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CARBON TAX IMPLEMENTATION IN BANTEN'S COAL POWER PLANT: IRIO METHOD

Fahrizal Taufiqqurrachman[1]
Bojonegoro University, Bojonegoro, Indonesia

Edy Suhartono[2]
Bojonegoro University, Bojonegoro, Indonesia

Hartiningsih Astuti[3]
Bojonegoro University, Bojonegoro, Indonesia

Sutrisno[4]
Bojonegoro University, Bojonegoro, Indonesia

Retno Muslinawati[5]
Bojonegoro University, Bojonegoro, Indonesia

Correspondence Author: fahrizaltaufiqqurrachman@gmail.com

Abstract

Facing global commitments to reduce greenhouse gas emissions while promoting a just energy transition, implementing carbon taxes in the coal-fired power generation sector becomes a strategic policy requiring in-depth analysis of its spatial and sectoral economic impacts, particularly in regions with high concentrations of coal-fired power plants like Banten. This research focuses on determining the impact of carbon tax implementation at the Banten Power Plant in 2025. This study uses a quantitative research method, utilizing data on the amount of carbon emissions produced multiplied by the carbon tax rate of Rp 30,000/ton CO2e. The resulting carbon tax revenue is then used as an exogenous shock in the D sector: Electricity and Gas in Banten Province, as shown in the Indonesian IRIO table, as well as labor and community income sourced from the Indonesian Central Bureau of Statistics. The analysis methods used include backward and forward linkages, the impact of shocks on sector (D) on 17 other sectors, and capturing the spatial spillover effect on output, income, and labor in 34 provinces. The research results show that in Banten, the greatest impact on output, income, and labor is in the same sector, namely (G) Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles. The greatest aggregate impact on output, income, and labor is in South Sumatra Province, and the majority is still dominated by provinces on Java Island.

Keywords: Cabon Tax; Coal Power Plant; IRIO; Banten; Linkage

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INTRODUCTION

Many countries have expanded the use of environmental tax instruments, such as taxes on sulfur dioxide, plastic bags, solid waste, and batteries. Even in the United States, there is now strong support for a price-based approach (carbon tax) rather than a system cap-and-trade, leveling and raising the price of carbon emission taxes is the key to decarbonizing the economy. However, the public will only support this tax if the revenue is returned to them (Chiroleu-Assouline & Fodha, 2014). Concerns about the implementation Green Tax Shift (The shift to green taxes) will lead to public rejection, especially among low-income groups, where carbon taxes tend to be regressive as poor households spend a larger proportion of their income on energy consumption, transportation and heating (cooking). The implementation of this green tax aims to reduce distorting energy taxes and potentially generate environmental and economic benefits (Aubert & Chiroleu-Assouline, 2019).

Poor air quality in Banten Province is caused by carbon-based industrial estates and coal-fired power plants located in the area (Manan, 2025). Banten is the highest area with the Air Pollution Standard Index (ISPU) in Indonesia as of November 13, 2025 (Fadhlurrahman, 2025; Permana, 2025) The increase in air pollution that occurred in Banten, West Java, and DKI Jakarta provinces has had an impact on the increase in cases of Acute Respiratory Infections (ARI) (Yuningsih, 2023), Air pollution pollution in Banten Province caused by coal-fired power plant activities so that it has an impact on the community (Lauri Myllyvirta, 2020; Puspaningtyas et al., 2024).

The issue of global warming is a central topic in contemporary sustainability policy discourse and research. This phenomenon is scientifically associated with the accumulation of greenhouse gases (GHGs) in the atmosphere due to anthropogenic activities, which reinforce the greenhouse effect and disrupt the Earth's radiative balance.More than 75% of the composition of greenhouse gases (GHGs) in the atmosphere is made up of carbon dioxide (CO_2), thus reducing CO contribution$_2$ derived from a wide range of anthropogenic activities have the potential to significantly reduce the intensity of global warming and, in turn, mitigate the increasingly worrying impacts of climate change. (Budi & Suparman, 2013). Premature mortality rate (Premature mortality) globally is significantly associated with exposure to air pollution, which continues to increase year on year; Without effective policy interventions, the health burden due to air pollution is projected to escalate further. One of the most promising mitigation strategies to lower carbon dioxide (CO) concentrations$_2$) is a transition to a low-emission technology-based power generation system. Amount of CO emissions$_2$ produced by a power plant depends directly on Emission FactorThe higher the emission factor, the greater the carbon footprint produced per unit of energy. In this context, fossil fuel power plants—particularly coal and oil—are major contributors to CO emissions$_2$, given that the process of converting primary energy into electricity involves the oxidation of hydrocarbon compounds, which inherently release significant amounts of carbon dioxide into the atmosphere (Solihat, 2019).

Indonesia has implemented a carbon tax policy regulated in the Regulation of the Minister of Energy and Mineral Resources (EMR) with the aim of not only increasing state revenue, but the most important thing is to change the behavior of business actors in the

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power source sector, namely coal-fired power plants companies, to care more about the environment by reducing carbon emissions produced lower by using low-carbon technology to support the sustainability of new and renewable energy (Personal, 2021).

This study offers an innovative economic-environmental analysis by combining specific climate policies, namely the application of carbon taxes on Steam Power Plants (PLTU) in Banten Province, with an input-output modeling framework based on Inter-Regional Input-Output (IRIO). Interestingly, this research is a multi-scale and multidimensional approach that not only evaluates local impacts in Banten Province as the province with the highest concentration of coal-fired power plants in Indonesia, but also traces the transmission of impacts to all 34 provinces through inter-regional trade networks. Sectorally, it also takes into account the backward linkage and forward linkage of the electricity sector in Banten Province to 17 business fields, so that it is known that the sectors are most vulnerable to increased costs due to carbon taxes. In addition, the analysis outputs also include the aggregate impact on total output, household income and labor absorption in each province, allowing for the mapping of the distribution of economic impacts (positive/negative) of localized climate policies.

