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Computable General Equilibrium Techniques for Carbon Tax Modeling

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Abstract: Problem statement: Lacking of proper environmental models environmental pollution is now a solemn problem in many developing countries particularly in Malaysia. Some empirical studies of worldwide reveal that imposition of a carbon tax significantly decreases carbon emissions and does not dramatically reduce economic growth. To our knowledge there has not been any research done to simulate the economic impact of emission control policies in Malaysia. **Approach:** Therefore this study developed an environmental computable general equilibrium model for Malaysia and investigated carbon tax policy responses in the economy applying exogenously different degrees of carbon tax into the model. Three simulations were carried out using a Malaysian social accounting matrix. **Results:** The carbon tax policy illustrated that a 1.21% reduction of carbon emission reduced the nominal GDP by 0.82% and exports by 2.08%; 2.34% reduction of carbon emission reduced the nominal GDP by 1.90% and exports by 3.97% and 3.40% reduction of carbon emission reduced the nominal GDP by 3.17% and exports by 5.71%. **Conclusion/Recommendations:** Imposition of successively higher carbon tax results in increased government revenue from baseline by 26.67, 53.07 and 79.28% respectively. However, fixed capital investment increased in scenario 1a by 0.43% and decreased in scenarios 1b and 1c by 0.26 and 1.79% respectively from the baseline. According to our policy findings policy makers should consider 1st (scenario 1a) carbon tax policy. This policy results in achieving reasonably good environmental impacts without losing the investment, fixed capital investment, investment share of nominal GDP and government revenue.

Key words: Emission, environmental general equilibrium, Malaysian economy

INTRODUCTION

There has been growing concern among environmentalists and economists over the linkage between economic development and the environment. Higher awareness has led to greater scrutiny being placed on development policies in order to assess the long-term negative effects of further economic development on the environment and its sustainability[1,2]. Some studies that have addressed the role of trade in the development and how that affects the environment are Bullard and Herendeen[3] Herendeen and Bullard[4] Herendeen[5] Stephenson and Saha[6] Strout[7] Han and Lakshmanan[8] Ferraz and Young[9] Wier[10] Antweiler *et al.*[11] Munksgaard and Pedersen[12] Kakali and Debesh[13] Al-Amin *et al.*[14]. The methodologies employed in these studies are varied, however results of most of these studies indicate that economic development harms environment unless appropriate environmentally friendly policy put in place. Although a number of previous studies have given a detailed evaluation of economic development and environment in the world perspective, little attention has been given to enquiring about these relationships in the newly industrializing countries of Southeast Asia, in particular Malaysia.

Adopting an export-led growth strategy, Malaysia has increasingly diversified its exports in terms of products and markets resulting in large changes in the composition of exports and experiencing strong economic growth over the last three decades (Table 1 and Fig. 1). Economic growth could affect the environment in two ways; -firstly it encourages industrialization and manufacturing of production, leading to increased pollution. Secondly, industrialization and manufacturing of production lead to increased overuses of environmental resources (energy) and results in environmental degradation. All goods and services produced in Malaysia are directly or indirectly associated with uses of power and energy

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Table: 1 Direction of Malaysian trade in the world economy from 1990-2005

	RM million (US$1 = RM3.50)						Percentage of total (RM)					
	Exports			Imports			Exports			Imports		
Direction	1990	2000	2005	1990	2000	2005	1990	2000	2005	1990	2000	2005
ASEAN	23065.5	99028	139208	15085.0	74940	110823	29.0	26.5	26.1	19.1	24.1	25.5
Singapore	18052.1	68574	83333	11800.0	44696	50828	22.7	18.4	15.6	14.9	14.4	11.7
Indonesia	920.7	6484	12580	850.8	8623	16566	1.2	1.7	2.4	1.1	2.8	3.8
Thailand	2788.0	13485	28723	1881.2	11987	22889	3.5	3.6	5.4	2.4	3.8	5.3
Philippines	1054.6	6558	7476	427.3	7562	12192	1.3	1.8	1.4	0.5	2.4	2.8
European Union	12204.5	51019	62629	12494.4	33527	50512	15.5	13.7	11.7	15.8	10.8	11.6
United Kingdom	3136.0	11566	9470	4312.3	6080	6522	3.9	3.1	1.8	5.5	2.0	1.5
Germany	3096.8	9336	11259	3389.2	9282	19265	3.9	2.5	2.1	4.3	3.0	4.4
USA	13487.0	76579	105033	13232.5	51744	55918	16.9	20.5	19.7	16.7	16.6	12.9
Canada	-	3043	2847	-	1445	2133	-	0.8	0.5	-	0.5	0.5
Australia	-	9210	18042	-	6052	8171	-	2.5	3.4	-	1.9	1.9
Selected NEA[1]	-	103784	149105	-	117828	169236	-	27.8	27.9	-	37.8	39.0
Japan	12588.9	48770	49918	23584.5	65513	62982	15.8	13.1	9.4	16.7	21.0	14.5
China	-	11507	35221	-	12321	49880	-	3.1	6.6	-	4.0	11.5
Hong Kong	2523.1	16854	31205	1497.5	8557	10797	3.2	4.5	5.8	1.9	2.7	2.5
Korea Rep.	3677.0	12464	17945	2033.6	13926	21604	4.6	3.3	3.4	2.6	4.5	5.0
Taiwan	1728.1	14189	14813	4323.0	17511	23974	2.2	3.8	2.8	5.5	5.6	5.5
South Asia	-	10529	21245	-	3030	4504	-	2.8	4.0	-	1.0	1.0
India	-	7312	14972	-	2748	4164	-	2.0	2.8	-	0.9	1.0
CSA	-	5633	6169	-	2587	6786	-	1.5	1.2	-	0.8	1.6
Africa	-	2996	7649	-	1421	2511	-	0.8	1.4	-	0.5	0.6
Others	-	11449	21866	-	18886	23415	-	3.1	4.1	-	6.1	5.4
Rest of the world	10372.3	-	-	11478.8	-	-	13.0	-	-	14.5	-	-

