PROSIDING PERKEM ke-9 (2014) 175 - 182
ISSN: 2231-962X

Reducing CO_2 Emissions in Malaysia: Do Carbon Taxes Work?

Jamal Othman
Universiti Kebangsaan Malaysia
E-mail: jortman@ukm.edu.my

Masoud Yahoo
Universiti Kebangsaan Malaysia
E-mail: masoud_10442@yahoo.com

ABSTRAK

Dalam dekad kebelakangan ini, pemanasan global dan kesan-kesannya terhadap perubahan iklim menjadi satu kebimbangan utama di peringkat global. Malaysia telah bertekad secara sukarela untuk mengurangkan intensiti pelepasan gas karbon dioksida (CO2e) terhadap Keluaran Dalam Negara Kadar (KDNK) sehingga 40 peratus berbanding asas tahun 2005 menjelang tahun 2020. Salah satu strategi untuk mencapai matlamat ini ialah dengan memperkenalkan cukai karbon. Kajian ini mensimulasi potensi kesan-kesan ekonomi dan alam sekitar bagi cukai karbon dengan menggunakan model keseimbangan umum dengan mengambilkira input tenaga dan pelepasan karbon secara eksplisit. Senario dengan dan tanpa dasar pampasan telah diambilkira dalam simulasi ini. Hasil kajian menunjukkan terdapat kemungkinan bagi pengeluar-pengeluar untuk menggantikan bahanapi konvensional dengan bahanapi alternatif yang lebih bersih. KDNK Malaysia dijangka menurun dengan sedikit sahaja, manakala pengurangan ketara dalam pelepasan gas rumah hijau akan dapat dicapai. Tambahan, dasar pampasan yang bertujuan mengurangkan kesan cukai-cukai tidak langsung terhadap kebajikan isirumah akan memberikan kesan yang kecil terhadap pelepasan karbon manakala dalam masa yang sama kesan ekuiti akibat cukai karbon dapat dikurangkan secara signifikan.

Kata kunci: Cukai karbon; Pemodelan CGE; Kesan alam sekitar; Malaysia

ABSTRACT

In recent decades, global warming and its effects on climate change have become a major global concern. Malaysia has made a pledge to reduce voluntarily its CO2e gas emission’s intensity of GDP by up to 40 percent based on 2005 levels by 2020. One of the possible strategies to achieve this aim is to introduce a carbon tax. This paper simulates the potential economic and environment effects of a carbon tax by using the computable general equilibrium model with explicit energy and emission extensions. Both with and without compensation policy scenarios were considered in the simulation. Results suggest that there are possibilities for producers to substitute conventional fuel with other primary factors and particularly the greener fuel alternative. Malaysia's GDP is projected to decline only marginally, while substantial reductions in emissions can be realized. Further, a compensation policy which seeks to reduce the impact of indirect taxes on households’ welfare will have a small effect on carbon emissions while significantly mitigate the equity effects of the carbon tax.

Keywords: Carbon tax; CGE modelling; Environmental effects; Malaysia

INTRODUCTION

The increase in atmospheric concentrations of greenhouse gases and the environmental and social impacts of any ensuing climate pose challenges for the introduction of more restrictive environmental regulations by policy makers around the world. In Malaysia, the Prime Minister announced during COP15[1] in Copenhagen that Malaysia would voluntarily reduce by 40% its carbon emissions intensity of GDP (gross domestic product) by the year 2020 compared to 2005 levels. Data from IEA (2011) shows that among Southeast Asia nations, Malaysia has relatively high CO2 emission rate per capita and per GDP measures at 5.97 (tonnes CO2 per capita) and 1.20 respectively. TABLE 1 compares CO2 emission related indices for Southeast Asia nations.

[1] 15th Conference on Parties

Measures used to control CO2 emissions include market based instruments and the command and control approach with the former focusing on energy and carbon taxes[2] and tradable carbon permits. This paper seeks to appraise the impact of implementing carbon taxes in the Malaysian economy as a means to mitigate the country's CO2 emissions. The paper will also consider the equity impact of such a policy instrument in the economy with emphasis on the household sector. Note that study does not attempt to identify the most efficient policy for reducing CO2 emissions in Malaysia.

