REGIONAL DEVELOPMENT ECONOMICS: EVALUATION OF THE IMPACTS OF CORPORATE HOG PRODUCTION IN TEXAS COUNTY, OKLAHOMA

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DOCTOR OF PHILOSOPHY
December, 2000

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ACKNOWLEDGMENTS

I would like to express my sincere appreciation to my major adviser, Dr. Larry D. Sanders, for his guidance, encouragement, and support me in all of the time I study in the Oklahoma State University and for the completion of this dissertation. Special thanks to Dr. Dean Schreiner, who provided very efficient discussions in constructing the CGE model, and spending time to revise the dissertation. I also would like to thank members of my committee: Dr. Daniel S. Tilley, Dr. Francis Epplin, and Dr. Doug Hamilton for the guidance and providing comments to improve this dissertation. I appreciate Ms. St. Clair for providing the IMPLAN software and data for this study. I would like to thank Ms. Donna Rhea for her help and support.

I would like to thank the Fulbright and the Department of Agricultural Economics for providing me scholarship and assistantship, respectively, to complete the Ph.D. degree. Many thanks to all of the faculty and staff members of the Department of Agricultural Economics for teaching and supporting during the time I study in the Oklahoma State University.

I would like to appreciate Ms. Tam Phan and her family for the warm friendship and her taking care during the time I had health problem.

The deepest appreciation is to my parents who take care of me and encourage me to go further. Finally, I would like to share the happiness of the graduation to my wife, Thuy Ngo, and my two children, Thien Do, and Giang Do who are always waiting for this day.

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CHAPTER I

INTRODUCTION

1.1. PROBLEM STATEMENT

In 1987, the population of Texas County, Oklahoma, decreased and the unemployment rate increased because of the closure of Swift Beef Packing Plant and the slow down of the oil and gas industry (Figure 1.1). In hopes of reversing population and unemployment trends, the policy makers of Oklahoma and Texas County implemented development policies to create incentives for industrial recruitment in the county. Government intervention included tax exemption, income tax credit, low interest loan, subsidized energy, and other financial support (Barlett and Steele, 1998). Seaboard Farms responded to the incentives offered by Texas County. It purchased land in this area in 1994 to establish corporate-owned swine production. The company started the packing plant in 1995 at Guymon, Oklahoma, in Texas County (North Central Regional Center for Rural Development). The number of hog and pig farms in Texas County decreased from 49 in 1987 to 22 farms in 1997, while market value of hogs and pigs grew from $1.4 million in 1987 to $199.5 million in 1997 (USDA, 1997 Census of Agriculture). The change in number of farms and product value implies that the rapid increase in hog activity and hog farm size in this county was directly related to the Seaboard integrated approach.

As shown in Figure 1.2, hog and pig inventory in Oklahoma has increased rapidly since 1994 while that of other livestock is almost constant. The trends in hogs and pig inventory classified by districts presented in Figure 1.3 indicate that inventory in the Panhandle (includes Texas County) provides the largest contribution to the increase of hog and pig production of Oklahoma. This suggests, again, that the corporate integrated hog activity played a major role in the fastest growing activity in Oklahoma agriculture.

Research of St. Clair et al., 1998, showed that county employment increased 65% from 1993 to 1998. Total personal income of Texas County increased from $245 million in 1987 to $300 million in 1995. The report ended with the conclusion:

> "The opening of new industries, in addition to the expansion of Seaboard, have had a tremendous impact on the communities and surrounding areas. The opening of the Seaboard pork processing plant in the City of Guymon and pork production operations in Texas County has created 3,700 new jobs over the last 4-5 years. Since Seaboard's opening in 1993, numerous other industries have grown in Texas County. This has had a multiplier effect and has created a tremendous amount of secondary employment." (St. Clair et al., 1998, p. 75)

However, besides these positive impacts from hog production, there may also be other impacts, both positive and negative. The waste from hog farming may adversely impact water and air quality not only at adjacent areas but also ground water as a non-point source of pollution. Hog farming may increase the value of housing in the county because of increasing demand for housing, but also may decrease some home values because of environmental degradation. The economic impact of hog farming consists of both market and non-market values.

The North Central Regional Center for Rural Development reported that, although the increase of corporate hog farming (because of investment of Seaboard Farm) brought jobs into the community, those who were hired are not residents of Texas County. The unemployment rate of the county was as low as 3.7 percent and the wage paid by Seaboard was $7 per hour, lower than the local average wage ($8.31 per hour). As a result, the average income per capita decreased 13 percent from 1993 to 1996 while average income of Oklahoma increase 12 percent during the same period. With Seaboard's new workers and their families and related business support, the population of Texas County increased about 10 percent from 1990 to 1997. The increase of population caused pressure on housing and schools. The housing rental rates increased 84.5 percent (from average of $218 to $400 a month). Violent crimes increased 378 percent and thefts increased 64 percent. The dropout rate in Texas County schools increased to one out of every 16 students, while this rate of other counties was one out of every 45 students. The ethnic mix also changed in the community. By 1997, about 450 students (21%) had limited proficiency in English, so the school was compelled to add English-as-a-second-language classes (Barlett and Steele, 1998).

The report of North Central Regional Center for Rural Development reported concern about the environmental cost caused by corporate hog operations to Texas County. The large amounts of waste, as much as 1.738 billion pounds produced per day, caused significant adverse odor to adjacent areas and may contaminate ground water. Applying large amounts of manure to the farmland purportedly caused nitrate pollution, phosphorus build up and increased salinity to the soil and water. Seaboard operation increased 66 percent of water used for livestock between 1990 to 1998. The water table dropped 12 feet during this period because of overuse of ground water. The authors offered the following conclusion:

> "...The entrance of the hog industry has polluted the community... And who has benefited from the state, county and local incentives that lured Seaboard Farms to the areas? Certainly not the taxpayers... Certainly not the school children... Certainly not the wage earners... Certainly not the law enforcement officers... The main beneficiaries of the agreement between Texas County and

> Seaboard Farms are the stockholders of Seaboard Farms." (North Central Regional Center for Rural Development, p. 57)

The general objective of development policy is to obtain economic growth in a specific region. Economic growth is defined as an increase in the well being of people, particularly as an increase in income. The well being of people also includes the quality of housing, community services, and environment (Tweeten, 1972). All sectors of the economy affect the well being of people. Distribution of well being is also a main concern of policy makers. The operation of industry has various impacts on the economy in production areas, such as increasing income of residents, increasing employed people, increasing demand for services. Increasing operation of one industry also interacts with other sectors of the economy. So, to evaluate the impact of development policies, the changes that take place in all sectors of the economy as a whole system need to be evaluated even though the policies directly affect only one or a few sectors.

The operation of Seaboard Farms in Guymon and Texas County has affected the region's economy, possibly including both negative and positive impacts. It is necessary to research the economy as an integrated system to obtain more accurate impacts of policies that brought Seaboard Farms to Texas County.

1.2. OBJECTIVES

The general objective of this research is to identify the changes in the regional economy in response to policies that created incentives for hog producers and processors.

The specific objectives are as follows:

Determine the impacts of policy on changes in regional income, employment and demand for goods and services.

Identify income changes of regional household groups. This will show policy makers how impacts were distributed among groups of people.

Measure other changes in welfare of the region. Investment of the industry in a region typically changes prices of goods and services in the region. These price changes cause changes in welfare of the various regional household groups. The change of regional welfare is one of the indicators to identify efficiency of the policy.

The public investment to attract Seaboard Farms and private investment by Seaboard has had significant impacts on Texas County's economy and adjacent areas. The impact is not only on the hog and pig production industry, but also on other industrial sectors, employment, income of residents, infrastructure of region. Hog production activities may cause environmental problems in the region. However, because of time and resource constraints, this study does not include the environmental impact in the analysis.

Figure 1.1 Labor Force of Texas County.

(USDA 1997 Census of Agriculture on CD includes supplementary data to January 2000)

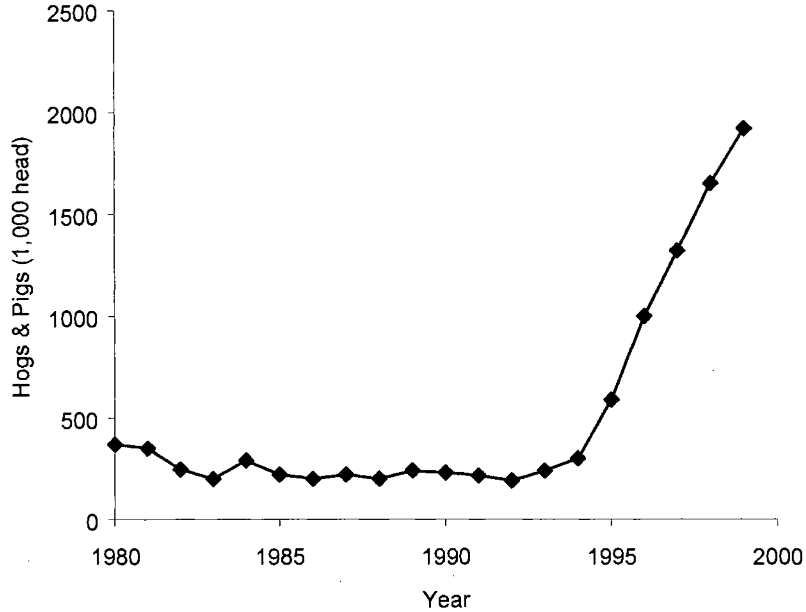

Figure 1.2a Hogs and Pigs Inventory in Oklahoma from 1980 to 1999.

(Oklahoma Department of Agriculture, Oklahoma Agricultural Statistics 1980-1999)

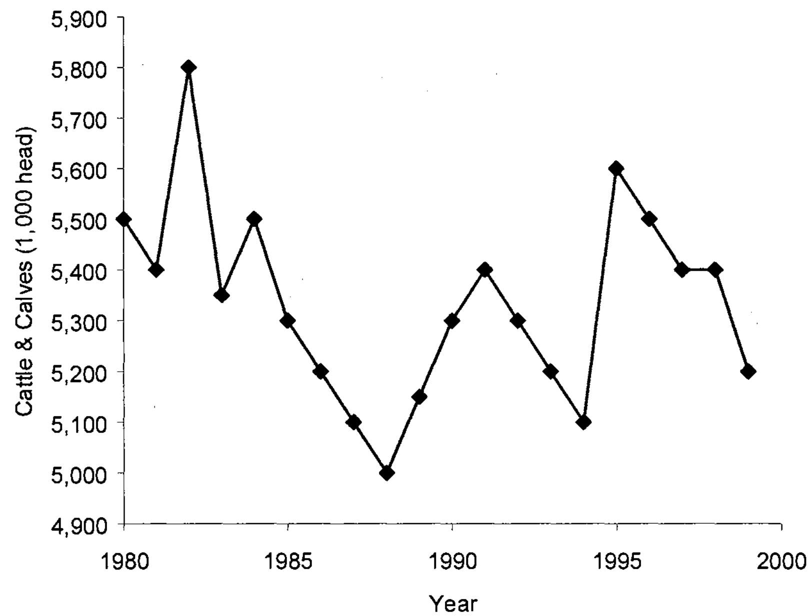

Figure 1.2b Cattle and Calves Inventory in Oklahoma from 1980 to 1999.

