THE IMPACT OF CAPITAL INTENSIVE FARMING IN THAILAND:

A COMPUTABLE GENERAL EQUILIBRIUM APPROACH

BY

ANUWAT PUE-ON
BERT D. WARD

DEPT OF ECONOMICS AND FINANCE
FACULTY OF COMMERCE

LINCOLN UNIVERSITY

CHRISTCHURCH, NEW ZEALAND

April 2009

Capital Intensive Farming:
A Computable General Equilibrium Analysis of Thailand

Anuwat Pue-on , Bert D. Ward
Dept of Economics and Finance
Lincoln University, New Zealand

Abstract

Although the structure of Thai economy has been transformed from an agricultural economy to an industrialized country (measured by the share of agriculture to GDP), in 2008 nearly 40 % of overall employment was still engaged in the agricultural sector. In addition, the majority of the poor (57 % of total poor) were farm operators and farm workers. The outflow of workers from the agricultural sector to the non-agricultural sectors has been increasing since 1960. This shortage of agricultural labour has resulted in an increase in the use of farm machinery, a trend that seems to be continuing. Hence, Thai agriculture is expected to be more capital-intensive farming rather than labour-intensive farming in the future.

The aim of this study is to explore whether efforts to encourage producers to use agricultural machinery and equipment will significantly improve agricultural productivity and income distribution amongst sectors and social groups in Thailand. Using the Thai 2000 Social Accounting Matrix (SAM) as a data set, a Computable General Equilibrium (CGE) model was developed for the Thai economy. The CGE model is employed to simulate the impact of capital intensive farming on the Thai economy under two technological change simulations. Simulation 1 is an increase in share parameter of capital in agricultural sector by 5 % and simulation 2 is a 5 % increase in agricultural capital stock.

The results indicate that simulation 2 has accelerated the capital intensification of all agricultural sectors, whereas simulation 1 led to more capital intensity only in some agricultural sectors. The effects of two simulations had a simultaneous impact on output in every sector. Simulation 1 led to a fall of the level activity, domestic output, export, import and composite supply in almost all sector. Meanwhile, simulation 2 brought the opposite results to the simulation 1 above. In terms of institutional income effect, simulation 1 led to the decrease in factor, households and enterprises incomes. Consequently, government income dropped by 0.87 % due to less tax collections. In contrast, simulation 2 resulted in the increase in income of households, enterprises, and governments.

Finally, regarding macro variables, Simulation 1 had a negative impact on private consumption, government consumption, investment, exports and imports. In the end, Gross Domestic Product dropped by 1.05 %. On the contrary, simulation 2 had a positive impact on those same variables which then affected a rise of GDP by 0.53 %.

Key words: Capital intensive farming, CGE, general equilibrium, SAM, Thailand

1. Introduction

Although the share of labour in the Thai agriculture sector has been decreasing since 1960 because of the outflow of workers to non-agricultural sectors, the agricultural sector is still an important engine of economic growth and development because nearly 40 percent of overall employment was still engaged in agricultural sector. The downward trend of the labour supply available in agriculture sector resulted in farming patterns being divided into two categories; "casual farmers" and "progressive farmers" (Siamwalla, 1996). The first category is old and conservative while the second one is more progressive and uses modern technology.

In the theory of production function, total output can be increased if the inputs such as labour or machinery are increased. Moreover, technological change and improvements in the process for producing goods and services can shift production functions upward (Samuelson and Nordhaus, 1995). However, changes in inputs and/or technological change in one sector may affect reallocation of factors used as intermediate inputs in other sectors. (Hayami and Ruttan, 1985)

Therefore, this study proposes to investigate the impact of capital intensive farming on the Thai economy under two different policy scenarios; the technological change concept by Jackson (1998) in terms of the percentage increase in share parameter of agricultural input capital with the percentage decrease in share parameter of agricultural labour, and the increase in capital stock in agricultural sector. The primary analytical tool is a Computable General Equilibrium (CGE) model. This CGE model has 20 production sectors, which is a part in the first author's PhD research.

This paper is organised as follows. Section 2 describes the structure of the CGE model. The structure of the Social Accounting Matrix (SAM) and the calibration of the CGE model are presented in Section 3. The empirical results of the simulation are presented in Section 4. Section 5 concludes the research findings and presents the important policy implications and limitation of the study.

2. The structure of the Thai CGE model

2.1 General features of Thai CGE model

A basic single-country CGE model is a set of simultaneous equations describing the flow of the economic interaction among agents; producers, households, firms, governments and the rest of the world (Hanson et al, 2002). This standard model is based on a Social Accounting Matrix (SAM) data base which represents the flow of resources among agents in an economy (Provide Project, 2003) (see Section 3).

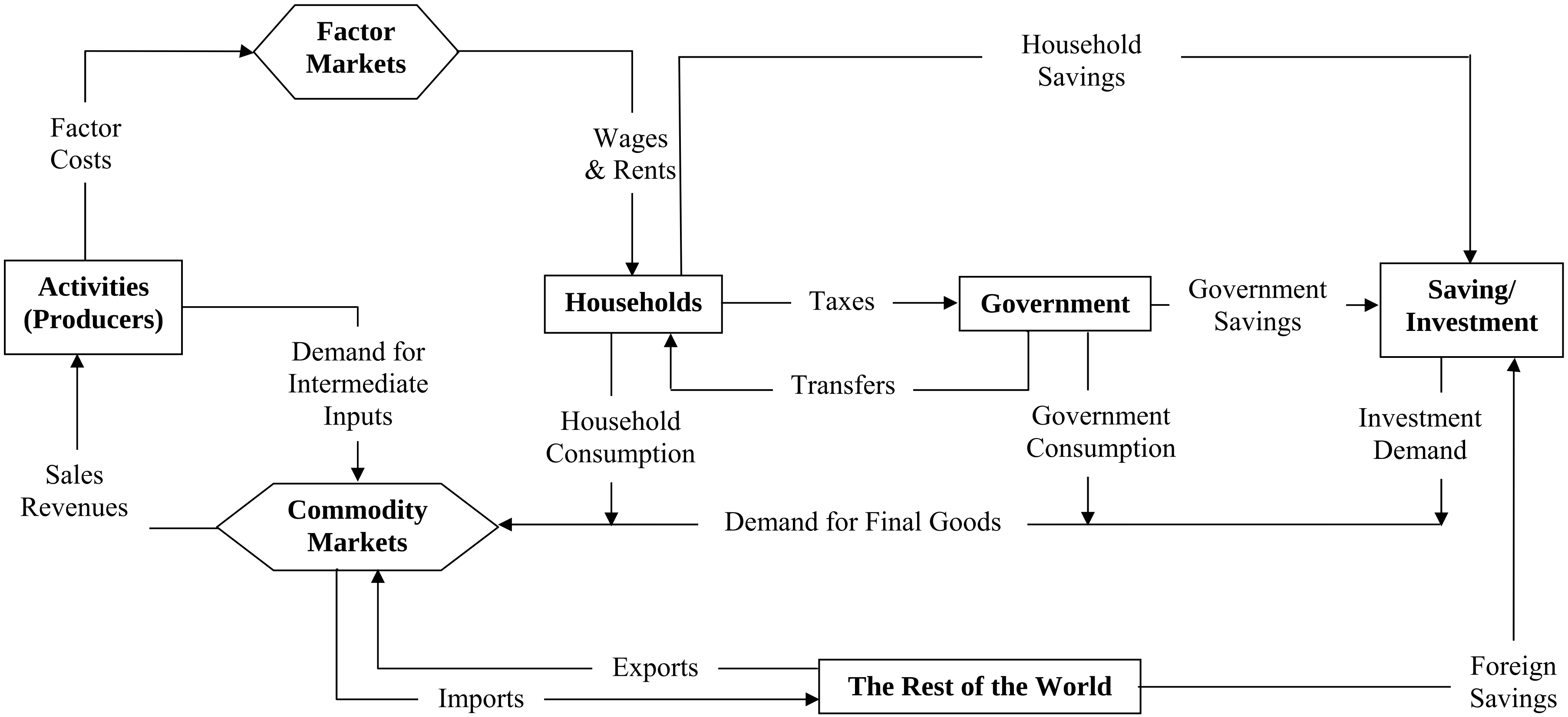
The circular flow of income in a basic SAM and CGE model is shown in Figure 1. Producers purchase intermediate commodity goods and pay value-added to factors (rent for capital and wages for labour in the factor market which belong to household) to produce commodity goods. On the other hand, a producer receives payments from selling commodity goods to domestic markets. Robinson (2003) defines the commodity account as a department store which buys products from domestic and international markets. Their receipts are from selling the products to other economic agents and from exporting to the world market.

Households' payments are consumption (buying commodities), direct taxes (paying to government) and household savings (investment in capital account). In terms of government expenditure, there are a few outlay transactions - government consumption and transfers to households, firms and saving.

The transactions in the capital account relate to in investment and saving. The sources of funds for investment are from institutional savings (households, firms and government) and the rest of the world.

