CHAPTER 3

METHODOLOGY

This study focuses on quantifying the economic impacts of FDI productivity spillover on Thai economy as a result of the technological advantages diffused from MNC affiliates to domestic firms in the automotive sector. This study employs a quantitative approach called the Computable General Equilibrium model, hence for the CGE model, to evaluate such impacts. In this chapter, the first section will provide some descriptions about the CGE model and its structure while the next section will present the theoretical structure of the CGE model used in this study. The closure of the CGE model will be provided in the last section.

3.1 The Computable General Equilibrium Model

The CGE model is one type of model representing relationship among various economic agents living in an economy in which it can be called as 'multisectoral model'. The multisectoral model in this case can be disaggregated into three main types which are the Input-Output (I-O) model, the Social Accounting Matrix (SAM) model and the CGE model.

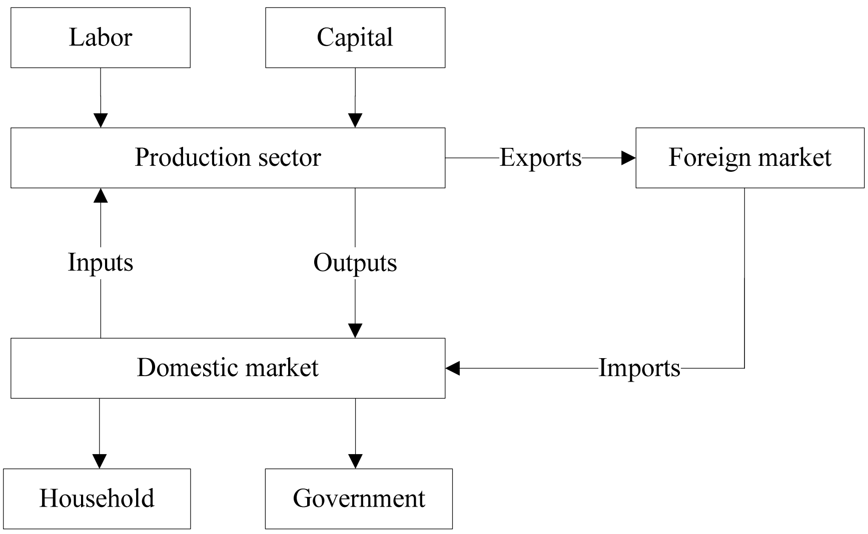
The CGE model has been developed from a foundation based on both the I-O model and SAM model. The I-O model and SAM model present relationship of all variables in the model in terms of only values, thus making these two unable to answer either the change of model variables deriving from the change in prices or the change in quantities, while the CGE model defines all variables in the model and their relationship in terms of separating prices and quantities. This special feature enables the CGE model to explain the change of all economic variables by classifying the change in prices and the change in quantities.

Strong points of the CGE model denote the capability in showing relationship of all economic variables in the model which is considered as an essential key in analyzing the impacts of some certain policy on resource allocation including the impacts on economic structure as well. Since the CGE model concerns an economic adjustment which is relative and linkable together, thus enabling more reliable results. From good points of the CGE model, it can be used as a tool to make a general assessment to the great extent especially in an analysis of the impacts of policy affecting the wider margin.

The CGE model satisfies the fact that an economy works simultaneously. This is because the CGE model simulates the functioning of an economy by explicitly capturing behavior of all economic agents in an economy which generally are producer, household, government, investor, exporter and importer, and by including the institutional framework through the market clearing processes. Figure 3.1 shows the simple structure of the CGE model.

Figure 3.1

Basic Structure of the CGE Model



The CGE model is designed to provide a description of the evolution of an economy over a number of periods given the exogenous parameters and policy instruments. Its structure can be separated into static general equilibrium model which solves within each period and dynamic general equilibrium model which links over some successive periods. Supply and demand of factor inputs, commodities and foreign exchanges are derived based on the behavior optimization of economic agents. A set of equilibrium prices that balances supply and demand in each market within each period can be calculated given the behavioral rules of agents, exogenous parameters and the market system. After supply and demand in each market have been determined, the price system have to be found to clear the market.

The CGE model used in this study is in the Johansen class in which the distinguishing characteristic of the Johansen-type model is that it is written as a system of linear equations in the percentage changes of the variables (Dixon et al., 1982). In matrix notation, the Johansen model can be represented by

$$A.z \quad = \quad 0$$

where A is an $m \times n$ matrix of coefficients

z is an $n \times 1$ vector of the percentage changes of the model variables

The equations of a typical Johansen model are classified into five groups:

(1) equations describing household and other final demands for commodities;

(2) equations describing the industry (producer) demand for primary factors and intermediate inputs;

(3) pricing equations setting pure profits from all activities to zero;

(4) market clearing equations for primary factors and commodities; and

(5) miscellaneous definitional equations, e.g. equations defining GDP, aggregate employment and the consumer price index.

The model normally contains more variables than equations. Where n is total number of variables and m is total number of equations (where $n > m$), hence, the selection of $n - m$ variables must be declared exogenous. The exogenous variables are selected to suite the study purpose and largely user-determined. Once, the choice of exogenous variables has been made, the first equation is rewritten as

$$A_1.y \;+\; A_2.x \quad = \quad 0$$

where y is the $m \times 1$ vector of endogenous variables where y is subvector of z

x is the $n \times 1$ vector of exogenous variables where x is subvector of z

A_1 is the $m \times m$ matrix formed by the m columns of A corresponding to the number of endogenous variables

A_2 is the $m \times n$ matrix formed by the m columns of A corresponding to the number of exogenous variables

Provided that A_1 is invertible (A_1 will be invertible for all sensible classifications of variables between the exogenous and endogenous categories in which the number of endogenous variables must equal with the number of equations), then one can express the solution of y in terms of x as

$$y = -A_1^{-1}.A_2.x$$

This expresses the percentage change in each endogenous variable as a linear function of the percentage changes of all exogenous variables. Noting that $\left(-A_1^{-1}A_2\right)_{ij}$ is an elasticity of the i^{th} endogenous variable with respect to the j^{th} exogenous variable.

To perform a linear formulation of the Johansen approach, all equations in the model need to be transformed into the rate of change in percentage change forms of all variables. Therefore, let y (denoted by the small letter) be the percentage change of variable Y (denoted by the capital letter) such that $y = \left(dY/Y\right) \times 100$. Details and derivations about transforming the equation into the percentage change form are shown in Appendix D.

3.2 The Theoretical Structure of the CGE Model in This Study

The model used in this study is adapted from the theoretical features of ORANI (Dixon et al., 1982) and NARAI1 (Office of Industrial Economics, 2004) in the Johansen type. The model descriptions are as follows:

1. The model is a comparative static CGE model for investigating the impacts of FDI productivity spillover on Thai economy.
2. Thai economy is considered as a small and open economy which consists of various economic activities; the production sector, the household sector, the government sector, the investment sector and the international trade sector including exports and imports.

3. The sectors of production assumed in the model are classified into nine sectors corresponding to the supply chains of the automotive sector which are Metal and metal products (met), Rubber and plastic products (rub), Components (com), Engines (eng), Electrical machineries (ele), Agricultural and mining (agm), Other manufacturing (oma), Services (ser) and Motor vehicle (mot). Thus, let IND be the set of production sectors whose elements ('i') are the sectors of production:

$$i \in IND = \{ met, rub, com, eng, ele, agm, oth, ser, mot \}$$

4. Each production sector produces only one type of output, thus let COM be the set of commodities ('c') used as intermediate inputs for the production and also consumption goods for final users. It is noticed that the set of commodities (COM) and the set of production sectors (IND) are equal set such that $IND = COM$:

$$c \in COM = \{ met, rub, com, eng, ele, agm, oth, ser, mot \}$$

5. Commodities can come from domestic production or foreign market by importing such commodities. Thus, let SRC be the set of sources of commodity whose elements ('s') are domestic and import sources:

$$s \in SRC = \{ dom, imp \}$$

6. There are two main types of factor of production which are intermediate composite commodities (domestic and imported commodities) and primary inputs (labor and capital).
7. Labor and capital are mobile factors.
8. The producers in all production sectors produce outputs in perfectly competitive market with constant return to scale production technology.
9. Final demand for domestic and imported commodity comes from household and government consumption, exports (only domestic goods), capital formation and change in inventories.

The model is derived from solutions to optimization problems of various economic agents which are producers, household, government and investor where foreign demand for Thai's exports depends on the commodities' prices in terms of foreign currency. The model also contains market clearing conditions, prices determinations and some other related equations. The model equations are arranged in eleven equation groups as follows: production sector and factor market, household income and consumer demand, government revenue and expenditure, international trade, capital formation demand, demand of the change in inventories, market clearing conditions, zero profit conditions, price determinations, miscellaneous equations and nested structure of productivity spillovers.

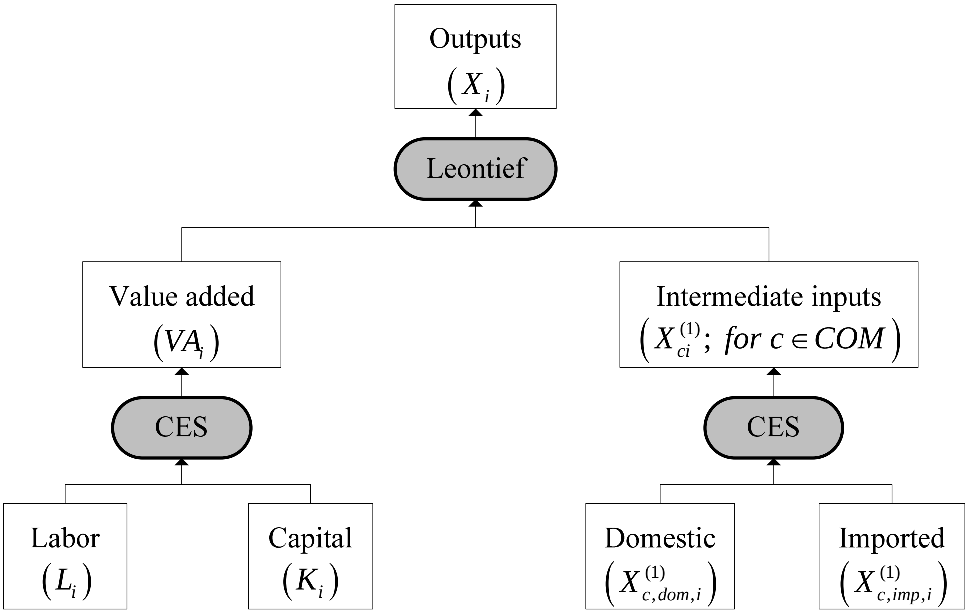
3.2.1 Production Sector and Factor market

Demand for inputs of the producers is derived from solutions to optimization problems. The producers choose their inputs to minimize cost subject to nested Leontief or CES (Constant Elasticity of Substitution) constant-return-to-scale production functions. From a schematic diagram of nesting production shown in Figure 3.2, the production structure of all production sectors comprises of two levels which are factor combination level and factor type selection level. For factor combination level (an activity level), it is set as a Leontief combination of composite primary factor and composite intermediate input. For factor type selection level, the model assumes two types of primary input, which are labor and capital, and two sources of intermediate input, which are domestic production and imports. As a result, a CES function is applied for factor type selection level in aggregating two types of primary input and two sources of intermediate input.

For factor combination level, the producer in production sector i combines the effective input combination of labor and capital or the value added product and the composite intermediate input in a constant proportion using the Leontief production function in order to produce the output. There is no substitution between input categories or between intermediate inputs and primary inputs, in other words, they are perfectly complemented. Noting that the solution to the optimization of the Leontief function has no price variables in the demand equation.