(Oklahoma Department of Agriculture, Oklahoma Agricultural Statistics 1980-1999)

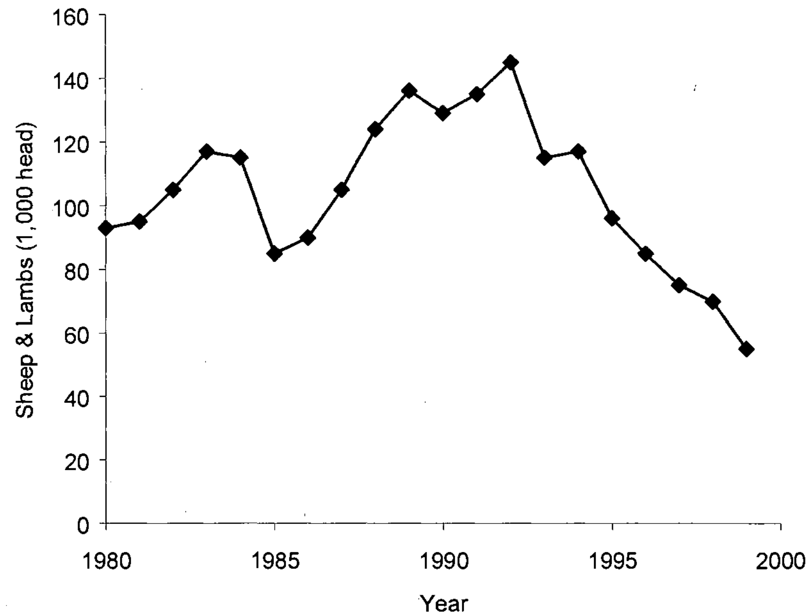

Figure 1.2c: Sheep and Lambs Inventory in Oklahoma from 1980 to 1999.

(Oklahoma Department of Agriculture, Oklahoma Agricultural Statistics 1980-1999)

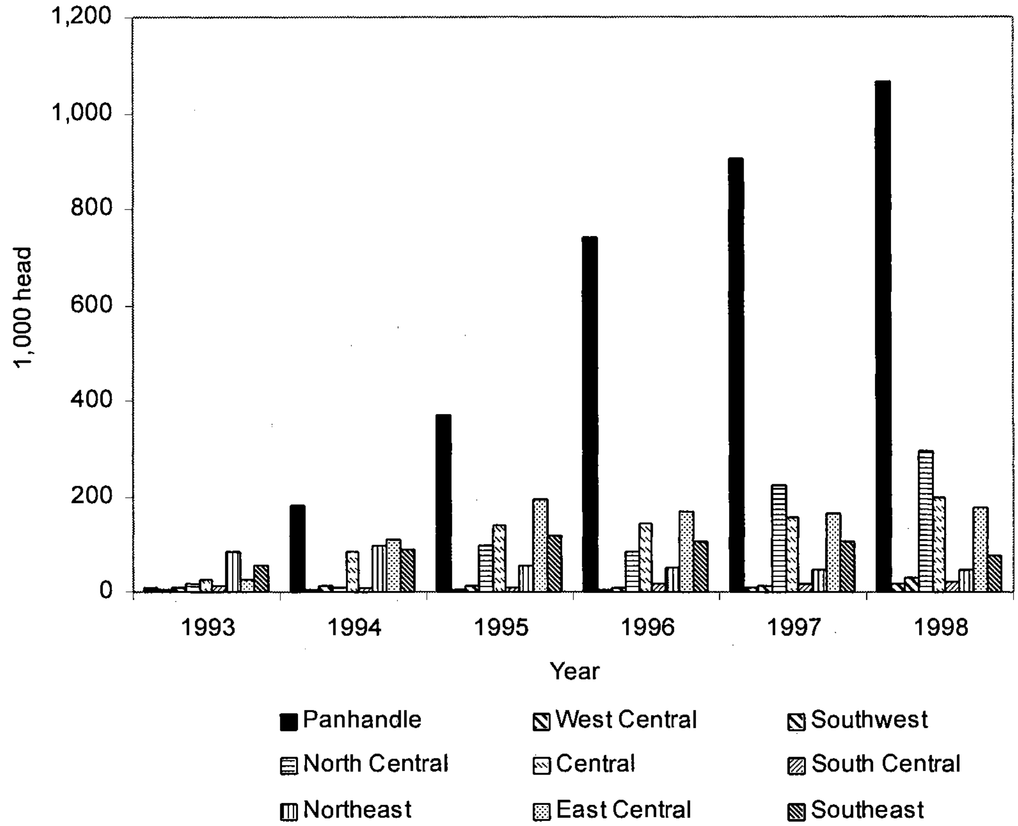

Figure 1.3 Hogs Production in Oklahoma.

(Oklahoma Department of Agriculture, Oklahoma Agricultural Statistics 1993-1998)

CHAPTER II

LITERATURE REVIEW

METHODS TO MEASURE ECONOMIC IMPACTS

The general objective of regional development is to improve the welfare of people. To achieve that objective the policy makers apply policy such as increasing government expenditures, changing tax rates, creating incentives and attracting new firms to the region. Changes in the economic environment outside the region, such as export price, also affects the regional economy. When a new plant enters the region it employs a certain number of people. These new employees depend on others to provide food, housing, clothing, services, education, etc. This creates new demand, sometimes called the multiplier effect, for goods in the region. This process raises such questions as "What are the direct effects of this new activity on output of the region?" or "What are indirect effects to the employment and income in the region?"

To measure the effects on regional economy, the economists often use the instrument known as "regional impact analysis." This analysis emphasizes the regional benefits associated with the changes in structure of a regional economy and is normally based on demand-oriented models.

This section reviews the methods that are usually applied for regional impact analysis, from the simplest economic-base model to the more complete input-output model. The general equilibrium model is the most complex method and will be reviewed lastly.

2.1. ECONOMIC-BASE MODELS

The economic-base concepts aim to predict the impact of new economic activities on regions. The economic-base models focus on the demand side of the economy. They ignore the supply side, or the productive nature of investment. It is better to start with the simplest model, the simple Keynesian model of a closed economy.

2.1.1. SIMPLE KEYNESIAN MODEL

Definition or identity:

Expenditure = Consumption + Investment

$$E \equiv C + I$$

Income (output) = Consumption + Savings

$$Y \equiv C + S$$

Behavioral or technical assumptions:

Consumption is a linear function of income

$$C = a + cY$$

where 0<c<1, the marginal propensity to consume.

Investment is an exogenously determined value

$$I = I'$$

Equilibrium condition:

Income = Expenditure

$$Y = E$$

$$C + I = C + S \Rightarrow I = S$$

Solution for investment multiplier

$$Y = C + I$$
$$Y = a + cY + I'$$
$$(1 - c)Y = a + I'$$
$$Y = \frac{1}{1 - c} * (a + I')$$

The Keynesian investment multiplier is

$$\frac{dY}{dI} = \frac{1}{1 - c}$$

The multiplier is used to measure the change of endogenous variables (income) caused by the change of the exogenous variable (investment).

2.1.2. EXPORT-BASE MODEL

The export-base model applies to an open-economy that includes both imports and exports. The exports are an exogenous factor. In this model an endogenous variable is defined as "domestic expenditure" that includes consumption, saving and investment. Imports are assumed to be a linear function of income.

Definitions or identities:

Total expenditures = Domestic production + Exports

$$E \equiv D + X$$

Income (output) = Domestic Expenditure + Imports

$$Y \equiv D + M \text{ or } D \equiv Y - M$$

Behavioral or technical assumptions:

Imports is a linear function of income

$$M = mY$$

where 0<m<1, the marginal propensity to import.

Exports is an exogenously determined value

$$X = X'$$

Equilibrium condition:

$$\text{Income} = \text{Total Expenditures}$$

$$Y = E$$

$$D + M = D + X \Rightarrow M = X$$

Solution for investment multiplier

$$\begin{aligned} Y &= D + X \\ Y &= Y - M + X' \\ Y &= Y - mY + X' \\ Y - Y + mY &= X' \\ Y &= \frac{1}{m} * X' \end{aligned}$$

The export-base multiplier is

$\frac{dY}{dX} = \frac{1}{m}$ change of income is inverse of marginal propensity to import.

2.2. INPUT-OUTPUT MODEL

The Input-Output model is often used in regional analysis because it is an excellent descriptive tool that provides the structure of the regional economy (Hasting and Bruker, 1993). It shows information about individual industrial size, behavior and interaction with the rest of economy. It also provides a way to predict how the economy will respond to exogenous changes. The Input-Output model was introduced by Vassily Leontief so it is known as the Leontief model (Sadoulet and de Janvry, 1995). This section provides basic information about the Input-Output model as a basic knowledge to extend to the more complex one – the Computable General Equilibrium (CGE) model.

The Input-Output model is based on the following assumptions (Bills and Barr, 1988):

There is no substitution between inputs.

There are no price effects, changing technology, or economies of scale.

No external economies of scale exist.

The in-state and out-of- state distribution of purchases and sales is fixed.

Supply is infinite and perfectly elastic. The supply curve is horizontal.

There is no under-employment of resources.

In this model the economic activities are classified into two types: production and final demand. Final demand sectors consist of households, government, etc. Production sectors (e.g. agriculture, mining, manufacturing, services, etc) use output from other production sectors as intermediate inputs and value-added factors (labor, capital, land) from final demand sectors to produce output. The amount of intermediate input from sector i that production sector j used per unit of its output is assumed fixed and called input-output coefficients. The output levels of production sectors are determined within the model so they are called endogenous variables. The activity levels of final demand sectors are assumed to be determined outside the model so they are called exogenous variables.

Sadoulet and de Janvry (1995) derived the solution of the changes of output levels corresponding to the change of final demand as following:

Assume the economy without foreign trade, the output of production sectors is used as intermediate inputs by production sectors or as final goods by final demand sectors. The output level of production sector i is identified as X_i. The amount of X_i used by production sector j (or itself) as intermediate input is X_{ij}; the remainder is used by final demand sectors as final goods, called F_i.

X_{ij} is assumed to be a fixed proportion of sector j's output X_j. Therefore

$$X_{ij} = a_{ij}X_j \qquad i,j=1,2,...,n \tag{2.1}$$

where a_{ij} is called an input-output coefficient

The material balance is identified by equating the production sectors' output (supply) with the used output (demand) as shown in following equation.

$$X_i = \sum_j X_{ij} + F_i \tag{2.2}$$

Substitute (2.1) into (2.2)

$$X_i = \sum_j a_{ij}X_j + F_i \tag{2.3}$$

When the exogenous final demand increases, say ΔF_i, the required output increases. To produce sufficient output the required intermediate goods are also increased. The cycle repeats until the economy meets the new equilibrium. At this point the change in output is ΔX_i. To solve for ΔX_i the equation (2.3) is written in matrix notation

$$X = AX + F \tag{2.4}$$

where A is a matrix of input-output coefficients

Solve for X

$$X = (I - A)^{-1} F \tag{2.5}$$

where I is a unit matrix.