The outflow transaction from the local economy to the rest of the world involves buying goods or services (imports), transferring to institutions and the capital account. On the other hand, the rest of the world receipts [do you mean 'receives'?] payments from local commodities as well.

Figure 1: The circular flow of income in the basic CGE model



Source: IFPRI, 2003

This Thai CGE model has been developed from the standard CGE model of Lofgren (2002). The model refers to a small open economy with 20 production sectors (see Appendix A). Each sector has two inputs; capital and labour. There are three types of institutions (household, enterprise and government). The model is calibrated using data from the 2000 Social Accounting Matrix (SAM), which is constructed using the latest (2000) Input-Output table for Thailand, national income accounts, capital stock of Thailand from Office of National Economic and Social Development Board (NESDB), and the labour force survey from the National Statistical Office. The model is coded and run in GAMS software (General Algebraic Modelling System) following guidelines developed in Lofgren (2003). In the discussion below, endogenous variables are in uppercase Latin letters, whereas exogenous variables and parameters are in lowercase Latin or Greek letters. The definitions of all indices, endogenous and exogenous variables and the parameters in the model are given in Appendix B.

2.2 Equations The equations shown in this section are based on, and extend, those given in Lofgren et al, 2002, Lofgren, 2003 and Thaiprasert, 2006.

The model can be divided into 4 blocks; price block, production and commodity block, institution block and system constraint block. Each block contains equations relating to their functions.

2.2.1 Price block

The price system of the model is defined in the price block which consists of equations 1 to 6. Each price links to other prices and other model variables. As we assumed that Thailand is small relative to the world market, the import and export commodity price equations can be written as equation 1 and 2.

$$PM_c = \left(1 + tm_c\right) \cdot EXR \cdot pwm_c, \qquad c \in CM \qquad (1)$$

$$PE_c = \left(1 + te_c\right) \cdot EXR \cdot pwe_c, \qquad c \in CE \qquad (2)$$

The absorption for each commodity is the total domestic spending on the commodity at domestic prices ($PQ_c \cdot QQ_c$). It can be expressed as the spending of domestic output ($PD_c \cdot QD_c$) plus imports ($PM_c \cdot QM_c$) including an upward adjustment for sale tax as shown in equation 3. Therefore, the composite price (PQ_c) could be derived by dividing equation 3 by composite supply (QQ_c) (see discussion of QQ_c on equation 11).

$$PQ_c \cdot QQ_c = \left\lfloor PD_c \cdot QD_c + \left(PM_c \cdot QM_c\right)_{|c\in CM} \right\rfloor \cdot \left(1 + tq_c\right), \qquad c \in C \tag{3}$$

Domestic output value at the producer price ($PX_c \cdot QX_c$) is the value of domestic sales ($PD_c \cdot QD_c$) plus the export value ($PE_c \cdot QE_c$). It can be expressed as equation 4. Again, the producer price (PX_c) could be derived when dividing equation 4 by domestic output (QX_c).

$$PX_c \cdot QX_c = \left\lfloor PD_c \cdot QD_c + \left(PE_c \cdot QE_c\right)_{|c\in CE} \right\rfloor, \qquad c \in C \tag{4}$$

The last two price equations are activity price (PA_a) and value-added price (PVA_a). Equation 5 describes activity price which is the sum of producer price times yields whereas equation 6, value-added price, is the activity price minus value added tax and input cost per activity unit.

$$PA_a = \sum_{c\in C} PX_c \theta_{ac}, \qquad a \in A \tag{5}$$

$$PVA_a = PA_a \cdot \left(1 - tia_a\right) - \sum_{c\in C} PQ_c \cdot ica_{ca}, \qquad a \in A \tag{6}$$

2.1.2 Production and commodity block

It is assumed that each producer maximize profits subject to its production function which is using Cobb-Douglas production technology with two inputs (capital and labour). Therefore, activity production function can be expressed as equation 7.

$$QA_a = ad_a \prod_{f\in F} QF_{fa}^{\alpha_{fa}}, \qquad a \in A \tag{7}$$

With perfect competition and profit maximization, the demand for factor inputs is derived as equation 8. The factor markets are clear when the model solves for average factor prices (WF_f). The parameters ($WFDIST_{fa}$) are equal to 1 when there are no distortions in the factor markets.

$$WF_f \cdot WFDIST_{fa} = \frac{\alpha_{fa} \cdot PVA_a \cdot QA_a}{QF_{fa}} \quad , \qquad f \in F \text{ and } a \in A \tag{8}$$

Equation 9 is the demand for intermediate inputs which is fixed. It is the function of activity level. Equation 10, another kind of function of activity level, is the output function

$$QINT_{ca} = ica_{ca} \cdot QA_a \tag{9}$$

$$QX_c = \sum_{a \in A} \theta_{ac} QA_a - ag_a \quad , \qquad c \in C \tag{10}$$

According to the Armington assumption, the composite commodities (QQ_c) are produced by using domestic commodities (QD_c) from domestic markets and from imported markets (QM_c) for this commodity. As the original idea of Armington assumption was based on the Constant Elasticity of Substitution function (CES), the composite supply (Armington) function can be written as equation 11.

$$QQ_c = aq_c \left[\delta_c^q \cdot QM_c^{-\rho_c^q} + (1 - \delta_c^q) \cdot QD_c^{-\rho_c^q} \right]^{-1/\rho_c^q} , \qquad c \in CM \tag{11}$$

The optimal mixture between imports and domestic output (QX_c) in equation 11 is described in Equation 12. It is the import-domestic demand ratio for commodity c.

$$\frac{QM_c}{QD_c} = \left[\left(\frac{PD_c}{PM_c} \right) \cdot \frac{\delta_c^q}{1 - \delta_c^q} \right]^{\frac{1}{1+\rho_c^q}} , \qquad c \in CM \tag{12}$$

Similarly to the composite commodity, the domestic output has the choices between selling its commodity on the domestic market or on foreign market as exports (QE_c) which is captured by equation 13. We use Constant Elasticity of Transformation function: CET because its property is as same as CES function except for only the elasticity. Therefore, the output transformation (CET) function can be written as equation 13.

$$QX_c = at_c \cdot \left[\delta_c^t \cdot QE_c^{\rho_c^t} + \left(1 - \delta_c^t\right) \cdot QD_c^{\rho_c^t} \right]^{\frac{1}{\rho_c^t}}, \quad c \in CE \tag{13}$$

In the same way as equation 12, the optimal mixture between exports and domestic sale in equation 13 is described in Equation 14 which is the export-domestic demand ratio for commodity c.

$$\frac{QE_c}{QD_c} = \left[\left(\frac{PE_c}{PD_c} \right) \cdot \frac{1 - \delta_c^t}{\delta_c^t} \right]^{\frac{1}{\rho_c^t - 1}}, \quad c \in CE \tag{14}$$

2.1.3 Institution block

In the institution block, there are nine equation types; factor income, institution factor incomes, household income, household consumption demand, enterprise income, enterprise expenditure, investment demand, government revenue and expenditure.

Equation 15 defines income of factor f (YF_f), capital and labour, which equal to the sum of average factor prices (WF_f) multiply by quantity demand of factor f (QF_{fa}) with distortion wage ($WFDIST_{fa}$). This factor income in equation 15 then is split to household and enterprise in fixed shared ($shryid_{id,f}$) as shown in equation 16. Labour income belongs to household whereas capital income must be subtracted the payment of tax on capital before flowing to household and enterprise.

$$YF_f = \sum_{a \in A} WF_f \cdot WFDIST_{fa} \cdot QF_{fa}, \quad f \in F \tag{15}$$

$$YFID_{id,f} = shryid_{id,f} \cdot \left[\left(1 - tcap_f\right) \cdot YF_f \right], \quad id \in ID, f \in F \tag{16}$$

Household income YH_h is from three sources, factors (capital and labour), transfer from government and remittance from aboard as described in equation 17. In contrast, households' expenditure is direct income taxes (paying to government) and direct payment to enterprise as interest or insurance. Income after above expenditure is household savings which is used to calculate household saving rate or Marginal Propensity to Save (MPS) for household. The rest households' payments are consumption (buying commodities). It is assumed that a household maximise a Cobb-Douglas utility function subject to budget constraints. The result of first -order conditions is then derived for household consumption demand QH_{ch} as shown in equation 18.

$$YH_h = \sum_{f \in F} YFID_{hf} + tr_{h,gov} + EXR \cdot tr_{h,row}, \qquad h \in H \tag{17}$$

$$QH_{ch} = \frac{\beta_{ch} \cdot (1 - mps_h) \cdot (1 - ty_h) \cdot (1 - \text{int}_{ent,h}) \cdot YH_h}{PQ_c}, \; c \in C, h \in H \tag{18}$$

Equation 19 and 20 define enterprise income and expenditure respectively. The sources of its income are from rent, interest payment from household, transfer from government and transfer from the rest of the world (equation 19) ,whereas, firms distribute their incomes by transferring to households and abroad and paying taxes to government (equation 20).