As the experiences of other countries show, there is some uncertainty over the impacts of carbon taxes and its relative incidence on equity-related variables. Emission taxes on fossil fuel energy products such as coal and oil products like gasoline have far-reaching impacts throughout the economy. Achieving nominal emission reduction targets also require changes in the production structure of industries, altering wage or employment mechanisms and, most importantly, in the relative prices of fossil fuels in particular. In general, an emission tax may have the overall effect of being positive or negative. In an ideal solution, emission taxes reduce both CO2 emissions and offer a source of additional tax revenue for the government that may be used to improve the equity conditions in society, without altering its net budget balance. On the other hand, a carbon tax may also increase the cost of other commodities in the economy and lead to decreases in real wages and incomes.

This paper examines the potential effects of a carbon tax with and without a compensation policy. For this purpose, a single country static Computable General Equilibrium (CGE) model is constructed together with an environmentally extended input output table. The simulation results of the exercise may shed light on the environmental and macroeconomic impact of a carbon tax policy in the short run.

Following this introduction, the next section reviews the literature on the application of CGE models on environmental policies, particularly environmental taxes. Subsequent sections describe the model structure and database construction, simulation results, and concluding remarks.

LITERATURE REVIEW

The theoretical bases of environmental taxes can be traced to, Pigou (1932), Baumol (1972, 1988), and Baumol and Oates (1971). The economic impacts of carbon tax policies have been researched fairly considerably internationally. A general equilibrium model which includes all economic sectors within a closed cycle is thought as the most appropriate tool for such analyses. Hudson established the basis for most applied general equilibrium models formulated for analyzing energy-taxation scenarios (Hudson & Jorgenson, 1974). Bhattacharyya (1996) reviewed the major early energy-related applied general equilibrium models. Recent reviews of energy and climate-change general equilibrium models were provided by Weyant (2004). The carbon tax sub-branch of CGE studies began with the works by Beauséjour, et. al. (1992) , Zhang (1998), Hamilton and Cameron (1994), Labandeira, et. al. (2004) , Wissema and Dellink (2007), and Devarajan, et. al. (2011).

This study contributes to the broad literature on the use of economic instruments for climate change mitigation in developing countries. Specifically, it implements a carbon tax on fossil fuels in a CGE framework for the case of Malaysia. The model incorporates explicitly substitution possibilities for producers to switch to renewable energy alternatives[3] as well as other less carbon intensive fuels, and further tax revenues are reallocated to address households' equity.

THE MODEL AND DATABASE

A CGE model was constructed to represent the Malaysian economy in a static form with a small open economy structure. The fundamental economic structure of the model is similar to the ORANI-G model of the Australian economy which is fully described in Horridge (2000). The baseline data comprises production linkages in the Malaysian input output tables, a representative household, a general government sector, an investment sector, inventory changes and a foreign sector combined with macro- and micro-economic specifications of market clearing, resource supplies, trade balances and other constraints.

The model includes different energy commodities such as coal, crude oil, natural gas, petroleum products, distributed gas and electricity. Electricity is disaggregated into five new sectors based on different technologies for electricity generation while other non-energy commodities and

[2] Or CO2 emission tax
[3] Specifically in electricity production sector

activities are aggregated into 16 production sectors. In total, the Malaysian economy is represented by 27 commodities and industries (out of 120 sectors). It incorporates energy flows between industries as intermediate use and among other final demanders. CO2 emissions are linked to the intermediate use of fossil fuels for the production of commodities and as household sector demand for final use.

Renewable electricity generation includes electricity from biomass, hydroelectricity and an aggregated other renewable energy sources such as biogas, mini hydro, wind and solar, which were reflected in the Malaysian electricity supply industry (2006). To avoid double-taxing issues in the model, it is assumed that electricity production emits CO2 while its usage does not. Also for producing electricity the generation technologies demand fuels designed for that purpose; for example, coal electricity uses only coal and so on. To provide emission reduction possibilities for producers that will decrease CO2 levels after the imposition of the carbon tax on fuels, the production structure of the model involves substitution possibilities between different energy commodities as well as between energy-capital on one side and other primary inputs such as labour and land on the other.

Generally, as TABLE 1: CO_2 emissions of Southeast Asian countries, 2009

Country	**Population (million)**	**GDP-EX (billion 2000 US dollars)**	**CO2 emissions (million tonnes)**	**CO_2/population (tonnes CO_2/capita)**	**CO_2/GDP (kg CO_2 / 2000 US dollar)**
Brunei	0.4	6.8	8.1	20.25	1.19
Cambodia	14.8	7.5	4.3	0.29	0.57
Indonesia	230	258.5	376.3	1.64	1.46
Malaysia	27.5	137.1	164.2	5.97	1.20
Myanmar	50	19.9	10.1	0.20	0.51
Philippines	92	111.7	70.5	0.77	0.63
Singapore	5	143.5	44.8	8.96	0.31
Thailand	67.8	173.9	227.8	3.36	1.31
Vietnam	87.3	58.8	114.1	1.31	1.94