Given the specified change of exogenous variable (final demand), e.g. government expenditure, ΔF, the equation (2.5) can be used to determine the change of output, ΔX, necessary to satisfy the new demand,.

$$\Delta X = (I - A)^{-1} \Delta F \tag{2.6}$$

The matrix $(I - A)$ is a "Leontief matrix." The inverse matrix $(I - A)^{-1}$ is called "Leontief inverse" which can be used to calculate the change of output correspondent to the change of exogenous final demand.

Call r_{ij} an element of matrix $R = (I - A)^{-1}$ then

$$Output\ multiplier = \frac{dX_i}{dF_j} = r_{ij} \tag{2.7}$$

is partial output multiplier of production sector i correspondent to change of final demand on sector j's output. $\sum_i r_{ij}$ is total output multiplier for production sector j.

When the level of output X is known, the level of required factor input (labor, capital, land) can be identified as a fixed proportion of output X. The change of household income can be calculated based on the share of resource owners.

Call YH_{ih} the level of income of household h coming from production sector i. The household income multiplier caused by the change of final demand on sector j's output is

$$Income\,multiplier_h = \sum r_{ij} * \frac{YH_{ih}}{X_i} \tag{2.8}$$

The trade of output often takes place in the regional economy. The region may export output to other regions or other countries and import goods from outside to use as final goods or intermediate goods. The multiplier of input-output model including trade was introduced by Dervis and Robinson, 1982. Including imports (M) and exports (E) into the balance equation (2.5), the result is

$$X + M = AX + F + E \tag{2.9}$$

Making rearrangement, and solve for X

$$X = (I - A)^{-1}(F + E - M) \tag{2.10}$$

The value in the second parentheses $(F + E - M)$ is called the net demand for regionally produced goods. The change of output corresponding with the change of final demand can be determined by equation (10). In this equation the exports and imports are assumed to be perfect substitutes and they are added together to form total commodity supply.

Henry and Johnson (1993) stated that, with the increased ability of computers, the Input-Output model promised to be an effective technique. Total gross output, income and employment impacts of economy can be computed with the appropriate input-output coefficients. The Input-Output model can provide direct, indirect and household induced effects by sectors due to the exogenous event.

2.3. GENERAL EQUILIBRIUM MODEL

The General Equilibrium (GE) Model is based on the assumption that all markets in the economy are in equilibrium. The model covers the system that includes not only markets of all commodities but also markets of factor inputs. To understand the GE model it is better to review the basic background of equilibrium of one market individually.

2.3.1. PARTIAL EQUILIBRIUM

The model that concerns equilibrium of the market for one commodity is called the partial equilibrium model. The review of this section is from Nicholson (1995).

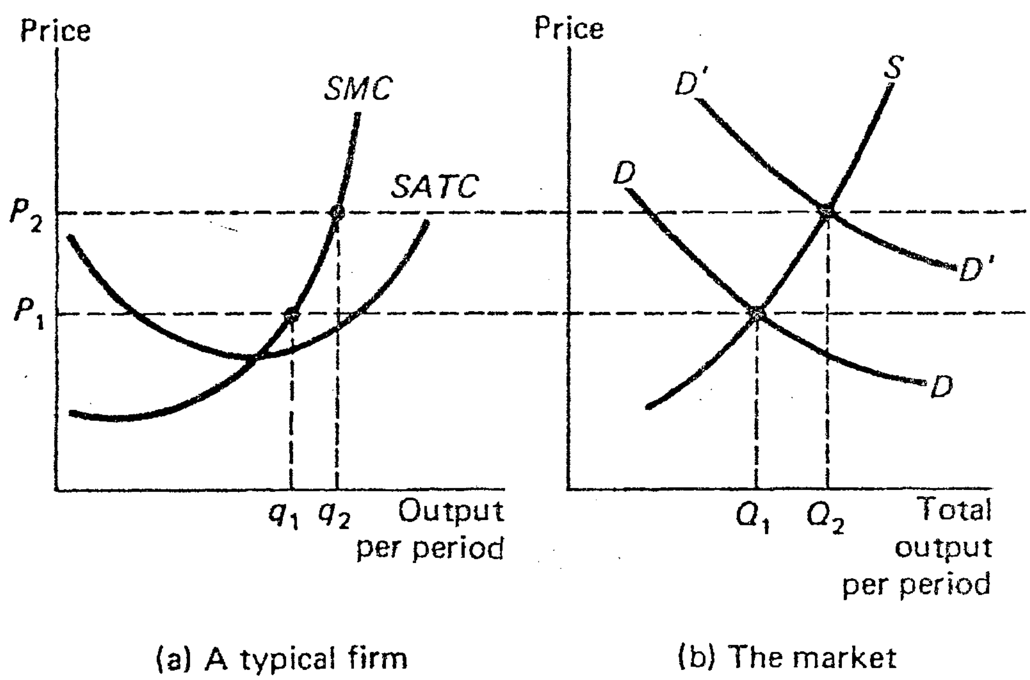

Figure 2.1 Supply of commodity (Source: Nicholson, 1995, P. 452).

Partial equilibrium in the short-run

Part (a) of Figure 2.1 shows the supply curve of a typical maximizing profit firm. This supply curve is an upper part of the marginal cost (MC) curve started at the intersection point of average cost (AC). At this point the AC is minimum and equal to MC, this implies that profit of firm is zero. Part (b) shows the market supply and demand curves. In short-run the market supply curve is the horizontal sum of supply of all firms in the economy. The price level where the quantity of demand equals the quantity of supply is called equilibrium price. The quantity of commodity traded at this equilibrium price is called equilibrium quantity. The shift of demand or supply curves will cause the change of equilibrium price and equilibrium quantity. The initial equilibrium price is P_1. At this price the quantity that the individual firm sells is q_1, and market quantity sold is Q_1. Suppose the commodity is a normal good; if income of consumers increases, the demand for this commodity will increase and the demand curve will shift up. Shifting up the demand curve increases equilibrium price to P_2 and the new equilibrium quantity of commodity sold to Q_2. The demand curve shifting up increases both equilibrium price and quantity. The magnitude of effect of the shifting of demand curve on equilibrium price and quantity depends on the elasticity of supply and elasticity of demand. The more elasticity supply, the more quantity increases (vise versa for price) when the demand curve shift up as shown in Figure 2.2. The shifting of demand curves may be caused by income change, prices of substitutes or complements change, preference of consumers change.

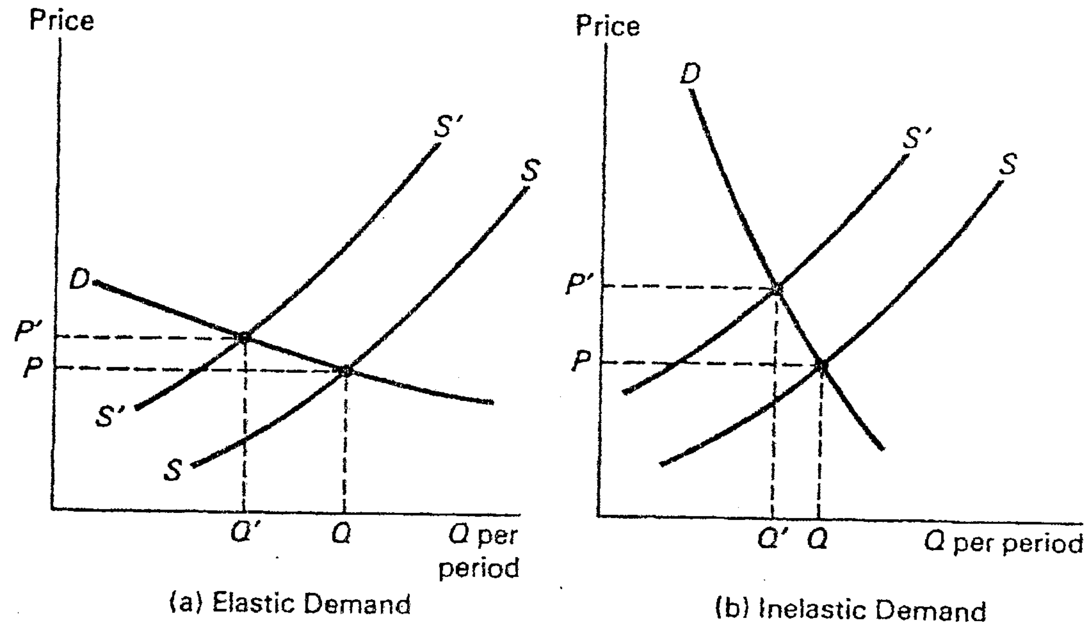

Figure 2.2 Elasticity of Demand (Source: Nicholson, 1995, P. 455).

Shifting upward of supply curves increases equilibrium price and decreases equilibrium quantity (Figure 2.3). Similar to the shifting of demand curves, the magnitude of the change of price and commodity quantity depends on elasticity of demand. The more elastic the demand curve, the more change there is in quantity demanded (the less change of price) when supply shifting. Shifting of supply curves may be caused by input price change, technology change, number of producers change.

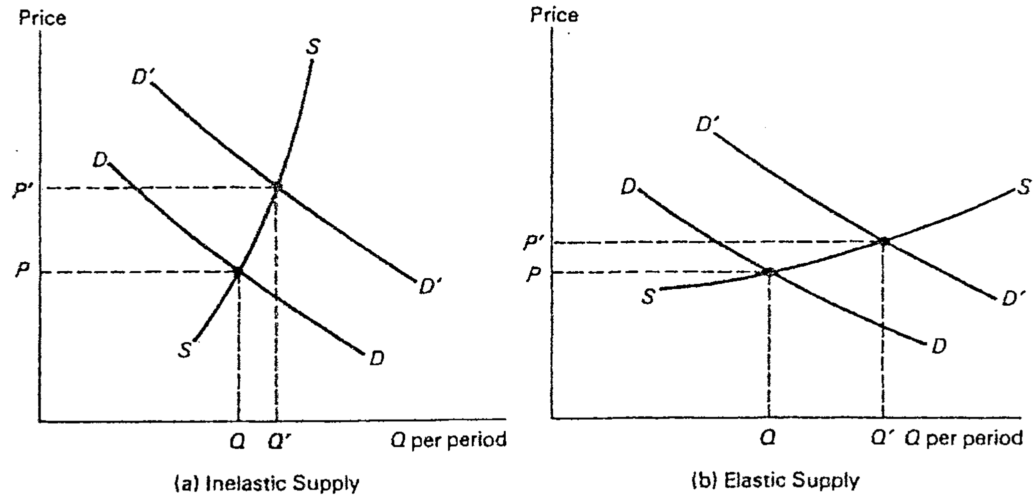

Figure 2.3 Elasticity of Supply (Source: Nicholson, 1995, P. 456).

