IJEEP
INTERNATIONAL JOURNAL OF ENERGY ECONOMICS AND POLICY
EJ EconJournals
ISSN: 2146-4553

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2024, 14(3), 647-657.

EJ EconJournals

The Impact of Implementing a Carbon Tax on Welfare: Case Study of Indonesia and The Other ASEAN Member Countries

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Received: 07 January 2024 **Accepted:** 14 April 2024 **DOI:** https://doi.org/10.32479/ijeep.15779

ABSTRACT

Green house gases emitted into the atmosphere over decades cause global warming now. The aim of this research is the impact of implementing the carbon tax on welfare in Indonesia. The research method used is the computable general equilibrium method using Global Trade Analysis Project (GTAP)-E to evaluate energy policy in the economy. GTAP-E consists of 140 countries and 57 sectors combined into forty-two regions and eight sectors. Using carbon tax scenario (simulation 1 is 1.93 USD/ton CO_2 simulation 2 is 3.72 USD/ton CO_2 and simulation 3 is 4.83 USD/ton CO_2). The results of the Indonesian equivalent variation (EV) show a negative value. The higher the carbon tax is applied, the greater the decline in welfare. This is also felt by all research countries except the Philippines, Singapore, Thailand, Oceania, Other SEAsia, East Asia, Argentina, Japan, Poland, Portugal, and Ukraine. The variable of the regional demand, it can be seen that the carbon tax causes Indonesia's regional income to increase, and Singapore's income to decrease, while other countries experience no change in income. The primary factor return ratio also shows that the increase in the carbon tax caused a decline in the Land, Unsklab, Sklab, Capital, and Natural Resources sectors. Indonesia's GDP also shows a decrease if a higher carbon tax is implemented, but other countries have no impact on GDP. The Carbon emissions show that it decreases to Indonesia. So, the implementation of the carbon tax causes a decrease in welfare as seen from the EV, primary return ratio, and GDP in Indonesia. The government must have an alternative policy if a carbon tax is implemented in Indonesia.

Keywords: Carbon Tax, Equivalent Variation, Demand Net for Saving, Household Income, Price, Carbon Emission, Global Trade Analysis Project
JEL Classifications: Q50, Q52, Q58

1. INTRODUCTION

Greenhouse gases, or greenhouse gases, which have been emitted into the atmosphere for decades are now causing global warming. Emissions from world industrial and other activities create negative externalities. Nobel laureate William Nordhaus sees climate change as a big challenge because of its negative impact on the environment, even causing disasters such as droughts, floods, and destruction of ecosystems.

There has been research discussing efforts to reduce greenhouse gases, namely quantity-based and price-based (Perman, 2011). In addition, Wei et al. (2014) stated that there are three popular reduction procedures for reducing greenhouse gases, namely price-based, quantity-based, and command-control approaches. In the same vein, Nordhaus (2006) recommends that the government use price-based and quantity-based mechanisms. Perman (2003) show that a price approach is the right policy to reduce greenhouse gas emissions. This is consistent with the view of Pizer (2002) that simulations based on equilibrium models show that price control is more efficient because the benefit from the optimal price policy (carbon tax) is 5 times the expected benefit from the quantity policy (permit).

Carbon tax is one of the pricing policies that is widely used by several countries (Calderón et al., 2016; Li and Su, 2017; Wei, 2014; Wesseh and Lin, 2016). Research by Timilsina et al. (2018) showed that the use of a carbon tax of 16% could reduce CO_2 emissions. Guo et al. (2014) used the same country but with different simulations and models. Shows that the higher the carbon tax produced, the higher the reduction in emissions. This result is in line with Wattanakuljarus (2019) who also used the Dynamic computable general equilibrium (CGE) Model in Thailand, the use of a carbon tax of 20% was able to reduce emissions by 2030. Not only with the Dynamic CGE model, research using Global Trade Analysis Project (GTAP) E (Ayu, 2018; Bi et al., 2019; Cao et al., 2016; Coxhead et al., 2013; Kat et al., 2018; Nong, 2018; Nurdianto & Resosudarmo, 2016; Ojha et al., 2020; Ward & Batista, 2016; Yusuf & Resosudarmo, 2015), the SAM model (Frey, 2017; Grottera et al., 2017), the MIT EPPA model (Octaviano et al., 2014) reveals that a carbon tax will be able to reduce carbon emissions.

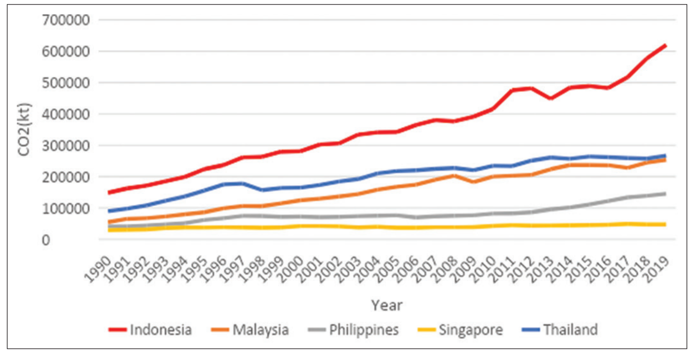
Providing a carbon tax not only has an impact on the environment but also on welfare. Fried et al. (2021) using a general equilibrium gene calibrated to reflect heterogeneity in the United States economy found the optimal policy of using two-thirds of carbon tax revenues to reduce tax distortions on capital income while the remaining third is used to increase the progressivity of labor income taxes. Optimal policies achieve higher and more equal welfare than lump-sum tax approaches. Jogerson et al. (2018), using a carbon tax in welfare, found that welfare will decrease, but the allocation of company demand increases and the savings rate increases. Pradhan, 2012 found that the implementation of a carbon tax has different results for each scenario, if the tax scenario is large and right on target then it can increase economic growth, and equivalent variation (EV) (welfare), but if the tax scenario is small it will reduce economic growth and welfare as measured by EV.

The interesting thing from Dissou and Siddqui's (2014) research in Canada shows that the equivalent variable effect of taxes will decrease for energy commodities but is positive for non-energy commodities. Apart from that, carbon tax primary factors or inputs can increase inequality in wages, energy goods prices, and capital, while inequality in non-energy prices is negative or not unequal. Alonso (2022), a range of implementable country-specific policies in Asia and the Pacific were found to compensate households, reduce inequality, and build support for the adoption of carbon taxes.

Figure 1 shows the movement of carbon dioxide emissions in ASEAN-5 (Indonesia, Malaysia, the Philippines, Thailand, and Singapore) from 1990 to 2019. The graph shows that the five countries except Singapore always experience an increase in CO_2 emissions from year to year. The interesting thing here is that the five Indonesian countries produce the highest CO_2 compared to other countries. In fact, since 2001, only Indonesia has produced CO_2 above 300,000 kt. Singapore, as a developed country that has implemented a carbon tax, is relatively stable in terms of CO_2.

