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General equilibrium economy-wide impacts of the increased energy taxes in Vietnam

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ABSTRACT

The Vietnamese Government is proposing a new tax levy on either petroleum products or coal, or both. That is, the Government expects to increase the current tax rates to the maximum levels set previously. In this instance, the tax on coal is intended to increase by 50%, while the tax on petroleum products is intended to increase by 33.33%. This study employs a computable general equilibrium model to assess the effects of these increases in taxes on the Vietnamese economy, focusing on energy, transportation, and the private sectors. Results show that an increase in tax on petroleum products will considerably affect the country with a reduction of real GDP by 1.99%. Exports and imports are also highly unfavorably affected. In this instance, the total emission level will be reduced by 7.12%. The increased tax on coal, however, will allow Vietnam to experience much lower unfavorable effects, while being able to cut a substantial amount of the emission level. For example, real GDP would only decline by 0.51%, while total emission level will be reduced by 10.25%. If these taxes are increased together, Vietnam will experience considerable contractions in the economy, but it is able to reduce a substantial emission level.

1. Introduction

Rapid industrialization and economic growth rates in Vietnam in recent decades have considerably increased demands for fossil fuels, leading to substantial increases in the emission levels in the country. In particular, greenhouse gas (GHG) emissions in Vietnam have increased by 57% in 1990–2010 and 99% in 2000–2012, reaching 311Mt of Carbon Dioxide equivalent (CO_2-e) in 2012 (World Bank, 2015). As a result, Vietnam is among the most rapidly growing emission countries that contribute to the greenhouse effect globally. Vietnam, however, was one of the first countries to ratify the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol in order to tackle climate change and limit increased global temperature below 2-Celsius degrees.[1]

The country has generated several national and regional programs and in planning, estimates the potential impact on climate change and responses to climate change issues. Vietnam has also introduced policies to mitigate GHG emissions. In addition, several programs and policies have been introduced to improve energy efficiency and renewable energy production technology so that the country is able to move to a low carbon economy and achieve a sustainable development in the near future (Luong, 2015). For example, the National Target Programs on Energy Efficiency was issued in 2006, while the law on Economical and Efficient Use of Energy was launched in 2010. On January 1st, 2012, the Environmental Protection Tax was also commenced in order to apply tax rates on specific goods, including petroleum, oil, gas, and coal that are both purchased domestically and imported.[2] However, these low tax rates and programs are apparently not powerful enough to enable Vietnam to lower its emissions growth rates as the emission level is still growing at a high rate (Fig. 1). In this context, a more powerful climate change policy is needed with an emissions trading scheme that can restrict the country's emissions to a fixed level, as was proposed in 2012 with Prime Minister Nguyen Tan Dung not signing off the plan until October 2015.[3]

Recently, Vietnam further committed to the Paris Agreement on climate change, putting the country under greater pressures to reduce its emission levels. In particular, the Vietnamese Government committed to reduce the country's emission level by 8% by 2030 compared to the business-as-usual scenario or by 25% if there are international supports to finance the implementation of adaptation measures, as the

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[1] http://www4.unfccc.int/ndcregistry/PublishedDocuments/Viet%20Nam%20First/VIETNAM%27S%20INDC.pdf.

[2] http://vietnamlawmagazine.vn/environmental-protection-tax-4058.html.

[3] https://carbon-pulse.com/11090/.

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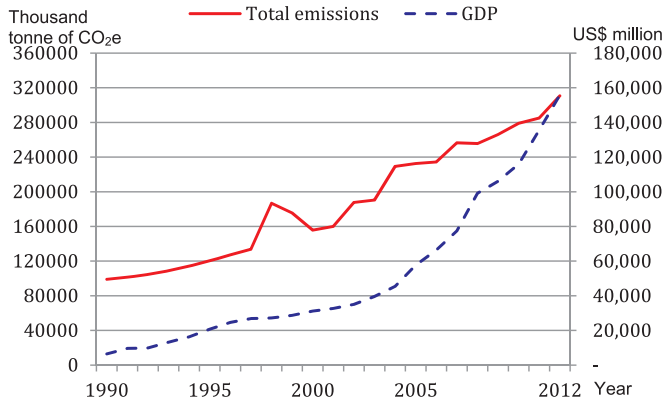

Fig. 1. GDP and total GHG emissions in Vietnam in 1990–2012. Source: World Bank (2015, 2017a).

national budget is estimated to adequately cover only one-third of the financial needs.[4] Given 66% of total emissions released from energy resources (United States Agency for International Development, 2016), the Vietnamese Government is expecting to reduce substantial emission levels from energy consumption, as well as to promote the development of renewable energy in a sustainable economy. Consequently, the Government has recently proposed to increase the tax rates on consumed energy to the maximum levels set previously.[5] In particular, the Government proposed to increase the consumption tax rates for petroleum and diesel by 33.33% and for coal by 50% (Fig. 2). Of these, the Government primarily recommends to increase the tax rate on petroleum products with additional consideration of the increased tax on coal; hence, it is still uncertain whether the country would only increase the tax rates on the petroleum products or also increase the tax rates on coal (Vu, 2018). Such increases are also dependent on approval by the National Assembly. There are therefore several potential scenarios: (1) only one increased tax on petroleum products or coal is approved or (2) the increased taxes on these two groups of fuels are implemented simultaneously or (3) no increased taxes are allowed.

In any circumstances, the increased energy taxes are twofold. On one hand, the new taxes would help the country to lower its emission level in order to somewhat fulfill the committed emissions target at the Paris Conference. This policy, however, results in unknown and uncertain emission reductions in a long period. Hence, to achieve the committed emission target the country may need to have a stronger and consistent policy, such as an emissions trading scheme, which allows a certain emission level that a country is permitted to release into the atmosphere. On the other hand, the new taxes would help the Vietnamese Government to improve its budget because the Government has been running a budget deficit for a decade, with a deficit in 2017 equivalent to −3.5% of the country's gross domestic product (GDP) (Lan, 2018; Trading Economics, 2018). Such substantially increased taxes though only on petroleum products or coal or on both groups of these energy commodities simultaneously are recently major concerns; hence, the National Assembly continues to delay consideration of the proposal because these commodities are major energy sources for the economy (Nhan Dan, 2018). Such increased taxes may have considerable unfavorable impacts on the Vietnamese economy, energy sectors, transportation and households. In addition, whether emission levels are considerably reduced under these increased taxes is still questionable.