The novelty of this study is first, most of the carbon tax policy analyses in Indonesia were previously aggregate and static or used the Computable General Equilibrium (CGE) approach which lacks spatial heterogeneity where this study actually utilizes Indonesia's IRIO table to capture spatial spillover effects from localized sectoral policies. Second, this study integrates structural analysis through linkage analysis with distributional impacts (output, income and labor) so that it not only answers how big the impact is, but also where and who is affected. Third, with a focus on the Banten Provincial PLTU which supplies most of the electricity for the JABODETABEK industrial area, this study will provide contextual empirical evidence regarding the trade-off between the energy transition and regional economic stability. Thus, this study not only enriches the environmental economic literature but also provides empirical evidence-based analytical tools for policymakers in designing effective, fair and sustainable carbon tax policies, including potential compensation mechanisms or transition incentives for affected provinces and sectors.

REVIEW OF LITERATURE

Carbon tax has become one of the primary market-based policy instruments adopted by many countries to address climate change by internalizing the external costs of greenhouse gas (GHG) emissions. Rooted in Pigouvian tax theory, carbon taxation imposes a levy on carbon emissions generated from fossil fuel consumption, thereby encouraging producers to adopt cleaner technologies and improve energy efficiency. In Indonesia, the legal basis for carbon taxation was established through Law No. 7 of 2021 concerning the Harmonization of Tax Regulations (HPP Law), which introduced carbon pricing as part of the national strategy to achieve the Nationally Determined Contribution (NDC) and the Net Zero Emission (NZE) target by 2060 or sooner. The initial implementation focuses on coal-fired power plants (PLTU), considering that the electricity sector contributes a significant proportion of Indonesia's total carbon emissions (Hakim et al., 2025; Astuti et al., 2026).

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The implementation of carbon tax in Indonesia has attracted considerable scholarly attention since 2021. Previous studies indicate that carbon taxation has the potential to reduce greenhouse gas emissions while simultaneously generating government revenue that can be reinvested in renewable energy development and climate adaptation programs. Nevertheless, the policy also introduces higher production costs for carbon-intensive industries, potentially reducing industrial competitiveness and increasing electricity prices if compensation mechanisms are not adequately designed. Therefore, successful implementation requires an integrated policy framework combining fiscal instruments, emissions trading systems (ETS), and targeted incentives for green investment (Siregar et al., 2025; Astuti et al., 2026). Coal-fired power plants remain the dominant source of electricity generation in Indonesia and are among the largest contributors to national carbon emissions. Banten Province occupies a strategic position within the Java-Bali electricity system due to the presence of several large-scale coal power plants supplying electricity to industrial and urban centers. Consequently, the introduction of carbon taxation in Banten is expected to influence not only the operational costs of electricity producers but also the production costs of downstream industries that rely heavily on electricity as an intermediate input. These indirect effects highlight the importance of evaluating carbon tax policies using comprehensive economic modeling approaches capable of capturing intersectoral and interregional relationships (Hakim et al., 2025).

Recent studies demonstrate that the economic impacts of carbon taxation extend beyond the electricity sector. Carbon tax policies may reduce carbon emissions by encouraging technological innovation, fuel substitution, and energy efficiency improvements. However, in the short term, increased production costs may reduce industrial output, household purchasing power, and regional economic growth, particularly in provinces where coal-fired power generation constitutes a major economic activity. To minimize these adverse effects, many researchers recommend recycling carbon tax revenues into productive sectors such as renewable energy, public infrastructure, and social protection programs (Astuti et al., 2026; Siregar et al., 2025). Among various analytical approaches, the Interregional Input–Output (IRIO) model has emerged as one of the most appropriate methods for evaluating the regional economic impacts of carbon taxation. The IRIO framework extends the traditional Leontief Input–Output model by incorporating economic interactions among multiple provinces, thereby allowing researchers to estimate both direct and indirect effects of policy interventions across regions. Unlike conventional Input–Output analysis, which examines only a single regional economy, IRIO captures interregional trade flows and production linkages, making it particularly suitable for assessing how carbon taxation in one province affects economic activities in other provinces through supply-chain networks (Kamil et al., 2023).

Empirical evidence from IRIO-based studies demonstrates the usefulness of this approach in analyzing Indonesia's carbon tax policy. Kamil et al. (2023) simulated a carbon tax of IDR 30,000 per ton of CO_2 emissions using Indonesia's 2016 IRIO table covering 34 provinces and 17 economic sectors. Their findings indicate that Java would contribute approximately 73% of national carbon tax revenue due to the concentration of coal-fired power plants. More importantly, when carbon tax revenues were recycled into sectors with

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high economic multipliers, national output, regional income, and employment increased despite the higher production costs imposed on electricity generation. These findings suggest that the economic consequences of carbon taxation depend not only on the tax rate but also on how the resulting revenues are allocated. Several recent studies have also examined carbon taxation from alternative analytical perspectives. Hakim et al. (2025) employed a System Thinking approach using a Causal Loop Diagram (CLD) to illustrate the interactions among electricity demand, coal consumption, carbon emissions, renewable energy investment, and fiscal policy. Their study identified reinforcing and balancing feedback loops showing that carbon taxation can gradually reduce fossil fuel dependence while strengthening government capacity to finance climate mitigation programs. Similarly, Sunanda et al. (2025) compared carbon tax and emissions trading mechanisms using the TIMES energy model and concluded that combining carbon taxation with emissions trading could achieve greater emission reductions while maintaining electricity system reliability.

Although previous studies have significantly advanced the understanding of carbon taxation in Indonesia, several research gaps remain. First, most studies focus on national-level impacts rather than province-specific analyses, despite substantial regional differences in industrial structure and electricity generation. Second, relatively few studies specifically investigate the implementation of carbon taxation in Banten Province, where coal-fired power plants play a strategic role in Indonesia's electricity supply. Third, limited research employs the Interregional Input–Output (IRIO) framework to evaluate regional spillover effects resulting from carbon taxation in Banten. Existing literature generally examines national economic impacts or conceptual policy implications without providing detailed interregional assessments of output, value added, employment, and sectoral multipliers. Therefore, this study seeks to address these gaps by applying the Interregional Input–Output (IRIO) model to analyze the implementation of carbon taxation in Banten's coal-fired power plants. The IRIO approach enables a comprehensive assessment of both direct and indirect economic impacts across provinces and industrial sectors, thereby providing evidence-based policy recommendations for balancing Indonesia's climate mitigation objectives with sustainable regional economic development.

