A COMPUTABLE GENERAL EQUILIBRIUM APPROACH TO TRADE AND ENVIRONMENTAL MODELLING IN THE MALAYSIAN ECONOMY

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Abstract

Environmental pollution is now a serious problem in many developing countries. One approach to mitigate the problem is to implement various pollution control policies. However, due to a lack of adequate quantitative models, the economic impacts and effectiveness of many pollution control policies are still unknown. Therefore, there is a greater need to know whether economic liberalization, trade, environment and social welfare can be joined in one direction under environmental taxation and policies. Empirical studies for developed countries reveal that imposition of a carbon tax would decrease CO_2 emissions significantly and might 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. Studying the potential economic impact of emission control policies is very important because inappropriate policies that reduce carbon emission may at the same time reduce highly economic growth. It is thus important to find the correct pollution tax that could be imposed such that environmental pollution is reduced at the same time does not dampen economic growth. The method developed for this study is applied computable general equilibrium model (MYCGE) for imposing environmental taxation policies in the Malaysian economy. Three simulations were carried out using a Malaysian Social Accounting Matrix. The first simulation is related to the trade based and the last two are carbon based simulations. The model results indicate that further trade liberalization is not sensitive in the Malaysian economy. Particularly, the reasons could be attributed to the fact that Malaysian export duty is already low and Malaysian trade policy already highly liberalized. The carbon tax policy illustrates that a 1.21 percent reduction of carbon emission (via carbon tax) reduces the nominal GDP by 0.82 percent and exports by 2.08 percent; a 2.34 percent reduction of carbon emission reduces the nominal GDP by 1.90 percent and exports by 3.97 percent and a 3.40 percent reduction of carbon emission reduces the nominal GDP by 3.17 percent and exports by 5.707 percent.

Keywords: Trade, Air Emission, Environmental General Equilibrium, Malaysian Economy

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1. Introduction

Interest in trade liberalization has been growing during the last two decade. This is in part driven by the postulate that international trade will lead to economic growth and development. Statistics show that from 1990 to 2005 imports and exports of commodities increased from 20% to 30% share of worldwide GDP (Al-Amin & Chamhuri Siwar, 2006). However, production and consumption generates environmental damages, either in the form of air and water pollution or depletion of natural resources (Copeland & Taylor 2003). Further, recent emergence of global environmental issues such as climate change, global warming, ozone depletion and acid rain, the assertion that free trade leads to welfare maximization becomes questionable.

At the same time, there has been growing concern among environmentalists and economists over the linkage between trade liberalization and the environment. Higher awareness has led to greater scrutiny being placed on trade policies in order to assess the long-term negative effects of further economic liberalizations on the environment and its sustainability (Xing & Kostland 2000; Antweiler et al. 2001; Levinson & Taylor 2004; Cole & Elliot 2003, 2005). Some studies that have addressed the role of international trade and how trade growth affects the environment are Wright (1974); Bullard and Herendeen (1975); Herendeen and Bullard (1976); Herendeen (1978); Stephenson and Saha (1980); Strout (1985); Han and Lakshmanan (1994); Wyckoff and Roop (1994); Ferraz and Young (1999); Lenzen (1998); Wier (1998); Antweiler et al. (2001); Machado et al. (2001); Munksgaard and Pedersen (2001); Dietzenbacher and Kakali (2004); Kakali and Debesh (2005); Al-Amin et al. (2008). The methodologies employed in these studies are varied, however results of most of these studies indicate that trade liberalization harms the environment unless appropriate environmentally friendly trade policy is put in place. Although a number of previous studies have given a detailed evaluation of trade 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.

Malaysia has been experiencing strong economic growth over the last three decades.[2] The main engine of growth is its export-oriented manufacturing sector. Electronics, crude petroleum, palm oil and processed timber are currently the major foreign exchange earners. 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. Consequent to this, manufacturing share of GDP has increased from 26.9% in 1990 to 58.8% in 1997; and manufacturing share of total export increased from 58.8% in 1990 to 81.0% in 1997 (see Figure 1). Malaysia's total trade expanded by 19.1% per annum during the 7th plan period (1996-2000), 12.6% during the 8th plan period (2001-2005), and is projected to grow at 7.2% during the 9th plan period (2006-2010).[3] ASEAN countries, Japan, the US, and the EU are major

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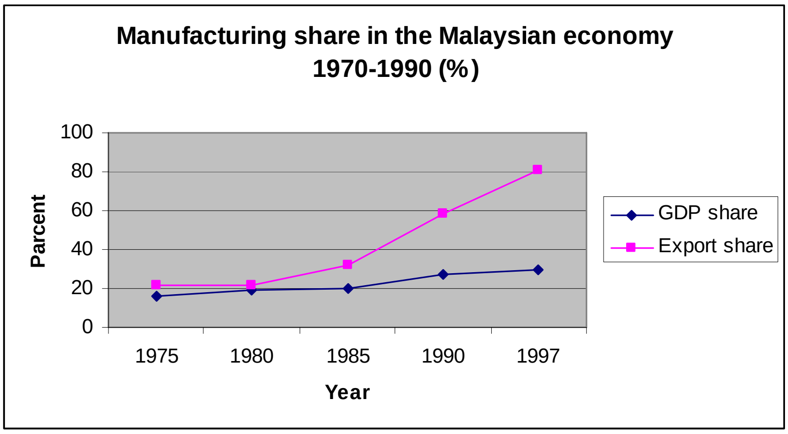
[2] Exception was during the Asian financial crisis from 1997 to 2000.

[3] Beginning 1965, Malaysia's overall development goals and broad development strategies are stated in series of 5-year plan books known as The Malaysia Plan. The 1st Malaysia Plan started in 1965. The latest of the sequence is the 9th Malaysia Plan (2006-2010).

trading partners of Malaysia accounting for about 75% of total exports. Total trade almost doubled from RM379.3billion in 1995 to RM685.7 billion in 2000. Trade with Australia, other Southeast Asian countries, and South Asia also increased, reflecting efforts by the Government to diversify its markets.

Malaysia's total trade with Southern countries expanded by 18.7% between the period from 1990 to 2005. Total trade increased from RM79.64 billion in 1990 to RM373.27 billion in 2000 and RM533.79 billion in 2005.[4] Foreign trade is a major factor in shaping the structure of Malaysian economy (see Table 1). Consequently, trade has a significant effects the countries' energy use and various air emissions (Al-Amin et al. 2007). Therefore, one key question arises: Is there any trade-offs between energy use, air pollution emissions, and economic growth in the Malaysian economy? This study is an attempt to answer the question via an environmental extended computable general equilibrium model. Empirical studies on developed countries have revealed that imposition of carbon tax would significantly decrease CO_2 emissions but not necessarily reduce economic growth (Babiker et al. 1997, Beghin et al. 2001, Li 2005). For developing countries such as Malaysia, the relationship is quite uncertain. Does economic liberalization increase pollution emission? If economic growth of Malaysia is export-led, what are the consequences on the economy of carbon tax on production? If there is pollution rise as a result of economic liberalization and if government imposed environmental tax (carbon tax), then what would be social impact? That is, what would happen to GDP, private consumption, public consumption, investment demand, and exports and imports? In other words, this study attempts to determine the outcome of imposing carbon tax to wrest air pollution while pursuing deeper liberalization in a small open economy; in particular Malaysia. To answer the questions posed in the paragraph above, a computable general equilibrium model for Malaysia is developed. Several scenarios are then simulated.

