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Article

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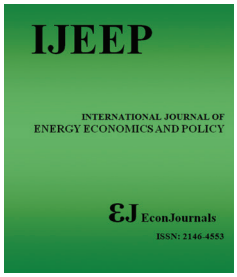

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Regional Impact Analysis of Carbon Tax Implementation on Indonesia's Coal Power Plant with Interregional Input-output Method

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ABSTRACT

The excessive use of greenhouse gases (mainly carbon dioxide) causes a global emission of greenhouse gases. This has eventually brought climate change and global warming, that will affect the human life standard. Also it has several economical impacts such as increasing the mitigation budget for anticipating the climate change problems by applying a carbon tax as one of strategies to reduce carbon emissions. Carbon tax is one of additional economic instrument and has high possibility to be implemented in Indonesia to help its future low carbon development especially on energy sector. Under such a circumstance, this paper aims to predict the possible impact of implementing a carbon tax implementation on Coal Power Plant (CPP) and revenue recycling for 6 regions in Indonesia i.e. Sumatera, Jawa, Bali and Nusa Tenggara, Kalimantan, Sulawesi, Maluku and Papua. The IRIO (InterRegional InputOutput) model of six regions in Indonesia has been developed based on the Central Bureau of Statistics with seventeen sectors in 2016 to evaluate the impact of carbon taxes with a carbon price of 2,1 USD/ton on CPP and to show the scenarios for the distribution impact of carbon tax revenues on output, wages, and GRDP. The results show the implementation of a carbon price of e 2.1USD/ton will give extra revenue of around 241 Billion Rupiah nationally with the distribution of 73%, 15%, 7%, 3%, 2%, and 1% from Java, Sumatera, Kalimantan, Bali-Nusa Tenggara, and Maluku-Papua, respectively. Through revenue recycling, those values could increase the total output, wages, and GDRP per region by around 451, 100, and 169 Billion Rupiah, respectively. The revenue recyling option and its economic impact for each 17 sectors are also identified in the study with spesific characteristics for each region. In conclusion, the result could help the government determine its climate change mitigation strategy, so it could boost the regional economy. Based on the study results, this paper recommends the government to conduct an intensive monitoring and evaluation on low carbon policies for CPP in Java and Sulawesi.

Keywords: Carbon Tax, Economic Impact, Inter-regional Input-output Model, Gross Regional Domestic Product, Wages
JEL Classifications: C67, D57, Q52, R15

1. INTRODUCTION

1.1. Climate Change Issues and Their Impacts

Energy and climate have a unique relationship, energy is directly affected by climate, high temperatures trigger a surge in demand for energy, and they have an important role in supporting adaptations such as cooling, heating, irrigation, trade, and so on. Simultaneously, energy use is the largest anthropogenic contributor to climate change (Carleton and Hsiang, 2016). An increase in temperature will have an impact on an increase in electricity demand, on hot days people tend to use air conditioning on the same day (Auffhammer, 2014; Davis and Gertler, 2015; Sailor and Pavlova, 2003). Rising temperatures will affect everything from the amount of energy we consume to heating and cooling homes and offices to our ability to work outside. Even up to, 2030 the world's energy demand will increase by 45% or an average

increase of 1.6% per year. Most of around 80% of the world's energy needs are supplied by fossil fuels[1].

Climate change is a global issue that must be anticipated by many countries. The United Nations (UN) Convention on Climate Change defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is, in addition to natural climate variability, observed over comparable time periods" (Miraglia et al., 2009). The increase in global temperature not only affects the increase in global temperature but also changes the climate system which will affect many aspects of changes in nature and human life, for example, the quality and quantity of water, habitats, forests, health, agricultural land and coastal ecosystems.

Two basic factors cause climate change, including natural processes (biogeographical) and human activities (anthropogenic). Astronomical factors include changes in the eccentricity of the Earth's orbit and changes in the tilt of the ecliptic plane. On the other hand, anthropogenic factors in climate change involve human activities that emit amounts of greenhouse gases into the atmosphere that deplete the ozone layer or activities that reduce the amount of carbon absorbed from the atmosphere (Akpodiogaga-a and Odjugo, 2010). Humans are one of the main actors contributing to CO_2 emissions, this can be seen in the increase in greenhouse gases including industrialization, burning of fossil fuel, gas flaring, urbanization and agriculture. On the other hand, human activities that reduce the amount of carbon sinks are deforestation, alterations in land use, water pollution and agricultural practices. Human factors have been proven to be responsible for the ongoing unequivocal climate change or global warming (Pachauri et al., 2007).

The impact of climate change on the environment will affect many aspects, one of which is the economic aspect. the study of the direct effects of climate change on agricultural yields, where the importance of climatic factors is clearest (Auffhammer and Schlenker, 2014). A recent finding is that temperature often dominates rainfall, in the production of staple crops (Schlenker and Roberts, 2009; Welch et al., 2010). Climate change will cause uneven rainfall, within a single growing season, farms that experience a small number of extremely rainy days suffer damaged yields, relative to the same quantity of rain distributed evenly across growing days (Fishman, 2016). The agricultural sector has a very important role in building the national economy, including the regional economy, because the agricultural sector functions as a provider of food for community food security, as an instrument of poverty alleviation, as a provider of employment, as well as a source of community income.

