DOI: 10.26417/ejes.v4i1.p110-120

The Impact of Carbon Tax Application on the Economy and Environment of Indonesia

Putri Ayu

Master of Science in Economics, Faculty of Economics and Business, Universitas Gadjah Mada, Indonesia

Abstract

As the most efficient market with a mitigation instrument basis, carbon tax is highly recommended by economists and international organizations. This paper examines the impact of implementing carbon tax policy on value of change in GDP, GDP Quantity Index, Government Household Demand, Private Household Demand, and CO_2 emission effects in Indonesia by using the dynamic energy Computable General Equilibrium (CGE) model. This study used GTAP-E that was part of GTAP 9 in 2011. GTAP-E consists of 140 countries and 57 sectors aggregated into eleven regions and eight sectors. There were three scenarios of carbon tax used in this paper that were China, Singapore, and India. The result shows that both GDP and GDP index have a negative impact due to the carbon tax of US \$20/tCO_2, US\$ 10/tCO_2, and US \$1.60/t CO_2. The greater the application of the carbon tax is, the greater the decrease of values of GDP, Government Household Demand, Private Household Demand towards carbon tax policies in Indonesia are. The negative impact of carbon tax is greater for the Private Household Demand that is indicated by all commodities except crude oil has decreasing demand from baseline scenario (no tax). While in the Government Household Demand, agriculture sector, crude oil, refined oil product, and other industries, carbon tax has a positive impact. In the environmental facet, if the carbon tax in Indonesia is implemented in accordance with the above simulation, then it appears that carbon tax can reduce emissions of CO_2.

Keywords*: C*arbon Tax, GDP, Government Household Demand, Private Household Demand, CO_2 Emissions, GTAP-E

Introductions

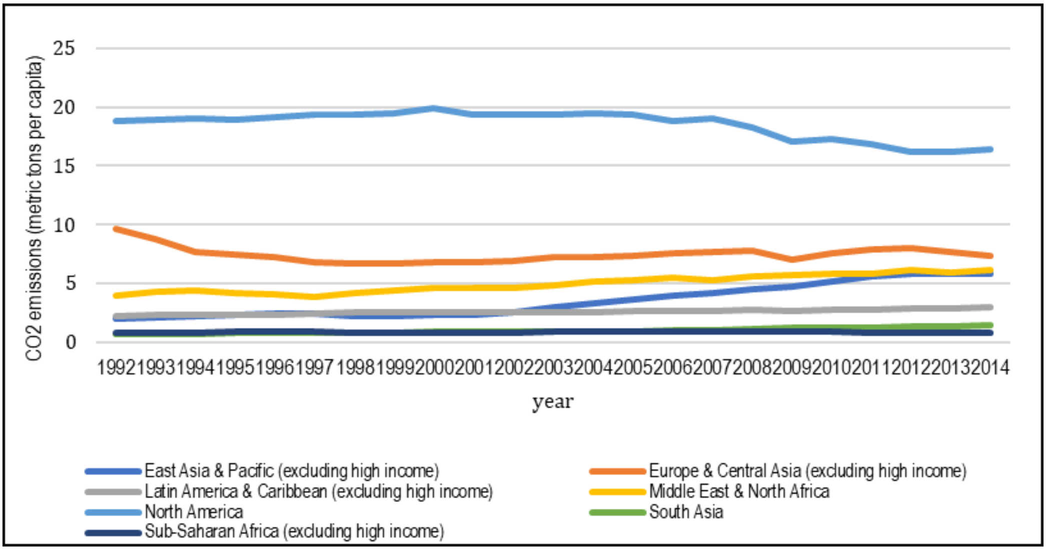
Global warming is now an interesting issue because of the many disasters having recently occurred (Yusuf *et al.*, 2015). The total of anthropogenic GHG emissions had continued to increase in 1970 to 2010 with larger absolute decadal increases towards the end of this period. Despite a growing number of climate change mitigation policies, the annual GHG emissions grow on average by 1.0 gigatonne carbon dioxide equivalent ($GtCO_2eq$) or 2.2% per year from 2000 to 2010 if compared to 0.4 $GtCO_2eq$ (1.3%) per year from 1970 to 2000 (IPCC, 2014). IPCC (2014) suggest that it can make significant and dangerous global climate changes.

The Kyoto Protocol and the United National Framework Convention on Climate Change are two of climates policies in the world (Wesseh *et al*., 2017). The climates policies still have a debate about procedures of greenhouse gas (CHG) abatement. Controversy still hangs over a specific abatement mechanism. Perman (2003) reveals that institutional approaches to facilitate internationalization of externalities and command, control instruments, and economic incentive (market-based) instruments are the instruments available for pollution control. Furthermore, Wei (2014) suggest that the price-based, quantity-based, and command-and-control mechanisms are three popular procedures of abatement.

Nordhaus (2014) recommends that the government should use the price-based and quantity-based mechanisms as a tool to reduce GHG. Perman (2003) suggests that command and control provide advantages enabling polluters to be flexible in reducing pollution, but it may not always be feasible or desirable on other grounds for establishing regulations in such ways. Quantity-based mechanism is a mechanism to reduce highly redundant costs. Polluters will buy permits in that the total emissions will be equal to the total emissions generated so that only the lowest cost reductions will be made (Perman, 2003 and Wei, 2014). The most attractive mechanism is the price-based mechanism, i.e. taxes such as the carbon tax where the payments are made per unit of CO_2 emissions produced (Wei, 2014; Calderón *et al*., 2016; Lin & Li, 2011; Wesseh *et al*., 2017). A carbon tax means that controlling carbon price can directly decrease the level of emissions.