Figure 3.2

Production Nesting



Consequently, demand for the effective combination of primary inputs or the value added bundle of labor and capital and demand for the composite intermediate input c of production sector i can be found from a problem that the producer in production sector i tries to minimize the cost of input combinations subject to the Leontief production function of all input categories. As a result, this minimization problem can be shown as

$$\underset{VA_i,\, X_{ci}^{(1)}}{Min} \quad P_{VA_i}.VA_i + \sum_{c \in COM} P_c.X_{ci}^{(1)}$$

$$st. \qquad X_i = \min\left\{A_{X_i}.VA_i\ ,\ X_{ci}^{(1)}\right\}\ ;\ \ for\ \ i \in IND, c \in COM$$

where X_i is the output produced by production sector i

$X_{ci}^{(1)}$ is the composite commodity c used as intermediate input in producing the output of production sector i

VA_i is the value added product or the effective input combination of primary factors used in producing the output of production sector i

P_c is the price of composite commodity c

P_{VA_i} is the price of value added product faced by production sector i

A_{X_i} is the Hicks-Neutral Technical Progress (HNTP) parameter representing total factor productivity (TFP) or the primary factor augmenting technical change parameter of production sector i

Results to the minimization problem are demand for the composite primary input or value added product and intermediate input demand for composite commodity c of production sector i:

$$VA_i = \frac{X_i}{A_{X_i}} \; ; \; for \;\; i \in IND \qquad (1)$$

$$X_{ci}^{(1)} = X_i \; ; \; for \;\; i \in IND, c \in COM \qquad (2)$$

In percentage change form, equation (1) and (2) become

$$va_i = x_i - a_{X_i} \; ; \; for \;\; i \in IND \qquad (1a)$$

$$x_{ci}^{(1)} = x_i \; ; \; for \;\; i \in IND, c \in COM \qquad (2a)$$

From equation (1a), when total factor productivity of current production of sector i increases, at the given level of output produced, the producer in production sector i will demand less composite primary factor. Equation (2a) indicates that the output level of production sector i is the only factor that has direct effect on the industry's requirements for composite intermediate input c.

Labor and capital are primary factors in the model and they are assumed to be substitutable within the group. Thus, in factor type selection level of the primary factors, the producer in production sector i combines labor and capital in order to produce the effective input combination of primary inputs or the value added product used in producing the output of production sector i. Since labor and capital are not perfectly substituted, then the CES production function is applied in representing the degree of substitution between labor and capital.

Demand for labor and capital of the production sector i can be found from a problem that the producer in production sector i chooses labor and capital such that the combined costs of using the primary factors are minimized subject to the CES aggregates of primary factors. This problem can be shown as

$$\underset{L_i,\,K_i}{Min} \quad P_{VA_i}.VA_i \;=\; W_i.L_i + R_i.K_i$$

$$st. \qquad VA_i \;=\; \left(L_i^{-\rho_i} + K_i^{-\rho_i}\right)^{-\frac{1}{\rho_i}} \;;\; for \;\; i \in IND$$

where L_i and W_i are the quantity and wage rate of labor used in producing the value added product of production sector i

K_i and R_i are the quantity and rental rate of capital used in producing the value added product of production sector i

$\sigma_i^{LK} = \left(\frac{1}{1+\rho_i}\right)$ is an elasticity of substitution between labor and capital in producing the value added product of production sector i

After solving this minimization problem (see Appendix E), demand for labor and capital used in producing the value added product of production sector i will be obtained. The optimal solution to each primary factor demand is determined by the total usage of a composite primary factor and the price of that primary factor relative to the average price of composite primary factor.

$$L_i \;=\; VA_i.\left(\frac{W_i}{W_i + R_i}\right)^{-\sigma_i^{LK}} \;;\; for \;\; i \in IND \tag{3}$$

$$K_i \;=\; VA_i.\left(\frac{R_i}{W_i + R_i}\right)^{-\sigma_i^{LK}} \;;\; for \;\; i \in IND \tag{4}$$

Demand for labor and capital of production sector i in equation (3) and (4) can be transformed into the percentage change form as

$$\ell_i \;=\; va_i - \sigma_i^{LK}.\left(w_i - SL_i^{(1)}.w_i - SK_i^{(1)}.r_i\right) \;;\; for \;\; i \in IND \tag{3a}$$

$$k_i \;=\; va_i - \sigma_i^{LK}.\left(r_i - SL_i^{(1)}.w_i - SK_i^{(1)}.r_i\right) \;;\; for \;\; i \in IND \quad (4a)$$

where $SL_i^{(1)}$ is the labor cost share in total cost of producing the value added product of production sector i or $SL_i^{(1)} = \left(\frac{W_i.L_i}{W_i.L_i + R_i.K_i}\right)$

$SK_i^{(1)}$ is the capital cost share in total cost of producing the value added product of production sector i or $SK_i^{(1)} = \left(\frac{R_i.K_i}{W_i.L_i + R_i.K_i}\right)$

such that $SL_i^{(1)} + SK_i^{(1)} = 1 \;;\; for\ all \;\; i \in IND$

Equation (3a) and (4a) indicate that one percent increase in production sector i's output level leads to one percent increase in the production sector's requirements for labor and capital, in general, if there is no change in the relative prices of primary factors and also the production technology. However, if the wage rate faced by sector i increases relative to price of capital where the production technology is unchanged, then sector i's use of labor will increase slower than its use of capital. The elasticity of substitution between labor and capital will determine the rate of substitution between these two primary factors.

For primary factor market, the factor prices faced by the producer will be equal for all production sectors if that factor can move freely across the sectors of production, while in the case of immobile factors, the factor prices will not be the same for all production sectors. Since this study focuses on the short-run result and assumes that labor and capital are mobile factors, therefore wage rates of labor and rental rates of capital will be equal for all production sectors. Thus, the equilibrium conditions for primary factor price are shown as

$$W_i \;=\; W \;;\; for \;\; i \in IND \quad (5)$$

$$R_i \;=\; R \;;\; for \;\; i \in IND \quad (6)$$

where W is wage rate at the equilibrium condition of labor market

R is rate of return at the equilibrium condition of capital market

In percentage change form, equation (5) and (6) become

$$w_i \;=\; w \;;\;\; for \;\; i \in IND \qquad (5a)$$

$$r_i \;=\; r \;;\;\; for \;\; i \in IND \qquad (6a)$$

In factor type selection level of the intermediate inputs, commodities used as intermediate inputs in producing the output of production sector i come from two sources which are domestic production and imports. The composite intermediate input is aggregated of domestic and imported commodities which are taken to be imperfect substituted; therefore the CES function is applied in representing the degree of substitution between domestic and imported commodities.

Consequently, intermediate input demand for commodity c from source s of the production sector i can be found from a problem that the producer in production sector i chooses commodity c from different sources and then used as intermediate input in producing its output given the intermediate use of composite commodity c such that the cost of intermediate use is the least. As a result, this minimization problem of the producer can be shown as

$$\underset{X^{(1)}_{csi}}{Min} \quad \sum_{s \in SRC} P_{cs}.X^{(1)}_{csi}$$

$$st. \qquad X^{(1)}_{ci} \;=\; CES_{ci}\left[X^{(1)}_{c,dom,i}, X^{(1)}_{c,imp,i}\right] \;;\;\; for \;\; i \in IND, c \in COM$$

where $X^{(1)}_{csi} = \left(X^{(1)}_{c,dom,i}, X^{(1)}_{c,imp,i}\right)$ is commodity c from source s used as intermediate input in producing the output of production sector i

P_{cs} is the price of commodity c from source s

Result to the minimization problem is intermediate input demand for commodity c from source s of production sector i:

$$X^{(1)}_{csi} \;=\; X^{(1)}_{ci}.\left(\frac{P_{cs}}{\sum_{q \in SRC} P_{cq}}\right)^{-\sigma^{(1)}_c} \;;\;\; for \;\; i \in IND, c \in COM, s \in SRC \qquad (7)$$

Equation (7) can be transformed into the percentage change form as

$$x_{csi}^{(1)} \ = \ x_{ci}^{(1)} - \sigma_c^{(1)} . \left(p_{cs} - \sum_{q \in SRC} S_{cqi}^{(1)} . p_{cq} \right) \ ; \ \ for \ \ i \in IND, c \in COM, s \in SRC \qquad (7a)$$

where $\sigma_c^{(1)}$ is an elasticity of substitution between domestic and imported commodity c of the producer

$S_{csi}^{(1)} \ = \ \left(S_{c,dom,i}^{(1)}, S_{c,imp,i}^{(1)} \right)$ is the cost share of commodity c from source s used as intermediate input in producing the output of production sector i in total cost of intermediate input c or $S_{csi}^{(1)} \ = \ \left(\frac{P_{cs}.X_{csi}^{(1)}}{\sum_{q \in SRC} P_{cq}.X_{cqi}^{(1)}} \right)$

such that $S_{c,dom,i}^{(1)} + S_{c,imp,i}^{(1)} \ = \ 1 \ ; \ \ for \ all \ \ c \in COM, i \in IND$

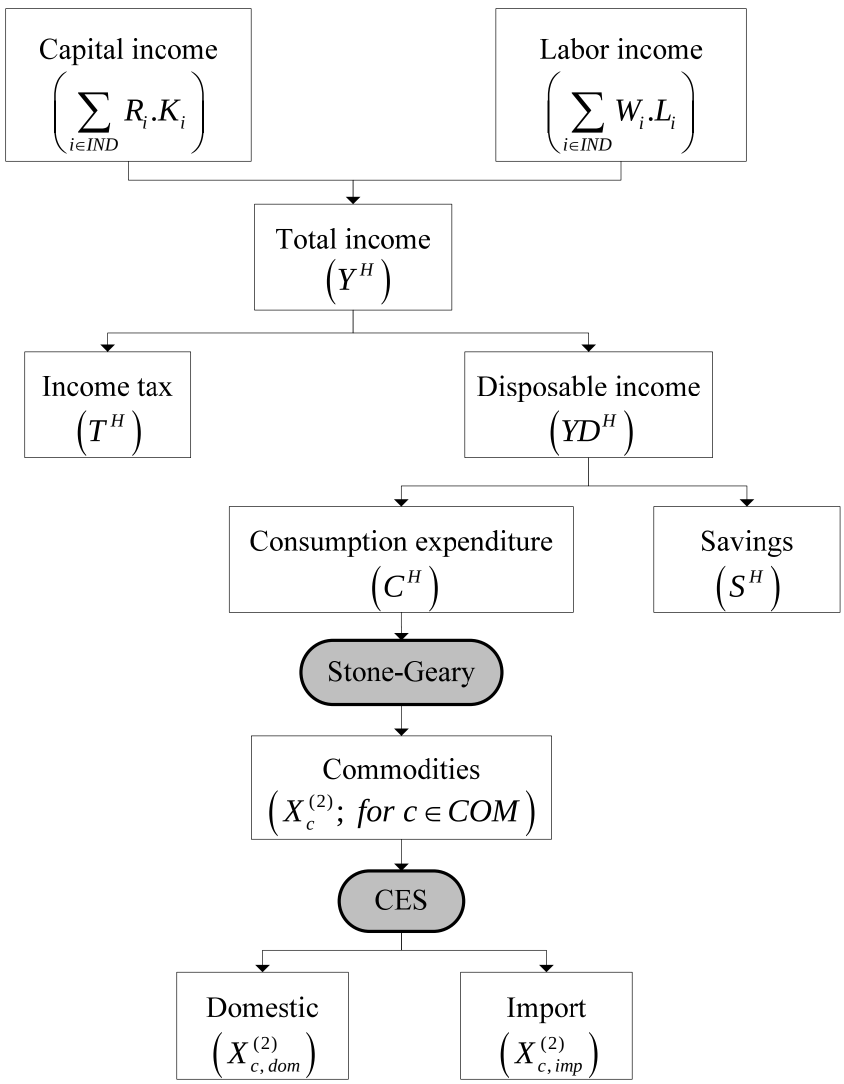
Equation (7a) indicates that if there is no change in the relative price of commodity c from different sources, then one percent increase in the output level leads to one percent increase in each of the demand for intermediate input c from source s used in current production of sector i. This reflects the assumption of constant return to scale. However, if the price of domestic commodity c faced by production sector i rises relative to the price of imported commodity c, then demand for intermediate input c from domestic source will increase less rapidly than the output level. This is due to the substitution against the domestic source of commodity c in favor of imports. The strength of this substitution effect depends on the value of the elasticity of substitution between domestic and imported commodity.

