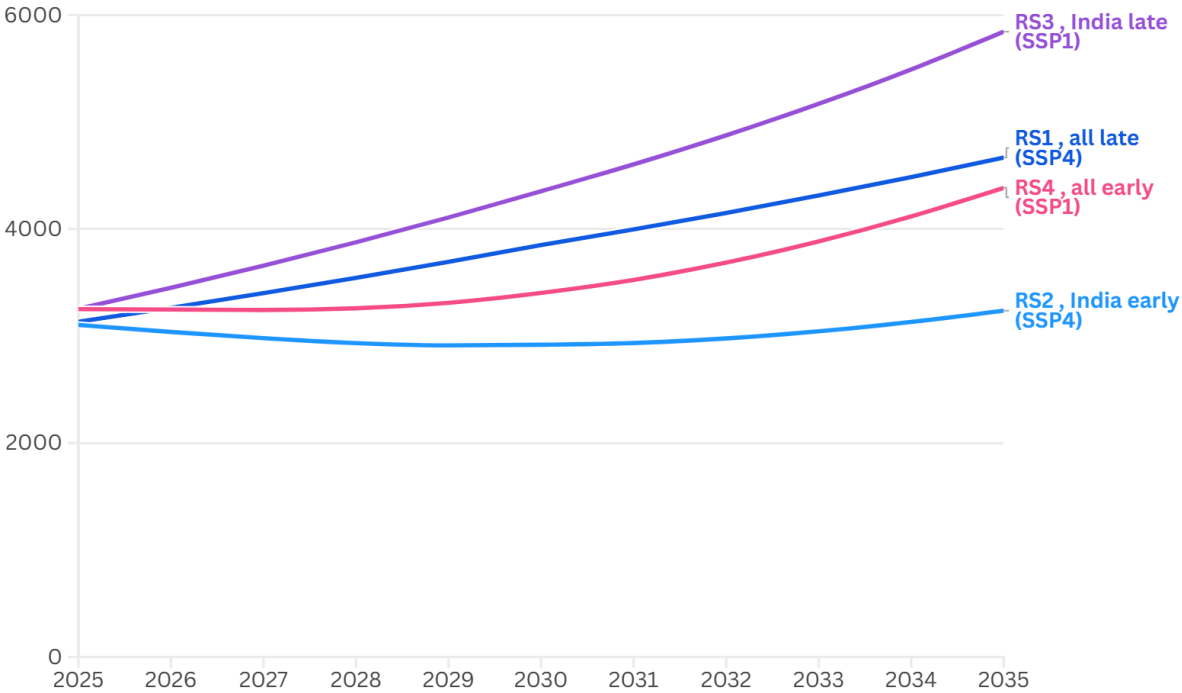
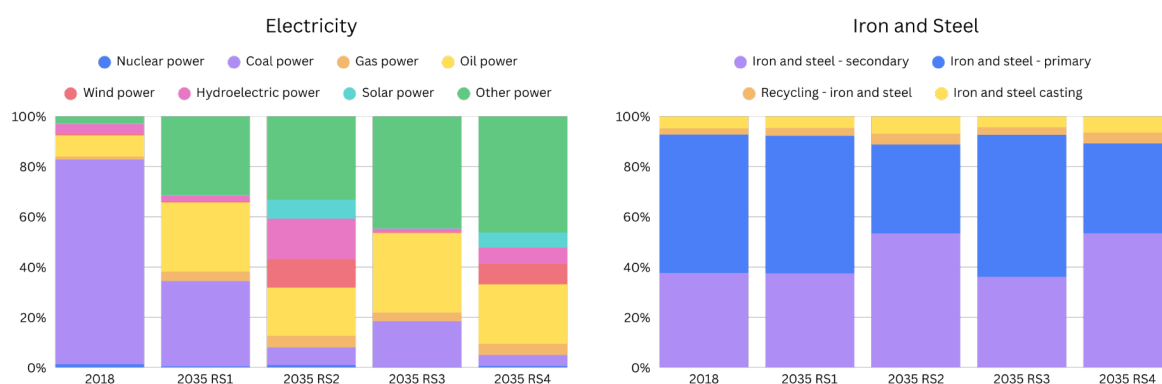


Figure 6 depicts the change in the composition of electricity and steel production from 2018 to 2035 for the different reference scenarios. In RS1 and RS3 India is assumed to delay action; the share of renewables in 2035 is lower in these scenarios than in early action scenarios (RS2 and RS4). The share of primary steel remains constant in RS1 and RS3, but decreases from 55% to 35% in RS2 and RS4, where early action is taken.

