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ORIGINAL RESEARCH PAPER

Carbon and energy taxes in a small and open country

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ABSTRACT: Malaysia, as a small and developing country, must reduce carbon emissions because the country is one of the top CO_2-emitting countries in the ASEAN region. Therefore, the current study implements two environmental tax policies; carbon and energy taxes, in order to examine the impacts of these policies on the reduction of carbon emission in the whole of the economy by applying a computable general equilibrium model. Since the whole of the government revenue from these tax policies is transferred to all household and labor types through two schemes, a lump sum tax, and a labor tax, respectively, it is assumed that there is revenue neutrality in the model for the government. The findings from simulated scenarios indicate that the carbon tax policy is the more efficient policy for reducing CO_2 emission, in both transferring schemes, while its impact on macroeconomic variables is almost lower than the equivalent energy tax. The carbon tax is more effective than the energy tax for Malaysia to achieve 40% carbon reduction target in comparison with its 2005 level. The carbon tax, compared to the energy tax, also leads to more decrease in consumption of fossil fuels. The carbon tax policy, in comparison with the energy tax, due to revenue recycling causes much more increase in the welfare of rural and urban households in Malaysia, especially the welfare of rural (lower income) households.

KEYWORDS: Carbon tax; CO_2 emission; Computable general equilibrium (CGE); Energy tax; Greenhouse gases;Revenue recycling.

INTRODUCTION

One of the main concerns of consumption of non-renewable fuels is their environmental impact, especially an increase in carbon emissions. Low fossil fuel prices in developing and oil exporting countries increases demand for them and causes environmental damage and by implementing some policies and regulations can decrease high consumption of them and can reduce their negative impacts on economic and environment (Karbassi *et al.,* 2007; Abbaspour *et al.,* 2013; Alipour *et al.*, 2011; Karbassi *et al.,* 2008; Solaymani *et al.*, 2015b; Solaymani, 2016; Solaymani and Kari, 2014). The dependency of Malaysia as a developing country to fossil fuels is high to cover commercial energy demand. Malaysia requires electricity generation to continue its economic growth until it becomes a developed country. In 2014, the total energy demanded in Malaysia was estimated at 52.2 million tons of oil equivalent, a 37.5% increase compared to the year 2000 (Fig. 1). Economic growth needs significant consumption of all kinds of fossil fuels and consequently, CO_2 emission increases inevitably. As indicated in Fig. 2, in 2013, the total CO_2 emission level that Malaysia made it from combustion of fuels was 207.2 million tons of CO_2 (Mtc), of which the biggest polluter was the power generation sector with 95.9 Mtc, and the transport sector with 57.6 Mtc and the industries by 29.1 Mtc are the second and the third biggest polluters, respectively (IEA, 2015). Total CO_2 emission in Malaysia have increased significantly since the early 1990s and settled at the

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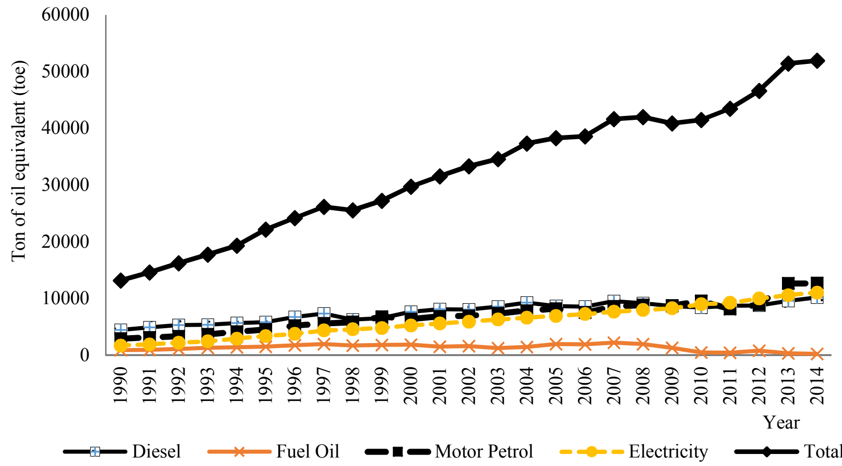

Fig. 1: The world energy demand and 4 top fuel type
(National Energy Balance, 2015)

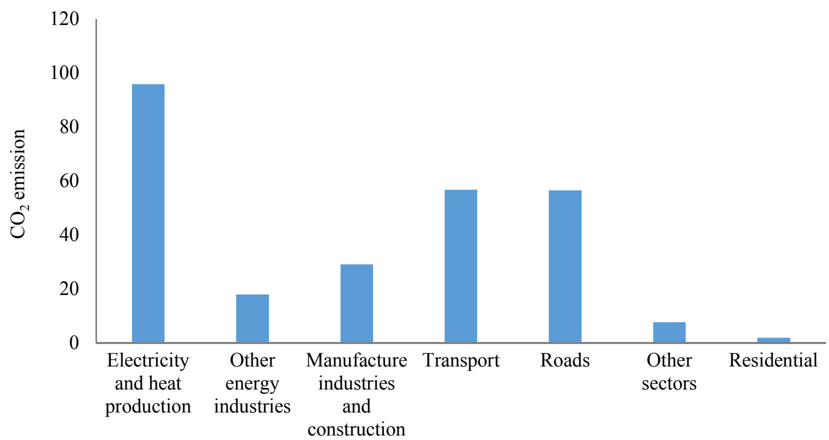

Fig. 2: CO_2 emissions by sectors in Malaysia
(IEA, 2015)

upper 100 million tons at the end of the 1990s. It later exceeded to 188.4 million tons of CO_2 in 2010 and at the level of 207.2 Mtc in 2013, as illustrated in Fig. 3. Recently, the Malaysian government has planned to reduce carbon emission based on the Copenhagen agreement. In comparison with 2005 carbon emission intensity of Gross domestic product (GDP), Malaysia predicted to achieve up to a 40% reduction of it by the year 2020. One of the proposed measures, as highlighted in the literature, is imposing a tax, like a carbon tax, on fossil fuel consumption, which has a strong effect on reducing greenhouse gasses (GHGs) from air polluters.