3.2.2 Household Income and Consumer Demand

In this study, it is assumed that there is only one representative household in which the structure of household income and consumption is shown in Figure 3.3. A household earns its income from being labor and capital input supplied in the production sectors since household is the one being an ownership of primary factors used for the production. Thus, total income of a household comprises of labor and capital income while other sources of household income are overlooked. Total income of a household after income tax reduction results in a disposable income for which the disposable income of a household is divided into consumption expenditure and savings. For household consumption, a household uses its consumption expenditure to consume commodities in the set COM in which the commodity composites are aggregated by a Stone-Geary utility function, rather than the Leontief composition. At the bottom level of the nest, a household consumes both domestic and imported commodities which are aggregated by the CES function.

Figure 3.3

Structure of Household Income and Consumption



Total income of a household is the sum of labor and capital income from being labor and capital input supplied in all production sectors:

$$Y^H \;=\; \sum_{i \in IND} W_i . L_i + \sum_{i \in IND} R_i . K_i \tag{8}$$

where Y^H is the total income of a household

$W_i . L_i$ is the labor income from being labor supplied in production sector i

$R_i . K_i$ is the capital income from being capital supplied in production sector i

Equation (8) can be transformed into the percentage change form as

$$y^H \;=\; \sum_{i \in IND} SL_i^{(2)} . \left(w_i + \ell_i \right) + \sum_{i \in IND} SK_i^{(2)} . \left(r_i + k_i \right) \tag{8a}$$

where $SL_i^{(2)}$ is the share of labor income from being labor input supplied in production sector i to total income of a household or $SL_i^{(2)} = \left(\frac{W_i . L_i}{Y^H} \right)$

$SK_i^{(2)}$ is the share of capital income from being capital input supplied in production sector i to total income of a household or $SK_i^{(2)} = \left(\frac{R_i . K_i}{Y^H} \right)$

such that $\sum_{i \in IND} SL_i^{(2)} + \sum_{i \in IND} SK_i^{(2)} \;=\; 1$

Disposable income that household can spend on consuming commodities comes from total income after personal income tax reduction:

$$YD^H \;=\; \left(1 - T^{(2)} \right) . Y^H \tag{9}$$

where YD^H is the disposable income of a household

$T^{(2)}$ is the personal income tax rate

Equation (9) can be transformed into the percentage change form as

$$yd^H \;=\; y^H - \left(\frac{T^{(2)}}{1 - T^{(2)}} \right) . t^{(2)} \tag{9a}$$

The disposable income of a household is divided into consumption expenditure and savings:

$$YD^H = C^H + S^H \tag{10}$$

where C^H is the total household consumption expenditure

S^H is the household savings

Equation (10) can be transformed into the percentage change form as

$$YD^H . yd^H = C^H . c^H + 100. \Delta S^H \tag{10a}$$

where ΔS^H is the change form of household savings (for the household savings, using the change form is more appropriate than using the percentage change since household savings can take positive or negative values)

Total consumption expenditure of a household is used up for consuming any type of composite commodities in the set COM in which this relationship can be viewed as a household's budget constraint:

$$C^H = \sum_{c \in COM} P_c . X_c^{(2)} \tag{11}$$

where $X_c^{(2)}$ is the household consumption of composite commodity c

Equation (11) can be transformed into the percentage change form as

$$c^H = \sum_{c \in COM} S_c^C . \left(p_c + x_c^{(2)} \right) \tag{11a}$$

where S_c^C is the share of household consumption expenditure on commodity c to total household consumption expenditure or $S_c^C = \left(\dfrac{P_c . X_c^{(2)}}{C^H} \right)$

such that $\sum_{c \in COM} S_c^C = 1$

Utility function of a household is set in the form of Linear Expenditure System (LES) for the reason of empirical expediency; here it is the Stone-Geary utility function. The Stone-Geary utility function is similar to the Cobb-Douglas utility function but different in the sense of having the sufficient level of consumption. According to the Stone-Geary utility function, the composite commodities are split into two parts which are subsistence and luxury components. The subsistence demand for composite commodities is determined by the taste variables. Only the luxury component enters the household Cobb-Douglas utility function. However, household demand derived from the Stone-Geary utility function has a constant elasticity of total consumption expenditures, but it does not necessary equal to one likes household demand derived from the Cobb-Douglas utility function.

As a result, household demand for composite commodity c can be found from the problem that a household maximizes its utility received from consuming any type of commodities in the set COM subject to its budget constraint or total consumption expenditure in the case:

$$\underset{X_c^{(2)}}{Max} \quad U = \prod_{c \in COM} \left(X_c^{(2)} - \Theta_c \right)^{\beta_c}$$

$$st. \quad C^H = \sum_{c \in COM} P_c . X_c^{(2)}$$

where U is the utility function of a household

Θ_c is the minimum or subsistence level of composite commodity c or the floor consumption of composite commodity c

β_c is the marginal budget share of composite commodity c

such that $\sum_{c \in COM} \beta_c = 1$ and $\left(X_c^{(2)} - \Theta_c \right) \geq 0 \; ; \; for \;\; c \in COM$

The solution to the optimizing utility results in a linear expenditure system. This means the household consumption expenditure on each type of commodity is a linear function of commodity prices and household income. After solving the maximization problem of a household (see Appendix F), household demand for composite commodity c is given by

$$X_c^{(2)} = \frac{\beta_c.\left(C^H - \sum_{k \in COM} P_k.\Theta_k\right)}{P_c} + \Theta_c \ ; \ for \ c \in COM \qquad (12)$$

Demand function in equation (12) indicates that household demand for composite commodity c is up to the subsistence consumption of commodity c (Θ_c) while the remaining income after necessity consumption or the supernumerary income $\left(C^H - \sum_{k \in COM} P_k.\Theta_k\right)$ is distributed to the luxury consumption of commodity c using the marginal budget share of commodity c (β_c) and price of commodity c (P_c).

Equation (12) can be transformed into the percentage change form as

$$x_c^{(2)} = \varepsilon_c . c^H + \sum_{k \in COM} \eta_{ck} . p_k \ ; \ for \ c \in COM \qquad (12a)$$

where ε_c is the household expenditure elasticity of commodity c

η_{ck} is the price elasticity of demand for commodity c including own and cross price elasticity where c and k are in the set COM

such that $\sum_{k \in COM} \eta_{ck} = -\varepsilon_c \ ; \ for \ all \ c \in COM$

This formulation directly expresses the comparative static implication of homogeneity of degree zero such that an equal percentage change in all prices and wealth leads to no change in demand (Mas-Colell et al., 1995). Equation (12a) indicates that, at any fixed value of elasticities, household demand for commodity c is determined by the consumption expenditure and all commodity prices.

Household demand for commodity c from source s can be found from the problem that a household minimizes the cost of consuming any type of commodities given the consumption level of composite commodity c:

$$\underset{X_{cs}^{(2)}}{Min} \quad \sum_{c \in COM} P_{cs}.X_{cs}^{(2)}$$

$$st. \quad X_c^{(2)} = CES_c\left[X_{c,dom}^{(2)}, X_{c,imp}^{(2)}\right] \ ; \ for \ c \in COM, s \in SRC$$

where $X^{(2)}_{cs} = \left(X^{(2)}_{c,dom}, X^{(2)}_{c,imp}\right)$ is the household consumption of commodity c from source s which are domestic production (dom) and imports (imp)

From this minimization problem of a household, the result is household demand for commodity c from source s:

$$X^{(2)}_{cs} = X^{(2)}_{c}.\left(\frac{P_{cs}}{\sum_{q \in SRC} P_{cq}}\right)^{-\sigma^{(2)}_{c}} \quad ; \ for \ c \in COM, s \in SRC \qquad (13)$$

Equation (13) can be transformed into the percentage change form as

$$x^{(2)}_{cs} = x^{(2)}_{c} - \sigma^{(2)}_{c}.\left(p_{cs} - \sum_{q \in SRC} S^{(2)}_{cq}.p_{cq}\right) \quad ; \ for \ c \in COM, s \in SRC \qquad (13a)$$

where $\sigma^{(2)}_{c}$ is an elasticity of substitution between domestic and imported commodity c of a household

$S^{(2)}_{cs} = \left(S^{(2)}_{c,dom}, S^{(2)}_{c,imp}\right)$ is the household consumption expenditure share of commodity c from source s in total consumption expenditure on commodity c

or $S^{(2)}_{cs} = \left(\frac{P_{cs}.X^{(2)}_{cs}}{\sum_{q \in SRC} P_{cq}.X^{(2)}_{cq}}\right)$

such that $S^{(2)}_{c,dom} + S^{(2)}_{c,imp} = 1$; *for all* $c \in COM$

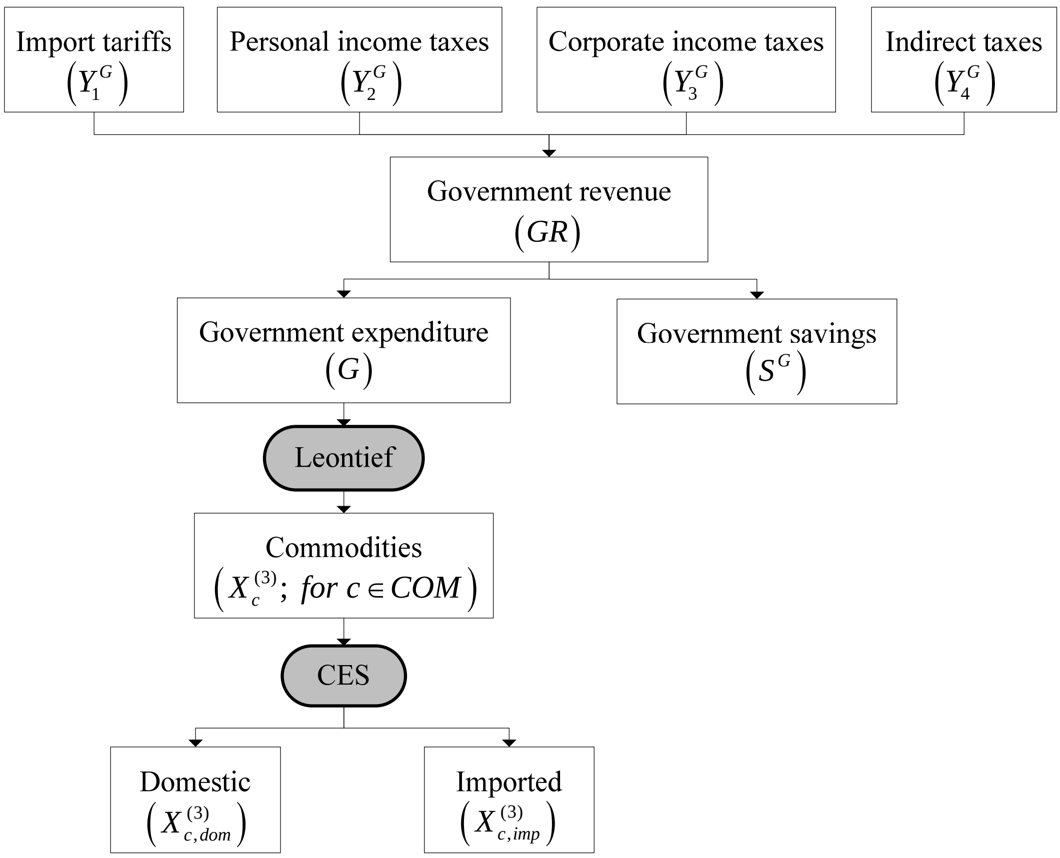
Similar to the interpretation of equation (7a), equation (13a) indicates that the change in relative price of domestic and imported commodity c results in a substitution in uses of these two types of commodity such that if the price of domestic commodity c faced by a household rises relative to the price of imported commodity c, then the household demand for commodity c from domestic source will increase less rapidly than the consumption level of composite commodity c. The strength of this substitution effect depends on the value of the elasticity of substitution between domestic and imported commodity.