Source: Government of Malaysia[15]; [1]: North East Asia

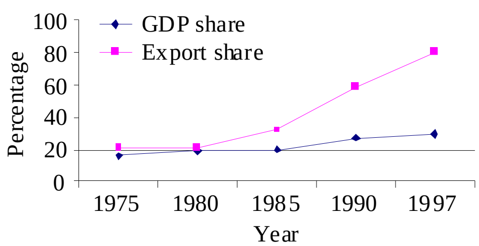

Fig. 1: Manufacturing share in the Malaysian economy 1970-1997

(petroleum oil, coal and gas)[20]. According to the types of fuel utilized, emissions of that energy are obvious as well. Moving towards sustainable development and for better environmental performance, there is a policy goal in the Malaysian 9th Development Plan[15]. However due to lack of efficiency of environmental policy options, Malaysia failed to achieve the environmental goal. The existing Malaysian environmental tax policies have lack of effectiveness and the present level of pollution charge is very low as most of the cases it found insignificant[16]. The main reason is that the environmental tax is not appropriate. It should be mentioned that currently there is no carbon tax policy model in Malaysia and environmental monitoring system does not cover all polluting sectors. Therefore, the model developed for this study is applied Computable General Equilibrium (CGE) model for imposing carbon taxation policy in the Malaysian economy. The model captures the changes in factors of production, industry output, consumer demand, trade, private consumption, public consumption and other macroeconomic variables resulting from environmental policy changes. Specifically, a minimum carbon tax policy developed for Malaysia to reap the maximum benefit of trade, economic development as well as to reduce the further environmental degradations.

MATERIALS AND METHODS

A static Computable General Equilibrium (CGE) model of the Malaysian economy is constructed for this study[21]. The model consists of ten industries, one representative household, three production factors and rest of the world. The CGE technique is an approach that models the complex interdependent relationships among decentralized actors or agents in an economy by considering the actual outcome to represent a 'general equilibrium'. Briefly, the technique expresses that the 'equilibrium' of an economy is reached when expenditures by consumers exactly exhaust their disposable income, the aggregate value of exports exactly equals import demand and the cost of pollution is just equal at the marginal social value of damage that it causes.

Table 2: Sectoral aggregation of Malaysian SAM 2000 ('000 RM)

Incomes/Expenditure		1 Commodities /activities (1-94)	2 Factors: Labor	Capital	3 Institutions: Household	Firms	Government	4 Capital account	5 Rest of the world	Total
1 Commodities /activities (1-94)		Intermediate inputs 271,699,945			Household consumption 116,582,745		Government consumptions 34,861,875	Investment 74,303,819	Exports 399,379,409	Domestic demand 896,827,793
2 Factors	Labor	Value added 99,138,139							Factor incomes from abroad 0	GNP at factor cost 345,270,111
	Capital	Value added 246,131,970								
3 Institutions	Household		Household income from labor 99,138,140	Household income from capital 42,289,296		Transfers 10,890,000	Transfers 3,700,138		Transfers from abroad 0	Household income 156,017,574
	Firms			Farm cap. Income 154,100,045	Transfers		1,940,000			Firms income 158,699,045
	Government	Tariffs, indirect taxes 8,406,755			Income taxes 7,015,000	Taxes 22,141,000		Others 1,771,839	Borrowing 11,357,419	Government income 50,692,013
4 Capital account					Households savings 32,419,829	Firms savings 125,668,045	Government savings 10,190,000			Total savings 168,277,875
5 Rest of the world		Imports 271,450,981		Inflow 49,742,630				Foreign capital 92,202,217	Capital transfer 14,028,333	Total row 427,424,161
Total		Domestic Supply 896,827,792	Factor outlay 345,270,111		Household expenditure 156,017,574	Firms expenditures 158,699,045	Government expenditure 50,692,013	Total investment 168,277,875	Foreign exchange earnings 427,424,161	2,203,208,571

The benchmark model representing the baseline economy is constructed using a SAM: Social Accounting Matrix (SAM matrix is estimated by the Authors using the Malaysian 2000 input-output table and 2000 national accounts of Malaysia). SAM is the snapshot of the economy and it reflects the monetary flow arising from interactions among institutions in the Malaysian economy. The Malaysian SAM of the year 2000 is shown in Table 2.