This study aims to answer the question what are the likely economy-wide impacts of such increased taxes on energy, particularly focusing on energy, transportation and household sectors. This study also estimates the efficiency of the new tax rates in terms of emission reduction in order to answer whether tradeoffs between economic downgrade and amount of emission abatements are reasonable. In addition, this study will provide useful information about the national budget and government consumption. In this context, it is still uncertain whether the country will only increase the tax rate on either petroleum products or coal, or if it will increase the tax rates on both petroleum products and coal simultaneously. This study therefore examines the impacts of each policy separately. In addition, the Global Trade Analysis Project Energy/Environment (GTAP-E) model is employed with updated database from 2011 to 2018. This is a linear model; hence, it is likely to predict the potential impacts when the increased taxes on petroleum products and coal are implemented at the same time. This is because the impacts of such a scenario are linearly aggregated from the impacts when these two policies are implemented separately.

In the model, non-CO_2 emissions are also incorporated in the database to capture most emission levels in all countries or regions so that emission level fluctuations can be estimated accurately. This computable general equilibrium (CGE) approach has been selected, as it includes all agents and economic interactions in an economy. All households, governments, producers and investors are well connected in the model through the sets of equations based on economic theory. There are also domestic and international markets that importers and exporters connect together via a bilateral mechanism. Consequently, when a tax, such as an environmental tax, is imposed on particular commodities, the potential effects that spread out to other sectors throughout the economy can be captured by using this approach.

2. Survey of climate change policies and energy tax

Climate change policies and energy taxes have been introduced in many countries around the world. For example, emissions trading schemes are in effect in the European Union countries, South Korea, New Zealand, and in California in the United States, an Emissions Reduction Fund has been implemented in Australia, and taxes have been imposed on fuels in China and the United States. These policies attract great attention from policy makers and researchers, leading to substantial literature development on this topic (for example, see Babiker et al., 2003; Böhringer and Welsch, 2004; Lennox and Van Nieuwkoop, 2010; Meng et al., 2013; Nong et al., 2017; Nong and Siriwardana, 2018a, 2018b). There are also many studies that examine the impact of fuel taxes, for example Andre et al. (2005), Fullerton and Heutel (2007), Golosov et al. (2014), and Rausch and Schwarz (2016).

Studies of an environmental tax in Vietnam are limited, particularly those that use a general equilibrium approach. There are several studies that examine other aspects or use different techniques to tackle climate change but do not directly relate to assessing the impact of an environmental tax on the Vietnamese economy. For example, Le et al. (2013) examined the social costs of fuel transition between biofuels and fossil fuels by using the life-cycle assessment approach, which estimates the emission levels released from the production and consumption of biofuels. The results show that the substitution of ethanol for gasoline considerably reduces the social costs of gasoline. Ha-Duong and Nguyen-Trinh (2017) examined the costs of different techniques of carbon capture and storage in Vietnam and found that capture readiness would reduce the costs but it has not yet been mandatory. Zimmer et al. (2015) interviewed policymakers and other stakeholders to investigate what are the motivations for Vietnam towards the introduction of climate change policies in order to move to a low carbon economy. Zimmer et al. found that the motivations among Vietnamese are complex as Vietnam has a small economy for which emission reductions would only have a small contribution towards reducing global warming impacts. Greater interest towards introducing climate change policies would need to combine financial and economic restructuring

[4] http://www4.unfccc.int/ndcregistry/PublishedDocuments/Viet%20Nam%20First/VIETNAM%27S%20INDC.pdf.

[5] It is noted that under the Law on Environmental Protection Tax, there are specific maximum levels of the taxes on particular fuels that the Government is not allowed to exceed in such tax rates on fuels. This Law is intended to stabilize the development of the economy (The National Assembly, 2010).

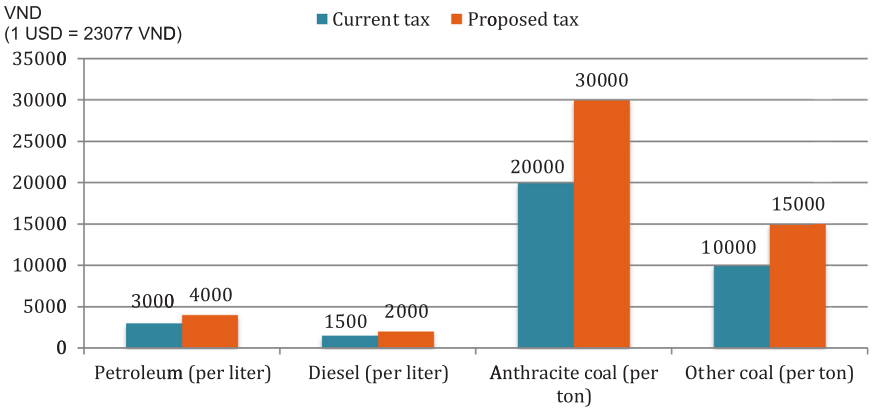

Fig. 2. Current and proposed energy tax in Vietnam. Source: Das (2018).

targets and benefits.

There are only two studies that use economic models to examine the impact of the environmental taxes on the Vietnamese economy and households. El Obeid et al. (2002) used a national dynamic CGE model to estimate the impacts of a proposed environmental tax and trade liberalization in Vietnam on emission levels. The model has a similar production structure to the GTAP-E model regarding the production of and demand for energy inputs. However, this model allows industrial sectors to form the energy composite by selecting between all energy sources (i.e., electricity, coal, oil, gas, and petroleum products), while these energy sources are divided into three different groups of energy inputs subject to three Constant Elasticity of Substitution (CES) functions (which will be described in Fig. 3). While El Obeid et al.'s study has important implications for studying the emission levels released from different sources, it lacks the economy-wide impacts of the policies, particularly the analysis of the impacts on energy sectors and markets, and related sectors such as transportation and households. Results show that Vietnam experiences relatively small impacts on the economy in most cases of the environmental tax and degrees of trade liberalization.

Coxhead et al. (2013) examined the effects of the Vietnamese environmental tax introduced in 2012 on industries and different household groups. The authors converted the environmental tax to a carbon tax by using the emission intensities; however, the emission levels in Vietnam were not described or mentioned. In their study, Coxhead et al. (2013) used a national static CGE model, the ORANI-G model and linked the input-output data with the national household survey data in order to examine detailed impacts on household welfare and consumption levels. There are 20 household groups in the model. The analysis extension related to different household groups are value-added in this study, but the production and consumption structure description were not included. However, as the authors used the ORANI-G model without any modification, it indicates that energy inputs are treated equally to other non-energy commodities in the production and consumption functions. This is much simpler than the structures in the GTAP-E model, which divides energy inputs into different layers and groups of energy commodities. Such a structure of energy inputs allows industrial, private and public sectors to substitute one energy input for another specific energy input when the relative price of one energy commodity changes. In addition, the database was constructed from the national accounts, which represent the Vietnamese economy in 2007 but the authors did not update the database to 2012 when the policy was examined. As a result, the authors showed that real Vietnamese GDP reduces by 0.35–0.63% under different assumptions for the labor market. Outputs of crude oil and petroleum products decline substantially relative to output reductions of other fuels. Households in urban areas would be affected at higher rates compared to the impacts on rural households.