3.2.3 Government Revenue and Expenditure

From the structure of government revenue and expenditure in Figure 3.4, total government revenue comprises of four different sources of revenue which are import tariffs, personal income taxes collected from a household, corporate income taxes collected from the producers and indirect taxes imposed on total value of all commodities. For expenditure side, government expenditure is the consumption expenditure on any type of commodities in the set COM using the Leontief function. The government consumes domestic and imported commodities in which these two sources of commodities are not perfectly substituted. Thus, they are aggregated using the CES function. Finally, the inconsistency of total government revenue and expenditure results in the government savings.

Figure 3.4

Structure of Government Revenue and Expenditure



Government revenue from import tariffs is collected from total value of all imported commodities in the set COM in terms of Baht:

$$Y_1^G \quad = \quad \sum_{c \in COM} T_c^M . P_c^W . \Phi . MD_c \tag{14}$$

where Y_1^G is the government import tariff revenue

T_c^M is the import tariff rate imposed on imported commodity c

P_c^W is the world price of commodity c in foreign currency term (Dollar)

Φ is the exchange rate, here quoted as Baht/Dollar

MD_c is the aggregate level of imported commodity c

Equation (14) can be transformed into the percentage change form as

$$y_1^G \quad = \quad \sum_{c \in COM} G_c^M . \left(t_c^M + p_c^W + \phi + md_c \right) \tag{14a}$$

where G_c^M is the share of import tariff revenue imposed on imported commodity c to total import tariff revenue or $G_c^M = \left(\dfrac{T_c^M . P_c^W . \Phi . MD_c}{Y_1^G} \right)$

such that $\sum_{c \in COM} G_c^M = 1$

Government revenue from personal income taxes is collected from total income of a household:

$$Y_2^G \quad = \quad T^{(2)} . Y^H \tag{15}$$

where Y_2^G is the government personal income tax revenue

$T^{(2)}$ is the personal income tax rate imposed on a household

Y^H is the total income of a household

Equation (15) can be transformed into the percentage change form as

$$y_2^G \quad = \quad t^{(2)} + y^H \tag{15a}$$

Government revenue from corporate income taxes is collected from total value of the output produced by all production sectors in the set IND:

$$Y_3^G \quad = \quad \sum_{i \in IND} T_i^{(1)}.P_{i,dom}^0.X_i \qquad (16)$$

where Y_3^G is the government corporate income tax revenue

$T_i^{(1)}$ is the corporate income tax rate imposed on production sector i

X_i is the output produced by production sector i

$P_{i,dom}^0$ is the producer price of output produced by production sector i

Equation (16) can be transformed into the percentage change form as

$$y_3^G \quad = \quad \sum_{i \in IND} G_i^{(3)}.\left(t_i^{(1)} + p_{i,dom}^0 + x_i\right) \qquad (16a)$$

where $G_i^{(3)}$ is the share of corporate income tax revenue collected from the producer in production sector i to total corporate income tax revenue or $G_i^{(3)} = \left(\dfrac{T_i^{(1)}.\left(P_{i,dom}^0.X_i\right)}{Y_3^G}\right)$

such that $\sum_{i \in IND} G_i^{(3)} = 1$

Government indirect tax revenue is the government receipt from collecting taxes on total value of all commodities in the set COM :

$$Y_4^G \quad = \quad \sum_{c \in COM} C_c^{ITAX} \qquad (17)$$

$$C_c^{ITAX} \quad = \quad T_c^0.Z_c^0 \;\; ; \;\; for \;\; c \in COM \qquad (18)$$

$$Z_c^0 \quad = \quad P_{c,dom}^0.\,X_c + P_{c,imp}^0.\,MD_c \;\; ; \;\; for \;\; c \in COM \qquad (19)$$

where Y_4^G is the government indirect tax revenue

C_c^{ITAX} is the indirect taxes imposed on commodity c

T_c^0 is the indirect tax rate imposed on commodity c

Z_c^0 is the total value of commodity c

X_c is the aggregate level of domestic commodity c

MD_c is the aggregate level of imported commodity c

P_{cs}^0 is the producer price of commodity c from source s

In percentage change form, equation (17), (18) and (19) become

$$y_4^G = \sum_{c \in COM} G_c^0 . c_c^{ITAX} \tag{17a}$$

$$c_c^{ITAX} = t_c^0 + z_c^0 \; ; \; for \;\; c \in COM \tag{18a}$$

$$z_c^0 = V_{c,dom}.\left(p_{c,dom}^0 + x_c\right) + V_{c,imp}.\left(p_{c,imp}^0 + md_c\right) \; ; \; for \;\; c \in COM \tag{19a}$$

where G_c^0 is the share of indirect tax revenue imposed on commodity c to total indirect tax revenue or $G_c^0 = \left(\frac{T_c^0 . Z_c^0}{Y_4^G}\right)$

$V_{c,dom}$ is the share of the value of domestic commodity c to total value of commodity c or $V_{c,dom} = \left(\frac{P_{c,dom}^0 . X_c}{Z_c^0}\right)$

$V_{c,imp}$ is the share of the value of imported commodity c to total value of commodity c or and $V_{c,imp} = \left(\frac{P_{c,imp}^0 . MD_c}{Z_c^0}\right)$

such that $\sum_{c \in COM} G_c^0 = 1$

and $\sum_{s \in SRC} V_{cs} = 1 \; ; \; for\ all \;\; c \in COM$

Total government revenue is the sum of all government receipts:

$$GR = \sum_{j=1}^{4} Y_j^G \tag{20}$$

where GR is the total government revenue

$Y_j^G = \left\{ Y_1^G, Y_2^G, Y_3^G, Y_4^G \right\}$ is the government revenue received from source j which are import tariffs (Y_1^G), personal income taxes (Y_2^G), corporate income taxes (Y_3^G) and indirect taxes (Y_4^G)

Equation (20) can be transformed into the percentage change form as

$$gr = \sum_{j=1}^{4} A_j^{(3)} . y_j^G \tag{20a}$$

where $A_j^{(3)}$ is the share of government revenue received from source j to total government revenue or $A_j^{(3)} = \left(\frac{Y_j^G}{GR} \right)$

such that $\sum_{j=1}^{4} A_j^{(3)} = 1$

Total government expenditure is used up for consuming any type of commodities in the set COM. Government consumption on composite commodities in the set COM is set in the form of Leontief function such that government consumption on any type of composite commodities is in a fixed proportion while government consumption on domestic and imported commodities are aggregated by the CES function. Thus, government demand for commodity c from source s can be found from a problem that the government consumes domestic and imported commodity c such that the cost of consumption is the least:

$$\underset{X_{cs}^{(3)}}{Min} \quad G = \sum_{c \in COM} \sum_{s \in SRC} P_{cs} . X_{cs}^{(3)}$$

$$st. \qquad Z^{(3)} = \min \left\{ X_c^{(3)} \right\}$$

$$and \qquad X_c^{(3)} = CES_c \left[X_{c,dom}^{(3)}, X_{c,imp}^{(3)} \right] ; \ \ for \ \ c \in COM$$

where G is the total government consumption expenditure

$Z^{(3)}$ is the aggregate level of government consumption

$X_c^{(3)}$ is the government consumption of composite commodity c

$X_{cs}^{(3)} = \left(X_{c,dom}^{(3)}, X_{c,imp}^{(3)} \right)$ is the government consumption of commodity c from source s which are domestic production (dom) and imports (imp)

Implicitly, government demand for commodity c from source s can take the form as $X_{cs}^{(3)} = f_{cs}^{G}\left(Z^{(3)}, P_{c,dom}, P_{c,imp} \right)$, this implicit demand function in percentage change form is given by

$$x_{cs}^{(3)} \;=\; z^{(3)} - \sigma_c^{(3)}.\left(p_{cs} - \sum_{q \in SRC} S_{cq}^{(3)}.p_{cq} \right) \;;\; for \;\; c \in COM, s \in SRC \qquad (21a)$$

where $\sigma_c^{(3)}$ is an elasticity of substitution between domestic and imported commodity c of the government

$S_{cs}^{(3)} = \left(S_{c,dom}^{(3)}, S_{c,imp}^{(3)} \right)$ is the government consumption expenditure share of commodity c from source s in total consumption expenditure on commodity c

or $S_{cs}^{(3)} = \left(\dfrac{P_{cs}.X_{cs}^{(3)}}{\sum_{q \in SRC} P_{cq}.X_{cq}^{(3)}} \right)$

such that $S_{c,dom}^{(3)} + S_{c,imp}^{(3)} = 1 \;;\; for\ all \;\; c \in COM$

Equation (21a) indicates that the change in relative price of domestic and imported commodity c results in a substitution in uses of these two types of commodity. If the price of domestic commodity c faced by the government rises relative to the price of imported commodity c, then the government demand for domestic commodity c will increase less rapidly than the aggregate consumption level of commodity c. The strength of this substitution effect depends on the value of the elasticity of substitution between domestic and imported commodity c.

Total government expenditure for consuming any type and any source of commodities in the percentage change form is given by

$$g \;=\; \sum_{c \in COM} \sum_{s \in SRC} S_{cs}^{G}.\left(p_{cs} + x_{cs}^{(3)} \right) \qquad (22a)$$

where $S_{cs}^{G} = \left(S_{c,dom}^{G},\, S_{c,imp}^{G}\right)$ is the share of government consumption expenditure on commodity c from source s to total government consumption expenditure or $S_{cs}^{G} = \left(\dfrac{P_{cs}.X_{cs}^{(3)}}{\sum\limits_{k \in COM} \sum\limits_{q \in SRC} P_{kq}.X_{kq}^{(3)}} \right)$

such that $\sum\limits_{c \in COM} \sum\limits_{s \in SRC} S_{cs}^{G} = 1$

The inconsistency between total government revenue and expenditure results in the government savings:

$$GR = G + S^{G} \tag{23}$$

where S^{G} is the government savings

Equation (23) can be transformed into the percentage change form as

$$GR.\, gr = G.\, g + 100.\, \Delta S^{G} \tag{23a}$$

where ΔS^{G} is the change form of government savings (for the government savings, using the change form is more appropriate than using the percentage change since government savings can take positive or negative values)

3.2.4 International Trade

Export demand function used in this study is determined according to the model specification in Horridge (2003). Thus, foreign demand for Thai's exports of commodity c having a fixed elasticity is given by

$$X_{c}^{(4)} = F_{c}^{(4)}.\left(\frac{P_{c}^{E}}{P_{c}^{W}.\Phi} \right)^{-\gamma_{c}} \quad ; \; for \;\; c \in COM \tag{24}$$

where $X_{c}^{(4)}$ is the total export of commodity c

$F_{c}^{(4)}$ is the shift variable of foreign demand for Thai's exports of commodity c

P_c^E is the export price of commodity c in local currency term (Baht)

P_c^W is the world price of commodity c in foreign currency term (Dollar)

Φ is the exchange rate, here quoted as Baht/Dollar

γ_c is the foreign elasticity of demand for Thai's exports of commodity c

Equation (24) can be transformed into the percentage change form as

$$x_c^{(4)} = f_c^{(4)} - \gamma_c.\left(p_c^E - p_c^W - \phi\right) \;;\; for \;\; c \in COM \qquad (24a)$$

Equation (24a) indicates that an increase in export price of commodity c reduces the foreign demand for Thai's exports of that commodity in which the size of this reduction is determined by the value of foreign elasticity of demand such that the higher the value of elasticity, the lower the value of its reciprocal, and hence, the smaller the effects on Thai's exports.