The Malaysian CGE model is comprised of a set of non-linear simultaneous equations and follows closely the specifications in Dervis *et al.*[17] and Robinson *et al.*[18] with some modifications in terms of functional form in the production technology to allow for pollution emission estimation incorporating carbon emission block into the model; where the number of equations is equal to the number of endogenous variables. The equations are classified in five blocks, i.e., (i) The price block, (ii) The production block, (iii) The institutions block, (iv) The system constraints block and carbon emission block.

Price block:

Domestic price: Domestic goods price by sector, PD_i is the carbon tax induced goods price, t_i^d times net price of domestic goods, $\overline{PD}_i$ can be expressed as follows:

$$PD_i = \overline{PD}_i(1+t_i^d) \quad (1)$$

Import price: Domestic price of imported goods PM_i, is the tariff induced market price times Exchange Rate (ER) and can be expressed as:

$$PM_i = pwm_i(1+tm_i)\cdot ER \quad (2)$$

Where:
tm_i = Import tariff and
pwm_i = The world price of imported goods by sector

Export price: Export price of export goods, PE_i, is the export tax induced international market price times exchange rate and is express as:

$$PE_i = pwe_i(1-te_i)\cdot ER \quad (3)$$

Where:
te_i = Export tax by sector and
pwe_i = The world price of export goods by sector

Composite price: The composite price, P_i, is the price paid by the domestic demanders. It is specified as:

$$P_i = \left(\frac{PD_iD_i + PM_iM_i}{Q_i}\right) \quad (4)$$

Where:
D_i and M_i = The quantity of domestic and imported goods respectively

PD_i = The price of domestically produced goods sold in the domestic market
PM_i = The price of imported goods and Q_i is the composite goods

Activity price: The sales or activity price PX_i is composed of domestic price of domestic sales and the domestic price of exports can be expressed as:

$$PX_i = \frac{PD_i.D_i + PE_i.E_i}{X_i} \quad (5)$$

where, X_i stands for sectoral output.

Value added price: Value added price PV_i is defined as residual of gross revenue adjusted for taxes and intermediate input costs, is specified as:

$$PV_i = \frac{PX_i \cdot X_i(1 - tx_i) - PK_i \cdot IN_i}{VA_i} \quad (6)$$

Where:
tx_i = Tax per activity and
IN_i = Stands for total intermediate input
PK_i = Stands for composite intermediate input price
VA_i = Stands for value added

Composite intermediate input price: Composite intermediate input price PK_i is defined as composite commodity price times input-output coefficients:

$$PK_i = \sum_j a_{ij} \cdot P_j \quad (7)$$

where, a_{ij} is the input-output coefficients

Numeraire price index: In CGE model, the system can only determine relative prices and solves for prices relative to a numeraire. In this model the numeraire is the gross domestic product price deflator (or gross national product can also be used). Producer price index and CPI are also commonly used as numeraire in applied CGE studies. In this model:

$$PP = \frac{GDPVA}{RGDP} \quad (8)$$

Where:
PP = GDP deflator
GDPVA = The GDP at value added price and
RGDP = The real GDP

Production block: This block contains quantity equations that describe the supply side of the model. The fundamental form must satisfy certain restrictions of general equilibrium theory. This block defines production technology and demand for factors as well as CET (constant-elasticity-of-transformation) functions combining exports and domestic sales, export supply functions and import demand and CES (constant elasticity of substitution) aggregation functions. Sectoral output X_i is express as: (The production function here is nested. At the top level, output is a fixed coefficients function of real world value added and intermediate inputs. Real value added is a Cobb-Douglas function of capital and labor. Intermediate inputs are required according to fixed input-output coefficients and each intermediate input is a CES aggregation of imported and domestic goods):

$$X_i = a_i^D \prod_f FDSC_{if}^{\alpha_{if}} \quad (9)$$

Where:
$FDSC_{if}$ = Indicates sectoral capital stock and
a_i^D = Represents the production function shift parameter by sector

The first order conditions for profit maximization as follows:

$$WF_f.wfdist_{if} = PV_i.\alpha_{if} \frac{X_i}{FDSC_{if}} \quad (10)$$

Where:
$wfdist_{if}$ = Represents sector- specific distortions in factor markets
WF_f = Indicates average rental or wage
α_{if} = Indicates factor share parameter of production function

Intermediate inputs IN_i are the function of domestic production and defined as follows:

$$IN_i = \sum_j a_{ij} \cdot X_j \quad (11)$$

On the other, the sectoral output is defined by CET function that combines exports and domestic sales. Sectoral output is defined as:

$$X_i = a_i^T[\gamma_i E_i^{\rho_i^T} + (1-\gamma_i) D_i^{\rho_i^T}]^{\frac{1}{\rho_i^T}} \quad (12)$$

Where:
a_i^T = The CET function shift parameter by sector
γ_i = Holds the sectoral share parameter
E_i = The export demand by sector and
ρ_i^T = The production function of elasticity of substitution by sector