Source: Author’s calculation using data from the IEA, 2011 shows, the production structure is a seven-layer CES-Leontief function. There are possibilities for producers to substitute carbon intensive fuels with non-carbon intensive or green energy ones as well as primary factors for their outputs. To combine domestic production and imports, the Armington[4] assumption (Armington, 1969) is employed by a CES function. In the supply side of the nested of production, a homogeneous Armington commodity is adopted. Utilizing a CET[5] functional form shows the options for producers to supply their output in the domestic market or for export in favor of higher prices between the two markets. It should be noted that the elasticity of substitution between domestically produced and imported goods in intermediate consumption are identical for investment and household users, but varies across products.

Representative household expenditure functions are indicated by the Klein-Rubin (1947) utility function form. The investment structure also has a Leontief–CES function which is a simple three-layer nested comprising intermediate inputs with primary factors and other cost expenditures to determine the optimal level of capital creation for each industry. To model the demand for exports, the commodities in this study are based on associated export shares and divided into two groups. Individual export commodities[6] include all the main export commodities for which foreign demand has an inverse relationship with that commodity's price. For the balance of the commodities, collective export commodities, demand is inversely related to their average price.

Finally, it is assumed that a MYR30 carbon tax is levied on the industries and household sectors based on the level of their emitted CO2 (tonnes). As mentioned above, to avoid double counting in calculating the CO2 tax base, a uniform CO2 tax is imposed on all energy goods except for crude oil, natural gas and different electricity commodities.

Basic carbon dioxide emissions data are based on CO2 emission data from the GTAP (Narayanan, Aguiar, & McDougall, 2012) database. To form an emission extended input output table, based on different energy commodities and sectors, the basic data from input output table and emission data are merged and emission intensities calculated based on each fuel and each industry. The emission intensity for residential fuel consumption is also proportional to household's associated fuel consumption and, again, using data from absorption matrix for the residential sector, CO2 emissions attributed to the representative household sector is calculated.

The value for Armington elasticities and the primary factor substitution elasticity except for capital are taken from ORANI-G. Other substitution elasticities are derived from energy related CGE model literature such as Rutherford and Paltsev (2000) and it should be noted that sensitivity tests have been done for all values of elasticities as covered in the discussion section.

To complete the model, a short run closure is assumed. Moreover, the exchange rate is selected to be the numéraire of the model and changes in all other price variables in the model are measured relative to this variable. Industry-specific endowment of capital is assumed to be fixed and capital is immobile between sectors. There is free movement of labour between industries and wages are assumed to be sticky as the real wage rate is assumed to be fixed. Accordingly, the associated capital and labour markets are cleared by endogenous factor prices.

RESULTS AND DISCUSSIONS

This study examines and compares two scenarios where in scenario 1 only a carbon tax is introduced while in scenario 2 the same price of carbon is charged but is accompanied by a compensation policy. In the latter scenario, the tax revenues from scenario 1 is excluded from the government's income base and rechanneled into the system by reducing indirect taxes on commodities and services consumed by households. Unless specified, all results reported in this study are in terms of percentage changes.
Based on

FIGURE 1: Nested of production

[4] Domestically produced commodities and imported ones are imperfect substitutes.
[5] Constant Elasticity of Transformation
[6] Commodity which it's export share > 15% and is not special.