$$YENT_{ent} = \sum_{f \in F} YFID_{ent,f} + \left(\sum_{h \in H} \text{int}_{ent,h} \cdot YH_h \right) + tr_{ent,gov} + EXR \cdot tr_{ent,row}, \; ent \in ENT \tag{19}$$

$$YENT_{ent} - (tent_{ent} \cdot YENT_{ent}) - EXR \cdot tr_{row,ent} = ENTSAV_{ent}, \quad ent \in ENT \tag{20}$$

Equation 21 defines quantity demand for investment. It multiplies base-year investment demand ($qinvbar_c$) by investment adjustment factor ($IADJ$).

$$QINV_c = qinvbar_c \cdot IADJ \tag{21}$$

In terms of government sector, its income and expenditure are shown in equations 22 and 23, respectively. Government revenue (YG_c) are direct income taxes from domestic institutions (household and enterprise), direct taxes from factors, value added tax, import tariff, export tax, sale tax and transfers from the rest of the world (equation 22). On the other hand, government expenditure (EG_c) is export subsidies to product activities, government consumption in commodity goods and transfers to households, firms and capital account (equation23).

$$YG = \left(\sum_{f \in F} tcap \cdot YF_f\right) + \left(\sum_{h \in H} ty_h \cdot YH_h\right) + \left(\sum_{ent \in ENT} tent_{ent} \cdot YENT_{ent}\right)$$

$$+ \sum_{c \in C} tic_c \cdot \left(PD_c \cdot QD_c + \left(PM_c \cdot QM_c\right)_{|c \in CE}\right)$$

$$+ \left[\sum_{a \in A} tia_a \cdot \left(PA_a \cdot QA_a\right)\right] + \left(\sum_{c \in CM} tm_c \cdot EXR \cdot pwm_c \cdot QM_c\right)$$

$$+ \left(\sum_{c \in CE} te_c \cdot EXR \cdot pwe_c \cdot QE_c\right) + EXR \cdot tr_{gov,row} \qquad (22)$$

$$EG = \left(\sum_{a \in A} PA_a \cdot ag_a\right) + \left(\sum_{c \in C} PQ_c \cdot qg_c\right) + \sum tr_{h,gov} + \sum tr_{rnt,gov} + \sum EXR \cdot tr_{row,gov} \qquad (23)$$

2.1.4 System constraint block

Equations in this block define the system constraints that must be satisfied by the model. Commodity and factor markets are clear by the flexible prices while current account balance is clear by for foreign exchange rate. The model is satisfied by Walras' Law. Therefore, the macro constraint will satisfy the identity in equation 27 which means saving equals to investment.

The equilibrium in the factor market is defined in equation 24 which is the equality in factor demand and supply. In this model, it is assumed that the supplies of factors (capital and labour) are exogenous and given as parameters. The factor market is cleared by the average factor prices (WF_f).

$$\sum_{a \in A} QF_{fa} = QFS_f, \qquad f \in F \qquad (24)$$

The condition in equation 25 is the equality in composite commodity supply and demand. The composite commodity supply (QQ_c) are from the Armington function as described in equation 11 while the composite commodity demand is the sum of domestic demand for commodity by activity, household, government and investment demand. This market is clear by the composite commodity price (PQ_c).

$$QQ_c = \sum_{a \in A} QINT_{ca} + \sum_{h \in H} QH_{ch} + qg_c + QINV_c, \qquad c \in C \qquad (25)$$

Regarding the current account balance (expressed in foreign currency), the country's earning is equal its spending of foreign exchange which is represented by equation 26. The earning side are from export revenue, transfer from aboard and foreign saving. While the spending side comes from import spending, transfer to the rest of the world and foreign investment. In this model, foreign saving is fixed and the current account balance is clear by the foreign exchange rate.

$$\sum_{c\in CE} pwe_c \cdot QE_c + \sum_{i\in I} tr_{i,row} + FSAV = \sum_{c\in CM} pwm_c \cdot QM_c + \sum_{i\in I} tr_{row,i} + finv \qquad (26)$$

Another macro constraint is saving-investment balance as shown in equation 27. Total saving is the sum of saving from household, enterprise, government and the rest of the world. In contrast, total investment is the sum of the value of investment. The *WALRAS* variable is introduced in this equation in order to check wether the saving-investment is held. If the model works, the value of *WALRAS* will be zero.

$$\sum_{h\in H} mps_h \cdot (1 - ty_h) \cdot (1 - \text{int}_{\text{int},h}) \cdot YH_h + (YG - EG)$$

$$+ \left[\sum_{ent\in ENT} YENT_{ent} - (tent_{ent} \cdot YENT_{ent}) - EXR \cdot tr_{row,ent} \right] + EXR \cdot FSAV$$

$$= \sum_{c\in C} PQ_c \cdot QINV_c + EXR \cdot finv + WALRAS \qquad (27)$$

The last equation in the system constraint block is price normalization (equation 28). The consumer price index is defined as a weight sum of composite commodity price (PQ_c). The weights ($cwts_c$), commodities weight in consumer price index, are the ratio of demand for each commodity to total demand. The consumer price index (cpi) in equation 28 is fixed. Hence, in a simulation, when a simulated price is changing, it can be directly given a value via-a`-vis the cpi .

$$\sum_{c\in C} PQ_c \cdot cwts_c = cpi \qquad (28)$$

2.2 Equilibrium condition and macro closure

There are three main equilibrium conditions which are the market equilibrium (equation 25), current account balance (equation 26) and saving-investment balance (equation 27).

Since the model has chosen the neoclassical closure which is based on Walrasian models, it is assumed that at equilibrium, there is a full employment in the economy and all investment is determined by saving or another word it is the saving driven model (Thissen, 1998). The model must be satisfied by the Walras' law, therefore, a slack variable ($WALRAS$) is introduced in equation 27. The number of endogenous variable is equal to the number of equations. The $WALRAS$ variable should return a zero value at equilibrium when the model is fully closed and all market is cleared.

As the simulation results are determined by the macro closure, therefore in section 4, we assume that investment is savings driven, input capital is activity-specific and fully utilized, labour is mobile and fully employed and exchange rate is flexible.

3. SAM and model calibration

SAM is "a comprehensive, economy-wide data framework" Lofgren et al, 2002; pp3). The idea of SAM is to present transactions (flow of income) in a form of square matrix (Table 1) which can represent the flow of resources among agents in an economy as already showed and explained in section 2.1 and Figure 1. The most important property of a SAM is that it is "based on a fundamental principle of economics: for every income and receipt there is a corresponding expenditure or out lay. This principle underlies the double-entry accounting procedure that makes up the macroeconomics accounts of any country" (Reinert and Roland-Host 1997; pp95).

We applied this SAM concept to construct data base for CGE model by using information in the year 2000 of national income, input-output table, capital stock of Thailand from Office of National Economic and Social Development Board (NESDB) and labour force survey from Office of National Statistics. This constructed database here is called 2000 macro Social Account Matrix (SAM) for Thailand. However, cells in a SAM come from the various sources. Therefore, the total amount of each column and row could not be equal at the first time. To solve this problem, software called General Algebraic Modelling System (GAMS) is introduced in order to estimate the SAM by using "cross entropy method" (Robison, S., Cattaneo, A. and Said, M.E., 1998). The

2000 macro SAM for Thailand is presented in Table 2. After that, this 2000 macro SAM is disaggregated into a micro SAM with 20 production sectors. Finally, the CGE model is run by GAMS again using this micro SAM (data available upon request). The CGE GAMS codes are based on, and extend, those given in Lofgren et al, 2002, Lofgren, 2003.

Most parameters in the model are calibrated from the micro SAM of Thailand. In calibration, it is assumed that all initial prices at equilibrium in the model are equal to 1. Therefore, demand and supply of goods are obtained as the base year solution of the model that must be equal to the initial equilibrium as captured by SAM. After obtaining the base year values for variables in the model, parameters are derived from equations in the model. For example, in equation 7, there are three parameters which are production function efficiency parameter (ad_a) and two production function share parameters for factor f in activity a (α_{fa} and $1-\alpha_{fa}$). With the first order conditions for profit maximization, the demand for factor inputs is derived as equation 8 which can solve for share parameter (α_{fa} and $1-\alpha_{fa}$).

However, because there was limited time series data on elasticity estimation in Thailand, elasticity of substitution between domestic goods and imports for commodity c or Armigton elasticity (σ_c^q) are taken from Warr, P.G and Lapiz, E.A (1994). Similar reason, the elasticity of transformation between domestic sales and exports for commodity c (σ_t^q) are taken from Warr, P.G and Lapiz, E.A (1994) and Wattanakuljarus, A. and Coxhead, I. (2006). Both elasticities are presented in Appendix C.

The other numbers, number of employed workers and the value of net capital stock of Thailand in each sector in the year 2000, from outside micro SAM of Thailand are introduced into the model. These numbers are used to calculate the average factor return (wage and rent) of workers and capital respectively (Appendix D).