The sectoral export supply function which depends on relative price (P^e/P^d) can be expressed in the following functional form:

$$E_i = D_i \left[\frac{P_i^e (1-\gamma_i)}{P_i^d . \gamma_i} \right]^{1/\rho_i^T} \quad (13)$$

Similarly, the world export demand function for sectors in an economy, $econ_i$, is assumed to have some power and is expressed as follows:

$$E_i = econ_i \left[\frac{pwe_i}{pwse_i} \right]^{\eta_i} \quad (14)$$

Where:
$pwse_i$ = Represents the sectoral world price of export substitutes and
η_i = The CET function exponent by sector

On the other, composite goods supply describes how imports and domestic product are demanded. It is defined as:

$$Q_i = a_i^C \left[\delta_i M_i^{-\rho_i^C} + (1-\delta_i) D_i^{-\rho_i^C} \right]^{-1/\rho_i^C} \quad (15)$$

Where:
a_i^C = Indicates sectoral Armington function shift parameter and
δ_i = Indicates the sectoral Armington function share parameter

Lastly, the import demand function which depends on relative price (P^d/P^m) can be expressed as follows:

$$M_i = D_i \left[\frac{P_i^d . \delta_i}{P_i^m (1-\delta_i)} \right]^{1/1+\rho_i^C} \quad (16)$$

Domestic institution block: This block consists of equations that map the flow of income from value added to institutions and ultimately to households. These equations fill out the inter-institutional entries in the SAM.

First is the factor income equation Y_f^F defined as:

$$Y_f^F = \sum_i WF_f \cdot FDSC_{if} \cdot wfdist_{if} \quad (17)$$

Where:
$FDSC_{if}$ = The sectoral capital stock
$wfdist_{if}$ = Represents sector-specific distortion in factor markets and
WF_f = Represents average rental or wage

Factor income is in turn divided between capital and labor. The household factor income from capital can be defined as follows:

$$Y_{capeh}^H = Y_1^F - DEPREC \quad (18)$$

Where:
Y_{capeh}^H = The household income from capital
Y_1^F = Represents capital factor income and
$DEPREC$ = Capital depreciations

Similarly household labor income Y_{labeh}^H is defined as:

$$Y_{labeh}^H = \sum_{f \neq 1} Y_f^F \quad (19)$$

where, Y_f^F is the factor income. Tariff equation TARIFF is expressed as follows:

$$TARIFF = \sum_i pwm_i \cdot M_i \cdot tm_i \cdot ER \quad (20)$$

Similarly, the indirect tax INDTAX is defined as:

$$INDTAX = \sum_i PX_i \cdot X_i \cdot tx_i \quad (21)$$

Likewise, household income tax is expressed as:

$$HHTAX = \sum_h Y_h^H \cdot t_h^H \quad (h = cap, lab) \quad (22)$$

Where:
Y_h^H = Households income
t_h^H = Represents household income tax rate

Export subsidy FXPSUB (negative of export revenue) is be expressed as:

$$EXPSUB = \sum_i pwe_i \cdot E_i \cdot te_i \cdot ER \quad (23)$$

Total Government Revenue (GR) is obtained as the sum up the previous four equations. That is: (The sign for EXSUB depends on the economic policy on whether the government is receiving export tax revenue or giving export subsidies):

$$GR=TARIFF+INTAX+HHTAX+EXPSUB \quad (24)$$

Depreciation (DEPREC) is a function of capital stock and is defined as:

$$DEPREC = \sum_i depr_i \cdot PK_i \cdot FDSC_i \quad (25)$$

where, $depr_i$ represents the sectoral depreciation rates

Household savings (HHSAV) is a function of marginal propensity to save (mps_h) and income. It is expressed as:

$$HHSAV = \sum_h Y_h^H \cdot (1 - t_h^H) \cdot mps_h \quad (26)$$

Government Savings (GOVSAV) is a function of GR and final demand for government consumptions (GD_i). That is:

$$GOVSAV = GR - \sum_i P_i.GD_i \quad (27)$$

Lastly, the components of total savings include financial depreciation, household savings, government savings and foreign savings in domestic currency (FSAV·ER):

$$SAVING = HHSAV+GOVSAV+DEPREP+FSAVER \quad (28)$$

The following equations (29-36) provide equations map that complete the circular flow in the economy and determining the demand for goods by various actors. First, the private consumption (CD) is obtained by the following assignments:

$$CD_i = \sum_h \left[\beta_{ih}^H \cdot Y_h^H (1 - mps_h)(1 - t_h^H) \right] / P_i \quad (29)$$

where, β_{ih}^H is the sectoral household consumption expenditure shares.

Likewise, the government demand for final goods (GD) is defined using fixed shares of aggregate real spending on goods and services (gdtot) as follows:

$$GD_i = \beta_i^G \cdot gdtot \quad (30)$$

where, β_i^G is the sectoral government expenditure shares

Inventory demand (DST) or change in stock is determined using the following equation:

$$DST_i = dstr_i X_i \quad (31)$$

where, $dstr_i$ is the sectoral production shares.