In Vietnam, an environmental tax has recently been proposed by increasing the tax rates on energy to maximum levels; hence, it is important to conduct studies that assess the impacts of such increased tax rates on the Vietnamese economy. This is because when the tax rates are increased substantially they may greatly affect the country's development, income and consumption of households. Also the previous limited number of studies in Vietnam only examined the limited impacts of the environmental tax when it was first commenced. There is therefore a timely need for a study that is able to examine the effects, if such a tax is imposed. Given these potential contributions to the literature and the country's climate change policy analysis, this study employs a well-known CGE model that is able to undertake such research.

3. Model, data and scenario design

This study employs a new version of the GTAP-E model extended by Nong and Siriwardana (2017). The model allows industries to use energy resources subject to different technology. Production structures of all industries in all countries are similar but with different assumptions for parameter values at various levels of the CES function. Fig. 3 shows the relationships between producers and consumers in the GTAP-E model. In the lower box, the coal mining and petroleum product manufacturing industries demand for inputs to produce their outputs (i.e., coal and petroleum products, respectively). The inputs include different types of energy resources, labor, capital, and intermediate inputs. Such inputs are selected via different levels of CES functions subject to particular groups of commodities. The CES functions allow these two industries to select inputs based on relative price changes between inputs, thereby enabling them to minimize their costs. The Leontief function however only allows these two industries to select inputs at fixed proportional rates without considering relative price changes of inputs. Outputs of these two industries, coal and petroleum products, are then supplied to other industries used as intermediate inputs. The selection processes in other industries are the same as the processes in the coal mining and petroleum product manufacturing industries. The coal mining and petroleum product manufacturing industries also supply their outputs for households and government use in the domestic market and for the international markets via a bilateral trade mechanism. In a similar way to these two industries, other industries act in the same way, creating a circular flow for commodities in all economies.

In each economy, households play a role as suppliers of labor forces, receiving incomes for their labor supply. Households use their income for purchasing goods and services, while the remaining is used for saving. Households are modeled to maximize their utility subject to their budget constraints. Government, on the other hand, receives revenues by collecting taxes, such as production, income, sales, import,

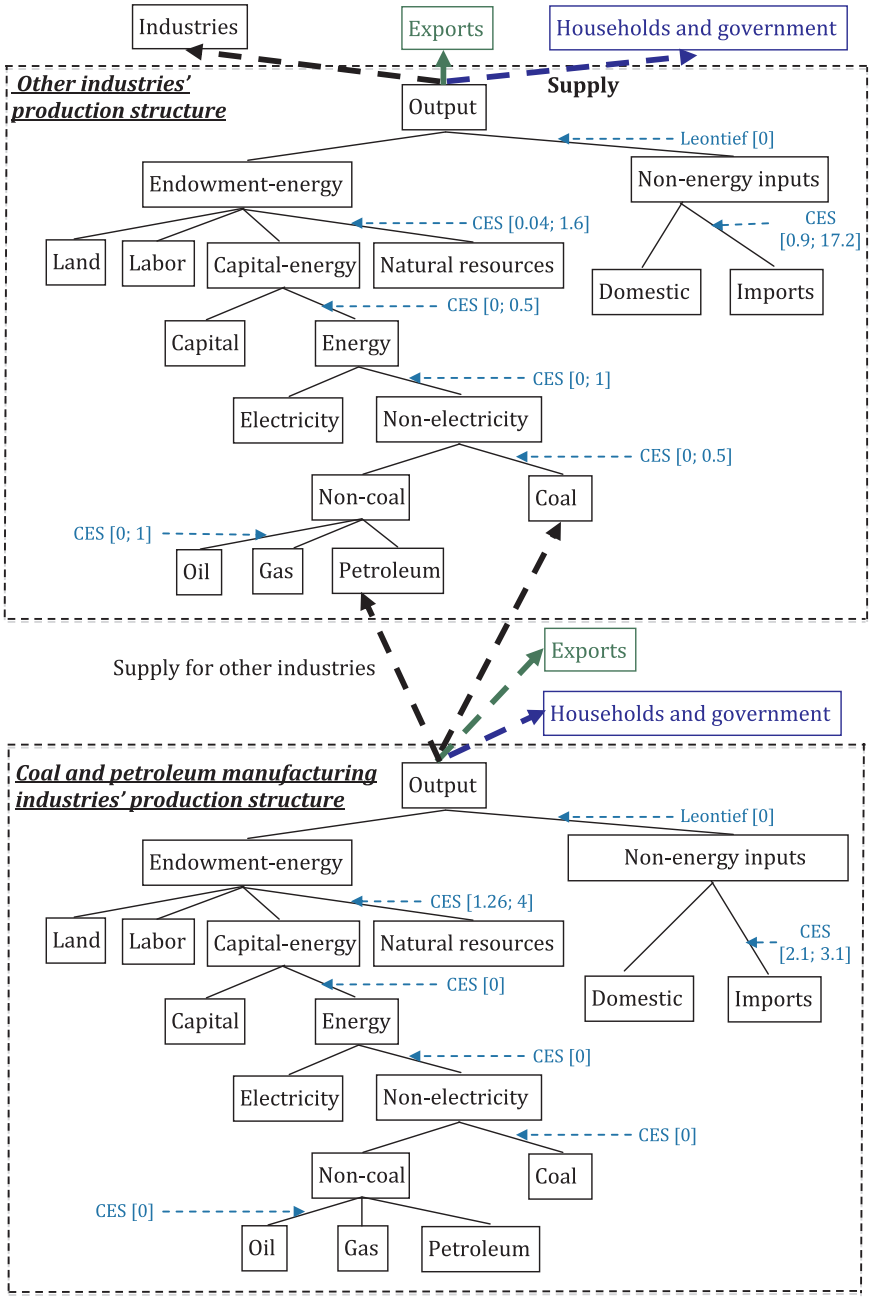

Fig. 3. The production structure in the GTAP-E model.

and export taxes. Government also uses their revenues for purchasing goods and services and for subsidies, while the remainder is public savings. In most countries, governments mainly spend their funds for services. In the model, government is modeled to balance its budget. Both households and governments in the GTAP-E model separate energy and non-energy inputs (e.g., see Fig. 4). These two final consumers select a composite of energy input between coal, oil, gas, petroleum products, and electricity through the CES function. Government continues to make selections between non-energy commodities and energy composite through the CES function. However, households select non-energy commodities and energy composite via the constant difference of elasticity (CDE) function. This CDE function allows households to select these commodities according to changes in both income and price levels.

