# Modeling impact of higher energy prices on income distribution with substitutions in production and household sectors

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**Abstract**

A recent petroleum price hikes has compelled developing countries to review energy subsidy schemes as a part of rebalanced fiscal allocation and thus pushing-up domestic prices. Deregulation of energy pricing policy is hindered by uncertainty implications on welfare of households. In this paper, distributional implications of higher domestic petroleum prices on households across ethnic groups are examined. An economy-wide analysis which is represented by a social accounting matrix (SAM) is applied to study the impacts. A unique modification of the present model is that the static SAM model is refined by specifying substitution possibilities among production inputs and consumption. Results indicate that the income distribution become worse due to tremendous erosion in real income of the rural households in general, and the Malay in particular. Further analyzing the impacts on factors of production, we reach a conclusion that erosion in real wages can be put forward to explain for decline in real income and thus the increase in income gap.

**Keywords**: petroleum price; income distribution; social accounting matrix (SAM); substitution effect.
**JEL Codes**: C67; D30; D57

## 1. Introduction

A policy of subsidizing petroleum prices have been pursued in developing countries to keep the prices well below the international levels. When this traded commodity is a policy variable, a tremendous increase in the world prices raises a basic question: should the domestic prices be adjusted? The criterion which based on economic efficiency recommends that domestic prices should be kept in line with the increasing world prices, which would likely result increased in prices, inducing additional production output and simultaneously restraining fiscal allocation. However, that based on equity consideration usually recommends and warns against the unfavourable effects on income distribution of an implementation of such energy pricing policy (see, for example, Saboohi, 2001; Gangopadhyay, et al., 2005). This perceived conflict between efficiency and equity has hampered the formation and implementation of energy pricing policies.

Recently, inter-relationships between production sector and income distribution effects appear to have been virtually neglected in the discussion of rising energy prices. To the best of our knowledge, this issue has been received relatively great attention in the energy literature in the past two decades (see, for instance, Berndt and Morrison, 1979; Behrens, 1984; Common, 1985). The current studies although examine the impact of higher energy prices on aggregate labor income, a limited focus attention on income distribution effects has been given (see, for instance, Kratena, 2005; Welsch and Ochsen, 2005; Neuwahl, et al., 2009).

The purpose of this paper is therefore, to examine empirically the effects of rising domestic petroleum prices on the costs of households at detailed household groups. An economy-wide analysis which is represented by a social accounting matrix (SAM) price model is applied to study the impacts. A large dataset provided in the SAM would allowing for extensive analyses of the extent to which household groups as well as production sectors will gain or lose due to the increase in petroleum prices within a single framework. Hence, both equity and efficiency issues can be addressed simultaneously in such a model.

A unique modification of the model is that we attempt to refine the static SAM price model by specifying substitution possibilities among production inputs and consumption. In response to the change in energy prices, producers for example, tend to choose bundle of inputs which minimizes total costs, given the current level of output. The direct implication of this behavioral is that the extent to which income of household groups affected depends largely on the degree of substitutability between energy and labor inputs. Moreover, when labors are disaggregated into several groups, the size of the elasticity of substitution is a matter for analyses of income distribution. To capture the substitution effects, elasticity of substitution are estimated separately by econometric models, which in turn link consistently to the static SAM price model.

For empirical analysis, we run a SAM for Malaysia for year 2000. Uniquely, our SAM includes detailed information on ethnic groups which comprises the Malay, Chinese, Indian and a group of other ethnic minority groups (simply defined as others) across geographical locations. Such detailed household disaggregation make possible for us to provide insights on tackling issues of how the current energy price shocks could have different effects on wages, which in turn has implication on distribution of income.

The rest of this paper is organised as follows: Section 2 explains technical details of the estimations of the substitution effects among production inputs and consumption according to the producer and consumer behaviours. Section 3 discusses technical details of our SAM model in which emphasize is given to the price model version. It then links the estimated substitution parameters as in Section 2 into the standard SAM price model. Section 4 briefly explains sources of data. Then in section 5, we illustrate our empirical findings by simulating a substantial increased in petroleum prices. Section 6 finally suggests key mitigating measures for protecting the welfare of the most affected household groups.

## 2. Estimation of substitution effects due to change in energy prices

### 2.1 Substitution among production inputs

There are a number of functional forms, including generalized Leontief (GL), translog (TL), constant elasticity of substitution (CES) and Cobb-Douglas (CD) functions that are most frequently applied to estimate elasticity of substitution at production levels. The GL and TL functions offer a flexible functional form, permitting the elasticity of substitution between inputs to vary and to vary along time. In practice however, these two functional forms require a large number of observations because parameters are estimated in a system equation. For the sake of data limitation, nested (or multi-levels) functional forms are applied.

The production functions are represented by a set of nested CD and Leontief (fixed) input coefficient, as shown in Figure 1. A CD function is only applied when substitutions are imposed for a particular set of input. At the top nest, for example, substitutions between energy, and value added and non-energy material inputs are characterized by a CD function. The connections between two value added components—capital and labor, and intermediate inputs—domestic and imported, at nest 2 are modeled as a Leontief fixed coefficient. To get detailed connection among the remaining domestic non-energy inputs, a Leontief fixed coefficient is applied at nest 3. In nest 4, the aggregate labor is split up into three skill types—low, medium and high by using a CD function. In the last three nests, a Leontief fixed coefficient is applied to model the connections between citizenships, geographical locations (rural and urban) and ethnic groups (Malay, Chinese, Indian and others).

<**Figure 1 about here**>

Nesting the structure of production functions by this way would allow greater flexibility in specifying elasticity of substitution among disaggregated pairs of inputs. The only issue remaining is, to decide which combinations of inputs that matches with each other. How to choose to match the pairs of inputs may depend on the empirical analyses. For example, the existing literature suggests that labors by skill types are more sensitive to the changes in substitution parameters and productivity (see, for example, Dupuy and Grip, 2006; Wacker et al., 2006; Morrison Paul and Yasar, 2008). In our study, the above structures are well suited to the available dataset. However, imposing a substitution among ethnic groups may contribute a significant explanation on income distribution. Unfortunately, a limited current dataset leads us to nest skill types at the top of ethnic groups instead of the other way round.

The expanded CD model for output as a function of value added ($Q$), energy ($E$)[1] and material inputs ($D$) can be written in a standard form as:

$$Y = A(t)Q^{\alpha}E^{\beta}D^{\lambda} \quad (1)$$

Since (1) is multiplicative, it can be estimated in a log-linear form as:

$$\ln Y = \ln A(t) + \alpha \ln Q + \beta \ln E + \lambda \ln D \quad (2)$$

where $Y$ is output and $A(t)$ denotes a constant of proportionality. The estimated coefficients $\alpha$, $\beta$ and $\lambda$ are partial elasticity of output with respect to (w.r.t.) value added, energy and material inputs, respectively. Assuming the production function exhibits constant return to scale (i.e., homogenous of degree one), then

$$\alpha + \beta + \lambda = 1 \quad (3)$$

[1] Energy input is represented by input of petroleum products.

In the *QED* model with a focus on energy, a partial elasticity of substitution between energy and other input components can be simply represented by a marginal rate of substitution (MRS) of the particular input components for energy. This corresponds to the slope of isoquant curve, which can be viewed as follows;

$$\delta Y = \left(\frac{\delta Y}{\delta Q}\right)\delta Q + \left(\frac{\delta Y}{\delta E}\right)\delta E + \left(\frac{\delta Y}{\delta D}\right)\delta D \quad (4a)$$

$$0 = \delta Y = MP_Q \delta Q + MP_E \delta E + MP_D \delta D \quad (4b)$$

Setting $MP_D = 0$, a partial elasticity of substitution of value added for energy, for example, is equivalent to

$$\left(\frac{\delta Q}{\delta E}\right) = -\left(\frac{MP_E}{MP_Q}\right) = -\left(\frac{\beta Q}{\alpha E}\right) = \sigma_{QE} \quad (5)$$

The elasticity of substitution among different pairs of input derived from this model allows to vary, but it is constant regardless of relative input prices. For example, if price of energy *e* rises by some percentage holding price of value added *q* constant, relative price of energy $(e/q)$ would increase by the same percentage. Since $(Q/E) = -(\alpha/\beta)(e/q)$, $(Q/E)$ rises by the same percentage.