Figure 6. Composition of electricity and steel production in 2018 and in 2035 for different reference scenarios.



3.2.2 Policy scenario - BCA

The policy scenario, a BCA, implements hypothetical destination-based carbon pricing in Canada, EU, Japan, Oceania, UK and USA. It is modelled as an import tax on embedded carbon, covering scope 1 and 2 (indirect electricity) emissions. Implementing regions recognize the carbon prices of trading partners.

Covered activities for destination-based carbon pricing are:

- Basic production and casting of steel
- Production and casting of aluminium
- Manufacture of coke and refined petroleum products
- Production of cement
- Manufacture of fertilizers
- Generation of electricity

A full implementation of the BCA is assumed in 2025, with the model following a timeline until 2035.



Decarbonization instruments

The reference scenarios employ several decarbonization instruments. Specifically, a carbon price, as detailed in section 2.2, may be implemented for selected regions and countries. In addition to the activities listed in section 3.2.2., a carbon price is also applied on fossil fuel use in the mining of coal, oil and gas.

The carbon tax impacts production and demand through relatively strong price increases for products with higher emission content. For production, energy sources can be partly substituted, for example in favour of renewable electricity generation.

The second decarbonization instrument involves investing in renewable energy sources and accelerating the depreciation of fossil fuel electricity production. All regions except India are assumed to invest 25% of carbon tax revenue in renewable electricity generation (wind, hydro and solar). India invests 80% of carbon tax revenue in renewable electricity generation (implemented in RS2 and RS4).

It is also assumed that India invests the remaining 20% of its carbon tax revenue in reducing the emission intensity of its steel production by promoting secondary steel production and accelerating the phasing out of primary steel plants.⁶

⁶ In the recursive dynamic model, capital available to a sector consists of old capital, subject to depreciation (e.g. existing machinery), and new capital created from investment in the previous period (t-1). In the 'taking action scenarios,' the government finances additional investment for renewable energy and secondary steel that goes beyond the market allocation. At the same time, fossil fuel energy and primary steel products are subject to a higher depreciation rate of 15% to accelerate technological change, compared with 5% in other sectors.

Assumptions for India and other emerging or developing countries

Two different sets of assumptions are applied in the reference scenarios:

Early decarbonization:

- Implementing the carbon price according to specified pathway
- Investing 25% of carbon tax revenue in green energy (India: 80%)
- Investing 20% of carbon tax revenue in secondary steel production (India).

No or delayed decarbonization:

- No change from status quo with respect to carbon prices;
- No additional investment in green energy;
- No additional investment in secondary steel production (India).

3.2.3 Closures

Macroeconomic closure conditions determine the way the model adjusts to exogenous shocks and reflect assumptions about macroeconomic behaviour. Changes in savings and investment increase the capital stock in the subsequent period.

The closure set-up used in the reference scenario and policy simulations assume a fixed external balance; foreign borrowing does not change. The exchange rate adjusts to maintain a constant trade balance. Capital use for activities is predefined: old capital is immobile and subject to depreciation, and new capital is distributed among sectors, allowing for partial adjustment governed by relative returns on capital and a capital mobility parameter. All other factors are mobile and fully employed. The consumer price index serves as numeraire.

In the reference scenario, investment volume is fixed and the government account clears adjusting income tax rates. Government expenditures and the government balance are fixed.

The closure applied in the policy simulations substitutes the investment volume with the household savings adjuster, which is exogenously adjusted to reflect investment growth incorporated in the reference scenario.