Figure1 Manufacturing share in the Malaysian economy, 1970-97



Source: Department of Statistics 1999, Malaysia

[4] Cited from the 9th Malaysia Plan.

The paper is organized as follows. In the next section, we present the underlying model, which is based on the extended environmental CGE techniques. Simulation results are presented in Section 3. Discussions on policy recommendations are given in Section 4. Appendix A is a presentation of the Malaysian computable general equilibrium model in complete equation form.

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

	RM million						% of Total					
	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[5]	-	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	-	-

Sources: 8th and 9th Malaysia Plan, Department of Statistics, Malaysia

[5] Selected North East Asian Countries

2. Methodology

A static computable general equilibrium (CGE) model of the Malaysian economy is constructed for this study.[6] The model consists of ten industries, one representative household, three factor production, 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. The benchmark model representing the baseline economy is constructed using a Social Accounting Matrix (SAM).[7] A SAM is a snapshot of the economy and it reflects the monetary flow arising from interactions among institutions in the Malaysian economy. The Malaysian year 2000 SAM is shown in Table 2.

The Malaysian CGE model is presented in this section. The model is comprised of a set of non-linear simultaneous equations and follows closely the specifications in Dervis et al (1982) and Robinson et al (1999) with minor modifications in terms of functional form in the production technology to allow for pollution emission estimation in the emission block; where the number of equations is equal to the number of endogenous variables. The equations are classified in four blocks, i.e., (i) the price block, (ii) the production block, (iii) the institutions block, and (iv) the system constraints block.

2.1 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:

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

Import price

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

$$PM_i = pwm_i(1+tm_i)\cdot ER \tag{2}$$

where tm_i is import tariff and pwm_i is the world price of imported goods by sector.

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[6] Compared with other modeling techniques, such as the input–output approach or linear programming, the CGE approach has appealing features for modeling environmental policy analysis. This modeling approach can consider simultaneously environmental policy analysis and welfare effects of trade and trade policies. A prominent advantage of CGE models lies in the possibility of combining detailed and consistent real-world database (Social Accounting Matrix) of trade and environment with a theoretically and empirically sound framework (Perroni & Wigle, 1994).

[7] SAM matrix is estimated by the Authors using the Malaysian 2000 input-output table and national accounts Malaysia 2000.

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

			1	24		3			4	5	
Incomes			Commodities /activities (1..94)	Factors		Institutions			Capital account	Rest of the world	Total
				Labor	Capital	Household	Firms	Government			
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 expenditure 158,699,045	Government expenditures 50,692,013	Total investment 168,277,875	Foreign exchange earnings 427,424,161	2,203,208,571

Source: Authors’ calculations

Export price

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

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

where te_i export tax by sector and pwe_i is 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:

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

where D_i and M_i are the quantity of domestic and imported goods respectively; and PD_i is the price of domestically produced goods sold in the domestic market, PM_i is 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:

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

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:

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

where tx_i is tax per activity and IN_i stands for total intermediate input, PK_i stands for composite intermediate input price and 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.

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

where a_{ij} is the input-output coefficient.

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:

$$PP = \frac{GDPVA}{RGDP} \tag{8}$$

where *PP* is GDP deflator, *GDPVA* is the GDP at value added price, and *RGDP* is the real GDP.

2.2 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 define 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:[8]

$$X_i = a_i^D \prod_f FDSC_{if}^{\alpha_{if}} \tag{9}$$

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:

$$WF_f .wfdist_{if} = PV_i .\alpha_{if} \frac{X_i}{FDSC_{if}} \tag{10}$$

where $wfdist_{if}$ represents sector- specific distortions in factor markets, WF_f indicates average rental or wage; and α_{if} indicates factor share parameter of production function.

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

$$IN_i = \sum_j a_{ij} \cdot X_j \tag{11}$$

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

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

[8] 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.

where a_i^T is the CET function shift parameter by sector, γ_i holds the sectoral share parameter, E_i is the export demand by sector and ρ_i^T is 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:

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

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

$$E_i = econ_i \left[pwe_i \Big/ pwse_i \right]^{\eta_i} \tag{14}$$

where $pwse_i$ represents the sectoral world price of export substitutes and η_i is the CET function exponent by sector.

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

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

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:

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

2.3 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:

$$Y_f^F = \sum_i WF_f \cdot FDSC_{if} \cdot wfdist_{if} \tag{17}$$

where $FDSC_{if}$ is 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:

$$Y^H_{capeh} = Y^F_1 - DEPREC \tag{18}$$

where Y^H_{capeh} is the household income from capital, Y^F_1 represents capital factor income and *DEPREC* is capital depreciations.

Similarly household labor income Y^H_{labeh} is defined as:

$$Y^H_{labeh} = \sum_{f \neq 1} Y^F_f \tag{19}$$

where Y^F_f is the factor incomes.

Tariff equation *TARIFF* is expressed as follows:

$$TARIFF = \sum_i pwm_i \cdot M_i \cdot tm_i \cdot ER \tag{20}$$

Similarly, the indirect tax *INDTAX* is defined as:

$$INDTAX = \sum_i PX_i \cdot X_i \cdot tx_i \tag{21}$$

Likewise, household income tax is expressed as:

$$HHTAX = \sum_h Y^H_h \cdot t^H_h \qquad (h = cap, lab) \tag{22}$$

where Y^H_h is households income, t^H_h represents household income tax rate

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

$$EXPSUB = \sum_i pwe_i \cdot E_i \cdot te_i \cdot ER \tag{23}$$

Total government revenue (*GR*) is obtained as the sum up the previous four equations. That is:

$$GR = TARIFF + INDTAX + HHTAX + EXPSUB \qquad (24)$$ [9]

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

$$DEPREC = \sum_i depr_i \cdot PK_i \cdot FDSC_i \tag{25}$$

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:

$$HHSAV = \sum_h Y^H_h \cdot (1 - t^H_h) \cdot mps_h \tag{26}$$

[9] The sign for *EXSUB* depends on the economic policy on whether the government is receiving export tax revenue or giving export subsidies.

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

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

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

$$SAVING = HHSAV + GOVSAV + DEPREP + FSAV.ER \qquad (28)$$

The following section provides equations 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:

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

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:

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

where β_i^G is the sectoral government expenditures.