Table 1: The Basic SAM structure used in the CGE model

		Expenditure								
		Activities (1)	**Commodities (2)**	**Factors (3)**	**Households (4)**	**Enterprises (5)**	**Government (6)**	**Saving-Investment (7)**	**Rest of World (8)**	**Total**
Receipts	**Activities (1)**		Marketed outputs				Export subsidies			**Activity income**
	Commodity (2)	Intermediate Inputs			Households consumption		Government consumption	Investment	Exports	**Domestic demand**
	Factors (3)	Value-added								**Factor income**
	Household (4)			Factor income to households		Transfer to households	Transfer to household		Transfers to household from ROW	**Household income**
	Enterprises (5)			Factor income to enterprises	Transfer to enterprises		Transfer to enterprises		Transfers to enterprises from ROW	**Enterprise income**
	Government (6)	Producer taxes, Value-added taxes	Sales taxes, tariffs, export taxes	Factor income to government	Transfer to government, direct taxes	Transfer to government, enterprise taxes			Transfers to government from ROW	**Government income**
	Saving-Investment (7)				Household savings	Enterprise savings	Government saving		Foreign savings	**Total saving**
	Rest of the World (ROW) (8)		Imports	Factor income to ROW		Current transfer abroad	Government transfer to ROW			**Foreign exchange outflow**
	Total	**Activity expenditure**	**Supply expenditures**	**Factor expenditures**	**Households expenditures**	**Enterprise expenditures**	**Government expenditure**	**Total investment**	**Foreign exchange inflow**	

Source: Lofgren et al (2002)

Table 2: 2000 Macro SAM for Thailand (Million baht)

	Activities	Commodities	Factors	Enterprises	Households	Government	S-I	ROW	**Total**
Activities		11,389,818				18,298			**11,408,116**
Commodities	7,021160				2,218,272	566,001	927,659	3,598,005	**14,331,097**
Factors	4,112,397								**4,112,397**
Enterprises			1,478,651		8,950	11,836		19,237	**1,518,673**
Households			2,567,515			30,538		13,570	**2,611,624**
Government	274,559	205,174	66,231	182,872	45,686			1,510	**776,032**
S-I				864,407	338,716	148,307		415,003	**1,766,433**
ROW		2,736,105		471,394		1,052	838,774		**4,047,325**
Total	**11,408,116**	**14,331,097**	**4,112,397**	**1,518,673**	**2,611,624**	**776,032**	**1,766,433**	**4,047,325**	

Source: Author's calculation

4. Policy simulation design and results

4.1 Simulation design

The main hypothesis of this study is to examine the impact of capital intensive farming in Thailand. In order to measure this impact by increasing the share parameter of agricultural input capital with a decreasing in share parameter of agricultural labour, this study has applied non-neutral technological change concept from Jackson (1998) as follows.

Before going into the technological change forms, it is necessary to understand the terms of the definition of "*technical change*" and "*technological change*" because both terms are used in research involving invention and innovations. Jackson (1998) defines technical change as "any change in knowledge about production: about methods of production, about products or about inputs to making products and it results in both invention and innovations" pp. 14. However, he states that technological change is the process innovation which involves "a physical alteration (plant, equipment or intermediate products) as a central feature. He also points out that capital-saving (or using) and labour-saving (or using) are the parts of non-neutral technological change (Jackson, 1998; pp15).

Actually, non-neutral technological change was first introduced by W.E.G. Salter. The original definition of non-neutral technological change was "the labour or capital-saving biases of technical advance are measured by the relative change in capital per labour unit when relative factor prices are constant" (Salter, 1969; pp 31-32). Jackson (1998) followed Salter's definition in the production functions as follows:

$$Q = ZL^{a}K^{b} \qquad (29)$$

where

Q = quantity output per period

Z = adjustment factor

L = Quantity of input of labour

K = the acquisition cost at constant price of the fixed capital stock

a = the partial elasticity of Q with respect to L (when K is constant) or production function share parameter for factor L in activity a (or α_{fa} in the model).

b = the partial elasticity of Q with respect to K (when L is constant) or production function share parameter for factor K in activity a (or $1-\alpha_{fa}$ in the model).

$a+b=1$

Equation (29) can be expressed in K as a function of Q and L:

$$K = \left(Q/Z\right)^{\frac{1}{b}} L^{\frac{-a}{b}} \tag{30}$$

If we take derivative of equation (30) with respect to L, $\frac{dK}{dL}$:

$$\frac{dK}{dL} = -\left(a/b\right)\left(Q/Z\right)^{\frac{1}{b}} L^{\left(\frac{-a}{b}-1\right)} = \left(a/b\right)\left(Q/Z\right)^{\frac{1}{b}} L^{-\left(\frac{1}{b}\right)} \tag{31}$$

The condition for cost minimization is given as follows:

$$\frac{dK}{dL} = -\frac{p_L}{P_K} \tag{32}$$

where:

P_L = wage rate per labour-hour

P_K = price of a unit of capital

Therefore, equation (31) is equal to equation (32):

$$-\left(a/b\right)\left(Q/Z\right)^{\frac{1}{b}} L^{-\left(\frac{1}{b}\right)} = -\left(\frac{P_L}{P_K}\right) \tag{33}$$

If we solve equation (33) for the minimum cost quantity of input of labour *(L*)*:

$$L^{*} = \left[\frac{\left(a/b\right)}{\left(p_L/p_K\right)}\right]^{b}\left(\frac{Q}{Z}\right) \tag{34}$$

Similarly, the value of the minimum cost quantity of capital input *(K^*)* can be derived as follows:

$$K^{*} = \left[\frac{\left(a/b \right)}{\left(p_L / p_K \right)} \right]^{-a} \left(\frac{Q}{Z} \right) \tag{35}$$

If equation (35) is divided by equation (34), we can obtain the minimum cost of the capital-labour ratio $\left(K/L \right)^{*}$ as follows:

$$\left(K/L \right)^{*} = \left[\frac{p_L / p_K}{a/b} \right] \tag{36}$$

Jackson (1998) called a non-neutral technological change as "capital-using" or "labour saving" if the ratio of exponents $\left(\frac{a}{b} \right)$ falls and then the capital-labour ratio at minimum cost $\left(K/L \right)^{*}$ increases which means capital is substituted for labour. In contrast, he defined a non-neutral technological change as "capital-saving" or "labour using" if the ratio of exponents $\left(\frac{a}{b} \right)$ rises and then the capital-labour ratio at minimum cost $\left(K/L \right)^{*}$ decreases which means labour is substituted for capital (Table 3). The capital-using concept here is applied into this CGE model when running the simulation.

Table 3: A synopsis of possibilities of non-neutral technical change

The ratio of exponents $\left(\frac{a}{b} \right)$	The capital-labour ratio at minimum cost $\left(K/L \right)^{*}$	Non-neutrality is referred to as:
Falls	Increases	Capital-using/ Labour-saving
Rises	Decreases	Labour-using/ Capital-saving

Source: Jackson (1998)

Since values of variables and parameters have been obtained from the 2000 SAM of Thailand and elasticity is introduced into the model, base year values of the SAM are created and set as the base run. In this study, there are two simulations to be conducted to answer the research objectives. The first simulation is to decrease the ratio of exponents a/b following Jackson's concept to answer the question: What are the impacts of capital-using in agricultural sector? In this experiment, we assumed that production function share parameter for factor K (b in the Jackson's concept or $1-\alpha_{fa}$ in the model) in agricultural sectors (Sector 1-8) are increased by 5 percents. The increase in b affects a or (α_{fa} in the model) to be decreased. This is because the constant return to scale in production function assumed that $a+b=1$ (or $\alpha_{fa}+1-\alpha_{fa}=1$ in the model). In the end, the ratio of exponents a/b is fallen.

Another of Jackson's concepts, leading to our second simulation, deals with the impact of capital intensive farming when the capital-labour ratio at minimum cost $\left(K/L\right)^*$ increases in agricultural sector. In this experiment, we shock the model by increasing net capital stock (K) in agricultural sector (Sector 1-8) by 5 percent. When capital stock (K) is increased, this affects the capital-labour ratio $\left(K/L\right)^*$, causing it to increased as well.

The simulations are determined by the closure rules. For both simulations, we assume that investment is savings driven, input capital is activity-specific and fully utilized, labour is mobile and fully employed and exchange rate is flexible.

4.2 Simulation results

This section reports and discusses the results of a non-neutral technological change as "capital-using" following Jackson's concept in agricultural sector of Thailand. There are two types of policy simulations. The first shock is the 5 percent increase in the production function share parameter (α_{fa}) for input capital in agricultural sector (Sector 1-8). The second simulation is the 5 percent increase in the net capital stock in agricultural sector (Sector 1-8) by 5 percent. The impact of both policy experiments can be divided into four analyses: input factor effects, sectoral output effects, income effects and finally macro economic effects.