In the model, the CO_2 emission levels related to output activities are linked with the quantity of output produced by industries, while the CO_2 emissions levels related to input consumption (i.e., energy combustion and chemical usages) are linked to products consumed by industries, households, and governments. In addition, the non-CO_2 emission levels are also modeled in the same way as for CO_2 emission levels. As a result, emission levels can be assessed when output and input levels change. In this study, when the increased taxes on petroleum products and coal change, their commodity prices will directly affect demands by other sectors, thereby affecting their output levels, as well as their demands for other inputs such as labor, capital and intermediate inputs. In addition, changes in the prices of coal and petroleum products will also change their relative prices vis-a-vis other commodities, especially other energy inputs, leading to change in proportions of inputs due to substitution effects in the CES functions. Household incomes are also affected because changes in demands for labor and real wage rates, result from changes in industries' output levels. Consequently, the increased taxes on coal and petroleum

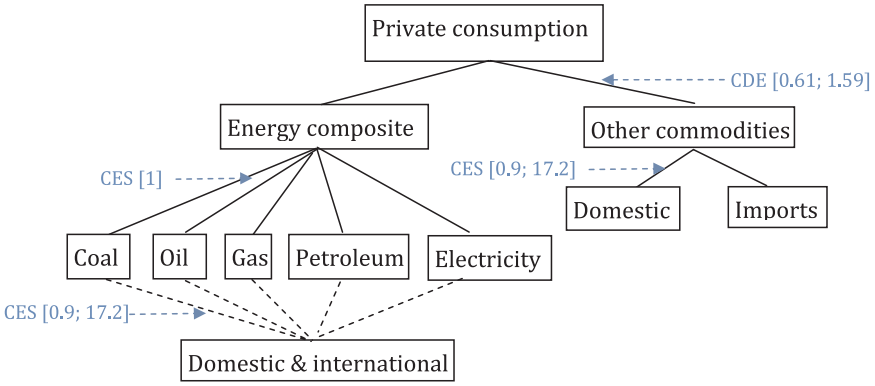

Fig. 4. Private consumption in the GTAP-E model.

products will affect the whole economy. Although Vietnam is a small country, which has little affect on the world prices of commodities, changes in domestic prices will affect export prices from the country, thereby altering trade volumes with other economies via bilateral trade frameworks.

In this study, the GTAP-E database version 9 with the base year 2011 is utilized. This database contains 140 regions and 57 industries. Non-CO_2 emissions levels are incorporated in the database to enhance the accuracy of emission levels released in every region. Regions and industrial sectors in this study are then aggregated into 6 regions and 18 industries (Table A1 in Appendix). Since the taxes may take effects in 2018, the database is updated from 2011 to 2018. In particular, real GDP, population, and supply of unskilled and skilled labor for regions are projected (Table 1). Population projections for all regions are provided by World Bank (2017b). Real GDP for all regions, except Vietnam, are collected from OECD (2016), while real GDP for Vietnam is provided by the Statista (2017). Supplies of labor follow projections in Golub (2013). Since real GDP is naturally endogenous in the closure setting, this variable is swapped with the output augmenting technical change variable. This technical variable is selected because it determines output levels that affect the GDP level in a country.

The analysis in this study is designed in two policy scenarios in comparison with the baseline projections. The policy scenarios are also simulated in the short run closure setting. That is, the real wage rate is fixed, while employment level can be changed. In addition, capital stock is fixed in the short run. These two policy scenarios include:

- Petroleum tax scenario: the tax rate on petroleum products increases by 33.33%.
- Coal tax scenario: the tax rate on coal increases by 50%.

Table 1
Growth rates in 2011–2018 (percentage change). Source: Golub (2013), Organisation for Economic Co-operation and Development OECD (2016), World Bank (2017b), and Statista (2017).

	Real GDP	Population	Supply of labor	
			Unskilled	Skilled
Vietnam	50.55	1.01	16.80	9.20
Japan	8.91	− 0.01	− 4.40	− 10.50
USA	16.67	0.54	8.80	2.10
China	62.07	0.31	− 8.40	11.60
EU28	17.42	0.16	4.50	0.10
ROW	26.37	1.01	7.20	17.20

Note: For the rest of the world (ROW), the real GDP and population growth rates are calculated based on the real indexes in 2011 and 2018. That is, the measures of real GDP and population are computed by deducting the measures of Vietnam, Japan, USA, China, and the EU28 from the world's measures. Then, the growth rates are calculated based on these indexes. For unskilled and skilled labor, the growth rates are simply calculated as the average growth rates of all regions, excluding Vietnam, Japan, USA, China, and the EU28.

4. Results and discussion

Fig. 5 shows primary energy demands by sectors in Vietnam in the database. It is evident that petroleum products and coal are dominant sources of primary energy for all sectors. These shares of energy inputs are fundamental in order to foresee that the increased tax on petroleum products would cause higher unfavorable impacts on the Vietnamese economy than the impacts from the increased tax on coal. In addition, since the GTAP-E model applies a linear approach, it is also able to predict the impacts on the economy when taxes on petroleum products and coal are increased at the same time. That is, the effects are likely to aggregate the effects on the economy when these two taxes are increased independently.

4.1. Impact on the overall economy

Table 2 shows the macroeconomic results from tax increases on sources of different forms of primary energy. In general, 33.33% increases in the tax on petroleum products considerably affect the Vietnamese economy, which outweigh the effects from increasing the tax on coal by 50%. As shown in Fig. 5, petroleum products are the main commodities consumed by other sectors. Among primary energy demands, the private sector spends 86% of $8548 million for petroleum products, while the expense on coal only accounts for 13% of total expenditure for primary energy. All industries also use petroleum products as main energy inputs with 47% of total expense for primary

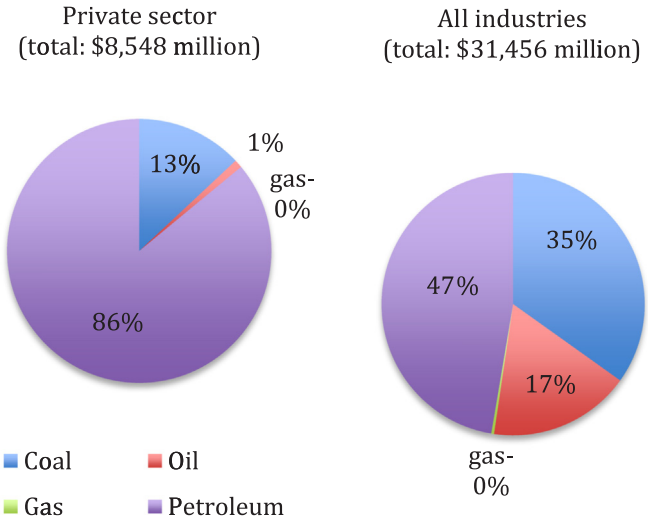

Fig. 5. Primary energy demand by sectors in Vietnam.