The aggregate value of Thai's exports of all domestic commodities in the set COM in terms of local currency (Baht) is given by

$$E = \sum_{c \in COM} P_c^W.\Phi.X_c^{(4)} \qquad (25)$$

where E is the total export value

In the percentage change form, equation (25) becomes

$$e = \sum_{c \in COM} S_c^{(4)}.\left(p_c^W + \phi + x_c^{(4)}\right) \qquad (25a)$$

where $S_c^{(4)}$ is the export share of commodity c in total export value or

$$S_c^{(4)} = \left(\frac{P_c^W.\Phi.X_c^{(4)}}{E}\right)$$

such that $\sum_{c \in COM} S_c^{(4)} = 1$

The aggregate of imported commodity c comprises of demand for imported commodity c of all users including producers in all production sectors, household, government, investor and the change in inventories:

$$MD_c \;=\; \sum_{i \in IND} \left(X^{(1)}_{c,imp,i} \right) + X^{(2)}_{c,imp} + X^{(3)}_{c,imp} + X^{(5)}_{c,imp} + X^{(6)}_{c,imp} \;\; ; \;\; for \;\; c \in COM \qquad (26)$$

where MD_c is total demand for imported commodity c

$\sum_{i \in IND} \left(X^{(1)}_{c,imp,i} \right)$ is demand for imported commodity c used as intermediate input in producing the output of all production sectors

$X^{(2)}_{c,imp}, X^{(3)}_{c,imp}, X^{(5)}_{c,imp}$ and $X^{(6)}_{c,imp}$ are demands for imported commodity c used for household consumption, government consumption, capital formation and change in inventories, respectively

In the percentage change form, equation (26) becomes

$$md_c \;=\; \sum_{i \in IND} \left(M^{(1)}_{ci} \,.\, x^{(1)}_{c,imp,i} \right) + M^{(2)}_c \,.\, x^{(2)}_{c,imp} + M^{(3)}_c \,.\, x^{(3)}_{c,imp} \qquad (26a)$$

$$+ M^{(5)}_c \,.\, x^{(5)}_{c,imp} + M^{(6)}_c \,.\, x^{(6)}_{c,imp} \;\; ; \;\; for \;\; c \in COM$$

where $M^{(1)}_{ci}$ is the share of imported commodity c used as intermediate input in producing the output of production sector i to total imported commodity c

$M^{(2)}_c, M^{(3)}_c, M^{(5)}_c$ and $M^{(6)}_c$ are the shares of imported commodity c used for household consumption, government consumption, capital formation and change in inventories to total imported commodity c, respectively

such that $\sum_{i \in IND} \left(M^{(1)}_{ci} \right) + M^{(2)}_c + M^{(3)}_c + M^{(5)}_c + M^{(6)}_c \;=\; 1 \;\; ; \;\; for \; all \;\; c \in COM$

The aggregate value of imports of all commodities in the set COM in terms of local currency (Baht) is given by

$$M \;=\; \sum_{c \in COM} P^W_c \,.\Phi.MD_c \qquad (27)$$

where M is the total import value

In the percentage change form, equation (27) becomes

$$m \;=\; \sum_{c \in COM} U^M_c \,.\left(p^W_c + \phi + md_c \right) \qquad (27a)$$

where U_c^M is the import share of commodity c in total import value or

$$U_c^M = \left(\frac{P_c^W.\Phi.MD_c}{M} \right)$$

such that $\sum_{c \in COM} U_c^M = 1$

Balance of payments comprises of trade balance and net capital flows. The balance of trade is the difference between total export and total import values while the net capital flows are set to be exogenous and determined as the net between foreign capital inflows and outflows. Exchange rate, here quoted as Baht/Dollar, is determined as the equating term between the value in foreign currency term (Dollar) and local currency term (Baht).

$$TBAL = E - M \tag{28}$$

$$S^F = S^{FW}.\Phi \tag{29}$$

$$B = TBAL + S^F \tag{30}$$

where $TBAL$ is the balance of trade or the net export value
B is the balance of payments
S^F is the value of net capital flows in terms of local currency (Baht)
S^{FW} is the value of net capital flows in terms of foreign currency (Dollar)

In the percentage change form, equation (28), (29) and (30) become

$$100.\Delta TBAL = E.e - M.m \tag{28a}$$

$$100.\Delta S^F = 100.\Delta S^{FW} + \Phi.\phi \tag{29a}$$

$$\Delta B = \Delta TBAL + \Delta S^F \tag{30a}$$

where $\Delta TBAL$, ΔB, ΔS^F and ΔS^{FW} are the change forms of trade balance, balance of payments, value of net capital flows in Baht and Dollar, respectively

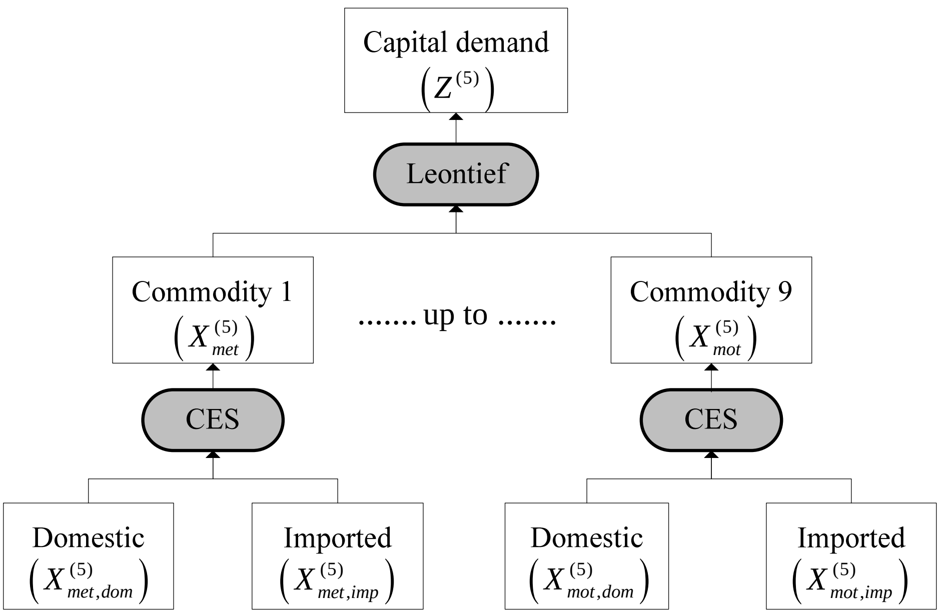
Noting that instead of using terms rate of growth of the trade balance, balance of payments, and value of net capital flows, the change forms of these variables are applied. This is because the trade balance, balance of payments and value of net capital flows can take positive or negative values, and hence, calculating the rate of growth of these variables would result an error term.

3.2.5 Capital Formation Demand

Capital formation demand is another type of the final demand for domestic and imported commodity c representing demand for commodity c from domestic production and imports used as intermediate input in the production of new capital. From the structure of capital formation shown in Figure 3.5, at top-level of the nest, total cost of capital formation is minimized subject to the Leontief composition of all composite commodities. At bottom-level of the nest, total cost of using all domestic and imported commodities is minimized subject to the CES aggregation of these two types of commodity since they are not perfectly substituted. It should be noted that primary factors are not used directly as inputs to capital formation.

Figure 3.5

Structure of Capital Formation



Capital formation demand for commodity c from source s is derived from the cost minimization problem such that the investor chooses domestic and imported commodity c such that total cost of capital formation is the least:

$$\underset{X_{cs}^{(5)}}{Min} \quad I \;=\; \sum_{c \in COM} \sum_{s \in SRC} P_{cs}.X_{cs}^{(5)}$$

$$st. \quad Z^{(5)} \;=\; \min\left\{X_{c}^{(5)}\right\}$$

$$and \quad X_{c}^{(5)} \;=\; CES_{c}\left[X_{c,dom}^{(5)},\, X_{c,imp}^{(5)}\right] \;;\; for \;\; c \in COM$$

where I is the investment expenditure or total cost of capital formation

$Z^{(5)}$ is the aggregate level of capital

$X_{c}^{(5)}$ is the investment use of composite commodity c

$X_{cs}^{(5)} = \left(X_{c,dom}^{(5)}, X_{c,imp}^{(5)}\right)$ is the investment use of commodity c from source s which are domestic production (dom) and imports (imp)

Implicitly, capital formation demand for commodity c from source s takes the form as $X_{cs}^{(5)} = f_{cs}^{I}\left(Z^{(5)}, P_{c,dom}, P_{c,imp}\right)$ in which this implicit demand function can be transformed into the percentage change form as

$$x_{cs}^{(5)} \;=\; z^{(5)} - \sigma_{c}^{(5)}.\left(p_{cs} - \sum_{q \in SRC} S_{cq}^{(5)}.p_{cq}\right) \;;\; for \;\; c \in COM, s \in SRC \qquad (31a)$$

where $\sigma_{c}^{(5)}$ is an elasticity of substitution between domestic and imported commodity c of the investor

$S_{cs}^{(5)} = \left(S_{c,dom}^{(5)}, S_{c,imp}^{(5)}\right)$ is the investment expenditure share of commodity c from source s in total investment expenditure on commodity c or $S_{cs}^{(5)} = \left(\dfrac{P_{cs}.X_{cs}^{(5)}}{\sum_{q \in SRC} P_{cq}.X_{cq}^{(5)}}\right)$

such that $S_{c,dom}^{(5)} + S_{c,imp}^{(5)} = 1 \;;\; for\ all \;\; c \in COM$

Equation (31a) indicates that the change in relative price of domestic and imported commodity c causes a substitution in uses of domestically produced commodity and imported commodity in the production of new capital such that if the price of domestic commodity c faced by the investor increases relative to the price of imported commodity c, then the capital formation demand for domestic commodity c will increase less rapidly than the aggregate level of new capital. The strength of this substitution effect depends on the value of the elasticity of substitution between commodity from different sources, i.e. domestic production and imports.

Total investment expenditure in uses of any type and any source of commodities in the set COM in the percentage change form is given by

$$i \;=\; \sum_{c \in COM} \sum_{s \in SRC} S^{I}_{cs} . \left(p_{cs} + x^{(5)}_{cs} \right) \qquad (32a)$$

where $S^{I}_{cs} \;=\; \left(S^{I}_{c,dom} ,\, S^{I}_{c,imp} \right)$ is the share of investment expenditure on commodity c from source s in total investment expenditure or $S^{I}_{cs} \;=\; \left(\dfrac{P_{cs} . X^{(5)}_{cs}}{\sum_{k \in COM} \sum_{q \in SRC} P_{kq} . X^{(5)}_{kq}} \right)$

such that $\sum_{c \in COM} \sum_{s \in SRC} S^{I}_{cs} \;=\; 1$

For this study, it is assumed that total investment expenditure is equal to the aggregate domestic savings of household and the government and the value of net foreign capital flows in terms of local currency (Baht):

$$I \;=\; S^{H} + S^{G} + S^{F} \qquad (33)$$

Equation (33) can be transformed into the percentage change form as

$$I . i \;=\; 100. \Delta S^{H} + 100. \Delta S^{G} + 100. \Delta S^{F} \qquad (33a)$$

Since the household savings, government savings and the value of net capital flows can take positive or negative values, then using the change forms of these variables (ΔS^{H}, ΔS^{G} and ΔS^{F}) would be more appropriate.