Empirical studies highlighted that a carbon tax reduces the carbon emission from fuel combustion while it has a negative impact on economic growth (Callan *et al.*, 2009; Bruvoll and Larsen, 2011; Alton *et al.*, 2014). Wendner (2001), using a general equilibrium, showed that a CO_2 tax influences negatively economic growth, labor demand, investment and consumption but with initial magnitudes. However, this policy has a small impact on travel behavior and reducing CO_2 emission from international aviation (Tol, 2007). Furthermore, comparing carbon and energy taxes, showed that the carbon tax can reduce carbon emission more efficient than the energy tax (Wissema and Dellink, 2007). Previous studies in the Malaysian context, which focused on climate change policies, have shown that a carbon tax policy can reduce carbon emission more efficient than the energy tax.

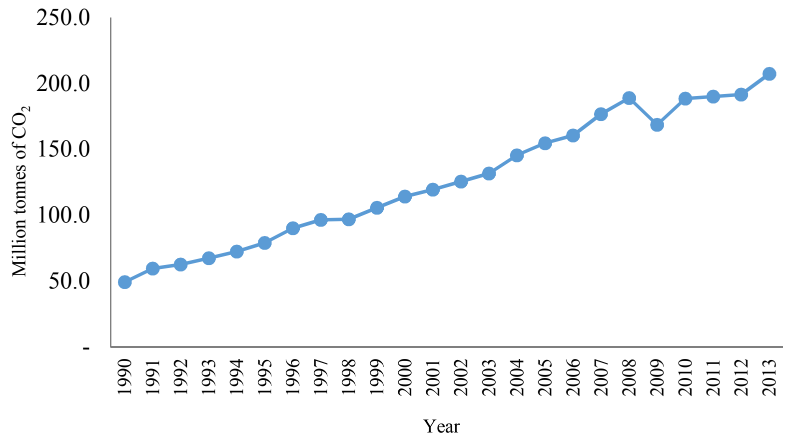

Fig. 3: Total CO_2 emission
(IEA, 2015)

For instance, Solaymani *et al.* (2015a) found that greater magnitude of taxes on CO_2 emission leads to more decline in carbon emission, nominal GDP and export of Malaysia. Solaymani *et al.* (2015c) also argued that climate change policies can protect Malaysia against oil price hikes in the international oil market, but with initial magnitude. Another study covering the Malaysian economy is the Nurdianto and Resosudarmo (2011) study, which studied the effect of different rates of the carbon tax in the ASEAN region. They showed that a tax value of US$20 per ton of CO_2 emission could decrease carbon emission in Malaysia. This policy also influences negatively real GDP and sectoral production of Malaysia while increases carbon emissions and decreases the value of other economic indicators in Indonesia. Totally, in order to answer to the above concerns as well as investigating the prospective effects of carbon and energy taxation, as climate change policies, comprehensively, the current study aims to find the effect of a carbon tax, in comparison with an energy tax, on the main indicators in the Malaysian economy.

This study has been carried out in Malaysia during 2014 based on 2005 input-output data and other socioeconomic output for the year 2005.

MATERIALS AND METHODS

In this study, a computable general equilibrium model is used to investigate prospective economic and environmental effects of both carbon and energy taxes in Malaysia according to 2005 data. These models provide an opportunity to trace the impacts of these policies on all indicators and sectors in the model such as household welfare, economic growth and sectoral investment, employment, output and environmental indicators at the sectoral level. The theoretical structure of the model is explained as follows. There are four factors of production, including capital and three labor types, namely, rural, urban and noncitizen workers. The household section also consists of three household types, namely rural, urban and noncitizen households. It is assumed that each household maximizes its utility by choosing commodities to be consumed, subject to their budget constraints and firms produce goods and services by maximizing their profit subject to their production costs.

The model covers 22 economic sectors, as their list is illustrated in Figs. 7 and 8. There are four transport sectors and five energy sectors (electricity plus four fossil fuel inputs) in the model. The model consists of the following five modules: price, production and trade, income, expenditure, saving-investment and capital accumulation, and equilibrium in the market.

The composite of value added and energy, *EKL*, and intermediate inputs, *IN,* are the components of the production function in the model, which is a constant elasticity of substitution (CES) function:

$$X_i = \alpha_i^x . \left[\beta_i^x . IN_i^{-\rho_i^x} + (1-\beta_i^x).EKL_i^{-\rho_i^x} \right]^{-\frac{1}{\rho_i^x}} \quad (1)$$

Where, α_i^x is the shift parameter and β_i^x is the share parameter.