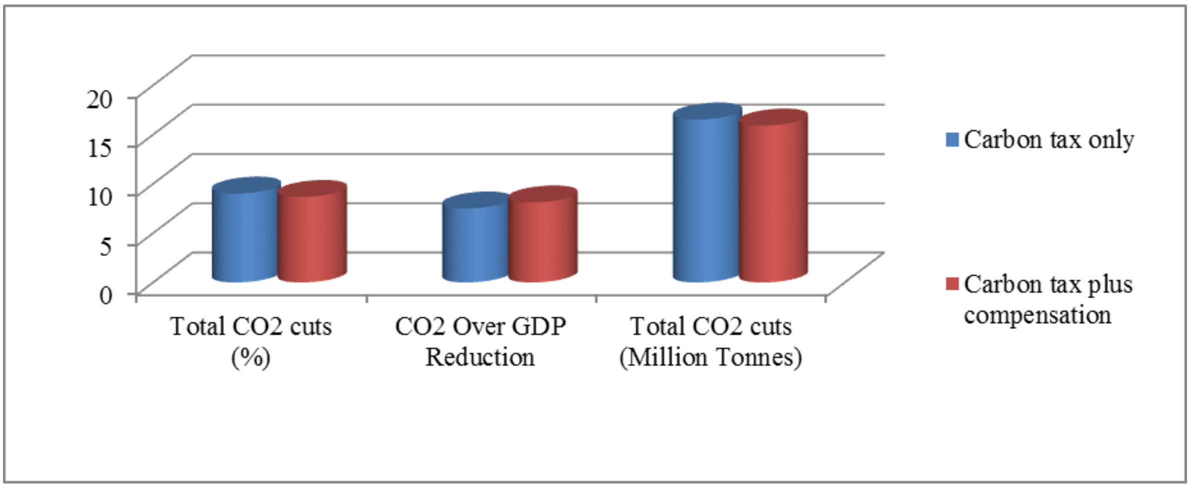

FIGURE 2, a carbon tax of MYR30 is applied under both scenarios. In the first scenario, total carbon emissions decreased by 9.02% or 16.5 million tonnes. In comparing the two scenarios it is obvious that the compensation plan does not significantly alter the level of carbon emissions. Imposing a carbon tax increases the production cost of carbon intensive goods such as coal and petroleum products and the subsequent fall in demand will decrease the level of emissions. However, a compensation strategy would offset this decrease by restoring the demand for carbon intensive goods. The reduction in CO2 emission levels from 16.5 Mt to 15.9 Mt in the compensation scenario confirms this claim. Closer observation of the emission intensity on GDP reduction shows that a carbon tax of MYR30 per tonne of carbon would reduce the ratios by 7.51% and 8.12% in the first and second scenarios respectively, which is in line with previous explanations. This is due to the lower decrease in real GDP as a result of the compensating carbon tax policy in the second scenario.

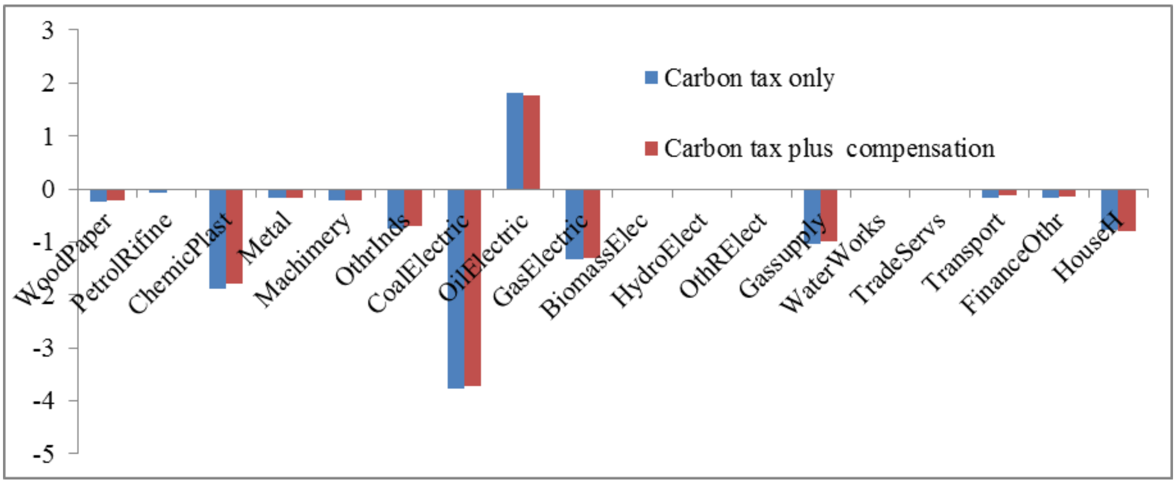

FIGURE 3 shows the carbon emission reduction in various sectors arising from the MYR30 carbon tax. As can be clearly seen, the major contributors to total CO2 emission reduction are coal electricity, gas electricity, and chemical products. Household contribute to a 0.8% reduction in total CO2 reduction in scenario 1 and 0.7% in scenario 2. The contribution of the other producers is relatively small. Of interest is that one sector had an increase in its level of emissions despite the tax, and this could be explained by the substitution effect. The tax on coal and natural gas shifted inputs for electricity generation to oil whose demand increased resulting in higher emissions from the oil-generated electricity sector.

An analysis of the results among industries shows that the range of impacts is wide (the full table of sectoral outputs is available on request). The most inversely affected are the coal and gas generated electricity and chemical product industries. The sectors which experienced positive output changes are biomass, hydro, other renewable electricity, and oil generated electricity. In the compensating scenario, only some sectors have inverse affects for example the machinery, trade and financial service industries. It is important to note that the sectoral level results confirm that the energy intensive industries are most affected by the tax.

