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# Trade, Economic Development and Environment: Malaysian Experience

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The growth and structural transformation of the Malaysian economy over the last three decades has occurred within the framework of a liberal trade and investment regime. The environmental impact arises due to direct or indirect use of power and energy in production and, according to the type of fuel utilised, with emissions as well. Is there any trade-offs among energy use, environment and economic growth in the Malaysian economy? This paper examines the Malaysian economy wide discharge implications of $CO_2$, $SO_2$ and NOx emissions of year 2000 and scenario projections for year 2020 using input-output analysis, which allows the calculation of emission effect in the export-import activities as well as throughout the economy. Following the Fifth Fuel Diversification Strategy incorporated conversion efficiency until the year 2020, the results show that the proposed fuel mix strategy would result in significantly higher $CO_2$, $SO_2$ and NOx emissions in the year 2020. This study is important for rethinking of energy-mixed strategy and the projections might be used to formulate Malaysian future environmental policy.

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## I. INTRODUCTION

Trade liberalisation consists of policies aimed at opening up the economy to foreign investment and industrialisation. However, while trade may stimulate growth it simultaneously may lead to more pollution in the economy. The negative impact of trade related growth on an economy is not a new subject among specialists, researchers and intergovernmental institutions. Most of the environmental problems derive from energy demand to sustain economic growth as well as increase trade activities (Mukhopadhyay and Chakraborty 2005, Antweiler Copeland and Taylor 2001). Trade can affect the environment generally in two ways: first, trade and trade liberalisation encourage industrialisation and manufacturing of production for exports, leading to increased energy use and results in generation environmental pollution; and second industrialisation and manufacturing of production lead to overuses of environmental resources and results in environmental degradation.[1] These are well evidenced in the literature. In fact, all goods and services produced in an economy are directly or indirectly associated with uses of power[2]and energy (i.e. various petroleum oil, gas and coal). According to the types of fuel utilised, emissions of that energy are obvious as well.

Malaysia, a small open economy, has been experiencing a strong economic growth over the last three decades. Among the economic indicators, export-oriented manufacturing sectors are contributing significantly to economic growth; and its share in GDP contributing significantly. Electronics, crude petroleum, palm oil and timber are currently the most important commodities in terms of export value and Malaysia has increasingly diversified its exports in terms of products and markets, the result of which has made large changes in the composition of exports (EPU, 2006). The growth and structural transformation of the economy over the last three decades has occurred within the framework of a liberal trade and investment regime as well as extensive use of functional and selective industrial policies. The outcome of industrial development in Malaysia has emerged due to shift towards market-based policies and industrial policy adjustments introduced since the late 1980s as a result of trade liberalisation (EPU 2003).

[1]The first one is our consideration in this study.

[2] In Malaysia, primary energy supply, which was recorded at 20,611 ktoe (kilo tonne of oil equivalent) in 1991, increased to 50,658 ktoe in 2000 and increased further to 54,194 ktoe in 2003. Final energy demand, which was recorded at 14,560 ktoe in 1991, increased to 29,996 ktoe in 2000 and increased further in 2003 to 34,586 ktoe. Electricity demand, which was 22,273 GWh (Giga Watts Hour) in 1991, increased to 60,299 GWh in 2000 and also increased further to 71,159 GWh in 2003 (National Energy Balance, Malaysia 2003).

Following trade liberalisation Malaysia has cut its import tariffs by almost one half since 1993. The average applied most-favored-nation (MFN) tariff has declined from 15.2 per cent in 1993 to 8.1 per cent in 1997 (EPU 2003). Of the industrial items, duties on 217 items were reduced at rate faster (acceleration) than that required under the WTO proportionate cuts reduction schedule; 318 items were reduced to their bound rates while 1,031 items were reduced to levels lower than the bound rates (deepening). For agricultural products, 80 items had their tariff rates reduced faster than was required, 147 items were reduced to their bound rates, while another 524 items had their tariff rates reduced lower than the bound rates. In the 1996 budget excise tariffs on a total of 1,047 items were reduced. This included tariff reduction on 998 industrial items and 49 agricultural items. Of the industrial items, 33 were reduced at a rate faster (acceleration), 125 items were reduced to their bound rates, and 840 items were reduced to levels lower than the bound rates (EPU 2003). During the period 1992-96, investment in Malaysia averaged 40 per cent of GDP, with a considerable share coming from abroad, especially in manufacturing, where more than half of all firms' equity is now foreign-owned. Investments are encouraged by an array of tax and non-tax incentives granted (WTO 1997).

During the period of 2001-2005, Malaysia has continued to liberalise its policies on international trade. Indeed, imports and exports of goods respectively were on average equivalent to 86 per cent and 110 per cent of GDP during this period. Inflows of foreign direct investment (FDI), although down from the high level of 7 per cent of GDP between 1990 and 1997, were around 3 per cent of GDP during the period 1999-04, a level more in line with the world average (EPU 2006). Growth in real GDP, after slowing to 0.3 per cent in 2001, owing to a contraction in exports, rebounded to 4.4 per cent in 2002, 5.4 per cent in 2003, and 7.1 per cent in 2004. Malaysia’s current account surplus widened from 8.3 per cent of GDP in 2001 to 12.6 per cent of GDP in 2004 (WTO 2005). There has been little change in Malaysia’s trade-related institutional framework from 2001 to 2005; however, Malaysia has continued efforts to liberalise its relatively open trade and investment (Table I). What has been the impact of such a changed performance of trade on the environment in Malaysia? The present research concentrates on this question and aims to quantify environmental impacts.