Partial equilibrium in the long-run

Firms in a perfect competitive market are price takers. In the long-run the level of output is set for which price is equal to long-run marginal cost (MC) to maximize profit. The long-run time frame permits the entry or exit of new firms into or out the market. There is incentive for new firms to enter the market when profit is positive, and vise versa. The numbers of firms is stable when profit is equal to zero. That is where marginal cost is just equal to average cost (AC) as shown in part (a) of Figure 2.4 at point (P_1,q_1). Consequently, in the long-run the maximizing profit perfect competitive firms always operate at MC=AC. So, the slope of long-run supply curves (LS) depends on the impact of the entry of firms into the market on prices of inputs, then production cost, marginal cost (MC) and average cost (AC).

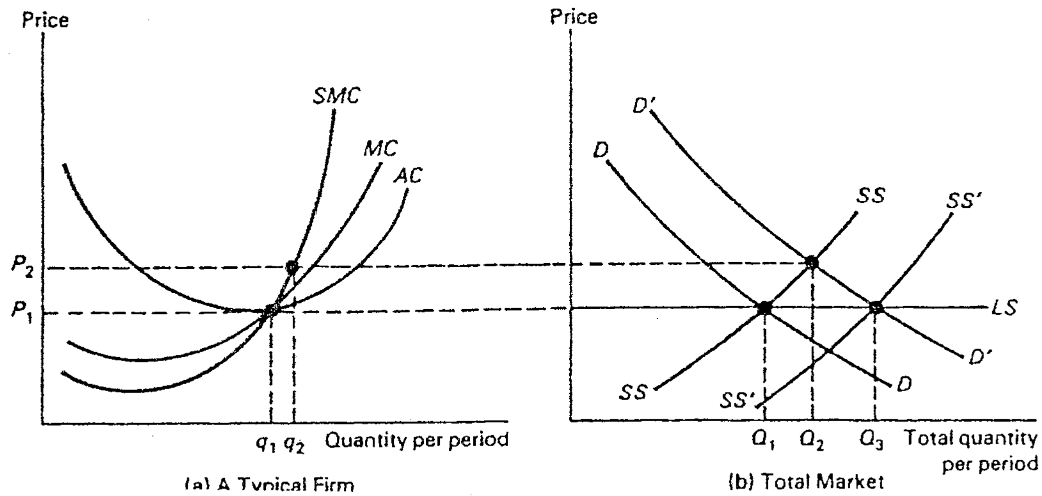

Figure 2.4 Perfectly Elasticity Long-run Supply Curve (Source: Nicholson, 1995, P. 464).

Note: SMC is short-run marginal cost, MC is long-run marginal cost, AC is average cost, SS is short-run supply curve, LS is long-run supply curve.

Figure 2.4 shows the slope of LS is zero (perfectly elastic) if the entry of new firms does not affect prices of inputs. The initial equilibrium is at price P_1 and quantity Q_1. At price P_1 the individual firm produce at level q_1 with profit equal to zero. Supposed the demand shifting up, price increases to P_2. At this price, firm increases output to q_2 and earns positive profit (MC>AC). The positive profit creates incentive for the entry of new firms into the market. Operation of new firms increases commodity supply. The short-run supply curve SS shifts to SS' until new equilibrium price equal to the initial price P_1 where profit equal to zero. Therefore, in this case, the long-run supply curve LS is horizontal, perfectly elastic.

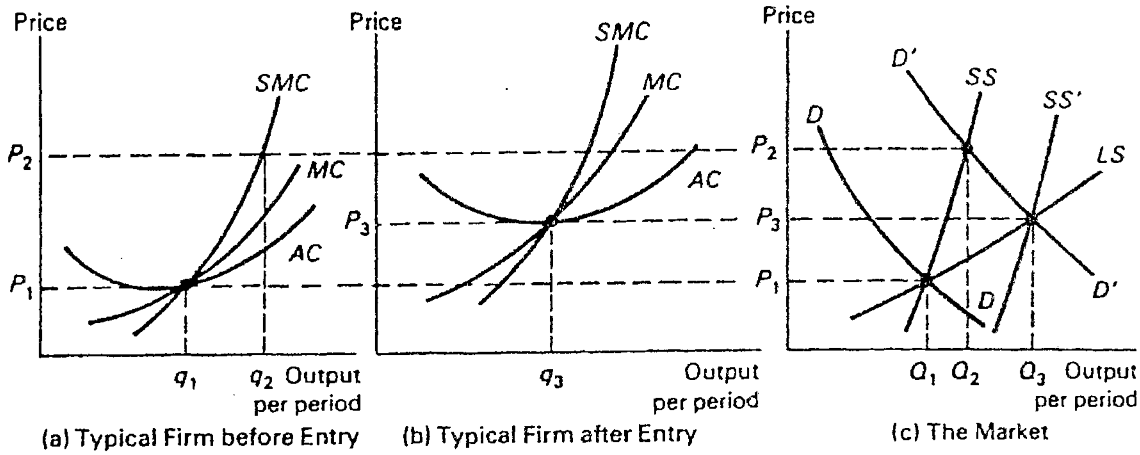

Figure 2.5 Upward Sloping Long-run Supply Curve (Source: Nicholson, 1995, P. 468).

Figure 2.5 shows upward slope LS in case the entry of new firms increases prices of inputs. Initial demand and supply curves are DD and SS, respectively. The equilibrium point is (P_1, Q_1). When demand shifts up the market price increases to P_2, individual firms decide to produce output level q_2 to maximize profit. Profit at this point is positive because MC>AC. The positive profit attracts new firms to enter the market thus causes supply curve shift to the right. The entry of new firms increases input prices and moves both MC and AC up. The zero profit point (intersected point of MC and AC) moves up to point (P_3,q_3) as shown in Figure 2.5b. The right shifting of SS will stop at new equilibrium price is P_3, the new zero profit price, that is higher than initial price P_1. Therefore the LS, in this case, is upward slopping, as shown in Figure 2.5c.

Figure 2.6 shows the case where the entry of new firms reduces prices of inputs, the new zero profit price will lower the initial one, part (b). The downward sloping LS curve in part (c) can be explained in similar way as Figure 2.5.

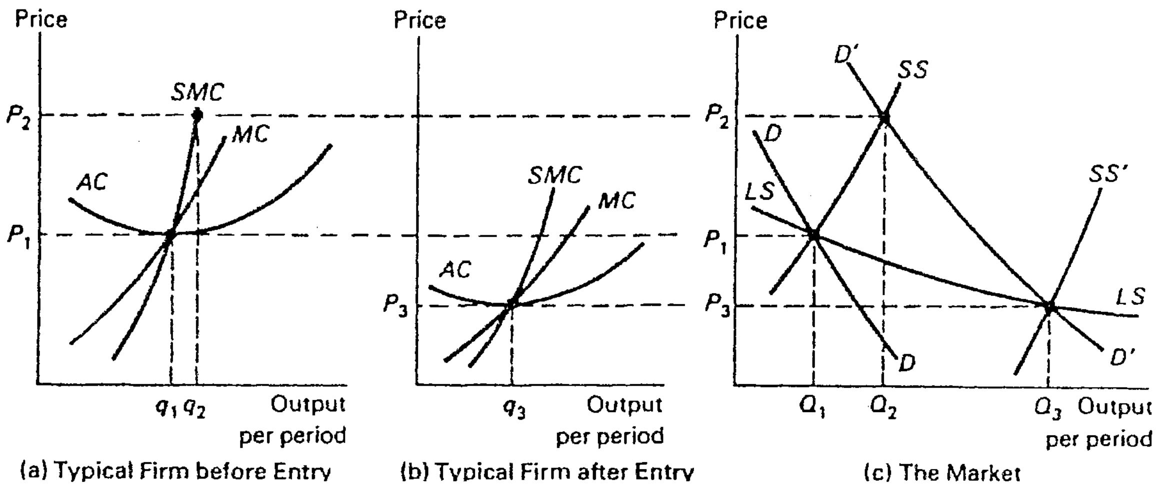

Figure 2.6 Downward Sloping LR Supply Curve (Source: Nicholson, 1995, P. 469).

2.3.2. GENERAL EQUILIBRIUM

The review in the previous section discusses the interaction between supply and demand to generate equilibrium price and quantity sold. The supply and demand curves are affected by many factors such as consumers' income, prices of other commodities, prices of inputs, technology, and number of firms in the industry. Causally, the equilibrium is changed. It is clear that the partial equilibrium is not adequate to capture all of impacts of the economy.

The general equilibrium model includes markets of all commodities and input factors. It also considers consumers' income as an important factor that affects the equilibrium point of the economy. The GE model assumes that all agents in the economy are rational. The supply of commodities is a result of maximizing profit of producers. The demand for commodities is caused by the consumers' decisions to maximize utility based on constraint of their income. The income of consumers comes from their labor, returns of resources that they own, and the transfer payment from other institutions.

Producers try to maximize the efficiency of inputs that they use to produce commodities based on their technology conditions. Supposed the economy with two commodities X and Y, the prices of these goods are P_x and P_y, respectively. Producers decide the level of X and Y to produce based on fixed amount of available resources and technology conditions. An Edgeworth Box diagram is used to explain the combination levels of X and Y that yield the most technological efficiency. The curve connects all efficient level of X and Y is called "production possibility frontier." The specific level of X and Y that firms decide to produce depend on ratio of P_x and P_y. In Figure 2.7, the firm decides to produce X_1 and Y_1 where the production possibility frontier tangent with straight line C with slope equals $\frac{-P_x}{P_y}$. Line C is also a society's budget constraint.

The consumers try to maximize utility by selecting amount of commodity is X_1' and Y_1' where the budget line C tangents with the indifferent curve U_3. At this point, there exist an excess demand for commodity X, $(X_1^{'} - X_1)$ and an excess supply of commodity Y, $(Y_1^{'} - Y_1)$. The inequilibrium condition causes price of X to increase and price of Y to decrease, and then the budget line rotates to be steeper. This process will stop when demand equal to supply for both commodity. The equilibrium point is point E, where slope of production possibility frontier is equal to that of indifferent cure U_2 and equal to the new budget line C*, is a ratio of new commodity prices, $\frac{-P_x^*}{P_y^*}$. At this point, the demand for commodity X equal to supply, X* and similar for commodity Y, at Y*.