Substitutions among labors by skill types are modeled as follows;

$$L = A(l) S_L^{\kappa} S_M^{\varphi} S_H^{\rho} \quad (6)$$

where *L* is aggregate labor, and disaggregation by low-, medium- and high-skilled are given by $S_L$, $S_M$ and $S_H$, respectively. $A(l)$ represent a constant of proportionality, and $\kappa, \varphi$ and $\rho$ are parameters to be estimated. Similar to (3), constant returns to scale are imposed. Notice that for (6), derivation of a partial elasticity of substitution between pairs of inputs is not necessary. At this nest, the share parameters— $\kappa, \varphi$ and $\rho$ are used to distribute effects of labors across skill types.

### 2.2 Substitution in consumption

Consumer choices can be handled exactly in the same way as producers with respect to cost minimization. Consumers tend to consume a set of commodities which maximize utility given a current level of income or expenditure. There are several functional specifications that can model the consumer behaviors with AIDS (almost ideal demand system) of Deaton and Muellbauer

(1980) is highly recommended. This functional form is considerably efficient than others because it is able to fulfill all the properties of demands. However, the measurement of consumer choices using this function as well as other functional forms seems to be a generally difficult task if price information is not available. This is the constraint that we encounter in study[2].

An increase in commodity prices affects consumers through two effects—the effects of own-price and that of income. However, the absent of commodity prices limits us to estimate expenditure (proxy for income) elasticity only. For the approximation, the ratio semi-log specification is applied given by the fact that it satisfies the additivity property (see, Working, 1943; Leser, 1963; Deaton and Muellbauer, 2007).

$$Z_i = \varepsilon_i + \theta_i \log X \qquad (7)$$

where $Z_i$ is the expenditure share of commodity $i$, $X$ is the total expenditures, $\varepsilon_i$ and $\theta_i$ are parameters to be estimated. Adding-up requires that $\sum Z_i = 1$, which is satisfied provided

$$\sum \varepsilon_i = 1, \ \sum \theta_i = 0 \qquad (8)$$

## 3. A refined SAM model

### 3.1 SAM price model

SAM is a general equilibrium framework that is widely applied for the analyses of income distribution and poverty (see, for example, Thorbecke and Jung, 1996; Khan, 1999; Llop and Manresa, 2004). It is a presentation of national accounts in a matrix form, but typically incorporates whatever degree of details is required for specific interest. In a SAM, incomes are recorded in row ($i$) for a certain recipient while expenditures are given as outlays in the corresponding column ($j$). The corresponding row and column totals of the matrix must be identical, consistent with the accounting principal that the sum of incomes equals the sum of expenditures for each single account. The basic structure of the Malaysian SAM that applied in this study is illustrated in Table 1.

**<Table 1 about here>**

[2] In Malaysia, consumer price index is available yearly but no disaggregation of consumption by types of commodities or by groups of households is available. Household expenditure survey contains a detailed consumption of commodities by household groups but prices are not available.

As a comprehensive data system, SAM can be used as a starting point for economy-wide impact analysis through a multiplier modeling. Derivation of the multiplier requires to distinguishing the SAM accounts into endogenous and exogenous accounts. Conventionally, production, factor of production, household and company are considered as endogenous accounts while the rest of the remaining accounts, which are government, consolidated capital, the rest of the world and indirect tax are treated as exogenous accounts (see, for instance, Pyatt and Round, 1979; Khan and Thorbecke, 1989; and James and Khan, 1997).[3]

In the standard SAM multiplier modeling, endogenous accounts **y** can be obtained simply by post-multiplying the SAM inverse matrix $(\mathbf{I} - \mathbf{A})^{-1}$ with vector of exogenous incomes **x**. That is,

$$\begin{aligned} \mathbf{y} &= \mathbf{Ay} + \mathbf{x} \\ &= (\mathbf{I} - \mathbf{A})^{-1}\mathbf{x} = \mathbf{Mx} \end{aligned} \qquad (9)$$

where **I** is the identity matrix and $\mathbf{A} = \mathbf{T}\hat{\mathbf{y}}^{-1}$ is a matrix of average expenditure propensities for endogenous accounts, **M** is simply the matrix of SAM multipliers which indicates the economy-wide effects on all endogenous accounts induced by an injection of any exogenous account. These economy-wide effects are studied by assuming excess capacity and unused resources existed, and linear relationships (fixed expenditure propensities) are presumed throughout the framework. Equation (9) is also known as a quantity model where assuming quantity levels may vary while prices are fixed.

Te dual for the quantity model is a price model (also known as a cost-push model). The model may be useful for analysis of price shocks given prices may vary while quantities are assumed to be fixed[4]. In this study, we propose a refined price model, which we will introduce after presenting the standard price model.

Expressing the model in terms of column vectors instead of row vectors, the standard price version can be summarised as follows:

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[3] SAM may provide flexibility in determining component of endogenous and exogenous accounts. The choice between these two account components depends largely upon the type of analysis. For instance, government sector may be considered as endogenous component in an analysis of income distribution in order to capture the redistribution effect from the public spending.

[4] Surprisingly, application of SAM model for price formation and cost transmission is rather limited. The first attempt for cost effect analyses using a price model can be traced back to Roland-Holst and Sancho (1995). Afterwards, we are not aware of other studies that attempt to apply the price model for the cost effect analyses.

$$\begin{aligned}\mathbf{p} &= \mathbf{p}\,\mathbf{A} + \mathbf{p}_{\mathrm{v}}\mathbf{v} \\ &= (\mathbf{I} - \mathbf{A}^{'})^{-1}\,\mathbf{p}_{\mathrm{v}}\mathbf{v} \;=\; \mathbf{M}^{'}\mathbf{p}_{\mathrm{v}}\mathbf{v} \qquad (10)\end{aligned}$$

where, $\mathbf{p}$ is the vector of normalized prices for the endogenous accounts, $\mathbf{A}^{'}$ is a transposition of the matrix of average expenditure propensities, $\mathbf{p}_{\mathrm{v}}$ is the vector of normalized prices for the exogenous accounts and $\mathbf{v}$ is termed as vector of exogenous expenditure coefficients ( $\mathbf{v} = \mathbf{L}\hat{\mathbf{y}}^{-1}$ )[5]. For the base-year equilibrium, $\mathbf{M}^{'}\,\mathbf{p}_{\mathrm{v}}\mathbf{v}$ is simply equivalent to $\mathbf{M}^{'}\mathbf{v}$.

In our price model, prices of import and of direct and indirect taxes are treated as exogenous variables. The size of effects due to change in exogenous prices on endogenous unit cost (**p**) is determined by **v**. Although the same coefficients of the SAM inverse matrix ($(\mathbf{I} - \mathbf{A})^{-1}$) are applied in (9) and (10), both models are independent. Quantities and prices move independently—**y** determined by **x** and **p** by $\mathbf{p}_{\mathrm{v}}$. In (9) supply is perfectly price elastic whereas in (10) demand is perfectly price inelastic[6].

By definition in Table 1, it is not difficult to see that (10) can be partitioned as in (11). For simplicity, household and company accounts are simply grouped in an account, the so-called "institution".

$$\begin{bmatrix} p_1 \\ p_2 \\ p_3 \end{bmatrix} = \begin{bmatrix} p_1 \\ p_2 \\ p_3 \end{bmatrix} \begin{bmatrix} A_{11} & A_{21} & \\ & & A_{32} \\ A_{13} & & A_{33} \end{bmatrix}^{'} + \begin{bmatrix} p_{v1} \\ p_{v2} \\ p_{v3} \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix} \qquad (11)$$

where row $p_1$ refers to the cost of production per unit of output, row $p_2$ represent factor costs (for example, wage rate for labor) and row $p_3$ indicates institution (mainly household) consumption costs per unit of expenditure.

The above linear model shows an economy-wide price effect, which captures not only cost linkages among production sectors, but also factor of production and household. Producers pay raw materials ($A_{11}$) and factor of production ($A_{21}$) which combined to produce output. Factor of production makes use of household and non-household endowments ($A_{32}$) to supply firms with

[5] In SAM terminology, **v** also is known as average expenditure to leak (see Pyatt and Round, 1979).

[6] An extensive discussion between price and quantity models can be referred to Oosterhaven (1996)

labor and capital. Then, households purchase output ($A_{13}$) from production to obtain consumption. Transfer from company ($A_{33}$) can be considered as re-distribution cost linked to household. Therefore, each this sector has implicit price index which is linked to the rest of price indices along the coefficient sub-matrices of the SAM.