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Results

4

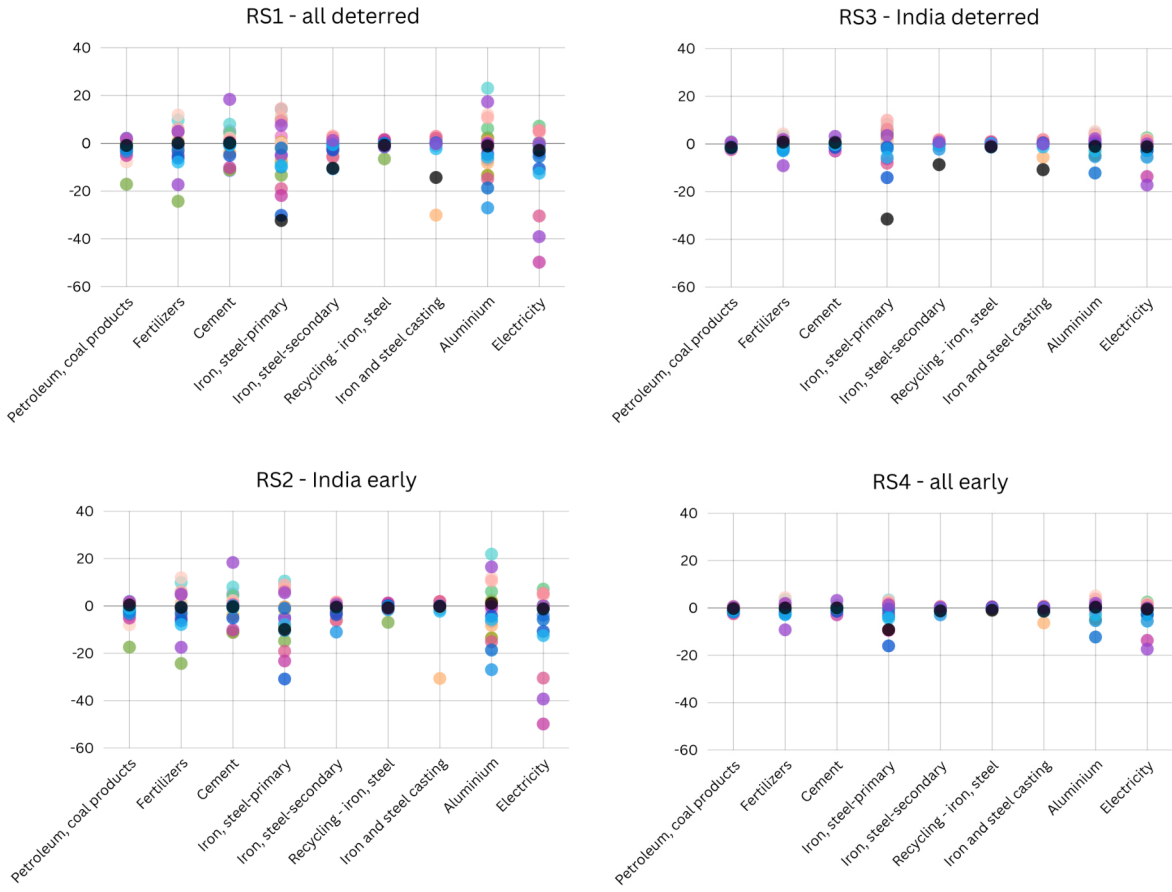
The analysis assesses economic impacts of a BCA at various intervals until 2035. The policy simulation, that is, a BCA put in place by high-income regions, is implemented in four different reference scenarios that assume different mitigation actions by India and other emerging and developing regions. RS1 and RS2 are simulated in a divided world (SSP4), while RS3 and RS4 happen in a world of coordinated action (SSP1). It is important to note that these scenarios are not a description of how India acts.

4.1 Global macro effects

A BCA is a measure that affects trade of goods based on their emission intensity. The rate of BCA depends, first, on the emission intensity of production in each sector and region, meaning emissions embedded in a region's exports (section 2.2). Second, it depends on domestic carbon pricing (section 2.3), which is recognized in the BCA and therefore reduces the enforced BCA rate.

Figure 7 depicts effects on exports by sector, focusing on the sectors targeted in the BCA. Effects on other sectors are small. Each dot represents the impact for a specific region. Results show that impacts on exports differ strongly among regions. For example, Canada increases its aluminium exports by 23% relative to RS1, while aluminium exports from South Africa are 27% lower than in RS1.

Figure 7. Effects of BCA on real exports (2035, in percentage changes, in all four reference scenarios)



Note: Each dot represents the effect for a specific region. The black dots represent India.