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

$$DST_i = dstr_i . X_i \qquad (31)$$

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:

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

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

$$DK_i = kshr_i . FXDINV / PK_i \qquad (33)$$

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:

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

The last two equations of this section 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:

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

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

2.4 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:

$$Q_i = IN_i + CD_i + GD_i + ID_i + DST_i \quad (37)$$

Market clearing requires that total factor demand equal total factor supply 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:

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

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.

2.5 Carbon emission

The aggregate CO_2 emission is formulated as follows:

$$TQ_{CO_2} = \varphi_{coal} X_{coal} + \varphi_{oil} X_{oil} + \varphi_{gas} X_{gas} \quad \text{or} \quad TQ_{CO_2} = \sum_i \varphi_i \mathrm{X}_i \quad (41)$$

and

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

where TQ_{CO_2} is the total CO_2 emission and $\overline{TQ}_{CO_2}$ is 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 is the carbon tax of domestic product by sector and t_i^m is 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 is the carbon emission coefficient per unit of (domestic) fuel use by sector, ω_i^d is a fossil fuel coefficient per unit of domestic goods by sector, ψ_i^m is the carbon emission coefficient per unit of (import) fuel use by sector, and ω_i^m is the fossil fuel coefficient per unit of import goods by sector and P_{CO_2} indicates price of carbon.

3. Results and discussion

This section presents results obtained from the different policy simulations carried out using CGE modeling. The simulations carried out are based on year 2000 SAM of the Malaysian economy where the production sectors have been aggregated to 10 sectors. The SAM matrix was assembled using national accounts data published by the Department of Statistics, Malaysia. The scenarios are listed in Table 3.

Scenario 1 represents the liberalization without carbon tax policy scenario. Simulation of this scenario is carried out in three versions (i.e., scenario 1 version a, scenario 1 version b, and scenario 1 version c) by increasing the degree of reduction of import tariff and export duty. Scenario 1 is carried out to see the macroeconomic impacts and environmental effects of trade liberalization. In scenario 1 version a and version b, a 50% and 75% reduction of import tariff and export duty, respectively, were imposed on the model. Full trade liberalization (zero tariffs and zero export duty) was imposed in scenario 1 version c. Results from these three versions of scenario 1 will show how much environmental impact would arise as a consequent of these trade policies as well as showing the possible losses in government revenues.

Scenario 2 represents the carbon tax policy impact scenario. As in scenario 1, this scenario is carried out in three versions where an exogenously determined carbon tax was imposed on domestic products. 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 1	Scenario 1a	50% cut in tariff and export tax
	Scenario 1b	75% cut in tariff and export tax
	Scenario 1c	100% cut in tariff and export tax
Scenario 2	Scenario 2a	Imposition of carbon tax of domestic product by sector
	Scenario 2b	2 times increase in carbon tax of domestic product by sector
	Scenario 2c	3 times increase in carbon tax of domestic product by sector
Scenario 3	Scenario 3a	Scenario 1a + Scenario 2a (1st trade liberalization + carbon tax policy)
	Scenario 3b	Scenario 1b + Scenario 2b (2nd trade liberalization + carbon tax policy)
	Scenario 3c	Scenario 1c + Scenario 2c (3rd trade liberalization + carbon tax policy)

Scenario 3 simulates the combine effect of trade liberalization and imposition of carbon tax on domestic output. Three version of this scenario were simulated where higher degree of liberalization was paired with imposition of higher carbon tax. This scenario is simulated see the impact of interaction of between liberalization and carbon tax on the environmental and macroeconomic variables in the Malaysian economy.

3.1 Reduction/elimination of import tariff and export duty

Import tariff and export duty are the most commonly used policy to regulate trade. Import tariff and export tax create a barrier between domestic and international market price. Generally the impositions (reduction) of tariff pushed the domestic price of imported products up (down) and thereby stimulate (dampen) the production of import-competing industries and depress (stimulate) demand for imports which are generally use as raw materials in some industries for their production process. The general idea is that if any country import more on finish product then CO_2 emission generally decrease, however if imported goods are used as raw materials or in the form of capital goods in the production of domestic goods then the reduction or elimination of tariff may raise emissions. On the other hand, reduction of export tax generally stimulates the exports as well as domestic productions. This in turn increases CO_2 emissions. The net result of simultaneous reduction of import tariffs and export duties depends on export-import elasticity and other macroeconomic behavior in the economy. The next section presents simulation results of tariff and export tax reduction on the Malaysian economy and the resulting CO_2 emissions due to the reduction or elimination of import tariff and export tax.

3.1.1 *Impacts on domestic output, trade, macro variables and pollution emission*

Table 4 presents the simulation results of simultaneous tariff and export tax reduction and elimination on domestic output.

Table 4 Impacts of tariff and export tax reduction or elimination on domestic output

Sectors	Baseline (100 million RM)	Percentage change from the baseline		
		Scenario 1a	Scenario 1b	Scenario 1c
Agriculture	375.523	0.275	0.389	0.552
Utility	438.138	0.250	0.352	0.501
Industry	4,953.847	0.547	0.773	1.097
Electricity and gas	173.448	0.297	0.421	0.598
Buildings and constructions	450.135	-1.458	-2.065	-2.925
Wholesale and retail trade	523.324	0.283	0.400	0.568
Hotels, restaurants & entertainment	210.296	0.150	0.214	0.302
Transport	519.999	0.196	0.277	0.392
Financial services & real estate	825.918	-0.342	-0.483	-0.686
Other services	497.063	-0.033	-0.047	-0.067

Source: Authors' simulations

The tariff and export tax reduction and elimination raised the level of domestic output in comparison to the base level in almost all sectors in scenario 1a, 1b and 1c. The results are conformable to economic theory.[10] Domestic output for scenarios 1a, 1b and 1c increased because major portions of Malaysian imports are in the form of capital goods used in domestic production sectors. National accounts for year 2000 also indicate that Malaysian total net imports were quite high and that comprised largely of capital goods as well FDI investment.