Imposing substitution possibilities among production inputs and consumption imply that we specify input demand as a function of relative input prices, say, relative prices between energy and non-energy material inputs, $(p_e/p_d)$. That is,

$$\mathbf{A} = \mathbf{A}\left( p_e / p_d \right) \tag{12}$$

The implication of (12) to (9) and (10) is that,

$$\mathbf{y} = \left[ \mathbf{I} - \mathbf{A}\left( p_e / p_d \right) \right]^{-1} \mathbf{x} \tag{13}$$

$$\mathbf{p} = \mathbf{p}\,\mathbf{A}\left( p_e / p_d \right) + \mathbf{p}_v \mathbf{v} \tag{14}$$

Inserting factor demand (12) in the basic SAM model shows that changes in supply side of (14) also has implications on the demand side of (13).

To incorporate the substitution possibilities into the SAM, the estimated substitution and share parameters as in Section 2.1 and 2.2 are used to alter the fixed SAM coefficients. For production account, the estimated elasticity of substitution and share parameters are combined to modify elements of sub-matrices $A_{11}$ and $A_{21}$. For household consumption (sub-matrix $A_{32}$), expenditure elasticity is applied[7]. Accordingly, a mixed-coefficient matrix $\overleftrightarrow{\mathbf{A}}'$ is introduced as an alternative to the fixed-coefficient matrix $\mathbf{A}'$

$$\begin{bmatrix} p_1 \\ p_2 \\ p_3 \end{bmatrix} = \begin{bmatrix} p_1 \\ p_2 \\ p_3 \end{bmatrix} \begin{bmatrix} \overleftrightarrow{A}_{11} & \overleftrightarrow{A}_{21} & \\ & & \overleftrightarrow{A}_{32} \\ A_{13} & & A_{33} \end{bmatrix}' + \begin{bmatrix} p_{v1} \\ p_{v2} \\ p_{v3} \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix}$$

which equivalent to

$$\mathbf{P} \quad = (\mathbf{I} - \overleftrightarrow{\mathbf{A}}')^{-1}\, \mathbf{p}_v \mathbf{v} \ = \ \overleftrightarrow{\mathbf{M}}'\, \mathbf{p}_v \mathbf{v} \tag{15}$$

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[7] Derivation of $\overleftrightarrow{A}_{32}$ is less complicated compared to that of $\overleftrightarrow{A}_{12}$ and $\overleftrightarrow{A}_{32}$. $\overleftrightarrow{A}_{32}$ can be simply derived by multiplying each element $A_{32}$ by expenditure elasticity $\theta$

where $\overleftrightarrow{A}_{11}$ , $\overleftrightarrow{A}_{12}$ and $\overleftrightarrow{A}_{32}$ are new coefficient matrices which contain substitution effects. Importantly, the mixed-coefficient matrix $\overleftrightarrow{\mathbf{A}}'$ contains new coefficients, but still maintains the same column sums as the fixed-coefficient matrix $\mathbf{A}'$.

### 3.2 Imposing a price shock

A price shock examined by the SAM price model can be imposed in two ways: (i) a price shock due to an increase in exogenous cost component, e.g., cost of import; or (ii) due to increase in cost of an endogenous component, e.g., petroleum products. We adopt the second approach in this study. The price of petroleum products is assumed entirely exogenous regarding the major price components in the energy products are controlled by the government.

Treating the price of petroleum products as exogenous in the model implies that we are now working with a constraint-price multiplier method[8]. To illustrate this approach, we re-arrange the refined SAM price model in (15) by differentiating the endogenous accounts into constrained and non-constrained accounts. Constrained account is represented by the petroleum sector while non-constrained accounts are defined as the rest of the production activities, factor of production and household. For the base-year equilibrium, the approach is summarised in (16).

$$\left[\frac{p_{nc}}{p_c}\right] = \left[\frac{\overleftrightarrow{A}_{nc} \quad Q}{R \quad \overleftrightarrow{A}_c}\right]\left[\frac{p_{nc}}{p_c}\right] + \left[\frac{v_{nc}}{v_c}\right] \qquad (16)$$

where $p_{nc}$ and $p_c$ are the price vector for the non-constrained and constrained accounts, respectively. Analogously, $v_{nc}$ and $v_c$ are the exogenous vector for non-constrained and constrained account, respectively. $\left[\frac{\overleftrightarrow{A}_{nc} \quad Q}{R \quad \overleftrightarrow{A}_c}\right]$ is the transposition element of average expenditure propensities matrix where $A_{nc}$ and $A_c$ respectively represent average expenditure propensities among the non-constrained and constrained accounts. $R$ is a matrix of average expenditure propensities of non-constrained accounts on constrained account and $Q$ is a matrix of average expenditure propensities of constrained account on non-constrained accounts. By treating $p_c$ exogenously determined and re-arranging preceding equations, we obtain

[8] Hartono and Resosudarmo (2008) and Resosudarmo and Thorbecke (1996) for instance, applied this approach within a context of quantity-based model. This approach is similar to the mixed endogenous-exogenous input-output model as in Miller and Blair (1985, 2009).

$$\left[\frac{p_{nc}}{v_c}\right] = \left[\begin{array}{c|c} (I - \overleftrightarrow{A}_{nc}) & 0 \\ \hline -R & -I \end{array}\right]^{-1} \left[\begin{array}{c|c} I & Q \\ \hline 0 & -(I - \overleftrightarrow{A}_c) \end{array}\right] \left[\frac{v_{nc}}{p_c}\right] \qquad (17)$$

By assuming the exogenous costs remain unchanged, this matrix reflects the impact of changes in price of petroleum products ($p_c$) on the prices of the rest of production activities, of factor of production and of household which broadly represented by the vector of ($p_{nc}$). The vector of $v_c$ is considered as the extra revenues that will be collected by the government in form of indirect taxes.

Notice that the price-transmission matrix $\overleftrightarrow{\mathbf{M}}'$ is derived from several structural relationships, comprising the effects of $\overleftrightarrow{A}_{11} + \overleftrightarrow{A}_{21} + \overleftrightarrow{A}_{32} + A_{13} + A_{33}$. In turn, we can decompose the effects of petroleum price shocks into three separate effects namely transfer effect, open-loop effect and closed-loop effect (see, Pyatt and Round, 1979 for an overview). Although there are a number of decomposition forms which can be applied to breakdown the effects, this decomposition is preferred because it explains the main cycle in the circular flow of costs between production, factor of production and household. The decomposition of matrix $\overleftrightarrow{\mathbf{M}}'$ can be illustrated as follows:

$$\overleftrightarrow{\mathbf{M}}' = \overleftrightarrow{\mathbf{M}}'_1 \overleftrightarrow{\mathbf{M}}'_2 \overleftrightarrow{\mathbf{M}}'_3 \qquad (18)$$

$\overleftrightarrow{\mathbf{M}}'_1$, $\overleftrightarrow{\mathbf{M}}'_2$ and $\overleftrightarrow{\mathbf{M}}'_3$ are termed as transfer effect, open-loop effect and closed-loop effect, respectively.

where $\overleftrightarrow{\mathbf{M}}'_1 = (\mathbf{I} - \widetilde{\mathbf{A}}')^{-1}; \overleftrightarrow{\mathbf{M}}'_2 = (\mathbf{I} + \hat{\mathbf{A}}' + \hat{\mathbf{A}}'^2); \overleftrightarrow{\mathbf{M}}'_3 = (\mathbf{I} - \hat{\mathbf{A}}'^3)^{-1}$ (19)

Specifically, matrix $\widetilde{\mathbf{A}}'$ and $\hat{\mathbf{A}}'$ can be defined as follows;

$$\widetilde{\mathbf{A}}' = \begin{bmatrix} \overleftrightarrow{A}_{11} & & \\ & & \\ & & A_{33} \end{bmatrix} \qquad \hat{\mathbf{A}}' = (\mathbf{I} - \widetilde{\mathbf{A}}')^{-1}\mathbf{W};\ \mathbf{W} = \begin{bmatrix} & \overleftrightarrow{A}_{21} & \\ & & \overleftrightarrow{A}_{32} \\ A_{13} & & \end{bmatrix} \qquad (20)$$

Concerning shocks in petroleum prices, matrix $\overleftrightarrow{\mathbf{M}}'_1$ captures how an increase in prices affect costs of production of other economic activities through inter-industry cost linkages. Matrix $\overleftrightarrow{\mathbf{M}}'_2$ indicates how the same exogenous cost increase ends up having an impact on cost of factor of production and household. Matrix $\vec{\mathbf{M}}'_3$ on the other hand indicates the effect of full circular expenditure flows after capturing consumption of commodities.