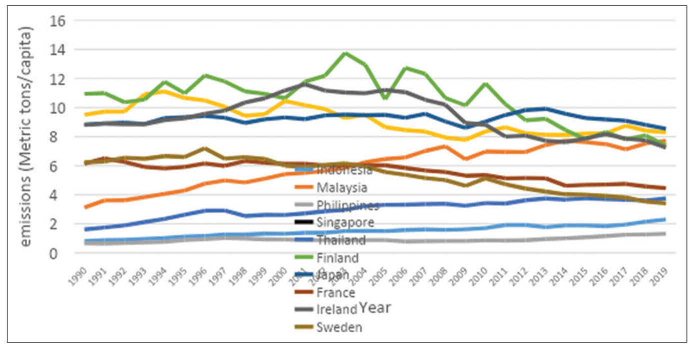
Figure 2 shows the movement of CO_2 emissions per capita in several countries. If we look at the CO_2 produced per capita, Malaysia, Indonesia, the Philippines, and Thailand always experience an increase every year. Where Malaysia ranks first, followed by Thailand, Indonesia, and the Philippines. Finland, as the first country to implement a carbon tax, shows that CO_2 emissions per capita, although slightly fluctuating, show a downward trend. Sweden, Ireland, France, Japan, and Singapore, which have also implemented a carbon tax in their countries, also show a fluctuating but negative trend in CO_2 emissions per capita around 2000. It can be seen that the implementation of a carbon tax is thought to be able to reduce carbon emissions in the world.

Figure 1: Carbon emissions in ASEAN-5 1990-2019



Source: World Bank (2022)

Figure 2: Carbon Emissions/capita in ASEAN-5 and in several countries that have implemented a carbon tax in 1990-2019



Source: World Bank (2022)

Indonesia has the fourth largest population in the world, namely 3.43% of the world's population in 2016, which has great potential to cause global climate change. Hasudungan (2016) revealed that in 2000 Indonesia was ranked fourth with the largest total emissions as a result of land use and non-CO_2 gas and was ranked 21st in the country when only CO_2 emissions from fossil fuels were calculated. Without these aspects, Indonesia was ranked 15th among the other top 25 countries as the largest GHG emitter in 2000.

At the 21st Conference of Parties of the United Nations Framework Convention on Climate Change (UNFCCC) in Paris from 30 November to 13 December 2015, the President of Indonesia announced to increase in his greenhouse gas emission reduction target from 26% to 29% without conditions or no action (Business as Usual or BAU) in 2030. In addition, with international support (conditional) Indonesia is targeting a 41% reduction in emissions (UNFCC, 2016). Indonesia makes its largest contribution to global warming. So, both Indonesia and the world need to understand the distributional impacts of climate policy in Indonesia (Hasudungan, 2016).

Indonesia has also set a time for its implementation. First, implementation in April 2022. However, the plan was postponed because the regulations were not yet ready. The next one was set for July 1 2022 and that was postponed again. At the end of December

2022, it was postponed again because it would carry out the best study for the good of the Indonesian state. The carbon tax aims to make the Indonesian economy greener. The purpose of a carbon tax is not to tax emissions but a combination of cap and trade, so a review is needed. In 2021, there are already several draft carbon tax rates in the draft Law on Harmonization of Tax Regulations, namely IDR 75/kg of Carbon dioxide equivalent (CO_2e), and most recently IDR 30/kg of CO_2e.

Based on the research background above, previous studies reveal that the implementation of a carbon tax has positive implications for CO_2, and negative for GDP, employment, the Gini coefficient of per capita income, and poverty. However, some researchers found different results. And the existence of interesting things in Indonesia based on the data above is the reason for the author to analyze "The Impact of Variables on Indonesia's Welfare". The selection of research topics on the impact of carbon taxes on welfare is by the scope and is part of the long-term research roadmap of the research leader and research members. In general, the road map prioritizes the topics of Economics, Macroeconomics, and People's Economics.

2. THEORY

2.1. Carbon Tax

Perman (2003) explains that pollution tends to be an externality of market processes and its consequences are not sufficiently reflected in private market decisions. Considering pollution reduction, the level of control that maximizes net benefits to the firm is different from the level that maximizes net social benefits. Economists often recommend economic efficiency criteria as pollution targets in companies. This can be thought of as selecting pollution targets to maximize net social benefits. However, economic efficiency is not the only relevant criterion for setting pollution targets. Certain criteria are important to policymakers and tend to reflect policy objectives and the constraints under which they operate (Perman, 2003).

Perman (2003) believes that to achieve pollution targets, instruments are needed to reduce pollution. There are three pollution control instruments, namely (Perman, 2003):

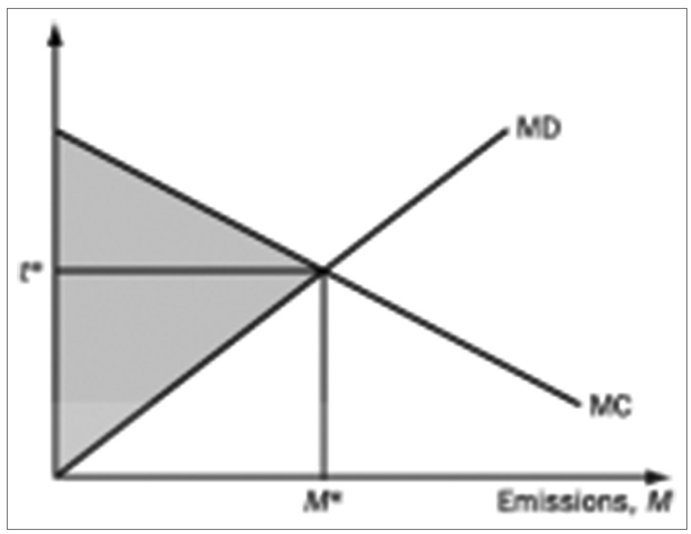
1. Institutional approaches to facilitate the internalization of externalities Institutional approaches to facilitate the internalization of externalities: Facilitation of bargaining, specification of responsibilities, and development of social responsibility
2. Command and control instruments: Input control over quantity and/or mix of inputs, technology control, output quotas or prohibitions, emission licenses, and location control (zoning, planning control, relocation)
3. Economic incentive instruments (market-based) or Economic incentive (market-based) instruments: emissions levies/taxes, user/nature levies/fees, resource taxes, product levies/taxes, emission reductions and resource management subsidies, emission permits that can marketable (transferable), deposit return system, non-compliance fees, performance bonds, and payment of obligations.

In many pollution control instruments, economic incentive (market-based) instruments are more cost-effective than command and control instruments but not in all (Perman, 2003).