Rising development in Malaysia brings about higher energy consumption. In the past two decades, there has been a significant growth in the Malaysian energy sector. Primary energy supply in 1991 was 20,611 ktoe (kilo tonnes of oil equivalent) but in 2000 it had increased to 50,658 ktoe. In 2003, it further increased to 54,194 ktoe (PTM 2003). Final energy demand, which were recorded at 14,560 ktoe and 29,996 ktoe in 1991 and 2000 respectively, increased to 34,586 ktoe in

2003. Electricity demand increased from 22,273 GWh (Giga Watts Hour) in 1991 to 60,299 GWh in 2000 and increased further to 71,159 GWh in 2003 (PTM 2003). As a new industrialised country Malaysia cannot ignore off the use of energy. Environmental issues appear as energy like fossil fuels are used for power generation and used as inputs for industrial sectors. Is there any trade-offs among energy use, economic growth and environmental emissions in the Malaysian economy? A number of quantitative studies can be found on that issue, especially on the world economy (Wyckoff and Roop 1994, Wier 1998, Antweiler Copeland and Taylor 2001, Munksgaard and Pedersen 2001but little attention has been put in place on Malaysia. Here we investigate trade issues, economic development and environmental problems for the Malaysian economy using environmental Input-Output (I-O) techniques. The rationale of using the I-O modelling structure is that it's enabling to exploit both direct and indirect environmental implications of different patterns of final demand through a vector of structural coefficients. It also quantifies the relationship between the intermediate inputs consumed in the production process and indirectly involved in the supply chain.[3] We here present and discuss energy-trade-environment-economic development related air emissions, (particularly $CO_2$, $SO_2$ and $NO_x$) and future scenario projections for the year 2020 to support policymakers' decision process directed toward the achievement of sustainable development.[4]

TABLE I
**MALAYSIAN TRADE DIRECTIONS**

| Direction | % of Total | | | | | |
|---|---|---|---|---|---|---|
| | Exports | | | Imports | | |
| | 1990 | 2000 | 2005 | 1990 | 2000 | 2005 |
| ASEAN | 29.0 | 26.5 | 26.1 | 19.1 | 24.1 | 25.5 |
| Singapore | 22.7 | 18.4 | 15.6 | 14.9 | 14.4 | 11.7 |
| Indonesia | 1.2 | 1.7 | 2.4 | 1.1 | 2.8 | 3.8 |

*(Table I Contd.)*

[3] Economic sectors such as service sectors, transportation and building industry, which are not direct object of trade but indirectly affect the environment involving other energy related supply chain.

[4] Here we noted that environment pollution confined GHGs gases together with the by-products of industrial processes. It is obvious that industrial process excretes harmful effluents but in this study we restricted our analysis only on energy-trade-economic development related pollution emissions.

| | | | | | | |
|---|---|---|---|---|---|---|
| Thailand | 3.5 | 3.6 | 5.4 | 2.4 | 3.8 | 5.3 |
| Philippines | 1.3 | 1.8 | 1.4 | 0.5 | 2.4 | 2.8 |
| European Union | 15.5 | 13.7 | 11.7 | 15.8 | 10.8 | 11.6 |
| United Kingdom | 3.9 | 3.1 | 1.8 | 5.5 | 2.0 | 1.5 |
| Germany | 3.9 | 2.5 | 2.1 | 4.3 | 3.0 | 4.4 |
| USA | 16.9 | 20.5 | 19.7 | 16.7 | 16.6 | 12.9 |
| Canada | - | 0.8 | 0.5 | - | 0.5 | 0.5 |
| Australia | - | 2.5 | 3.4 | - | 1.9 | 1.9 |
| Selected NEA | - | 27.8 | 27.9 | - | 37.8 | 39.0 |
| Japan | 15.8 | 13.1 | 9.4 | 16.7 | 21.0 | 14.5 |
| China | - | 3.1 | 6.6 | - | 4.0 | 11.5 |
| Hong Kong | 3.2 | 4.5 | 5.8 | 1.9 | 2.7 | 2.5 |
| Korea Rep. | 4.6 | 3.3 | 3.4 | 2.6 | 4.5 | 5.0 |
| Taiwan | 2.2 | 3.8 | 2.8 | 5.5 | 5.6 | 5.5 |
| South Asia | - | 2.8 | 4.0 | - | 1.0 | 1.0 |
| India | - | 2.0 | 2.8 | - | 0.9 | 1.0 |
| CSA | - | 1.5 | 1.2 | - | 0.8 | 1.6 |
| Africa | - | 0.8 | 1.4 | - | 0.5 | 0.6 |
| Others | - | 3.1 | 4.1 | - | 6.1 | 5.4 |
| Rest of the World | 13.0 | - | - | 14.5 | - | - |

RM million (US $ 1=RM 3.5)

| Direction | Exports | | | Imports | | |
|---|---|---|---|---|---|---|
| | 1990 | 2000 | 2005 | 1990 | 2000 | 2005 |
| ASEAN | 23065.5 | 99028 | 139208 | 15085.0 | 74940 | 110823 |
| Singapore | 18052.1 | 68574 | 83333 | 11800.0 | 44696 | 50828 |
| Indonesia | 920.7 | 6484 | 12580 | 850.8 | 8623 | 16566 |
| Thailand | 2788.0 | 13485 | 28723 | 1881.2 | 11987 | 22889 |
| Philippines | 1054.6 | 6558 | 7476 | 427.3 | 7562 | 12192 |
| European Union | 12204.5 | 51019 | 62629 | 12494.4 | 33527 | 50512 |
| United Kingdom | 3136.0 | 11566 | 9470 | 4312.3 | 6080 | 6522 |

*(Table I Contd.)*

| | | | | | | |
|---|---|---|---|---|---|---|
| Germany | 3096.8 | 9336 | 11259 | 3389.2 | 9282 | 19265 |
| USA | 13487.0 | 76579 | 105033 | 13232.5 | 51744 | 55918 |
| Canada | - | 3043 | 2847 | - | 1445 | 2133 |
| Australia | - | 9210 | 18042 | - | 6052 | 8171 |
| Selected NEA | - | 103784 | 149105 | - | 117828 | 169236 |
| Japan | 12588.9 | 48770 | 49918 | 23584.5 | 65513 | 62982 |
| China | - | 11507 | 35221 | - | 12321 | 49880 |
| Hong Kong | 2523.1 | 16854 | 31205 | 1497.5 | 8557 | 10797 |
| Korea Rep. | 3677.0 | 12464 | 17945 | 2033.6 | 13926 | 21604 |
| Taiwan | 1728.1 | 14189 | 14813 | 4323.0 | 17511 | 23974 |
| South Asia | - | 10529 | 21245 | - | 3030 | 4504 |
| India | - | 7312 | 14972 | - | 2748 | 4164 |
| CSA | - | 5633 | 6169 | - | 2587 | 6786 |
| Africa | - | 2996 | 7649 | - | 1421 | 2511 |
| Others | - | 11449 | 21866 | - | 18886 | 23415 |
| Rest of the World | 10372.3 | - | - | 11478.8 | - | - |