**4. Sources of data**

The major dataset used in this study is a SAM for Malaysia for 2000. The SAM is constructed mainly for the purpose of analysis of income distribution across ethnic groups in Malaysia. It contains broadly nine groups of accounts namely, production, factor of production, household, company, government, consolidated capital, current and capital for the rest of the world, and indirect tax. The SAM is detailed in the following respect: (i) production is classified into 92 production activities; (ii) factor of production is disaggregated into 25 types of labors and two capital inputs; and (iii) household is distinguished into nine groups. The rest of the SAM accounts are in an aggregate form.

Production account is structured based on classifications of the existing input-output tables. However, some industries are consolidated with other related-industries which results the reduction in classifications of industries from 92 to 41 industries. The reason for the aggregations is that the available dataset for econometric estimation do not cover at very detailed industries as listed in our SAM. For example, a complete series of annual data that needed to perform the nested CD function is only available at 2-digits Malaysian Standard Industrial Classification (MSIC, Department of Statistics, 2000b). Similarly, classifications of consumption in the household expenditure survey (HES) do not cover at very detailed commodities (see, Department of Statistics, 2000a).

In the account for factor of production, a distinction is made between labor and capital. The first distinction of labor is made between citizens and non-citizens. There are 24 types of citizenship labors are disaggregated (4 ethnic groups × 3 skill types × 2 geographical areas = 24 types)[9]. Capital inputs are distinguished into the capital inputs that owned by household and corporate.

[9] Skills are classified based on certificates obtained from school, college or university. Those who do not have any formal education or a primary school certificate are classified as the low skill category, those with secondary school certificates (e.g. L.C.E., M.C.E. or H.S.C.) are assigned as the medium skill category, while those with at least a diploma or degree are considered as the high skill category. Geographical locations are distinguished into rural and urban areas.

The criteria for classifying household and labor are inevitably inter-related given that characteristics of individuals are the essential ingredients common to both sets of accounts. Therefore, the classification of household in the SAM follows closely to the labor classifications, with the only exception is with respect to the skill types. This would lead to the nine distinguished household groups (4 ethnic groups × 2 geographical areas + 1 non-citizen = 9).

To estimate parameters in the nested CD function, we collect the series of annual output and cost components—costs of capital, of labor (compensation of labor), of energy and of non-energy materials from 1985 to 2005, subject to the availability of data. The main source of the data is the annual manufacturing survey, conducted by the Department of Statistics (various years). All the data are unpublished materials but can be extracted by requesting officially to the authority.

The HES for 2000 is used to estimate the expenditure elasticity by types of commodities. The survey covers about 14,084 randomly sampled households throughout the country. The fact is that classifications of commodities in the HES are classified by a so-called COICOP (classifications of individual consumptions by purposes) whereas production industries are defined based on the MSIC. The reclassification of the commodities from COICOP to MSIC classification is easily achieved as the Department of Statistics provides correspondence classification between these two classification schemes.

## 5. Results and discussion

The first part of this section discusses estimation results of elasticity of substitution between energy and other inputs, and elasticity of labor. The second part links the estimated elasticity into the SAM model. Due to lack of time-series data for agriculture, mining and construction, and services sectors, substitutions among production inputs are imposed only into 17 manufacturing sectors. Thus, input structures for the rest of the sectors in our SAM are fixed (zero substitution) as in the standard SAM model.

### 5.1 Elasticity of substitution

Regression results based on (2), (3) and (5) are given in Table 2. Estimated elasticity of output, their standard errors along with the $R^2$, Durbin-Watson (*D*-*W*) and *F* statistics for constant return to scale restriction, and elasticity of substitution are provided. Before we discuss the estimation results, it is a common practice in time-series econometrics to assess whether data that used for (2), (3) and (5) are stationary and, if necessary, cointegrated. In the presence of non-stationary variables, estimation of the standard Ordinary Least Squares (OLS) as in Table 2 may lead to misleading results. This is known as a spurious regression problem[10]. Thus, a confirmation of stationarity of the variables is conducted by using the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1981). We observe that almost all variables across all industries are found to be stationary at first-difference form or *I*(1). If the first-difference (*d*) is introduced into the logarithm variables, it may make interpretation of the elasticity of output difficult.

**<Table 2 about here>**

Estimation of the variables at level although not stationary is valid as long as a group of the non-stationary variables is cointegrated. This is a situation in which one or more linear combination among the variables is stationary. To confirm it, we conduct a cointegration test which developed by Johansen (1991, 1995). The cointegration test suggests that the variables are cointegrated for all industries. This indicates that there is a stable equilibrium linear relationship among the variables and estimation as in Table 2 would not give misleading results.

A cursory glance at Table 2 shows that six industries exhibits non-constant return to scale. Statistical test for the adding-up coefficient restriction ($\alpha + \beta + \lambda = 1$) by using a Wald test (see $F$ statistics in column (7)) indicates that these industries have return to scale different from 1. When coefficients for these industries are summing-up however, they deviate not more than 7%. Next, our primary interest is on columns (1) to (3). The estimated elasticity of output w.r.t. value added ($\alpha$) and material inputs ($\beta$) are statistically significant for all industries but, that of energy ($\lambda$) is not statistically significant for eight industries. A zero marginal products of energy may cause an estimation constraint because the same coefficient is applied to calculate the elasticity of substitution.

Notice that the elasticity of substitution are simply ratios of energy to value added and to material input coefficients (see columns (7) and (8)). Coefficients may individually not but, jointly may significant. Therefore, we provide a more formal test to find out whether the ratios between energy and the two input coefficients are in fact different than zero, using a delta approach. Our results confirm a zero elasticity of substitution of value added ($\sigma_{QE}$) and material inputs ($\sigma_{DE}$) for energy for the eight industries. A direct implication of these outcomes is that at

[10] Franser (2002) examines the time-series properties of data in Cobb and Douglas (1928) and finds a mix of stationary and non-stationary variables.

the top nest for those industries, value added, energy and material inputs are characterized by a Leontief technology.

The estimated elasticity of labor with respect to skill types are given in Table 3. All estimation properties—stationarity of the variables, return to scale restriction and serial correlation are tested and corrected. The results indicate that coefficients for elasticity of low-skilled ($\kappa$), medium-skilled ($\varphi$) and high-skilled ($\rho$) are statistically significant than zero for all industries. Among the skill types, elasticity for the low-skilled labor attributes the biggest impact on aggregate labor demand than other skills do for 11 industries. There are five industries—tobacco products, chemical products, petroleum products, basic metal products and fabricated metal products register the highest impact on high-skilled labor. We may classify these sectors as capital-intensive activities, which the advanced capital goods are biased towards skilled labor (i.e. skill intensive).

**<Table 3 about here>**

### 5.2 Simulation of price shock

A simulation of changes in petroleum prices on costs of households is made by using a refined SAM price model. In this model, elasticity of substitution that estimated in the previous sub-section have consistently linked to the standard SAM model. A caution should be kept in mind while linking the elasticity of substitution into the SAM coefficients. The manner in which the CD has been developed, the sum over the elasticity of substitution may not be equal to zero, which results the column sum of the modified SAM coefficients would not be equal to one[11]. Therefore, a normalization of the coefficients after imposing the elasticity of substitution is required.

The question of how much petroleum subsidies should be reduced by the government is a policy variable. Most governments in developing countries (including Malaysia) in 2008 have reviewed the present petroleum subsidy scheme, in response to the dramatic increased in the world prices in history, hitting at 94.45 USD per barrel (see Organization of the Petroleum Exporting Countries, OPEC, 2010). At this price level, the Malaysian government is expected to

[11] The column sum of modified SAM coefficients only can be satisfied using elasticity of substitution estimated in generalized Leontief and translog functions. The reason is that summation of the elasticity of substitution as in the generalized Leontief and translog functions would equal to zero.

subsidize petroleum about 35 billion MR (Malaysian Ringgit), which is 116% higher than amount in 2007 (see Ministry of Finance, various years). Since subsidies in 2007 are considerably "ideal" for costs to the government, we simulate an elimination of 54% subsidies in our analysis.