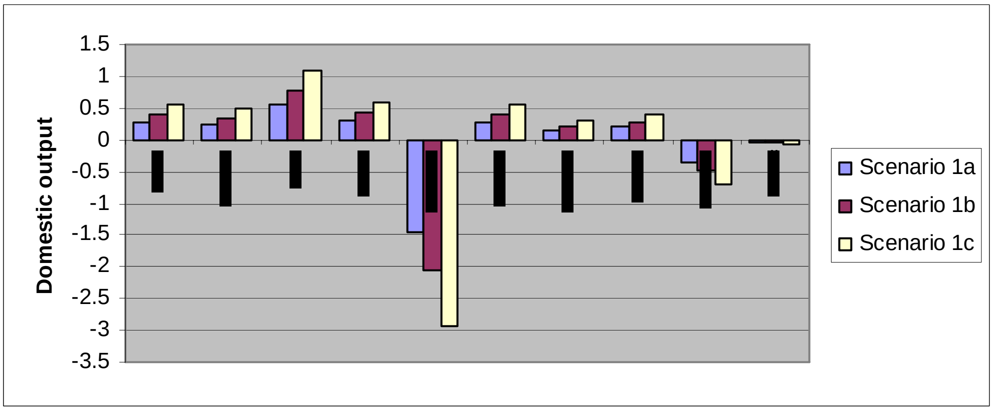

Figure 2 Impact of tariff and export reduction or elimination on domestic output (% change from baseline)

In scenarios 1a, 1b and 1c, total domestic output increased in almost all production sectors; except other services, implying that tariff reduction or elimination does not have any significant impact on this sector (last row of Table 4). As shown in Figure 2, the industrial sector has the highest increase from the baseline. For scenarios 1a, 1b and 1c, output increased by 0.55%, 0.77% and 1.10% respectively. The sector that has the least percentage increase is the hotel, restaurant and entertainment sector. For each of the version of the liberalization scenario, output increased from the baseline by 0.15%, 0.21% and 0.30% respectively. However, trade liberalization negatively affects the domestic output of building and construction, and financial

[10]The general idea is that if imported goods are used as intermediate inputs and capital goods then higher imports pushes the domestic production up.

service and real estate (Table 4). The vital reason is that these sectors are service related sectors and trade liberalization does not impact primarily on these sectors.

The effects of different degree of trade liberalizations on imports are shown in Table 5. The simulation results of scenario 1a, 1b, and 1c show that trade liberalization increased imports in seven of the ten sectors. These sectors are: agriculture (0.45%), industry (0.72%), electricity and gas (0.53%), wholesale and retail trade (0.40%), hotels restaurants and entertainment (0.21%), and transportation (0.24%).[11] At the same time trade liberalization decrease imports in the utility, building and construction, and financial services and real estate sectors. Impact on other services is negligible.

Table 5 Impacts of tariff and export tax reduction or elimination on imports

Sectors	Baseline (100 million RM)	Percentage change from the baseline		
		Scenario 1a	Scenario 1b	Scenario 1c
Agriculture	30.695	0.225	0.316	0.450
Utility	32.905	-0.173	-0.243	-0.340
Industry	2,385.795	0.356	0.504	0.716
Electricity and gas	19.729	0.264	0.375	0.532
Buildings and constructions	105.464	-1.497	-2.119	-3.001
Wholesale and retail trade	44.878	0.201	0.283	0.403
Hotels restaurants & entertainment	31.718	0.104	0.148	0.211
Transport	88.689	0.118	0.168	0.237
Financial services & real estate	51.380	-0.426	-0.601	-0.851
Other services	50.001	-0.034	-0.048	-0.068

Source: Authors' simulations

On the export side, reduction or elimination of tariff and export tax shows an increase almost all in sectors in all versions of this liberalization scenario (Table 6). This could be a justification for implementing further trade liberalization policy to expand growth. The effect on the industrial sector is substantial. Liberalization changes the domestic terms of trade in favor of exports, so more exported commodities are exported in Malaysia.

Table 6 Impact of tariff and export tax reduction or elimination on exports

Sectors	Baseline (100 million RM)	Percentage change from the baseline		
		Scenario 1a	Scenario 1b	Scenario 1c
Agriculture	53.345	0.276	0.392	0.555
Utility	269.269	0.277	0.391	0.556
Industry	3142.145	0.588	0.831	1.180
Electricity and gas	0.059	0.000	0.000	0.000
Buildings and constructions	14.607	-1.403	-1.985	-2.184
Wholesale and retail trade	106.871	0.324	0.458	0.650
Hotels restaurants & entertainment	0.000	--	--	--
Transport	214.791	0.209	0.296	0.417
Financial services & real estate	154.234	-0.301	-0.426	-0.605
Other services	15.253	-0.033	-0.046	-0.066

Source: Authors' simulations

[11] Percentages represent change in the full liberalization scenario.

As shown in Table 6, the total elimination of tariff and export tax increases exports of industrial output by 1.18% relative to baseline, wholesale and retail trade output by 0.65%, utility by 0.56%, agriculture by 0.56%. On the other hand, the building and construction sector decrease by 2.18% while the financial services and real estate sector decrease by 0.65%. Impact on other services is negligible.

In this study, the model results confirmed the assertion that trade liberalization increase the household consumption. The reduction or elimination of tariff and export tax shows an increase in household consumptions in all sectors (Table 7). Figures in Table 7 also elucidate the fact that the higher the degree of liberalization, the higher is the increase in household consumption. Possible explanation for this is that in the Malaysian economy, tariff reduction effects are higher than export tax reduction effect.

Table 7 Impact of tariff and export tax reduction or elimination on household consumption

Sectors	Baseline (100 million RM)	Percentage change from the baseline		
		Scenario 1a	Scenario 1b	Scenario 1c
Agriculture	73.391	0.164	0.232	0.327
Utility	0.000	--	--	--
Industry	335.312	0.223	0.317	0.488
Electricity and gas	40.720	0.169	0.243	0.344
Buildings and constructions	2.128	0.094	0.188	0.235
Wholesale and retail trade	24.142	0.166	0.236	0.336
Hotels restaurants & entertainment	147.839	0.142	0.204	0.286
Transport	179.783	0.194	0.276	0.388
Financial services & real estate	265.432	0.160	0.229	0.322
Other services	106.997	0.050	0.081	0.121

Source: Authors' simulations

Graphically the general equilibrium effect of tariff and export tax removal on household welfare (i.e. in terms of private consumption, private savings and eventually total economic savings) is presented in Figure 3. For simplicity, it is assumed that only two commodities X and Y are produced, consumed and traded. Generally tariff changes the domestic prices ratio of the tariff imposing country and this domestic price ratio determines the level of production and consumption. The tariff ridden production and consumption points are p and c respectively, where the line DD shows the slope of domestic price ratio tangential with the production possibility curve at p. the slope of WW shows the free trade international price ratio. This study finds that in scenario 1c, consumers obtain higher welfare and. When tariff and export tax of Malaysia (scenario 1c) are reduced then the commodity Y is cheaper and the importer (it may be producer, however according to our objective our intention on only consumption side) of domestic market adapts these changes in relative price in the domestic market and total production is to be set from *P* to *P** and the new consumption point changes from *C* to *C** , where higher the higher indifference curve *II** is tangential with the slope of the international price ratio *WW**. So the reduction of tariff and export tax (scenario1c) increases consumer welfare, since the consumption shifts to higher indifference curve.