From the economic viewpoint, it is obvious that real GDP growth experienced negative rates, by 1.63% and 0.61%, in scenarios 1 and 2, respectively. This is because the introduction of the new tax leads to economic distortions. The lower GDP growth rate (0.61%), under the compensation scenario is because the reallocation of the tax revenue from scenario 1, by implementing a decrease in indirect tax rate for household will improve the contracted situation caused by the first scenario. As mentioned previously the negative change in CO2 over the real GDP ratio under the second scenario is higher at 8.12% compared to 7.51% in the first scenario which is due to the decrease in real GDP under the second scenario assumption.

shows that under both scenarios, payments to capital decreased by 0.59% and 0.37% respectively, while labour only decreased under the first scenario by 0.51%. The negative numbers for capital do not deviate much from expectations because of the economic contractions after the imposition of the carbon tax. Also, based on the second scenario, total employment increased by 1.5% while under the carbon tax only, it decreased by 1.3% due to the reallocation of production resources after returning the tax revenues which resulted in an increase in demand for primary factors especially labour. The compensation policy also has a positive effect on labour supply.

The total exports of commodities under both scenarios reduced by 1.77% and 0.4%, respectively, showing the price effect of the carbon tax. The tax on Malaysian produced goods increases their prices and reduces overseas demand. However, under the carbon tax only scenario, total imports experienced negative growth of 0.3% while under the compensation regime they increased by 0.2%. This is due firstly to the increase in demand for commodities arising from the 'recycling' back of tax revenues to final consumers and, secondly, as domestic price increases while nominal exchange rates are fixed, there will be an appreciation of the Malaysian Ringgit in real terms which provides extra purchasing power for imported goods. This however has a negative impact on the country's balance of trade under the compensation scenario which decreased by 0.01%.

A sensitivity test on all behavioural parameters and elasticities of the mode after the simulation exercise shows that elasticity of substitution between composited energy and capital and elasticity between renewable-based and fossil-based electricity have positive effects on results. It means that for higher assumed elasticities, the switch from fossil fuels to greener fuels or capital is easier, the decrease in CO2 emissions is larger, and GDP is reduced moderately.

CONCLUDING REMARKS

This study employed a 27-sector computable general equilibrium model to quantify the environmental as well as the macroeconomic and sectoral effects of a carbon tax in Malaysia. An environmentally extended input-output table was constructed to specifically demonstrate the impact of CO2 emissions from fuel consumption. The impact of a carbon tax was analysed under two scenarios in the paper. Under scenario 1, the impact of only imposing a MYR30 carbon tax was examined, while in scenario 2 a compensation policy was added to the equations by reallocating the carbon tax revenue to households in the form of a reduction in indirect tax rates.

This study highlights the necessity of including a compensation plan with other policies and measures such as redistributing the carbon tax revenues by reducing other distortionary taxes to mitigate the negative economic effects of a carbon tax and to improve the environment as well as to assist heavily energy-dependent industries and households. The results show that resource allocations, GDP and CO2 emission are affected under both scenarios. GDP growth decreases by 1.63% and 0.6% under scenarios 1 and 2, respectively, while CO2 emissions changed slightly under the second scenario. In terms of equity indices such as household utility and consumption patterns, the results show that returning tax revenues to final consumers through a reallocation had a positive effect on households.

Providing substitution opportunities to reduce the use of carbon intensive as well as other primary factors show that introducing renewable energy sources into the model, lead to considerable CO2 emission reductions through this channel while output of these renewable energy sources increases to meet the demand for aggregated energy.

ACKNOWLEDGEMENT

This paper is part of the research funded by UKM YSD-IKPI (ZF-2014-002) on the Development of the Malaysian Environmental Input-Output Database for Climate Change Policy Analysis.

REFERENCES

Armington, P. S. (1969). A Theory of Demand for Products Distinguished by Place of Production (Une théorie de la demande de produits différenciés d'après leur origine)(Una teoría de la demanda de productos distinguiéndolos según el lugar de producción). *Staff Papers-International Monetary Fund*, 159-178.

Baumol, W. J. (1972). On taxation and the control of externalities. *The American Economic Review*, 307-322.

Baumol, W. J. (1988). *The theory of environmental policy*: Cambridge University Press.

Baumol, W. J., & Oates, W. E. (1971). The use of standards and prices for protection of the environment. *Swedish Journal of Economics, 73*(1), 42-54.