Next, we need to specify exogenously in our model percentage increase in domestic petroleum prices when the subsidies have been eliminated by 54%. We could not measure this directly because of lacking on subsidy data. As an alternative, we calculate a price pass-through index (see Baig et al., 2007), which measure a price transfer rate from international to domestic petroleum prices[12]. On this basis, we observe the average price pass-through index for Malaysia is 0.5043, which is a common for a net oil exporting country[13].

Since petroleum prices in Malaysia are determined by the government through the administered price mechanism, the price pass-through implies that a 1% increase in world prices would pass 0.5043% into the domestic prices while the rest of 0.4957% are subsidized by the government. In the case of removal subsidies by 54%, it implies that percentages contribution of the government into the market is declined by 0.2676% (0.54 × 0.4957%). In turn, the domestic prices are likely to increase by 0.7719% (0.5043% + 0.2676%). Taking the average basket OPEC price as a reference, 36.72% increase in world prices between 2007 and 2008 would lead us to simulate the domestic price shocks by 28.34% (36.72% × 0.7719%).

The analyses involve two steps—one is run for the price model and the other one is run for the quantity model. For the price model, the analyses are run by simulating price of petroleum product would has been 28.34% above their actual level. For the quantity model, demand of this product is assumed would has been 28.34% below their actual level. This is a unitary own price elasticity as indicated by the CD specification. In these exercises, we provide a consistent link between the econometric price and input demand with SAM price and quantity models. In addition, to quantify the extent to which input substitution affect the outcomes, we apply the same procedures as above for the standard model (fixed input coefficient).

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[12] A degree responsiveness of domestic petroleum prices also can be estimated by regressing domestic prices again world prices in logarithm form. Results however, show that the regression and pass-through approaches yield outcomes that are close to each other.

[13] Baig et al. (2007) show that the average price pass-through index for a group of net oil exporting countries for gasoline, kerosene and diesel are 0.46, 0.43 and 0.70, respectively.

Table 4 details impacts of the petroleum price hike on household expenditure (or cost of living) and of income distribution. In Panel A, rows (1) and (2) shows the differences for index cost of living and income impacts between two model versions—standard and refined models. We observe that the differences in the index cost of living and income effects between the two model solutions are marginal. In most cases, imposing input substitution effects of the increase (decline) in petroleum price (demand) on the index cost of living (income) is larger than that of the fixed input coefficient, which to a lesser extent, consistent with the outcomes as in Kratena (2005)[14]. On average, we observe the differences are 0.23% for the index cost of living and 0.13% for the income effects. The major finding here is that substitution effects that have been imposed by the CD function may have limited effects on the cost of living and income. For the discussion throughout this paper, we will focus our attention on the impacts that generated by the model with input substitution.

**<Table 4 about here>**

Panel B presents the impacts on index cost of living. For each household group, the index measures the implicit cost of acquiring the benchmark basket of goods. An increase in the index reflects, therefore, the additional income needed to keep purchasing the original basket and as such provides a simple measure of the welfare impact on individuals (Roland-Holst and Sancho, 1995). Results in row (3) indicate that the rise in the living expenses for the Chinese and Indian is higher in urban areas than in the rural areas. The ratios between urban and rural are 1.62 for the Chinese and 2.46 for the Indian (setting the rise in rural living expenses at unity). The opposite holds for the Malay and others, which the ratios are 0.71 and 0.87 (setting the rise in rural living expenses at unity). Among the ethnic groups, increase in the living costs of the Malay is the highest compared with other ethnic groups for both rural and urban areas. For rural households, we find that the rise in living expenses of Chinese, Indian and others are equal to 0.34, 0.24 and 0.49 (setting the rise in rural Malay living expenses at unity). For urban households, the differences are smaller: 0.77, 0.84 and 0.61 for Chinese, Indian and others. This provides an

[14] Kratena (2005) imposes substitution effects in an input-output model by the means of generalized Leontief function and observes that the differences in output effects of the model with input substitution compared with the fixed input coefficient for all industries are 0.2%. Using a CES function within a general equilibrium analysis Tokutsu (1994) however, shows output effects of model with input substitution are smaller than that of the fixed input coefficients.

indication those lower income households, i.e. the Malay have smaller possibilities for price substitution against energy, and thus would bear a larger proportional burden than higher income households.

In rows (4), (5) and (6), we decompose the total expenditure effects (row (3)) into the effects that contributed by the transfer effect ($\mathbf{M}_1$), open-loop effect ($\mathbf{M}_2$) and closed-loop effect ($\mathbf{M}_3$). Notice that the transfer effect is zero for all ethnic groups because this effect only affects among production sectors (see methodological discussion in Section 3.2)[15]. The main observation here is that open-loop effect contributes the most for the rise in the household cost of living. The closed-loop effect not only shows a smaller effect but also less variance across ethnic groups. For example, the deviations in the rise in living expenses for urban households as explained by the closed-loop effect are 1.16 for Chinese, 1.11 for Indian and 1.23 for others compared to 0.69, 0.78 and 0.47 as indicated by the open-loop effect (setting the rise in urban Malay living expenses at unity).

In Panel C, we calculate the nominal and real income effects after the price shock as in rows (7) and (8). The real income effects can be obtained by simply taking ratios between nominal income (row (7)) and changes in index cost of living (row (3)). Figures in parentheses denote the percentages reduction in income after the shock compared with the income before the shock. For example, the nominal income after the shock for the rural Malay are 25 billion MR, which have been reduced by 1.13%, compared with the income before the shock.

In comparison to the income before the shock, the erosion in nominal income is smaller across the ethnic groups, which declines not more than 2%. However, the percentages erosion in real income are tremendous, which population in rural areas in general, and the Malay in particular, suffer seriously. For the rural households, the burden of the Malay is about triple of the Chinese, quadruple of the Indian and double of others. For the urban households, the deviations are comparable across ethnic groups. As far as the real income is concerned, the direct implication of these outcomes on income distribution is that income gap among geographical locations and ethnic groups likely to widen. Our results in Panel C confirm this expectation.

Panel C gives the percentages distribution of the population and of income before and after the shock in rows (10), (11) and (12). Rows (13) and (14) present the real per capita income, before and after the shock in real terms. Notice that ratios in rows (13) and (14) are normalized

[15] The complete empirical results for the production sectors are available upon request from the authors

such that the (weighted) average ratio for all nine population groups equals one. For example, in row (13) we see that the real per capita income for rural Malay is 46% of the average per capita income in Malaysia. As we would already expect, results in Panel C show that the distribution of the overall effects tends to be regressive, i.e. the decrease in real per capita income is higher for the lower income households. For rural households, the real per capita income of the Chinese, Indian and others increases from 1.89, 1.88 and 2.94 to 2.14, 2.18 and 3.23 (setting per capita income of rural Malay at unity). For urban households, the increases in the real per capita income gap for these ethnic groups are smaller, which rise from 1.34, 1.11 and 2.40 to 1.38, 1.14 and 2.53 (again, setting per capita income of urban Malay at unity).

An important element in explaining the distributional impact of higher petroleum prices is analysis of the effects on income and cost of factors of production. The reason is that almost two-thirds of household income is contributed by the factor income. Table 5 shows the impacts on two types of labor—employees (distinguished by ethnic groups) and non-employees. Rows (1) and (2) show the real per capita labor income or payment per labor, before and after the shock. The real labor income is defined as ratios between nominal labor income and the increase in index wage rates (after shock). For employee categories, results in row (2) are obtained by taking ratios between distribution (or share) of real income as in (3) and of labor as in (5) across ethnic groups[16]. The same procedures are applied for results in row (1). For non-employee category, the real per capita labor income is obtained by simply taking a ratio between their actual income and labor. No further distinction of non-employee is made in our SAM.

<**Table 5 about here**>

Analyzing the results in rows (1) and (2) provide a clear indication that reduction in real per capita employees income can be put forward to explain for the increase in income gap due to the shock. We observe that the distribution of the "real wage rate" for the Malay reduces substantially whereas that of Chinese, Indian and others increases. As a result, the gap in real wage rate for the Chinese, Indian and others increases from 1.40, 1.29 and 0.74 to 1.59, 1.49 and 0.80 in rural areas (setting payment per rural Malay employees at unity). For urban employees, the gap is relatively smaller, which rises from 1.04, 0.94 and 0.72 to 1.07, 0.97 and 0.76. The non-employees income may not show a significant effect on the overall household income because their payment per labor decreases only by 1.63%.