Nordhaus (2014) and Pizer (2002) reveal that price and quantity controls have different treatments and will lead to different welfare consequences caused by uncertainty of compliance costs. Pizer (2002) argues that price controls are more efficient. Simulations based on a stochastic computable general equilibrium model indicate that the expected welfare gained from an optimal price policy (carbon tax) is five times higher than the expected gain from the optimal quantity policy (permits). Although carbon tax is more efficient but there is still a literary debate over the most efficient mechanism (Wesseh *et al*., 2017).

Figure 1. The Value of CO_2 Emissions of Seven Continents in 1992-2014

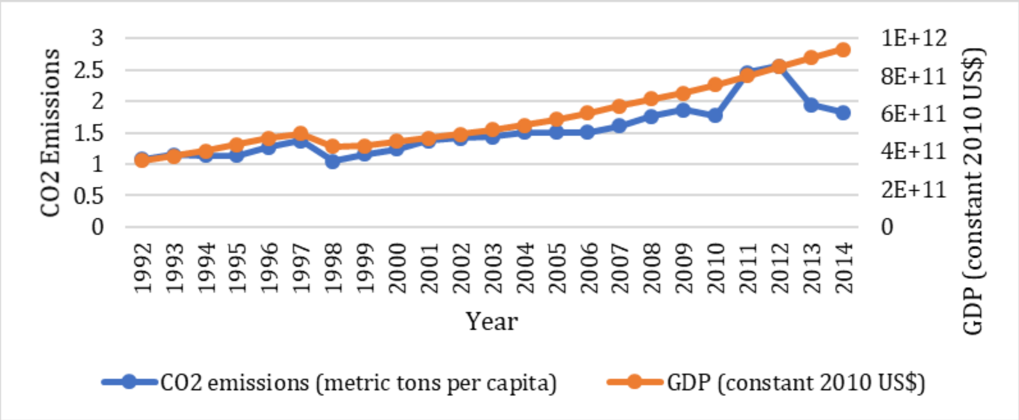


Sources: World Bank Data (2017)

Figure 1 illustrates the value of CO_2 emissions of seven continents in 1992-2014. North America is the world's largest emitter of CO_2, followed by Europe and Central Asia, Middle East and North Africa, East Asia and Pacific, Latin America and Caribbean, South Asia, and Sub-Saharan Africa. Although North America's carbon emissions are the highest in the world but in 2004-2014 CO_2 they decreased. Europe and Central Asia have increasing carbon emissions but they are not as high as the increasing of carbon emissions in the Middle East and North Africa continents. The interesting thing here is that from 1992-2014 the continents of East Asia and Pacific have continuously increased the CO_2 emissions, even in 2011-2014 carbon emissions had plunged into the continents of Middle East and North Africa. This means that there should be special attention to the continents of East Asia and Pacific including Indonesia as one of the states from this continent.

Indonesia had the fourth largest population in the world that is 3.43% of the world population in 2016 that was very potential in causing global climate changes. Hasudungan *et al*. (2016) reveals that in 2000, Indonesia ranked as the fourth country with the largest total emissions as a result of land use and non-CO_2 gases and ranked as the 21th country when only CO_2 emissions from fossil fuels were counted. Without these aspects, Indonesia was ranked as the fifteenth country among other top 25 countries as the largest GHG emitters in 2000. In addition, Figure 2 shows the value of CO_2 emissions and GDP in 1992-2014. It can be seen that the increase of GDP from year to year is also accompanied by the increases of CO_2 emissions although two years ago they had an inverse relationship.

Figure 2. The CO_2 Emissions and GDP of Indonesia in 1992-2014



Source: World Bank data (2017)

At the 21st Conference of Parties (COP) of the United National Framework Convention on Climate Change (UNFCCC) in Paris on November 30th to December 13th, 2015, the President of Indonesia announced to raise its greenhouse gas emission reduction targets from 26-29% with an unconditional or no-action (Business as Usual) capability in 2030. In addition, with international supports (conditional) Indonesia is targeting to reduce emissions as much as 41% (Cabinet Secretariat of Indonesia, 2015). Indonesia makes its greatest contribution to global warming. So, it is important for both Indonesia and the world to understand the distributional impact of climate policy in Indonesia (Hasudungan *et al*., 2016).

Reducing carbon emissions can be done by increasing the payment cost of "carbon tax". Carbon taxes have been widely adopted by countries in the world, such as the United States, China, India, Singapore, European Union, and Colombia (Abdullah & Morley, 2014; Li & Su, 2017; Pizer, 2002; Wesseh *et al*., 2017; Zhou, Shi, Li, & Yuan, 2016; Calderón *et al*., 2016). Meanwhile, Indonesia still has not implemented this policy because it still considers the impact and profit that will occur if applied.