The size of the effects depends on the assumed behaviour of regions. Effects are considerably smaller when emerging and developing countries implement their own carbon policies. However, the negative effects on electricity and primary steel production are still relatively large, even when all regions are assumed to take early action, as in RS4. This mainly reflects strongly differing emission intensities among regions.

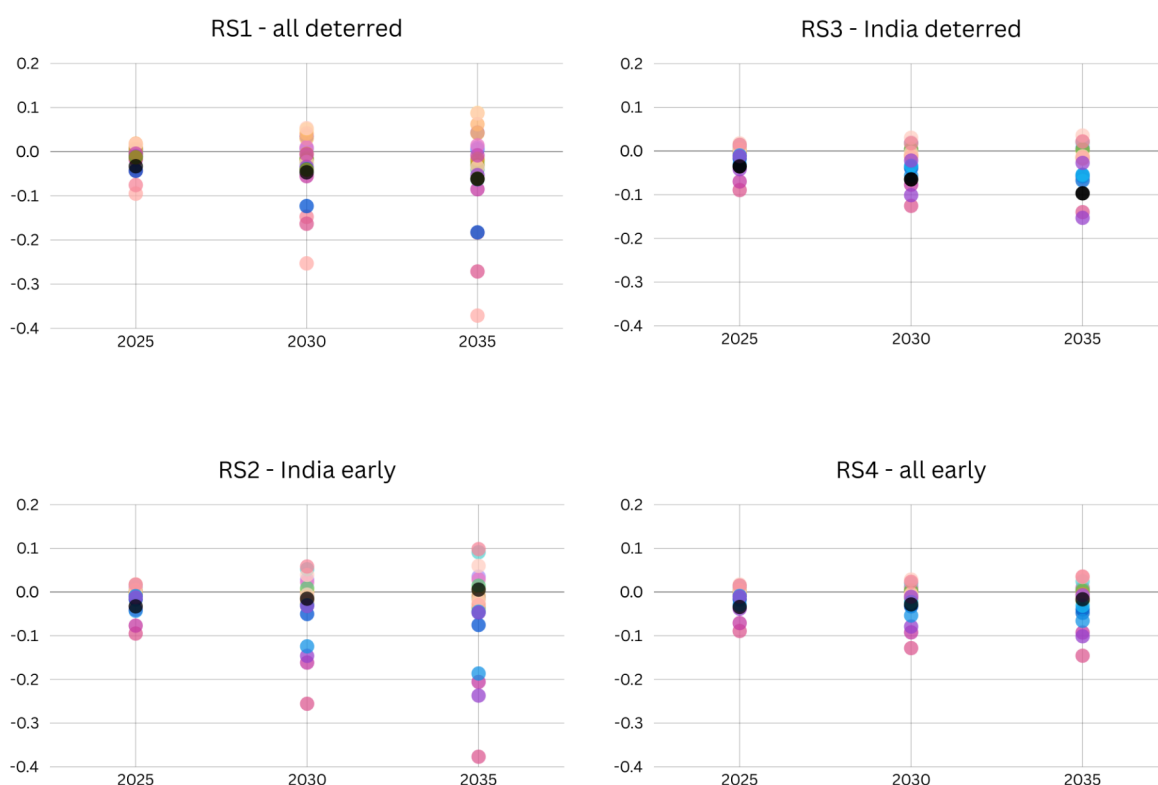
Effects on India’s exports are concentrated in primary and secondary iron and steel production and casting. The size of the impact depends strongly on what action India takes. Primary steel exports are 32% lower compared with RS1 and RS3, where India does not take early action. However, compared with RS2 and RS4, where India takes early action, exports are about 10% lower. Action by other regions does not visibly affect the export results.

The BCA impacts vary by region: some regions experience an increase and some a decrease in trade and domestic production. Figure 8 shows effects on GDP, with each

dot representing one region. Regions that do not take action (e.g. oil-producing regions) are among the most negatively affected, but they can reduce these impacts by taking action. Figure 8 shows that effects, negative and positive, typically increase over time. The distribution of effects is significantly smaller when the majority of a region implements mitigation measures early.

India's GDP is 0.03% lower in all scenarios immediately following the introduction of the BCA. The loss in GDP increases when India delays taking mitigation action. GDP losses are higher when all regions except India are taking global action, so it matters what other regions are doing. Results show that India can minimize losses if it takes early action, with a lower, but still positive trend when all regions take coordinated action.