## II. SUMMARY LITERATURE

The energy-environment issues have been the concern of researchers in the 1970s due to energy supply crises and it was revived in the 1990s by environmental concerns and later on the globalisation process in course makes this matter more and more evident. During the last one decade there has been increasing interests among environmentalists and economists about the free trade policies such as trade liberalisation in decoding the linkages between trade and environment in order to assess the long-term effects of further trade liberalisations on the environment (Machado, Schaeffer and Worrell 2001, Copeland and Taylor 2004). It is evident now that trade liberalisation harms the environment unless appropriate trade policy is in place. A good number of studies can be found on these issues (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, Lenzen 1998, Wier 1998, Antweiler, Copeland and Taylor 2001, Machado, Schaeffer and Worrell 2001, Munksgaard and Pedersen 2001, Mukhopadhyay and Chakraborty 2005).

Nearly all production process and many forms of consumption generate environmental damage, either in the form of air and water pollution or the depletion of natural resources; increased trade due to trade liberalisation leads to an increase in production of certain commodities in line with comparative advantage. This results in emissions of pollutants through the production process and overuse of environmental resources, which affect the welfare level of the society in the presence of environmental policy regulations. The trade-oriented studies have pointed out that imports and exports could not be neglected for a relatively open economy; otherwise, energy and environmental figures might be badly distorted for this economy (Machado, Schaeffer and Worrell 2001). Moreover, some studies have presented evidences to support that international trade should be considered in the global warming agreements to avoid "carbon leakage" (Wyckoff and Roop 1994, Lenzen 1998).

## III. METHODOLOGY

This study is based on Leontief's input-output framework (Miller and Blair, 1985, Hamid, Al-Amin and Siwar 2008, Al-Amin, Siwar and Hamid 2009) where the structure of an economy is analyzed in terms of interrelationships between production sectors. In matrix notation this system of I-O techniques can be expressed as:

$$x = Ax + f$$

Which is known as the fundamental equation of the open Leontief system, stating that gross output **x** equals all intermediate demand **Ax** and final demand **f**. The solution of the I-O model can be written as

$$x = (I - A)^{-1} f$$

where, $(I - A)^{-1}$ known as "Leontief Inverse" or multiplier matrix, A input coefficients, and I is a n*x*n identity matrix.[5]

[5] In this study we first used the general I-O approaches to define Leontief's matrix formulation, and then we updated general I-O techniques to environmental I-O techniques incorporating environmental matrix ***e*** which includes direct and indirect resource use on production processes. Here we need to clearly point out that using Miller and Blair (1985) technology, environmental I-O modelling does not lead to loss any Leontief basic form of multiplier matrix. Basically environmental I-O modelling is an extension of I-O techniques.

**III.1 The Emission Model**

An environmental extension of the input-output model can be obtained by incorporating a matrix ***e*** which includes, for each sector, direct and indirect resources use for one unit of their monetary output. The multiplication of the environmental matrix ***e*** and the Leontief inverse $(I - A)^{-1}$ gives the multiplier matrix $\varepsilon$, which shows the (direct and indirect) resources intensity of each sector:

$$\varepsilon = \boldsymbol{e}\,(\mathbf{I} - \mathbf{A})^{-1}$$

To study how much pollution is generated using energy in an economy, we need to multiply pollutants emission factor (shown below), using the guidelines of the "Intergovernmental Panel on Climate Change" (IPCC).[6] The conversion factors are estimated as follows:

$$\begin{pmatrix} Emissions\ per \\ mtoe\ of\ fuel \end{pmatrix} = \begin{pmatrix} Fuel's\ emission \\ factor \end{pmatrix} \times \begin{pmatrix} Fraction\ of \\ pollution\ oxidized \end{pmatrix} \times \begin{pmatrix} Molecular\ weight \\ ratio\ of\ emission \end{pmatrix}$$

More concretely, the final step is how much input of fossil fuels and coal is required to produce **x**, therefore is required (directly and indirectly) to satisfy final demand **f**. Using input coefficients[7] corresponding fuel oil, and coal sectors of **Ax** and for any exogenously specified final demand of **f**, the total emission such as carbon, sulphur and nitrogen emission ($CO_2$, $SO_2$, and NOx respectively) can be written as:

Detailed Environmental I-O matrix formation and technology can be found on Miller and Blair (1985).

[6]In the case of crude petroleum (oil), the carbon emission factor equals 0.77 mt of carbon per mtoe of oil, and 99.25 per cent of the carbon oxidized. The molecular weight of $CO_2$ is 44.01 and that of Carbon (C) is 12.011, thus the molecular weight ratio equals 44.01/ 12.01= 3.66 mt of $CO_2$ per mt of C. Consequently, the combustion of one mtoe of oil results in generation of 0.77 ×0.9925 × (44.01/12.01)=2.80 mt of CO2 emission. Multiplication of this number by mtoe/(million RM) ratio of oil industry gives mt of $CO_2$ that is generated by the combustion of one million RM of oil.

[7] Total energy use divided by the total output.

$$\begin{bmatrix} c' \\ s' \\ n' \end{bmatrix} = \begin{bmatrix} c_1 & c_2 \\ s_1 & s_2 \\ n_1 & n_2 \end{bmatrix} \varepsilon \text{ f} \quad \text{or} \quad \begin{bmatrix} c' \\ s' \\ n' \end{bmatrix} = \begin{bmatrix} c_1 & c_2 \\ s_1 & s_2 \\ n_1 & n_2 \end{bmatrix} e_{ij} \text{ (I} - \text{A)}^{-1} \text{ f}$$

where, $c'$, $s'$, $n'$ express the vectors of total emissions of $CO_2$, $SO_2$, and $NO_x$ at the sectoral level, respectively, and $c_1$…..$n_2$ are conversion factors for $CO_2$, $SO_2$, and $NO_x$ and $e_{ij}$ energy intensity of sector i to j.[8]

### III.2 Data Preparation

This study uses Malaysian I-O table of the year 2000. The industrial classification system of the energy statistics is applied as a base for defining the appropriate sectoral classification. The selected emissions are estimated by IPCC guidelines (IPCC 1996). The Input-Output table of the year 2000 contains 94x94 sectors. For the purpose of empirical studies, we aggregated I-O table from 95x94 to 13x13 sectors in order to achieve the desired results. Imports matrix is used to cover imports of goods to satisfy intermediate imports and final demand. The difference between the imports column of the input-output table and imports matrix accounts for imported services. The information of energy balance of the year 2000 for the Malaysian economy is taken from Ministry of Energy, Water and Communications (PTM 2000) and energy balances of non-OECD countries (1999-2000) from OECD publication (IEA 2000). The export-import data is collected from 8th and 9th Malaysian Plans (EPU 2003, 2006) and Department of Statistics Malaysia (DOS 2003).