Based on the above background, a carbon tax is considered to be more efficient than other policies. The CO_2 emissions from the East Asia and Pacific continents increase every year including Indonesia as the fifteenth emitter in the world. Hence, this study aims to examine the impact of GDP, government household demand, private household demand, and CO_2 emission reductions in Indonesia if carbon tax is applied in Indonesia. Research related to these aspects in Indonesia has been conducted by Yusuf *et al*. (2015) and Hasudungan *et al*. (2016). The difference of this research with the previous research are that this research uses GTAP and has different simulations. In session two, the researcher explains the framework of the theory and empirical studies related to this research. The session three discusses the methodology and data used, the session four shows results and discussions, and the last session is the conclusion.

Theoretical Framework and Empirical Studies

Theoretical Framework

Perman (2003) explains that pollution tends to be an externality to the market process and as a result it is not adequately reflected in private market decisions. Considering pollution abatement, the control level that maximizes net benefits to firms is different from the level that maximizes social net benefits. Economists often recommend an economic efficiency criterion as pollution targets in a firm. This can be thought of as selecting pollution targets to maximize social net benefits. However, the economic efficiency is not only a relevant criterion for pollution target setting. Certain criteria are important to policy makers and tend to reflect their policy objectives and the constraints where they are operated (Perman, 2003).

Perman (2003) believes that to achieve the target of pollution, instruments are needed to reduce pollution. Before knowing the instruments, we must know criteria for selection of pollution control instruments. Perman (2003) suggests there are nine criteria for selection of pollution control instruments in the certainty that are cost effectiveness, long run effects, dynamic efficiency, ancillary benefits, equity, dependability, flexibility, cost of use under uncertainty, and information requirements.

But in uncertainty, criteria for selection of pollution control instruments are dependability, flexibility, cost of use under uncertainty, and information requirements.

There are three instruments of pollution control that are (Perman, 2003):

Institutional approaches to facilitate internalization of externalities: facilitation of bargaining, specification of liability, and development of social responsibility

Command and control instruments: input controls over quantity and/or mix of inputs, technology controls, output quotas or prohibitions, emissions licenses, and location controls (zoning, planning controls, relocation)

Economic incentive (market-based) instruments: emissions charges/taxes, user charges/fees/natural, resource taxes, product charges/taxes, emissions abatement and resource management subsidies, marketable (transferable marketable) emissions permits, deposit-refund systems, non-compliance fees, performance bonds, and liability payments.

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

Figure 3. Target Setting under Perfect Information

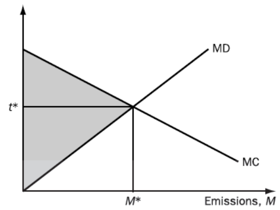
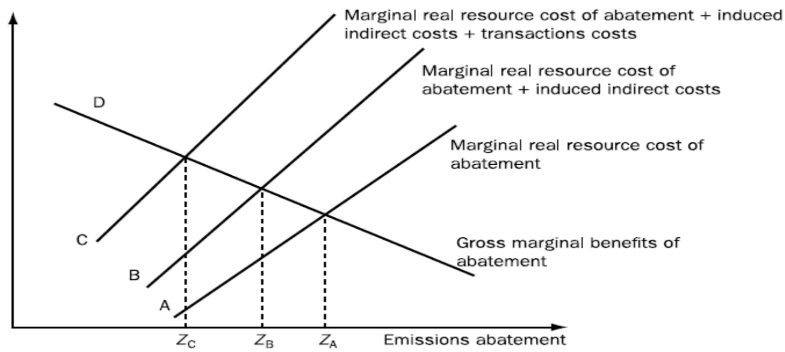


Figure 3 displays that the efficient target (*M**) is the level of emissions that equates the marginal cost of emissions abatement (MC) and the marginal damage of emissions (MD). The total net social benefit represented by the shaded area in Figure 3. This is the maximum net benefit available. The emissions are at any level other than *M** that means the efficiency losses and thus attained net benefits fall short of their maximum level (Perman, 2003).

The equilibrium if there are transaction cost and environmental regulation can be seen in Figure 4 (Perman, 2003).

Figure 4. The Benefit Regulations



Source: Perman (2003)

Curve D represents the marginal gross benefits of pollution abatement (the damages are avoided). The marginal, real resource costs of pollution abatement correctly are represented by the curve labelled as D. If there are no other costs, an efficient outcome will require ZA units of abatement. Indirect costs including impacts on unemployment and trade competitiveness may also be induced. Adding these to the resource abatement costs, the composite cost curve B is obtained with a correspondingly lower efficient abatement level, ZB. If the induced effects are beneficial rather than harmful, the curve B will lead to the right (rather than to the left) of curve A. Finally, the curve C adds in transactions costs to the previous two categories of costs. The efficient abatement level, taking all relevant items of information into consideration is Z. One of cost abatement is by tax or permit.

This does provide a useful way of thinking about instrument selection. The preferred instrument is the one that has a lower total cost of achieving a particular target. Even if one instrument is superior in terms of real resource cost of abatement, it does not need to be superior anymore when induced effects and transactions costs are also considered.

Literature Review

Wei (2014) suggests that the price-based mechanism, quantity-based mechanism and command-and-control mechanism are three popular procedures of abatement. Nordhaus (2014) recommends that the government should use the price-based mechanism and the quantity-based mechanism as tools to reduce GHG.