Table 2
Macroeconomic impacts in Vietnam (Percentage change).

	Petroleum tax	Coal tax
CPI	2.58	0.3
Terms of trade	1.26	0.11
Real export	− 5.58	− 0.57
Real import	− 3.69	− 0.39
Tax revenue (% change)	1.98	3.91
Tax revenue ($ million)	585	1154
Real private consumption	− 1.16	− 0.5
Real Public consumption	0.44	− 0.08
National deficit	− 2.8	− 1.65
Real investment	− 0.59	− 0.12
Real GDP	− 1.99	− 0.51
Equivalent variation ($ million)	− 1755	− 763
Equivalent variation (% change)	− 3.26	− 1.42
Emission levels	− 7.12	− 10.25

energy, followed by coal (35%) and oil (17%). The demand shares among primary energy inputs particularly petroleum substantially explain the negative effects on the Vietnamese economy compared with the impacts resulting from the increased tax on coal.

An increased tax on petroleum products considerably increases the price level in Vietnam because of the important roles of these commodities in all sectors, for example, the consumer price index (CPI) increases 2.58%. The CPI, on the other hand, only increases by 0.3% when tax on coal increases by 50%. This is because coal only accounts for a small fraction in total private expenditure.

The terms of trade will also increase over the two scenarios as are expected due to increased price levels in the domestic market that leads to higher export price levels. In this instance, the terms of trade improves by 1.26% in the petroleum tax scenario, whereas there will be improvements of 0.11% in the coal tax scenario. Such improvements in the terms of trade will directly affect export and import volumes. In particular, higher export price levels will discourage importers, leading to reductions in export volumes. Real exports will considerably decline by 5.58% in the petroleum tax scenario compared to a decline of 0.57% in the coal tax scenario because of primary energy input shares demanded by industries. Increased prices for petroleum products are especially painful for the industrial sectors because these products are main inputs that substantially increase their output prices. In the case of increased prices for coal, a smaller share of coal as input demands will lead to smaller impacts on their output prices. In addition, not many sectors use high volumes of coal as inputs. As a result, exports in the coal tax scenario will decline at smaller rates than those in the petroleum tax scenario. It is noted that there is no explicit nominal exchange rate in the model because this is a global economic model and there is only one currency in the model: the US dollars. As a result, all transactions are converted or measured in million-dollar values. Hence, bilateral trade between countries is only affected by the price indexes in the origin and destination countries that are reflected in the terms of trade – the relative price changes between export prices and import prices, while the real exchange rate is hidden or plays no role in the model.

The effects on real imports may need more explanation. On one hand, higher domestic prices could lead to increased demands for foreign commodities since the world prices are constant. On the other hand, higher tax rates in the country would cause the production levels to decline, leading to lower demands for inputs, such as for intermediate inputs and labor. Such lower demands for inputs include demands for both domestic and international commodities. The effects on the production side outweigh the effects raised from the price changes; hence, import volumes could decline in all scenarios. Also, due to the relative price changes between the domestic and international markets that lead to increased demands for international commodities, the impact on import volumes is smaller than the impact on export volumes in terms of absolute values. For example, import volumes would decline by 3.69% and 0.39% in the petroleum tax and coal tax scenarios, respectively.

In this study, the analysis is performed in the short-run closure setting; hence, the real wage rate is stable or fixed. As a result, household income levels change depending on the demand for labor. In this instance, lower production levels particularly reduce demands for labor, leading to lower income levels. In addition, inflation rates in these two scenarios are detrimental to household's purchasing power. These effects cause real private consumption to decline. For example, the real private consumption declines by 1.16% in the petroleum tax scenario and by 0.5% in the coal tax scenario. It is also noted that tax revenue increases by 1.98% (or $585 million) in the coal tax scenario and by 3.91% (or $1154) million in the petroleum tax scenario. The higher tax collection in the latter scenario results from higher consumption shares of petroleum products among the total energy consumption compared to a small consumption level of coal. These tax revenues will contribute to the country's incomes with allocations to private and public sectors used for consumption, and to the national savings. As a result, the effects on the private consumption level are moderate. In addition, the national deficit will decline by 2.8% and 1.65% in the petroleum tax and coal tax scenarios, respectively. The real public consumption also improves by 0.44% in the petroleum tax scenario, while it slightly reduces the consumption level by 0.08% in the coal tax scenario. It is expected that the increased tax on either coal or petroleum products raises additional revenues for the Government and available for consumption; however, the Government also faces higher price levels for commodities. As a result, in the coal tax scenario, since the increased revenue is relatively small, the real public consumption level declines, while the tax revenue is relatively higher in the petroleum tax scenario leading to an increased real consumption level of the public sector.

The increased taxes on primary energy also cause the price of investment to increase in these two scenarios, leading to lower real investment levels in Vietnam. In particular, real investment falls by 0.59% and 0.12% in the petroleum tax and coal tax scenarios, respectively. The effects on real investment are relatively small because capital stock is fixed in the short-run. All such negative impacts on consumption, net exports, and investment levels contribute to reductions in real GDP in these two scenarios. In the case of an increase in tax on petroleum products, the effects on the Vietnamese economy are considerable with a reduction of real GDP by 1.99%. This is because petroleum products are substantially consumed by all sectors compared with the expenditures for other energy inputs. In particular, expenses for petroleum products account for 86% of total private budget allocated for primary energy. It is also evident that an increased tax on coal is likely to affect the Vietnamese economy at smaller rates, as real GDP only declines by 0.51%. This is because coal is not widely consumed by many sectors and expenses on coal only account for a small fraction of the budget allocated for primary energy. Such findings indicate that the impacts on the Vietnamese economy, when the taxes on the consumed energy inputs increase substantially, are relatively higher than the impacts when the taxes were first introduced and examined in El Obeid et al. (2002) and Coxhead et al. (2013).

Table 2 also reports changes in equivalent variation measured by dollar values, as well as percentage changes of this indicator. In terms of absolute values, equivalent variation reduces by $1755 million in the petroleum tax scenario and by $763 million in the coal tax scenario. Such reductions in equivalent variation would result from increased prices due to tax increases on primary energy. The results in terms of percentage changes in equivalent variation indicate that the effects from increased taxes are significantly detrimental to households and the economy in the case of increased tax on petroleum products. In terms of emission reductions, the increased tax on coal would be a more efficient policy in order to help Vietnam to reduce its emission levels rather than the increased tax on petroleum products. For example, the increased tax

on coal helps the country to reduce the emission levels by 10.25%, while the reduction of emissions is only of 7.12% when the tax on petroleum products is increased. This is because coal has a much higher emission-intensity compared to those for petroleum products.