## IV. RESULTS AND DISCUSSION

### IV.1 Malaysian Energy Intensity and Energy Multiplier

The input-output model has been used first (e.g. Leontief fundamental equation $\mathbf{x = (I - A)^{-1} f}$, and multiplier matrix $\varepsilon = \boldsymbol{e}\ \mathbf{(I - A)}^{-1}$) to signal out the sectoral energy intensity that uses fossil oil and coal in the electricity sector in the Malaysian economy of the year 2000. The sectoral direct (***e=energy/industry output or TOE/RM)*** and indirect energy intensities ($\boldsymbol{e}\ \mathbf{(I - A)}^{-1}$) to the total output and to the final demand represents thousand tonnes of $CO_2$, $SO_2$, and $NO_x$ emitted per thousand RM (ringgit Malaysia) of final demand for each sector (e.g. detailed emission estimation procedures can be found in Hamid, Al-Amin and Siwar (2008). Table II contains the estimated corresponding figures. The sectoral energy multiplier of coal

[8] Abdul, Hamid, Al-Amin, and Siwar 2008.

in mining sector is 0.40, which is high compared to other sectors. The oil sectoral multiplier on electricity, gas, transport and recycling products sectors is high compared to other sectors, which are 0.83, 0.69, 0.40 and 1.21 respectively. However, in terms of total energy demand, industry and manufacturing sector require highest oil energy demand, followed by electricity, transport, services and building & construction sectors. Industry and manufacturing sector also requires highest coal energy demand, followed by building & construction and electricity sector. These figures are very significant for future energy policy and policy makers' decision process.

TABLE II

**SECTORAL ENERGY MULTIPLIER AND DIRECT AND INDIRECT ENERGY DEMAND IN THE YEAR 2000**

| Sectors | Sectoral energy multipliers ($\varepsilon$) | | Direct & indirect energy for final demand (TOE*/RM)[a] | |
|---|---|---|---|---|
| | Coal | Oil | Coal | Oil |
| Industry & Manufacturing | 0.00313123 | 0.04492609 | 1089008.1 | 15624805. |
| Building & constructions | 0.01290572 | 0.02951913 | 578324.48 | 1322796.1 |
| Transport | 0.00150415 | 0.40034424 | 34052.00 | 9063250.0 |
| Wholesale & retail trade | 0.00201324 | 0.02089953 | 28695.22 | 297886.56 |
| Hotels & restaurants | 0.00400331 | 0.06940545 | 56851.65 | 985637.01 |
| Agriculture | 0.00077289 | 0.01353500 | 11784.03 | 206364.08 |
| Crude oil, gas & coal | 0.00082552 | 0.00966893 | 38361.91 | 449313.00 |
| Electricity | 0.09940407 | 0.82552643 | 321265.16 | 2668028.2 |
| Gas &water supply | 0.00768378 | 0.68606671 | 4141.32 | 369768.41 |
| Mining | 0.40249450 | 0.04661459 | 61030.64 | 7068.22 |
| Repair motor vehicles | 0.00299274 | 0.05862943 | 2008.27 | 39343.11 |
| Recycle products | 0.08498113 | 1.20816814 | 67257.63 | 956195.01 |
| Services | 0.00194446 | 0.02220894 | 180234.57 | 2058575.1 |

*TOE=Total Oil Equivalent (mtoe =toe/1000x1000); [a]Direct & indirect energy demand= $\boldsymbol{e}\,(\mathbf{I}-\mathbf{A})^{-1}\,\mathbf{f}$.

**Source:** Authors' calculations.

**IV.2 Selected Pollution Emissions on Malaysia**

Table III figures out selected emissions in 13-sectors' economy for export activities and verifies that the $CO_2$ emission is the highest in the industry & manufacturing (11.04 mt[9]), followed by mining (0.95 mt), recycle products (0.49 mt), crude oil, natural gas & coal (0.32 mt) using coal. On the other hand, the $CO_2$ emission is also highest in the industry & manufacturing (66.96 mt), followed by recycling products (2.96 mt), crude oil, natural gas & coal (1.57 mt), wholesale & retailer trade (0.94 mt), agriculture (0.33) using oil energy. Likewise, trade liberalisation causes $SO_2$ emissions highest (both coal and oil energy use) in the industry & manufacturing sector. The $SO_2$ emission is also soaring in recycling products (31.5 tt), and crude oil, natural gas & coal sectors (16.7 tt) for using oil energy. However, in the case of $NO_x$ emissions, industry & manufacturing sector is emitting the highest both for using coal and oil energy, but $NO_x$ is comparatively higher in coal energy use than oil energy, followed by mining and recycling sectors (Table III).

TABLE III
**EXPORTS ACTIVITY RELATED EMISSION ON MALAYSIA IN THE YEAR 2000**

| Sectors | Emission / ' 000 tonnes $CO_2$ | | Emission / ' 000 tonnes $SO_2$ | | Emission / ' 000 tonnes NOx | |
|---|---|---|---|---|---|---|
| | Coal | Oil | Coal | oil | Coal | Oil |
| Industry & Manufacturing | 11035.76 | 66956.32 | 32.8974 | 712.7926 | 323.6743 | 77.8693 |
| Crude oil, gas & coal | 316.49 | 1567.51 | 0.9434 | 16.6872 | 9.2825 | 1.8230 |
| Agriculture | 44.78 | 331.62 | 0.1335 | 3.5303 | 1.3134 | 0.3857 |
| Electricity | 3.19 | 11.21 | 0.0095 | 0.1193 | 0.0936 | 0.0130 |
| Gas &water supply | 0.21 | 7.99 | 0.0006 | 0.0851 | 0.0062 | 0.0093 |
| Mining | 948.94 | 46.47 | 2.8288 | 0.4947 | 27.8322 | 0.0540 |
| Wholesale & retail trade | 213.96 | 939.23 | 0.6378 | 9.9987 | 6.2753 | 1.0923 |
| Repair motor vehicles | 0.00 | 0.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Recycle products | 491.89 | 2957.21 | 1.4663 | 31.4814 | 14.4270 | 3.4392 |

**Source:** Authors' calculations.

[9] 1 million ton (mt) = $10^3$ thousand ton (tt).