RESEARCH METHOD

This research method will be carried out in 2 stages, namely by calculating the amount of revenue from the carbon tax of coal-fired power plants in Banten which will then be used as a shock to the IRIO Indonesia model which will be explained in the following model:

Carbon Tax Analysis

The data for this study is sourced from the IRIO 2016 table, the Central Statistics Agency with a classification of 17 sectors and 34 provinces. Analysis focused on Banten Province In estimating carbon tax revenues of IDR 30,000/ton CO2e, the researchers used data from Global Coal Plant Tracker (Global Energy Monitor, 2025). The calculation of Indonesia's carbon tax of IDR 30,000/ton CO2e is as follows:

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$$\text{Emisi Karbon } CO_2\left(\text{Ton}/\text{Tahun}\right) = \text{Konsumsi Energi } CO_2(\text{TJ}) \text{ x Factor Emission } (CO_2) \quad (1)$$

$$\text{Pajak Karbon } \left(\text{Rp}/\text{Tahun}\right) = \text{Emisi Karbon } CO_2 \left(\text{Ton}/\text{Tahun}\right) \text{ x Pajak Karbon } \left(\text{Rp 30.000}/\text{Ton}\right) \quad (2)$$

1 Ton	:	1,000 kg
1 Terajoule (TJ)	:	1012 Joule
1 PCS	:	1,000 TJ
1 Joule	:	1 x 10-12 TJ
1 MBTU	:	1,055,000 Joules
1 MMBTU	:	1,055,000,000 Joules

Approach shock The carbon tax of coal-fired power plants in Banten Province will be adjusted to one of the sectors in the data table Inter-Regional Input-Output namely in the D. Electricity and Gas Procurement because a) Coal Power Plant included in this sub-sector; b) the main source of direct CO2 emissions; c) Backward linkage which is strong because all sectors (industry, services, households) are highly dependent on electricity; and d) effects Pass-through The implementation of a carbon tax will increase operational costs so that there will be an adjustment in the selling price of electricity that will flow to all sectors of the economy (Aziz et al., 2025).

Inter-Regional Input-Output Analysis (IRIO)

The matrix of the technical direct input coefficient (regional input coefficient) for regions A and B is obtained by the formula:

$a_{ij}^{AA} = \frac{Z_{ij}^{AA}}{Y_j^{A}}$ and , for $a_{ij}^{BB} = \frac{Z_{ij}^{BB}}{Y_j^{B}}$i,j = 1, ... 17 The Gospel of Jesus Christ

Description:

a_{ij}^{AA} : The input coefficient of sector i from region A is used for sector j in region A.

a_{ij}^{BB} : The input coefficient of sector i from region B is used for sector j in region B.

Z_{ij}^{AA} : The use of sector i inputs from region A by sector j in region A.

Z_{ij}^{BB} : The use of sector i inputs from region B by sector j in region B.

Y_j^{A} : Total use of sector j inputs or sector j outputs in region A.

Y_j^{B} : Total use of sector j inputs or sector j outputs in region B.

Then to find a_{ij}^{AB} and which reflects the direct input coefficient between regions is obtained by the formula:a_{ij}^{BA}

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$a_{ij}^{AB} = \frac{z_{ij}^{AB}}{Y_j^B}$ and $a_{ij}^{BA} = \frac{z_{ij}^{BA}}{Y_j^A}$

Coefficients a_{ij}^{AB} and is often referred to as the trade coefficient or trade coefficient between regions. The coefficient means that the output value of sector i located in area A is used as an input to produce one unit of sector j output money in area B. $a_{ij}^{BA} a_{ij}^{AB}$(Saban & Falatehan, 2023; Taufiqqurrachman, 2022).

Backward Linkage Index (Upstream)

IDP for region A sector j

$$IDP_j^A = p \frac{m_j^A}{\sum_{j=1}^{n} m_j^A + \sum_{j=1}^{n} m_j^B}$$

IDP for region B sector j

$$IDP_j^B = p \frac{m_j^B}{\sum_{j=1}^{n} m_j^A + \sum_{j=1}^{n} m_j^B}$$

Description:

IDP_j^A : Sector spread coefficient j Region A
IDP_j^B : Sector spread coefficient j region B
m_j^A : Sectoral backlinkage j Region A
m_j^B : Sectoral backlinkage j region B
p : Matrix size

If:

$IDP_j^A > 1$: Sector j region A is able to increase the production growth of its upstream sector

$IDP_j^A < 1$: Sector j region A is unable to increase the production growth of its upstream sector

Forward Linkage Index (Downstream)

IDK for region A sector i

$$IDK_i^A = p \frac{h_i^A}{\sum_{i=1}^{n} h_i^A + \sum_{i=1}^{n} h_i^B}$$

IDK for region B sector i

$$IDK_i^B = p \frac{h_i^B}{\sum_{i=1}^{n} h_i^A + \sum_{i=1}^{n} h_i^B}$$

Description:

IDK_i^A : Sector spread coefficient i Region A
IDK_i^B : Sector spread coefficient i region B
h_i^A : Sectoral backlinkage i Region A
h_i^B : Sectoral backlinkage i region B
p : Matrix size

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If:

$IDP_i^A > 1$: Sector I region A is able to increase the production of its downstream sector

$IDP_i^A < 1$: Sector I region A is unable to increase production in its downstream sector

The Impact (Shock) of the Carbon Tax on Output

Output change in region A sector i

$$\Delta X_i^A = \sum_{j=1}^{n} k_{ij}^{AA}\, \Delta Y_j^A + \sum_{j=1}^{n} k_{ij}^{AB}\, \Delta Y_j^B$$

Changes in output in region B sector i

$$\Delta X_i^B = \sum_{j=1}^{n} k_{ij}^{BA}\, \Delta Y_j^A + \sum_{j=1}^{n} k_{ij}^{BB}\, \Delta Y_j^B$$