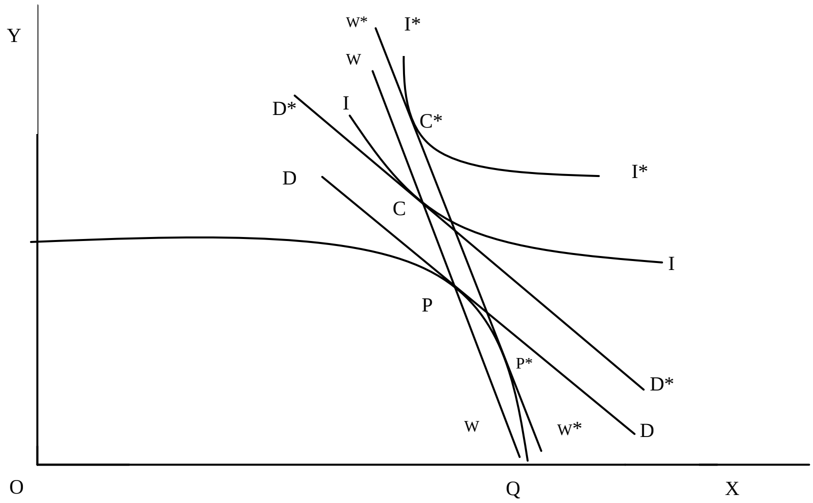

Figure 3 Impact of household consumption of tariff and export tax reduction

At the macroeconomic level, generally a decrease in tariff causes depreciation in the real exchange rate, and increases both exports and imports. It also causes a fall in both the government revenue and government savings and other macroeconomic variables. In Malaysia, the tariff and export tax reduction or elimination decrease almost all macroeconomic variables in all scenarios. However, the highest negative impact goes to the full trade liberalization scenario. The full trade liberalization policies sharply decrease the real GDP by 0.34%, nominal GDP by 0.90%, government revenue by 8.19%, investment by 2.80%, fixed capital investment by 3.77%, and household tax and household savings both by 0.10% (Table 8).

Table 8 Impact of tariff and export tax reduction or elimination on GDP, revenue and savings

Sectors	Baseline (100 million RM)	Percentage change from the baseline		
		Scenario 1a	Scenario 1b	Scenario 1c
Real GDP	3,499.192	-0.171	-0.238	-0.342
Nominal GDP	3,500.216	-0.443	-0.708	-0.897
Government revenue	356.898	-4.084	-5.847	-8.189
Investment	968.237	-1.392	-2.049	-2.795
Fixed capital investment	706.323	-1.876	-2.735	-3.765
Tariff	40.370	-50.000	-75.000	-100.000
Export tax	11.028	-50.000	-75.000	-100.000
Enterprise tax	204.856	0.091	0.047	0.173
Household tax	67.843	-0.044	-0.143	-0.097
Enterprise savings	1,162.722	0.091	0.047	0.173
Household savings	303.704	-0.044	-0.142	-0.097

Source: Authors’ simulations

Table 9 presents impacts of liberalization on CO_2 emissions. This policy simulation is vital in the case of Malaysian economy because Malaysia adopts a relatively open economy. As such, domestic production, consumption as well as other macroeconomic variables are highly sensitive export and import trade policies.

According to the policy simulations, when trade is liberalized, domestic production increased in seven of the ten sectors. As shown in Table 9, CO_2 emissions increase in agriculture, utility, industry, electricity and gas, wholesale and retail trade and transport sectors. On the other hand, CO_2 emissions decrease in the service oriented sectors such as building and construction, hotel, restaurant and entertainment, financial services and real estate and other service related sectors (Figure 4).

Table 9 Impact of tariff and export tax reduction/elimination on CO_2 emission

Sectors	Baseline (million MT)	Percentage change from the baseline		
		Scenario 1a	Scenario 1b	Scenario 1c
Agriculture	5.257	0.285	0.399	0.552
Utility	6.134	0.245	0.359	0.505
Industry	69.354	0.546	0.773	1.097
Electricity and gas	2.428	0.329	0.453	0.618
Buildings and constructions	6.302	-1.460	-2.063	-2.920
Wholesale and retail trade	7.327	0.273	0.396	0.560
Hotels restaurants & entertainment	2.994	-1.503	-1.470	-1.369
Transport	7.28	0.192	0.275	0.385
Financial services & real estate	11.563	-0.346	-0.484	-0.683
Other services	6.959	-0.029	-0.043	-0.072

Source: Authors' simulations

As a result of full trade liberalization, CO_2 emissions increased by 1.10% in the industrial sectors, 0.62% in the electricity and gas sector, 0.56%in the wholesale and retail trade sector, 0.55% in the agriculture sector, and 0.51% in the utility sector. On the other hand, and CO_2 emissions decreased in the service oriented sectors; emission decreased by 2.92% in the building and construction sector, 1.37% in the hotel, restaurant and entertainment sector, 0.68% in the financial services and real estate sector. Emission from the other sector change only slightly.

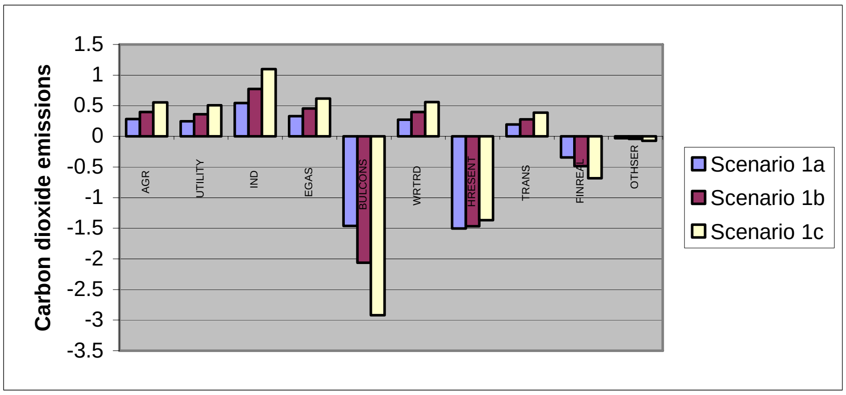

Figure 4 Impact of tariff and export tax reduction/elimination on CO_2 emission
(% change from baseline)

3.2 Carbon tax policy

This section presents simulation results of imposing carbon tax into the model. The purpose of this exercise is to investigate the implications carbon tax on the Malaysian economy with respect to total domestic production, household consumption, total exports, value-added, real and nominal GDP, and government revenue and savings.

3.2.1 *Carbon dioxide emission implications via carbon tax*

Figure 5 illustrate the outcome of imposing a unit carbon tax. Consider the supply and demand of a good where as equilibrium 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.[12] 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_PBC.