These macroeconomic results indicate that the increased tax on coal is much more efficient than the increased tax on petroleum products in terms of emission reductions and tradeoffs for economic growth. Results show that the impact on the Vietnamese economy is relatively small when the tax on coal is increased by 50%, as this increased tax can help the country to reduce the emission level by 10.25%. On the other hand, the increased tax on petroleum products is particularly harmful to the whole economy because these products are largely consumed by many sectors, particularly in the private sector. Reductions in emission levels, however, are not efficient compared to the reduction levels under the increased tax on coal scenario.

4.2. Impact on industries

Since the gas extraction industry is relatively small in Vietnam and demands for gas are negligible (Fig. 5), this study will not report the results related to the gas commodity and sector. Table 3 shows the results related to the prices of energy and transportation services, and private demand for these commodities. It is noted that the elasticity of substitution between energy sources in the private consumption function in the GTAP-E model has a value of 1 as shown in Fig. 4(a perfect substitution possibility). Hence, there is no difference in private demand for different sources of energy; the fluctuation will then depend on the original share of energy consumption shown in the database and the fluctuation of the commodity prices. In the petroleum tax scenario, it is expected that the increased tax on petroleum products substantially increases the price of this commodity. For example, the price for petroleum products will increase by 33.25%. Such an increase in the price will lead to increased demands for coal, oil and electricity to substitute for petroleum products. As a result, the private demands for coal, oil and electricity will increase by 12.14%, 12.93%, and 8.09%, respectively, while the private demand for petroleum products will reduce by 16.35%.

The effects on the prices of coal, oil, and electricity may need more explanation. It is not unreasonable, for example, that the price of electricity will increase but private demand for electricity will also increase. This is because the increased price for electricity is still lower than the increased prices for petroleum products. In addition, in the general equilibrium analysis, prices are determined iteratively with adjustments of the supply and demand curves. In this case, when the tax is increased, there will be increased costs for industries, leading to reductions in overall output levels of all industries. Consequently, the supply curves will shift backwards. The demand curves will also shift backwards because of lower levels of outputs, leading to lower demands for inputs. These shifts of the supply and demand curves cause prices to either increase or decrease, depending on the elasticity of each curve and the effects on each of the demand and supply sides. In this instance, the prices of coal and oil respectively reduce by 0.77% and 1.46%, while the price of electricity rises by 2.95%. The effects on the prices of these commodities indicate that the effects on the demand side of coal and oil may outweigh the effects on the supply side of these commodities, that is the supply curves are more elastic than the supply curves for these two commodities. The reason for the price of electricity is explained in converse terms. It is also evident that increases in the price of petroleum products will considerably raise the price of transportation services because this sector uses petroleum products as the main inputs to provide outputs. Substantial improvement in the price of transportation services will eventually reduce private demand for this commodity. In addition, income levels of households will also decline due to lower demands for labor, leading to contractions in their budgets for consumption. Hence, private demand for transportation services is likely to reduce by 4.13% when the tax on petroleum products increases by 33.33%.

Table 3
Prices of commodities and private demand in Vietnam (percentage change).

	Petroleum tax		Coal tax	
	Demand	Price	Demand	Price
Coal	12.14	− 0.77	− 30.28	43.46
Oil	12.93	− 1.46	0.48	− 0.45
Petroleum products	− 16.35	33.02	0.46	− 0.44
Electricity	8.09	2.95	− 1.01	1.04
Transportation	− 4.13	15.05	− 0.69	− 0.38

Table 3 also shows the effects when the tax on coal is increased by 50% in the coal tax scenario. The tax increases on coal significantly enhance the price of coal by 43.46%, leading to decreased private demand for coal by 30.28%. There may be a consequent increase in demand for oil, petroleum products, and electricity. In this case, the effects on the demand and supply curves of oil and petroleum products will cause the prices of these two commodities to decline slightly by 0.45% and 0.44%, respectively. As a result, private demands for oil and petroleum products slightly increase by 0.48% and 0.46%, respectively. The private demand for electricity may need more explanation. Since coal is a major source for generating electricity, an increased price for coal will lead to higher production costs of the electricity generation sector. It consequently causes the price of electricity to increase by 1.04%, leading to lower private demand for electricity by 1.01%. The effects are slightly different to the effects resulting from the increased tax on petroleum products because expenditure shares for these energy commodities are different. In the case of the increased tax on coal, the effects on the price of transportation services are relatively small rather than the effects in the petroleum tax scenario because this transportation sector only uses a small amount of coal. Although the price of transportation services will decline by 0.38%, the private demand for this commodity will decline by 0.69%. This is because household income levels also reduce due to lower demands for labor by industrial sectors.

Fig. 6 shows output levels of the energy and transportation industries in Vietnam in the two scenarios. In the petroleum tax scenario, when the tax on petroleum products increases by 33.33%, there will be a considerable increase in the prices of products, leading to lower demands for these commodities. As a result, the output level of this manufacturing industry is likely to decline by 23.58%. Oil is a direct substitute for petroleum products via a CES function (Fig. 3); hence, the increased prices for petroleum products will lead to increased demands for oil. However, industries and the private sector consume small amounts of oil. As a result, demands for oil will only increase at relatively small rates, which will not be adequate to compensate for reductions in demands for petroleum products. Consequently, the output level of the oil extraction industry will only increase slightly by 0.15% and demands for non-coal composite (i.e., a combination of oil, gas, and petroleum products) will decline. Similarly, increased prices for petroleum products raise the price for non-coal composite, leading to substitution of coal for non-coal composite. Consequently, output of coal also increases slightly by 0.57%. The sequent price effect will also lead to an increased price for non-electricity composite (i.e., a combination of coal and non-coal composite), further encouraging substitution of electricity for non-electricity composite. Private demand for electricity will also increase by 8.09% as shown in Table 3. As a result, the output level of electricity will increase by 0.3%. The transportation sector is the most unfavorably affected industry due to substantial increases in the price of petroleum products. The increased price of petroleum products significantly increases input prices for the transportation industry, leading to increased supply price of the transportation services. Subsequently, there will be reduced demands for this commodity, thereby lowering the output level of the transportation sector.