Pizer (2002) argues that price controls are more efficient. Simulations based on a stochastic computable general equilibrium model indicate that the expected welfare gained from the optimal price policy (carbon tax) is five times higher than the expected gain from the optimal quantity policy (permits).

If ignoring the enviromental benefits, the developing countries' carbon taxes must be lower than the developed countries'(Wesseh *et al*., 2017). His research uses GTAP version 8 by aggregating the data into six regions and ten sectors. By using some optimum stimulations of carbon taxes and testing their effects, the results introducing carbon taxes leads to both welfare and environmental gains in all regions except low-income countries especially when accrued environmental benefits. This makes carbon taxes very important for these countries. However, carbon taxes bring welfare reduction for low-income countries but at the same time reduce environmental damages in these countries as well. This result points to insights that economic growth will contribute more to welfare for low-income countries than to environmental improvements.

In line with Wesseh *et al*. (2017), Farzin & Tahvonen (1996) investigated how efficient environmental externalities are. The authors point out the results that imposing a carbon tax is indeed an optimal strategy of abatement. However, marginal abatement cost changes as well as changes of fossil fuel demand are very sensitive towards the marginal abatement cost changes as well as changes in the demand for fossil fuels because of the tax carbon implementation.

Besides, Zhou *et al*. (2011) conducted an analysis of impacts of CO_2 mitigation because of carbon tax policies by using a dynamic energy environment economy CGE model. This research results that there is a negative impact on GDP from carbon tax. Carbon tax will have adverse impacts on energy production, energy intensive sectors, and household income if the carbon tax increased makes energy demand limited by increasing price signal and decreasing the CO_2 emission.

The assumption that carbon and energy taxes will decrease the CO_2 emissions to a proposed target is supported by Nakata & Lamont (2001). This paper states that carbon taxes cause a shift in resources used, from coal to gas. In line with Nakata & Lamont (2001), using a different method (DID) to estimate the real mitigation effect of the five northern European countries, Lin & Li (2011) suggest that the carbon tax in Finland also has had a significant and negative impact on per capita of CO_2 emission growth. Meanwhile, the impact of carbon taxes in Denmark, Sweden, and the Netherlands is negative but insignificant.

Li & Su (2017) analyzed the impact of different uses of carbon and BCA using the Input-output tables in Singapore and found that carbon taxes were more effective than BCA since carbon taxes reduced emissions of energy, manufacture and land transport sectors. In Indonesia, Yusuf & Resosudarmo (2015) also estimated how the carbon tax impacted by using SAM with the ORANI-G model and concluded that carbon tax had impacts on either urban or rural household income.

Based on the previous research, the researcher wanted to analyze what impacts if the carbon tax applied in Indonesia were. The difference of this research is in the tool that is GTAP E and use different scenario.

Methodology and Data

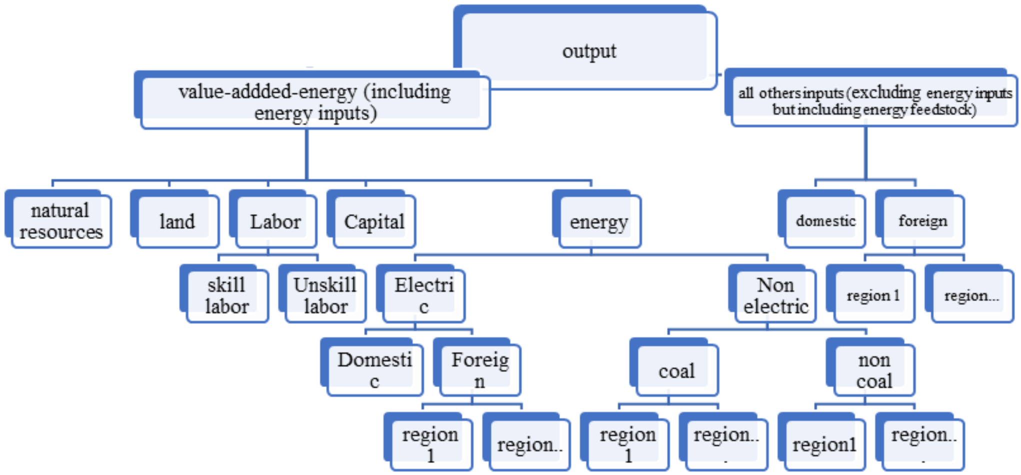
Methodology

A multiregional CGE model with focus on how variables like quotas, subsidies, and taxes interact and the dynamics through which these policy variables are connected to other indicators such as employment, income, and trade are named as the Global Trade Analysis Project or GTAP model. Nevertheless, previous studies have used GTAP for modelling the energy-economy-environment-trade relations that is one of the important goals of the implementation of economic policy. However, the modelling of this linkage in GTAP is not yet complete. This is because the energy substitution, a key factor in this linkage chain, does not exist in the standard model specification.

Burniaux & Truong (2002) used GTAP-E to evaluate energy policy. Burniaux & Truong (2002) remedied this deficiency by incorporating energy substitution into the standard GTAP model. It was begun by reviewing some existing approaches of this problem in the contemporary CGE models. It then suggested an approach of GTAP that incorporated some of these desirable energy substitution features. The approach was implemented as an extended version of GTAP model called GTAP-E. In addition, GTAP-E incorporates carbon emissions from the combustion of fossil fuels as well as a mechanism to internationally trade these emissions.