Intermediate inputs, *IN*, is a function of input-output coefficients, io_{ij}, and sectoral output, X_i.

$$IN_i = \sum_j io_{ij}.X_j \quad (2)$$

The function of value added and energy composite is a CES function of energy inputs, EN_i, (five energy inputs) and primary factors, KL_i (four primary inputs).

$$EKL_i = \alpha_i^{EKL}.\left[\beta_i^{EKL}.EN_i^{-\rho_i^{EKL}} + (1-\beta_i^{EKL}).KL_i^{-\rho_i^{EKL}}\right]^{-\frac{1}{\rho_i^{EKL}}} \quad (3)$$

The value added itself takes a CES form and is a function of demand for all production factors, $FDSC_{if}$, namely three labor types and capital.

$$KL_i = \alpha_i^{KL}.\left[\sum_f \beta_{i,f}^{KL}.FDSC_{if}^{-\rho_i^{KL}}\right]^{-\frac{1}{\rho_i^{KL}}} \quad (4)$$

where α_i^{KL} is the shift parameter and β_{if}^{KL} denotes the share parameter.

The demand for production factors is formulated as follows:

$$\frac{FDSC_{i,f}}{KL_i} = \left(\frac{\beta_{if}^{KL}.PV_i}{(\alpha_i^{KL})^{\rho_i^{KL}}.WF_i.wfdist_{i,f}}\right)^{\frac{1}{1+\rho_i^{KL}}} \quad (5)$$

where WF_i is factor price. $wfdist_{if}$ is sectoral wage rates, and PV_i is sectoral price of value added.

Energy function, which has a CES form, is disaggregated to fuels, *FUL*, and electricity, *ELEC*, inputs.

$$EN_i = \alpha_i^{EN}.\left[\beta_i^{EN}.FUL_i^{-\rho_i^{EN}} + (1-\beta_i^{EN}).ELEC_i^{-\rho_i^{EN}}\right]^{-\frac{1}{\rho_i^{EN}}} \quad (6)$$

Demands for electricity and fuel using the fixed input-output coefficients, io_{ij}, are as follow:

$$ELEC_i = \sum_{elp} io_{elp,i}.X_i \quad (7)$$

$$FUL_i = \sum_{flp} io_{flp,i}.X_i \quad (8)$$

Fuel also is a CES function of oils, *OILS*, and gases, *GASES*:

$$FUL_i = \alpha_i^{FL}.\left[\beta_i^{FL}.OILS_i^{-\rho_i^{FL}} + (1-\beta_i^{FL}).GASES_i^{-\rho_i^{FL}}\right]^{-\frac{1}{\rho_i^{FL}}} \quad (9)$$

Finally, oils and gases were separated to their sub-groups. Where the oils were disaggregated to crude oil, *CRUDE*, and petroleum products, *PETROL*, and gases were disaggregated to natural gas, *NGAS*, and city gas, *GAS*:

$$OILS_i = \alpha_i^{OIL}.\left[\beta_i^{OIL}.CRUDE_i^{-\rho_i^{OIL}} + (1-\beta_i^{OIL}).PETROL_i^{-\rho_i^{OIL}}\right]^{-\frac{1}{\rho_i^{OIL}}} \quad (10)$$

$$GASES_i = \alpha_i^{GAS}.\left[\beta_i^{GAS}.NGAS_i^{-\rho_i^{GAS}} + (1-\beta_i^{GAS}).GAS_i^{-\rho_i^{GAS}}\right]^{-\frac{1}{\rho_i^{GAS}}} \quad (11)$$

The *Armington* function (Eq. 12), which indicates substitution between import, M_i, and domestic demand, D_i, and the constant elasticity of transformation (*CET*) function (Eq. 13), which distributes domestic products between domestic demand and foreign demand, E_i, are formulated as follow.

$$Q_{im} = \propto_{im}^c.\left[\beta_{im}^c.M_{im}^{-\rho_{im}^c} + (1-\beta_{im}^c).D_{im}^{\rho_{im}^c}\right]^{-\frac{1}{\rho_{im}^c}} \quad (12)$$

where Q_i is demand for composite goods which including import and domestic demand; $\propto_{im}^c$ and β_{im}^c are the shift and the share parameters, and ρ_{im}^c is elasticity of substitution.

$$X_{ie} = \propto_{ie}^t.\left[\beta_{ie}^t.E_{ie}^{\rho_{ie}^t} + (1-\beta_{ie}^t).D_{ie}^{\rho_{ie}^t}\right]^{\frac{1}{\rho_{ie}^t}} \quad (13)$$

Eqs. 12 and 13 take a *CES* functional form. The structure of the above functions is presented in Fig. 4. Total cost/revenue of the carbon/energy tax is formulated as Eqs. 14.

$$TC_i = Q_i.\tau_i^{env} \quad (14)$$

$$\tau_i^{env}: environmental\ tax\ rate\ in\ sector\ i$$

Sectoral CO_2 emission is also formulated as follows:

$$CO2_i = \sum_j IOF_{j,i}.ef_i.\omega_i.\tau_i^{env}, \quad (15)$$

$$i = crude\ oil, natural\ gas, petroleum, gas$$

Where, *IOF*, intermediate fossil fuels; ω_{ful}, is a convertor; and ef_i denotes a factor for emission.