Table IV indicates import activities related emission that of $CO_2$, $SO_2$ and $NO_x$ emissions and the finding is very similar, especially for industry & manufacturing sectors for using coal and oil energy.[10]

TABLE IV
**IMPORTS ACTIVITY RELATED EMISSION ON MALAYSIA IN THE YEAR 2000**

| Sectors | Emission / ' 000 tonnes $CO_2$ | | Emission / ' 000 tonnes $SO_2$ | | Emission / ' 000 tonnes NOx | |
|---|---|---|---|---|---|---|
| | Coal | Oil | Coal | Oil | Coal | Oil |
| Industry & manufacturing | 7228.77 | 43858.47 | 21.5488 | 466.9013 | 212.0167 | 51.0068 |
| Electricity* | 1489.80 | 5231.92 | 4.4411 | 55.6971 | 43.6953 | 6.0847 |
| Agriculture | 26.46 | 195.94 | 0.0789 | 2.0859 | 0.7760 | 0.2279 |
| Crude oil, gas & coal | 118.50 | 586.90 | 0.3532 | 6.2479 | 3.4755 | 0.6826 |
| Gas & water supply | 17.53 | 661.71 | 0.0522 | 7.0443 | 0.5140 | 0.7696 |
| Mining | 1656.71 | 81.14 | 4.9386 | 0.8637 | 48.5905 | 0.0944 |
| Wholesale & retail trade | 119.77 | 525.78 | 0.3570 | 5.5972 | 3.5129 | 0.6115 |
| Repair motor vehicles | 17.70 | 146.60 | 0.0528 | 1.5607 | 0.5190 | 0.1705 |
| Recycle products | 286.10 | 1720.02 | 0.8529 | 18.3107 | 8.3913 | 2.0004 |

**Source:** Authors' calculations.

Table V is presented to quantify the environmental impacts in the whole Malaysian economy. We here show the $CO_2$, $SO_2$ and $NO_x$ emissions for the year 2000. Our figures show that total $CO_2$ emissions is highest in industry & manufacturing sector, 86.5 mt, followed by transport (43.57 mt), electricity (16.3 mt), building & constructions (12.8 mt) and service sector (11.8 mt). The $SO_2$ emission is also highest in industry & manufacturing sector, 827 tt, followed

[10] Repairing motor vehicles (Tables III and IV) indicates no CO2, SO2 and NOx emissions because their export activities in the year 2000 were zero on Malaysia.

by transport (459.9 tt) and electricity (145.82 tt) sectors. The $NO_x$ emission is highest for industry & manufacturing (445.56 tt) sector, followed by building & constructions (198.04 tt) and electricity (120.71 tt) sector.[11]

TABLE V
**SELECTED EMISSIONS OF MALAYSIA IN YEAR 2000**

| Sectors | Emission / ' 000 tonnes $CO_2$ | | Emission / ' 000 tonnes $SO_2$ | | Emission / ' 000 tonnes NOx | |
|---|---|---|---|---|---|---|
| | Coal | Oil | Coal | oil | Coal | Oil |
| Industry & manufacturing | 12245.48 | 74295.95 | 36.5036 | 790.9277 | 359.1549 | 86.4052 |
| Building & construction | 6503.04 | 6289.90 | 19.3854 | 66.9599 | 190.7314 | 7.3151 |
| Transport | 382.90 | 43095.75 | 1.1414 | 458.7817 | 11.2303 | 50.1198 |
| Agriculture | 132.51 | 981.26 | 0.3950 | 10.4461 | 3.8864 | 1.1412 |
| Crude oil, gas & coal | 431.37 | 2136.48 | 1.2859 | 22.7442 | 12.6518 | 2.4847 |
| Electricity* | 3612.50 | 12686.47 | 10.7688 | 135.0556 | 105.9533 | 14.7542 |
| Gas &water supply | 46.57 | 1758.25 | 0.1388 | 18.7177 | 1.3658 | 2.0448 |
| Mining | 686.27 | 33.61 | 2.0457 | 0.3578 | 20.1279 | 0.0391 |
| Wholesale & retail trade | 322.67 | 1416.45 | 0.9619 | 15.0790 | 9.4637 | 1.6473 |
| Hotels & restaurants | 639.28 | 4686.70 | 1.9057 | 49.8929 | 18.7497 | 5.4506 |
| Repair motor | 22.58 | 187.08 | 0.0673 | 1.9915 | 0.6623 | 0.2176 |
| Recycle products | 756.29 | 4546.71 | 2.2545 | 48.4026 | 22.1816 | 5.2878 |
| Services | 2026.67 | 9788.52 | 6.0415 | 104.2051 | 59.4414 | 11.3839 |

**Source:** Authors' calculations; *here we did not incorporated emissions for generation and distribution phases.

[11] The general idea is that if any country imports more on finish products, then pollution emission generally decreases; however, if imported goods are used as raw materials or in the form of capital goods in the production of domestic goods, then it may raise emissions. EPU (2006) indicates that Malaysian total net imports were quite high and that comprised largely of capital goods as well as foreign direct investment (FDI). The share of domestic and intermediate inputes can be found in total intermediate input use table. The composite intermediate input matrix is decomposed into the matrices for domestic and imported intermediate inputs and corresponding shares in input use are computed. Most of the FDI is used in producing non-import substitute product.