Beauséjour, L., Smart, M. B., & Lenjosek, G. (1992). *An environmental CGE model of Canada and the United States*: Department of Finance, Fiscal Policy and Economic Analysis Branch.

Bhattacharyya, S. C. (1996). Applied general equilibrium models for energy studies: a survey. *Energy Economics, 18*(3), 145-164.

Devarajan, S., Go, D. s., Robinson, S., & Thierfelder, K. (2011). Tax Policy to Reduce Carbon Emissions in a Distorted Economy: Illustrations from a South Africa CGE Model. *The B.E. Journal of Economic Analysis and Policy, 11*(1), 1-22.

Electricity Supply Industry In Malaysia, Performance and Statistical Information. (2006): Department of Electricity Supply Regulation, Energy Commission.

Hamilton, K., & Cameron, G. (1994). Simulating the Distributional Effects of a Canadian Carbon Tax. *Canadian Public Policy, 20*(4), 385-399.

Horridge, M. (2000). *ORANI-G: A General Equilibrium Model of the Australian Economy*. Australia: Centre of Policy Studies, Monash University.

Hudson, E. A., & Jorgenson, D. W. (1974). US energy policy and economic growth, 1975-2000. *The Bell Journal of Economics and Management Science*, 461-514.

IEA. (2011). *CO2 Emissions From Fuel Combustion*. Paris: International Energy Agency.

Klein, L. R., & Rubin, H. (1947). A constant-utility index of the cost of living. *The Review of Economic Studies, 15*(2), 84-87.

Labandeira, X., Labeaga, J. M., & Rodríguez, M. (2004). Green tax reforms in Spain. *European Environment, 14*(5), 290-299.

Narayanan, G. B., Aguiar, A., & McDougall, R. (2012). Global Trade, Assistance, and Production: The GTAP 8 Data Base, Center for Global Trade Analysis, Purdue University.

Pigou, A. C. (1932). *The Economics of Welfare* (4 ed.). London: Macmillan.

Rutherford, T. F., & Paltsev, S. V. (2000). *GTAP-energy in GAMS: The Dataset and Static Model* (Vol. 2). Boulder: Department of Economics, University of Colorado

Weyant, J. P. (2004). Introduction and overview. *Energy Economics, 26*(4), 501-515.

Wissema, W., & Dellink, R. (2007). AGE Analysis of the Impact of a Carbon Energy Tax on the Irish Economy. *Ecological Economics, 61*(4), 671-683. doi: 10.1016/j.ecolecon.2006.07.034

Zhang, Z. (1998). Macro-economic and Sectoral Effects of Carbon Taxes: A General Equilibrium Analysis for China. *Economic Systems Research, 10*(2), 135-159. doi: 10.1080/09535319808565471

TABLE 1: CO_2 emissions of Southeast Asian countries, 2009

Country	**Population (million)**	**GDP-EX[7] (billion 2000 US dollars)**	**CO2 emissions (million tonnes)**	**CO_2/population (tonnes CO_2/capita)**	**CO_2/GDP (kg CO_2 / 2000 US dollar)**
Brunei	0.4	6.8	8.1	20.25	1.19
Cambodia	14.8	7.5	4.3	0.29	0.57
Indonesia	230	258.5	376.3	1.64	1.46
Malaysia	27.5	137.1	164.2	5.97	1.20
Myanmar	50	19.9	10.1	0.20	0.51

[7] GDP based on exchange rate

Philippines	92	111.7	70.5	0.77	0.63
Singapore	5	143.5	44.8	8.96	0.31
Thailand	67.8	173.9	227.8	3.36	1.31
Vietnam	87.3	58.8	114.1	1.31	1.94