[16] Sectoral labor-output ratio is used to calculate the total labor requirements after the price shock.

It should be stressed that the declining in the real per capita employees income is influenced by two forces—the number of labor and the real employees income. Results in row (5) indicate that percentage reduction of labor due to the price shock not only smaller but also less variance across ethnic groups. However, the percentage reduction in real "wages" is substantial as much as the percentage erosion in real household income. For rural employees, we observe the impact of the Malay is 2.5 *times* the Chinese, 3.4 *times* the Indian and 1.8 *times* others. For urban employees, the deviations are smaller which results, as shown above, the lesser gaps in real household income and real employees income. In Panel B, the reduction in real "wages" is disaggregated by skill types. For each ethnic group, the reduction rates are considerably constant irrespective skill types, which indicate a constant increase in index wage rates for each ethnic group across skill types[17].

Although the substitution effects are smaller in magnitude, it may worth to discuss the degree substitutability of the labors across ethnic groups with respect to energy. Results in row (5) show that the degree substitutability of labors for the Chinese and Indian slightly higher than the Malay. For example, the percentage reductions of labors after the shock are 0.98%, 1.00% and 1.22% for the Malay, Chinese and Indian in rural areas, and in urban areas, the percentage reductions are 1.01%, 1.02% and 1.20%. The similar observations hold for the nominal income effects as in row (4). To a lesser extent, rising energy price favors the Malay labor at the expense of Chinese and Indian labors. Disaggregating the labors by skill types as in Panel C, the high-skilled labors explain the most for the Malay; the percentage reductions are 0.63% for rural household and 0.73% for urban household.

## 6. Conclusion and policy recommendations

We have shown that increase in petroleum price with the aim of eliminating petroleum subsidies may have serious implications on the distribution of income. Households in rural areas in general

[17] We observe in the price model version, the effects of changes in commodity prices on wage rates across skill types for each ethnic group constant for a particular production sector. These outcomes may reflect the homogeneity assumption of the distribution of employees income on household groups. For example, the incomes of the low-, medium- and high-skilled of rural Malay employees is entirely destined for rural Malay households. As a consequence, the column coefficients for the low-, medium- and high-skilled have the same share, which in turn leads to the constant coefficients across skill types for a particular production sector.

and lower income groups in particular, could be affected severely. Therefore, as a counter policy, it would be necessary for the government to compensate the reduction in real income of the lower income households. We observe in our model that 16.75% (which equivalent to 18,335 million MR) of additional revenues in the form of indirect taxes would be collected as a result of increase in 28.34% of petroleum price.

The additional revenues can be used to alleviate the negative effects of living costs of households in two ways—immediate and long-term measures. For the immediate measures, the designed compensation programs must be specific to the target groups. For example, a policy for subsidizing commodities that are mostly affected due to petroleum price hike may not be effective because higher income households may consume larger quantities of the commodities and thus they benefit relatively more from the subsidies (see, for instance, Saboohi, 2001; Gangopadhyay, et al., 2005).

The first option for the immediate action would be to provide some direct cash transfers to the lower income households as were applied in many countries, such as, Indonesia and Jordan. For the simplest example, if 30% of additional revenues (or 5,501 million MR) are re-distributed directly to the rural Malay, we observe that the gap in per capita income for rural households after the shock would be reduced to 1.69 for the Chinese, 1.72 for the Indian and 2.56 for others (setting per capita income of rural Malay at unity). Another option is to provide subsidy coupons for fishery products, petroleum products, electricity and gas, and transport services. The reason is that price of these commodities have increased largely in response to the petroleum price hike and these commodities are among the largest consumed by the lower income households. As a consequence, the lower income households pay less than the market prices for the commodities and would benefit directly from the subsidy schemes.

For the long-term mitigating measures, the additional revenues can be used to expand and modernize public transport networks. Households consume a large part of their income on petroleum products (mainly petrol and diesel) because substitution to public transports might be "unwelcome" under the situation of limited connection of public transports. Another area for the mitigating measures is to develop or design a social security program for the lower income households. Expanding the access to the basic need items, such as, foods, clothes, education and health should be given priority in the program.

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**Figure 1**
The nested structure of the production functions

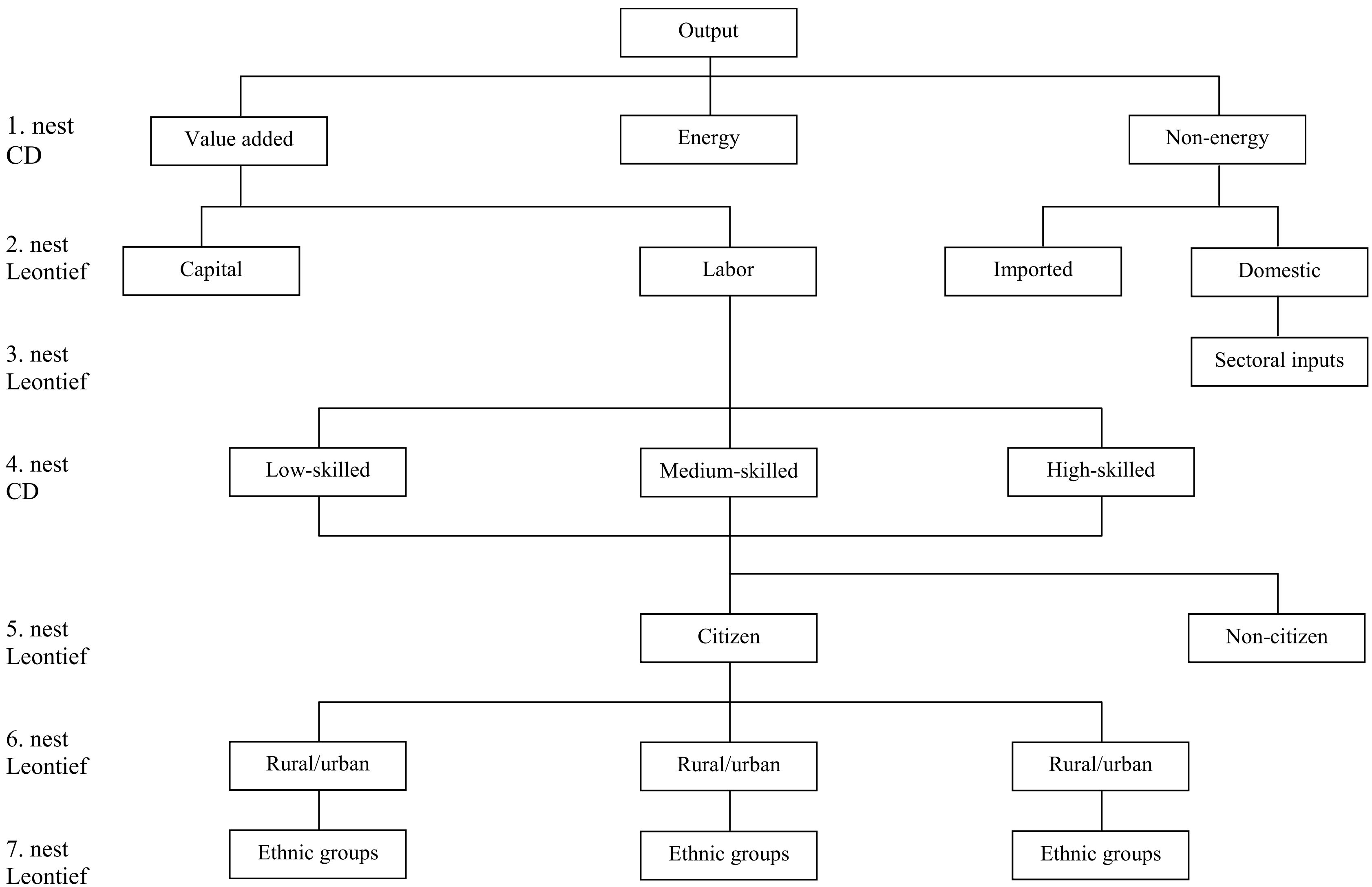

**Table 1**
Schematic representation of endogenous and exogenous accounts in SAM for Malaysia for 2000

| | | | Expenditures ($j$) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Endogenous accounts | | | | Exo. account | Total |
| | | | (1) | (2) | (3) | (4) | (5) | (6) |
| Incomes ($i$) | Production | (1) | $T_{11}$ | 0 | $T_{23}$ | 0 | $x_1$ | $y_1$ |
| | Factor of production | (2) | $T_{21}$ | 0 | 0 | 0 | $x_2$ | $y_2$ |
| | Household | (3) | 0 | $T_{32}$ | 0 | $T_{34}$ | $x_3$ | $y_3$ |
| | Company | (4) | 0 | $T_{42}$ | 0 | 0 | $x_4$ | $y_4$ |
| | Exogenous accounts | (5) | $L_{51}$ | $L_{52}$ | $L_{53}$ | $L_{54}$ | t | $y_5$ |
| | Total | (6) | $y'_1$ | $y'_2$ | $y'_3$ | $y'_4$ | $y'_5$ | |