Following the structure by Burniaux & Truong (2002), the basic model was built. Observing the production side, energy must be taken out of the intermediate input 'nest' to be incorporated into the 'value-added' nest. The incorporation of energy into the value-added nest was conducted in two steps. Energy commodities were firstly separated into 'electricity' and 'non-electricity' groups (Figure 5). Some degrees of substitution were allowed within the non-electricity group as well as between the electricity and the non-electricity groups.

Figure 5. Structure of Production Module in the Dynamic CGE Model



Source: accumulated by authors (according to Burniaux & Truong, 2002)

Data

Based on Burniaux & Truong (2002), this study used GTAP-E, a part of GTAP 9 in 2011. GTAP-E consists of 140 countries and 57 sectors aggregated into eleven regions and eight sectors. The aggregated region comprises Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Philippines, Singapore, Thailand, Vietnam, Ocean, East Asia, South East Asia, North America, Latin America, Eu_25, MENA, SSA, and the rest of the world. The eight aggregated sectors of the 57 sectors are 1. Primary Agriculture, Forestry, and Fishing; 2. Coal Mining; 3. Crude Oil; 4. Natural Gas Extraction; 5. Refined Oil Products; 6. Electricity; 7. Energy Intensive Industries; and 8. Other Industries.

Scenario

To analyze the impact of the carbon tax on a country's economy, it is necessary to adopt a carbon tax scenario that will be applied in a country. Application of scenarios based on the policies taken by the government, predictions, or rules applied (Zhou *et al*., 2011). Zhou *et al.* (2011) applied a simulation based on the authors' predictions by only referring to previous research. Likewise, Li & Su (2017) applied their scenarios based on the analysis and the existing phenomenon.

There are still many debates about the imposition of carbon tax. The researcher states this will harm consumers and producers but it will reduce carbon emissions. The debate is due to the fact that not all countries will be ready to implement this policy. Based on this, this study would like to see what impacts of national carbon tax if implemented in Indonesia are. The simulation used in this research were:

- Scenario one (SIM 1): Carbon tax of US \$20 per ton for CO_2
- Scenario two (SIM 2): Carbon tax of S \$10 (US \$7,478) per ton of CO_2
- Scenario three (SIM 3): Carbon tax of 100 rupees (US \$1.06) per ton of CO_2

Scenario one was based on the use of Chinese carbon tax (ministry of China). Since China is the world's largest of population and the first country to apply the carbon tax in Asia, the authors assumed that this might be applicable in Indonesia because of the similarity of features. The second scenario followed the tax implications that Singapore's state (SU \$10/tCO_2) applies. This simulation was used because Singapore is the only ASEAN country that implements carbon tax. Indonesia applies the same amount of assumptions as neighboring countries whose aim is to reduce emissions. Finally, India implements a carbon tax of 100 rupees (US \$1.06) per ton of CO_2. This simulation was used by considering the facts that Indonesia and India are in the top five countries with the largest population and that they both are developing countries.

The author would see the effect change in values of GDP, GDP Quantity Index, Government and Private Household Demands for Commodity in Indonesia and CO_2 emission because of carbon tax in different scenarios.

Result and Discussions

Result

Table 1. Impacts of Carbon Tax on Changes of Values of GDP in Nineteen Regions

No.	Change of Value of GDP	SIM 1	SIM 2	SIM 3	No.	Change of Value of GDP	SIM 1	SIM 2	SIM 3
1	Brunei Darussalam	-0.05	-0.02	0	11	East Asia	0.02	0.01	0
2	Cambodia	0.02	0.01	0	12	Other SE Asia	0.01	0.01	0
3	Indonesia	-0.07	-0.02	-0.001	13	South Asia	0.02	0.01	0
4	Laos	0.01	0	0	14	North America	0.02	0.01	0
5	Malaysia	0	0	0	15	Latin America	0.01	0.01	0
6	Philippines	0.02	0.01	0	16	EU_25	0.02	0.01	0
7	Singapore	0	0	0	17	MENA	-0.01	0	0
8	Thailand	0.01	0.01	0	18	SSA	0	0	0
9	Vietnam	-0.01	0	0	19	Rest of World	0	0	0
10	Oceania	-0.01	-0.01	0					

Table 1 shows the impact of using the Indonesian carbon tax scenario on the change of value of GDP in the aggregated nineteen regions by observing how the percentage changes from the baseline to the new shock/equilibrium. It is observed that Indonesia itself has the greatest impact due to the implementation of carbon tax. When applying a carbon tax of US \$ 20/tCO_2 (SIM1), the change of value of GDP to the baseline is -0.07 meaning that the decline of GDP value is 0.07%. In the second scenario, there is a decrease in GDP by 0.02% but not as big as the implementation of the carbon tax in the scenario one. In contrast, the use of carbon taxes of US \$ 1.06 (100 rupee)/tCO_2 GDP makes all regions not change the GDP. In the scenario one, the impact of Indonesia's carbon tax on scenario one and two brings advantages on the GDP values of Cambodia, Laos, Philippines, Thailand, East Asia, other SE Asia, South America, North America, Latin America, Eu_25, and MENA; while Brunei Darussalam, Vietnam, and MENA have a decreased value of GDP. Other regions do not change.