Total CO_2 emissions include CO_2 emission from economic sectors and other parts of the economy that consume fossil fuels, i.e. government, *GD*, investment, ID_i, and household, *CD*.

$$TCO2 = \sum_i CO2_i + \sum_i\left[(CD_i + GD_i + ID_i).ef_i.\omega_i.\tau_i^{env}\right] \quad (16)$$

The price of composite commodities, PQ_i, is a function of domestic sales prices, PD_i, import prices, PM_i, and quantity of composite commodities, Q_i:

$$PQ_i = \frac{(PD_i.D_i + PM_i.M_i)}{Q_i} \quad (17)$$

Total expenditure on the domestic output of a sector is equal to the sum of the expenditure on the domestically supplied domestic output and export of the sector. This provides the price of the aggregate domestic output, PX_i, of the sector:

$$PX_i = \frac{(PD_i.D_i + PE_i.E_i)}{X_i} \quad (18)$$

The value added price, PV_i, is defined as the output price after indirect taxes (τ_i^x) and intermediate costs deductions (computed from the fixed input-output coefficients):

$$PV_i = \frac{PX_i.X_i(1-\tau_i^x) - PIN_i.IN_i}{KL_i} \quad (19)$$

The price of capital goods, PK_i, is the weighted sum of the cost of capital goods used in each sector:

$$PK_i = \sum_j ccmat_{ji}.PQ_j \quad (20)$$

where $ccmat_{ji}$ denotes the capital composite matrix. The price of environment is a function of price of composite commodities and carbon/energy tax, τ_i^{env} .

$$PENV_i = PQ_i + \tau_i^{env} \quad (21)$$

The income of production factors, YF_f, is a function of the employment and factors' wage rates.

$$YF_f = \sum_i WF_f.wfdist_{if}.FDSC_{if} \quad (22)$$

On the other hand, the income of production factors is the main source of household income, which as mentioned in Eq. 12, comes from the labor and capital employment and their prices. In addition, other sources of household income are government transfers and factor income from abroad.

$$YH_h = \sum_f hhdis_{h,f}.YF_f + \text{ctrn}_h.\text{YCORP}.(1\text{-ctax}).(1\text{-csav}) + \text{gtrn}_h.GOVTRN + FACTIN.\text{sfin}_h.EXR \quad (23)$$

Where *ctax* and *csav* are corporate income tax and corporate saving, respectively; $hhdis_{hf}$ is the household income share for household *h* from factor *f*. $gtrn_h$ is the household share of government returns. $ctrn_h$ is the household share of firm income. $sfin_h$ is household share of factor income from abroad; and the foreign exchange rate is represented by *EXR*.

Household consumes its income after deduction of savings, mps_h, and taxes, τ_h :

$$THCON_h = \sum_i \left[hhclesi_{ih}.YH_h.(1-mps_h).(1-\tau_h)\right] \quad (24)$$

Additionally, companies'/firms' income comes from capital income, government transfer and other receipts from abroad. Government collects its income

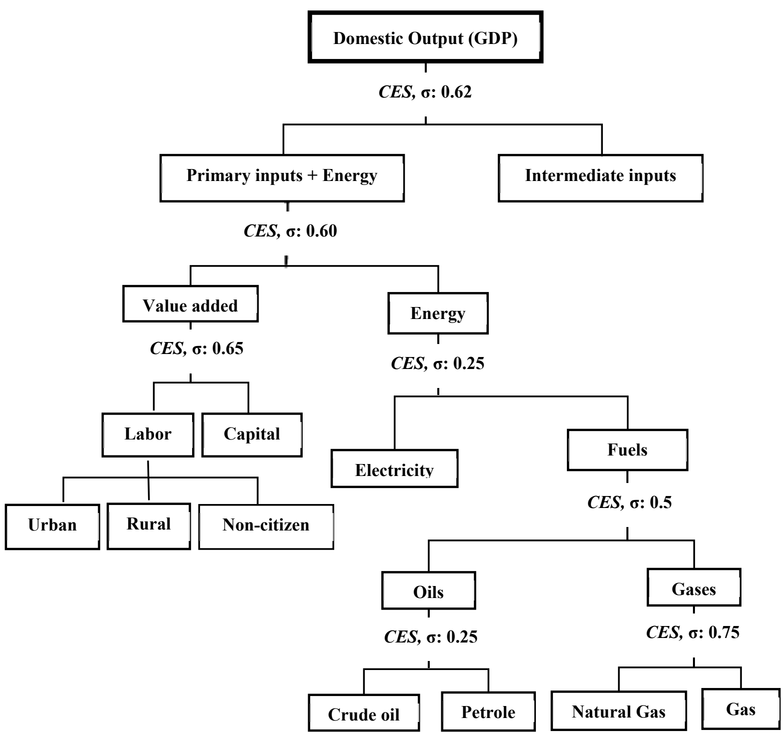

Fig. 4: The structure of Malaysia computable general equilibrium model

from a number of sources such as income taxes from household and corporate, tariffs, indirect taxes, export taxes and so on. The government expenditure is a function of commodity demand, transfer to all household types and enterprises.

Use of fossil fuel in the economy for growth and development, which are 4 fuels in this study, causes low air quality and environmental damage. Nowadays, policymakers are concerned about this damage and are trying to find out suitable and potential tools to reduce the environmental effects of these fuels on production and consumption in the household and industrial sector. One of these tools is environmental taxes. These taxes imposed on the consumption of these fuels. The environmental goal of implementing of these taxes, as used in this study, is reducing carbon emission from fossil fuel combustion. In order to achieve this goal, this study introduces two environmental tax policies, namely carbon and energy taxes.