Figure 3 shows that the efficient target (M*) is the emission level that equates the marginal cost of emission reduction and the marginal damage of emissions. The total net social benefit is visible in the shaded area in Figure 3. This is the maximum net benefit available. Emissions are at any level other than M*, which means efficiency losses and net benefits obtained do not reach their maximum level (Perman, 2003).

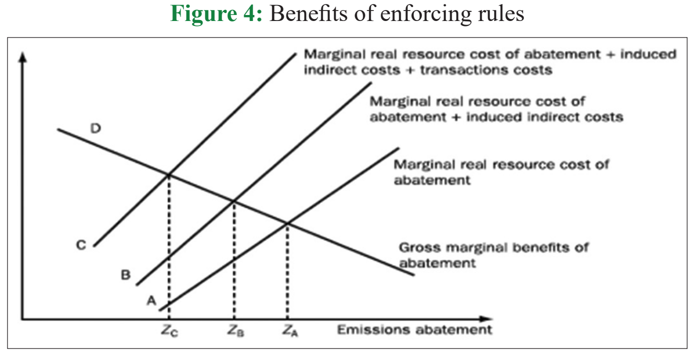
The equilibrium if there are transaction costs and environmental regulations can be seen in Figure 4 (Perman, 2003). Curve D shows the marginal gross benefit from pollution reduction (damage avoided). The marginal, real resource cost of reducing pollution is represented by the curve labeled D. If there were no other costs, an efficient outcome would require ZA units of reduction. Indirect costs including impacts on unemployment and trade competitiveness may also be incurred. Adding to the resource reduction costs, the combined cost curve B is obtained with a lower efficient reduction rate, ZB. If the induced effect is beneficial rather than harmful, curve B will point to the right (rather than to the left) of curve A. Finally, curve C adds transaction costs to the previous two cost categories. The efficient reduction rate, taking into account all relevant information items is Z. One cost reduction is by taxes or permits. This does provide a useful way of thinking about instrument selection. The preferred instrument is the instrument that has lower total costs to achieve a certain

Figure 3: Equilibrium in a perfectly competitive market



Source: Perman (2003)

Figure 4: Benefits of enforcing rules



Source: Perman (2003)

target. Even if one instrument is superior in terms of real resource cost reduction, it is not necessarily superior when the effects and transaction costs are also considered.

2.1.1. Welfare

EV is a measure of the change in economic welfare associated with a price change. John Hicks (1939) on Varian (2010) is credited with introducing the concepts of compensation and EV.

The EV is a change in wealth, at current prices, which will have the same impact on consumer welfare as a change in price, with income unchanged. This is a useful tool when current prices are the best place to make comparisons (Figure 5).

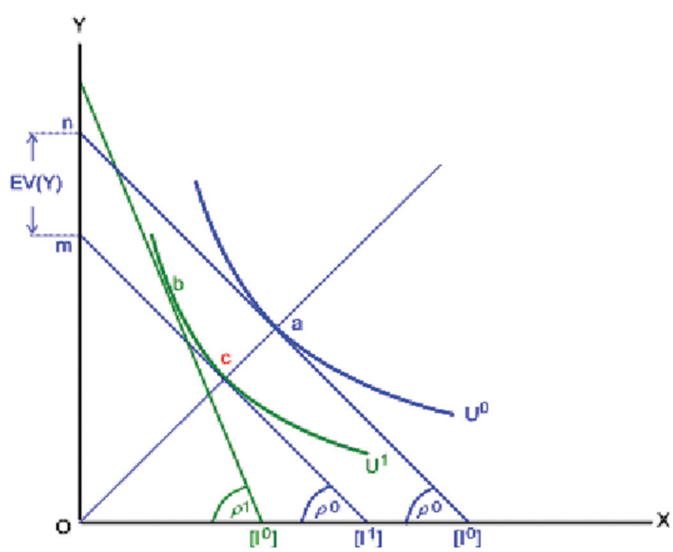
Like compensating variation, EV is an estimate, in dollars, of the welfare impact of a price change. However, while the compensating variation measures the amount of income consumers need to be as happy as they were before the price change, the EV asks: if prices had not changed.

2.2. Literature Review

2.2.1. Impact of carbon tax on the environment

Carbon tax is one of the pricing policies that is widely used by several countries (Calderón et al., 2016; Li and Su, 2017; Wei, 2014; Wesseh and Lin, 2016). Research by Timilsina et al. (2018) using the CGE model in China showed that the use of a carbon tax of 1.4 USD/tCO_2e to 22.6 USD/tCO_2e was able to reduce emissions by 16% CO_2. Guo et al. (2014) using the same country but different simulations and models also show that the higher the carbon tax produced, the higher the reduction in emissions. This result is in line with Wattanakuljarus (2019) who also used the Dynamic CGE Model in Thailand, the use of a carbon tax of 1.37% to 1.43% was able to reduce emissions by 20% in 2030. Puttanapong et al. (2015) also found that increasing the carbon tax was able to reduce carbon emissions. Not only with the Dynamic CGE model, research using GTAP E (Nong, 2018 and Ayu, 2018), the SAM model (Frey, 2017; Grottera et al., 2017), the MIT EPPA model (Octaviano et al., 2014) revealed that a carbon tax would be able to reduce carbon emissions.

Figure 5: Equivalent Variation Graph



Source: Varian (2010)

2.2.2. Impact of carbon tax on welfare

Providing a carbon tax not only has an impact on the environment but also welfare. Fried et al. (2021) using a general equilibrium gene calibrated to reflect heterogeneity in the United States economy found the optimal policy of using two-thirds of carbon tax revenues to reduce tax distortions on capital income while the remaining third is used to increase the progressivity of labor income taxes. Optimal policies achieve higher and more equal welfare than lump-sum tax approaches. Jogerson et al. (2018), using a carbon tax in welfare, found that welfare will decrease, but the allocation of company demand increases and the level of savings increases. Pradhan, 2012 found that the implementation of a carbon tax has different results for each scenario, if the tax scenario is large and right on target then it can increase economic growth, and EV (welfare), but if the tax scenario is small it will reduce economic growth and welfare as measured by EV.

The interesting thing from Dissou and Siddqui's (2014) research in Canada shows that the equivalent variable effect of taxes will decrease for energy commodities but is positive for non-energy commodities. Apart from that, carbon tax primary factors or inputs can increase inequality in wages, energy goods prices, and capital, while inequality in non-energy prices is negative or not unequal. Alonso (2022), a range of implementable country-specific policies in Asia and the Pacific were found to compensate households, reduce inequality, and build support for the adoption of carbon taxes.