Description:

ΔX_i^A : Changes in sector output i Region A

ΔX_i^B : Changes in sector output i region B

k_{ij}^{AA} : Element of the value of the Leontief inverse matrix sector i region A against sector j Region A

k_{ij}^{AB} : Element of the value of the Leontief inverse matrix sector i region A against sector j region B

k_{ij}^{BA} : Element of the value of the Leontief inverse matrix sector i region B against sector j Region A

k_{ij}^{BB} : Element of the value of the Leontief inverse matrix sector i region B against sector j region B

ΔY_j^A : Change in final demand for sector j region A

ΔY_j^B : Changes in final demand for sector j region B

The Impact (Shock) of the Carbon Tax on Revenue

Changes in income in region A sector i

$$\Delta W_i^A = w_i^A \left(\sum_{j=1}^{n} k_{ij}^{AA}\, \Delta Y_j^A + \sum_{j=1}^{n} k_{ij}^{AB} \Delta Y_j^B \right)$$

Changes in income in region B sector i

$$\Delta W_i^B = w_i^B \left(\sum_{j=1}^{n} k_{ij}^{BA}\, \Delta Y_j^A + \sum_{j=1}^{n} k_{ij}^{BB} \Delta Y_j^B \right)$$

Description:

ΔW_i^A: Changes in income sector i region A

ΔW_i^B: Changes in income in sector I region B

w_i^A : Sector income coefficient i Region A

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w_i^B : Sector income coefficient i region B

k_{ij}^{AA} : Element of the value of the Leontief inverse matrix sector i region A against sector j Region A

k_{ij}^{AB} : Element of the value of the Leontief inverse matrix sector i area A to the sector j region B

k_{ij}^{BA} : Element of the value of the Leontief inverse matrix sector i region B against sector j Region A

k_{ij}^{BB} : Element of the value of the Leontief inverse matrix sector i region B against sector j region B

ΔY_j^A : Changes in the sector's final demand j Region A

ΔY_j^B : Changes in the sector's final demand j region B

The Impact (Shock) of the Carbon Tax on Labor

Workforce changes in region A sector i

$$\Delta L_i^A = t_i^A \left(\sum_{j=1}^{n} k_{ij}^{AA}\, \Delta Y_j^A + \sum_{j=1}^{n} k_{ij}^{AB} \Delta Y_j^B \right)$$

Workforce change in region B sector i

$$\Delta L_i^B = t_i^B \left(\sum_{j=1}^{n} k_{ij}^{BA}\, \Delta Y_j^A + \sum_{j=1}^{n} k_{ij}^{BB} \Delta Y_j^B \right)$$

Description:

ΔL_i^A : Changes in the sector's workforce i Region A

ΔL_i^B : Changes in the sector's workforce i region B

t_i^A : Sector labor coefficient i Region A

t_i^B : Sector labor coefficient i region B

k_{ij}^{AA} : Element of the value of the Leontief inverse matrix sector i region A against sector j Region A

k_{ij}^{AB} : Element of the value of the Leontief inverse matrix sector i area A to the sector j region B

k_{ij}^{BA} : Element of the value of the Leontief inverse matrix sector i region B against sector j Region A

k_{ij}^{BB} : Element of the value of the Leontief inverse matrix sector i region B against sector j region B

ΔY_j^A : Changes in the sector's final demand j Region A

ΔY_j^B : Changes in final demand for sector j region B

RESULTS AND DISCUSSION

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Indonesia is a country that has just implemented a carbon tax policy that aims to reduce greenhouse gas emissions which is mainly aimed at maintaining public health and increasing state revenue, but more importantly to change the behavior of business actors in the coal power sector to further reduce the emissions produced to be lower and able to adopt changes in low-carbon technologies such as new and renewable energy. Before discussing the impact of the carbon tax policy on the Indonesian economy, the author will present the results of data processing analysis using Microsoft Excel to show the calculation of carbon tax revenues at each coal-fired power plant in Banten Province. This analysis takes into account Indonesia's carbon tax price of IDR 30,000 million/ton of CO2e and the emission platform is set by the Ministry of Mineral Resources and Energy of the Republic of Indonesia.

The greater the carbon emissions produced, the greater the carbon tax revenue that will be obtained, we have presented data on the calculation of carbon tax revenue in Banten Province with all companies engaged in the Coal Power Plant business in table 1 which shows that the Banten Suralaya power station produces the largest carbon emissions of around 8,279,069 million/ton, then the carbon tax that must be paid is IDR 248,372,056,985 (billion). Overall, the carbon tax revenue received from all coal-fired power plants in Banten Province in 2025 amounted to IDR 652,365,792,890 (billion). The additional imposition of a carbon tax will have an impact on the increase in the selling price of electricity and will increase the burden of state subsidies. The burden of electricity subsidies can be minimized by re-investing from carbon tax revenues into renewable energy technologies which have the potential to have a high multiplier effect to reduce carbon emissions (CO2e) (Kamil et al., 2023).

Table 1
Revenue from Carbon Tax if applied at IDR 30,000/ton CO2e

Steam Power Plants (PLTU)	Carbon Emissions Millions/Tons	Income (Rp)
Asahimas Chemical power station	756.673	22.700.193.989
Banten Labuan power station	1.530.405	45.912.164.577
Banten Lontar power station	3.007.154	90.214.607.090
Banten Attack Power Station	2.711.273	81.338.184.924
Banten Suralaya power station	8.279.069	248.372.056.985
Cemindo Gemilang power station	302.669	9.080.077.596
Cilegon PTIP Power Station	204.054	6.121.621.944
Indah Kiat Serang power station	617.950	18.538.491.758
Jawa-7 power station	4.004.692	120.140.758.369
Peacock power station	331.588	9.947.635.658
TOTAL	21.745.526	652.365.792.890

Source: The author's data processing on coal-fired power plant emissions from the Global Coal Plant Tracker on July 2025 assuming the imposition of a tax of Rp 30,000/ton CO2e