Climate change is also an economic problem for fishing communities in Indonesia, fishing communities cannot fulfil their needs and are vulnerable to poverty, while in social problems, fishermen cannot determine the season that occurs because of unpredictable weather, the distance to find fish is further and reduced fishery resources (Ulfa, 2018). Before and after the occurrence of climate change in Indonesia there are significant differences in red chilli farmers, it can be concluded that the production and income of red chilli farmers have decreased (Naura and Riana, 2018) (Naura and Riana, 2018).

Climate change is believed to increase the risk of hydrogeometeorgic disasters, 80% of the total traditional disasters in Indonesia. poor and marginalized populations tend to live in areas that are at high risk of flooding, landslides, sea level rise and water scarcity throughout the dry season (Ministry of Environment and Forestry, 2016b). Energy and climate have a unique relationship, energy is directly affected by climate, high temperatures trigger a surge in demand for energy, they have an important role in supporting adaptations such as cooling, heating, irrigation, trade, and so on. Simultaneously, energy use is the largest anthropogenic contributor to climate change (Carleton and Hsiang, 2016). An increase in temperature will have an impact on an increase in electricity demand, on hot days people tend to use air conditioning on the same day (Auffhammer, 2014; Davis and Gertler, 2015; Sailor and Pavlova, 2003). Rising temperatures will affect everything from the amount of energy we consume to heating and cooling homes and offices to our ability to work outside. Even up to 2030 the world's energy demand will increase by 45% or an average increase of 1.6% per year. Most or around 80% of the world's energy needs are supplied from fossil fuels[2].

Many countries have realized that the impact of climate change is very dangerous for many aspects, some countries claim that climate change is a problem that can be tackled collectively, thereby strengthening social solidarity and paving the way for transnational cooperation to combat climate change (Blau and Stoner, 2018). Focuses on the paris agreement which is the first legally-binding global treaty on climate change agreed in COP21 in Paris in 2015, under the Paris Agreement, almost all countries in the world have committed to keep the rise in global average temperature to "well below" 2°C, and ideally 1.5°C, above pre-industrial levels (UNFCCC, 2015).

Indonesia has ratified the Paris Agreement through Law Number 16 of 2016 concerning Ratification of the Paris Agreement to The United Nations Framework Convention on Climate Change and submitted its proposal in the form of an NDC. Indonesia's target that has been stated in the NDC is to reduce emissions in 2030 by 29% by own business (BAU) and 41% if there is foreign assistance, with the projected base year being 2010 (Ministry of Environment and Forestry, 2016b). Climate change has a considerable impact on Indonesia. Many events have occurred in Indonesia as a result of climate change and global warming, such as: changes in rainfall patterns and distribution. occurrence of droughts, floods and landslides. decreased agricultural production/failure of panels, incidence of forest fires, temperature in urban areas, rising sea levels (Sumastuti and Pradono, 2016).

1 (Global Electricity Demand Is Growing Faster than Renewables, Driving Strong Increase in Generation from Fossil Fuels - News - IEA, n.d.)(Global Electricity Demand Is Growing Faster than Renewables, Driving Strong Increase in Generation from Fossil Fuels - News - IEA, n.d.)

2 (Global Electricity Demand Is Growing Faster than Renewables, Driving Strong Increase in Generation from Fossil Fuels - News - IEA, n.d.)(Global Electricity Demand Is Growing Faster than Renewables, Driving Strong Increase in Generation from Fossil Fuels - News - IEA, n.d.)

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Climate change is believed to increase the risk of hydrogeometeorgic disasters, 80% of the total traditional disasters in Indonesia. poor and marginalized populations tend to live in areas that are at high risk of flooding, landslides, sea level rise and water scarcity throughout the dry season (Ministry of Environment and Forestry, 2016a). based on the analysis of the potential impacts of climate change on the food, water, energy, and health sectors, it can reduce GDP from 0.66% to 3.45% in 2030. This potential impact really needs attention by considering national economic growth between 5, 4 and 6.0% per year which aims to reduce the level of poverty, unemployment, and inequality, as well as increase the welfare of the community (Ministry of Environment and Forestry, 2020).

1.2. Coal Power Plant Contribution as Green House Gas (GHG) Emitter

Coal Power Plant (CPP) plants are the largest source of power generation and the largest single source of energy-related CO_2 emissions, CPP accounted for 37% of global electricity output in 2019, 72% of CO_2 emissions from the electricity sector and 30% of global energy-related CO_2 emissions (International Energy Agency, 2021).