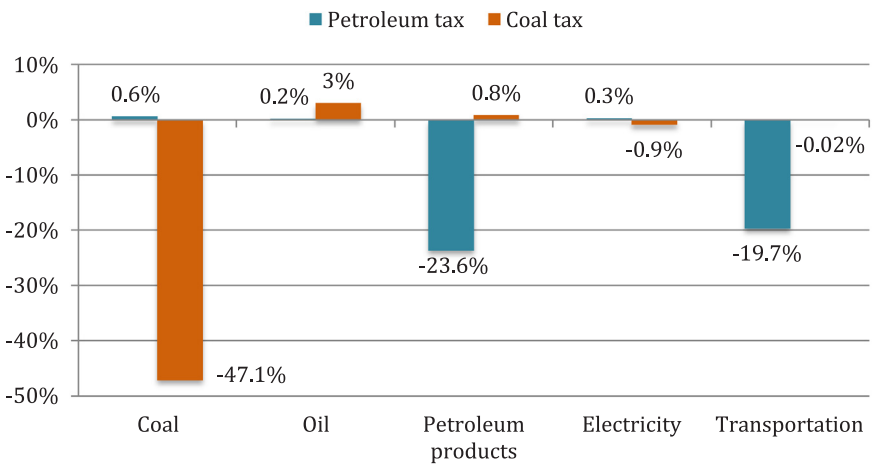

Fig. 6. Output levels of selected industries in Vietnam (percentage change).

In this instance, the transportation sector reduces its output level by 19.7%.

In the coal tax scenario, the effect is quite different because coal and non-coal commodities are selected at the same level of a CES function that is, at a higher level compared with the selection between oil, gas, and petroleum products to form the non-coal composite. As a result, the increased tax on coal will considerably increase the price of coal, leading to this commodity being more expensive relative to the non-coal composite. Hence, sectors tend to substitute non-coal for coal in this instance, leading to increased demands for the components of the non-coal composite. As a result, output levels of oil and petroleum products will slightly increase by 3% and 0.8%, respectively. Since the prices of oil and petroleum products decline in this instance and industries substitute non-coal (i.e., a composite of oil, gas and petroleum products) for coal, this makes the price of non-electricity composite (i.e., a composite of coal and non-coal commodities) relatively cheaper than the price of electricity. Hence, industrial sectors will substitute non-electricity for electricity, leading to reduction in the output level of the electricity generation industry by 0.86%. The output level of transportation is unlikely to be affected when the tax on coal increases because coal is not the main inputs of this sector. The transportation sector only uses a relatively small amount of coal.

Fig. 7 shows real exports and imports for Vietnam. It is noted that since the Armington elasticities of substitution for each commodity are the same across all countries/regions, export and import results for a particular commodity between Vietnam and any other countries are similar to the average import and export results of the corresponding commodity shown in Fig. 7. In this regard, among many trading partners Vietnam mainly exports coal to China and Japan, crude oil to China, Japan, and the United States, while the country imports considerable petroleum products from China.

In Fig. 7, it is clear that the increased tax on petroleum products substantially reduces export volumes of this commodity due to a higher supply price. In this instance, exports of petroleum products will decline by 80.2%. Transportation services that Vietnam provides for the international transportation network will also decline considerably by 41.2%. This decline will occur because the price of transportation services in Vietnam will increase at a relatively high rate of 15.05% (Table 3), making this service relatively expensive for international users. Electricity exports to nearby regions will also decline due to higher prices of electricity in the domestic market, leading to a decline of total electricity export from Vietnam by 15%. However, exports of coal and oil will improve by 4.3% and 15.4%, respectively because their prices are lower when the tax on petroleum products increases. From the import perspective, imports of coal and oil will decline by 3.7% and 35.1%, respectively because of differences in the relative prices of these two commodities between the domestic and international markets. Similarly, increased prices of electricity and transportation services will lead to increased demand for these commodities from the international market. Hence, imports of electricity and transportation services will improve by 10.3% and 26.4%, respectively. Imports of petroleum products will decline by 21.2% because any petroleum products consumed in the Vietnamese domestic market will incur the imposed increased taxes. Hence, demands for petroleum products from either the domestic or international markets will decline.

In the coal tax scenario, the increased tax on coal will lead to a reduction in exports of due to a higher price for the commodity. In addition, any coal consumed in the Vietnamese market will suffer

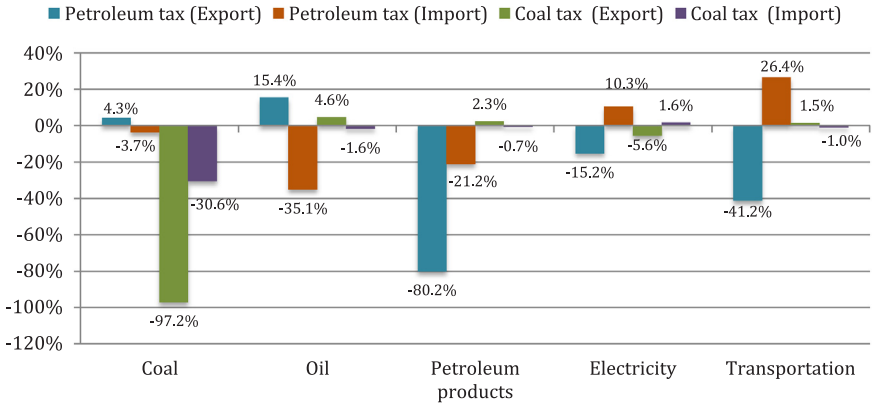

Fig. 7. Exports and imports of energy and transportation commodities in Vietnam (percentage change).

increased taxes; hence, imports of coal also decline by 30.6%. The effect on exports of coal is higher than the effect on its imports in terms of absolute value because the increased tax on coal directly affects the price of coal sold in the Vietnamese domestic market. Slight reductions in the prices of oil, petroleum products, and transportation services will lead to increased exports of these commodities, while reducing their imports. For example, Fig. 7 shows that exports of oil, petroleum products and transportation services increase by 4.6%, 2.3%, and 1.5%, respectively, while imports of these commodities fall by 1.6%, 0.7%, and 1%, respectively. Exports of electricity to nearby regions will also decline due to a higher supply price of this commodity, leading to a reduction of total electricity export by 5.6%. Total electricity import may increase by 1.6% due to a relatively lower price of electricity in the international market.

4.3. Systematic Sensitivity Analysis

This study examines the economic effects of the increased taxes on the consumption of coal and petroleum products with the parameter sets provided by Burniaux and Truong (2002). In the production structure shown in Fig. 3, industries select energy inputs via various levels of the CES function. Fig. 4 also shows that households select a composite of energy from various energy resources based on a CES function. In addition, the taxes are levied on these energy commodities. Hence, the simulation results may considerably depend on the magnitudes of parameters assumed at these CES levels. This study therefore examines the robustness of the results by conducting the systematic sensitivity analysis (SSA), according to a triangular distribution. It is noted that the SSA requires a continuous distribution that allows each endogenous variable to vary infinitely between the minimum and maximum values. Under the triangular distribution, values near the minimum and maximum values are less likely than those near the mean. Since there are two options for setting a distribution in RunGTAP: triangular and uniform distributions, and there are no specific advantages or disadvantages of one method over the other method, this study simply selects the triangular distribution to conduct the SSA.