Figure 8. Effect of BCA on nominal GDP (in percentage changes, in all four reference scenarios)

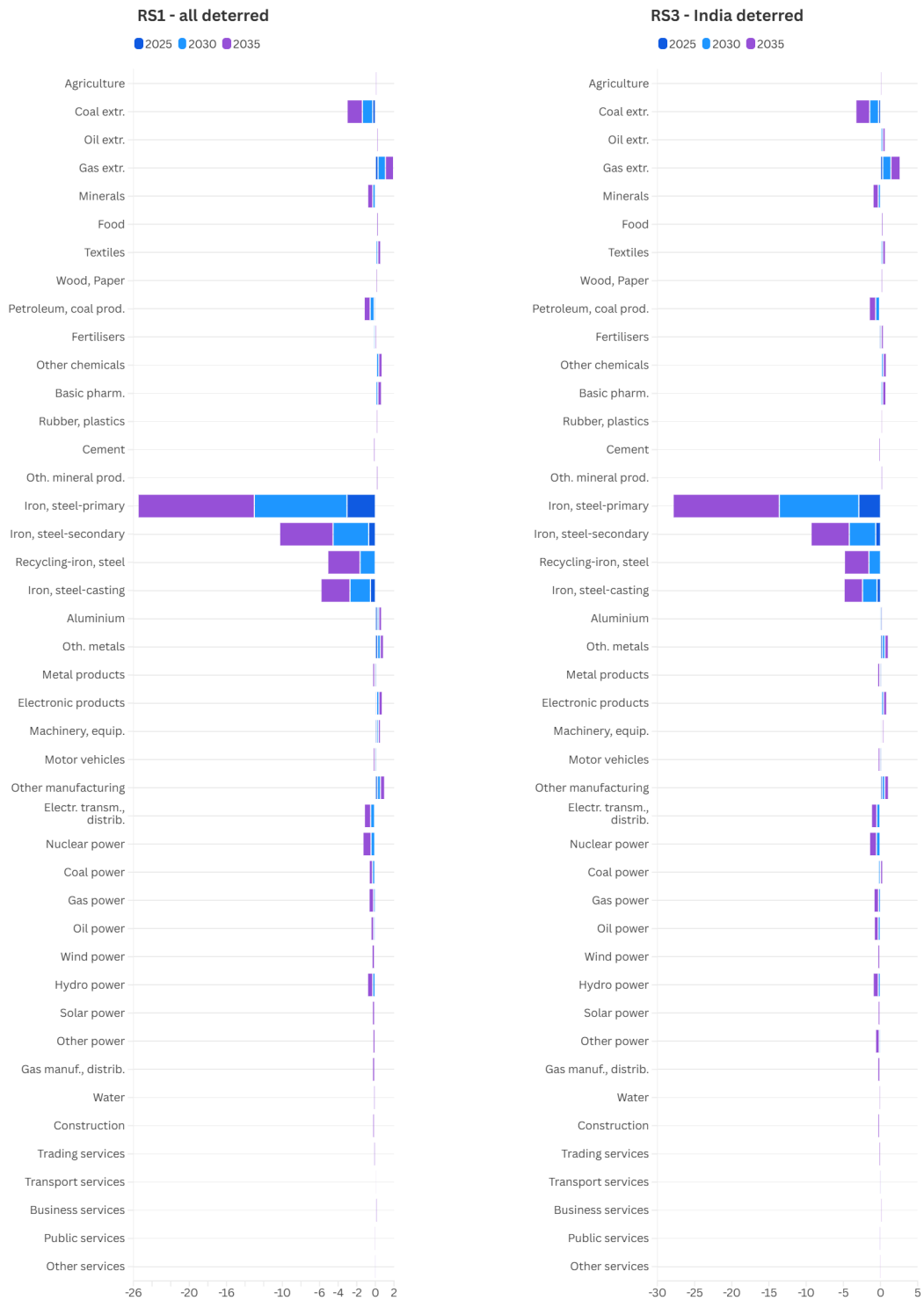


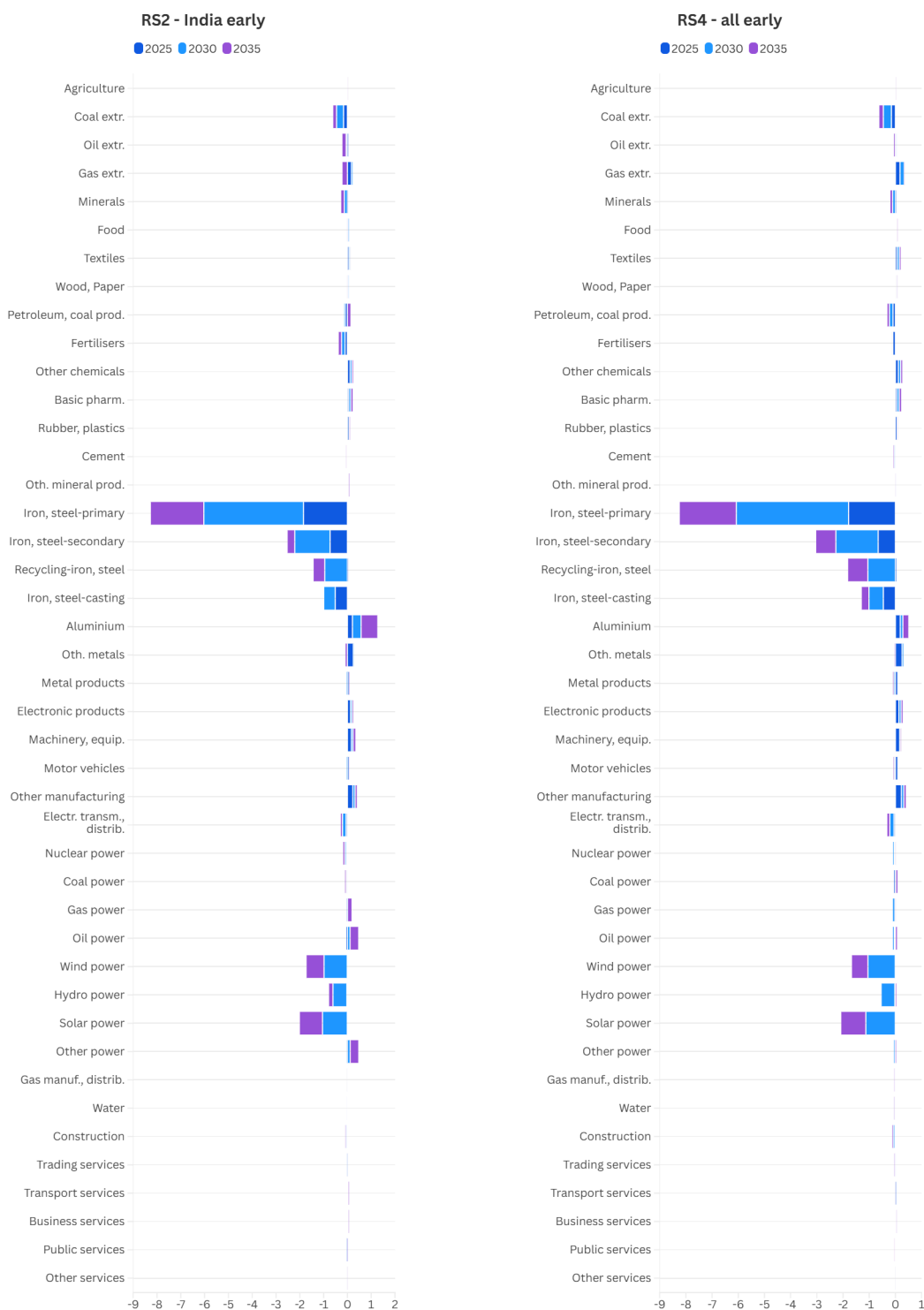
Note: Each dot represents the effect for a specific region; India is highlighted in Black.

4.2 Effect on production in India

Effects on production in India are concentrated in primary iron and steel production, coal extraction and electricity generation (figure 9).