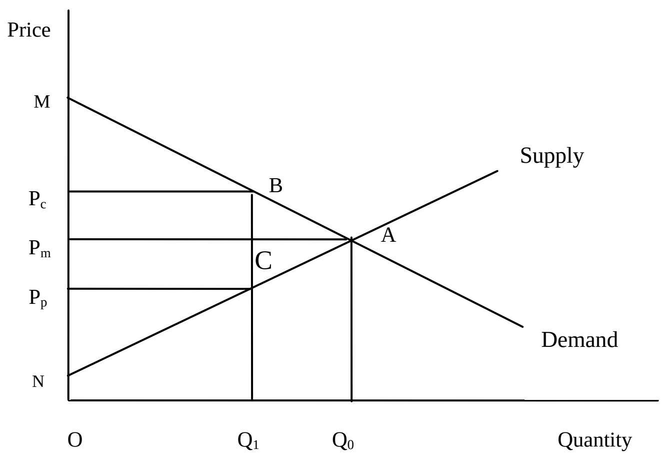

Figure 5 Effects of a carbon tax

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. Tables 10 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.

This study finds that the imposition of carbon tax on domestic production sectors reduce the carbon emissions (first row of Table 10). Simulations 2a, 2b and 2c indicate that imposition of carbon tax result in lower carbon emissions, domestic production, exports, value-added, private consumption, real and nominal GDP, tariff revenue, export tax revenue, enterprise tax revenue, household tax revenue, enterprise savings, and private savings (Table 10). In contrast the government revenue and investment share of nominal GDP are positive in all versions of scenario 2. However, investment and fixed capital investment are higher than the baseline level at low level of carbon tax (scenarios 2a) but is lower than the baseline as the carbon tax becomes higher (scenario 2c).

[12] It is assumed that emission is linear function of outputs throughout this paper.

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% percent and 4.80% respectively. However, government revenue increased from the baseline by 26.67%, 53.07% and 79.28 percent respectively. On the other hand, fixed capital investment increased in scenario 2a by 0.43% and decreased in scenarios 2b and 2c by 0.26% and 1.79% respectively from the baseline (Table 10).

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 Figure 2, the industrial sector has the highest increase from the baseline for scenarios 2a, 2b and 2c. For the respective sub-scenarios, household consumption share of nominal GDP decline by 0.19%, 0.47% and 0.80%.

Table 10 Impact of carbon tax imposition on the Malaysian economy

Sectors	Baseline (100 million RM)	Percentage change from the baseline		
		Scenario 2a	Scenario 2b	Scenario 2c
Carbon dioxide emission*	125.548	-1.212	-2.347	-3.401
Domestic production	8967.691	-1.213	-2.346	-3.401
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	3500.216	-0.818	-1.898	-3.167
Government revenue	356.898	26.668	53.072	79.281
Investment	968.237	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	-3.937
Enterprise savings	1162.722	-1.299	-2.924	-4.796
Household savings	303.704	-1.012	-2.357	-3.938
HH consumption share of nominal GDP**	33.078	-0.193	-0.466	-0.795
Investment share of nominal GDP**	27.662	1.385	2.220	2.625

Note: *million tonnes, ** percent

3.3 Effects of trade liberalization and carbon tax policies on Malaysian economy

This section presents simulation results from introducing trade liberalization and carbon tax policy simultaneously into the model. The purpose of this exercise is to investigate their implications on the Malaysian economy with respect to domestic production, household consumption, exports, value-added, investment, and government revenue and savings.

As shown in Table 11, this mixed policy results in lower level (relative to the base line) of domestic output, exports, value-added, private consumption, real and nominal GDP, investment, fixed capital investment, tariff revenue, export tax revenue, enterprise tax revenue, household tax revenue, enterprise savings, and private savings. In contrast government revenues and investment share of nominal GDP increased.

Results from scenario 3a, 3b and 3c indicate that carbon emissions respectively decreased by almost one percent, two percent, and three percent. With respect to other variables: nominal GDP decreased by 1.26%, 2.61% and 4.07%; real GDP decreased by 1.01%, 2.15% and 3.53%; domestic production decreased by 0.96%, 2.01% and 2.93%; exports decreased by 1.58%, 3.32% and 4.74%; value added decreased by 0.84%, 3.61% and 4.85%; investment by 0.85%, 1.78% and 3.46%; fixed capital investment by 1.46%, 2.99% and 5.60%; enterprise tax revenue by 1.22%, 2.93% and 4.69%; household tax revenue by 1.07%, 2.53% and 4.09%; enterprise savings by 1.22%, 2.91% and 4.09% respectively from the baseline. However, the government revenue increased by 22.66%, 47.48% and 71.50%; and investment share of nominal GDP increased by 0.43%, 0.85% and 0.64% respectively from the baseline in scenarios as shown in Table 11.

Table 11 Effects of trade liberalization and carbon tax policies on Malaysian economy

Sectors	Baseline (100 million RM)	Percentage change from the baseline		
		Scenario 3a	Scenario 3b	Scenario 3c
Carbon dioxide emission*	125.548	-0.964	-2.006	-2.926
Domestic production	8967.691	-0.964	-2.006	-2.925
Exports	4478.429	-1.584	-3.323	-4.737
Value added	3470.867	-0.843	-3.611	-4.845
Household consumption	1175.744	-2.155	-4.625	-7.202
Real GDP	3499.192	-1.007	-2.145	-3.534
Nominal GDP	3500.216	-1.263	-2.606	-4.072
Government revenue	356.898	22.656	47.477	71.501
Investment	968.237	-0.846	-1.777	-3.464
Fixed capital investment	706.323	-1.457	-2.992	-5.601
Tariff	40.370	-50.721	-75.794	-100.000
Export tax	11.028	-50.036	-75.384	-100.000
Enterprise tax	204.856	-1.221	-2.913	-4.692
Household tax	67.843	-1.067	-2.529	-4.092
Enterprise savings	1162.722	-1.221	-2.913	-4.692
Household savings	303.704	-1.067	-2.528	-4.091
HH consumption share of nominal GDP**	33.078	0.200	0.082	-0.021
Investment share of nominal GDP**	27.662	0.423	0.853	0.636

Note: *million tonnes, ** percent.

Lastly, the effects of trade liberalization and carbon tax policy result in reduced household consumptions by 2.16%, 4.63% and 7.20% respectively from the baseline. Likewise household savings decreased by 1.07%, 2.53% and 4.09%. On the other hand, household consumption share of nominal GDP increased by 0.20% and 0.08% in the scenarios 3a and 3b but decreased marginally in scenario 3c.