3.2.6 Demand of the Change in Inventories

The change in inventories is the last group of final demand for domestic and imported commodity c assumed in the model. Due to the fact that the output produced by all production sectors in each period is not equal with the demand for that output of all users in that period, therefore the difference between total supply of output (domestically produced commodity) and total demand for that commodity is recorded as the change in inventories in that period.

The remaining stock of domestic and imported commodity c is assumed to be exogenous, i.e. the change in inventories is constant over time:

$$X_{cs}^{(6)} = F_{cs}^{(6)} \quad ; \quad for \;\; c \in COM, s \in SRC \tag{34}$$

where $X_{cs}^{(6)} = \left(X_{c,dom}^{(6)}, X_{c,imp}^{(6)}\right)$ is the remaining stock of commodity c from source s which are domestic production (dom) and imports (imp)

$F_{cs}^{(6)}$ is the exogenous factor determining demand for commodity c from source s of the change in inventories

Equation (34) can be transformed into the percentage change form as

$$x_{cs}^{(6)} = f_{cs}^{(6)} \quad ; \quad for \;\; c \in COM, s \in SRC \tag{34a}$$

Equation (34a) can be interpreted as the percentage change in demand for commodity c from sources of the change in inventories is according to the percentage change in exogenous factor determining the remaining stock.

3.2.7 Market Clearing Conditions

In determining the equilibrium commodities and factor prices, market clearing conditions need to be specified. These conditions ensure that supply and demand in commodity market and in factor market are equal. For commodity market, commodity price is considered as an adjusting variable to attain the equilibrium condition between demand for commodity and supply of that commodity.

Market clearing condition for domestic production suggests that total supply of domestic commodity c (or total output produced by production sector i) must equal to total demand for domestic commodity c of all users, i.e. producers, household, government, investor, exporter and change in inventories

$$X_c \;=\; \sum_{i \in IND} \left(X^{(1)}_{c,dom,i} \right) + X^{(2)}_{c,dom} + X^{(3)}_{c,dom} + X^{(4)}_{c} + X^{(5)}_{c,dom} + X^{(6)}_{c,dom} \;\; ; \;\; for \;\; c \in COM \qquad (35)$$

where X_c is total supply of domestic commodity c

$\sum_{i \in IND} \left(X^{(1)}_{c,dom,i} \right)$ is demand for domestic commodity c used as intermediate input in producing the output of all production sectors

$X^{(2)}_{c,dom}$, $X^{(3)}_{c,dom}$, $X^{(4)}_{c}$, $X^{(5)}_{c,dom}$ and $X^{(6)}_{c,dom}$ are demands for domestic commodity c used for household consumption, government consumption, exports, capital formation and change in inventories, respectively

In the percentage change form, equation (35) becomes

$$x_c \;=\; \sum_{i \in IND} \left(U^{(1)}_{ci} \,.\, x^{(1)}_{c,dom,i} \right) + U^{(2)}_{c} \,.\, x^{(2)}_{c,dom} + U^{(3)}_{c} \,.\, x^{(3)}_{c,dom} \qquad (35a)$$

$$+ U^{(4)}_{c} \,.\, x^{(4)}_{c} + U^{(5)}_{c} \,.\, x^{(5)}_{c,dom} + U^{(6)}_{c} \,.\, x^{(6)}_{c,dom} \;\; ; \;\; for \;\; c \in COM$$

where $U^{(1)}_{ci}$ is the share of domestic commodity c used as intermediate input in producing the output of production sector i

$U^{(2)}_{c}, U^{(3)}_{c}, U^{(4)}_{c}, U^{(5)}_{c}$ and $U^{(6)}_{c}$ are the shares of domestic commodity c used for household consumption, government consumption, exports, capital formation and change in inventories, respectively

such that $\sum_{i \in IND} \left(U^{(1)}_{ci} \right) + U^{(2)}_{c} + U^{(3)}_{c} + U^{(4)}_{c} + U^{(5)}_{c} + U^{(6)}_{c} \;=\; 1 \;\; ; \;\; for\ all \;\; c \in COM$

For primary factor markets, the model does not disaggregate labor and capital by the uses of production sectors since the model assumes that labor and capital are perfectly mobile factors. Market clearing conditions for primary factor markets suggest that total demand for each primary factor is equal with total fixed supply of that primary factor shown in equation (36) and (37):

$$LS = \sum_{i \in IND} L_i \tag{36}$$

$$KS = \sum_{i \in IND} K_i \tag{37}$$

where LS is the total supply of labor

KS is the total supply capital

L_i is the labor demand of production sector i

K_i is the capital demand of production sector i

Equation (36) and (37) can be transformed into the percentage form as

$$\ell s = \sum_{i \in IND} B_i^L . \ell_i \tag{36a}$$

$$ks = \sum_{i \in IND} B_i^K . k_i \tag{37a}$$

where B_i^L is the share of labor demand of production sector i to total labor supply

B_i^K is the share of capital demand of production sector i to total capital supply

such that $\sum_{i \in IND} B_i^L = 1$ and $\sum_{i \in IND} B_i^K = 1$

3.2.8 Zero Profit Conditions

At the competitive equilibrium, each of the production activities, which are current production, exporting and importing, is assumed to have the zero pure profits. Based on the assumption of zero pure profits and constant returns to scale production technology, the basic-value prices (production costs) of commodities or the producer prices of domestic commodities are functions just of the relevant input prices (intermediate and primary input prices) and corporate income taxes. The basic-value of import prices in domestic economy are the domestic currency equivalents of the foreign currency at c.i.f. prices plus tariffs. The purchasers' prices of exports are defined as the basis prices of domestic commodity.

Zero profit condition in current production means that profit of each production sector i is equal to zero, in other words, total revenue of the producer in each production sector i is equal to total cost of production:

$$\Omega_i . P^0_{i,dom} . X_i \quad = \quad \sum_{c \in COM} \sum_{s \in SRC} \left(P_{cs} . X^{(1)}_{csi} \right) + W_i . L_i + R_i . K_i + C^{ITAX}_i \quad ; \quad for \;\; i \in IND \qquad (38)$$

where $\Omega_i \;=\; \left(1 - T^{(1)}_i \right) \;;\;\; for \;\; i \in IND$

and $T^{(1)}_i$ is the corporate income tax rate imposed on production sector i

Equation (38) can be written in the percentage change form as

$$\omega_i + p^0_{i,dom} + x_i \quad = \quad \sum_{c \in COM} \sum_{s \in SRC} D^{(1)}_{csi} . \left(p_{cs} + x^{(1)}_{csi} \right) + D^L_i . \left(w_i + \ell_i \right) \qquad (38a)$$

$$+ D^K_i . \left(r_i + k_i \right) + D^{ITAX}_i . c^{ITAX}_i \quad ; \quad for \;\; i \in IND$$

where $\omega_i \;=\; - \left(\dfrac{T^{(1)}_i}{1 - T^{(1)}_i} \right) . t^{(1)}_i \;;\;\; for \;\; i \in IND$

$D^{(1)}_{csi}$ is the cost share of intermediate input c from source s in total cost of production sector i

D^L_i is the labor cost share in total cost of production sector i

D^K_i is the capital cost share in total cost of production sector i

D^{ITAX}_i is the other cost share in total cost of production sector i

such that $\sum_{c \in COM} \sum_{s \in SRC} \left(D^{(1)}_{csi} \right) + D^L_i + D^K_i + D^{ITAX}_i \;=\; 1 \;;\;\; for\; all \;\; i \in IND$

Zero profit condition of exporting means that export price of commodity c is equal to producer price of domestic commodity c:

$$P^E_c \quad = \quad P^0_{c,dom} \quad ; \quad for \;\; c \in COM \qquad (39)$$

In the percentage change form, equation (39) becomes

$$p^E_c \quad = \quad p^0_{c,dom} \quad ; \quad for \;\; c \in COM \qquad (39a)$$

Zero profit condition of importing means that import price of commodity c is equal to the world price of commodity c including import tariffs in terms of

$$P_{c,imp}^{0} \quad = \quad P_c^W.\Phi.\left(1+T_c^M\right) \ ; \ \ for \ \ c \in COM \tag{40}$$

Equation (40) can be transformed into the percentage change form as

$$p_{c,imp}^{0} \quad = \quad p_c^W + \phi + \left(\frac{T_c^M}{1+T_c^M}\right).t_c^M \ \ ; \ \ for \ \ c \in COM \tag{40a}$$

3.2.9 Price Determinations

The following equation is defined to link the purchaser price of commodity c from source s to the producer price of commodity c from source s:

$$P_{cs} \quad = \quad P_{cs}^0 .\left(1+T_c^0\right) \ ; \ \ for \ \ c \in COM, s \in SRC \tag{41}$$

where $P_{cs} = \left(P_{c,dom}, P_{c,imp}\right)$ is the purchaser price of commodity c from source s

$P_{cs}^0 = \left(P_{c,dom}^0, P_{c,imp}^0\right)$ is the producer price of commodity c from source s

T_c^0 is the indirect tax rate imposed on commodity c

In the percentage change form, equation (41) become

$$p_{cs} \quad = \quad p_{cs}^0 + \left(\frac{T_c^0}{1+T_c^0}\right).t_c^0 \ \ ; \ \ for \ \ c \in COM, s \in SRC \tag{41a}$$

Determination of the average price of commodity c is given by

$$P_c \quad = \quad \sum_{s \in SRC} V_{cs}.P_{cs} \ \ ; \ \ for \ \ c \in COM \tag{42}$$

In the percentage change form, equation (42) becomes

$$p_c \quad = \quad \sum_{s \in SRC} V_{cs}.\, p_{cs} \ \ ; \ \ for \ \ c \in COM \tag{42a}$$

3.2.10 Miscellaneous Equations

Average price index of all commodities in the set COM is determined by

$$PID \ = \ \sum_{c \in COM} W_c . P_c \tag{43}$$

where PID is the price index (weighted average of all composite prices)