4.2.1 Input factor effects

Before going into the detail of simulation results of this section, it has better to explain the basic role of production share parameter for factor. According to Chung (1994), he states that in a Cobb-Douglas production function, $y = f(x_1,...,x_n) = A\prod_{i=1}^{n} x_i^{a_i}$, "each parameter ($a_i$) directly indicates the share of output paid to the respective input". In addition, he points out that "if the value of parameter a_i is greater than the value of parameter a_j, the output (y) share of input i is greater than the share of input j". Moreover, Chung explains that if there are only two inputs let x_i and x_j be capital (K) and labour (L) respectively, "if the capital-labour ratio (K/L) of output y_1 is greater than that of output y_2 for the given wage-rental ratio, output y_1 is called the capital-intensive goods whereas output y_2 is called the labour-intensive goods.

Considering the base year value of production function share parameter (α_{fa}) of factor input obtained from the model (Table 4), it can be seen that the output of every sector paid to capital rather than labour (α_{fa} of capital is greater than α_{fa} of labour in each sector). Another word, the share of capital input is greater than the share of labour input in each sector in the Thai economy. The increase in α_{fa} of capital by approximately 5 percent (Simulation 1) resulted in the decrease in α_{fa} of labour in all agricultural sectors (sector 1 to 8) by approximately 8-21%. That means output of agricultural sector paid to input capital more than in the base year. Meanwhile, the production function share parameter remained the same in simulation 2 (Assumed).

The effect of both simulations in terms of quantity demand of factor is shown in Table 5. Simulation 1 led to the decrease in demand for labour in some agricultural sectors (sector 3, 4, 6 and 7) and some non agricultural sectors (sector 9, 10, 13, 16 and 20). The 5 percent increase in the net capital stock in agricultural sector (simulation 2), on the other hand, resulted in the increase in demand for labour mostly in agricultural sectors (sector 3, 4, 6, 7 and 8).

Table 4: Percentage change of share parameter of factor input (α_{fa}) in the production functions from simulation results compared with base year

Sectors	α_{fa} (Base year)		α_{fa} of Simulation 1 (%Δ)		α_{fa} of Simulation 2 (%Δ)	
	Labour	Capital	Labour	Capital	-	-
1. Paddy and Maize	0.381	0.619	-8.14	5.01	-	-
2. Cassava, Beans and Nuts	0.353	0.647	-9.07	4.95	-	-
3. Vegetables, Sugarcane and Fruits	0.247	0.753	-14.98	4.91	-	-
4. Rubber and Latex	0.216	0.784	-18.06	4.97	-	-
5. Other Crops	0.228	0.772	-17.11	5.05	-	-
6. Livestock	0.193	0.807	-20.73	4.96	-	-
4. Forestry	0.367	0.633	-8.72	5.06	-	-
8. Fishery	0.266	0.734	-13.91	5.04	-	-
9. Mining and Quarrying	0.346	0.654	-	-	-	-
10. Food Manufacturing	0.341	0.659	-	-	-	-
11. Textile Industry	0.426	0.574	-	-	-	-
12. Paper Industries and Printing	0.182	0.818	-	-	-	-
13. Rubber Chemical and Petroleum Industries	0.335	0.665	-	-	-	-
14. Non Metallic Products	0.341	0.659	-	-	-	-
15. Metal Product and Machinery	0.362	0.638	-	-	-	-
16. Agricultural Machinery	0.536	0.464	-	-	-	-
17. Other Manufacturing	0.379	0.621	-	-	-	-
18. Electricity, Water Work and Public Utilities	0.529	0.471	-	-	-	-
19. Construction and Trade	0.211	0.789	-	-	-	-
20. Service Transportation and Communication	0.597	0.403	-	-	-	-

Source: Model simulations

Table 5: Percentage change on quantity demand of factor (QF) from simulation results compared with base year

Sector	QF (%Δ) Simulation 1		QF (%Δ) Simulation 2	
	Labour (L)	Capital (K)	Labour (L)	Capital (K)
1. Paddy and Maize	1.58	-	-1.80	5.0000
2. Cassava, Beans and Nuts	10.55	-	-5.38	5.0002
3. Vegetables, Sugarcane and Fruits	-2.21	-	1.04	5.0000
4. Rubber and Latex	-8.63	-	4.50	5.0000
5. Other Crops	4.99	-	-2.03	5.0001
6. Livestock	-7.89	-	4.34	5.0000
7. Forestry	-5.00	-	1.34	5.0000
8. Fishery	0.67	-	2.83	5.0000
9. Mining and Quarrying	-2.08	-	1.10	-
10. Food Manufacturing	-1.85	-	0.68	-
11. Textile Industry	3.50	-	-1.20	-
12. Paper Industries and Printing	1.13	-	-0.39	-
13. Rubber Chemical and Petroleum Industries	-2.55	-	1.08	-
14. Non Metallic Products	2.93	-	-0.95	-
15. Metal Product and Machinery	1.34	-	-0.50	-
16. Agricultural Machinery	-25.43	-	11.76	-
17. Other Manufacturing	0.62	-	-0.17	-
18. Electricity, Water Work and Public Utilities	2.67	-	-0.78	-
19. Construction and Trade	1.29	-	-0.45	-
20. Service Transportation and Communication	-0.58	-	0.35	-

Source: Model simulations

If we consider the capital-labour ratio (K/L) in each sector in the base year (Table 6), it is found that most K/L of non agricultural sector (sector 9-20) is greater than agricultural sectors (sector 1-8). This means that non agricultural sector is the capital-intensive sector compared to agricultural sector which is labour-intensive sector. The result of simulation 1 had an effect on the increase and decrease in K/L in some agricultural sector. Meanwhile in simulation 2, there was an increase in this ratio in all agricultural sectors.

Therefore, it can be concluded that the 5 percent increase in the net capital stock in agricultural sector (Simulation 2) affected to all agricultural sector and some non-agricultural sector to be more capital intensive sector but more labour intensity came in sector 9, 10, 13 and 16. Whereas, the increase in share parameter (α_{fa}) of capital in agricultural sector by 5 % (Simulation 1) affected to only some agricultural sectors (sector 3, 4, 6 and 7) to be more capital intensive.

Table 6: Percentage change of the capital-labour ratio (K/L) from simulation results compared with base year

Unit: Baht/Person

Sector	K/L		
	Base year[1/]	Simulation1 (%Δ)	Simulation2 (%Δ)
1. Paddy and Maize	0.049	-0.016	0.069
2. Cassava, Beans and Nuts	0.056	-0.095	0.110
3. Vegetables, Sugarcane and Fruits	0.092	0.023	0.039
4. Rubber and Latex	0.110	0.094	0.005
5. Other Crops	0.103	-0.048	0.072
6. Livestock	0.126	0.086	0.006
7. Forestry	0.053	0.053	0.036
8. Fishery	0.410	-0.007	0.021
9. Mining and Quarrying	3.341	0.021	-0.011
10. Food Manufacturing	0.634	0.019	-0.007
11. Textile Industry	0.443	-0.034	0.012
12. Paper Industries and Printing	1.497	-0.011	0.004
13. Rubber Chemical and Petroleum Industries	0.631	0.026	-0.011
14. Non Metallic Products	0.642	-0.029	0.010
15. Metal Product and Machinery	0.549	-0.013	0.005
16. Agricultural Machinery	0.289	0.341	-0.105
17. Other Manufacturing	0.541	-0.006	0.002
18. Electricity, Water Work and Public Utilities	12.335	-0.026	0.008
19. Construction and Trade	0.290	-0.01	0.00
20. Service Transportation and Communication	1.302	0.01	-0.00

Source: Model simulations

[1/] 100 million baht/100 persons

4.2.2 Sectoral output effects

Due to constant return to scale, the increase in production function share parameter of capital by 5 % in agricultural sector caused the decrease in production function share parameter of labour around 8-14 % in its sector. The simulation 1 tried to put more share of output paid for capital rather than labour in agricultural sector. The results of simulation 1 generally shows that there was a decrease in level of activity a (QA), quantity of domestic output (QX), quantity of export (QE), output sold domestically (QD), composite commodity (QQ) and some quantity of import (QM) in almost all sector especially in agricultural sector (Table 7). The reasons behind the above decrease is that the reduction in QA simultaneously led to domestic output (QX), exports (QE), imports (QD) and composite supply (QQ) in the agricultural sector decreasing. A fall in agricultural domestic output was compensated by a rise of some agricultural imports.

The result of simulation 2 confirms production function theory as mentioned in the introduction that output can be increased if the inputs are increased. It can be seen from the Table 7 that when the input capital was injected into agricultural sector (sector 1-8), level of activity a (QA) in sector 1-8 (which was using Cobb-Douglas production function) were increased. Consequently, QX, QE, QD, QQ were increased as the same reason as explained in simulation 1. The positive changing of QA in agricultural sector simultaneously affected the reallocation of factors as intermediate inputs of other sectors as a result.