In Indonesia as of December 2020, according to Indonesia's Electricity Supply Business Plan (RUPTL), the realization of the number of power plants was 6,609 units, most of the generation in the form of CPP or around 179 units, of which 102 are self-owned, 3 are leased, and 74 are private (State Electricity Company, 2021) (State Electricity Company, 2021).

Energy storage has a large role in contributing to global CO_2 emissions, as shown in Figure 1 the energy sector is divided into several types of fuel, and one of the largest is coal fuel. Coal-fired power generation is a major contributor to greenhouse gas (GHG) and toxic air emissions worldwide. It can be seen that Coal power generation is a primary cause of greenhouse gas (GHG) and toxic airborne emissions globally, even though Indonesia is one of the countries that produce large amounts of coal (Oberschelp et al., 2019).

The results of Indonesia's GHG inventory calculation show that the 2019 GHG emission level is 1,866,552 Gg CO_2e, an increase of 680,324 Gg CO_2e compared to the 2000 emission level as the initial GHG inventory carried out and an increase of 250,983 Gg CO_2e compared to the 2010 emission level as the base year for GHG emission calculations on NDCs. the 2019 GHG emission rate is 1,866,552 Gg CO_2e, with GHG emissions in each category/sector, namely: (1) Energy of 638,808 Gg CO_2e; (2) Utilization of Industrial Processes and Products 60,175 Gg CO_2e; (3) Agriculture 108,598 Gg CO_2e; (4) Forest and Peat Fire 924,853 Gg CO_2e; (5) Waste of 134,119 Gg CO_2e (Ministry of Environment and Forestry, 2021a).

According to the Energy Sector GHG Emissions Inventory Report issued by the Ministry of Energy and Mineral Resources in 2020 (Ministry of Environment and Forestry, 2021a), energy sector GHG emissions are the second largest emission contributor after the forestry sector and peat fires, as seen in the energy sector emissions of 638.45 Gg CO_2e. From Figure 2, the largest categories of emission contributors, respectively, are energy-producing industries (43.83%), transportation (24.64%), manufacturing and construction industries (21.46%), and other sectors (4.13%). The energy producer industry category has a subcategory of power generation as the largest emitter.

1.3. Carbon Pricing (Tax and Trade) in Indonesia: Current Condition and Plans

Several countries have implemented various methods of mitigating climate change, as well as Indonesia which will implement climate change mitigation by applying the economic value of carbon or carbon credit. Indonesia refers to presidential regulation number 98 of the year in Article 47 paragraph 1 which states that "the implementation of the Carbon Economic Value is carried out through the following mechanisms: (a) Carbon Trading (b) Performance-Based Payments; (c) Carbon Charges; and/or (d) Mechanisms. others by the development of science and technology as determined by the Minister.

The first carbon credit policy to be implemented in Indonesia is carbon levies through a carbon tax scheme (mandated in Law

Figure 1: Global energy-relate CO^2 emissions from fuel combustion in 2019 (International Energy Agency, 2021)

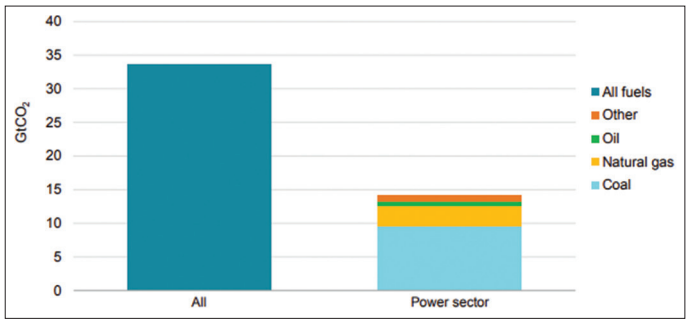
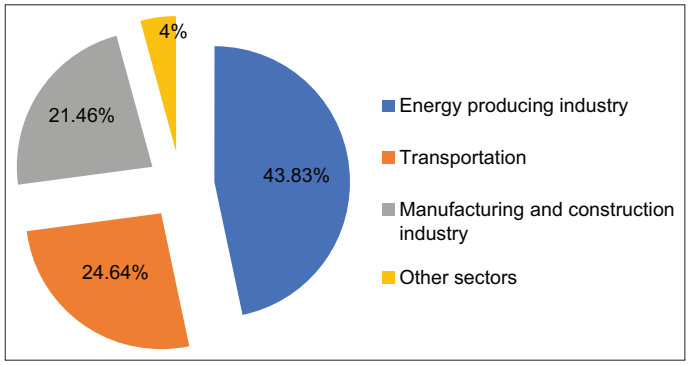


Figure 2: Energy sector emission contributor



number 7 of 2021 concerning harmonization of tax regulations in article 13). This mechanism will be carried out in stages with the principles of fairness and affordability through the following implementation plans: (a) imposed on carbon emissions that have a negative impact (b) minimum tariff of IDR 30,000/t CO_2e (c) starting in 2022 at the CPP.