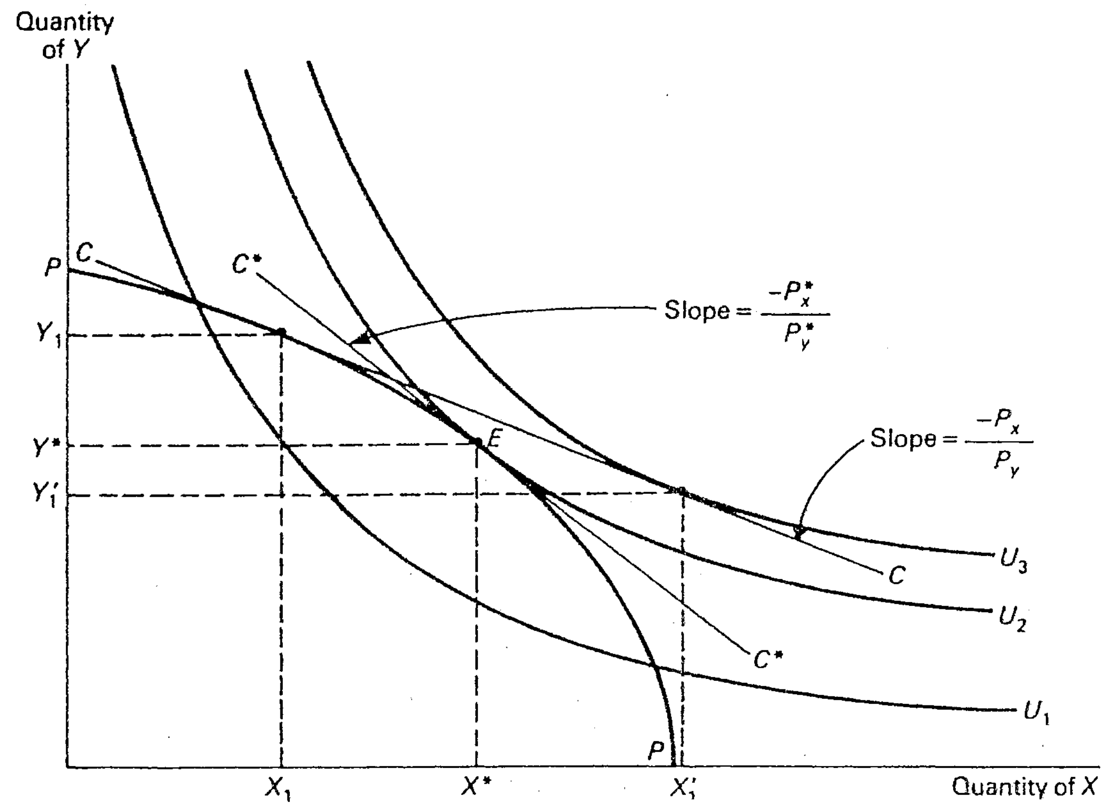

Figure 2.7 General Equilibrium (Source: Nicholson, 1995, P. 521).

For a complicated economy with n commodities, in absolutely fixed supply, P is defined as a vector of prices of these commodities. The excess demand of commodities is given as

$$ED_i(P) = D_i(P) - S_i \tag{2.11}$$

Let P* is equilibrium prices, the equilibrium condition satisfies equation (2.12)

$$ED_i(P^*) = D_i(P^*) - S_i = 0 \tag{2.12}$$

Leon Walras proved that n excess demand function are not independent, they follow the relation determined by equation (2.13). This equation is called Walras' law.

$$\sum_i P_i * ED_i(P) = 0 \tag{2.13}$$

Using Walras' law and Brouwer's Fixed-Point theorem, it can be proved that the set of prices that makes all markets in equilibrium exist. Because n equations of (2.12) are not independent, it is possible to find relative equilibrium prices that satisfy equation (2.13). In addition, the excess demand function is homogeneous degree of zero in all prices, so equilibrium prices can be numeraire for the convenience of a specific model.

CHAPTER III

SOCIAL ACCOUNTING MATRIX (SAM)

3.1. THEORETICAL BACKGROUND

3.1.1. INTRODUCTION TO SAM

According to Pyatt and Round (1985), constructing the database for macro-economic policy and planning is a difficult topic for economists. The attention has continued since the publication of "The Social Frame Work" (Hicks, 1942). That database provides the information needed for macroeconomic analysis in short-term and long-term, as well. The database was extended for other applications in interindustry economics such as Leontief input-output model, and more extensive models of growth and development in particular economies.

De Melo (1988) stated that interest in social accounting started at least in famous work of Quesnay's "tableau economique." Social accounting has three branches of the active literature on economy-wide general equilibrium models. The closest to accounting literature is work of Richard Stone et al. (from de Melo, 1988) related to standard for national accounts that laid the basic for the "fixed-price" multiplier models. These models are based on the relation embodied in a social accounting matrix (SAM). The second branch extended the early work of Johansen (1960) of Norway, and is concerned primarily with distributional issues in developing countries, often referred to as computable general equilibrium (CGE). The third branch is closer to the spirit of neoclassical economics and deals with the welfare cost of alternative taxation and tariff structures.

SAM is an extension of input-output accounts (Schreiner et al, 1999), developed during the late 1960's. Like input-output account, SAM provides accounting structure of market-based productive activities and commodity consumption. In addition, SAM focuses on the households and tracks how household income generated and distributed. SAM can take a variety of forms depending on how the constituent accounts are defined. The most important form is provided by UN System of National Accounts (SNA) (Pyatt and Round, 1997).

3.1.2. STRUCTURE OF SAM

According to Pyatt (1988), there is only one fundamental law of economics: "for every income there is a corresponding outlay or expenditure". The law is the equivalent for economists of the physicists' law of energy conservation." SAM is a simple and efficient way to present this law. So, every row total (income) of SAM is equal to its corresponding column total (expenditure). SAM can be presented as

$$T = \left[t_{jk}\right]$$

T is a square matrix. By definition, receipts of transactor j are entered in row j, and expenditures of transactor k are entered in column k. t_{jk}, is an element at row j and column k, is the value of receipt of j from k. Correspondingly, t_{kj} is value of j's payment to k.

A criticism of the above fundamental law is that SAM should satisfy two characteristics. (1) a square matrix, to ensure that each transactor has its own row and column; (2) corresponding row and column must be equal.

The second restriction can be written as

$$\sum_j t_{jk} = \sum_k t_{jk}$$

Every economic model has its corresponding accounting framework, in other words, has its own format of SAM. In general, the elements of SAM should cover two groups of accounts: production accounts and institutional accounts. Productions accounts trace monetary flow of production activities. Elements of these accounts may be groups of industrial sectors, such as agriculture, construction, services, etc. Institutional accounts consist of two groups: current and capital, and can be disaggregated into different types of households (low, medium, high income), different branches of governments (federal, local) (Pyatt, 988.)

3.1.3. IMPLAN SAM STRUCTURE

The format of SAM depends on the objectives of research, but consists of attributes as mentioned above. Because this research uses a SAM generated by IMPLAN, the format of IMPLAN SAM is introduced in this section. IMPLAN Pro version 2.0 user's guide (MIG, Inc, 1999) is a main reference for writing this section and Section 3.2.

TABLE 3.1

IMPLAN SOCIAL ACCOUNTING MATRIX

	Industry (1)	Commodity (2)	Factors (3)	Institution (4)	Exports (5)	Total (6)
Industry (1)		Make 1x2			Commodity Exports 1x5	Industry Output
Commodity (2)	Use 2x1			Domestic Final Commodity 2x4		Domestic Commodity Output
Factors (3)	Value Added 3x1					Value Added
Institution (4)		Domestic Commodity Sales 4x2	Factor Distribution 4x3	Inter-Institutional Transfers 4x4	Institutional Exports 4x5	Institutional Receipts
Imports (5)	Intermediate Commodity Imports 5x1		Factor Services Imports 5x3	Final Commodity Imports 5x4	Trans-shipments 5x5	Commodity Fact Service Import, Remittances
Total (6)	Industry Outlay	Domestic Commodity Outlay	Factor Outlay	Institutional Outlay	Commodity Fac.services Exports	

The format of IMPLAN is to capture monetary flows out and into the region. Its elements can be classified into two groups, namely, industrial sectors and institutions. The industries are production sectors that use intermediate inputs and primary factor inputs (labor, capital and land) to produce output for domestic consumption or export. The institutions are household, government, enterprise, inventory, and capital formation. Institutions provide primary factor inputs to industries and in return receive factor payment. Institutions consume industry outputs as final goods. The transaction between producers and consumers is called market flow. The transaction within agents of institutions is non-market flow and called inter-institution transaction. Table 3.1 presents a structure of SAM generated by IMPLAN.

The first row (industry) records receipts of industry made from regionally consumed (column commodity) and exported commodities (column exports). The regional consumed cell is called the "make matrix." The second row (commodity) records receipts of industrial commodities from two kinds of consumption: intermediate goods (column industry) and final goods (column institution). Value-added (receipt of factor payment) is recorded in the third row. The fourth row keeps track of income of institutional agents from different sources: commodity sale, factor payment, inter-institution transfer and commodity and factor services exports. The fifth row records imported commodities used by industry and institution. In the last row are values of total columns that are equal to corresponding total rows (written in the last column). To explain elements of SAM, each cell of SAM will be referred to by its position (row by column), e.g. "Domestic Commodity Use" is 2x1. The best way to understand the SAM is examining the functions of its elements in the relation of activities of agents of economy, namely, industries and institutions.

<u>Industrial sectors</u>

The outputs of industrial sectors are locally used in the region or exported out of region or country. The level of locally used commodity is recorded in cell 1x2, called the "Make matrix." The exported portion is recorded in cell 1x5, is called "commodity exports." Total of 1x2 and 1x5 is industry outputs and in SAM this amount is presented in monetary term and they are also receipts of industrial sectors. IMPLAN disaggregates exported commodities into "Domestic exports", consumed out of region but within the country; and "Foreign exports", portion exported out of country. The amount of locally used commodities is shown in two ways: by industrial sectors as intermediate goods, cell 2x1; and by institution agents as final goods, cell 2x4.

The industrial sector uses two kinds of inputs in production process. First, intermediate inputs come from two sources: locally from output of regional industrial sectors, cell 2x1; or imported from outside the region, cell 5x1. The amount of imported intermediate inputs is also separated into "Domestic import" and "Foreign import" similarly defined as the export term. Second, primary factor inputs, are also called value-added, 3x1. Typically, value added is classified into labor, capital and land. Sometimes labor is classified into different groups based on skill levels. IMPLAN includes indirect business tax into value-added account. Total locally produced and imported intermediate inputs and primary factor inputs are total expenditure of industrial sectors. These expenditure amounts are equal to receipts.

Institutions

Institutions are also called final demand sectors. These consist of household, government, enterprise, and capital formation sectors. Institutions consume commodities as final goods and make non-market transfer payments (inter-institution transfer). The final goods consumed by institution come from two sources: locally produced (cell 2x4), and imported (cell 5x4). Institution transfers are monetary flows within institution agents without operation of market so are called non-market payments. These transfer payments include federal government grants of money to local governments, and to household as welfare and social security payments; households pay taxes to government and saving to capital accounts; enterprises pay a share of earning to households and retained earning to capital, and so on. Total expenses of households for final goods and services are known as Personal Consumption Expenditure (PCE). Total consumption for final goods and inter-institution payments are total expenses of institutions.