Table 7: Percentage change of level of activity QA, Quantity of domestic output QX, Quantity of export QE, output c sold domestically QD, Quantity of import QM and composite commodity QQ from simulation results compared with base year

Sector	Simulation 1 (%Δ)						Simulation 2 (%Δ)					
	QA	*QX*	*QE*	*QD*	*QM*	*QQ*	*QA*	*QX*	*QE*	*QD*	*QM*	*QQ*
1. Paddy and Maize	-8.41	-3.38	-7.85	-2.27	4.22	-2.22	2.36	1.31	3.25	0.81	-1.79	0.79
2. Cassava, Beans and Nuts	-5.94	-4.58	-6.05	-3.80	0.86	-2.58	1.21	1.65	2.30	1.30	-0.65	0.78
3. Vegetables, Sugarcane and Fruits	-9.01	-2.77	-2.99	-2.75	1.33	-2.60	4.01	1.22	1.31	1.21	-0.45	1.15
4. Rubber and Latex	-9.75	-1.10	-3.31	-0.86	1.81	-0.86	4.89	0.49	1.51	0.36	-0.81	0.36
5. Other Crops	-7.56	-1.66	-0.19	-1.96	-13.46	-4.38	3.36	0.72	0.21	0.82	5.13	1.64
6. Livestock	-9.15	-1.44	-1.54	-1.42	-0.56	-1.41	4.87	0.71	0.76	0.70	0.25	0.69
7. Forestry	-10.46	-2.36	-2.51	-2.30	-1.54	-2.07	3.65	0.91	0.98	0.89	0.60	0.80
8. Fishery	-3.07	-0.76	-0.57	-0.76	-1.46	-0.77	4.42	0.46	0.58	0.46	0.88	0.46
9. Mining and Quarrying	-0.73	-0.33	-0.09	-0.34	-0.62	-0.41	0.38	0.18	0.10	0.18	0.28	0.21
10. Food Manufacturing	-0.64	-3.86	-4.01	-3.74	0.62	-2.79	0.23	1.86	1.92	1.81	0.10	1.43
11. Textile Industry	1.48	0.62	0.65	0.60	-0.21	0.42	-0.51	-0.17	-0.18	-0.16	0.17	-0.09
12. Paper Industries and Printing	0.20	-0.05	-0.05	-0.04	0.05	-0.02	-0.07	0.04	0.04	0.04	0.04	0.04
13. Rubber Chemical and Petroleum Industries	-0.86	-1.00	-0.91	-1.03	-1.97	-1.30	0.36	0.52	0.48	0.53	0.94	0.65
14. Non Metallic Products	0.99	-0.02	-0.01	-0.05	-0.22	-0.09	-0.33	0.07	0.07	0.08	0.14	0.09
15. Metal Product and Machinery	0.48	0.37	0.39	0.34	-0.16	0.06	-0.18	-0.13	-0.14	-0.11	0.13	0.02
16. Agricultural Machinery	-14.55	-3.84	-2.92	-3.88	-10.40	-6.83	6.14	1.64	1.28	1.66	4.92	3.08
17. Other Manufacturing	0.24	-0.17	-0.16	-0.18	-0.42	-0.32	-0.06	0.09	0.09	0.10	0.26	0.19
18. Electricity, Water Work and Public Utilities	1.40	0.17	0.12	0.17	0.24	0.17	-0.41	0.03	-0.00	0.03	-0.05	0.03
19. Construction and Trade	0.27	-0.09	-1.40	-0.07	-0.31	-0.07	-0.10	0.10	-1.55	0.13	0.26	0.13
20. Service Transportation and Communication	-0.35	-0.61	-0.62	-0.61	-0.52	-0.60	0.21	0.35	0.36	0.35	0.24	0.33

Source: Model simulation

4.2.4 Income effects

This section, we show the simulation results particularly on income effect of domestic institutions (enterprise, household and government). Generally, it seems that simulation 1 brought the negative income effects to the domestic institutions. In contrast, there was a positive effect on domestic institutions in simulation 2 (Table 8).

In the simulation 1, as explained in section 4.2.1 that the increase in α_{fa} of capital by approximately 5 percent resulted in the decrease in α_{fa} of labour in all agricultural sectors (sector 1 to 8) by approximately 8-21% while α_{fa} of capital and labour in other sectors remained the same. This resulted in the decline of the average price (WF_f) of labour in the economy. Consequently, there was a decrease in income of factor f (YF_f). This factor income is split to household and enterprise in fixed share. Labour and capital incomes belong to household whereas only capital income flows to enterprise. Finally, overall labour income dropped by 1.20 % while capital income dropped by 1.02 %.

Household and enterprise own input factor, therefore, when there is a decrease in labour and capital income that means enterprise and household earn less income. For this reason, the simulation 1 simultaneous affected enterprise income and household income in a negative direction by 1.01 and 1.11 %. Finally, government revenue was decreased approximately 0.87 % because the government had received less income tax from both household and enterprise.

The result of simulation 2 in terms of income effects on domestic institutions was opposite from simulation 1. When the 5 % of capital stock was injected into agricultural sector, it caused an increase in supply of agricultural input capital (QF of capital) in total but the supply of overall labour in economy was still the same. Considering equation 15, $YF_f = \sum_{a \in A} WF_f \cdot WFDIST_{fa} \cdot QF_{fa}$, therefore, this effect caused the increase in factor income (YF). Similar reason to the simulation 1 but opposite direction, the increase in factor income (0.57 % from labour income and 0.51 % from capital income) brought about the increase in enterprise and household income by 0.51 and 0.54 %. Finally, it affected to the increase in government income by 0.42 % (Table 8).

Table 8: Percentage change on factor income (YF), enterprise income ($YENT$), household income (YH), and government income (YG) from simulation results compared with the base year

Variables	Base year ('00 Million baht)	Simulation 1 (%Δ)	Simulation 2 (%Δ)
Factor income (YF)			
Labour (L)	16,064.610	-1.1992	0.5740
Capital (K)	25,028.235	-1.0174	0.5123
Enterprise income ($YENT$)	15,207.352	-1.0098	0.5083
Household income (YH)	26,094.807	-1.1102	0.5404
Government income (YG)	7,765.204	-0.8746	0.4222

Source: Model simulations

4.2.5 Macro economic effects

The last impact of capital intensive farming on the overall macro economic indicators is showed in Table 9. In general, simulation 1 had confirmed a negative effect on private consumption ($PRVCON$), government consumption ($GOVCON$), Investment ($INVEST$), Export (EXP), Import (IMP) and Gross Domestic Product (GDP). On the other hand, simulation 2 led to a rise of above macro economic indicators.

In simulation 1, regarding private consumption, it is calculated from the summation of household consumption (QH_{ch}) multiply by composite commodity price (PQ_c). Nevertheless, household consumption is also based on their income (equation 18: $QH_{ch} = \frac{\beta_{ch} \cdot (1 - mps_h) \cdot (1 - ty_h) \cdot (1 - \text{int}_{ent,h}) \cdot YH_h}{PQ_c}$). As a result of a decline in household income (described in previous section), therefore private consumption decreased by 1.10 %. The government consumption was decreased by 0.33 % because government revenue was declined. The overall investment demand was decreased by 1.69 % because there was a decrease in quantity of investment demand in every sector. Simulation 1 also affected a drop of import and export by 1.01 and 0.90 % respectively because exchange rate was depreciated by 0.4 %.

In simulation 2, because of a rise in household income, therefore, it affected to the 0.55 % increase in private consumption. The demand for government consumption was increased by 0.08 %. Investment demand was increased by 0.92 %. Due to the exchange rate was appreciated by 0.1 %, it affected to the increase in export and import by 0.43 and 0.49 %.

As a result of the decrease in private consumption, government consumption, investment, export and import in simulation 1, there was a decrease in Gross Domestic Product (GDP) by 1 %. In contrast, those macro economic indicators were increased in simulation 2 which then resulted in a rise in GDP by 0.53 % (Table 9).

Table 9: Percentage change on macro economic indicators from simulation results compared with the base year

Macro economic variables	Base year ('00 Million baht)	Simulation 1 (%Δ)	Simulation 2 (%Δ)
Private Consumption (*PRVCON*)	22,238.60	-1.0977	0.5530
Government Consumption (*GOVCON*)	5,558.41	-0.3272	0.0786
Investment (*INVEST*)	11,565.25	-1.6866	0.9236
Export (*EXP*)	36,250.78	-0.8909	0.4279
Import (*IMP*)	29,720.99	-1.0055	0.4911
Gross Domestic Product (*GDP*)	46,142.22	-1.0463	0.5285

Source: Model simulations

5. Conclusion and Policy Implication

5.1 Conclusion

This 20 sector CGE model was constructed in order to investigate the impact of capital intensive farming by two different concepts from Jackson, 1998. The first shock was generated by increasing share parameter (α_{fa}) of capital in agricultural sectors. The second concept is the direct 5 % increase in capital stock in agricultural sectors.

The results of the two policy simulations were quite different in terms of sectoral input and output effects, institution income effects and macro economic variabless. The increase in share parameter (α_{fa}) of capital in agricultural sector (Sector 1-8) by 5 % led to more capital intensive in four agricultural sectors, whereas the 5 % increase in agricultural capital stock would spur a rise in the capital intensive sectors in all agricultural sector.