A carbon tax will be imposed on coal-fired power plants that have passed the Emissions Upper Limit (EUL). The Emission Upper Limit, according to the draft of the Minister of Energy and Mineral Resources concerning the Allowance for GHG Emissions quota, which has not changed so far, can be seen in Table 1 below.

Table 1 above shows the Coal Power Generation and its types, if the installed capacity in the last year exceeds the Upper Emission Limit, a carbon tax will be imposed. In 2021, Indonesia through the Ministry of Energy and Mineral Resources will test the implementation of a carbon tax on coal plants. Exchange rate assumption: IDR 14,350 US$, Sales: 265.85 TWh (Subsidized: 25% and Non-Subsidized 75%), CO_2 Production: 5.33 Million Tonnes/year, can be seen more clearly in Table 2 below:

Table 2 explains that if the imposition of a USD1/t CO_2e carbon tax will increase state revenue by IDR 76.49 billion, a USD1/t CO_2e carbon tax will have an impact on the addition of an electric power BPP of IDR 76.49 billion, a USD1/tCO_2e carbon tax will have an additional electricity subsidy of IDR 20.46 billion and compensation of IDR 61.38 billion. Thus, it can be concluded that for a carbon tax of USD 1/tCO_2e, the government will bear the additional burden of the state by IDR 5.35 billion with a compensation subsidy of IDR 81.84 billion less state revenue from the carbon tax of IDR 76.49 billion.

The strategic sectors that are the main priority in reducing emissions in Indonesia are the forestry sector, as well as the energy and transportation sectors which have covered 97% [4] of Indonesia's total NDC emission reduction targets. Even in the 2021 NDC update document (Ministry of Environment and Forestry, 2021b), through the LTS-LCCR[5] Indonesia has also targeted to achieve NZE in 2060 or earlier. The last document also stipulates the need for attention to aspects of climate change adaptation as one of the national strategic targets.

1.4. Various Carbon Tax Implementation

Previous research has been carried out using Indonesia's Computable General Equilibrium (CGE) model which focuses on the agricultural sector, the results show that in 2030 real gross domestic product (GDP) fell slightly and the Consumer Price Index (CPI) rose slightly (Oktaviani et al., 2011). Environmental risks and potential economic losses due to climate change are predicted to increase. Moreover, Indonesia is one of the countries that are prone to ecological disasters due to climate change (Wahidah and Antriyandarti, 2021).

Studies on the impact of carbon tax policies also have previously been carried out. One of the studies that have been conducted is to predict the possible impact of carbon taxes on economic losses in 30 provinces in China, using the CGE (Computational General Equilibrium) model with a carbon tax scenario with carbon prices from 20 USD/ton to 120 USD/ton up to 2030. The results show that China's industrial CO_2 is greatly reduced, but the implementation of the carbon tax will hinder the economic development of all provinces. Therefore, the concept of carbon tax efficiency is further proposed to evaluate the effectiveness of carbon tax by considering CO_2 reduction and GDP loss (Dong et al., 2017). Previous studies were still in China, the study aims to determine the economic impact of a carbon tax using an energy input-output model in hybrid units. the results show that the carbon tax has a small negative impact on GDP. However, there is a relatively large reduction in emissions (Zhang et al., 2019).

Research on carbon tax has also been carried out in Finland in 2020, this research aims to find out the effect of a carbon tax on social welfare and emission reduction in Finland, research uses the GTAP-E general equilibrium model, and the results obtained are carbon tax policy in Finland has been successful in reducing carbon dioxide emissions, but has a negative effect on Finnish social welfare. Therefore, an optimal level of carbon pricing is recommended for future policy revisions (Khastar et al., 2020). Further research was conducted in Ireland in 2008, by analyzing

3 The results of the field review to PLTU Paiton Units 1 and 2 and the FGD of the Directorate of Economic Policy, Employment, and Regional Development with the Java Bali Paiton Generation (PT PJB UP Paiton) on 15 and 16 March 2022.

4 (Badan Kebijakan Fiskal - Perpres Nilai Ekonomi Karbon Ditetapkan, Indonesia Siap Capai Target Penurunan Emisi Karbon 2030, n.d.)

5 (Indonesia Long-Term Strategy for Low Carbon and Climate Resilience 2050 (Indonesia LTS-LCCR 2050), 2021)

Table 1: The emission upper limit

Types of coal generation	Installed capacity	EUL*
Non-mine mouth and mine mouth	25 ≤ MW <100	1.30**
Non-mine mouth	> 400 MW	0.913**
Non-mine mouth	100 ≤ MW ≤ 400	1.013**
Mine mouth	≥ 100 MW	1.091**

*Last update on March 25, 2022, **In units of Ton CO_2e/MWH, Source: Directorate General of Electricity, 2022[3]