**Table 2**
Estimated partial elasticity of substitution between energy and non-energy inputs

| | Elasticity of output w.r.t. | | | $R^2$ | *D-W* | *F* | $\sigma_{QE}$ | $\sigma_{DE}$ |
|---|---|---|---|---|---|---|---|---|
| | $\alpha$ | $\beta$ | $\lambda$ | | | | $(-\beta Q/\alpha E)$ | $(-\beta D/\lambda E)$ |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Food and beverages | 0.1705[a] | 0.0130[a] | 0.8154[a] | 0.9999 | 1.9870 | 1.3668[d] | 0.0767[a] | 0.0160[a] |
| | (0.0042) | (0.0011) | (0.0034) | | | | (0.0074) | (0.0014) |
| Tobacco products | 0.5866[a] | 0.1828[a] | 0.2163[a] | 0.9329 | 1.7323 | 0.0440[d] | 0.3117[b] | 0.8453[b] |
| | (0.0744) | (0.0536) | (0.0291) | | | | (0.1123) | (0.3431) |
| Textile products | 0.4033[a] | 0.0068[d] | 0.6139[a] | 0.9986 | 1.7342 | 5.7277[b] | 0.0170[d] | 0.0112[d] |
| | (0.0131) | (0.0276) | (0.0303) | | | | (0.0685) | (0.0455) |
| Wearing apparel | 0.4550[a] | 0.0119[d] | 0.5413[a] | 0.9999 | 2.0849 | 3.2845[c] | 0.0262[d] | 0.0220[d] |
| | (0.0086) | (0.0095) | (0.0084) | | | | (0.0211) | (0.0179) |
| Leather and footwear | 0.4026[a] | 0.0076[d] | 0.5907[a] | 0.9995 | 2.0475 | 0.0063[d] | 0.0189[d] | 0.0129[d] |
| | (0.0237) | (0.0193) | (0.0247) | | | | (0.0481) | (0.0330) |
| Wood and wood products | 0.3902[a] | 0.0192[a] | 0.5939[a] | 0.9998 | 1.7329 | 0.4657[d] | 0.0492[a] | 0.0324[a] |
| | (0.0071) | (0.0058) | (0.0049) | | | | (0.0029) | (0.0100) |
| Paper products | 0.4113[a] | 0.0311[a] | 0.5515[a] | 0.9998 | 1.7699 | 1.3779[d] | 0.0757[a] | 0.0564[a] |
| | (0.0140) | (0.0085) | (0.0150) | | | | (0.0199) | (0.0167) |
| Chemical products | 0.6355[a] | 0.0516[d] | 0.3511[a] | 0.9984 | 2.0280 | 1.5457[d] | 0.0813[d] | 0.1471[d] |
| | (0.0563) | (0.0300) | (0.0382) | | | | (0.0486) | (0.0970) |
| Petroleum products | 0.2888[a] | 0.0018[d] | 0.7049[a] | 0.9997 | 1.9596 | 0.2552[d] | 0.0063[d] | 0.0026[d] |
| | (0.0144) | (0.0208) | (0.0227) | | | | (0.0722) | (0.0297) |
| Rubber and plastic products | 0.4941[a] | 0.0001[d] | 0.5477[a] | 0.9993 | 1.7478 | 1.0846[d] | 0.0002[d] | 0.0002[d] |
| | (0.0418) | (0.0335) | (0.0267) | | | | (0.0680) | (0.0613) |
| Non-metallic products | 0.4212[a] | 0.0869[a] | 0.4213[a] | 0.9988 | 2.0716 | 16.384[a] | 0.2064[a] | 0.2064[a] |
| | (0.0143) | (0.0205) | (0.0326) | | | | (0.0530) | (0.0616) |
| Basic metal | 0.1901[a] | 0.0269[a] | 0.7819[a] | 0.9999 | 1.8894 | 0.2507[d] | 0.1416[a] | 0.0344[a] |
| | (0.0069) | (0.0039) | (0.0062) | | | | (0.0224) | (0.0051) |
| Fabricated metal | 0.3981[a] | 0.0161[b] | 0.5962[a] | 0.9999 | 2.100 | 1.6349[d] | 0.0405[b] | 0.0271[b] |
| | (0.0107) | (0.0072) | (0.0073) | | | | (0.0185) | (0.0123) |
| Industrial machinery and equipment | 0.2803[a] | 0.0000[d] | 0.6967[a] | 0.9999 | 1.9673 | 3.6942[c] | 0.0003[d] | 0.0001[d] |
| | (0.0178) | (0.0231) | (0.0138) | | | | (0.0826) | (0.0332) |
| Electrical and electronics apparatus | 0.1878[a] | 0.0202[c] | 0.7598[a] | 0.9998 | 1.8044 | 17.980[a] | 0.1075[c] | 0.0266[c] |
| | (0.0159) | (0.0096) | (0.0124) | | | | (0.0507) | (0.0129) |
| Transport equipments | 0.2926[a] | 0.0335[c] | 0.6944[a] | 0.9997 | 1.7067 | 4.2076[c] | 0.1146[c] | 0.0483[c] |
| | (0.0101) | (0.0156) | (0.0128) | | | | (0.0551) | (0.0233) |
| Other manufacturing products | 0.6773[a] | 0.0114[d] | 0.3012[a] | 0.9996 | 2.1509 | 0.1284[d] | 0.0170[d] | 0.0381[d] |
| | (0.2127) | (0.0643) | (0.0131) | | | | (0.0959) | (0.2138) |

Sources: estimated from equations (2) and (5)
Notes: *a* = significant at 1% level; *b* = significant at 5% level; *c* = significant at 10% level; *d* = insignificant at 10% level. Figures in parentheses are standard error estimates