Both tax policies depend on the intensity coefficient for each tax. The value of the intensity coefficient for the carbon tax is the proportion of the carbon emission to the market value of the commodities and its value for energy taxes is the proportion of the fossil fuels to the market value of the commodities. The carbon emission measure is ton of carbon (tc) and the measure for energy content is ton of oil equivalent (toe).

Closures and data

The main database for the CGE model of this study is the social accounting matrix (SAM) for the year 2005 for Malaysian. Beside the SAM, a CGE model needs some parameters and elasticities for its functions that have been taken from Solaymani and Kari (2013) and Solaymani *et al.* (2014).

The exogenous variables are government consumption, government transfers to institutions, the current account balance, the marginal propensity to save, the three labor types and capital stock. The foreign exchange is a flexible variable. Factor prices are endogenous variables. Although labor is fully mobile between sectors the capital is not a mobile variable in the model. Therefore, total factor supply is fixed and the results of the model show a short-term period.

RESULTS AND DISCUSSION

Many studies investigated policy instruments to reduce CO_2 emission from combustion of fossil fuels. For instance, Scrimgeour *et al.* (2005) evaluated this issue using three instruments, a carbon tax, an energy tax and a fuel tax. Their results suggested that the carbon tax, compared to the energy tax, can reduce more carbon emission. Furthermore, an energy tax, in comparison with an income tax, effectively induces emissions reduction, and the distortionary of a carbon tax is more than the labor tax (Goulder, 1995,1993). Timilsina and Shrestha (2007) argued that compared to carbon-, sulphur-, energy- and output taxes, when the tax revenue is transferred to finance, a carbon tax can be more effective.

In order to analyze the prospective impacts of environmental tax instruments on fossil fuels, the simulations include the implementation of two tax instruments - an energy tax and a carbon tax.

Household welfare influences significantly from environmental tax policies and depends on the effect of two main parameters, the tax interaction and the tax recycling. Kim (2011) showed that if the effect of tax interaction is greater the effect of tax recycling causes greater welfare loss. Here, there is an assumption for the government revenues that is collected from these taxes, and it is revenue neutrality. It means that the government distributes all of this revenue to all household or labor groups. This assumption used for analyzing the welfare impact of tax instruments. There are two simulation schemes for revenue recycling. The first is a lump-sum transfer to all household groups and another is a deduction in labor tax of all labor types. Under the lump-sum transfer, the government distributes its revenue, which collected from carbon and energy taxes, among all household types, while in another recycling scheme, the government reduces the tax rates of all labor types. The economic impact of tax instruments depends on the type of tax instruments, the magnitude of tax policies and methods of revenue recycling. To assess the magnitude of the impacts of the alternative taxes, various levels of taxes is used in the simulations, from low to high levels, in order to decline carbon dioxide emissions.

Table 1 shows required rates of both taxes for reducing a specific level of CO_2 emission. For instance, to reduce 5% of carbon emission, in comparison with the base value, under the labor tax return, a carbon tax rate of 11.75 dollars per ton of carbon and 16.93 dollars per ton of oil equivalent of energy tax are required. Furthermore, under the lump-sum transfer scheme, a carbon tax rate of 7.94 dollars per ton of carbon and

Table 1: Impacts of different tax levels to decrease CO_2 emission

Rate for CO_2 emission deduction (%)	Carbon tax ($/tc)		Energy tax ($/toe)	
	Replacement		Replacement	
	Lump sum tax return	Labor tax return	Lump sum tax return	Labor tax return
5	7.94	11.78	11.41	16.93
10	15.99	23.76	22.97	34.12
15	24.19	35.98	34.73	51.65
20	32.57	48.51	46.75	69.62

Table 2: Aggregate impacts of both taxes: the case of 15% carbon reduction (% changes from benchmark value)

Variables	Carbon tax policy		Energy tax policy	
	Replacement		Replacement	
	Lump sum tax return	Labor tax return	Lump sum tax return	Labor tax return
GDP (real)	0.14	0.13	0.14	0.13
Export	0.74	0.70	0.77	0.73
Import	0.98	0.96	1.02	1.00
Exchange rate	-0.40	-0.35	-0.41	-0.36
Aggregate household consumption	21.48	21.45	22.37	22.33
Government revenue	54.55	18.56	56.73	19.30

energy tax rate of 11.41 ($/toe) are required. As shown in Table 1, to decline a given level of carbon emission, in compared to the baseline value, greater values of energy taxes than the carbon taxes are required. These findings confirm the results of previous researches (McDougall, 1993; Scrimgeour *et al.*, 2005; Timilsina and Shrestha, 2007). Furthermore, in order to decline a specific percentage of carbon emissions under the labor tax recycling, higher tax levels are required in comparison with the lump-sum transfer. According to Table 1, under both schemes for revenue recycling, by comparing different rates of carbon and energy taxes, to reducing 5%, 10% and 20% carbon emission, it can be concluded that for reducing 10% and 20% of carbon emission from the benchmark value, imposition of nearly double tax rates are required.

Under the both scenarios of government revenue recycling, both energy and carbon taxes increase real GDP of Malaysia (Table 2). By imposing a carbon tax, real GDP increases because of an increase in export, import and private consumption. Although in both tax policies, total household consumption increases, in both recycling schemes, it increases more in the lump-sum transfer scheme. The carbon tax policy increases household consumption less than the energy tax policy. Accordingly, direct recycling to households is more effective than the indirect ones. Both environmental taxes increase Malaysia exchange rate, resulting in an increase in total import for both tax policies, but with greater magnitudes for the energy tax, compared to the carbon tax. On the other hand, both taxes do not only fall total export, but also they increase more, in comparison with total import.