### IV.3 Scenario Analysis

This section makes use of scenario analysis, based on the I-O model presented in section III. The scenario analysis focuses on the Malaysian economy for the year 2020 (Malaysian development vision). Using final demand growth rate given in the development plans, we forecasted final demand, $Y_t$ from 2000 to 2020. The same procedure we used to estimate energy forecast, $Y_e$ for the year 2020. However, we used here Malaysian targeted composition of energy demand adopted from Fifth Fuel Diversification strategy (EPU 2006). The simulation, carried out in this study, is applicable not only for forecasting purposes but also for exploring the pollution structure of the Malaysian economy.[12]

### IV.3.1 Changes in the Structure and Forecast for Final Demand 2020

According to the figure published by Malaysian 8th Development Plan covering the period 2001-2005, the total supply of energy increased from 2,003 PJ (Petajoules) in 2,000 to 2,526 PJ in 2005, as shown in Table VI. The main sources of supply were crude oil, petroleum products, natural gas and coal. Following Fifth Fuel Diversification Strategy, the share of crude oil and petroleum products declined while that of coal and coke increased (EPU 2006); however, Fifth Fuel Diversification Strategy is under question (Hamid, Al-Amin, and Siwar 2008).

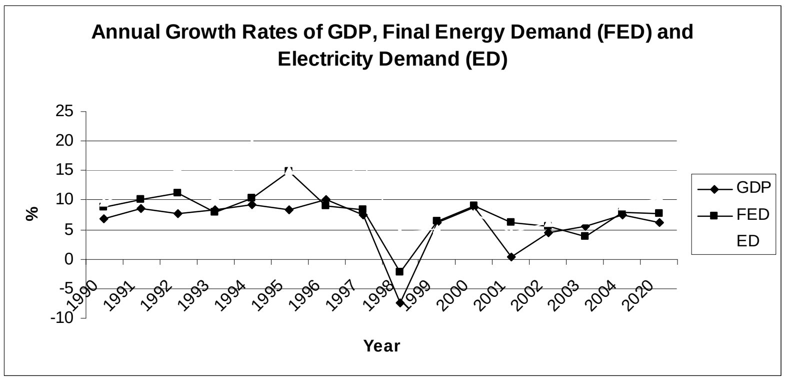
TABLE VI
**PRIMARY COMMERCIAL ENERGY SUPPLIES AND DEMAND BY SOURCE, 2000-2010**

| Source | Petajoules | | | % of Total | | | Average Annual Growth Rate (%) | |
|---|---|---|---|---|---|---|---|---|
| | 2000 | 2005 | 2010 | 2000 | 2005 | 2010 | 8MP | 9MP |
| Crude oil and petroleum products | 988.1 | 1181.2 | 1400.0 | 49.3 | 46.8 | 44.7 | 3.6 | 3.5 |
| Natural Gas | 845.6 | 1043.9 | 1300.0 | 42.2 | 41.3 | 41.6 | 4.3 | 4.5 |
| Coal and Coke | 104.1 | 230.0 | 350 | 5.2 | 9.1 | 11.2 | 17.2 | 8.8 |
| Hydro | 65.3 | 71.0 | 77.7 | 3.3 | 2.8 | 2.5 | 1.7 | 1.8 |
| Total | 2003.1 | 2526.1 | 3127.7 | 100.0 | 100.0 | 100.0 | 4.7 | 4.4 |

**Source:** EPU 2006.

[12] The detailed scenario estimation and forecast for energy demand can be found on Al-Amin, Siwar and Hamid (2009).

**Fig. 1: Annual Growth Rate of GDP, Final Energy Demand (FDI) and Electricity Demand (ED) from 1990 to 2020**




**Sources:** Author's estimation and PTM (2003)

The scenario analysis is based on macro forecasted growth rate formula and I-O model presented in section III. Using final demand growth rate given in the development plans, we forecasted final demand, $Y_t$ from 2000 to 2020 holding 2000 as the base year, as follows: $Y_t = Y_{2000}\ (1+ r_Y)^t$ where, t = 1,2,3,4,5............20, and $^r{}_Y$ is the annual final demand growth rate. The same formula we used to estimate energy demand for the year 2020, as $Y_e = Y_{2000}\ (1+ r_e)^t$ where, t = 1,2,3,4,5...........20. Here $Y_e$ indicates energy demand from 2000 to 2020 holding 2000 as base year and $^r{}_e$ used as projected energy growth rate in Fifth Fuel Diversification strategy for the year 2020 (EPU, 2006). The detailed analysis on how Malaysian targeted growth rates are related to energy demand and economic activity can be found in *Hamid et al.* (2008).

Based on the modified I–O table, the technological coefficients for the year of 2000–2020 are updated.[13] The values of fuel use per unit of output of producing sectors are estimated changes in energy proposed in Fifth Fuel Diversification Strategy and PTM (2003) database projections (Hamid, Al-Amin and Siwar 2008). Some assumptions are made due to unavailability of technological coefficients for 2010-2020 and actual energy uses. Furthermore, these analyses are focused on the assessment of economy-wide pollutant emissions proposed in Fifth Fuel Diversification Strategy.

[13] Detailed procedure can be found in Proops, Faber and Wagenhals (1993) for updating the technological coefficients.

### IV.3.3 Emission Scenario for 2020

The scenario allows us to realise that $CO_2$, $SO_2$ and $NO_x$ emission will increase in all aspects. Concerning Malaysian vision 2020 and targeted growth in proposed Fifth Fuel Diversification Strategy, the estimated result shows that in all aspects the selected air emissions would increase significantly. Table VII illustrates the $CO_2$, $SO_2$ and $NO_x$ emissions projection figures for the year 2020.

This analysis indicates that in the year 2000 the total $CO_2$ emissions (i.e. major sectors) of industry and manufacturing sectors were 86.5 mt and would be 183.9 mt in the year 2020, which is 112.6 per cent higher than the year 2000. The $CO_2$ emissions on transport sector were 43.4 mt that would be 93.4 mt (115.2 per cent higher than 2000) in year 2020, electricity sector were 16.3 mt and would be 50.1 mt (207.23 per cent higher than 2000), service sector were 11.8 mt and would be 39.6 mt. Likewise, in the year 2000, the $SO_2$ emissions of industry & manufacturing sectors were 0.83 mt, which would be 1.6 mt in 2020. The same for transport sector was 0.46 mt that would be 0.98 mt, for electricity sector it was 0.15 mt and would be 0.38 mt, and for service sector this was 0.11 mt and would be 0.85 mt. The $NO_x$ emissions of industry & manufacturing sectors were 0.45 mt in the year 2000 which would be 1.7 mt in 2020. The same for transport sector was 0.06 mt that would be 0.19 mt, for electricity sector it was 0.12 mt and would be 0.61 mt, and for service sector it was 0.07 mt and would be 0.55 mt. It is found that the fuel mix envisioned by the Fuel Diversification Strategy, designed to reduce Malaysia's dependence on fuel oil and increase its energy security, would increase undesired emissions.