3. RESEARCH METHODS

3.1. Research Design

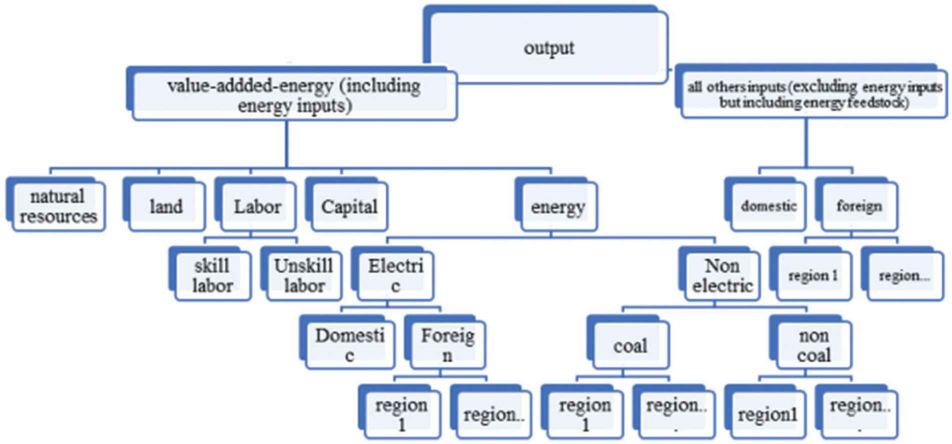
This research uses an economics approach that focuses on the impact of policies on economic variables. The type of research is descriptive and quantitative. A multiregional CGE model or a multiregional CGE model with a focus on how variables such as quotas, subsidies, and taxes interact and the dynamics in which these policy variables connect with other indicators such as employment, income, and trade is referred to as a Global Trade Analysis Project or GTAP model.

Burniaux and Truong (2002) used GTAP-E to evaluate energy policy. Burniaux and Truong (2002) overcome this shortcoming by incorporating energy substitution into the standard GTAP model. Following the structure by Burniaux and Truong (2002), a basic model was built as attached in Figure 6.

3.2. Data

This research uses GTAP-E, part of GTAP 9 of 2011. GTAP-E comprises 140 countries and 57 sectors combined into fourty two regions and eight sectors. The aggregate region consists of Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Philippines, Singapore, Thailand, Vietnam, Oceania, East Asia, Southeast Asia, North America, Latin America, Eu_25, MENA, SSA, and other regions described in table 2 .The eight sectors combined from 57 sectors, namely (1). primary agriculture, forestry, and fisheries; (2) coal mining; (3). crude oil; (4). natural gas extraction; (5). oil products; (6). electricity; (7). Energy intensive industry; and (8). other industries. The aggregation of eight sectors can be seen in table 1.

Figure 6: Structure of the production model in the dynamic CGE model



3.3. Scenario

To analyze the impact of a carbon tax on a country's economy, it is necessary to adopt a carbon tax scenario that will be implemented in a country. The application of scenarios is based on policies taken by the government, predictions, or rules implemented (Zhou et al., 2016). Zhou et al. (2016) implemented a simulation based on the authors' predictions with only reference to previous research. Likewise, Li and Su (2017) implemented their scenarios based on existing analyses and phenomena. Based on this, this research wants to see the impact of a national carbon tax if implemented in Indonesia. The simulation used in this research is

1. IDR 30/kg of CO_2 e or equivalent to 1.93 USD/ton CO_2
2. 3.72 USD/ton CO_2
3. IDR 75/kg of CO_2 e or equivalent to 4.83 USD/ton CO_2

Scenarios 1 and 3 are based on the 2022 Macro Policy Framework and Fiscal Policy Principles (KEM and PPKF) document which is part of the draft law concerning the fifth amendment to law number 6 of 1983 concerning general provisions and tax procedures (KUP). Within this macro and fiscal policy framework, the government plans to impose an Indonesian carbon tax rate of IDR 75/kg of CO_2e. Through this bill, the carbon tax is regulated in a new article. Where "The carbon tax rate is set at a minimum of IDR 30.00/kg of CO_2e or equivalent unit." So 30 is taken. R u piah/ton

The calculation is, if you equate it with the carbon tax unit applied by other countries, namely units per ton, then Indonesia's carbon tax is: 1 ton=1000 kg

Scenario 1

- tax = IDR 30/kg CO_2e
  =(Unit weightxRate per kg)
  = 1000 × Rp. 30
  =IDR 30,000/ton of carbon emissions
  The carbon tax rate unit is USD/ton of carbon emissions, so assuming dollars = Rp. 15,615,-. then the carbon tax is 1.92 USD/ton CO_2 e
- The second scenario is adopted from the implementation of a carbon tax. Singapore is one of the ASEAN countries that has implemented a carbon tax and Singapore has succeeded in reducing carbon emissions and this success is proven by the plan to increase the carbon tax in 2024.
- tax = IDR 4.83/kg CO_2e
  =(Unit weight × Rate/kg)
  =1000 × IDR 75
  =IDR 75,000 per ton of carbon emissions

The carbon tax rate unit is USD/ton of carbon emissions, so assuming dollars = Rp. 15,615,- then the carbon tax is 4.83 USD/ton CO_2 e.

Variables exposed to carbon tax shock

- welfare (EV) of Indonesia and neighboring countries;
- Regional demand for net savings in Indonesia
- Household and company income (regional household income) in Indonesia
- Rate of return on primary factors (Ratio return to primary factor) in Indonesia.

3.4. Data Collection Techniques

The data used in this research is secondary data. In the form of GTAP_E, from 42 regions and 8 aggregation sectors. Open access GTAP 9 E data is on the GTAP website.

4. RESULTS AND DISCUSSION

4.1. Research Overview

Carbon tax in this part of the world has been implemented since 1990 by two countries, namely Finland, namely 1.74% and Poland at 0.15%. Figure 7 shows the impact of a carbon tax on the share of annual global greenhouse gas emissions. It can be seen from 1990 that the role of carbon taxes in 2 countries was able to reduce greenhouse gases by 0.19%. From 1990 to 2023, many countries have implemented carbon taxes, most recently in 2023 as many as 34 countries. It can be seen that from 1990 to 2023 (except in 2020-2002 the effect of the Covid-19 pandemic) the more countries that use carbon taxes, the greater their contribution to reducing annual global greenhouse gas emissions. The interesting thing is that Sweden is a country that applies the highest carbon tax compared to other countries, even exceeding 100%.

Figure 8 shows a world map of countries that have implemented a carbon tax and countries that are still planning a carbon tax in 2023 (March). It can be seen that the regions that have implemented many carbon taxes are the continents of Europe and America. There are still some in Asia, namely Japan and Singapore.