The backward and forward linkages show the direct impact of increasing the output of final demand for one sector unit in increasing the total output of all sectors of the economy. This parameter shows the strength of the sector in driving the growth of other sectors through the output produced downstream and upstream. Understanding the role and position

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of the economic sector in encouraging output growth to the backward and future linkages will be divided into 4 quadrants (Taufiqqurrachman, 2022) which will be explained in Figure 1 below:

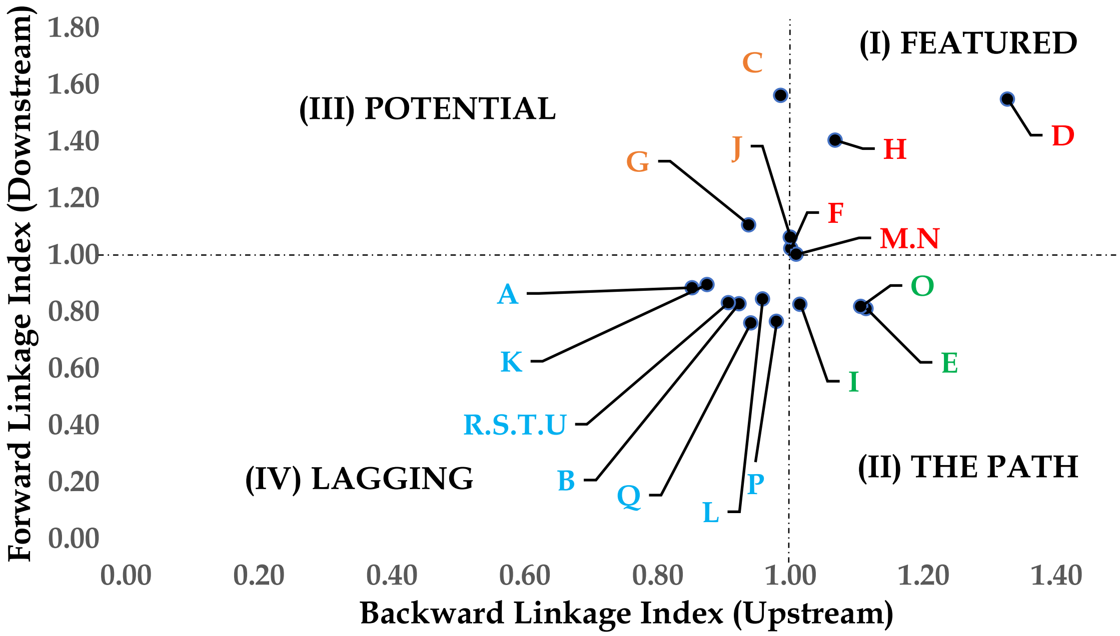

Figure 1
Backward and Forward Linkage Quadrant of Banten Province, 2025
Source: The author's data processing results using the IRIO Indonesia Table from 17 BPS sectors

Leading Sector, where this sector is not only able to drive the growth of other sectors through its output, but is also very responsive to changes in inputs for other sectors. The sector in this quadrant plays a key driver of the regional economy, because it has a strong dual effect on both upstream and downstream industries. So it deserves to be a priority in the formulation of regional economic development policies, because investment and taxes in this sector will have a wide impact on the entire economy (Saban et al., 2024; Saban & Falatehan, 2023). There are 4 sectors that are categorized as superior, namely (D) Electricity and Gas Procurement, (F) Construction, (H) Transportation and Warehousing, and (M.N) Corporate Services. The mainstay sector, where this sector excels in encouraging the growth of other sectors through the output generated but is not too sensitive to changes in inputs from other sectors. Sectors in this quadrant play a key driver of downstream industrial development, but are not too dependent on inputs from other sectors. So it is feasible to be developed as an export base or to strengthen the downstream value chain, because it has great potential to expand the market and increase added value (Saban et al., 2024; Saban & Falatehan, 2023). There are 4 sectors that are categorized as mainstays, namely (E) Water Procurement, Waste

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Management, Waste and Recycling, (I) Accommodation and Dining Provision and (O) Administration, Defense and Social Security Mandatory.

Potential Sectors, where this sector is very sensitive to changes in inputs from other sectors, but does not really encourage the growth of other sectors through its outputs. The sectors in this quadrant play a key role in the development of the upstream industry, as they are highly dependent on the availability of inputs from other sectors. Therefore, it is very important to strengthen in terms of providing inputs and supply chain efficiency, in order to increase the competitiveness and resilience of the sector (Saban et al., 2024; Saban & Falatehan, 2023). There are 4 sectors that are categorized as potential, namely (C) Processing Industry, (G) Wholesale and Retail Trade; Car and Motorcycle Repair and (J) Information and Communication. Disadvantaged Sector, where this sector does not excel either in encouraging the growth of other sectors and in terms of sensitivity to inputs from other sectors. The sector is generally oriented towards the domestic market and has weak linkages with other sectors. In the context of policy, sectors in this quadrant are usually not the top priority for development, but they still need to be considered so as not to be left behind in the development process. Strengthening this sector can be done through increasing internal efficiency and product diversification in order to increase its contribution to the regional economy (Saban et al., 2024; Saban & Falatehan, 2023). There are 4 sectors that are categorized as potential, namely (A) Agriculture, Forestry and Fisheries, (B) Mining and Quarrying, (K) Financial Services and Insurance, (L) Real Estate, (P) Educational Services, (Q) Health Services and Social Activities and (R.S.T.U) Other Services.

Based on the results of dividing the sector into 4 quadrants based on the relationship between upstream and downstream industries, local governments can formulate more targeted and effective policies. Leading and mainstay sectors can be the focus of development, while sectors in the potential and disadvantaged categories require special strategies to increase their role and contribution to the regional economy. This approach also encourages the importance of cooperation between regions and strengthening the value chain so that each sector can support each other and strengthen the overall economic structure (Saban et al., 2024; Saban & Falatehan, 2023).