4. Concluding remarks

Having developed the CGE model, a number of policy simulations (i.e. i. trade, ii. carbon tax and iii. mix policy) were carried out on the economic and environmental impact in the Malaysian economy. Simulation results indicate that by reducing tariff and export tax, domestic output increased almost all production sectors, except building construction, financial service and real estate of scenario and other services that means that tariff reduction/elimination does not impacts on service sectors. This is because the reduction (elimination) of tariff makes imports cheaper in the domestic market and imports increase in the production related sectors. The model results also confirm the theory that trade liberalization increases the household consumptions in all sectors. As a result of full trade liberalization, carbon dioxide emissions also increase in the industry sectors by 1.09% percent, electricity and gas by 0.62% percent, wholesale and retail trade by 0.56% percent. However, full trade liberalization policies sharply decrease the real GDP by 0.34%, nominal GDP by 0.90%, government revenue by 8.19%, investment by 2.80%, fixed capital investment by 3.77%, and household tax and household savings both by 0.10% from the baseline.

In the carbon taxation simulations, the imposition of carbon tax decrease domestic production, exports, value-added, private consumption, real GDP, nominal GDP, tariff revenue, export tax revenue, enterprise tax, household tax, enterprise savings, and private savings in all scenarios. In contrast the government revenues, investment share of nominal GDP are increase; however, investment shows positive impact in the scenarios 2a and 2b but again negative in the scenario 2c. 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 3.97%, 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% percent and household savings by 0.80% from the baseline.

Simultaneously trade liberalization and carbon tax policy indicate that domestic production, exports, value-added, private consumption, real GDP, nominal GDP, investment, fixed capital investment, tariff, export tax, enterprise tax, household tax, enterprise savings, and private savings are negative in all scenarios. In contrast, the government revenues, investment share of nominal GDP are positive. The mixed policy also illustrate that the decrease of the carbon emissions in 0.96% (almost 1%) results in decrease the nominal GDP by 1.26%, real GDP by 1.01%, investment by 0.85, household consumptions by 2.16%, household savings by 1.07% and enterprise savings by 1.22% from the baseline. However government revenue increases by 22.66% percent in that simulation. Likewise, the decrease of the carbon emissions in 2.01 (2%) percent results in decrease the real GDP by 2.14%, domestic production by

2.01%, investment by 1.78%, enterprise savings by 2.91%, household consumptions by 4.62%, and household savings by 2.53%. In contrast, this simulation increases the government revenue by 47.48% in that scenario. Similarly, the decrease of the carbon emissions in 2.93 (almost 3%) percent results in decrease the real GDP by 3.53%, exports by 4.74%, investment by 3.46%, enterprise savings by 4.09%, household consumptions by 7.20% and household savings by 4.09% from the baseline. However the government revenue increases by 71.50% in this policy simulation.

4.1 Policy recommendations for reducing carbon emission

In the literature on environmental economics and policy, 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 regulation. Until now Malaysia has implemented energy taxation, tradable emission permits, and environmental regulations. 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 a) taxing emissions, b) taxing inputs that cause pollution, c) taxing output of goods generating emissions; and d) providing subsidies for abatement activities. However, specifically this study sought to investigate the taxing of output of goods that generate emissions on domestic production in Malaysia. This implies that this study first investigates how much energy directly and indirectly is required to produce the entire domestic production in the Malaysian economy and then carbon tax imposed in the production side of the economy using the above mentioned (scenarios 3a, 3b and 3c) simulations and taxation policy[13].

The model results indicate that the total carbon emission in Malaysia was 125.6 million tones in the year 2000[14]. An important lesson from this study is that carbon emissions effects under trade, economic development, is basically a function of the change in the productive structure, the magnitude of aggregate economic activities and energy uses in the whole economy. The model results illustrate that a larger cut in carbon emissions will require a higher carbon tax. Moreover an increasing carbon tax decreases GDP at an increasing rate. It also increase the welfare losses in terms of losses of private consumption, private savings and eventually total economic savings in the whole economy tend to rise more sharply (i.e. see household consumption section of Table 10) as the degree of emission reduction increases[15]. The aggregate production tends to decrease at a proportional rate as the carbon emissions target becomes more stringent (drop by 5%), changes in gross production quite significant in the simulations. Considering the ‘strong’ environmental policy, the simulation finds that the macroeconomic impacts can be strong. Therefore, policy-

[13] 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.

[14] The World Resource Institute (Earth trends) published in 2003 that Malaysian carbon emissions of the year 2000 was 118.99 million tones (WRI 2003).

[15] 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.

makers should consider first carbon tax policy (scenario 2a). In this simulation the carbon tax reform (almost 1% reduction of carbon emissions) results in decrease real GDP 0.82%, however increases government revenue by 26.66% that appear to be able to achieve fairly good environmental results without losing the investment, investment share of nominal GDP and fixed capital investment. In contrast, if Malaysia adopt the simulation 3a (carbon tax policy adjustment with further trade liberalization) then the tax reforms aiming to impact on the economy shocking instead of good[16]. This simulation decreases real GDP 1.01% which is higher than scenario 2a. Similarly, it decreases the investment, fixed capital investment, government revenue, tariff and export tax, and investment share of nominal GDP more compared to scenario 2a and lastly carbon emissions impact also deteriorate (compared to scenario 2a) in this simulation. Similarly, if Malaysia adopt the simulation 3c (carbon tax policy adjustment with full trade liberalization policy) then the tax reforms aiming to impact on the economy shocking also instead of good. This simulation decreases nominal GDP 4.07% which is higher than scenario 3a (scenario 3a finds 3.17%). Likewise, it also decreases the investment, fixed capital investment, government revenue, tariff and export tax more compared to scenario 3a, and however investment share of nominal GDP increase and lastly carbon emission impacts do not improve (compared to scenario 3a)[17].

On the production side, upgrading equipment on production technology is also a very effective approach in reducing pollution generation and emissions. When Malaysian policymakers will impose carbon tax on domestic production to reduce more generation of emissions, then to avoid carbon tax polluters will upgrade equipments in the energy related sectors in the long run. On the other hand, to achieve environmental sustainability greater emphasis must also be given in improving the conversion efficiency of energy related sectors. In Malaysia the annual average efficiency of energy related sectors was 1.6% per annum from the year 1995 to 2000. If this rate of increase (without carbon tax) persists through 2020, the conversion efficiency would be approximately 48% (A. Hamid et al. 2008). This figure is still very low in terms of international standard, it will however, lessen the amount of emission that would have been generated had there been no efficiency gain. Therefore like other first world countries, Malaysia should pay great attention to importing advanced and less-polluting technology to increase productivity and reduce pollution intensities. Finally, moving towards sustainable development and for better environmental performance, there is a policy goal in the Malaysian 7th, 8th and 9th Development Plans. 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 (DOE 2001). The main reason is that polluters are not intensive to reduce pollution. It should be mentioned that currently there is not carbon taxation policy in Malaysia and environmental monitoring system does not cover all polluting sectors. Therefore, the carbon tax formation of scenario 2a should be considered (rather than version 2b, 3a, 3b and 3c) to reap the maximum benefit of trade as well as to reduce the further environmental degradations.