Households receive income from factor compensations depending on the level of labor they provided, share of capital and land rent based on portion of resources they own (cell 4x3). Beside factor payments (cell 4x3) and receipt from other institution agents (cell 4x4), institutions also receive income from out side the region (cell 4x5) and from providing services and commodities for the regional market (cell 4x2). Totals of institutions receipts (sum of row 4) are equal their spending (sum of column 4). Receipts of capital account (row) is called "saving" while its spending (column) is called "investment."

A portion of factor compensations is also paid for individuals from outside the region who own that resource (cell 5x3). Cell 5x5 records imported commodities that are exported out of region without processing, known as trans-shipment.

3.2. CONSTRUCTING SAM BY IMPLAN

3.2.1. SOURCE OF DATA

Constructing a SAM required a high volume of data. Cost will be very high if conducting a survey to collect data. The Minnesota Implan Group (MIG), Inc. uses government data sources to construct database for input-output models. IMPLAN was developed as a cost-effective way to construct database form existing data sources. It is known as a non-survey method of conducting data. IMPLAN consists of two components, the database and the software. Data source used by IMPLAN are as follows:

US Bureau of Economic Analysis Benchmark I/O Accounts of the US.

US Bureau of Economics Analysis Output Estimates.

US Bureau of Economics Analysis REIS Program.

US Bureau of Labor Statistics ES202 Program.

US Bureau of Labor Statistics Consumer Expenditure Survey.

US Census Bureau County Business Patterns.

US Census Bureau Deciennial Census and Population Surveys.

US Census Bureau Economic Censuses and Surveys

US Department of Agriculture

US Geological Survey.

The software was used to read the database and construct regional economic accounts. Users can use IMPLAN to construct SAM accounts, and perform impact analysis.

3.2.2. CONSTRUCTING REGIONAL SAM

There are three different levels of data: national, state, and county. The availability raw data depends on the level of the research area. At the national level, all database components are available. At the regional level, state and county level, some database components are available. In the process of constructing regional economic accounts, the national level accounts are computed first, then the national coefficients will be computed based on these accounts. The regional economic accounts will be computed later. The values of unknown variables are computed based on existing regional data and national coefficients. To explain the IMPLAN procedure of constructing regional SAM the economy is assumed to have three industrial sectors, say A, B and C. The process of constructing elements of a regional SAM follows.

Intermediate Inputs

Database components available at regional level are total industry outputs, final commodities purchase for final use, and value added as shown in Table 3.2. Value-added components are employee compensation, proprietor income, other proprietor type income, and indirect business taxes. The final demand components are personal consumption expenditures (PCE), state and local education and non-education purchases, federal military and non-military purchases, inventory purchases and capital formation.

TABLE 3.2 REGIONAL DATA

				Final Damands						
	INDUSTRY			HH	S&L		Fed		INV PURCH	Cap Form
	A	B	C	PCE	Non Edu	EDU	Non Mil	MIL		
A				3.0	2.0	0.0	1.0	0.0	5.0	0.5
Commodity B		?		19.0	2.0	3.0	0.5	0.0	1.0	0.5
C				3.5	1.5	1.0	0.4	0.1	1.5	0.0
Empl Comp	4.0	10.1	12.0							
Prop. Income	0.5	2.5	10.0							
Other Prop Inc	1.5	10.0	6.0							
Indir. Bus tax	0.5	1.5	2.0							
Total VA	6.5	24.0	30.0							
TIO	10.0	30.0	40.0							

Data for the amount of intermediate inputs used by industries is not available at the regional level. To find those values, it is assumed that the ratios of intermediate inputs used for every unit of output of regional industries are the same as national ratios, known as national input-output coefficients. The amounts of intermediate inputs used by industry at national levels are shown in Table 3.3.

Dividing elements of each column by the corresponding column total (national total industry output) yields national input-output coefficients. The table of these coefficients is known as the national absorption table, presented in Table 3.4.

TABLE 3.3 NATIONAL USE MATRIX

	INDUSTRY		
	A	B	C
A	400	0	8,000
Commodity B	800	3,00	0
C	1,600	14,00	2,00
Value-Added	5,200	20,00	40,00
National TIO	8,000	20,00	50,000

TABLE 3.4 NATIONAL ABSORPTION TABLE

	INDUSTRY		
	A	B	C
A	0.05	0.00	0.16
Commodity B	0.10	0.15	0.00
C	0.20	0.15	0.04
Value-Added	0.65	0.70	0.80
National TIO	1.00	1.00	1.00

The process of computing intermediate inputs used by regional industries based on the rule that sum of all coefficients of industry is equal to 1, as follows:

Dividing total value-added used by each industry column in Table 3.2 by corresponding total column (total industry output – TIO) yields regional VA coefficient.

Regional absorption subtotal (sum of intermediate input-output coefficients) is 1-regional VA coefficient.

National absorption subtotal of each industry is calculated by adding all its intermediate input-output coefficients.

Intermediate input-output coefficients of industry (B and C) that regional absorption subtotal is not equal to that of national are adjusted input-output coefficients. The adjustment ensures that the sum of all regional input-output coefficients of each industry is equal to 1. Formula of adjusted input-output coefficient is

$$Adjusted\ coefficient = National\ coefficient * \frac{Regional\ Absorption\ Subtotal}{National\ Absorption\ Subtotal}$$

For industry (A) that national absorption subtotal and regional one are equal the nation input-output coefficients are directly used as its coefficients.

Finally, intermediate inputs used by industries are calculated by multiplying regional input-output coefficients with corresponding regional TIO.

Final results of this process are presented in Table 3.5. The upper part of Table 3.5 is the National Absorption Matrix that used as reference to calculate the Regional Absorption Matrix (presented in middle part of the Table 3.5), by following the procedure discussed above. The Regional Absorption Matrix is actually a matrix of input-output coefficients of industries. It shows the levels of intermediate inputs and primary factors that industry used to produce one unit of output. In the Leontief input-output model, these coefficients are also called the production function.

TABLE 3.5

RESULT OF REGIONAL INTERMEDIATE INPUT CALCULATION

National Absorption matrix

	Industry A	Industry B	Industry C
Commodity A	0.05	0.00	0.16
Commodity B	0.10	0.15	0.00
Commodity C	0.20	0.15	0.04
Nat Absor Subtotal	0.35	0.30	0.20
Nat VA coefficient	0.65	0.80	0.75
National TIO	1.00	1.00	1.00

Regional Absorption matrix

	Industry A	Industry B	Industry C
Commodity A	0.05	0.00	0.20
Commodity B	0.10	0.10	0.00
Commodity C	0.20	0.10	0.05
Reg Absor Subtotal	0.35	0.20	0.25
Reg VA coefficient	0.65	0.80	0.75
Regional TIO	1.00	1.00	1.00

Gross Regional Use Matrix

	Industry A	Industry B	Industry C
Commodity A	0.50	0.00	8.00
Commodity B	1.00	3.00	0.00
Commodity C	2.00	3.00	2.00
Reg VA	6.50	24.00	30.00
Regional TIO	10.00	30.00	40.00

Given total industry outputs (TIO), the actual level of intermediate inputs used by each industry are calculated by multiply the corresponding intermediate input-output coefficients by its TIO. Amounts of intermediate inputs that each industry used to produce its actual TIO are shown in three columns of lower part of Table 3.5. This portion is called Gross Regional Use Matrix because each value in this matrix is sum of regionally purchase and imported intermediate input.

Imported commodities

The amount of intermediate inputs calculated in previous section is a composite of regionally purchased and imported commodities. IMPLAN uses regional purchase coefficients (RPC) to separate imported commodities from the composite amount. RPC is a proportion of total regional demands for a commodity is locally supplied by itself. For example RPC of feed grains sector is 0.85 that means 85 percent of demands for feed grains is locally purchased within region, the remained 15 percent is imported from outside. IMPLAN uses the empirical data from the Multi-Regional Input-Output Account (MRIOA) to estimate RPCs. MRIOA is a cross-section database of state input-output accounts linked with cross interstate trade flow.

The imported intermediate input is calculated by following formula

$$INTM_{ji} = (1 - RPC_i) * INT_{ji}$$

where $INTM_{ji}$ is imported intermediate inputs i used by industry j

INT_{ji} is total demand for intermediate input i used by industry j

The regionally purchased intermediate inputs is the remainder of total intermediate demand after deducting imported amount

$$INTR_{ji} = INT_{ji} - INTM_{ji}$$

where $INTR_{ji}$ is regionally purchased intermediate inputs i used by industry j

For each intermediate commodity the same regional purchase coefficient (RPC) is used to calculate the imported proportion for all industries.

The proportion of regionally purchased final commodities for institutions used is assumed the same as that of industries. So, for each commodity, the same regional purchase coefficient (RPC) is used to calculate imported commodity for institutions. Say, imported commodity i for household h is calculated by following formula

$$QM_{hi} = (1 - RPC_i) * Q_{hi}$$

where QM_{ji} is imported commodity i used by household h

Q_{hi} is total demand for commodity i used by household h

Similarly, regionally purchased amount is the remainder from the total after deducting imported amount

$$QR_{hi} = Q_{hi} - QM_{hi}$$

where QR_{hi} is regionally purchased commodity i used by household h

Commodity demands of other institution agents are calculated by the same way. After performing this step of calculation we four cells of SAM:

- Use matrix (cell 2x1) is a table consists of values of regionally produced intermediate input ($INTR_{ji}$) where j represents commodity and i represents industrial sector.

- Commodity imports (cell 5x1) is a table consists of values of imported intermediate input ($INTM_{ji}$)
- Domestic final commodity (cell 2x4)) is a table consists of values of regionally produced commodity consumed by households (QR_{hi}), and by governments, investment and inventory (QXR_{ni}) where h represents household, n represents institutions and i represent commodity.
- Final Commodity Imports (cell 5x4) is a table consists of values of imported commodity QM_{hi} , and QXM_{hn}

Regional Commodity Supply and Exports

Industrial sectors are the main suppliers of commodity for regional market. Government and households also provide a small portion of particular goods and services. In a specific time sales from inventory is known as a source of supply. Sales from inventory are another source of commodity supply. In case each industrial sector produces only one kind of output (no byproduct) regional commodity supply is total industry output (TIO) plus amount of commodity sales by household, government, and inventory.

Commodity exports are the remainder of regional commodity supply after deducting amount of regionally purchased of industry as intermediate good and amount of regionally consumed by institutions as final goods.

$$Exports = Regional\ Supply - Regional\ int.\ \ input - Regional\ final\ goods\ consumed$$

Amounts of exported commodities are presented in cell 1x5.

The “Make matrix” (cell 1x2) presents amount of industry output supply to regional market. This is equal to TIO minus exports.

The “Domestic commodity sales” (cell 4x2) presents amount of commodities and services provided by household, government and inventory.

Primary Factor Inputs and Factors Income distribution

Industrial sectors used intermediate inputs and primary factors to produce commodities (outputs). The primary factors are also known as value-added. Conventionally, primary factors are labor, capital and land.