TABLE VII
**SELECTED EMISSIONS SCENARIO FOR 2020 IN MALAYSIA**

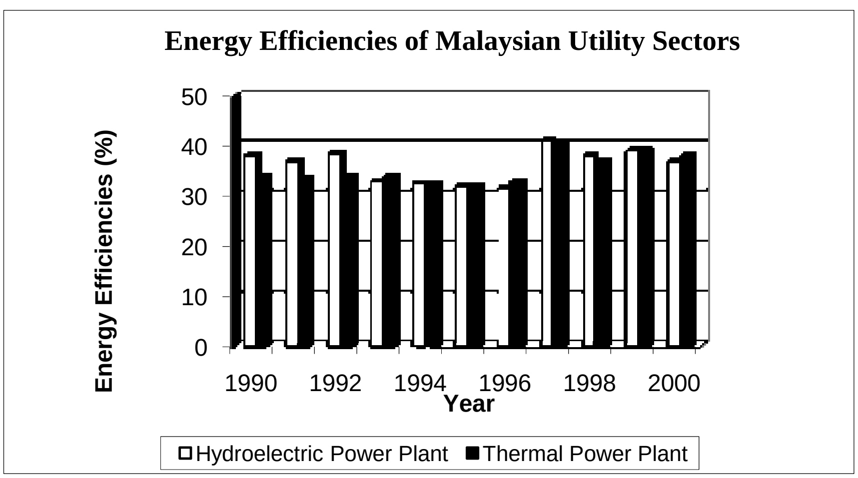
| Sectors | Emission / ' 000 tonnes $CO_2$ | | Emission / ' 000 tonnes $SO_2$ | | Emission / ' 000 tonnes NOx | |
|---|---|---|---|---|---|---|
| | Coal | Oil | Coal | oil | Coal | Oil |
| Industry & manufacturing | 51866.53 | 132008.33 | 154.61 | 1405.31 | 1521.22 | 153.52 |
| Building & construction | 66953.80 | 13029.75 | 199.59 | 138.71 | 1963.73 | 15.15 |
| Transport | 2481.69 | 91009.34 | 7.40 | 968.85 | 72.79 | 105.84 |
| Wholesale & retail trade | 1447.73 | 3194.14 | 4.32 | 34.00 | 42.46 | 3.71 |

*(Table VII Contd.)*

| Sectors | Emission / ' 000 tonnes $CO_2$ | | Emission / ' 000 tonnes $SO_2$ | | Emission / ' 000 tonnes NOx | |
|---|---|---|---|---|---|---|
| | Coal | Oil | Coal | oil | Coal | Oil |
| Hotels & restaurants | 2731.36 | 8781.46 | 8.14 | 93.48 | 80.11 | 10.21 |
| Agriculture | 443.35 | 2093.81 | 1.32 | 22.29 | 13.00 | 2.44 |
| Crude oil, gas & coal | 2532.48 | 4732.85 | 7.55 | 50.38 | 74.28 | 5.50 |
| Electricity* | 19527.85 | 30567.47 | 58.21 | 325.41 | 572.74 | 35.55 |
| Gas &water supply | 257.62 | 4226.93 | 0.77 | 45.00 | 7.56 | 4.92 |
| Mining | 3689.19 | 74.18 | 11.00 | 0.79 | 108.20 | 0.09 |
| Repair motor vehicles | 96.00 | 413.75 | 0.29 | 4.40 | 2.82 | 0.48 |
| Recycle products | 3563.48 | 9757.11 | 10.62 | 103.87 | 104.52 | 11.35 |
| Services | 17717.41 | 21890.78 | 52.82 | 233.04 | 519.64 | 25.46 |

**Source:** Authors' calculations; * here we did not incorporated emissions for generation and distribution phases.

**Figure 2: Energy Efficiencies of Malaysian Utility Sectors**




**Sources:** Hamid *et al.* (2008), Saidur *et al*. (2007).

## V. CONCLUSION AND DISCUSSIONS

This paper empirically explores the economy wide environmental impacts of trade and economic development for the year 2000 and scenario projections of 2020 that separately identify impacts on the environment. This study used I-O techniques with the core concept of multiplier analysis to explore the direct and indirect energy final demand within the economy. Some sectors might not use directly much energy (i.e. service); but may consume huge energy indirectly in other service related production process involved in the supply chain. Consequently, multiplier analysis is very useful to investigate energy and empirical emission quantifications (Table II). This study allows the calculation of $CO_{2,}$ $SO_2$ and $NO_x$ emission implications in export-import related activities as well as overall production processes throughout the economy. The scenario projections for the year 2020 are based on fuel mix strategy as specified in the Fifth Fuel Diversification Strategy incorporated in the Malaysian Energy Policy. The scenario analysis points out that in 2020 $CO_2$ emission of industry and manufacturing sectors would increase by 112.6 per cent and electricity sector by 207.23 per cent, which indicate, an alarming rate to unseating for sustainable economy.

Following Fifth Fuel Diversification Strategy incorporated conversion efficiency (Hamid, Al-Amin and Siwar 2008) until the year 2020, our results show that the proposed fuel mix strategy would result in significantly higher $CO_2$, $SO_2$ and $NO_x$ emissions in the year 2020. If the annual average efficiency would increase moderately by about 1.6 per cent per year from 1995 to 2000, then following Fifth Diversification Strategy the conversion efficiency in utility sector would be increased approximately by 48 per cent (Figure 2). This figure is still very low in terms of international standard (Saidur *et al.* 2007). So, it is necessary to consider energy (non-renewable) especially in the framework of natural resources-economy-environment analysis. Now the time has come to rethinking vis-à-vis the environmental concern in every step of trade and economic development.