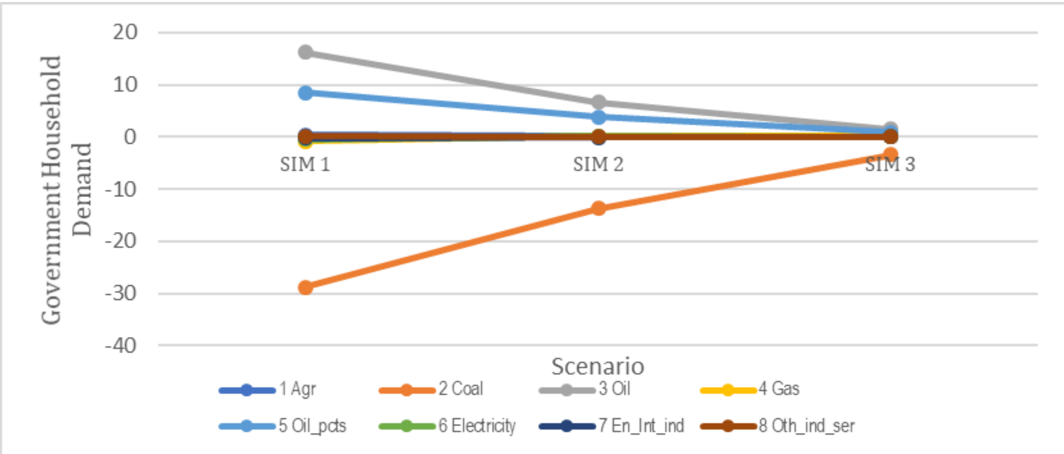
Table 2. Impacts of Carbon Tax on the GDP Quantity Index in Nineteen Regions

qgdp (GDP Quantity Index)	Pre SIM				qgdp (% Change)		
		Post SIM 1	Post SIM 2	Post SIM 3	SIM 1	SIM 2	SIM 3
Brunei Darussalam	16691.42	16691.313	16691.375	16691.408	-0.001	0	0
Cambodia	12829.56	12829.833	12829.663	12829.58	0.002	0.001	0
Indonesia	845924.6	845497.063	845834.25	845915.063	-0.051	-0.011	-0.001
Laos	8254.104	8254.124	8254.112	8254.106	0	0	0
Malaysia	289259.6	289260.188	289259.719	289259.594	0	0	0

Philippines	224095.3	224096.078	224095.578	224095.328	0	0	0
Singapore	274064.7	274064.688	274064.719	274064.719	0	0	0
Thailand	345669.8	345679.438	345673.625	345670.656	0.003	0.001	0
Vietnam	135539.9	135537.219	135538.875	135539.688	-0.002	-0.001	0
Oceania	1595230	1595229.875	1595229.75	1595230.25	0	0	0
East Asia	15203581	15203768	15203654	15203597	0.001	0	0
Other SE Asia	56480.4	56480.414	56480.402	56480.402	0	0	0
South Asia	2305595	2305698.25	2305635	2305603.5	0.004	0.002	0
North America	18490694	18490752	18490716	18490698	0	0	0
Latin America	4770430	4770457.5	4770440.5	4770432.5	0.001	0	0
EU_25	17368588	17368812	17368674	17368606	0.001	0	0
MENA	3988132	3988123.5	3988128.5	3988130.75	0	0	0
SSA	1460651	1460648	1460649.75	1460650.5	0	0	0
Rest of the world	4085433	4085339.5	4085392.25	4085423.5	-0.002	-0.001	0

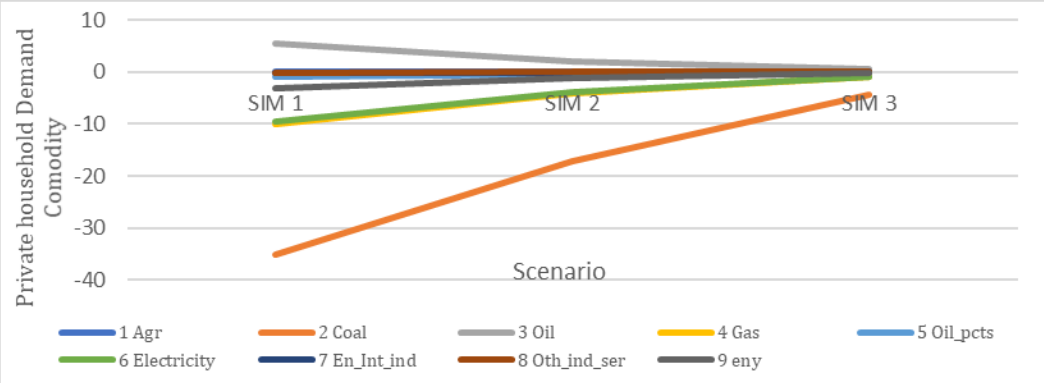
Table 2 illustrates the impact of carbon tax on the GDP Quantity Index in nineteen regions. It appears that the change of GDP Quantity index of Indonesia has the greatest decline. The higher the tax simulation is, the greater the decrease changes. Brunei Darussalam, Vietnam and, the rest of the world have negative impacts on Indonesia's carbon tax; while Cambodia, Thailand, East Asia, South Asia, Latin America, and Eu_25 have positive impacts for scenario one. In scenario three, the impact of carbon tax of US $1.06/t$CO_2$ on the GDP Quantity Index will only affect Indonesia with the value of -0.001%.