IMPLAN manipulates data from ES202 employment security data and REIS data, so the value-added is into four sub-components as follows

1. **Employee compensation** is wage and salary payments, health and life insurance, retirement payments, and any other non-cash compensation. This is income of workers paid by employers.
2. **Proprietary income:** This is income received by self-employed individuals.
3. **Other property type income:** This is income received from rents of property, royalties from contract, dividends stock holding, and corporate profits earned by corporations.
4. **Indirect business taxes:** This includes sales taxes paid by individuals to businesses, but does not include taxes on profit or income.

The primary factor inputs for industrial sectors are shown in the matrix “Value-added” (cell 3x1).

The factor incomes are distributed to household depends on portion of resource that household own. Portion of factor income to government is factor tax such as labor tax (pay for social security account), land tax, etc. All indirect business tax contributes to government account. Factor income distribution is shown in matrix "Factor distribution" (cell 4x3). Cell 5x3 (Factor Services Import) shows factor income distributed to the owners outside the region.

Inter-institution Transfers

The Inter-institution Transfer matrix keeps track of monetary flows from institutions to other institutions. This includes federal government grant money to local and state government, and to households as welfare and social security payment. Households pay tax to government and saving account. Values of these transactions are shown in cell 4x4.

Balancing

After all cells of SAM are calculated it is necessary to make adjustment to yield a balance SAM. That means all row totals must equal the corresponding column totals. The totals of column 1 industry outlays are equal to totals of industry outputs (totals of row 1). The totals of row 2 are receipts from selling domestic commodity outputs should be equal to regional commodity supplies. The compensations of factor inputs (totals of row 3) should be equal to factor income distributions (totals of column 3). Totals of institution incomes (totals of row 4) are equal to total institution expenditures (total of column 4).

The adjustments are made on the imports, exports and capital accounts based on the data in the regional economic accounts. For example, households receive income from industries through factor payments and from institutions. With this income, households spend for goods and services, pay tax to government. The difference between total income and total expenses is savings. The amount of savings can be negative because of the expenditure based on expected future earning (Schreiner et al, 1999).

3.3. TEXAS COUNTY SAM

3.3.1. INDUSTRIAL SECTORS

IMPLAN classified industry into 528 sectors. Because this research aims to measure the impacts of hog production and meat packing plants, industries sectors are aggregated into 11 sectors. The components of each aggregated sector are presented in Table 3.6.

TABLE 3.6 AGGREGATION USED FOR INDUSTRIAL SECTORS.

Aggregated sectors	IMPLAN sectors
Agriculture	
(1) Hog Production	7
(2) All other livestock	1-6, 8, 9
(3) Feed grains	12
(4) All other crops	10, 11, 13-24
(5) Oil, gas and products	28-47, 57, 210-215, 438, 444
(6) Construction	48-56
Manufacturing	
(7) Meat packing and prepared meats	58
(8) Prepared feeds	78
(9) All other prepared foods	59-77, 79-103
(10) All other manufacturing	104-209, 215-432
(11) Services	26-27, 433-437, 439-443, 445-518, 521,524-528

Each sector is assumed to produce one main commodity (there is no byproduct) that is named the same as each sector name.

Industry Outputs

Table 3.7 presents total industry output (TIO) of each sector of Texas County in year 1993. Table 3.7 also provides amount of commodity supply for region and amount of exported commodities.

TABLE 3.7 TOTAL INDUSTRY OUTPUT (TIO) OF TEXAS COUNTY, 1993

(THOUSAND DOLLARS)

Industrial sectors	Total Industry Output	Regional Supply	Exports	Regional Purchase Coefficient
Hogs Products	4,830.1	1,296.8	3,533.3	0.9814
Other Livestock	573,235.1	64,237.0	508,998.2	0.9713
Feed Grains	19,615.6	6,920.3	12,695.2	0.0920
Other Crops	21,098.3	2,448.3	18,650.0	0.0342
Oil Gas and Products	53,246.9	30,106.6	23,140.3	0.8158
Construction	52,023.2	51,961.1	62.1	0.8489
Meat Packing Plants	1,076.1	978.0	98.1	0.3515
Prepared Feeds	11,194.1	1,112.8	10,081.3	0.0109
Other Prepared Foods	1,248.9	63.0	1,185.8	0.0017
Other Manufacturing	19,632.6	16,683.9	2,948.7	0.1414
Services	250,789.1	243,003.6	7,785.5	0.5032
Total	1,007,989.9			

Prior to the operation of Seaboard (1993) the outputs of meatpacking and all other prepared foods are relatively small in comparison to other sectors (around one million dollars for each sector). Output of hog production is also small ($4.83 million). The regional purchase coefficient (RPC) shows that more than 95 percent of production of hogs and other livestock are regionally consumed. Thirty five percent of meatpacking is consumed within region.

Intermediate Inputs

Intermediate inputs used by industrial sectors are presented in Table 3.8. The amounts of regionally purchased inputs $INTRji$ and imported inputs $INTM_{ji}$ are calculated based on regional purchase coefficient (RPC) in the last column of Table 3.7. In Table 3.8, the columns present industrial sectors that purchase intermediate inputs, the rows present kind of commodities (intermediate inputs) to be purchased. Because each industrial sector produced only one commodity, Table 3.8 shows the flow of commodities between industrial sectors. For example, number $8,648 in column Other Livestock and line Feed Grains in the upper part of table ($INTR$) present amount of intermediate input that sector Other Livestock regionally purchased from sector Feed Grains. Go down to the lower part of table ($INTM$), the number $85,369 is interpreted similarly but the commodity is imported from outside the region.

TABLE 3.8 INTERMEDIATE INPUTS USED BY INDUSTRY, TEXAS COUNTY, 1993

(THOUSAND DOLLARS)

Intermediate input (j)	Industrial sectors (i)										
	Hog Prod	Other Lives-tocks	Feed Grains	Other Crops	Oil & Gas	Cons-truct.	Meat Pack.	Prep Feeds	Other Prep. Foods	Other Manuf	Ser-vices
Regionally Produced Intermediate Inputs ($INTR_{ji}$)											
Hogs Products	1,176	0	37	16	0	0	581	0	1	0	0
Other Livestock	13	64,202	742	308	0	0	0	2	106	4	54
Feed Grains	316	8,648	77	0	0	0	0	68	1	0	0
Other Crops	225	2,894	20	55	0	0	0	42	3	4	6
Oil Gas and Products	36	1,797	397	359	17,422	1,616	3	18	5	337	1,498
Construction	40	10,807	1,000	912	789	216	0	45	12	493	9,023
Meat Packing Plants	0	247	0	0	0	0	15	2	12	5	82
Prepared Feeds	14	1,087	0	2	0	0	0	18	0	0	0
Other Prepared Foods	1	23	0	0	0	0	0	45	0	0	4
Other Manufacture	19	3,194	774	687	361	2,328	3	189	22	1,290	1,642
Services	1,290	63,887	3,755	5,422	2,378	8,987	96	1,012	99	1,883	27,831

TABLE 3.8 INTERMEDIATE INPUTS USED BY INDUSTRY, TEXAS COUNTY, 1993 (CONTINUED)

(THOUSAND DOLLARS)

Intermediate input (*j*)	Industrial sectors (*i*)										
	Hog Prod	Other Lives-tocks	Feed Grains	Other Crops	Oil & Gas	Cons-truct.	Meat Pack.	Prep Feeds	Other Prep. Foods	Other Manuf	Ser-vices
Imported Intermediate Inputs (INTM$_{ji}$)											
Hogs Products	39	0	1	0	0	0	249	0	0	0	0
Other Livestock	1	1,898	22	9	0	0	0	0	3	0	2
Feed Grains	473	85,369	759	0	0	0	0	1,105	7	0	0
Other Crops	337	81,815	577	1,567	0	0	0	824	83	115	158
Oil Gas and Products	4	406	90	81	3,935	365	0	37	1	76	338
Construction	40	1,924	178	162	140	38	2	0	2	88	1,606
Meat Packing Plants	0	455	0	0	0	0	0	0	22	9	151
Prepared Feeds	461	98,190	0	155	0	0	0	591	0	0	6
Other Prepared Foods	54	12,980	0	85	10	0	4	3,217	204	26	2,215
Other Manufacture	142	19,396	4,702	4,174	2,192	14,137	19	1,414	133	7,835	9,969
Services	0	63,072	3,708	5,352	2,348	8,872	0	1,469	98	1,859	27,476

Primary Factors

In four components of IMPLAN value-added, the amount of indirect business tax goes directly to the government budget, while the other three components should be classified into three components of conventional primary factors to plug into the production function of CGE model. Classified value-added for agricultural sector based of primary factor shares reported by Robinson, Kilkenny, Hanson (1990). Primary factor shares of Livestock sector (Hog Products and Other Livestock) are 0.52 percent of labor and 99.48 percent of capital. Crop sectors (Feed Grains and Other Crops) factors share are 0.17 percent, 18.80 percent and 81.03 percent for labor, capital and land, respectively.

TABLE 3.9 PRIMARY FACTOR INPUTS OF TEXAS COUNTY, 1993

(THOUSAND DOLLARS)

Industrial sectors	IMPLAN VA			Primary Factors		
	Employ. Comp.	Propriet. Income	Other Proper. Income	Labor	Capital	Land
Hogs Products	15.6	69.4	45.3	0.7	129.6	
Other Livestock	2,337.9	35,084.4	7,671.1	233.4	44,860.0	
Feed Grains	50.2	1,578.9	752.0	4.0	447.7	1,929.5
Other Crops	66.3	907.0	548.4	2.6	286.1	1,233.0
Oil Gas and Products	9,740.9	1,883.3	10,163.2	10,332.5	11,455.0	
Construction	7,617.3	3,238.0	4,485.3	8,634.4	6,706.2	
Meat Packing Plants	80.3	1.0	13.5	80.6	14.2	
Prepared Feeds	788.7	9.5	231.3	791.7	237.8	
Other Prepared Foods	219.6	2.7	209.0	220.4	210.9	
Other Manufacturing	4,764.4	254.3	390.9	4,844.3	565.3	
Services	92,493.0	12,560.0	41,888.4	96,438.1	50,503.3	

Classifying primary factor for non-agricultural sector follow the method of Koh, Lee, and Budiyanti, for agricultural sectors such that 31.41 percent of proprietary income and all of employee compensation were account for labor, and 68.59 percent of proprietary income and all of other property type income were account for capital. Based on this estimation, three components of IMPLAN value-added were reallocated into three components of primary factors (labor, capital, and land) as shown in Table 3.9.

3.3.2. INSTITUTIONS

Institutions are also known as final demands sectors that buy goods and service for consumption. These goods and services used by these institutions are not used to generate more product and disappear from the economy; so it is called final goods. Final demand data comes from government surveys, Federal procurement and sales data. IMPLAN classified institution into 9 components.