**Table 3**
Estimated partial elasticity of labor

| | Elasticity of labor w.r.t. | | | $R^2$ | *D-W* | *F* |
|---|---|---|---|---|---|---|
| | $\rho$ | $\varphi$ | $\kappa$ | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Food and beverages | 0.3012[a] | 0.2690[a] | 0.4529[a] | 0.9999 | 1.7497 | 6.8594[b] |
| | (0.0269) | (0.0193) | (0.0107) | | | |
| Tobacco products | 0.4575[a] | 0.2997[a] | 0.3327[a] | 0.9953 | 1.8406 | 10.8283[a] |
| | (0.0406) | (0.0262) | (0.0125) | | | |
| Textile products | 0.2377[a] | 0.3068[a] | 0.4073[a] | 0.9988 | 1.9534 | 10.1995[a] |
| | (0.0464) | (0.0472) | (0.0134) | | | |
| Wearing apparel | 0.3153[a] | 0.2270[a] | 0.4993[a] | 0.9977 | 1.8847 | 3.4684[c] |
| | (0.0542) | (0.0603) | (0.0205) | | | |
| Leather and footwear | 0.3762[a] | 0.2119[a] | 0.4284[a] | 0.9970 | 1.6852 | 0.9090[d] |
| | (0.0487) | (0.0433) | (0.0143) | | | |
| Wood and wood products | 0.2614[a] | 0.1907[a] | 0.5414[a] | 0.9998 | 2.0501 | 1.7658[d] |
| | (0.0257) | (0.0165) | (0.0066) | | | |
| Paper products | 0.3000[a] | 0.3104[a] | 0.4298[a] | 0.9998 | 2.0389 | 2.9912[d] |
| | (0.0228) | (0.0192) | (0.0117) | | | |
| Chemical products | 0.3997[a] | 0.3042[a] | 0.3150[a] | 0.9990 | 2.0248 | 13.7608[a] |
| | (0.0156) | (0.0121) | (0.0076) | | | |
| Petroleum products | 0.4066[a] | 0.3442[a] | 0.2649[a] | 0.9993 | 2.0950 | 5.1807[b] |
| | (0.0239) | (0.0167) | (0.0150) | | | |
| Rubber and plastic products | 0.2856[a] | 0.2750[a] | 0.4653[a] | 0.9999 | 2.0015 | 102.0057[a] |
| | (0.0184) | (0.0131) | (0.0076) | | | |
| Non-metallic products | 0.3059[a] | 0.2735[a] | 0.4384[a] | 0.9999 | 1.6629 | 9.0074[a] |
| | (0.0424) | (0.0350) | (0.0086) | | | |
| Basic metal | 0.4254[a] | 0.3435[a] | 0.2286[a] | 0.9999 | 2.0197 | 1.5031[d] |
| | (0.0087) | (0.0083) | (0.0067) | | | |
| Fabricated metal | 0.3957[a] | 0.2399[a] | 0.3869[a] | 0.9998 | 1.4641 | 1.9297[d] |
| | (0.0300) | (0.0231) | (0.0117) | | | |
| Industrial machinery and equipment | 0.3023[a] | 0.3071[a] | 0.3991[a] | 0.9993 | 2.1661 | 0.6048[d] |
| | (0.0508) | (0.0398) | (0.0171) | | | |
| Electrical and electronics apparatus | 0.2827[a] | 0.3696[a] | 0.3611[a] | 0.9998 | 1.4367 | 0.1201[d] |
| | (0.0435) | (0.0420) | (0.0110) | | | |
| Transport equipments | 0.3304[a] | 0.2705[a] | 0.3965[a] | 0.9994 | 1.7960 | 0.0316[d] |
| | (0.0529) | (0.0338) | (0.0173) | | | |
| Other manufacturing products | 0.2156[a] | 0.3447[a] | 0.4807[a] | 0.9999 | 1.8667 | 34.8535[a] |
| | (0.0340) | (0.0263) | (0.0096) | | | |

Sources: estimated from equation (6).
Notes: *a* = significant at 1% level; *b* = significant at 5% level; *c* = significant at 10% level; *d* = insignificant at 10% level. Figures in parentheses are standard error estimates

**Table 4**
Impacts of 28.34% petroleum price hike on households

| | | Rural | | | | Urban | | | | Non- |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Malay | Chinese | Indian | Other | Malay | Chinese | Indian | Other | citizen |
| **A. Differences of the refined model compared with the standard model (%)** | | | | | | | | | | |
| Expenditure effects | (1) | -0.36 | 0.26 | 0.13 | 1.95 | -0.19 | 0.23 | -0.35 | 0.98 | 0.57 |
| Income effects | (2) | -0.43 | -0.72 | 1.03 | 1.53 | 0.40 | 0.94 | -1.17 | -4.58 | 0.12 |
| **B. Increase in expenditure (%)** | | | | | | | | | | |
| Total effects | (3) | 21.62 | 7.24 | 5.19 | 10.68 | 15.28 | 11.75 | 12.78 | 9.26 | 4.74 |
| Decomposition of total effects (3) | | | | | | | | | | |
| Transfer effect ($M_1$) | (4) | - | - | - | - | - | - | - | - | - |
| Open-loop effect ($M_2$) | (5) | 18.36 | 4.28 | 2.73 | 7.30 | 12.62 | 8.66 | 9.82 | 5.97 | 3.11 |
| Closed-loop effect ($M_3$) | (6) | 3.26 | 2.97 | 2.46 | 3.37 | 2.66 | 3.10 | 2.96 | 3.29 | 1.63 |
| **C. Income effects after shocks (million MR)** | | | | | | | | | | |
| Nominal income | (7) | 25,109 | 10,032 | 3,856 | 4,495 | 40,023 | 46,747 | 10,277 | 3,832 | 9,684 |
| | | (1.13) | (1.27) | (1.30) | (1.31) | (1.21) | (1.30) | (1.30) | (1.55) | (1.62) |
| Real income | (8) | 20,882 | 9,475 | 3,714 | 4,115 | 35,144 | 42,380 | 9,232 | 3,562 | 9,398 |
| | | (17.78) | (6.75) | (4.93) | (9.65) | (13.25) | (10.51) | (11.33) | (8.47) | (4.52) |
| **D. Distribution and per capita income effects** | | | | | | | | | | |
| Population (%) | (10) | 35.37 | 7.49 | 2.89 | 2.16 | 23.28 | 20.33 | 5.37 | 0.93 | 2.18 |
| Income before shock (%) | (11) | 16.28 | 6.51 | 2.50 | 2.92 | 25.96 | 30.35 | 6.67 | 2.49 | 6.31 |
| Real Income after shock (%) | (12) | 15.14 | 6.87 | 2.69 | 2.98 | 25.48 | 30.73 | 6.69 | 2.58 | 6.82 |
| Real per capita income before shock [ratio (11)/(10)] | (13) | 0.46 | 0.87 | 0.87 | 1.35 | 1.12 | 1.49 | 1.24 | 2.68 | 2.90 |
| Real per capita income after shock [ratio (12)/(10)] | (14) | 0.43 | 0.92 | 0.93 | 1.38 | 1.09 | 1.51 | 1.25 | 2.77 | 3.13 |

Source: estimated from equations (17) and (19).
Notes: figures in parentheses are the percentages reduction in income over income before the price shock.

**Table 5**
Impacts of 28.34% petroleum price hike on labors

| | | Employees | | | | | | | | | Non-employees |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rural Malay | Rural Chinese | Rural Indian | Rural other | Urban Malay | Urban Chinese | Urban Indian | Urban other | Non-citizen | |
| **A. Per capita labor income, income and labor** | | | | | | | | | | | |
| Real per capita labor income (MR) | | | | | | | | | | | |
| Before shock | (1) | 0.62 | 0.87 | 0.80 | 0.46 | 1.27 | 1.32 | 1.20 | 0.91 | 1.24 | 20.25 |
| After shock | (2) | 0.58 | 0.92 | 0.87 | 0.47 | 1.25 | 1.33 | 1.21 | 0.94 | 1.35 | 19.92 |
| Income and labor | | | | | | | | | | | |
| Real income (million MR) | (3) | 12,850 | 5,758 | 2,058 | 2,294 | 21,544 | 25,701 | 5,446 | 2,013 | 5,093 | 43,697 |
| | | (17.68) | (7.04) | (5.24) | (9.81) | (13.40) | (10.74) | (11.57) | (9.06) | (5.34) | (13.60) |
| Nominal income (million MR) | (4) | 15,550 | 6,164 | 2,162 | 2,532 | 24,743 | 28,637 | 6,123 | 2,194 | 5,327 | 49,332 |
| | | (0.39) | (0.49) | (0.46) | (0.44) | (0.54) | (0.55) | (0.59) | (0.87) | (0.98) | (2.45) |
| Labor (thousand) | (5) | 1,879 | 530 | 201 | 417 | 1,464 | 1,630 | 381 | 181 | 319 | 2,476 |
| | | (0.98) | (1.00) | (1.22) | (0.77) | (1.01) | (1.02) | (1.20) | (0.95) | (1.07) | (0.85) |
| **B. Reduction in real labor income by skill types (%)** | | | | | | | | | | | |
| Low skilled | (6) | 17.74 | 7.00 | 5.29 | 9.84 | 13.74 | 10.77 | 11.52 | 8.61 | | |
| Medium skilled | (7) | 17.63 | 7.01 | 5.16 | 9.83 | 13.29 | 10.69 | 11.47 | 9.19 | | |
| High skilled | (8) | 17.75 | 7.13 | 5.44 | 9.64 | 13.51 | 10.81 | 11.80 | 9.28 | | |
| **C. Reduction in labor by skill types (%)** | | | | | | | | | | | |
| Low skilled | (9) | 0.88 | 0.96 | 1.15 | 0.74 | 1.05 | 1.01 | 1.28 | 0.99 | | |
| Medium skilled | (10) | 1.11 | 1.07 | 1.28 | 0.87 | 1.06 | 1.05 | 1.22 | 0.91 | | |
| High skilled | (11) | 0.63 | 1.00 | 1.61 | 0.36 | 0.73 | 0.97 | 0.83 | 0.98 | | |

Source: estimated from equations (17) and (19).
Notes: figures in parentheses are the percentages reduction in income over income before the price shock.