Under the lump-sum transfer, the effects of different levels of carbon and energy taxes on CO_2 emissions are illustrated in Fig. 5. It is assumed that Malaysia's Copenhagen target is a 40% reduction in carbon emissions. It was found that the 40% emission reduction target, in comparison with the 2005 levels, is reached at a carbon tax rate between 60 and US$70 per ton of CO_2. The energy tax only reaches this abatement target when the tax rate stands over US$80 per ton of CO_2. It is clear that the carbon tax has a significant impact on the reduction of CO_2 emissions, particularly for tax rates that are low. These findings correspond to McDougall (1993), Scrimgeour *et al.* (2005), Timilsina and Shrestha (2007).

The welfare changes of both tax policies for the lump-sum transfer reported in Fig. 6. Both environmental tax policies, which increase the efficiency of the overall Malaysian tax system, in both rural and urban areas, leads to an increase in household welfare, especially the welfare of rural households as lower income households. However, these taxes decline the welfare of non-citizen households less than 40%, even for the highest tax rate that simulated.

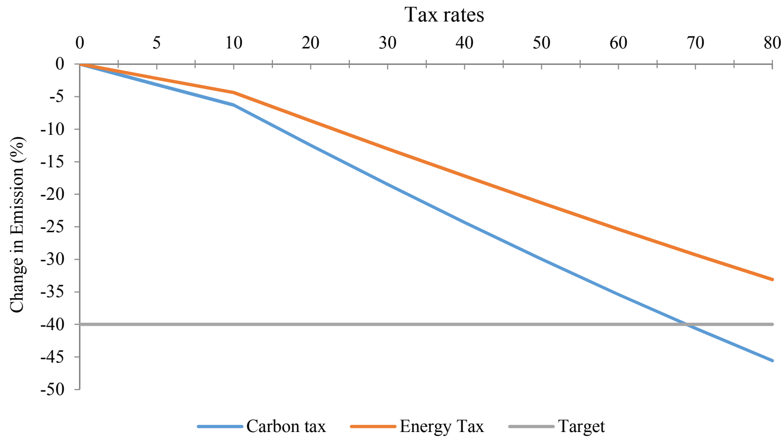

Fig. 5: Changes in emissions due to climate change policies at different tax levels - 0 to 80 $ per ton of CO_2; compared to the Copenhagen target CO_2

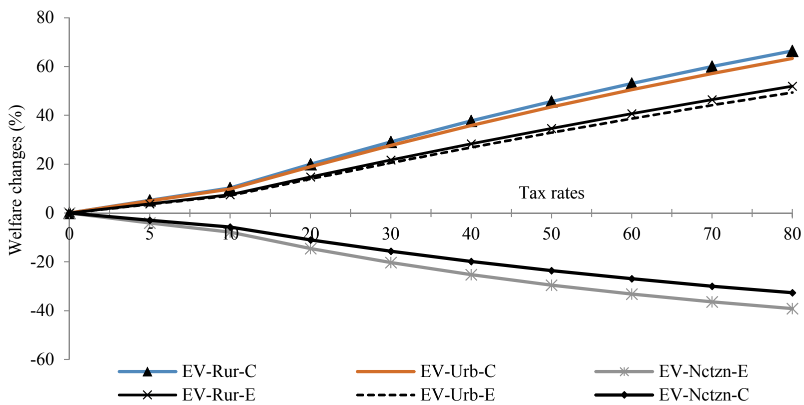

Fig. 6: Welfare changes of different rates of climate change taxes (from 0 to 80 $ per ton of CO_2)
Note: Rur, -Urb and -Nctzn denote rural, urban and noncitizen households, respectively. -E and -C denote energy and carbon taxes, respectively

The study findings are consistent with the findings of Beck *et al.* (2015) study. They found that lower income households, compared to high income households, benefit more from revenue recycling of carbon tax policy. For a specific tax rate, the carbon tax, in comparison with the energy tax, affect more the Malaysian economy, as it is a differentiated tax. A differentiated tax, such as the carbon tax as mentioned, compared to an equivalent tax such as an energy tax, makes more variation in economic patterns, such as a change in production and consumption patterns.

Welfare gains for implementing the carbon tax are higher than the energy tax, especially for higher levels of taxes. But, the welfare cost of the carbon tax, compared to the energy tax, to reach any target is lower. The required rate of energy tax to achieve the target, decreases welfare about 0.9%, while the required rate of the carbon tax to achieve that target, falls welfare about 0.3%. While climate change policies change the economic performance of Malaysia moderately, a number of sectors experienced significant changes in their output. Simulated results for carbon and energy taxes at 15% carbon reduction are presented in Fig. 7. As shown in this figure, the carbon tax strongly declines the levels of domestic production in some sectors such as cement and non-metal products, manufacturing, and iron and steel, as all of them are industries. The larger reduction in cement and non-metal products is due to the fact that its output is influenced by higher costs from the increase in the prices of fuels and