Source: Author's calculation using data from the IEA, 2011

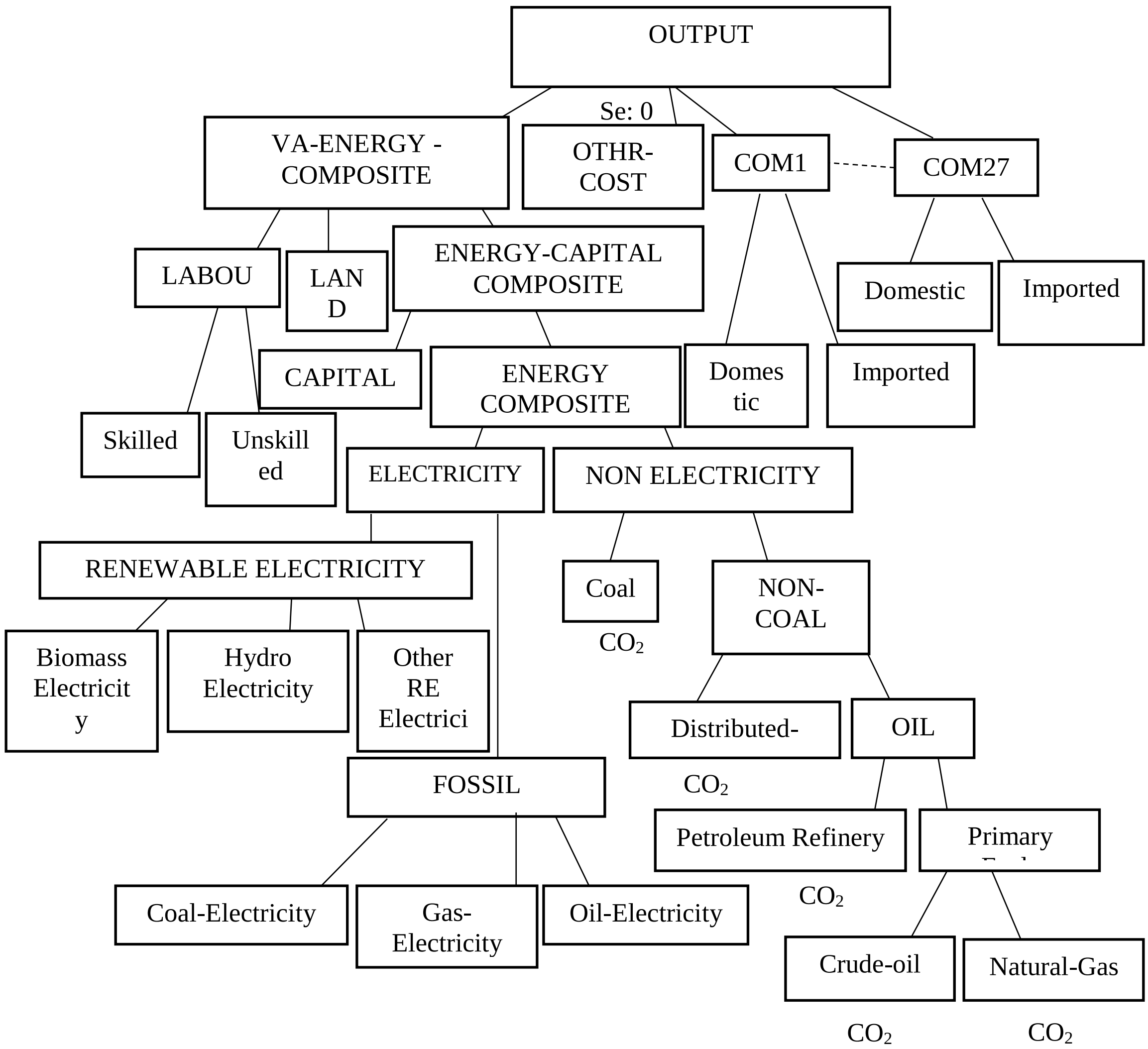

FIGURE 1: Nested of production

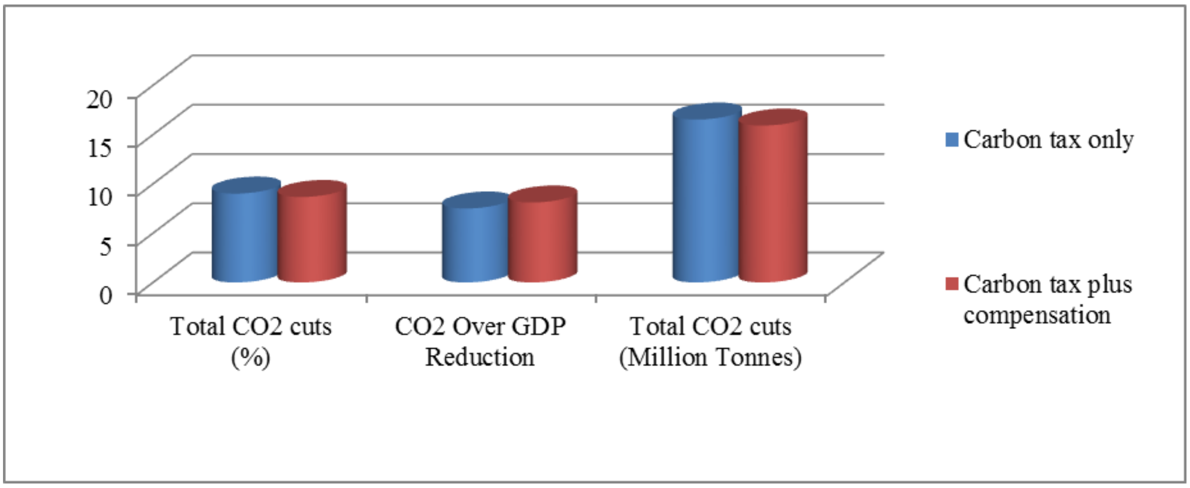