The effects of two simulations had a simultaneous impact on output in every sector. The 5 % increase in capital share parameter (α_{fa}) in agricultural sector (Sector 1-8) led to a fall of the level activity (QA), domestic output (QX), export (QE), import (QD) and composite supply (QQ) in almost all sector. Meanwhile, the 5 % input capital injected into agricultural sector brought the opposite results from the simulation 1 in terms of sectoral output.

Income effect, when simulating the 5 % increase in share parameter (α_{fa}) of capital input, there was a decrease in share parameter (α_{fa}) of labour input around 8-12 %. The average price of labour (WF_f) was decreased. This led to a drop in factor income which belongs to household and enterprise. Consequently, government income was declined by 0.87 % due to less collected tax. In contrast, the 5 % increase in agricultural capital stock resulted in the increase in income of household, enterprise, and government as above explanation but opposite direction.

Finally, the 5 % increase in capital share parameter (α_{fa}) in agricultural sector had a negative impact on all macro economic variables; private consumption, government consumption, investment, export, import and Gross Domestic Product. On the contrary, the 5 % increase in capital stock in agricultural sector had a positive impact on those above variables.

5.2 Policy Implications

The findings from this study will aid in the formation of guidelines for capital input policy, especially concerning the agricultural sector in Thailand. It seems that capital intensive farming in the perspective of the increase in net capital stock in agricultural sector (Simulation 2) had a positive effect in almost every economic variables rather than the increase in capital share parameter (α_{fa}) (Simulation 1).

Simulation 2 points out that agricultural sector would be more capital intensive. Furthermore, output of all agricultural sector (Sector 1-8), institutional incomes and macro variables (consumption, investment, export, import and GDP) would be increased. However, there was mobility in labour demand in each sector in the economic system as we assumed that labour is mobile and fully employed. Therefore, if government is planning to achieve these results, capital stock, for examples, tractors, water pumps, harvesting machine and other equipments need to be injected into agricultural sector. Nevertheless, government should be aware of labour relocation between agricultural sector to non-agricultural sector such as providing skill training to those workers who would be moving from one sector to another sector.

Although the increase in share parameter (α_{fa}) of capital in agricultural sector (Simulation 1) brought harmful effects to output almost all sector, institution's income and macro variables. This case may be chosen when the government would like to slow down the economic growth. The question is how can we increase the share parameter (α_{fa}) in agricultural sector in practice. From Cobb-Douglas production function (Chung 1994; pp95):

$$y = f(x_1, ..., x_n) = A\coprod_{i=1}^{n} x_i^{a_i}$$

where

y = output

x = input

$A > 0, 0 < a_i < 1$ and $\sum_i a_i = 1$

Its marginal product (MP) is $\frac{\partial y}{\partial x} = a_i \frac{y}{x} > 0$ (37)

At the optimum, we have $MP_i = \frac{w_i}{p}$ (38)

where

w_i = the price of input

p = the price of output

From equation (37) and (38) we obtain $a_i = \frac{w_i \cdot x_i}{p \cdot y}$ (39)

Hence, the share parameter in a production function (α_{fa}) or a_i in equation (39) can be increased if firstly there is an increase in w_i or x_i or both of them. Secondly if there is a decrease in p or y or both of them. This means that if government would like to obtain simulation's 1 results, policies for examples, an increase in a minimum wage and rent need to be imposed. In addition, the lower price of the agricultural product would be determined or the restriction of agricultural production policies would be required. Nonetheless, other policy needs to be prepared to compensate for its negative effects.

5.3 Limitation of the study

The advantage of CGE model is that it captures the circular flow of goods and services in an economy including the behaviour of economic agents such as households (maximize their utility), firms (maximize their profit) and government. CGE model has flexible choices of closure rules and assumptions that suitable for each simulation. Similarly to other CGE models, this study has some limitations and assumptions, for example, we used Cobb-Douglas production function with a constant return to scale. We also used

Cobb-Douglas technology in utility function. Furthermore, it is assumed that there was a full employment in the economy and all investment was determined by saving (or the neoclassical closure).

This study was using Cobb-Douglas production function because we would like to test the impact of technological change concept by Jackson (1998). This concept has not been applied to CGE model before. The future study may apply this concept into CGE model but using different production functions and utility function forms such as Constant Elasticity of Substitution (CES) or Stone-Geary for Linear Expenditure System to investigate weather the results are the same direction. In addition, the choice of macro closure may be switched to other closure such as Keynes and Johansen closure which is allowing unemployment in the model.

Appendix A

Sectoral Index

Sector No.	Name	Description
1	ACT01	Paddy and Maize Activity
2	ACT02	Cassava Beans and Nuts Activity
3	ACT03	Vegetables Sugarcane and Fruits Activity
4	ACT04	Rubber and Latex Activity
5	ACT05	Other Crops Activity
6	ACT06	Livestock Activity
7	ACT07	Forestry Activity
8	ACT08	Fishery Activity
9	ACT09	Mining and Quarrying Activity
10	ACT10	Food Manufacturing Activity
11	ACT11	Textile Industry Activity
12	ACT12	Paper Industries and Printing Activity
13	ACT13	Rubber Chemical and Petroleum Industries Activity
14	ACT14	Non Metallic Products Activity
15	ACT15	Metal Product and Machinery Activity
16	ACT16	Agricultural Machinery Activity
17	ACT17	Other Manufacturing Activity
18	ACT18	Electricity Water Work Public Utilities Activity
19	ACT19	Construction and Trade Activity
20	ACT20	Service Transportation and Communication Activity

Appendix B

SETS

$a \in A$	a set of activities with Cobb-Douglas function
$c \in C$	commodities
$c \in CM(\subset C)$	imported commodities
$c \in CE(\subset C)$	exported commodities
$f \in F$	factors (Labour and Capital)
$h \in H(\subset ID)$	households
$ent \in ENT(\subset ID)$	enterprise
$i \in ID(\subset I)$	institutions (ID = household, enterprise), (I = household, enterprise, government and the rest of the world.)

PARAMETERS

ad_a	production function efficiency parameter
ag_a	government subsidy for activity a
aq_c	shift parameter for composite supply (Armington) function
at_c	shift parameter for output transformation (CET) function
$capital_a$	net capital stock at 2000 cost (million baht)
$\cos tgap_{fa}$	gap calibrated factor cost-SAM value (should be zero)
cpi	consumer price index
$cwts_c$	commodity weight in cpi
$finv$	Thailand's foreign investment
ica_{ca}	quantity of c as intermediate input per unit of activity a
$\text{int}_{ent,h}$	rate of interest and insurance payments from household to enterprises
$labour_a$	quantity of labour employed by activity (million persons)
pwe_c	export price (foreign currency)
pwm_c	import price (foreign currency)

qg_c	government commodity demand
$qinvbar_c$	based year investment demand
$shryid_{id,f}$	share for domestic institutions except government in income of factor f
$tcap_f$	rate of tax on capital income
te_c	export tax rate
$tent_{ent}$	rate of corporate tax
tic_c	sale tax rate (indirect tax)
tia_c	value added tax rate (indirect tax)
tm_c	import tax rate
$tr_{i,i}$	transfer from institution i to institution i
ty_h	household income tax rate
wfa_{fa}	wage (rent) for factor f in activity a (for calibration only)
α_{fa}	production function share parameter or value-added share for factor f in activity a
β_{ch}	share of household consumption spending on commodity c
δ_c^q	share parameter for composite supply (Armington function)
δ_c^t	share parameter for output transformation (CET) function
θ_{ac}	yield of commodity c per unit of activity A
ρ_c^q	exponent for composite supply (Armington function) $-1 < \rho_c^q < \infty$
ρ_c^t	exponent for output transformation (CET) function $1 < \rho_c^t < \infty$
σ_c^q	elasticity of substitution between domestic goods and imports for commodity c
σ_t^q	elasticity of transformation between domestic sales and exports for commodity c

VARIABLES

EG	government expenditure
EXR	foreign exchange rate (domestic currency per unit of foreign currency
$ENTSAV_{ent}$	enterprise savings
FSAV	foreign savings
IADJ	investment adjustment factor
MPS_h	marginal propensity to save for household h
PA_a	activity price
PD_c	domestic output price
PE_c	export price (domestic currency)
PM_c	import price (domestic currency)
PQ_c	composite commodity price
PVA_a	value added price
PX_c	producer price
QA_a	activity level
QD_c	quantity of domestic output sold domestically
QE_c	export quantity
QF_{fa}	quantity demand of factor f by activity a
QFS_f	supply of factor f
QH_{ch}	quantity of consumption of commodity c by household h
$QINT_{ca}$	quantity of intermediate use of commodity c by activity a
$QINV_c$	quantity investment demand
QM_c	import quantity
QQ_c	composite supply (quantity supplied to domestic commodity demand)
QX_c	domestic output quantity
WALRAS	dummy variable (zero at equilibrium)
WF_f	average wage (rental rate) of factor f
$WFDIST_{fa}$	wage distortion factor for factor f in activity a
$YENT_{ent}$	enterprise income
YF_f	income of factor f
$YFID_{id,f}$	income transfer from factor f to domestic institutions
YG	government revenue
YH_h	household income