Principally, we estimated proposed fuel-mix energy demand and pollution projection for Malaysia that has significant environmental implications. Malaysian policymakers should consider proper future energy analysis, and consider problems associated with energy use. The energy agency should estimate energy demand efficiently in determining total energy requirements considering energy inputs from all producing sectors. Such estimation is useful in determining expected changes in energy demand given changes in the composition of industrial output. Policymakers must review relevant past applications of energy-environment analysis and its implication using Fifth Fuel Diversification Strategy. It is useful to simulate the effects of a variety of policies and possibilities, not only through changes in exogenous variables (final demand) but also through changes in the structural matrices and their coefficients. In this way, policy issues connected with energy use and environmental impacts, employment and economic welfare would be well investigated. The energy related emissions projected in this study for 2020 are analytically important for rethinking of energy-mixed strategy for the future energy policy. Forecasts of energy consumption are vital when energy demand and economic growth move faster.

**REFERENCES**

Al-Amin, Siwar and Hamid 2009: Al-Amin, Chamhuri Siwar and Abdul Hamid, "Energy Use and Environmental Impact of New Alternative Fuel Mix in Electricity Generation in Malaysia," *The Open Renewable Energy Journal*, Vol. 2 p.25-32.

Antweiler, Copeland and Taylor 2001: W. Antweiler, B.R. Copeland and M.S. Taylor, "Is Free Trade Good for the Environment?" *American Economic Review*, Vol. 91, No. 4, pp. 877-908.

Bullard and Herendeen 1975: Clark W. Bullard and Robert A. Herendeen, "The Energy Cost of Goods and Services," *Energy Policy*, Vol. 3, No. 4, pp. 268-78.

Copeland and Taylor 2004: B.R. Copeland and M.S. Taylor, "Trade, Growth and the Environment," *Journal of Public Literature*, Vol. 42, pp. 7-71.

DOS 2003: *Malaysia Economic Statistics–Time Series*, Department of Statistics, Malaysia.

EPU 2003: *Eight Malaysia Plan 2000-2005*, Economic Planning Unit, Malaysia.

_____ 2006: *Ninth Malaysia Plan 2006-2010*, Economic Planning Unit, Malaysia.

Hamid, Al-Amin and Siwar 2008: Abdul Hamid, A. Q. Al-Amin and Chamhuri Siwar, "Environmental Impact of Alternative Fuel Mix in Electricity Generation in Malaysia," *Renewable Energy*, Vol.33, pp.2229-35.

Han, and Lakshmanan 1994: Xiaoli Han, and T.K. Lakshmanan, "Structural Changes and Energy Consumption in the Japanese Economy 1975-85: An Input-Output Analysis," *Energy Journal*, Vol. 15, No.3, pp. 165-88.

Herendeen 1978: Robert A. Herendeen, "Energy Balance of Trade in Norway, 1973," *Energy Systems and Policy*, Vol. 2, No. 4, pp. 425-32.

Herendeen and Bullard 1976: Robert A. Herendeen and Clark W. Bullard, "US Energy Balance of Trade, 1963-1967," *Energy Systems and Policy*, Vol. 1, No. 4, pp. 383-90.

IEA 2000: "Energy Statistics of Non-OECD Countries, 2000-2001," OECD publications, Paris.

IPCC 1996: *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories,* IPCC/OECD/IEA Inventory Programme, Paris.

Mukhopadhyay and Chakraborty 2005: Kakali Mukhopadhyay and Debesh Chakraborty, "Is Liberalization of Trade Good for the Environment?- Evidence from India," *Asia-Pacific Development Journal,* Vol. 12, No.1, pp. 109-36.

Lenzen 1998: Manfred Lenzen, "Primary Energy and Greenhouse Gases Embodied in Australian Final Consumption: An Input-output Analysis," *Energy Policy,* Vol. 26, No. 6, pp. 495-506.

Machado, Schaeffer and Worrell 2001: G. Machado, R. Schaeffer and E. Worrell, "Energy and Carbon Embodied in the International Trade of Brazil: An Input-output Approach," *Ecological Economics,* Vol. 39, No. 3, pp. 409-24.

Miller and Blair 1985: Ronald Miller and Peter Blair, *Input-output Analysis: Foundations and Extensions*, Englewood Cliffs, New Jersey, Prentice-Hall.

Munksgaard and Pedersen 2001: J. Munksgaard and K.A. Pedersen, "CO2 Accounts for Open Economies: Producer or Consumer Responsibility?" *Energy Policy*, Vol. 29, No. 4, pp. 327-35.

Proops, Faber and Wagenhals 1993: L.R. Proops, M. Faber and G. Wagenhals, *Reducing CO2 Emissions, 1993. A Comparative Input–Output Study for Germany and the U.K.*, Springer-Verlag.

PTM 2000: *National Energy Balance of Malaysia,* Ministry of Energy, Communications and Multimedia, Malaysia.

_____ 2003: *National Energy Balance of Malaysia,* Ministry of Energy, Communications and Multimedia, Malaysia.

Saidur, Masjuki, Abdessalam, and Shahruan 2007: R. M.A. Sattar Saidur, H.H. Masjuki, H. Abdessalam and B.S. Shahruan, "Energy and Exergy Analysis at the Utility and Commercial Sectors of Malaysia," *Energy Policy,* Vol. 35, No.3, pp.1956-66.

Stephenson and Saha 1980: J. Stephenson and G.P. Saha, "Energy Balance of Trade in New Zealand," *Energy Systems and Policy*, Vol. 4, No. 4, pp. 317-26.

Strout 1985: Alan M. Strout, "Energy-intensive Materials and the Developing Countries," *Materials and Society,* Vol. 9, No.3, pp. 281-330.

Wier 1998: Mette Wier, "Sources of Changes in Emissions from Energy: A Structural Decomposition Analysis, *Economic Systems Research*, Vol. 10, No. 2, pp. 99-112

Wright 1974: David J. Wright, "Goods and Services: An Input-output Analysis," *Energy Policy*, Vol. 2, No. 4, pp. 307-15.

Wyckoff and Roop 1994: Andrew W. Wyckoff and Joseph M. Roop, "The Embodiment of Carbon in Imports of Manufactured Products: Implications for International Agreements on Greenhouse Gas Emissions," *Energy Policy*, Vol. 22, No. 3, pp. 187-94.

WTO 1997: *Annual Report*, World Trade Organization, Geneva.

_____ 2005: *Annual Report*, World Trade Organization, Geneva.