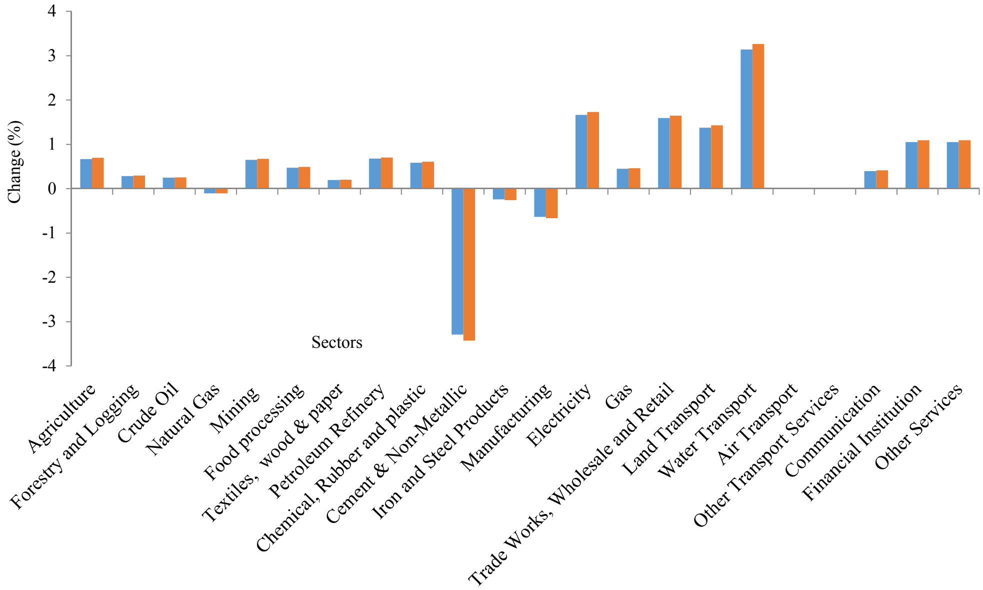

Fig. 7: Impacts of climate change policies on domestic sectoral output (the case of 15% carbon reduction)

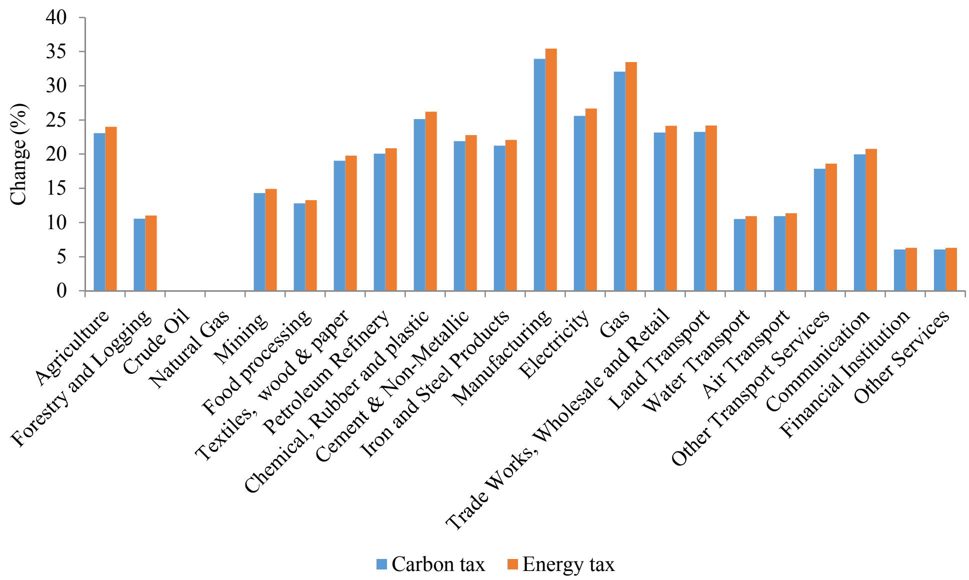

Fig. 8: Changes in aggregate household consumption in the 15% carbon reduction (lump-sum transfer case)

electricity because this industry uses both sources of energy for production. High energy intensive sectors such as manufacturing, iron and steel and natural gas suffer more greatly from higher costs of energy inputs. The output of water transport strongly increased, because this sector, especially rural water transport such as inland water transport uses by poor people, is supported by the government due to its potential to help reduce isolation and therefore poverty. The electricity sector also experiences a high level of output because it does not include fuel taxes. The output of low energy-intensive sectors such as trade, finance, and other services also increases moderately. There is a similar pattern for energy tax simulation,

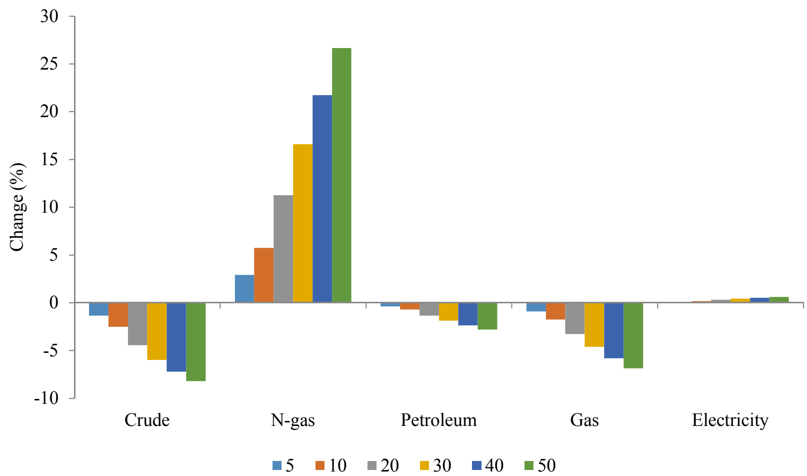

Fig. 9: Demand change of energy commodities due to different carbon tax
(5 to 50 $ per ton of CO_2)