Figure 9. Effect of BCA on production in India by sector (in percentage changes, in all four reference scenarios)





Results for production by sector (figure 9) show that early action lowers the direct effect of the BCA in 2025, the year it is implemented. The impact is smallest when India implements mitigation measures early. Under RS2 and RS4, mitigation action taken by India leads to a decline in production until 2030, with primary steel production falling by up to 4%. In 2035, the impact of the BCA lessens as Indian carbon prices partially catch up with carbon prices in high-income countries. Interestingly, action by other regions

only seems relevant for the immediate effect, in 2025, but there is no significant difference between RS2 and RS4 in 2030 and 2035.

The negative effect on electricity production results from lower demand under the BCA policy scenario relative to RS2 and RS4 owing to the overall negative effect on the economy (i.e. steel production).⁷

When India delays taking mitigation action, the loss in iron and steel production is bigger in the implementation year (2025), and the impact grows over the years. Most importantly, the effect is stronger in RS3, when only India delays taking mitigation action.

Table 4 shows effects of the BCA on trade, production and domestic supply, by sector, for the year 2035. The effect on cement is small, as the sector is characterized by very low export and import shares. India imports most of its fertilizer, and imports and domestic supply increase under the BCA. Aluminium exports account for a significant share of production. Under the BCA, production of aluminium increases slightly, and exports are redirected to the domestic market while imports decrease.

The steel sector is the most affected. The steel sector is already transforming in such reference scenarios, where India takes early action, with reduced domestic production, leading to lower exports and higher imports. Consequently, the impact of the BCA policy on production is significantly smaller compared to when India is deterred. Secondary steel production has lower embedded emissions than primary steel production and is therefore less impacted by the BCA. Secondary steel production in India, however, has relatively high emissions compared with the rest of the world and is thus subject to higher BCA rates than its competitors.

Carbon taxes on electricity generation, as simulated in this study, increase electricity prices. While the share of renewables in the electricity sector in India is increasing, coal remains an important source for electricity generation in 2035. This decreases the competitiveness of electricity-intensive production, such as that of secondary steel.

⁷ The effects are visible for the renewable energy sectors, whose growth is financed from carbon tax income in RS2 and RS4. A lower growth rate in the policy scenario results in lower tax revenue and translates in negative impacts on these renewable energy sectors. In RS1 and RS3, the renewable energy sectors do not benefit from such a support.

Table 4. Effect of BCA on trade, production and domestic supply by sector in 2035

	% change relative to reference scenarios				Export share		Import share	
	Exports	Production	Imports	Domestic Supply	Reference scenario	% change	Reference scenario	% change
Petroleum and coal products								
RS1	-0.93	-0.58	-0.04	-0.51	10.20	-0.35	5.67	0.47
RS2	0.38	0.12	0.98	0.15	10.47	0.26	5.79	0.83
RS3	-1.48	-0.78	-0.80	-0.71	10.27	-0.70	4.49	-0.10
RS4	-0.30	-0.07	0.27	-0.03	10.58	-0.22	4.63	0.30
Fertilizer								
RS1	0.09	0.07	1.09	0.41	2.02	0.02	31.63	0.68
RS2	-0.58	-0.12	1.77	0.49	2.07	-0.46	29.29	1.28
RS3	0.77	0.21	-0.44	0.04	2.38	0.56	20.16	-0.48
RS4	-0.01	0	0.33	0.08	2.45	0	18.54	0.26
Cement								
RS1	0.14	-0.08	0.62	-0.08	0.92	0.22	1.02	0.69
RS2	-0.36	-0.01	1.48	0.01	0.78	-0.36	1.34	1.46
RS3	0.56	-0.10	-0.99	-0.11	0.99	0.66	0.88	-0.87
RS4	-0.02	-0.02	0.04	-0.02	0.84	0	1.16	0.06
Iron and steel – primary								
RS1	-32.32	-12.43	7.59	-3.20	27.86	-22.71	9.62	11.15
RS2	-9.93	-2.22	1.70	-0.08	14.61	-7.89	37.97	1.78
RS3	-31.51	-14.20	8.96	-4.37	33.07	-20.18	5.57	13.94
RS4	-9.19	-2.16	0.72	-0.37	16.90	-7.19	26.01	1.09
Iron and steel – secondary								
RS1	-10.46	-5.68	3	-1.72	41.51	-5.06	8.05	4.81
RS2	-0.49	-0.30	0.75	-0.06	38.91	-0.19	10.25	0.81
RS3	-8.67	-5.06	2.44	-1.76	44.61	-3.80	5.70	4.27
RS4	-1.25	-0.75	0.48	-0.29	42.89	-0.51	6.74	0.77
Recycling – iron and steel								
RS1	-0.82	-3.41	-3.68	-3.51	0.90	2.68	26.56	-0.18
RS2	-0.79	-0.47	0.57	-0.12	0.92	-0.33	29.39	0.69
RS3	-1.19	-3.22	-3.08	-3.19	0.90	2.10	24.68	0.12
RS4	-0.98	-0.75	0.21	-0.45	0.91	-0.23	27.13	0.66
Iron and steel casting								
RS1	-14.33	-3.06	2.08	-0.25	19.10	-11.62	4.79	2.33
RS2	-0.20	0	0.73	0.09	17.40	-0.21	5.95	0.63
RS3	-10.80	-2.40	1.44	-0.27	19.50	-8.61	3.88	1.71
RS4	-1.35	-0.27	0.35	-0.01	18.05	-1.08	4.71	0.36
Aluminium								
RS1	-1.12	0.23	-0.81	0.05	18.66	-1.36	31.91	-0.86
RS2	1.09	0.68	-0.55	0.12	17.56	0.41	37.73	-0.66
RS3	-1	0.01	-0.65	-0.01	19.57	-1.01	24.04	-0.64
RS4	0.30	0.21	-0.26	0.04	18.43	0.10	28.64	-0.29
Electricity								
RS1	-2.95	-0.24	-0.54	-0.25	0.26	-2.72	0.16	-0.30
RS2	-1.27	0.01	0.13	0.03	0.25	-1.29	0.24	0.11
RS3	-0.52	-0.01	-0.03	-0.05	0.33	-0.46	0.17	0.02
RS4	-0.51	-0.01	-0.04	-0.05	0.34	-0.45	0.16	0.01