W_c is the value share of commodity c in gross value of all commodities

such that $\sum_{c \in COM} W_c \ = \ 1$

In the percentage change form, equation (43) become

$$pid \ = \ \sum_{c \in COM} W_c . \, p_c \tag{43a}$$

Nominal gross domestic product (GDP) in expenditure side is the sum of household consumption expenditure, government expenditure, investment expenditure of the investor and the net export values of the foreign sector:

$$GDP \ = \ C^H + I + G + \left(E - M\right) \tag{44}$$

Nominal GDP in equation (44) is written in the percentage change form as

$$gdp \ = \ N^C . c^H + N^I . i \ + N^G . g \ + N^E . e \ - N^M . m \tag{44a}$$

where N^C, N^I, N^G, N^E and N^M are the shares of nominal gross domestic product accounted for household consumption expenditure, investment expenditure, government consumption expenditure, total export values and total import values, respectively

such that $N^C + N^I + N^G + N^E - N^M = 1$

Gross domestic product in real term is given by

$$RGDP \ = \ \frac{GDP}{PID} \tag{45}$$

Real GDP in equation (45) can be written in the percentage change form as

$$rgdp \;=\; gdp \;-\; pid \tag{45a}$$

The real wage is determined by

$$RW \;=\; \frac{W}{PID} \tag{46}$$

Equation (46) can be written in the percentage change form as

$$rw \;=\; w \;-\; pid \tag{46a}$$

The real rate of return to capital is determined by

$$RR \;=\; \frac{R}{PID} \tag{47}$$

Equation (47) can be written in the percentage change form as

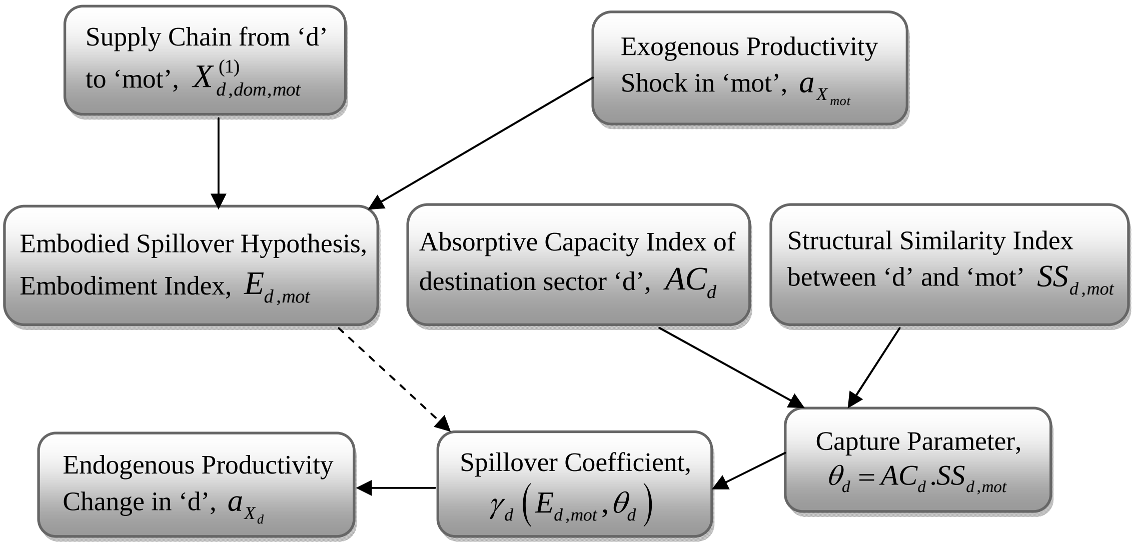
$$rr \;=\; r \;-\; pid \tag{47a}$$

3.2.11 Nested Structure of Productivity Spillovers

As a result of the diffusion of technology from MNC affiliates to domestic firms in the automotive industry, there will be an increase in productivity of the automotive industry. Since the automotive industry is synthetic industry having strong linkages to other industries, i.e. upstream and downstream industries, thus the increase of productivity of the automotive industry will yield results on the productivity of other related industries. For the time being, the Motor vehicle sector is considered to be the source sector where FDI productivity spillover is taken place. For other sectors relating to the Motor vehicle sector including Metal and metal products, Rubber and plastic products, Components, Engines, Electrical machinery, Agricultural and mining, Other manufacturing and Services, they are considered as the destination sectors or the recipient sectors of the effects of FDI productivity spillover.

Figure 3.6

Transmission Mechanism of Productivity Effects



Source: adjusted from Das and Powell (2000) by author

The transmission mechanism of productivity effects based on the framework of Das and Powell (2000) is undertaken in this study. The transmission mechanism in Figure 3.6 shows the way in which the productivity advantages in the Motor vehicle sector 'mot' (source sector) can spill over to the destination sector 'd' where 'd' is in the set $DES = \{met, rub, com, eng, ele, agm, oma, ser\}$. Specifically, the change of productivity in the source and destination sectors is Hicks-Neutral improvement in the productivity of each primary factor or Hicks-Neutral general total factor productivity represented by the percentage change of Hicks-Neutral Technical Progress (HNTP) parameter (a_{X_i} where $i \in IND$). Note that Hicks-Neutral Technical Progress is a change in the production function which satisfies certain economic neutrality conditions. A change is considered to be Hicks neutral if that change does not affect the balance of labor and capital in the production function.

By considering the transmission mechanism of productivity effects, the exogenous productivity increase of the Motor vehicle sector can affect the destination sector's productivity level via the Spillover Coefficient, $\gamma_d\left(E_{d,mot},\theta_d\right)$, incorporated with the spillover hypothesis.

The spillover hypothesis proposes that the productivity advantages in the Motor vehicle sector can be transferred to the destination sectors through the supply chains of the automotive sector. This is due to the fact that FDI productivity spillovers in the automotive sector occur mainly through the backward linkages rather than the forward linkages between the automotive sector and its related sector (Kohpaiboon, 2006a). Thus, the productivity advantages of the Motor vehicle sector can spill over and cause the change in productivity of the destination sectors only when their outputs are utilized as intermediate inputs in the production of the Motor vehicle. Embodiment Index ($E_{d,mot}$ where $0 \le E_{d,mot} \le 1$) is defined as the proportion of domestic intermediate input from the destination sector 'd' used in the production of Motor vehicle to total output produced by the Motor vehicle sector.

$$E_{d,mot} = \frac{X^{(1)}_{d,dom,mot}}{X_{mot}} \quad ; \quad for \quad d \in DES$$

The spillover hypothesis suggests that the destination sectors' abilities to harness the productivity advantages from the source sector depend on their absorptive capacity and also the congruence of production structure between the source and destination sectors. Therefore, the spillover hypothesis is captured by the transmission equation incorporating with the destination-specific which is Absorptive Capacity Index of destination sector 'd' (AC_d where $0 \le AC_d \le 1$) and the source- and destination-specific which is Structural Similarity Index between destination sector 'd' and source sector 'mot' ($SS_{d,mot}$ where $0 \le SS_{d,mot} \le 1$).

Absorptive Capacity Index (AC_d) and Structural Similarity Index ($SS_{d,mot}$) interactively determine the Capture Parameter (θ_d) in measuring the efficiency with which the productivity advantages in the Motor vehicle sector 'mot' can be captured by the destination sector 'd'. The productivity level realized from the potential streams of technology is dependent on $\theta_d \in [0,1]$ with $\theta_d = 1$ implying full realization of the technology-induced productivity improvement.

$$\theta_d = AC_d . SS_{d,mot} \quad ; \quad for \quad d \in DES$$

The Capture Parameter (θ_d) and Embodiment Index ($E_{d,mot}$) jointly determine the value of Spillover Coefficient for the destination sector 'd' or $\gamma_d\left(E_{d,mot},\theta_d\right)$ in which $\gamma_d\left(.\right)$ is assumed to be a concave function of $E_{d,mot}$ and a convex function of θ_d (increasing marginal returns to θ_d) taking the form as

$$\gamma_d\left(E_{d,mot},\theta_d\right) = \left(E_{d,mot}\right)^{1-\theta_d} \text{ where } 0 \le E_{d,mot} \le 1 \text{ and } 0 \le \theta_d \le 1$$

such that $\gamma_d(0) = 0, \gamma_d(1) = 1, \dfrac{\partial \gamma_d(.)}{\partial E_{d,mot}} > 0\,, \dfrac{\partial^2 \gamma_d(.)}{\partial E_{d,mot}^2} < 0\,, \dfrac{\partial \gamma_d(.)}{\partial \theta_d} > 0$ and $\dfrac{\partial^2 \gamma_d(.)}{\partial \theta_d^2} > 0$

Substitution of the Capture Parameter (θ_d) and Embodiment Index ($E_{d,mot}$) into the specified Spillover function, $\gamma_d\left(.\right)$, yields the equation governing the spillovers of productivity advantages from the Motor vehicle sector 'mot' (source sector) to the destination sector 'd' in the set DES.

$$a_{X_d} = \left(\frac{X_{d,dom,mot}^{(1)}}{X_{mot}}\right)^{1-AC_d.SS_{d,mot}} . a_{X_{mot}} \quad ; \quad for \;\; d \in DES \qquad (48a)$$

3.2 The Model Closure

In the theoretical structure of the CGE model, the equations representing relationship of all economic variables are derived based on the economic theory and needed to be transformed into the percentage change forms of all variables in the model. Thus, one can write the relationship of all variables in terms of linear equation system which heads to simplifying the method of finding the solution by using mathematical concept in matrix algebra. From the theoretical structure of the CGE model described in previous section, there are 501 linear equations shown in Table 3.1 representing the relationship among 571 variables in the model listed in Table 3.2. In order to find the solution of the model, 70 variables are chosen to be exogenous variables as shown by the list in Table 3.3 such that the number of endogenous variables is equal with the number of equations.

The set of determined exogenous variables in the model can be called as the model closure since it is necessary to close the model by setting the number of exogenous variables in such a way that the number of endogenous variables must equal with the number of equations. The determination of exogenous variables is dependent to the objectives of study; therefore different objectives indicating different settings of exogenous variables.

For this study, all policy variables which are import tariff rate, personal income tax rate, corporate income tax rate and indirect tax rate are exogenous variables since this study overlooks the impacts of policy shock. Total supply of labor is determined to be exogenous due to the resource constraint. The world commodity prices are exogenous since Thai economy is small economy such that domestic change does not affect the world commodity prices. Total supply of capital, the aggregate level of capital, the shift variable of export demand, the remaining stocks and the exchange rate are determined to be exogenous variables since this study focuses on the short run results assuming that these variables will bring no change in short period. The change in balance of payments is exogenously given in the model and assumed to be constant in order to makes balance of the model such that the deficit (or surplus) in trade balance would be equally compensated by the net capital inflows (or outflows). Since this study aims to evaluate the impacts of FDI productivity spillover or the effects of productivity increase of the Motor vehicle sector, therefore total factor productivity (TFP) of the Motor vehicle sector is considered exogenous in the model representing the change of productivity caused by FDI spillovers.

Step of solving the solution by using the matrix concept is shown by

$$A_1.y + A_2.x = 0$$

$$y = -A_1^{-1}.A_2.x$$

where A_1 and A_2 are matrices of coefficients in which A_1 is square matrix with dimension 501×501 and A_2 is 501×70 matrix

y is 501×1 vector of endogenous variables

x is 70×1 vector of exogenous variables

Table 3.1

Equations in the Model

1. Production Sector and Factor Market		**Number**
(1a)	$va_i = x_i - a_{X_i}$; $i \in IND$	9
(2a)	$x_{ci}^{(1)} = x_i$; $i \in IND, c \in COM$	81
(3a)	$\ell_i = va_i - \sigma_i^{LK}.\left(w_i - SL_i^{(1)}.w_i - SK_i^{(1)}.r_i\right)$; $i \in IND$	9
(4a)	$k_i = va_i - \sigma_i^{LK}.\left(r_i - SL_i^{(1)}.w_i - SK_i^{(1)}.r_i\right)$; $i \in IND$	9
(5a)	$w_i = w$; $i \in IND$	9
(6a)	$r_i = r$; $i \in IND$	9
(7a)	$x_{csi}^{(1)} = x_{ci}^{(1)} - \sigma_c^{(1)}.\left(p_{cs} - \sum_{q \in SRC} S_{cqi}^{(1)}.p_{cq}\right)$; $i \in IND, c \in COM, s \in SRC$	162
2. Household Income and Consumer Demand		**Number**
(8a)	$y^H = \sum_{i \in IND} SL_i^{(2)}.(w_i + \ell_i) + \sum_{i \in IND} SK_i^{(2)}.(r_i + k_i)$	1
(9a)	$yd^H = y^H - \left(\frac{T^{(2)}}{1-T^{(2)}}\right).t^{(2)}$	1
(10a)	$YD^H.yd^H = C^H.c^H + 100.\Delta S^H$	1
(11a)	$c^H = \sum_{c \in COM} S_c^C.\left(p_c + x_c^{(2)}\right)$	1
(12a)	$x_c^{(2)} = \varepsilon_c.c^H + \sum_{k \in COM} \eta_{ck}.p_k$; $c \in COM$	9
(13a)	$x_{cs}^{(2)} = x_c^{(2)} - \sigma_c^{(2)}.\left(p_{cs} - \sum_{q \in SRC} S_{cq}^{(2)}.p_{cq}\right)$; $c \in COM, s \in SRC$	18
3. Government Revenue and Expenditure		**Number**
(14a)	$y_1^G = \sum_{c \in COM} G_c^M.\left(t_c^M + p_c^W + \phi + md_c\right)$	1
(15a)	$y_2^G = t^{(2)} + y^H$	1
(16a)	$y_3^G = \sum_{i \in IND} G_i^{(3)}.\left(t_i^{(1)} + p_{i,dom}^0 + x_i\right)$	1
(17a)	$y_4^G = \sum_{c \in COM} G_c^0.c_c^{ITAX}$	1