Table 2: Carbon tax impact exercise

Scenario	Carbon tax (USD/ton CO_2)	impact			
		BPP(IDR billion)	BPP(Rp/kwh)	Subsidy(IDR billion)	Compensation *)(IDR billion)
	a	b=production CO_2×Carbon tax	c=b/sales	d=b×1.07×25%	e=b×1.07×75%
1	2	152,97	0.58	40,92	122,76
2	4	305,94	1.15	81,84	245,52
3	10	765,86	2.88	204,60	613,80

*If the non-subsidized customer class is not applied Tariff Adjustment. Source: Directorate General of Electricity, 2022

the medium-term effects of carbon taxes on growth and CO_2 emissions, this study used the HERMES macroeconomic model. the result is a double dividend if the carbon tax revenue is recycled through income tax deductions. If income is recycled by providing lump sum transfers to households, double dividends are unlikely to occur. then in determining that the greater incidence of carbon taxes falls on capital than on labour. Combined with the reduction in income taxes, there is a clear shift in the tax burden from labour to capital (Fitz et al., 2008).

1.5. State of the Art and the Objective of this Article

This research can provide an overview of income if a carbon tax worth IDR 30,000/Ton CO_2e is applied in Indonesia, and is viewed based on six regions (islands). by what is written in Act No.7 of 2021 concerning the harmonization of tax regulations. This research also has a novelty about how to see the impact of implementing carbon taxes in Indonesia using the Inter-Regional Input-Output (IRIO) approach which is described by region (island) so that it can show scenarios of the impact of distributing carbon tax revenue funds on output, wages, and GRDP.

2. MATERIALS AND METHODOLOGY

The data for this study are sourced from the 2016 IRIO table compiled by the Central Statistics Agency (BPS), with a classification of 17-seventeen business fields and 34 provinces, we divide 34 provinces into 6 islands in Indonesia. Table I-O is a statistical description in the form of a matrix that presents information about transactions of goods and services and the interrelationships between one sector and another, in a region at a certain period (Cahyono and Sumargo2, 2005). The matrix describes how the output process of a sector is allocated to other sectors to meet intermediate demand and final demand, where the columns show how intermediate inputs and primary inputs are used in the production process of a sector.

The analysis is focused on the regions contained in the 2016 IRIO table, where the regions are divided into 6 islands, namely Sumatra, Java, Bali and Nusa Tenggara, Kalimantan, Sulawesi, Maluku and Papua. in estimating carbon tax revenues of IDR 30,000/t CO_2e the researchers used data from the Global Energy Monitor (Global Coal Plant Tracker - Global Energy Monitor, n.d.). At the first stage, we calculate the income and emissions in each region that exceed the upper limit as shown in Table 1 and then assesses the impact of carbon tax revenues on total output, wages and GRDP.

2.1. IRIO Impact Analysis

One of the benefits of IRIO is that it can measure the impact of changes in total consumption demand on the supply system. In the Input-Output model, output has a reciprocal relationship with final demand, which means that the amount of output produced depends on the final demand (United Nations, 1999). But under certain circumstances, the output can also determine the amount of final demand. This can be measured by output impact analysis.

The output in the Input-Output model can be calculated as follows (Miller and Blair, 2009).

$$X_{FD} = (I-A)^{-1}(S+E-M) = (I-A)^{-1} F^{D} \quad (1)$$

Equation (1) shows the output (X) which is affected by the final demand (F^D), where X_{FD} is the amount of output formed due to the final domestic demand; F^D is the final demand composed of the S component, namely the sum of household consumption, household non-profit organization (LNPRT) consumption, government consumption, Gross Fixed Capital Formation (PMTB), and inventory changes, as well as components ($E-M$), namely total exports min total imports; $(I-A)^{-1}$ is the Leontief matrix.

From the output impact analysis, it can be calculated the impact of the Gross Added Value (NTB), which is the Gross Domestic Product (GDP)/Gross Regional Domestic Product (GRDP) based on the production approach which is widely used as an economic indicator to see the economy and level of welfare of a region. In the Input-Output model, the relationship between NTB and output is assumed to be linear, which means that if there is an increase/decrease in output, it will be followed proportionally by an increase/decrease in NTB. The impact of NTB can be calculated as follows (Miller and Blair, 2009).

$$V_{FD} = V\,[(I-A)^{-1} F^{D}] = V\,X_{FD} \quad (2)$$

Equation (2) shows the amount of added value (V_{FD}) formed as a result of domestic final demand (F^D) obtained from multiplication of the matrix V, namely the diagonal matrix of the proportion of gross added value to total output, with the impact of the Leontief matrix $(I-A)^{-1}$ and final demand matrix (F^D).

Impact on wages are calculated as follows:

$$\Delta I = h\,(I-A)^{-1}\Delta Y \quad (3)$$

Equation (3) shows additional wages for household (ΔI) due to any changes that occurs on final demands such as investment, export, and household consumption (ΔY). Additional wages for household can be calculated by multiplying the changes on final demand (ΔY) with wages matrix coefficient (h) and inverse matrix $(I-A)^{-1}$ that represent economic structure of each region in Indonesia.