Figure 7: Share of annual global greenhouse gas emissions by countries that implement global carbon taxes from 1990 to 2023

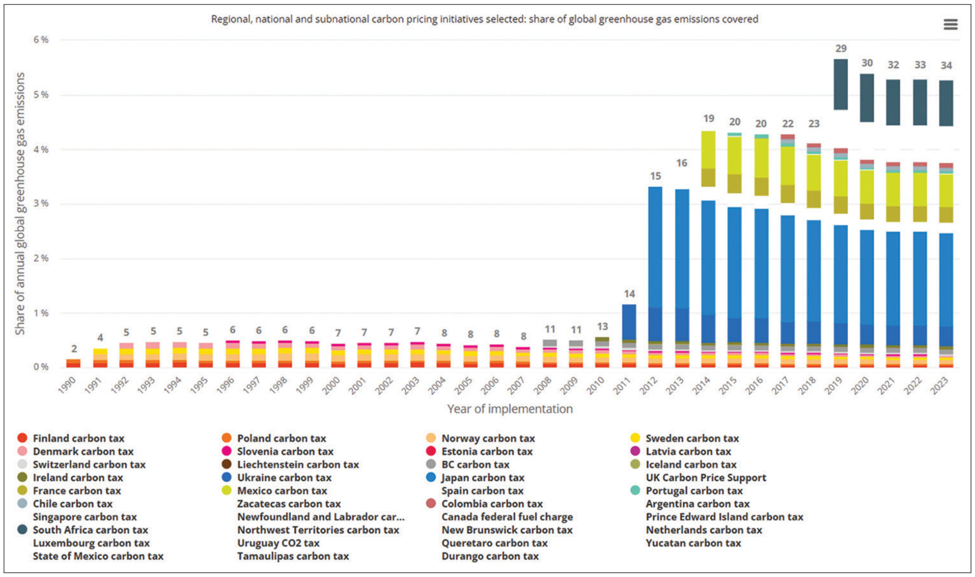
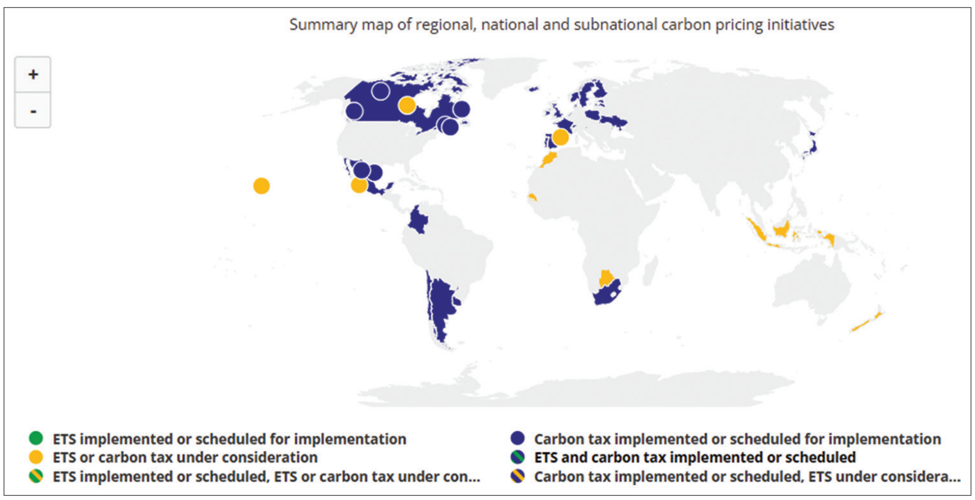


Figure 8: Countries that implement carbon taxes globally



Indonesia is characterized as a country that is still considering implementing a carbon tax in Indonesia. In fact, the last time there was such planning was in the 2022 Macro Policy Framework and Fiscal Policy Principles (KEM and PPKF).

4.2. Research Results

The research used three scenarios, namely simulation 1 of 1.93 USD/ton CO_2, simulation 2 of 3.76 USD/ton CO_2, simulation 3 of 4.83 USD/ton CO_2. Apart from using these three simulations the author also added a carbon tax from countries that have implemented a carbon tax on March 1, 2023, assuming these countries are included in the 140 countries. Based on this table, the regional aggregation obtained is 42 regional aggregates which come from Table 2, plus 10 ASEAN regions and other continents.

The impact of the carbon tax implemented in Indonesia on EV can be seen in Table 3 below:

Table 4 show that the implementation of the carbon tax in simulation 1 (Rp. 30/kg of equivalent carbon dioxide (CO_2e) or the equivalent of 1.93 USD/ton CO_2) causes the Indonesian EV to decrease by 30.54 million USD. Not only Indonesia is negative when implementing a carbon tax in Indonesia, but the countries of Brunei, Cambodia, Laos, Vietnam, and parts of ASEAN that have not implemented a carbon tax, have also experienced a decline. Colombia, Canada, Argentina, Estonia, Finland, France, Ireland, Latvia, Luxembourg, Mexico, Netherlands, Norway, Africa, Spain, Sweden, Switzerland, UK, Uruguay, the MENA region, SSA, and the rest of the world also experienced a decline.

However, not all countries have a negative effect, the carbon tax still causes a positive value on the EV for the Philippines, Singapore, Thailand, Argentina, Japan, Poland, Portugal, the South Asia region, the North America region, and the Latin America region.

For Indonesia, the higher the carbon tax implementation from simulation 1 to simulation 2 (3.72 USD/ton CO_2), towards simulation 3 (Rp. 75/kg of CO_2e) or equivalent to 4.83 USD/ton CO_2), the greater the decline in the welfare of the State which is

Table 1: Aggregation sector to be used

Sector name	Group description	Disaggregated sectors
Agriculture	Agriculture, fishing, and forestry	Paddy rice, wheat, cereal grains nec vegetables, fruit, nuts, oil seeds sugar cane, sugar beet, plant-based fibers nec crops, bovine cattle, sheep and goats animal products nec, raw milk, wool, silk-worm cocoons, forestry, fishing
Coal	Coal mining	Coal, Oil, Minerals nec, Petroleum, coal products, Mineral products nec
Oil	Crude oil	Textiles, wearing apparel, leather products, paper products, publishing, chemical products, basic pharmaceutical products, rubber and plastic products, Ferrous metals, Metals nec, metal products, computer, electronic and optic, electrical equipment, machinery and equipment nec, Motor vehicles and parts, Transport equipment nec, Manufacturing nec
Gas	Natural gas extraction	Gas, gas manufacture, distribution
Oil_Pcts	Refined oil products	Petroleum, coal products
Electricity	Electricity	Electricity, water, construction, trade, Accommodation, food and service
En_Int_ind	Energy intensive industries	Minerals nec, chemical, rubber, plastic products, mineral products nec, ferrous metals, metals nec
Oth_ind_ser	Other industries and services	Bovine cattle, sheep and goat, meat products, vegetable oils and fats, dairy products, processed rice, sugar, food products nec, beverages and tobacco products, textiles, wearing apparel, leather products, wood products, paper products, publishing , metal products, motor vehicles and parts, transport equipment nec, electronic equipment, machinery and equipment nec, manufactures nec, water, construction trade, transport nec, water transport, air transport, communication financial services nec. insurance, business services nec., recreational and other services, public admin. and defense, edu, ownership of dwellings