Table 2
Impact of Carbon Tax on Coal Plants in Banten Province (Millions)

Business Field	Output	Revenue	Workforce
A. Agriculture, Forestry, and Fisheries	173	66	4
B. Mining and Quarrying	3.043	879	20
C. Processing Industry	4.299	366	12
D. Electricity and Gas Procurement	1.091.715	62.662	245
E. Water Procurement, Waste Management, Waste and Recycling	42	6	1
F. Construction	1.144	272	4
G. Wholesale and Retail Trade; Car and Motorcycle Repair	18.165	5.168	227
H. Transportation and Warehousing	11.728	1.129	24

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Business Field	Output	Revenue	Workforce
I. Provision of Accommodation and Eating and Drinking	704	116	8
J. Information and Communication	3.847	53	5
K. Financial Services and Insurance	7.541	1.490	37
L. Real Estate	697	26	1
M.N. Corporate Services	14.110	1.786	115
O. Government, Defense and Compulsory Social Security Administration	663	251	5
P. Education Services	195	78	3
Q. Health Services and Social Activities	100	22	1
R.S.T.U. Other Services	466	174	12

Source: The author's data processing results used the IRIO Indonesia Table from 17 BPS sectors.

The carbon tax is imposed based on the amount of CO2e emissions produced by economic activities where the higher the emissions produced, the greater the tax burden. The impact of carbon tax on the increase in total output, income and labor in Banten Province in table 2 includes the electricity and gas sector with the largest contributor to carbon emissions, for example, the Suralaya PLTU. Although there is an increase in output, there is a threat of switching electricity users, especially business actors (industry) due to an increase in the selling price of electricity which will have the potential to decrease output. A decrease in demand from the industry will have an impact on the company's profit margin because tax costs cannot always be transferred to consumers due to receiving subsidies from the government. Companies have to delay expansion and even reduce capacity. Efficient operations carried out by the company will have an impact on reducing the workforce

The processing industry sector with carbon emissions contributors from the cement, steel, chemical and other heavy manufacturing industries that still use electricity from coal-fired power plants will increase production costs from these industries which will have an impact on decreasing output. This condition has a direct impact on the profit margins of companies that have a small scale will close (go bankrupt) or move so that workers will lose their jobs. The mining and quarrying sector with coal, sand and metal mining extraction activities using fueled machines but the emission per unit output is relatively lower than the electricity and gas sector, where the carbon tax will have more impact on the downstream (coal processing and combustion) than the mining itself. Coal mining will be under pressure due to declining demand due to carbon taxes in the electricity and gas sector. The downstream decline causes mining activities to decrease if the market is sluggish, so companies will switch to more efficient technology by reducing the number of workers. The transportation and storage sector with a very high dependence on fuel oil (BBM), when the carbon tax is applied, can have an impact on 2 things, namely an increase in fuel prices and an increase in vehicle taxes due to additional vehicle emissions.

The output of the transportation and warehousing sector will decrease because logistics costs will increase so that the demand for services will decrease and the company's

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profit margin will decrease, so it must reduce the fleet or increase tariffs (costs). However, the indirect impact on the wholesale and retail trade sectors; Repair of motor vehicles and motorcycles will experience a decrease in consumer demand even though trading activities do not produce emissions directly, but price increases are also influenced by increased logistics costs and production costs so that sales become sluggish and profit margins decrease. In the car repair section, it can also have an impact if the demand for vehicles decreases and also has an impact on the workforce. The majority of all sectors will experience a decline in terms of wages and labor absorption in the short term (temporarily) due to the implementation of the carbon tax policy (Wei & Yip, 2025), but there is great potential in long-term recovery and growth by accelerating clean and environmentally friendly renewable energy transition policies (PLTS and PLTB) if we do not want a deeper decline by re-investing from carbon tax revenues so that output, income and labor can be stable and even increase. Provide subsidies for industries that invest in energy efficiency and renewable energy. Training and assistance to protect the workforce with re-skilling and up-skilling programs to improve soft skills for adjustment to the green energy industry and strengthen the green infrastructure ecosystem.

Total Aggregate Output (IDR - Million)

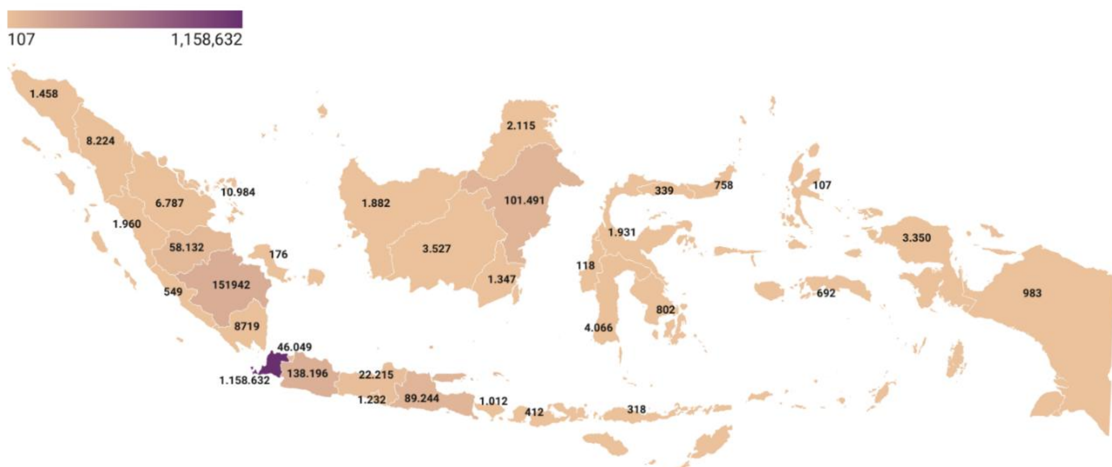

Figure 2
Map of Additional Distribution of Aggregate Output from Banten Province Carbon Tax on Coal Fired Power Plants in 2025
Source: The author's data processing results used the IRIO Indonesia Table from 17 BPS sectors.