3. RESULTS AND DISCUSSION

Indonesia is a country that has just implemented a carbon tax policy, which is regulated in the tax harmonization law, in general the purpose of implementing a carbon tax in Indonesia is in addition to increasing state revenues but the most important thing is to change the behavior of business actors in the sector coal electricity to further reduce the resulting emissions to be lower which is then expected to switch to low-carbon technologies such as new renewable energy.

Before discussing the impact of carbon tax policies on the Indonesian economy, the author presents the results of an analysis of data processing using Excel to show carbon tax revenues in Indonesia which are divided into 6 islands along with electricity generation managed by the state and managed by the private sector. this analysis has taken into account Indonesia's carbon tax price

of IDR30,000 t CO_2e and the emission ceiling set by the ministry of mineral resources and energy of the republic of Indonesia.

The greater the emission produced, the greater the carbon tax revenue obtained. We have presented carbon tax revenue for each island in Indonesia in Table 3. The Java region is the island with the largest carbon tax revenue in Indonesia with a total revenue of IDR 177,020,772,900 from emissions of IDR 110,200,000. The electricity distributed on the island of Java is 169,691 GWh (Central Bureau of Statistics, 2020) in total generated from all power plants not only from CPP. The largest carbon tax revenue after the Java region is the Sumatra region with a total revenue of IDR 35,298,722,880 with a total emission of IDR 24,500,000. Although emissions in the Sumatran region do not look large, it is known that the majority of CPP have crossed the emission ceiling, so their income is greater.

Increasing taxes will also have an impact on increasing the burden of subsidies on the state. The implementation of the carbon tax will have an impact on increasing electricity prices. The potential impact of rising electricity prices can be minimized by revenue recycling where the income is invested in the right sectors with a high multiplier effect and has the potential to reduce carbon/CO_2.

3.1. Indirect Backward Linkage

Indirect Backward Linkage (IBL) shows the indirect effect of increasing the final demand for one sector unit to increase the total output of all economic sectors. This parameter shows the strength of a sector in driving improvements in each region. In this study will only show 3 important sectors in increasing the total output of all economic sectors in each region.

Table 4 shows 3 sectors that have an effect if investing or shocks will have an impact on increases in other sectors, which means that it will increase the multiplayer effect on all sectors. This description is made only to make it easier for policy makers to determine the distribution of carbon tax revenue funds in general.

Table 3: Revenue derived from carbon tax if applied at IDR 30,000/t CO_2e

Region(island)	Revenue(Rp)	Emission ton/year
Bali and Nusa Tenggara	4.666.177.716	2.600.000
IPP	4.666.177.716	260.0000
Jawa	177.020.772.900	110.200.000
IPP	147.231.211.560	84.200.000
PLN	29.789.561.340	26.000.000
Kalimantan	15.709.423.920	9.700.000
IPP	11.383.708.800	5.300.000
PLN	4.325.715.120	4.400.000
Maluku and Papua	2.023.902.000	7.000.000
IPP	2.023.902.000	7.000.000
Sulawesi	6.172.227.000	27.200.000
IPP	3.326.299.800	25.400.000
PLN	2.845.927.200	1.800.000
Sumatera	35.298.722.880	24.500.000
IPP	13.159.069.080	14.500.000
PLN	22.139.653.800	10.000.000
Grand Total	240.891.226.416	181.200.000

Source: The author's data processing results use PLTU emission data from the Global Coal Plant Tracker January 2022 assuming a tax imposition of IDR 30,000/tCO_2e

3.2. Carbon Tax Impact

In this study, a simulation of the total output scenario was also carried out. the carbon tax revenue for each region (island) is an element that will be shocked at the total output of each region, so that the effect of changes in total output after being shocked or invested by carbon tax income can be known, the following is the shock scenario used in this study:

In Table 5, it can be seen how the components of carbon tax revenue that have been in shock (investment) form the total output. Table 5 depicts the invested or shock carbon tax revenues for the 17 sectors of Indonesia's IRIO table, and also depicts the totals for each region or island. the author interprets only the 4 sectors that are considered to contribute the largest emission reductions from other sectors, first Agriculture, Forestry and Fisheries, second Procurement of Electricity and Gas, third Water Procurement, Waste Management, Waste and Recycling, fourth Transportation and Warehousing.

The greatest impact of the investment or carbon tax revenue shock on total output is seen to be greater in the Electricity and Gas Procurement sector, with a total islandwide of 715,912 million rupiah. This is because some of the output of the Electricity and Gas Procurement sector is part of the electricity sector subsidies and the development of low-carbon energy technologies such as new and renewable energy. then the impact of the Agriculture, Forestry and Fisheries sectors only contributed a total output of 316,988 million rupiahs, the Water Procurement, Waste Management, Waste and Recycling sector amounted to 397,278 million rupiahs, and the Transportation and Warehousing sector amounted to 426,276 million rupiahs.