Aggregate nominal fixed investment (FXDINV) is express as the difference between total investment (INVEST) and inventory accumulation. That is:

$$FXDINV = INVEST - \sum_i P_i.DST_i \quad (32)$$

The sector of destination (DK) is calculated from aggregated fixed investment and fixed nominal shares ($kshr_i$) using the following function:

$$DK_i = kshr_i FXDINV/PK_i \quad (33)$$

The next equation translates investment by sector of destination into demand for capital goods by sector of origin (ID_i) using the capital composition matrix (b_{ij}) as follows:

$$ID_i = \sum_j b_{ij}.DK_j \quad (34)$$

The last two Eq. 35-36 show the nominal and real GDP, which are used to calculate the GDP deflator used as numeraire in the price equations. Real GDP (RGDP) is defined from the expenditure side and nominal GDP (GDPVA) is generated from value added side as follows:

$$GDPVA = \sum_i PV_i.X_i + INDTAX + TARIFF + EXPSUB \quad (35)$$

$$RGDP = \sum_i \left(CD_i + GD_i + ID_i + DST_i + E_i - pwm_i \cdot M_i \cdot ER \right) \quad (36)$$

Systems constraints block: This block defines the constraints that are must be satisfied by the economy as a whole. The model's micro constraints apply to individual factor and commodity markets. With few exceptions, in the labor, export and import markets, it is assumed that flexible prices clear the markets for all commodities and factors. The macro constraints apply to the government, the savings-investment balance and the rest of the world. For the government, savings clear the balance, whereas the investment value adjusts to changes in the value of total savings.

Product market equilibrium condition requires that total demand for composite goods (Q_i) is equal to its total supply as follows:

$$Qi = INi+CDi+GDi+IDi+DSTi \quad (37)$$

Market clearing requires that total factor demand equal total factor supply (fs_f) and the equilibrating variables are the average factor prices which were defined earlier and this condition can be expressed as follows:

$$\sum_i FDSC_{if} = fs_f \quad (38)$$

The following equation is the balance of payments represents the simplest form: Foreign savings (FSAV) is the difference between total imports and total exports. As foreign savings set exogenously, the equilibrating variable for this equation is the Exchange Rate (ER*)*. Equilibrium will be achieved through movements in ER that effect export import price. This balancing equation can be expressed as:

$$pwm_i M_i = pwe_i E_i + FSAV \quad (39)$$

Lastly the macro-closure rule is given as:

$$SAVING = INVEST \quad (40)$$

where, total investment adjusts to equilibrate with total savings to bring the economy into the equilibrium.

Carbon emission block: The aggregate CO_2 emission is formulated as follows:

$$TQ_{CO_2} = \varphi_i^{coal} X_i^{coal} + \varphi_i^{oil} X_i^{oil} + \varphi_i^{gas} X_i^{gas} \quad \text{or} \quad TQ_{CO_2} = \sum_i \varphi_i^k X_i^k \quad (41)$$

where, φ_i^k is carbon emission factors of k (coal, oil and gas) by sector and:

$$TQ_{CO_2} - \overline{TQ}_{CO_2} \le 0 \quad (42)$$

Where:
TQ_{CO_2} = The total CO_2 emission
$\overline{TQ}_{CO_2}$ = The carbon emission limit

Total carbon tax revenue (T_{CO_2}) is given by the following equation:

$$T_{CO_2} = \sum_i t_i^d \cdot PD_i \cdot D_i + \sum_i t_i^m \cdot PM_i \cdot M_i \quad (43)$$

Where:
t_i^d = The carbon tax of domestic product by sector
t_i^m = The carbon tax of imported product by sector

These rates are in tern determined as follows:

$$t_i^d = P_{CO_2} \psi_i^d \omega_i^d \quad (44)$$

$$t_i^m = P_{CO_2} \psi_i^m \omega_i^m \quad (45)$$

Where:
ψ_i^d = The carbon emission coefficients per unit of (domestic) fuel use by sector
ω_i^d = A fossil fuel coefficients per unit of domestic goods by sector
ψ_i^m = The carbon emission coefficients per unit of (import) fuel use by sector
ω_i^m = The fossil fuel coefficients per unit of import goods by sector
P_{CO_2} = Indicates price of carbon emission

RESULTS

Results: The scenario (simulation) carried out is based on year 2000 SAM of the Malaysian economy where the production sectors have been aggregated to 10 sectors. The scenario details are shown in Table 3.

Scenario 1 represents the virtual carbon tax policy impacts. This scenario is carried out in three versions (1a, b and c) where an exogenously determined carbon tax was imposed on domestic economy. Implementation of this scenario would allow us to see the possible reduction in CO_2 emissions and its impact on various economic variables such as domestic production, exports, imports, private consumption, gross investment, government revenues, GDP, as well as other incomes, revenues and savings variables.