FIGURE 2: Emission reduction

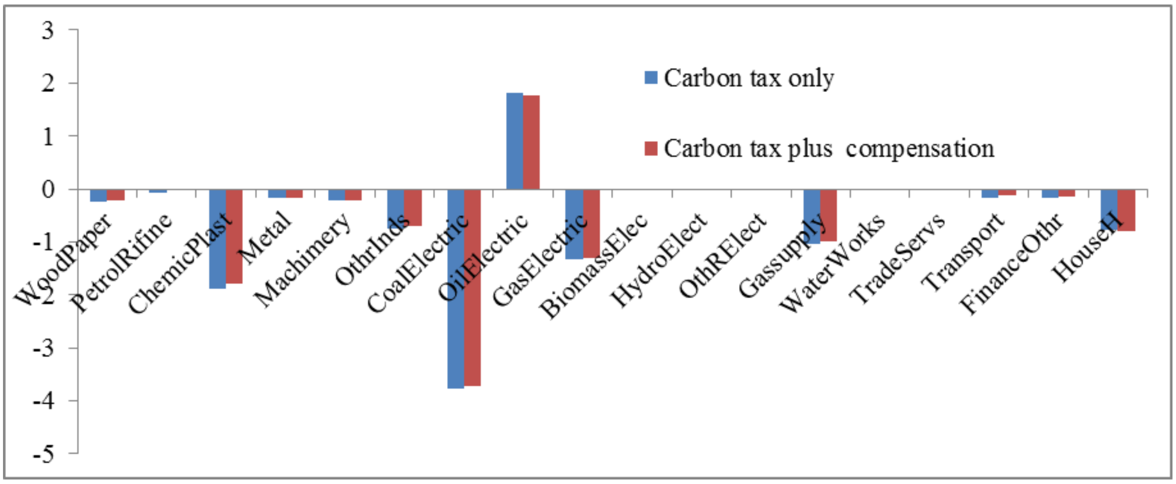

FIGURE 3: Sectoral carbon emission reduction

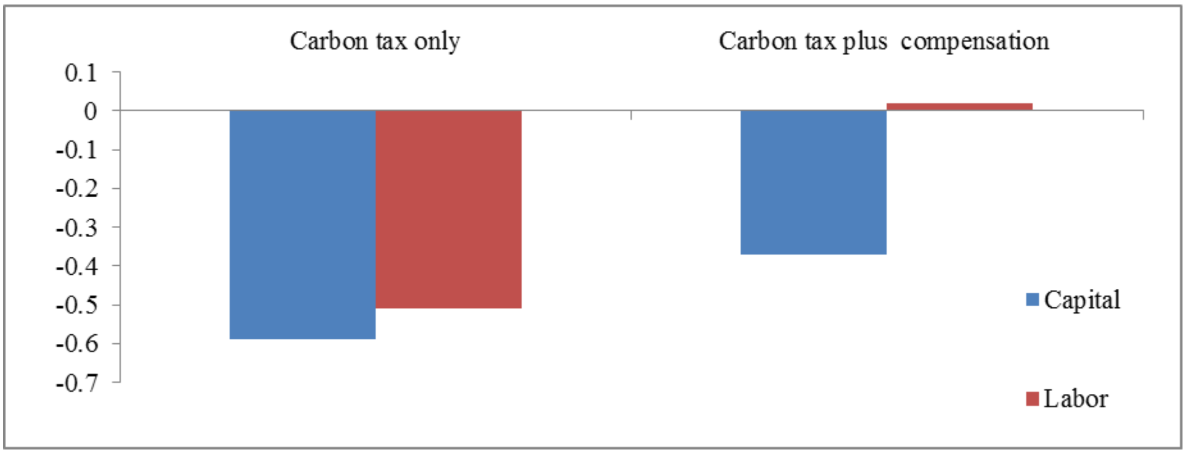

FIGURE 4: Payments to primary factors