Source: Authors' specification from GTAP E. 9 Database

Table 2: Forty two regions on region aggregat

Country	Code	Country	Code	Country	Code
Argentina	1	Luxembourg	18	SSA	35
Britishcolo	2	Malaysia	19	Sweden	36
Brunei Daras	3	MENA	20	Switzerland	37
Cambodia	4	Mexico	21	Thailand	38
Canada	5	NAmerica	22	UK	39
Denmark	6	Netherlands	23	Ukraine	40
EastAsia	7	Norway	24	Uruguay	41
Estonia	8	Oceania	25	Vietnamese	42
EU_25	9	OtherSEAsia	26		
Finland	10	Philippines	27		
France	11	Poland	28		
Indonesia	12	Portugal	29		
Ireland	13	RestofWorld	30		
Japan	14	Singapore	31		
Laos	15	South Africa	32		
LatinAmer	16	SouthAsia	33		
Latvia	17	Spain	34		

characterized by a greater decline in simulations 2 and 3 namely −93.35 and −132.66. This means that if the government wants to implement the 2022 Macro Policy Framework and Fiscal Policy Principles (KEM and PPKF) in the last choice of simulation, namely simulation 1, the reduction in EV is lower than if using Simulations 2 and 3, but this is certainly not effective because ideally a carbon tax for plans to reduce carbon emissions without sacrificing the welfare of national society.

An interesting thing happened to Thailand, the carbon tax of other countries was able to increase the welfare of the Philippines and Thailand even though they had not implemented a carbon tax in their country. Countries that have successfully implemented a carbon tax, even if there is a scenario of adding a carbon tax in Indonesia, these countries can still improve welfare, namely Singapore, Argentina, Japan, Poland, Portugal, the South Asia region, the North America region, the Latin America region.

Table 3: Carbon tax of countries globally on March 1, 2023

Country	Price of carbon tax (%)
Argentina	3.339010944
British Columbia	48.03073967
Baja California	9.42271984
Canada	48.03073967
Chile	5
Colombia	5.055810445
Denmark	26.52864568
Estonia	2,175
Finland	83.7375
France	48.5025
Iceland	38.53486837
Ireland	5,274,375
Japan	2.16511837
Latvia	16.3125
Liechtenstein	130.8115768
Luxembourg	48.111
Mexico	4.070614971
Netherlands	55,593
New Brunswick	48.03073967
Newfoundland and Labrador	48.03073967
Northwest Territories	48.03073967
Norway	90.86397129
Poland	0.079191317
Portugal	26,013
Prince Edward Island	36.94672283
Singapore	3.767897513
South Africa	8.925614268
Spain	16.3125
Sweden	125.5565536
Switzerland	130.8115768
Tamaulipas	17.25022864
United Kingdom	22.2759
Ukraine	0.820375951
Uruguay	155.8683502
Zacatecas	13.85694094

Source: Worldbank, 2023

Table 5 show that the implementation of the carbon tax in simulation 1 (Rp. 30/kg of CO_2e or the equivalent of 1.93 USD/

Table 4: Impact of the regional carbon tax on Welfare (equivalent variation) in Indonesia and neighboring countries

EV	Sim 1	Sim 2	Sim 3
Brunei Daras	−25.69	−26.23	−26.54
Cambodia	−2.75	−2.59	−2.49
Indonesia	−30.54	−93.35	−132.66
Laos	−4.19	−4.19	−4.19
Malaysia	−104.73	−104.13	−103.79
Philippines	77.45	78.82	79.6
Singapore	146.1	145.67	145.41
Thailand	114.79	117.32	118.78
Vietnamese	−11.57	−12.63	−13.24
Oceania	322.43	315.14	311.01
OtherSEAsia	7.59	7.64	7.66
EastAsia	2760.71	2795.01	2814.65
Argentina	144.47	144.65	144.76
Britishcolo	−281.5	−282.56	−283.18
Canada	−8219.38	−8221.35	−8222.54
Denmark	−1415.1	−1414.56	−1414.24
Estonia	−15.65	−15.57	−15.53
Finland	−2574.32	−2573.31	−2572.72
France	−6713.41	−6705.32	−6700.59
Ireland	−509.87	−509.72	−509.64
Japan	2554.69	2589.99	2610.35
Latvia	−10.88	−10.76	−10.68
Luxembourg	−175.93	−175.79	−175.71
Mexico	−935.11	−936.13	−936.72
Netherlands	−2403.79	−2402.15	−2401.15
Norway	−2663.58	−2665.8	−2667.07
Poland	170.34	171.77	172.61
Portugal	125.25	126.38	127.03
South Africa	−623.03	−623.18	−623.26
Spain	−834.32	−828.98	−825.9
Sweden	−2314.12	−2313.42	−2313.02
Switzerland	−2136.69	−2135.94	−2135.5
UK	−2465.53	−2461.39	−2458.98
Ukraine	154.12	155.47	156.24
Uruguay	−270.88	−270.77	−270.71
SouthAsia	966.74	988.34	1000.81
NAmerica	4688.51	4714.42	4729.51
LatinAmer	704.55	706.93	708.33
EU_25	2245.48	2272.2	2287.67
MENA	−3712.33	−3747.27	−3767.6
SSA	−859.62	−866.83	−871.02
RestofWorld	−3345.42	−3369.98	−3384.05

Source: GTAP 9 E (data processed). EV: Equivalent variation

ton CO_2) causes regional demand for net savings in Indonesia to increase by 0.01%. Not only Indonesia is positive about implementing a carbon tax in Indonesia, the Philippines, Singapore, Thailand, Argentina, Ireland, Japan, Latvia, Portugal, Brunei, Cambodia, Laos, Vietnam, and parts of ASEAN that have not implemented a carbon tax, have also experienced a decline. Colombia, Canada, Argentina, Estonia, Finland, France, Ireland, Latvia, Poland, Portugal, Spain, Ukraine, Uruguay, North America, Latin America, and EU-25, also experienced an increase. The rest show negative values.