Figure 6. Government Household Demand of Commodity in Indonesia



In Figure 6, it appears that the implementation of the carbon tax at US$20/t$CO_2$ will lead to a decrease in demand of Government Household for coal, gas, electricity, energy, and intensive industries commodities. The agriculture sector, crude oil, refined oil product, and other industries have a positive impact. However, when the carbon tax is lowered (SIM 2 and 3), the government household demand only occurs in the sectors of coal and energy intensive industries that are visible from the point where the curve is still below the zero point.

Figure 7. Private Household Demand of Commodity in Indonesia



In contrast to the Household Demand Government, the impact of carbon taxes on scenarios one, two, and three of all commodities except oil is a decrease in private household demand that is marked by a value below the zero line.

Table 3. CO_2 Emission in Different Carbon Tax Scenarios Compared with the Baseline Scenario in Nineteen Regions

No.	gco2tb	SIM 1	SIM 2	SIM 3	No.	gco2tb	SIM 1	SIM 2	SIM 3
1	Brunei Darussalam	0.02	0.01	0	10	Oceania	0.02	0.01	0
2	Cambodia	0.03	0.01	0	11	East Asia	-0.04	-0.02	0
3	Indonesia	-9.6	-4.2	-1	12	Other SE Asia	0.01	0	0
4	Laos	0.02	0.01	0	13	South Asia	-0.11	-0.04	-0.01
5	Malaysia	0.08	0.03	0.01	14	North America	0.01	0	0
6	Philippines	0.07	0.03	0.01	15	Latin America	0.01	0	0
7	Singapore	-0.02	-0.01	0	16	EU_25	0.01	0.01	0
8	Thailand	0.07	0.03	0.01	17	MENA	0.01	0.01	0
9	Vietnam	0.03	0.01	0	18	SSA	0.02	0.01	0
					19	Rest of World	0.01	0	0

In Table 3, the total of CO_2 emissions reaches -9.6%, -4.2%, and -1% under scenarios of SIM 1, SIM 2, and SIM 3, respectively in Indonesia. This indicates that the carbon tax will reduce CO_2 emissions in Indonesia. CO_2 emission reductions also affect Singapore (SIM 1 and 2), East Asia (SIM 1 and 2), and South Asia (SIM 1 to SIM 3); while other regions have a positive impact (addition of CO_2 emission). Even when using the scenario three, many regions do not have impact of carbon taxes that are marked by zero values in CO_2 emissions.

Table 4. CO_2 Emission in Different Carbon Tax Scenarios by Commodity in Indonesia

No.	gco2[Indonesia*]	SIM 1	SIM 2	SIM 3
1	coal	-23.65	-10.96	-2.65
2	oil	-9.28	-4.01	-0.92
3	gas	-8.22	-3.34	-0.74
4	oil pcts	-2.61	-0.98	-0.21

From the perspective of Indonesia's commodity side (Table 4), the biggest reduction of CO_2 emissions is coal with the values of -23.65%, -10.96, -2.65%, respectively at SIM 1, 2, and 3. Furthermore, the highest impact of carbon tax is on coal products followed by oil and gas products, respectively; while the lowest impact of carbon tax is on refined oil products (dampak pajak karbon tertinggi adalah pada coal produk yang kemudian diikuti oleh oil and gas products, sedangkan dampak pajak karbon terendah adalah pada refined oil products). Higher carbon tax will reduce CO_2 emissions in Indonesia.

Discussion

Table 1 and 2 show that the impact of a carbon tax in Indonesia will reduce GDP of the country itself and may also affect other countries. This study is equivalent to research conducted by Zhou *et al*. (2011) using GTAP 6 indicating that the use of carbon tax in China will reduce the value of GDP. Similar results are also obtained by Calderón *et al*. (2016) arguing that CO_2 mitigation policy will reduce GDP and the domestic consumption. The decline of GDP is due to the amount of tax paid by producers that will increase the price of commodities. The increase of prices will lead to low purchasing power that will adversely affect the economy.

Figure 6 and 7 show the demands of government and private households are against carbon tax policies in Indonesia. It turns out that the negative impact of carbon tax more affects the private household that is indicated by all commodities except crude oil that has decreasing demand from the baseline scenario (no tax). While in the government household, the agriculture sector, crude oil, refined oil product, and other industries have a positive impact. This is caused by the amount of income received by the government will be allocated to agriculture and other sectors as an effort to handle emission reduction. One of the efforts that can be done is the search of new renewable natural resources. It will boost the demand of this sector. A decrease in the demand of private side is also shown by the research of Zhou *et al*. (2011).

From the environmental side, if the carbon tax in Indonesia is implemented in accordance with the above simulation, then it appears that carbon emissions can reduce emissions of CO_2. A carbon tax of 20USD/tCO2 will be able to reduce CO_2 emissions by -9.6% meaning that when government policies want to reduce emissions to 29%, higher carbon taxes are required. However, that carbon taxes will also lower demand and GDP should also be noted. Moreover, if viewed from the commodity side, the coal commodity with the use of the carbon tax scenario one is nearing the ideals of Indonesia in the CO_2 emissions BAU. The carbon emission decreasing because of carbon tax is also indicated by the research of Calderón *et al*., (2016); Li & Su, (2017); Lin & Li, (2011); Nakata & Lamont, (2001); Yusuf & Resosudarmo, (2015); and Zhou *et al*., (2011).