Table 3: Scenario codes and definition of the simulations

	Scenario codes	Simulation specifications
	Scenario 1a	Imposition of carbon tax of domestic product by sector
Scenario 1	Scenario 1b	2 times increase in carbon tax of domestic product by sector
	Scenario 1c	3 times increase in carbon tax of domestic product by sector

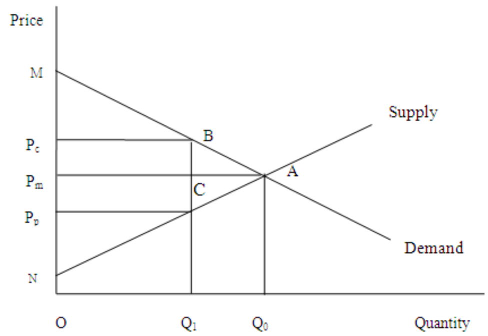

Fig. 2: Effects of a carbon tax

Table 4: Impact of carbon tax imposition on the Malaysian economy

Sectors	Baseline (100 million RM)	Percentage change from the baseline Scen 1a	Scen 1b	Scen 1c
Carbon dioxide emission*	125.548	-1.212	-2.347	-3.401
Domestic production	8967.691	-1.213	-2.346	-3.400
Exports	4478.429	-2.079	-3.972	-5.707
Value added	3470.867	-2.393	-3.470	-4.736
Household consumption	1175.744	-2.316	-4.836	-7.477
Real GDP	3499.192	-0.817	-1.898	-3.166
Nominal GDP (nGDP)	3500.216	-0.817	-1.898	-3.167
Government revenue	356.898	26.668	53.072	79.281
Investment	968.273	0.555	0.278	-0.624
Fixed capital investment	706.323	0.430	-0.255	-1.788
Tariff	40.370	-2.175	-4.164	-5.992
Export tax	11.028	-2.503	-4.824	-6.955
Enterprise tax	204.856	-1.299	-2.924	-4.796
Household tax	67.843	-1.013	-2.357	-3.938
Enterprise savings	1162.722	-1.299	-2.924	-4.796
Household savings	303.704	-1.012	-2.357	-3.938
HH consumption share of nGDP**	33.078	-0.193	-0.466	-0.795
Investment share of nGDP**	27.62	1.385	-2.220	-2.625

*: Million tones; **: Percent

This study finds that the imposition of carbon tax on domestic production sectors reduce the carbon emissions (first row of Table 4). Simulations 1a, b and c indicate that imposition of carbon tax result in lower carbon emissions, domestic production, exports, value-added, household consumption, real and nominal GDP, tariff revenue, export tax revenue, enterprise tax revenue, household tax revenue, enterprise savings and household savings (Table 4). In contrast the government revenue is positive in all versions of scenario 1 and investment share of nominal GDP is positive (1.39%) in version a of scenario 1 but negative in version b (2.22%) and version c (2.63%) from the base level. However, investment and fixed capital investment are higher than the baseline level at low level of carbon tax (scenarios 1a) but is lower than the baseline as the carbon tax becomes higher (scenario 1c).

More specifically, imposition of successively higher carbon tax result in 1.21, 2.35 and 3.40% reduction in carbon emissions. However, these reductions are also accompanied by 0.82, 1.90 and 3.17% decrease in nominal and real GDP. Exports decreased by 2.08, 3.97 and 5.71% while value-added decreased by 2.39, 3.97 and 4.74%, respectively. Enterprise savings is lower from the baseline by 1.30, 2.92 and 4.80% respectively. However, government revenue increased from the baseline by 26.67, 53.07 and 79.28% respectively. On the other hand, investment and fixed capital investment increased in scenario 1a by 0.56 and 0.43% respectively and fixed capital investment decreased in scenarios 1b and 1c by 0.26 and 1.79% respectively from the baseline (Table 4).

Carbon tax lowers household consumption and savings. Specifically, the simulation results show that for each of the three successively larger carbon tax, household consumptions decreased by 2.32, 4.84 and 7.48% from the baseline, respectively. Household savings decreased by smaller percentages, i.e., 1.01, 2.36 and 3.94% respectively for shown in Table 4. For the respective sub-scenarios, household consumption share of nominal GDP decline by 0.19, 0.47 and 0.80%.

DISCUSSION

Uncertainties regarding the economic benefit of limiting carbon emissions breed hesitation. In particular, changes in economic activity due to carbon tax lead to significant changes in factor prices, factors of production, consumption pattern, terms of trade and consequently, consumer welfare and gross domestic product. It follows that policy makers would seek to determine how to minimize dampen to the economy while pursuing environmentally sound objectives. Figure 2 shows the outcome of imposing a unit carbon tax. Consider the supply and demand of a good where an equilibrium (partial) level prior to tax is point A.

The quantity produced and consumed is Q_0 and the relevant price is P_m. Total surplus is given by the area MNA. When a unit carbon tax is imposed, the new equilibrium will be B where only Q_1 units will be consumed at price P_c. (It is assumed that emission is linear function of outputs throughout this study) Total surplus is reduced; the consumer surplus is now MBP_c and the producer surplus is now CP_PN and the government collects revenues represented by the area P_cP_PCB.