For Indonesia, the higher the carbon tax implementation from simulation 1 to simulation 2 (3.72 USD/ton CO_2), towards simulation 3 (Rp. 75/kg of CO_2e or equivalent to 4.83 USD/ton CO_2), the greater the increase in welfare based on the regional demand for net saving in Indonesia, which is characterized by an increase The value gets

Table 5: Impact of carbon tax on regional demand for net savings in Indonesia

Qsave	Sim 1	Sim 2	Sim 3
Brunei Daras	−0.21	−0.21	−0.21
Cambodia	−0.06	−0.05	−0.05
Indonesia	0.01	0.02	0.03
Laos	−0.1	−0.1	−0.1
Malaysia	−0.07	−0.07	−0.07
Philippines	0.02	0.02	0.02
Singapore	0.07	0.06	0.06
Thailand	0.02	0.02	0.02
Vietnamese	−0.04	−0.04	−0.04
Oceania	0.01	0.01	0.01
OtherSEAsia	−0.01	−0.01	−0.01
EastAsia	0.02	0.02	0.02
Argentina	0.03	0.03	0.03
Britishcolo	−0.13	−0.13	−0.13
Canada	−0.22	−0.22	−0.22
Denmark	−0.24	−0.24	−0.24
Estonia	−0.01	−0.01	−0.01
Finland	−0.64	−0.64	−0.64
France	−0.1	−0.1	−0.1
Ireland	0.04	0.04	0.04
Japan	0.05	0.05	0.05
Latvia	0.1	0.11	0.11
Luxembourg	−0.07	−0.07	−0.07
Mexico	−0.07	−0.07	−0.07
Netherlands	−0.04	−0.04	−0.04
Norway	−0.56	−0.56	−0.56
Poland	0.02	0.02	0.02
Portugal	0.04	0.04	0.04
South Africa	−0.07	−0.07	−0.07
Spain	0.01	0.01	0.01
Sweden	−0.23	−0.23	−0.23
Switzerland	−0.07	−0.07	−0.07
UK	0.02	0.02	0.02
Ukraine	0.14	0.14	0.14
Uruguay	0.14	0.14	0.14
SouthAsia	0.03	0.03	0.03
NAmerica	0.02	0.03	0.03
LatinAmer	0.01	0.01	0.01
EU_25	0.02	0.02	0.02
MENA	−0.13	−0.13	−0.13
SSA	−0.11	−0.11	−0.11
RestofWorld	−0.17	−0.17	−0.17

Source: GTAP 9 E (data processed)

bigger in simulations 2 and 3, namely 0.02 and 0.03. This means that if the government wants to implement the 2022 Macro Policy Framework and Fiscal Policy Principles (KEM and PPKF) in the final simulation option, namely Simulation 3, the increased regional demand for net savings is higher than when using Simulations 2 and 3. So if the government wants to implement a carbon tax with the assumption of 1 variable regional demand for net savings studied, the policy is effective because the carbon tax for carbon emission reduction plans increases regional demand for savings.

An interesting thing is that if there is an increase in the carbon tax then it has no impact on regional demand for net savings in other countries which is characterized by unchanged values for each country/region.

The results show that the implementation of the carbon tax in simulation 1 (Rp. 30/kg of CO_2e or the equivalent of 1.93 USD/

ton CO_2) causes Indonesian household and corporate income (regional household income) to increase by 0.15% (Table 6). Not only Indonesia is positive when implementing a carbon tax in Indonesia, but almost all countries show positive results on regional household income, except Brunei Darussalam, Cambodia, Laos, Colombia, Canada, Denmark, Estonia, Finland, France, Netherlands, Norway, South Africa, Sweden, MENA region, SSA, and Rest of the World.

For Indonesia, the higher the carbon tax implementation from simulation 1 to simulation 2 (3.72 USD/ton CO_2), towards simulation 3 (Rp. 75/kg of CO_2e or equivalent to 4.83 USD/ton CO_2) has no impact on welfare indicators based on Country Household and Corporate Income (regional household income). Indonesia is characterized by its constant value, which is the same as in simulations 2 and 3, namely 0.15%. Not only Indonesia, the countries that did not change from simulation 2 to 3 are the same as the countries that increased during simulation 1. Except for several countries, increasing the carbon tax simulation towards simulation 2 was able to increase regional household income in Cambodia, Japan, and Spain.

Table 6: Impact of carbon tax on household and company income (regional household income) in Indonesia

y	Sim 1	Sim 2	Sim 3
Brunei Daras	−0.18	−0.19	−0.19
Cambodia	0.08	0.09	0.09
Indonesia	0.15	0.15	0.15
Laos	−0.04	−0.04	−0.04
Malaysia	0.08	0.08	0.08
Philippines	0.22	0.22	0.22
Singapore	0.22	0.22	0.22
Thailand	0.19	0.2	0.2
Vietnamese	0.12	0.12	0.12
Oceania	0.21	0.2	0.2
OtherSEAsia	0.27	0.27	0.27
EastAsia	0.22	0.22	0.22
Argentina	0.26	0.26	0.26
Britishcolo	−0.21	−0.21	−0.21
Canada	−0.77	−0.76	−0.76
Denmark	−0.33	−0.32	−0.32
Estonia	−0.03	−0.03	−0.03
Finland	−1.29	−1.28	−1.28
France	−0.2	−0.2	−0.2
Ireland	0.25	0.26	0.26
Japan	0.34	0.35	0.35
Latvia	0.17	0.17	0.17
Luxembourg	0.03	0.03	0.03
Mexico	0.07	0.07	0.07
Netherlands	−0.15	−0.15	−0.15
Norway	−0.9	−0.9	−0.9
Poland	0.14	0.14	0.14
Portugal	0.19	0.19	0.19
South Africa	−0.33	−0.33	−0.33
Spain	0.03	0.04	0.04
Sweden	−0.23	−0.23	−0.23
Switzerland	0.03	0.03	0.03
UK	0.04	0.04	0.04
Ukraine	0.26	0.26	0.26
Uruguay	0.06	0.06	0.06
SouthAsia	0.21	0.21	0.21
NAmerica	0.24	0.24	0.24
LatinAmer	0.23	0.23	0.23
EU_25	0.14	0.15	0.15
MENA	−0.07	−0.07	−0.07
SSA	−0.05	−0.05	−0.05
RestofWorld	−0.13	−0.13	−0.13

Source: GTAP 9 E (data processed)

So if the government is going to implement a carbon tax with the assumption that it only looks at 1 variable in the form of regional household income then the policy is effective because the carbon tax for carbon emission reduction plans increases household income demand but will not affect it if it is increased to 4.36USD/ton CO2.

Figure 9 shows the impact of the carbon tax on the rate of return on primary factors (Ratio return to primary factor) in Indonesia. The results show that the higher the carbon tax produced, the lower the rate of return on primary factors (Ratio return to primary factor) in Indonesia, both for the Land, unskilled labor, skilled labor, Capital, and Natural Resources sectors. Only the primary sector in the form of land has a positive value, although it decreases if the carbon tax increases.