The biggest impact of the investment or carbon tax revenue shock on total wages is seen to be greater in the Agriculture, Forestry and Fisheries sectors with a total of 99,605 million rupiah for the entire island as shown in Table 6. This is because some of the

Table 4: Three important sectors in increasing the total output of all economic sectors in each region(IBL)

No	Sumatera	Jawa	Bali and Nusa tenggara	Kalimantan	Sulawesi	Maluku and papua
1.	Processing industry	Processing industry	Procurement of electricity and gas	Processing industry	Processing industry	Procurement of electricity and gas
2.	Mining and quarrying	Procurement of electricity and gas	Agriculture, forestry and fisheries	Mining and quarrying	Procurement of electricity and gas	Transportation and warehousing
3.	Agriculture, forestry and fishery	Wholesale and retail Trade; Car and motorcycle repair	Transportation and warehousing	Agriculture, forestry and fishery	Agriculture, forestry and fishery	Mining and quarrying

Source: The author's data processing results use the 2016 IRIO table of 17 BPS sectors

Table 5: Impact on output(Rp million)

Funding sector	Regional					
	Sumatera	Jawa	Bali and Nusa tenggara	Kalimantan	Sulawesi	Maluku dan papua
Agriculture, forestry and fisheries	46.539	231.418	5.906	22.012	8.289	2.825
Mining and excavation	57.327	246.560	6.344	27.505	8.686	3.287
Processing industry	71.350	302.911	8.351	31.860	12.685	5.454
Procurement of electricity and gas	128.299	451.763	11.768	92.419	18.604	13.059
Water procurement, waste management, waste and recycling	60.014	287.996	6.904	29.232	9.545	3.587
Construction	70.959	309.249	7.489	28.343	14.039	3.888
Wholesale and retail trade; car and motorcycle repair	52.516	253.365	6.618	24.238	8.767	3.052
Transportation and warehousing	68.512	304.328	7.572	31.623	10.649	3.591
Provision of accommodation and food and drink	72.065	290.503	8.119	32.314	15.063	4.493
Information and communication	53.970	273.269	7.185	25.124	9.486	3.331
Financial services and insurance	45.818	245.213	5.938	20.524	8.120	2.693
Real estate	47.063	237.036	6.205	21.307	8.049	2.720
Company services	54.938	277.980	7.552	24.777	9.744	3.231
Government administration, defense and compulsory social security	59.975	292.220	8.859	26.977	10.811	3.587
Education services	53.968	266.392	7.052	22.909	9.437	3.125
Health Services and Social activities	64.293	301.150	7.146	29.267	11.112	3.616
Other Services	56.393	268.148	7.628	26.140	10.188	3.312

Source: The author's data processing results use the 2016 IRIO table of 17 BPS sectors

Table 6: Impact on wages(Rp millions)

Funding sector	Regional					
	Sumatera	Jawa	Bali and Nusa tenggara	Kalimantan	Sulawesi	Maluku dan papua
Agriculture, forestry and fisheries	14.286	74.089	1.684	6.180	2.571	795
Mining and excavation	9.416	56.725	1.626	3.540	2.015	459
Processing industry	11.908	52.189	1.642	3.873	2.127	766
Procurement of electricity and gas	13.723	44.853	797	9.562	2.133	1.330
Water procurement, waste management, waste and recycling	11.461	49.354	1.406	4.223	1.645	478
Construction	14.256	57.792	1.720	4.477	2.797	542
Wholesale and retail trade; car and motorcycle repair	14.936	71.429	1.889	5.179	2.077	504
Transportation and warehousing	12.086	51.995	1.451	3.888	1.549	467
Provision of accommodation and food and drink	15.075	65.868	1.905	4.961	3.291	912
Information and Communication	10.209	51.849	1.137	2.640	1.455	616
Financial services and insurance	13.918	77.326	1.854	6.017	2.111	886
Real estate	4.179	23.898	575	1.835	594	321
Company services	15.342	72.085	2.213	4.410	2.955	884
Government administration, defense and compulsory social security	19.154	91.760	2.758	7.126	3.186	802
Education services	22.639	100.463	3.054	9.641	4.087	1.066
Health services and social activities	15.806	66.365	2.016	7.416	3.449	862
Other services	14.712	75.365	1.836	6.283	2.602	640

Source: The author's data processing results use the 2016 IRIO table of 17 BPS sectors

Table 7: Impact on GRDP(Rupiah million)