To capture the economy-wide effects of an artificial environmental tax policy, a unit carbon tax is imposed on the model where the unit of carbon tax is calculated by multiplying the exogenous carbon tax with the carbon content per unit domestic production. Changes in CO_2 emission is given by the difference between the baseline value and the simulated value. Table 4 shows the impact of carbon tax on carbon emissions and effects on macroeconomic variables. It should be noted that the effects of the carbon tax presented are for the short run. Generally substitution will occur in the long run thus resulting in changes in energy structure and resources will shift from energy intensive industries to less energy intensive industries.

CONCLUSION

Having developed a CGE model, three policy simulations were carried out to see the economic and environmental impact in the Malaysian economy. The simulation finds that 1.21% reductions of carbon emissions via carbon tax reduce the nominal GDP by 0.82%, domestic production by 1.21%, exports by 2.08%, enterprise savings by 1.30%, household consumptions by 2.32%, household savings by 1.01% and household consumption share of nominal GDP by 0.19%. However, the government revenue increases by 26.67% and fixed capital investment increases by 0.43%. Likewise, 2.35% reductions of carbon emissions via carbon tax reduce the nominal GDP by 1.90%, domestic production by 2.35%, exports by 3.97%, value added by 3.47%, enterprise savings by 2.92%, fixed capital investment by 0.25%, household savings by 2.36% and household consumption share of nominal GDP by 0.47% however, government revenue increases by 53.07%. Lastly 3.40% reductions of carbon emissions via carbon tax reduce the nominal GDP by 3.17%, domestic production by 3.40%, exports by 5.71%, value added by 4.74%, enterprise savings by 4.80%, household consumptions by 7.48% and household savings by 3.94% from the baseline.

Policy recommendations for reducing carbon emission: There are several ways of minimizing the negative effects of carbon emissions have been proposed by various researchers. These include: carbon taxation, energy taxation, tradable emission permits and regulations. Malaysia has experienced all policies like implemented energy taxation, tradable emission permits and environmental regulations except carbon taxation. Therefore, this study focuses on carbon taxation as an instrument for controlling the level of emissions. In practice, various tax schemes have been used in different countries in dealing with pollution problems, among others, includes i.e. taxing emissions, taxing inputs that cause pollution, taxing output of goods generating emissions; and providing subsidies for abatement activities. Specifically this study sought to investigate the taxing of output of goods that generate emissions on domestic production in the Malaysian economy (Generally, the emissions of pollutants such as carbon dioxide emission generally are not measured directly and in many cases direct measurement is quite difficult. Instead the emissions are estimated on the assumption that they are proportional to the use of various types of fossil fuels in the production process. This assumption implies that emission reductions can be brought about only by reductions of the consumption of fossil fuels or by changes in the composition of fossil fuel consumption in the domestic production).

According to our model results, in the year 2000 total carbon emissions of Malaysia were 125.6 million tones[22]. The model results illustrate that a larger cut in carbon emissions requires a higher carbon tax. Moreover an increasing carbon tax decreases GDP at an increasing rate. Different degrees of carbon tax increase the welfare losses in terms of losses of household consumption, household savings, enterprise consumption and enterprise savings and eventually total economic savings. The investment losses in the economy tend to rise more sharply as the degree of emission reduction increases (The carbon tax also falls of domestic production, exports, value-added, real GDP, tariff revenue, export tax revenue, enterprise tax, household tax and enterprise savings). The aggregate production tends to decrease at a proportional rate as the carbon emissions target becomes more stringent (drop by more than 3.4%, in scenario 1c) and the changes in gross production quite significant. Considering higher carbon tax policy such as version b and c of scenario 1, the simulation illustrates that the macroeconomic impacts could be strongly negative. Higher reductions of pollution emission such as a 2.35% of carbon emissions (scenario 1b) reduce the nominal GDP by 1.90%, domestic production by 2.35%, exports by 3.97%, fixed capital investment by 0.25%, household savings by 2.36% and enterprise savings by 2.92%. And, more reductions of pollution emission such as a 3.40% reduction of carbon emissions (scenario 1c) reduce the nominal GDP by 3.17%, domestic production by 3.40%, exports by 5.71%, household consumptions by 7.48%, household savings by 3.94% and enterprise savings by 4.80%. Therefore, policy-makers could consider first carbon tax policy (scenario 1a). Initial carbon tax reforms (1% CO_2 reduction) results in decrease real GDP 0.82%, however it increases fixed capital investment by 0.43% and investment share of nominal GDP by 1.39% and government revenue by 26.66%. And, revenues from the carbon tax can be used for the following purposes: (1) The revenue can be used to offset the negative effect on consumption welfare levels; (2) They can be financed to adoption of technological change in the long run. This policy results in achieving reasonably good environmental impacts without losing the investment, fixed capital investment, investment share of nominal GDP and government revenue.