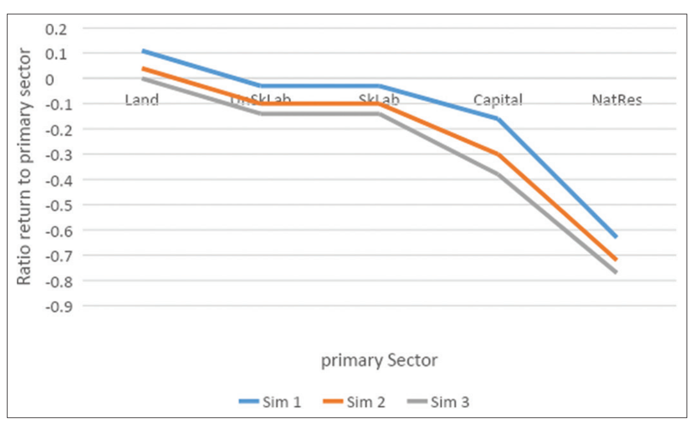
Table 7 shows that the implementation of a carbon tax is able to reduce carbon emissions in Indonesia. The higher the carbon tax, the greater the reduction in CO_2 emissions. This is in line with the theory which states that the higher the carbon tax, the more carbon emissions will be reduced. Not only Indonesia, if we look at almost all countries that have implemented a carbon tax have been able to reduce carbon emissions, except for Poland, Portugal and Argentina.

5. DISCUSSION

5.1. The Impact of a Carbon Tax on Welfare

The results of implementing the carbon tax in Indonesia were able to reduce the EV in Indonesia. This is in line with Jogerson et al (2018, using a carbon tax on welfare, finding that welfare will decrease, but the allocation of corporate demand increases and the level of savings increases. Pradhan 2012 finds that the implementation of a carbon tax has different results for each scenario, if the tax scenario is large and If the target is right it can increase economic growth, and EV (welfare), but if the tax scenario is small it will reduce economic growth and welfare as measured by EV.

Figure 9: Impact of carbon tax on the ratio of returns to primary factors in Indonesia



Source: GTAP 9 E (data processed)

Table 7: Impact of carbon tax on carbon dioxide emissions (CO_2) in indonesia

Gco2t	Sim 1	Sims 2	Sims 3	Gco2t	Sim 1	Sims 2	Sims 3
Brunei Daras	0.02	0.03	0.03	Latvia	−3.57	−3.57	−3.56
Cambodia	0.21	0.22	0.22	Luxembourg	−9.33	−9.32	−9.32
Indonesia	−1.07	−2.13	−2.72	Mexico	−2.64	−2.64	−2.64
Laos	0.58	0.58	0.58	Netherlands	−13.56	−13.56	−13.56
Malaysia	0.2	0.2	0.21	Norway	−10.31	−10.31	−10.3
Philippines	0.09	0.1	0.1	Poland	0.05	0.05	0.05
Singapore	−0.63	−0.64	−0.64	Portugal	0.39	0.39	0.39
Thailand	0.17	0.18	0.19	South Africa	−22.21	−22.21	−22.21
Vietnamese	0.13	0.14	0.14	Spain	−5.13	−5.13	−5.13
Oceania	0.11	0.11	0.11	Sweden	−16.48	−16.48	−16.48
OtherSEAsia	0.03	0.03	0.03	Switzerland	−19.37	−19.37	−19.37
EastAsia	0.02	0.02	0.01	UK	−8.56	−8.56	−8.56
Argentina	0.01	0.01	0.01	Ukraine	−0.38	−0.37	−0.37
Britishcolo	−3.39	−3.38	−3.38	Uruguay	−19.88	−19.88	−19.88
Canada	−23.15	−23.15	−23.15	SouthAsia	−0.09	−0.1	−0.1
Denmark	−8.39	−8.39	−8.39	NAmerica	0.11	0.11	0.11
Estonia	−0.07	−0.07	−0.07	LatinAmer	0.17	0.17	0.17
Finland	−20.03	−20.03	−20.03	EU_25	0.3	0.3	0.3
France	−9.19	−9.19	−9.19	MENA	0.22	0.22	0.22
Ireland	−12.61	−12.61	−12.61	SSA	0.62	0.62	0.62
Japan	−0.5	−0.49	−0.49	RestofWorld	0.26	0.26	0.26

Source: GTAP 9 E (data processed)

Carbon taxes on regional income from savings and from households are increasing in Indonesia. This is in line with research by Fried et al. (2021) using general equilibrium, calibrated to reflect heterogeneity in the United States economy, finding that the optimal policy is to use two-thirds of carbon tax revenues to reduce tax distortions on capital income while the remaining third is used to increase tax progressivity. labor income. Optimal policies achieve higher and more equal welfare than lump-sum tax approaches. This means that there is tax revenue that can increase people's income. Alonso (2022), a range of implementable country-specific policies in Asia and the Pacific were found to compensate households, reduce inequality, and build support for the adoption of carbon taxes.

The carbon tax on the declining rate of return from the primary sector in Indonesia is in line with research by Dissou and Siddqui (2014) in Canada showing that the equivalent variable effect of the tax will decrease on energy commodities but positive on non-energy commodities. Apart from that, carbon tax primary factors or inputs can increase inequality in labor wages, prices of energy goods, and capital, while inequality in non-energy prices is negative or not unequal. Thus reducing the rate of return.

5.2. Impact of Carbon Tax on the Environment

The implementation of a carbon tax can reduce carbon emissions in Indonesia, this is in line with research by Timilsina et al. (2018) using the CGE model in China which resulted in the use of carbon tax from 1.4 USD/tCO2e to 22.6 USD/tCO2e able to reduce emissions by 16% CO2. Guo et al. (2014) using the same country but different simulations and models also showed that the higher the carbon tax produced, the higher the reduction in emissions. This result is in line with Wattanakuljarus (2019) who also used the dynamic CGE Model in Thailand, the use of a carbon tax of 1.37% to 1.43% was able to reduce emissions by 20% in 2030. Puttanapong et al. (2015) also found that increasing the carbon tax was able to reduce carbon emissions. Not only with the dynamic CGE model, research using GTAP E (Nong, 2018 and Ayu, 2018), the SAM model (Frey, 2017; Grottera et al., 2017), the MIT EPPA model (Octaviano et al., 2014) revealed that a carbon tax would be able to reduce carbon emissions.

6. CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

1. The Indonesian carbon tax has a negative impact on the regional welfare (EV) of Indonesia and several neighboring countries;
2. Indonesia's carbon tax has a positive impact on regional demand for net savings in Indonesia
3. Indonesia's carbon tax has a positive impact on household and corporate income (regional household income) in Indonesia
4. Indonesia's carbon tax has a negative impact on the rate of return on primary factors (Ratio return to primary factor) in Indonesia
5. Indonesia's carbon tax has a positive impact on reducing carbon dioxin (CO_2).

6.2. Recommendations

There is a need for a review of the 2022 Macro Policy Framework and Fiscal Policy Principles (KEM and PPKF) which has a negative impact on welfare, especially the EV and rate of return in the primary sector. It may be necessary to review the amount of the carbon tax set and apply the carbon tax to the sector that is thought to produce the most carbon emissions first.

7. ACKNOWLEDGEMENT

We would like to thank the Faculty of Economics and Business, Andalas University for supporting and facilitating this research on the Excellent Research Program.

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