Conclusion

As one of the CO_2 mitigation methods, carbon tax can reduce energy use, improve energy efficiency, and simultaneously promote the development of renewable energy. Of course, carbon tax also has its defects. For example, it would slow down the economic growth, decrease social welfares, damage the competitiveness of related industries, and lead to carbon leakage. Therefore, scientific and rational carbon taxation is crucial for countries that implement carbon tax.

Motivated by the controversial issue of real mitigation effect of carbon taxed and CO_2 emissions of East Asia and Pacific continents including Indonesia that increase every year (Indonesia is the 15^{th} largest emitter in the world), the researcher analyzed the impact of GDP, government household demand, private household demand, and CO_2 emission reductions in Indonesia if carbon tax is applied in Indonesia under different carbon tax policies by using a dynamic energy environment economy CGE model with GTAP-E.

Both GDP and GDP index have a negative impact due to the carbon tax of US \$ 20/tCO_2, US \$ I0/tCO_2, and \$ 1.60/tCO_2. The greater the application of the carbon tax is, the greater the decrease of the value of GDP.

The demand of governments and private household is against carbon tax policies in Indonesia. It turns out that the negative impact of carbon tax affects private households more that is indicated by all commodities except crude oil that has decreasing demand of baseline scenario (no tax). In the government household, agriculture sector, crude oil, refined oil product, and other industries have a positive impact.

From the environmental side, if the carbon tax in Indonesia is implemented in accordance with the above simulation, then it appears that carbon tax can reduce emissions of CO_2.

Acknowledgments

I would like to thank to Indonesia Endowment Fund for Education of (LPDP) Ministry of Finance of the Republic of Indonesia for supporting the author by scholarship. I am so grateful as well to Prof. Tri Widodo, M.Ec.Dev., Ph.D for giving and always encouraging the author to accomplish this project. My best gratitude for my parents, Darmizal and Ermayetty; my grandmother; my brothers, thanks for your praying; and the last but not least, all my friends, Devi, Alia, Ade, Jum, Rini, and Ramlah for being together during working on and finishing this paper.

References

[1] Abdullah, S., & Morley, B. (2014). Environmental taxes and economic growth: Evidence from panel causality tests. Energy Economics, 42, 27–33.

[2] Burniaux, J.-M., & Truong, T. P. (2002). GTAP-E: an energy-environmental version of the GTAP model. GTAP Technical Papers, (16), 1–61. 3

[3] Calderón, S., Alvarez, A. C., Loboguerrero, A. M., Arango, S., Calvin, K., Kober, T., … Fisher-Vanden, K. (2016). Achieving CO 2 reductions in Colombia: Effects of carbon taxes and abatement targets. Energy Economics, 56, 575–586.

[4] Farzin, Y. H., & Tahvonen, O. (1996). Global carbon cycle and optimal time path for the carbon tax. Oxford Economic Papers, 48(4), 513–536.

[5] Hasudungan, V. W. H. (2016). The Impact of Implementing Carbon Tax and Feed-in Tariff: A CGE Analysis of the Indonesian Cas.

[6] Li, Y., & Su, B. (2017). The impacts of carbon pricing on coastal megacities: A CGE analysis of Singapore. Journal of Cleaner Production, 165, 1239–1248.

[7] Lin, B., & Li, X. (2011). The effect of carbon tax on per capita CO2 emissions. Energy Policy, 39(9), 5137–5146.

[8] Nakata, T., & Lamont, A. (2001). Analysis of the impacts of carbon taxes on energy systems in Japan. Energy Policy, 29(2), 159–166.

[9] Nordhaus, W. D. (2014). After Kyoto : Alternative Mechanisms to Control Global Warming. The American Economic Review, 96(2), 31–34.

[10] Perman, R., Ma, Y., McGilvray.J, Common., M. (2003). Natural Resource and Enviromental Econoics 3editionth. Perason, London

[11] Pizer, W. A. (2002). Combining price and quantity controls to mitigate global climate change. Journal of Public Economics, 85(3), 409–434.

[12] Resosudarmo, B. P. (2003). Computable General Equilibrium Model on Air Pollution Abatement Policies with Indonesia as a Case Study. Economic Record, 79(SpecialIssue), S63–S73.

[13] Wei, Y. (2014). Ceep-Bit Working Paper Series Climate policy modeling : An online SCI-E and SSCI based literature review Zhimin Huang Beijing Institute of Technology.

[14] Wesseh, P. K., Lin, B., & Atsagli, P. (2017). Carbon taxes, industrial production, welfare and the environment. Energy, 123, 305–313.

[15] Yusuf, A. A., & Resosudarmo, B. P. (2015). On the distributional impact of a carbon tax in developing countries: the case of Indonesia. Environmental Economics and Policy Studies, 17(1), 131–156.

[16] Zhou, S., Shi, M., Li, N., & Yuan, Y. (2011). Impacts of Carbon Tax Policy on CO2 Mitigation and Economic Growth in China. Advances in Climate Change Research, 2(3), 124–133.