4.3 Effect on households in India

The BCA results in lower household expenditure in all four scenarios. Households experience lower income from labour, with a greater negative effect on skilled labour, and lower returns from other production factors such as land, natural resources and capital. The effect on households is stronger negative and increases over time when India delays taking mitigation action. The negative effect is most pronounced when India is the only country delaying action.

When all regions and India take early action, wage effects are smaller, and wages partly recover by 2035. When only India acts early, impacts become positive. Producer prices are slightly lower in 2025, the year the BCA is introduced, but increase afterwards in all scenarios.

Figure 10. Effect of the border carbon adjustment on wages, prices and household expenditure (in percentage changes, in all four reference scenarios)



Note: PPI = producer price index.





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Conclusions

5

This study analyses the effects of a BCA on emission-intensive, trade-exposed sectors in India. The BCA is assumed to be implemented in high-income regions. The analysis considers four different reference scenarios that vary in the timing of decarbonization efforts by India and other emerging and developing countries.

The model results indicate negative impacts of the BCA on India in all scenarios, primarily from effects on the steel sector. However, India does markedly better under scenarios where it takes mitigation action.

Outcomes for India depend on the action taken by other BCA-impacted countries. Negative impacts are greater when India is assumed to be the last country to take action. India suffers fewer negative effects when it takes action early, before other regions.

Impacts reduce significantly over time in the scenarios where carbon prices in India increase. Higher carbon taxes increase the cost of emitting carbon and generate tax revenue that is invested in renewable energy and secondary steel production. The carbon content of exported goods decreases owing to an increased share of renewables in energy production and a shift towards less emission-intensive secondary steel production. The BCA is assumed to recognize carbon prices of trading partners. These effects are absent in the inaction scenarios. Moreover, India faces increasing BCA rates when carbon prices in developed countries increase over time.

The results show that some countries do markedly better in all scenarios. For example, of the countries implementing the BCA, Canada performs well in aluminium

production. The results also highlight that oil-producing countries do much better when they take action.

This study does not look at any specific action India could take. The implemented scenarios are general and hypothetical and assume a carbon tax with revenues from it allocated to renewable energy and industrial decarbonization in the steel sector. However, these transformations could also be funded through international support.

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United Nations Climate Change Katowice Committee on Impacts

Katowice Committee of Experts on the Impacts of the Implementation of Response Measures is a constituted body which was established in Katowice December 2018 to support the work programme of the forum on the impact of the implementation of response measures

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