Based on Figure 2, it presents the additional impact of aggregate output (in units of millions of rupiah) generated as a result of the implementation of the carbon tax policy on Steam Power Plants (PLTU) in Banten Province, by utilizing the Inter-Regional Input-Output (IRIO) analysis framework to capture ripple effects) cross-regional economy. This impact is not only limited to the electricity sector in Banten, but also spreads through interprovincial supply and demand chains, creating changes in total regional output due to adjustments in

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energy prices and production cost structures. The output values presented illustrate the amount of net contribution experienced by each province in response to the economic shock sourced from the energy sector in Banten, which is one of the largest power generation centers in Indonesia and a major supplier to the Greater Jakarta region.

Of all 34 provinces, Banten Province itself recorded the highest aggregate output impact, which was Rp 1,158,632 million, which can intuitively be interpreted as the largest direct and indirect impact due to changes in production costs in its local electricity sector. However, when viewed from the perspective of spatial spillover, South Sumatra Province occupies the second highest position with an output value of Rp 151,942 million, showing that sectors in this area have a very strong structural linkage with the energy supply chain from Banten. This linkage is most likely to come from the heavily industrial, mining, or highly energy-intensive manufacturing sectors, which depend on stable and cheap electricity supplies from the national electricity system influenced by coal-fired power plants in Banten. Furthermore, East Kalimantan amounted to IDR 101,491 million and West Java amounted to IDR 138,196 million also showed significant impacts, reflecting their important role as national industrial and logistics hubs sensitive to energy price fluctuations. In general, the dominance of impacts on the island of Java, especially West Java, Central Java, and DKI Jakarta confirms that these regions have a high backward linkage to the energy sector, so that any change in energy input costs will produce a wide multiplier effect. These findings provide profound policy implications: sectoral climate policies such as the carbon tax in Banten should not only be a local affair, but should be designed with inter-regional interdependence in mind, especially for provinces with energy-intensive industrial structures that are vulnerable to rising operational costs due to energy transition policies.

Based on figure 3, it illustrates the additional impact of aggregate household income (in units of millions of rupiah) generated as a consequence of the implementation of the carbon tax policy on Steam Power Plants (PLTU) in Banten Province, by utilizing the Inter-Regional Input-Output analysis framework (IRIO) to capture the transmission of economic effects across regions. This impact reflects changes in real household incomes due to adjustments in energy input prices, changes in sectoral demand, and labor market responses triggered by rising production costs in the electricity sector. The values presented are not only representations of direct impacts, but also include secondary and tertiary effects that propagate through interprovincial trade networks, thus providing a holistic picture of how sectoral climate policies can affect income distribution spatially.

Of all 34 provinces, Banten Province recorded the highest aggregate revenue impact, which was Rp 74,546 million, which logically was the largest direct and indirect impact due to changes in the production cost structure in its local energy sector. However, when viewed from the perspective of spatial spillover, South Sumatra Province occupies the second highest position with an income value of Rp 18,728 million, indicating that sectors in this area are most likely coal mining, manufacturing industries, or energy-intensive agro-industries to have a high dependence on a stable and cheap electricity supply from the national system, which is influenced by coal-fired power plants in Banten. Furthermore, East Kalimantan amounted to Rp 13,611 million and West Java amounted to Rp 14,477 million also showed significant impacts, reflecting their important role as centers of economic activity that are highly sensitive

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to fluctuations in energy costs. In general, the dominance of impacts on the island of Java, especially West Java, DKI Jakarta, and Central Java confirms that these regions have a strong backward linkage to the energy sector, so that any change in input costs will produce a multiplier effect on household income through the mechanism of wages, prices of goods, and consumption demand. These findings provide profound policy implications: climate policies such as the carbon tax in Banten must be designed with distributional and socio-economic dimensions in mind, as their impact is not only limited to the energy sector, but also has the potential to widen income inequality between regions if not accompanied by a fair fiscal compensation or redistribution mechanism.

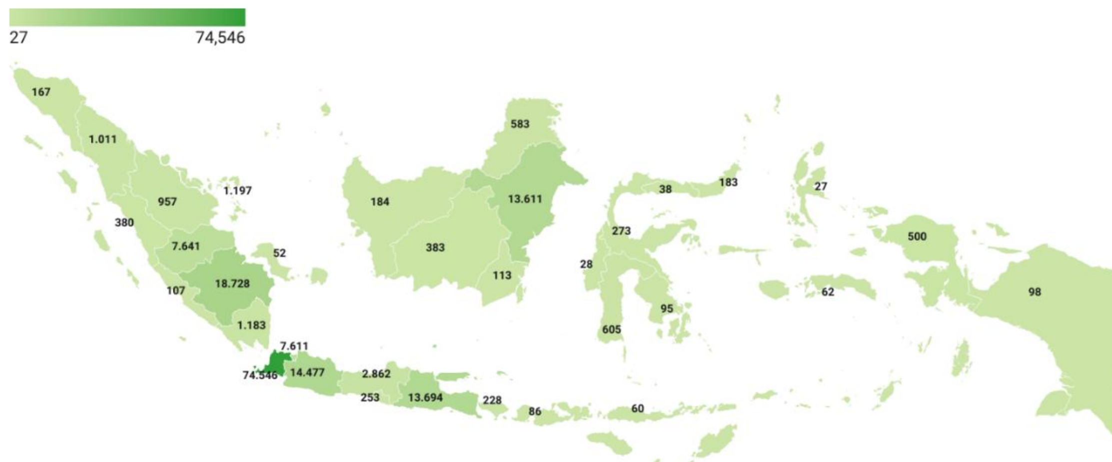

Figure 3.
Map of Additional Distribution of Aggregate Household Income from Banten Province Coal Fired Power Plant Carbon Tax in 2025
Source: The author's data processing results used the IRIO Indonesia Table from 17 BPS sectors

Since the global climate crisis has increased, especially in air pollution, countries have strengthened their environmental policy ambitions, one of which is to reduce carbon emissions, because carbon emissions are not local externalities but global (Stern, 2008), some studies show the impact on the labor market is declining (Curtis, 2018; Wei & Yip, 2025). Based on figure 4, it presents an additional impact Aggregate Workforce (in units of people) generated as a result of the implementation of the carbon tax policy on Steam Power Plants (PLTU) in Banten Province, by utilizing an analytical framework Inter-Regional Input-Output (IRIO) to capture the effects of cross-regional economic ripples. This impact reflects changes in labor absorption both directly and indirectly induced by production cost adjustments in the energy sector, which then propagate through interprovincial supply and demand chains. The values presented are not only representations of local sectoral impacts, but also illustrate how changes in energy input cost structures may affect labor market dynamics at the national level, including shifts in labor intensity, sectoral productivity, and human resource allocation in different regions.