Table 3: Sensitivity analysis: the effects of environmental policies on selected variables: Per cent changes from benchmark value (the case of 10% and 20% carbon reduction)

Variables	10% carbon reduction		20% carbon reduction	
	Carbon tax (lump sum)	Energy tax (lump sum)	Carbon tax (lump sum)	Energy tax (lump sum)
GDP (real)	0.13	0.13	0.11	0.12
Consumption	14.43	15.04	29.60	28.43
Rural	14.70	15.30	29.48	28.37
Urban	14.12	14.70	28.36	27.28
Non-citizen	-10.26	-10.65	-19.34	-18.70
Consumer price index (CPI)	-0.60	-0.62	-1.19	-1.15
Export	0.50	0.52	1.01	0.97
Import	0.67	0.69	1.33	1.28
Government revenue	37.09	38.60	74.15	71.36
Exchange rate	-0.26	-0.27	-0.56	-0.54

Note: similar results occurred for labor tax recycling scheme.

but the magnitudes of the impacts of this tax are greater than the carbon tax policy in most sectors.

Fig. 8 shows percentage changes in private consumption levels by commodity in the case of 15% carbon reduction. Although imposing a tax on consumption of fossil fuels increases prices of energy commodities, household demand for all commodities, increases due to the increase in direct (lump-sum) and indirect (labor tax) government transfers to them. Therefore, according to household consumption results, the interaction effects of both climate change taxes are smaller than the tax replacement effects resulting in welfare increasing. The findings correspond to previous studies, such as; Bye (2000) and Stampini (2001). They argued that a carbon tax policy is a beneficial policy for households, while a preexisting tax system decreases household welfare effect of a carbon tax. Bye (2000) also highlighted that a reduction on preexisting carbon tax leads to a welfare gain in Norway. Furthermore, other studies showed that recycling of carbon tax through reducing labor tax is the most effective way for increasing consumption and welfare of households (Bor and Huang, 2010).

Higher tax levels lead to more decrease in consumption of energy, as illustrated in Fig. 9 in the case of carbon tax policy. However, demand for natural gas increased. The electricity generation uses natural gas, coal, diesel and fuel oil by 53%, 40.4%, 1.3% and 0.4%, respectively. On the other hand, over 74% of natural gas uses in electricity generation and only 17% of it uses in industries. Therefore, the consumption of natural gas, a more clean energy than other energy commodities, causes an increase in carbon tax levels, while its cost also increases like other sources of energy for electricity generation.

Sensitivity analysis

Another simulation that has been run in this study is for analyzing the robustness of the above quantitative results, which is called sensitivity analyses. In the sensitivity analysis a target of 5% carbon emission reduction, lower and higher than the 15% carbon emission reduction is considered for both carbon and energy taxes. Table 3 reports the impacts of these simulations on selected variables. In general, by an increase/decrease in the level of carbon taxes the magnitudes of aggregate variables increase/decrease. For example, a 0.26% and 0.56% decline in the aggregate exchange rate is more severe than the benchmark value and the former simulated values, resulting in more increases in import (about 0.67% and 1.33% for carbon and energy taxes, respectively). Households benefited more from the lump-sum transfer of energy and carbon tax policies as their consumption stream decreased and increased, resulted in lower and higher welfare.

CONCLUSION

The current study aims to analyze prospective impacts of both carbon and energy taxes, as environmental tax policies, on carbon emission, consumption of energy commodities, household welfare, and the entire economy of Malaysia. This study uses a computable general equilibrium framework, as a comprehensive method that gives permission to the user to measure direct and indirect impacts of implementing these tax policies and trace their impacts on a specific sector. The simulated results show that a carbon tax rate of 60 to 70 $ per ton of CO_2 is required to achieve 40% reduction in carbon emission, compared to its 2005 levels, as a targeted policy in Malaysia. However, the rates of energy tax policy are much higher than these rates (over 80 $/ per ton of oil equivalent). Implementing any tax policy, like carbon and energy taxes, would increase government income. Therefore, two schemes are implemented for redistributing all extra government income (i.e. revenue neutrality) that generated from carbon and energy tax policies. They are lump sum tax returns and labor tax return. Findings also indicate that a carbon tax policy, in comparison with an energy tax policy, can play a significant role in reducing carbon emission and consumption of fossil fuel energy in Malaysia. However, both tax policies affect real GDP, export and import of Malaysia positively, but with greater magnitudes for energy tax policy. This shows a positive impact of these policies on the economic performance of the country. Both tax policies, in comparison with the benchmark value, increase real GDP of Malaysia by 0.14%. The carbon tax policy increases household consumption and consequently the welfare of households more than the energy tax policy. Furthermore, these climate change policies reallocate resources in the economy. That is, labor forces move from those sectors that have a high demand for energy commodities (i.e. energy-intensive sectors) to those sectors that use labor more significantly (labor-intensive sectors). The latter are those sectors that gain more from both tax policies.
The study recommends low levels of carbon reduction, as more suitable targets, if the government has a plan to consider an implementation of a tax on consumption of fossil fuels. This is because of low adverse effects of these low rates on the economic performance and welfare of Malaysia.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

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