The sensitivity analysis is performed in the petroleum tax scenario since Vietnam experiences relatively high impacts compared to the impacts in the coal tax scenario; hence, it is expected to generate larger fluctuation rates if applied. In particular, the parameters are assigned in the CES functions that are used to select (1) between petroleum products, oil and gas, (2) between coal and non-coal composite, (3) between electricity and non-electricity composite in the production structure, and (4) between coal, oil, gas, petroleum products, and electricity in the private consumption structure. These parameters are changed together by ±50% for all sectors in Vietnam.

Table 4 provides selected results at the 95% confidence interval when the selected parameters are changed together by ±50% for all sectors in Vietnam. The lower bound and upper bound results (columns 2 and 3) indicate the minimum and maximum values that the corresponding variables can vary within. Since the upper and lower bound results are quite close to the results in column (1) that were simulated with the original parameter values, the results are not highly sensitive subject to changing the selected parameters. In addition, the ranges of the fluctuations in the results shown in column (4) are also not large. However, results for total emission level, output of coal, petroleum products and electricity are relatively sensitive to changing the selected parameters.

Table 4
Sensitivity analysis for selected results (percentage change).

	Original results	Lower bound	Upper bound	The difference between upper bound and lower bound results
	(1)	(2)	(3)	(4)
CPI	2.58	2.49	2.67	0.18
Real GDP	− 1.99	− 2.12	− 1.86	0.27
Real export	− 5.58	− 6.03	− 5.13	0.89
Real import	− 3.69	− 4.00	− 3.38	0.63
Real private consumption	− 1.16	− 1.38	− 0.94	0.45
Real public consumption	0.44	0.26	0.62	0.36
Total emission level	− 7.12	− 9.71	− 4.53	5.19
Output				
Coal	0.57	− 3.45	4.59	8.05
Oil	0.15	− 1.06	1.36	2.41
Petroleum products	− 23.58	− 29.88	− 17.28	12.61
Electricity	0.28	− 4.64	5.20	9.83
Transportation	− 19.66	− 19.79	− 19.53	0.27

5. Conclusion and policy implications

The Environmental Protection Tax and several programs have been introduced in Vietnam for several years in order to tackle climate change issues and reduce emission levels. The current tax rates on energy seem not to be sufficient to help the country to reduce the emission levels and improve the environment, since the emissions level still increases considerably. In addition, the Vietnamese Government committed to curb its emissions levels at the Paris Agreement on climate change. Given the unsuccessful introduction of the emissions trading scheme in the past few years, the Government now proposes to increase the taxes on the consumption of coal and petroleum products to the maximum levels it had set previously. In particular, the tax on coal consumption will increase by 50%, while the tax on petroleum products will rise by 33.33%. The Government expects that such increased taxes will substantially reduce emission levels, as well as support the country to move to a low-carbon economy. The Government also expects that the tax will improve the government budget used for consumption and national savings. However, there are major concerns by the public that there will be highly negative impacts on the economy.

Given the very limited number of studies on this issue in Vietnam and the increased taxes have recently been proposed, this study is expected to make a substantial contribution to the country's policy development by providing a comprehensive analysis of the impacts related to the policy. In particular, this study employs a sound CGE model to analyze the economy-wide impact of these policies on the Vietnamese economy by focusing on an analysis of energy, transportation, and private sectors, since these sectors would be considerably affected. The increased taxes on coal and petroleum products are simulated in two different scenarios, while the effects on the economy from implementing these two policies simultaneously can be predicted as aggregated impacts of those shown in the two foregoing scenarios since the GTAP-E model applies a linear modeling approach.

The results show that the increased tax on the consumption of petroleum products is significantly harmful to the Vietnamese economy. This is because petroleum products are main sources of energy that are widely used by many sectors. Consumption of petroleum products also accounts for major expenditure on primary energy in the private sector. On the other hand, the increased tax on the consumption of coal seems to have a relatively small impact on the economy. In terms of emission reductions, the increased tax on petroleum products can only help the country to reduce its emission levels by 7.12%, while the increased tax on coal leads to a reduction of 10.25%. As a result, the increased tax on petroleum products is likely to be inefficient compared to the increased tax on coal in terms of economic growth and emission reductions. Under the scenario that the Government increases the tax on petroleum products, the country will experience relatively high contractions. As a result, tradeoffs between economic growth and emission reductions under the coal tax scenario are much smaller than those in the petroleum tax scenario. In addition, the increased tax either on coal or petroleum products improves the government budget used for public consumption and reduces the national deficit. From these two scenarios, it is foreseen that if these two policies are implemented at the

same time, the Vietnamese economy will be highly unfavorably affected since real GDP, exports and imports will decline at relatively high rates. The country will also experience relatively high inflation rates. However, Vietnam can also reduce a substantial amount of emissions by introducing these increased taxes together. The findings also indicate that if the taxes on petroleum products and coal are increased either independently or jointly, the impacts on the economy are relatively higher than those found in the previous studies, which examined the impacts of the taxes when they were first implemented in 2012.

Although Vietnam is not a big emitter compared to the emission levels released by China, India, the United States, Brazil, etc., a policy that would help Vietnam to reduce substantial emission levels would make a significant contribution to the international effort in mitigating greenhouse gas emission levels released into the atmosphere because it shows a real action by a small emitting country that can be applied by countries with a similar economy. The findings in this study also have important implications for use of energy taxes as useful tools to help a country that heavily relies on fossil fuels, to cut considerable emission levels. A tax on coal consumption is particularly efficient in reducing emission levels since this energy commodity makes a relatively high emission-intensive energy input. It is also important to note that a country, which mainly uses petroleum products compared to the consumption levels of other fossil fuels, would experience a relatively high contraction in the economy if there was a substantial tax on petroleum product consumption.

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Appendix

See Table A1

Table A1
Region and industry aggregation.

Aggregated regions	Aggregated industrial sectors
1. Vietnam	1. Agriculture, Forestry and Fishery
2. Japan	2. Coal mining
3. United States	3. Crude oil extraction
4. European Union 28	4. Natural gas extraction
5. China	5. Other mining
6. 6. Rest of world	6. Food and beverage
	7. Textile
	8. Wood and paper products
	9. Refined oil and petroleum products
	10. Chemical products
	11. Mineral products
	12. Metal products
	13. Machinery and equipment
	14. Electricity generation
	15. Gas supply
	16. Construction
	17. Transportation
	18. 18. Other services

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