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[16] This study already illustrates that further trade policy not effective due to Malaysia already experiencing highly liberalized economy.
[17] The investment share of nominal GDP increases because of full trade liberalization policy.

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Appendix A

The equations, variables and parameters of the CGE model of Malaysia are as follows:

A.1. Price Block

$$PD_i = PD_i(1+t_i^d)$$

$$PM_i = pwm_i(1+tm_i).ER$$

$$PE_i = pwe_i(1-te_i).ER$$

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

$$PX_i = \frac{PD_i.D_i + PE_i.E_i}{X_i}$$

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

$$PK_i = \sum_j a_{ij}.P_j$$

$$PP = \frac{GDPVA}{RGDP}$$

A.2. Production Block

$$X_i = a_i^D \prod_f FDSC_{if}^{\alpha if}$$

$$WF_f.wfdist_{if} = PV_i.\alpha_{if}\frac{X_i}{FDSC_{if}}$$

$$IN_i = \sum_j a_{ij}.X_j$$

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

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

$$E_i = econ_i\left[pwe_i \Big/ pwse_i\right]^{\eta_i}$$

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

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

A.3. Domestic Institution and Income Block

$$Y_f^F = \sum_i WF_f.FDSC_{if}.wfdist_{if}$$
$$Y_{capeh}^H = Y_1^F - DEPREC$$
$$Y_{labeh}^H = \sum_{f \neq 1} Y_f^F$$
$$TARIFF = \sum_i pwm_i.M_i.tm_i.ER$$
$$INDTAX = \sum_i PX_i.X_i.tx_i$$
$$HHTAX = \sum_h Y_h^H.t_h^H \quad h = cap, lab$$
$$EXPSUB = \sum_i pwe_i.E_i.te_i.ER$$
$$GR = TARIFF + INDTAX + HHTAX + EXPSUB*$$
$$DEPREC = \sum_i depr^i.PK_i.FDSC_i$$
$$HHSAV = \sum_h Y_h^H.(1-t_h^H).mps_h$$
$$GOVSAV = GR - \sum_i P_i.GD_i$$
$$SAVING = HHSAV + GOVSAV + DEPREP + FSAV.ER$$

A.4. Domestic Institution and Expenditure Block

$$CD_i = \sum_h \left[\beta_{ih}^H.Y_h^H.(1-mps_h).(1-t_h^H)\right] / P_i$$
$$GD_i = \beta_i^G.gdtot$$
$$DST_i = dstr_i.X_i$$
$$FXDINV = INVEST - \sum_i P_i.DST_i$$
$$DK_i = kshr_i.FXDINV / PK_i$$
$$ID_i = \sum_j b_{ij}.DK_j$$
$$GDPVA = \sum_i PV_i.X_i + INDTAX + TARIFF + EXPSUB$$
$$RGDP = \sum_i \left(CD_i + GD_i + ID_i + DST_i + E_i - pwm_i.M_i.ER\right)$$

A.5. Systems Constraints Block

$$Q_i = IN_i + CD_i + GD_i + ID_i + DST_i$$
$$\sum_i FDSC_{if} = fs_f$$
$$pwm_i.M_i = pwe_i.E_i + FSAV$$
$$SAVING = INVEST$$

A.6. Carbon Emission Block

$$TQ_{CO_2} = \varphi_{coal} X_{coal} + \varphi_{oil} X_{oil} + \varphi_{gas} X_{gas} \text{ or } TQ_{CO_2} = \sum_i \varphi_i \mathrm{X}_i$$

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

$$P_{CO_2} \geq 0$$

$$t_i^d = P_{CO_2} \psi_i^d \omega_i^d$$

$$t_i^m = P_{CO_2} \psi_i^m \omega_i^m$$

A.7. Indices

i, j	Production sectors
h	Household

A.8. Variables

Variables	Definitions
G_i	Government final demand
D_i	Domestic sales of domestic output
C_i	Final demand for private consumption
E_i	Exports
DEPREC	Total depreciation rate
DK_i	Investment by sector of destination
DST_i	Inventory investment by sector
EXPSUB	Total export taxes or export subsidy
$FDSC_{if}$	Factor demand
FSAV	Foreign savings
FXDINV	Fixed capital investment
GDPVA	Nominal GDP in factor price
GOVSAV	Government savings
GR	Total government revenue
HHSAV	Total household savings
HHTAX	Household tax revenue
ID_i	Final demand for investment goods
INDTAX	Total indirect tax revenue
INT_i	Intermediate input demand
INVEST	Total investment
Y_h^H	Household income
Y_f^F	Factor income
X_i	Domestic output
WF_f	Average output price

$TARIFF$	Tariff revenue
$SAVING$	Total saving
$RGDP$	Real GDP
R	Exchange rate
Q_i	Composite goods supply
$PINDEX$	GDP deflator
P_i^x	Output price
PW_i^e	World price of export
P_i^v	Value added price
P_i^q	Price of composite goods
P_i^m	Domestic price of imports
P_i^k	Price of a unit of capital in each sector
P_i^d	Domestic sales price
P_i^e	Domestic price of exports
T_{CO_2}	Total carbon tax revenues
TQ_{CO_2}	Total carbon emissions
P_{CO_2}	Carbon price ($/ton)
t_i^d	Carbon tax of domestic product by sector
t_i^m	Carbon tax of import product by sector

A.9. Parameters

Ψ_i^d	Carbon emission coefficient per unit of domestic fuel use by sector
Ψ_i^m	Carbon emission coefficient per unit of import fuel use by sector
ω_i^d	Fossil fuel coefficient per unit of domestic goods by sector
ω_i^m	Fossil fuel coefficient per unit of import goods by sector
a_{ij}	Input output coefficients
a_i^C	CES function shift parameter
a_i^D	Production function shift parameter
a_i^T	CET function shift parameter
$alpha_{if}$	Production function share parameter
b_{ij}	Capital composition matrix
$depr_i$	Depreciation rate
$dstr_i$	Inventory investment ratio
$econ_i$	Export demand shift parameter
$X_{i(coal)}$	Coal by sector
$X_{i(oil)}$	Oil by sector

$X_{i(gas)}$	Gas by sector
fs_f	Aggregate factor supply
$gdtot$	Real government consumption
$kshr_i$	Investment destination share
mps_h	Household savings rate
pw_i^m	World price of imports
$pwse_i$	World price of export substitutes
t_h^H	Household income tax rate
t_i^e	Export tax/subsidy rate
t_i^m	Tariff rate on imports
t_i^x	Indirect tax rate
$wfdist_{if}$	Factor market distortion parameter
α_{ij}	Production function exponent
β_i^G	Government expenditure share
β_{ih}^H	Household expenditure shares
δ_i	CES function share parameter
η_i	Export demand price elasticity
γ_i	CET function share parameter
ρ_i^C	CES function exponent
ρ_i^T	CET function exponent