Appendix C

Table C-1: Constant elasticity of substitution (CES) between domestically produced and import commodities (Armington elasticities)

Sector No.	Description	CES
1	Paddy and Maize	1.0694
2	Cassava, Beans and Nuts	1.9097
3	Vegetables, Sugarcane and Fruits	1.6296
4	Rubber and Latex	0.11
5	Other Crops	0.6954
6	Livestock	0.7587
7	Forestry	0.3646
8	Fishery	1.6722
9	Mining and Quarrying	0.1151
10	Food Manufacturing	1.6171
11	Textile Industry	1.463
12	Paper Industries and Printing	0.9807
13	Rubber Chemical and Petroleum Industries	0.8326
14	Non Metallic Products	0.5172
15	Metal Product and Machinery	0.9735
16	Agricultural Machinery	0.7359
17	Other Manufacturing	0.9692
18	Electricity, Water Work, Public Utilities	0.953
19	Construction and Trade	0.12
20	Service Transportation and Communication	0.8486

Source: Warr, P.G and Lapiz, E.A (1994)

Table C-2: Elasticity of transformation (CET) between domestically sold and exported commodities

Sector No.	Description	CET
1	Paddy and Maize	0.9777[1/]
2	Cassava, Beans and Nuts	0.9546[1/]
3	Vegetables, Sugarcane and Fruits	0.1
4	Rubber and Latex	0.1
5	Other Crops	0.1
6	Livestock	0.1
7	Forestry	0.1
8	Fishery	0.1
9	Mining and Quarrying	0.1
10	Food Manufacturing	0.1
11	Textile Industry	0.1
12	Paper Industries and Printing	0.1
13	Rubber Chemical and Petroleum Industries	0.1
14	Non Metallic Products	0.1
15	Metal Product and Machinery	0.1
16	Agricultural Machinery	0.1
17	Other Manufacturing	0.1
18	Electricity, Water Work, Public Utilities	0.1
19	Construction and Trade	0.12
20	Service Transportation and Communication	0.1

Source: [1/]Warr, P.G and Lapiz, E.A (1994)

Wattanakuljarus, A. and Coxhead, I. (2006)

Appendix D

Table D1: Quantity of labour employed by activity in Thailand, 2000

Unit: Persons

Sector No.	Description	Number of workers
1	Paddy and Maize	4,301,954
2	Cassava, Beans and Nuts	570,585
3	Vegetables, Sugarcane and Fruits	2,769,017
4	Rubber and Latex	997,168
5	Other Crops	962,316
6	Livestock	1,146,515
7	Forestry	252,294
8	Fishery	442,050
9	Mining and Quarrying	68,730
10	Food Manufacturing	929,460
11	Textile Industry	860,159
12	Paper Industries and Printing	101,820
13	Rubber Chemical and Petroleum Industries	690,281
14	Non Metallic Products	200,337
15	Metal Product and Machinery	1,483,844
16	Agricultural Machinery	5,065
17	Other Manufacturing	869,115
18	Electricity, Water Work, Public Utilities	101,630
19	Construction and Trade	6,588,070
20	Service Transportation and Communication	7,104,260

Sources: The Labour Force Survey 2001, National Statistical Office

Table D2: The quantity of net capital stock of Thailand in each sector, 2000

Unit: Million baht

Sector No.	Description	Net Capital Stock
1	Paddy and Maize	211,526
2	Cassava, Beans and Nuts	31,719
3	Vegetables, Sugarcane and Fruits	255,477
4	Rubber and Latex	109,524
5	Other Crops	98,921
6	Livestock	145,024
7	Forestry	13,252
8	Fishery	181,324
9	Mining and Quarrying	229,649
10	Food Manufacturing	589,372
11	Textile Industry	380,767
12	Paper Industries and Printing	152,406
13	Rubber Chemical and Petroleum Industries	435,473
14	Non Metallic Products	128,573
15	Metal Product and Machinery	814,478
16	Agricultural Machinery	1,464
17	Other Manufacturing	469,945
18	Electricity, Water Work, Public Utilities	1,253,577
19	Construction and Trade	1,912,144
20	Service Transportation and Communication	9,247,325

Sources: Capital Stock of Thailand 2006 Edition, NESDB

References

Chung, J. W. (1994). Utility and Production Function; Theory and Applications. Cambridge. Blackwell Publishers, Massachusetts.

Dimaranan, B V., McDougall R A. and Hertel, T W. (2008). Behavioral Parameters, GTAP 6 Data Base documentation. Retrieved May 10, 2008 from https://www.gtap.agecon.purdue.edu/resources/download/2931.pdf

Hayami Y. and Ruttan, V. W. (1985). Agricultural Development. The John Hopkins University Press, Baltimore.

Hanson, K., Gilan,E., Vogel,S. and Olmsted, J. (2002) tracing the Impact of Food Assistance Programs on Agricultural and Consumers: A Computable General Equilibrium Model, Food Assistance and Nutrition Research Report Number 18, USDA.

International Food Policy Research Institute (IFPRI). 2003. IFPRI in collaboration with Kuwait Institute for Scientific Research (KISR). January 13-15, training material in

Introduction To General Equilibrium Modeling For Policy Analysis course. Retrieved September 9, 2006 from http://www.ifpri.org/training/material/computerapps /cge/5SAMcircular.ppt

Jackson, D. (1998). Technological Change, the Learning Curve and Profitability. Cheltenham. Edward Elgar Publishing Limited.

Lofgren, H., Harris,R.L., Robinson, S. (2002). A Standard Computable General Equilibrium (CGE) Model in GAMS, Microcomputer in Policy Research Working Paper No.5, International Food Policy Research Institute, Washington DC.

Lofgren, H. (2003). Exercises in General Equilibrium Modelling Using GAMS, Microcomputer in Policy Research 4a, International Food Policy Research Institute, Washington DC.

Office of National Economic and Social Development Board. (2006). Capital Stock of Thailand 2006 Edition. Retrieved January 14, 2008 from http://www.nesdb.go.th/Portals/ /0/eco_datas/account/bs/2006/Capital%20Stock%202549%20Completed%20Report.pdf

Office of National Economic and Social Development Board. (2006). National income of Thailand 2006 Edition. Retrieved January 14, 2008 from http://www.nesdb.go.th/ Portals /0/eco_datas/account/ni/ni_1993-2006/book_ni2006.pdf.

Office of National Economic and Social Development Board. (2006). Input Output Table of Thailand 2000. Retrieved March 31, 2008 from http://www.nesdb.go.th/Default. aspx?tabid=97

Provide Project (2003). Social Accounting Matrices and Economic Modelling, Background paper 2003:4. Retrieved January 14, 2008 from http://www.elsenburg.com /provide/.

Reinert, K.A. and Roland-Host, D.W. (1997) Chapter 4: Social Accounting Matrices in Applied Methods for Trade Policy Analysis. Cambridge University Press, Cambridge, UK.

Robinson, S. (2003). Macro Models and Multipliers: Leontief, Stone, Keynes and CGE Models. International Food Policy Research Institute (IFPRI). International Food Policy Research Institute, Washington DC.

Robison, S., Cattaneo, A. and Said, M.E. (1998). Estimating Social Accounting Matrix Using Cross Entropy Methods.

Salter, W.E.G. (1969). Productivity and Technical Change. London. Cambridge University Press.

Statistical Forecasting Bureau, National Statistical Office. (2001). Report of the Labour Force Survey Whole Kingdom Quarter 1 January – March 2001. Bangkok, Thailand.

Thaiprasert, N. (2006). Rethinking the Role of Agricultural and Agro-Industry in Economic Development of Thailand: Input-Output and CGE Analyses. Ph.D. Dissertation, Nagoya University, Nagoya, Japan.

Thissen, M. (1998). A Classification of Empirical CGE Modelling. SOM Research Report 99C01, University of Groningen, The Netherlands.

The Provincial Decision-Making Enabling (PROVIDE) Project (2003). Social Accounting Matrices and Economic Modelling. Background Paper 2003:4, Elsenburg, Western Cape, South Africa.

Siamwalla, A. (1996). Thai Agriculture: From Engine of Growth to Sunset Status, TDRI Quarterly Review Vol.11 No.4 pp3-10 Thailand Development Research Institute.

Samuelson, P. A. and Nordhaus W. D. (1995). Microeconomics, McGraw-Hill, Inc.

Warr, P.G. and Lapiz, E.A. (1994) Estimation of Elasticity of Substitution/Transformation between Domestic and Imported/Exported Commodities. in Final Workshop Seminar: The PARA General Equilibrium Model of The Thai Economy. Office of Agricultural Economics and Australian National University.

Wattanakuljarus, A. and Coxhead, I. (2006) Is Tourism-Based Development Good for the Poor? A General Equilibrium Analysis for Thailand. Staff Paper No.502 Department of Agricultural & Applied Economics, University of Wisconsin-Madison.