There is another way to substitute energy use coupe with economic growth. Government policy that promote economic growth relying on heavy use of fossil fuels need to be replaced due to their fiscal, efficiency and environmental effects. Correct pricing on energy, by reducing generalized subsidies may be one good alternative policy to promote energy-saving technological change and mitigate carbon pollutions. Malaysia has decided on the environmental actions that take to mitigate climate change (effects of carbon emissions) and relate them to the use of policy instruments. This research suggests that an initial carbon tax can be applied for the central purpose of reducing the rate of growth of carbon emissions. Even in the absence of technological change on the Malaysian economy a carbon tax induces general equilibrium effects that offset the further negative effects on the economy. Our findings provide several suggestions and message to policy makers, who are considering carbon taxation policy together with economic development. This study serves as a guide to selection of more feasible and appealing environmental policies, the responses of the Malaysian economy to each policy changes and the relative merits of the range of policies that might be considered for reducing emissions.

REFERENCES

1. Levinson, A. and M. Taylor, 2004. Trade and Environment: Unmasking the pollution Haven Effect. NBER working paper no. W10629: 1-44. http://ssrn.com/abstract=565828
2. Matthew, A. and E. Robert, 2005. FDI and the capital intensity of dirty sectors: A missing piece of the pollution haven puzzle. Rev. Develop. Econ., 9: 530-548. DOI: 10.1111/j.1467-9361.2005.00292.x
3. Bullard, C. and R. Herendeen, 1975. The energy cost of goods and services. Energ. Policy, 3: 268-278. http://ideas.repec.org/a/eee/enepol/v3y1975i4p268-278.html
4. Herendeen, R. and C. Bullard, 1976. US energy balance of trade. Energ. Syst. Policy, 1: 383-390. http://www.osti.gov/energycitations/product.biblio.jsp?osti_id=7249357
5. Herendeen, R., 1978. Energy balance of trade in Norway. Energ. Syst. Pol., 2: 425-432. http://www.osti.gov/energycitations/product.biblio.jsp?osti_id=6178408
6. Stephenson, J. and G. Saha, 1980. Energy balance of trade in New Zealand. Energ. Syst. Policy, 4: 317-326. DOI: 10.1002/er.4440040408
7. Strout, A., 1985. Energy-intensive materials and the developing countries. Mater. Soc., 9: 281-330. http://www.osti.gov/energycitations/product.biblio.jsp?osti_id=5492809
8. Han, X. and T. Lakshmanan, 1994. Changes in the energy cost of goods and services of the Japanese economy. Ann. Reginal. Sci., 29: 277-302. DOI: 10.1007/BF01581781
9. Ferraz, Y., 1999. Trade Liberalization and Industrial Pollution in Brazil. United Nations Publications, Santiago, Chile. http://www.eclac.org/publicaciones/xml/3/4353/lcl1332i.pdf
10. Wier, M., 1998. Sources of changes in emissions from energy: A structural decomposition analysis. Econ. Syst. Res., 10: 99-112. DOI: 10.1080/09535319808565469
11. Antweiler, W., R. Copeland and M. Scott, 2001. Is free trade good for the environment? Am. Econ. Rev., 91: 877-908. http://www.e-aer.org/archive/9104/91040877.pdf
12. Munksgaard, J. and A. Pedersen, 2001. CO_2 Accounts for Open economies: Producer or consumer responsibility? Energ. Policy, 29: 327-335. DOI: 10.1016/S0301-4215(00)00120-8
13. Kakali, M. and C. Debesh, 2005. Is liberalization of trade good for the environment? Evidence from India. Asia Pacific Develop. J., 12: 109-136. http://www.unescap.org/pdd/publications/apdj_12 1/5_kakali.pdf
14. Al-Amin, A., S. Chamhuri, H. Abdul and H. Nurul, 2008. Globalization and environmental degradation: Bangladeshi thinking as a developing nation by 2015. IRBRP., 3: 381-395. http://www.bizresearchpapers.com/30-Al-Amin.pdf
15. Government of Malaysia, 2006. 9th Malaysia Plan, 2006-2010. Economic Planning Unit, Prime Minister's Department, Malaysia. http://www.epu.gov.my/rm9/english/Index.pdf
16. Government of Malaysia, 2001. Environmental Quality Report-2000. Ministry of Science Technology and the Environment, Malaysia, pp: 25-47.
17. Dervis, K., J. De Melo and S. Robinson, 1982. General Equilibrium Models for Development Policy. Cambridge University Press, Cambridge, ISBN: 0521270308, pp: 526.

18. Robinson, S., A. Yunez, R. Hinojosa, J. Lewis and S. Devarjan, 1999. From stylized to applied models: Building multisector CGE models for policy analysis. North Am. J. Econ. Financ., 10: 5-38. DOI: 10.1016/S1062-9408(99)00014-5
19. Government of Malaysia, 1999. Economic Report, Various Issues. Ministry of Finance, Department of Statistics, Malaysia, pp: 12-27.
20. Government of Malaysia, 2003. National Energy Balance of 2000. Ministry of Energy, Communication and Multimedia, Malaysia, pp: 1-47.
21. Perroni, C. and R. Wigle, 1994. International trade and environmental quality: How important the linkages? Can. J. Econ., 27: 551-67. http://www.jstor.org/stable/pdfplus/135783.pdf
22. Earth Trends, 2003. World Resource Institute. Washington DC., USA., pp: 1-4.