3. Government Revenue and Expenditure (continue)		**Number**
(18a)	$c_c^{ITAX} \;=\; t_c^0 + z_c^0 \;\; ; \; c \in COM$	9
(19a)	$z_c^0 \;=\; V_{c,dom}.\left(p_{c,dom}^0 + x_c\right) + V_{c,imp}.\left(p_{c,imp}^0 + md_c\right) \;;\; c \in COM$	9
(20a)	$gr \;=\; \sum_{j=1}^{4} A_j^{(3)}.\,y_j^G$	1
(21a)	$x_{cs}^{(3)} \;=\; z^{(3)} - \sigma_c^{(3)}.\left(p_{cs} - \sum_{q \in SRC} S_{cq}^{(3)}.p_{cq}\right) \;;\; c \in COM, s \in SRC$	18
(22a)	$g \;=\; \sum_{c \in COM} \sum_{s \in SRC} S_{cs}^G.\left(p_{cs} + x_{cs}^{(3)}\right)$	1
(23a)	$GR.\,gr \;=\; G.\,g \;+\; 100.\,\Delta S^G$	1
4. International Trade		**Number**
(24a)	$x_c^{(4)} \;=\; f_c^{(4)} - \gamma_c.\left(p_c^E - p_c^W - \phi\right) \;;\; c \in COM$	9
(25a)	$e \;=\; \sum_{c \in COM} S_c^{(4)}.\left(p_c^W + \phi + x_c^{(4)}\right)$	1
(26a)	$md_c \;=\; \sum_{i \in IND}\left(M_{ci}^{(1)}.\,x_{c,imp,i}^{(1)}\right) + M_c^{(2)}.\,x_{c,imp}^{(2)} + M_c^{(3)}.\,x_{c,imp}^{(3)} + M_c^{(5)}.\,x_{c,imp}^{(5)} + M_c^{(6)}.\,x_{c,imp}^{(6)} \;;\; c \in COM$	9
(27a)	$m \;=\; \sum_{c \in COM} U_c^M.\left(p_c^W + \phi + md_c\right)$	1
(28a)	$100.\,\Delta TBAL \;=\; E.\,e \;-\; M.\,m$	1
(29a)	$100.\,\Delta S^F \;=\; 100.\,\Delta S^{FW} \;+\; \Phi.\,\phi$	1
(30a)	$\Delta B \;=\; \Delta TBAL \;+\; \Delta S^F$	1
5. Capital Formation Demand		**Number**
(31a)	$x_{cs}^{(5)} \;=\; z^{(5)} - \sigma_c^{(5)}.\left(p_{cs} - \sum_{q \in SRC} S_{cq}^{(5)}.p_{cq}\right) \;;\; c \in COM, s \in SRC$	18
(32a)	$i \;=\; \sum_{c \in COM} \sum_{s \in SRC} S_{cs}^I.\left(p_{cs} + x_{cs}^{(5)}\right)$	1
(33a)	$I.\,i \;=\; 100.\,\Delta S^H + 100.\,\Delta S^G + 100.\,\Delta S^F$	1
6. Demand of the Change in Inventories		**Number**
(34a)	$x_{cs}^{(6)} \;=\; f_{cs}^{(6)} \;;\; c \in COM, s \in SRC$	18

7. Market Clearing Conditions		Number
(35a)	$x_c = \sum_{i\in IND}\left(U_{ci}^{(1)}.\, x_{c,dom,i}^{(1)}\right) + U_c^{(2)}.\, x_{c,dom}^{(2)} + U_c^{(3)}.\, x_{c,dom}^{(3)} + U_c^{(4)}.\, x_c^{(4)} + U_c^{(5)}.\, x_{c,dom}^{(5)} + U_c^{(6)}.\, x_{c,dom}^{(6)} \;;\; c\in COM$	9
(36a)	$\ell s = \sum_{i\in IND} B_i^L.\, \ell_i$	1
(37a)	$ks = \sum_{i\in IND} B_i^K.\, k_i$	1
8. Zero Profit Conditions		**Number**
(38a)	$\omega_i + p_{i,dom}^0 + x_i = \sum_{c\in COM}\sum_{s\in SRC} D_{csi}^{(1)}.\left(p_{cs} + x_{csi}^{(1)}\right) + D_i^L.\left(w_i + \ell_i\right) + D_i^K.\left(r_i + k_i\right) + D_i^{ITAX}.\, c_i^{ITAX} \;;\; i\in IND$	9
(39a)	$p_c^E = p_{c,dom}^0 \;;\; c\in COM$	9
(40a)	$p_{c,imp}^0 = p_c^W + \phi + \left(\frac{T_c^M}{1+T_c^M}\right).t_c^M \;;\; c\in COM$	9
9. Price Determinations		**Number**
(41a)	$p_{cs} = p_{cs}^0 + \left(\frac{T_c^0}{1+T_c^0}\right).t_c^0 \;;\; c\in COM, s\in SRC$	18
(42a)	$p_c = \sum_{s\in SRC} V_{cs}.\, p_{cs} \;;\; c\in COM$	9
10. Miscellaneous Equations		**Number**
(43a)	$pid = \sum_{c\in COM} W_c.\, p_c$	1
(44a)	$gdp = N^C.c^H + N^I.i + N^G.g + N^E.e - N^M.m$	1
(45a)	$rgdp = gdp - pid$	1
(46a)	$rw = w - pid$	1
(47a)	$rr = r - pid$	1
11. Nested Structure of Productivity Spillovers		**Number**
(48a)	$a_{X_d} = \left(\frac{X_{d,dom,mot}^{(1)}}{X_{mot}}\right)^{1-AC_d.SS_{d,mot}}.\, a_{X_{mot}} \;;\; d\in DES$	8

Total 501

Table 3.2

All Variables in the Model

Variable	Subscript Range	Number	Description
va_i	IND	9	Value added product of production sector i
ℓ_i	IND	9	Labor demand of production sector i
k_i	IND	9	Capital demand of production sector i
ℓs	-	1	Total supply of labor
ks	-	1	Total supply of capital
w_i	IND	9	Wage rate of labor by production sector i
r_i	IND	9	Rental rate of capital by production sector i
w	-	1	Wage rate at equilibrium condition
r	-	1	Rental rate at equilibrium condition
c_i^{ITAX}	IND	9	Indirect taxes imposed on production sector i
x_i	IND	9	Output produced by production sector i
$x_{ci}^{(1)}$	$COM \times IND$	81	Demand for composite commodity c used as intermediate in producing the output of production sector i
$x_{csi}^{(1)}$	$COM \times SRC \times IND$	162	Demand for commodity c from source s used as intermediate input in producing the output of production sector i
$x_c^{(2)}$	COM	9	Household demand for composite commodity c
$x_{cs}^{(2)}$	$COM \times SRC$	18	Household demand for commodity c from source s
$x_{cs}^{(3)}$	$COM \times SRC$	18	Government demand for commodity c from source s
$x_c^{(4)}$	COM	9	Export demand for commodity c
$x_{cs}^{(5)}$	$COM \times SRC$	18	Demand for commodity c from source s used for capital formation
$x_{cs}^{(6)}$	$COM \times SRC$	18	Demand for commodity c from source s of the change in inventories
p_{cs}^{0}	$COM \times SRC$	18	Producer price of commodity c from source s
p_{cs}	$COM \times SRC$	18	Purchaser price of commodity c from source s

Variable	Subscript Range	Number	Description
p_c	COM	9	Composite price of commodity c
p_c^W	COM	9	World price of commodity c in terms of foreign currency (Dollar)
p_c^E	COM	9	Price of exported commodity c in terms of local currency (Baht)
y^H	-	1	Total income of a household
yd^H	-	1	Disposable income of a household
c^H	-	1	Total household consumption expenditure
ΔS^H	-	1	Change form of household savings
gr	-	1	Total government revenue
y_1^G	-	1	Government import tariff revenue
y_2^G	-	1	Government personal income tax revenue
y_3^G	-	1	Government corporate income tax revenue
y_4^G	-	1	Government indirect tax revenue
t_c^M	COM	9	Import tariff rate of imported commodity c
$t^{(2)}$	-	1	Personal income tax rate of a household
$t_i^{(1)}$	IND	9	Corporate income tax rate of production sector i
t_c^0	COM	9	Indirect tax rate of commodity c
g	-	1	Total government consumption expenditure
ΔS^G	-	1	Change form of the government savings
ΔS^F	-	1	Change form of the net capital flows (Baht)
ΔS^{FW}	-	1	Change form of the net capital flows (Dollar)
z_c^0	COM	9	Total value of commodity c
$z^{(3)}$	-	1	Aggregate level of government consumption
$z^{(5)}$	-	1	Aggregate level of capital
$f_c^{(4)}$	COM	9	Right shift variable of export demand for commodity c
$f_{cs}^{(6)}$	$COM \times SRC$	18	Exogenous factor determining demand for commodity c from source s of the change in inventories

Variable	Subscript Range	Number	Description
md_c	COM	9	Total demand for imported commodity c
e	-	1	Total export value
m	-	1	Total import value
$\Delta TBAL$	-	1	Change form of the trade balance
ΔB	-	1	Change form of the balance of payments
ϕ	-	1	Exchange rate (Baht/Dollar)
i	-	1	Total investment expenditure
pid	-	1	Average price index
rw	-	1	Real wage rate
rr	-	1	Real rental rate
gdp	-	1	Nominal gross domestic product
$rgdp$	-	1	Real gross domestic product
$a_{X_{mot}}$	-	1	Total factor productivity (TFP) of the source sector or the Motor vehicle sector 'mot'
a_{X_d}	DES	8	Total factor productivity (TFP) of the destination sector 'd'

Total **571**

Table 3.3

Exogenous Variables in the Model

Variable	Subscript Range	Number	Description
ℓs	-	1	Total supply of labor
ks	-	1	Total supply of capital
p_c^W	COM	9	World price of commodity c in terms of foreign currency (Dollar)
t_c^M	COM	9	Import tariff rate of imported commodity c
$t^{(2)}$	-	1	Personal income tax rate of a household
$t_i^{(1)}$	IND	9	Corporate income tax rate of production sector i
t_c^0	COM	9	Indirect tax rate of commodity c
$z^{(5)}$	-	1	Aggregate level of capital
$f_c^{(4)}$	COM	9	Right shift variable of export demand for commodity c
$f_{cs}^{(6)}$	$COM \times SRC$	18	Exogenous factor determining demand for commodity c from source s of the change in inventories
ΔB	-	1	Change form of the balance of payments
ϕ	-	1	Exchange rate (Baht/Dollar)
$a_{X_{mot}}$	-	1	Total factor productivity (TFP) of the source sector or the Motor vehicle sector ‘mot’

Total **70**