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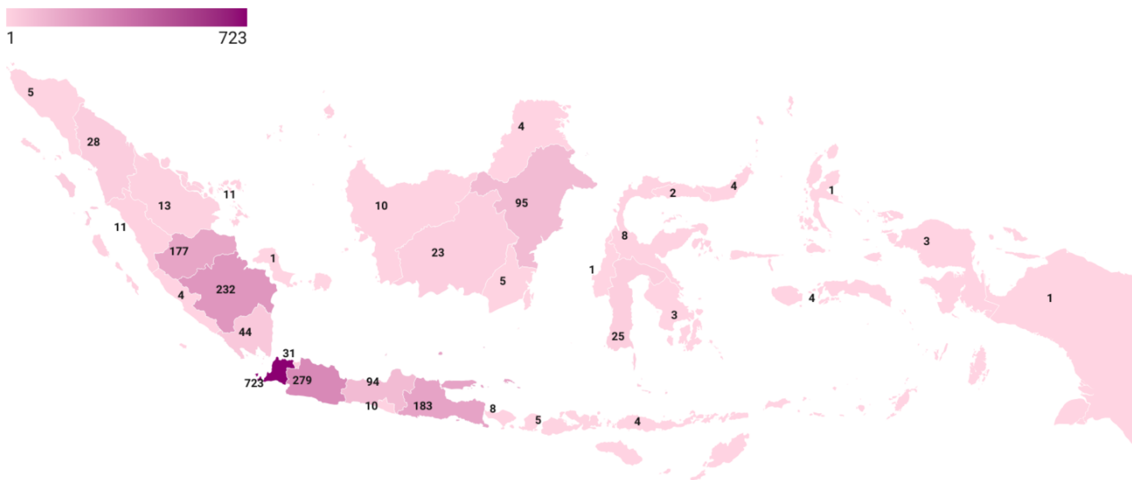

Figure 4.
Map of the Additional Distribution of Aggregate Labor from the Banten Province Coal Plant Carbon Tax in 2025
Source: The author's data processing results used the IRIO Indonesia Table from 17 BPS sectors.

Of all 34 provinces, Banten Province recorded the highest aggregate impact of labor absorption, at 723 people, which is intuitively a direct consequence of operational and structural adjustments in its local electricity sector in response to rising costs due to carbon taxes. However, when viewed from the perspective of spatial spillover, South Sumatra Province occupies the second highest position with a labor absorption value of 232 people, indicating that sectors in this area are most likely to be natural resource-based, manufacturing, or logistics industries that have a significant dependence on the stability of energy supply from the national system, so that any change in energy prices triggers an adjustment in the scale of operations and labor needs. Furthermore, West Java with 279 people and East Kalimantan with 95 people also showed significant impacts, reflecting their important role as centers of economic activity that are highly sensitive to fluctuations in energy costs, especially in the manufacturing and mining sectors. In general, the dominance of impacts on the island of Java, especially West Java, Central Java, and DKI Jakarta confirms that these regions have a strong backward linkage to the energy sector, so that any change in input costs will produce a multiplier effect on labor demand through the mechanism of expansion or contraction of production. These findings provide profound policy implications: climate policies such as the carbon tax in Banten must be designed with the employment dimension in mind as their impact is not only limited to the energy sector, but also has the potential to affect employment in related sectors, especially in areas with energy-intensive and labor-intensive industrial structures. Therefore, the integration of energy transition policies with retraining strategies and social protection is imperative to ensure a just and inclusive transition.

CONCLUSION

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Based on the comprehensive analysis conducted in this study, it can be concluded that the implementation of carbon tax on Steam Power Plants (PLTU) in Banten Province, which is one of the largest coal-based power plant concentration centers in Indonesia, has a broad and multidimensional economic impact, both directly at the local level and indirectly through spillover effects) between regions. Using a data-based Inter-Regional Input-Output (IRIO) analysis framework of 17 economic sectors in 34 provinces, this study revealed that the most affected sectors in Banten are not the energy sector itself, but the (G) Wholesale and Retail Trade sector; Car and Motorcycle Repair, which shows a strong structural linkage both upstream and downstream with the electricity sector. Furthermore, spatial analysis shows that the aggregate impact on output, household income, and labor absorption is not only concentrated in Banten, but also spreads significantly to other provinces, especially South Sumatra, which occupies the second highest position in the three indicators. This reflects the high dependence of sectors in South Sumatra, most likely extractive industries and energy-intensive manufacturing, on the stability of electricity supply and prices from the national system influenced by coal-fired power plants in Banten. The dominance of provinces on the island of Java, such as West Java, DKI Jakarta, and East Java, in capturing the multiplier effect further confirms their role as centers of economic activity that are highly sensitive to fluctuations in energy costs, while highlighting the inter-regional nature of interdependence in Indonesia's economic structure. From a structural perspective, the results of the linkage analysis place the Electricity and Gas Procurement sector in the "Superior" quadrant, which means that this sector has high leverage in encouraging the growth of the upstream and downstream sectors, thus becoming a strategic node in the formulation of energy transition policies. The policy implications of these findings are twofold. On the one hand, carbon tax policies are indeed effective in creating price incentives to internalize environmental externalities and encourage energy efficiency. However, on the other hand, these policies have the potential to cause an uneven economic burden, especially for energy-intensive and labor-intensive sectors and regions, which are at risk of output contraction, decreased income, and termination of employment in the short term. Therefore, the design of energy transition policies in Indonesia must be inclusive and multidimensional, not only relying on price instruments, but also integrated with income redistribution mechanisms such as the reinvestment of carbon tax revenues into renewable energy infrastructure as well as employment-based social protection programs, including retraining and upskilling) to facilitate the shift of the workforce to the green sector.

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