Funding sector	Regional					
	Sumatera	Jawa	Bali and Nusa Tenggara	Kalimantan	Sulawesi	Maluku dan Papua
Agriculture, forestry and fisheries	35.097	169.534	4.344	15.259	6.478	2.150
Mining and excavation	37.211	160.651	4.149	16.372	5.766	2.316
Processing industry	34.792	143.279	3.977	15.694	6.766	3.150
Procurement of electricity and gas	48.790	119.993	1.818	39.672	5.684	5.011
Water procurement, waste management, waste and recycling	32.766	155.417	3.909	14.847	5.811	2.071
Construction	34.484	142.804	3.547	12.932	7.287	2.104
Wholesale and retail trade; car and motorcycle repair	33.377	168.687	4.326	14.356	6.069	2.042
Transportation and warehousing	32.955	151.256	3.663	14.622	5.559	1.831
Provision of accommodation and food and drink	36.725	152.407	4.795	15.875	8.614	2.655
Information and communication	32.952	164.978	4.314	14.680	5.771	1.971
Financial services and insurance	33.743	167.233	4.502	15.088	6.075	1.959
Real estate	33.881	169.176	4.523	14.883	6.290	2.005
Company services	31.055	160.772	4.203	13.808	5.872	1.826
Government administration, defense and compulsory social security	33.943	155.558	4.929	14.640	6.216	1.864
Education services	34.317	163.028	4.575	14.480	6.139	1.899
Health services and social activities	33.793	150.006	3.893	15.406	6.220	1.844
Other services	33.662	159.648	4.439	15.008	6.089	1.958

Source: The author's data processing results use the 2016 IRIO table of 17 BPS sectors

output of the Agriculture, Forestry and Fisheries sectors is part of the empowerment and maintenance of forests, one of which is a mangrove forest which will have an impact on reducing emissions. then the impact of the Electricity and Gas Procurement sector only contributed a total wage of 72,398 million rupiah, the Water Procurement, Waste Management, Waste and Recycling sector amounted to 68,566 million rupiah, and the Transportation and Warehousing sector amounted to 71,436 million rupiah.

Based on Table 7, it is illustrated that the largest impact estimate from investment or carbon tax revenue shock on the total GRDP of all islands appears to have a greater impact on the Agriculture, Forestry and Fisheries sectors with a total of 232,862 million rupiah for the entire island. this is because some of the output of the Agriculture, Forestry and Fisheries sector is one that can increase Indonesia's economic growth because there are many of these sectors in Indonesia. Indonesia is an archipelagic country where there are still many forests in it, the Ministry of Environment and Forestry reports, the total forest area in Indonesia will reach 125.76 million hectares (ha) in 2022. This figure is equivalent to 62.97% of Indonesia's land area which is 191.36 million ha (Shilvina Widi, 2023). then the impact of the Electricity and Gas Procurement sector only contributed a total wage of 220,968 million rupiah, the Water Procurement, Waste Management, Waste and Recycling sector amounted to 214,821 million rupiah, and the Transportation and Warehousing sector amounted to 209,886 million rupiah.

4. CONCLUSION AND RECOMMENDATIONS

Based on research results the largest contributor to carbon tax revenues in Indonesia in 2022 is the Java region of IDR 177,020,772,900 with total emissions reaching 110,200,000 CO_2/year, the Java region is the area with the most population in Indonesia, and industries that really need electrical energy there. The largest emitters by power plant are CPPs managed by the private sector, while CPPs managed by the state (PLN) produce fewer emissions. a total of carbon tax revenues from all regions of Indonesia get IDR 240,891,226,416 from a total emission of 181,200,000 CO_2/year.

An important sector that will increase the multiplier effect on all sectors when viewed using IBL analysis from all regions in Indonesia is in the manufacturing industry sector, this shows that Indonesia has a lot of raw materials which if invested in the processing sector will have an impact on the development of other sectors.

The results show the implementation of a carbon price of e 2.1USD/ton will give extra revenue of around 241 Billion Rupiah nationally with the distribution of 73%, 15%, 7%, 3%, 2%, and 1% from Java, Sumatera, Kalimantan, Bali-Nusa Tenggara, and Maluku-Papua, respectively. Through revenue recycling, those values could increase the total output, wages, and GDRP per region by around 451, 100, and 169 Billion Rupiah, respectively.

The Ministry of Energy and Mineral Resources needs to carry out intensive monitoring and evaluation of low-carbon policies in the PLTU sector on the islands of Java and Sulawesi, because the data is the largest contributor to carbon emissions and carbon tax revenues. make special policies for private PLTU or Independent Power Producer (IPP) related to NEK because data is the largest emitter in Indonesia and. Make policies for the application of global warming technology to each coal-fired power plant, including the use of technology (co-firing), namely increasing the use of biomass waste as a fuel mixture. Carbon Capture and Storage (CCS) technology, because CCS is the only technology capable of mitigating the release of GHG emissions from the use of fossil fuels in industry and large-scale power plants.

The ministry of finance of the republic of indonesia needs to consider the appropriate carbon tax price so that it can change the behavior of CPP entrepreneurs to immediately make low-carbon technology or switch technology to new renewable energy power plants. with a price of IDR 30,000 t CO_2e, it is considered too small to be able to change the behavior of coal power plant business actors.

The potential impact of rising electricity prices can be minimized by revenue recycling where the income is invested in the right sectors with a high multiplier effect and has the potential to reduce carbon/CO_2. one of which can be invested in the Electricity and Gas Procurement sector wherein it is an acceleration to support low carbon technology.

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