1. Household Expenditures
2. Federal Government Military Purchases
3. Federal Government Non-Military Purchases
4. Federal Government Non-Military Investment
5. State and Local Government Non-Education Purchases
6. State and Local Government Education Purchases
7. State and Local Government Non-Education Investment
8. Inventory Purchases
9. Capital Formation

In this research three Federal Government sectors were aggregated into one sector and similarly for State and Local Government. In the IMPLAN data set of year 1993 households are classified into three groups based on income such as "Low" for households that have annual income lower than $15,000; "Medium" for ones that have annual incomes from $15,000 to $50,000; and "High" consists of households that have annual income higher than $50,000. Enterprise was included as a component of institutions to keep track of the distribution of enterprises income to other institutions. However, enterprise did not purchase commodity.

Final commodities

Commodities consumed by institutions are known as final commodities. Proportion of commodity that institutions agents regionally purchased were assumed equal to regional purchase coefficient (RPC), the same as that of industrial sectors.

The same procedures were use to calculate regionally purchased and imported commodity consumed by institutions. Amounts of final commodities were presented in Table 3.10.

TABLE 3.10 FINAL COMMODITIES CONSUMED BY HOUSEHOLDS OF TEXAS COUNTY, 1993. (THOUSAND DOLLARS)

Industrial sectors	Institutions						
	Low-income hhold	Med-income hhold	High-income Hhold	Federal govern.	Local govern.	Invest-ment	Inven-tory
Regionally produced commodity							
Hogs Products							
Other Livestock	25.3	41.5	70.9		8.1		7.6
Feed Grains	0.3	0.2	0.5		0.3		
Other Crops	14.1	12.9	27.4		1.6		0.2
Oil Gas and Products	1,468.0	1,483.6	3,213.3		658.8	12.9	33.3
Construction				351.6	9,140.9	19,131.2	
Meat Packing Plants	158.4	134.5	296.2		24.7		4.8
Prepared Feeds	0.2	0.2	0.3				
Other Prep. Foods	7.3	7.0	14.5		0.6		
Other Manufacture	1,041.8	1,567.7	2,754.4		533.9	356.5	113.1
Services	25,310.2	34,347.9	62,595.2	1,017.1	17,911.2	1,437.0	858.9
Imported commodity							
Hogs Products							
Other Livestock	0.1	0.1	0.2				
Feed Grains	0.2	2.2	4.7				
Other Crops	28.8	26.2	55.8				
Oil Gas and Products	331.6	335.1	725.8			2.9	
Construction				39.8	22.8	3,405.9	
Meat Packing Plants	292.2	248.2	546.4				
Prepared Feeds	15.6	13.5	29.3				
Other Prepared Foods	4,217.6	4,002.9	8,328.7				
Other Manufacture	6,326.1	9,519.5	16,726.0			2,164.7	
Services	24,987.0	33,909.4	61,796.1	464.1	540.0	1,418.7	

Factors Income Distribution

Table 3.11 presents distribution of factor income to institutions. Industrial sectors compensate factor inputs to institutions. Labor is supplied by households. Level of labor income households earned depends on the amount of labor they provided (to industrial sectors). A portion of labor compensation was distributed to government as labor tax (to social security account). The amount of capital account distributed to household groups based on proportion of resources owned by each group. About $29.7 million is distributed to enterprises (corporations).

Proportion of capital compensation added to the capital account is $23 million. Federal government subsidized for capital $11 million and State and Local government received $3.8 million as capital tax. All indirect business taxes contributed to government budget.

TABLE 3.11 DISTRIBUTION OF FACTOR INCOME, TEXAS COUNTY, 1993 (THOUSAND DOLLARS)

Institutions	Factors			Indirect Business Tax
	Labor	Capital	Land	
Low-income households	7,485.81	6,987.30	157.34	
Medium-income households	43,652.02	27,726.06	1,581.06	
High-income households	51,092.21	34,802.40	1,254.38	
Federal government	16,048.94	-11,005.72	169.73	6668.17
State and Local government	3,303.54	3,841.11		23896.05
Enterprises (Corporations)		29,657.69		
Capital /Saving		23,009.76		

Inter-Institution Transfers

Table 3.12 presents monetary flows within institution agents. Rows of household groups capture monetary transfers from government to households. Households receive payment from enterprise and capital formation, as well. Governments receive taxes from households, enterprise and capital formation. This table also captures money granted from Federal Government to state and local government, $10.65 million. Receipts of capital account from households are saving. There is no savings from households. Capital account received $30.76 million from Federal Government as capital subsidy, and $18.4 million from enterprise, known as retained earning from enterprise.

TABLE 3.12 INTER-INSTITUTION TRANSFERS, TEXAS COUNTY, 1993

(THOUSAND DOLLARS)

Institution (receipts)	Institutions (expenditures)						
	Low-income hhold	Med-income hhold	High-income hhold	Federal govern.	Local govern.	Enter-prise	Invert-ment
Low-income hh				25,652.3	267.7	35.0	11,790.3
Med-income hh				13,719.9	1,556.2	305.5	4,101.8
High-income hh				52,637.8	538.6	95.3	7,571.6
Fed government	1,211.0	13,497.0	14,725.0			9,445.8	
Local govern.	743.0	4,613.0	4,565.0	10,654.8		1,353.5	20,937.5
Capital/Saving				30,760.5		18,422.6	
Inventory							18,908.0

Institution Sell Commodity

Commodities provided by institutions were presented in Table 3.13. Services are provided by households and governments. Governments also supply oil and gas product and some kind of manufacturing product. Inventory operates as a buffer to store product and supply to the market in convenient time.

TABLE 3.13 INSTITUTIONAL SELLS COMMODITY, TEXAS COUNTY, 1993 (THOUSAND DOLLARS)

Commodity	Low-income hhold	Med-income hhold	High-income hhold	Federal govern.	Local govern.	Capital/ Saving	Inventory
Hogs Products							515.6
Other Livestock							1,347.8
Feed Grains							2,190.1
Other Crops							856.5
Oil Gas and Products				26.2	13.6		205.2
Construction							0.0
Meat Packing Plants							0.0
Prepared Feeds							8.1
Other Prep. Foods					35.2		4.1
Other Manufacture					24.6		70.6
Services	631.6	1,711.8	2,465.9	34.7	9,967.0	1,632.6	243.9

Balancing

The last step in constructing SAM is making an adjustment to ensure row totals equal to column totals. The industry outputs and commodities supply and demands are already balanced by previous steps. The differences between institution expenditure totals and sum of all sources of income were "institutional exports", cell 4x5, known as income from Rest-of-World (ROW). These adjusted values were shown in Table 3.14. The exports of households are known as Remittance from outside the region to households. The exports of governments are known as government income from Rest-of-World (ROW) or foreign borrow, similarly for enterprises and inventory. Actually, these values are not important to the model because they are treated as exogenous variables and will not change in the simulated model.

TABLE 3.14 INSTITUTIONAL EXPORTS, TEXAS COUNTY, 1993.

(THOUSAND DOLLARS)

Institutions	Exports
Low-income households	13,171.1
Med-income households	10,588.0
High-income households	24,837.3
Fed government	84,477.0
Local govern.	-52,742.4
Capital/Saving	17,413.6
Inventory	-23,332.0

CHAPTER IV

THE CGE MODEL OF TEXAS COUNTY, OKLAHOMA

4.1. THEORETICAL BACKGROUND

Traditional regional models such as input-output and economic base models are general equilibrium framed and based on the Keynesian model. These models assume perfectly elastic supply of resources and fixed prices, and predict total change in the economy to be proportionate with the exogenous change. Because there are no resource constraints and no price effects these models may be useful in estimating long-term impacts for small region where factors are fully mobile (Koh et al, 1993). The CGE model is based on the Walrasian general equilibrium framework, which is grounded in neoclassical theory. In this model the supply is less than perfectly elastic, and equilibration of demand and supply is achieved through flexible prices. The total response to an exogenous change is not necessarily proportionate, depending on elasticities of demand and supply. The fixed-price regional models can be viewed as limiting cases of the general Walrasian system (Partridge and Rickman, 1998).

The CGE model is based on behavior of agents in the economy in response to prices that bring markets in equilibrium. Producers select a level of output based on prices of output and inputs to maximize profit. Consumers select levels of commodity to purchase based on commodity prices and income constraints. The CGE also includes trade of commodities with other regions. On the supply side, producers decide whether to sell their outputs on the domestic market or export out of the region depending on the domestic price relative to the export price. On the demand side, domestic and imported products are imperfect substitutes. The consumption of domestic supply depends on their relative prices.

Sadoulet and de Janvry (1995) state that "In a CGE, all accounts are endogenous and must be in equilibrium. Producers sell their total products, factors distribute their income, firms and households spend their income, and investment is determined by available saving. The government budget is usually balanced by letting its saving, or deficit if negative, be residually computed" (p. 342).

The CGE model has been applied to measure impacts of a wide range of policy issues such as (a) foreign shocks (increase in the price of imported oil); (b) changes in economic policies (taxes, subsidies); and (c) changes in domestic economic and social structure (technology changes in agriculture, asset redistribution, human capital formation) (Sadoulet and de Janvry, 1995).

The regional CGE model is modified after their national counterparts. In the regional CGE model, firms are assumed to maximize profits with both product and factor markets perfectly competitive (Partridge and Rickman, 1998). According to Schreiner et al. (1999), in a market economy there is generally a large number of endogenous goods and services; each of these goods and services has a market price determined by forces of supply and demand. All markets are assumed to clear at these prices. The perfectly competitive CGE model assumes zero transaction cost, participants in the market are price taking, and information is perfect and available. Producers supply goods and services and also create demand for primary factors and intermediate inputs. Intermediate input may be purchased locally or imported. The institutions supply primary factors to industry, and in return, receive income from selling these resources depending on their share of resource ownership and factor rate of return. Consumption of final goods depends on level of income received by institutions from selling their resources. Similar to intermediate inputs, final goods can be purchased locally or imported. Besides payment for inputs producers also pay taxes and transportation costs that increase factor costs and thus increases producer prices.

Partridge and Rickman (1998), Schreiner et al (1999), state that the Regional CGE model is complicated because of the greater openness of the regional economy. Regional trade takes place with other regions and with foreign countries. Labor is more likely to be mobile between regions than between countries. Capital is also mobile in the long-run if there is a difference in regional capital rate of return and that of other regions. The number of national CGE models has exploded; however, applications of CGE models to regional economies are more recent (Partridge and Rickman, 1998). The two main reasons for low number of applications of regional CGE are (1) policy instruments available for regional government are less than for central government; and (2) lack of appropriate data at the regional level.

4.2. STRUCTURE OF THE CGE MODEL

The CGE model simulates the activities of all agents in the market economy in which markets operate to obtain equilibrium at the price that all markets are clear (quantity supplied equals to quantity demanded). The activities of agents in the economy are incorporated into the model as equations that describe their behavior such as producers maximize profit and consumers maximize utility based on their budget constraint. When there is an external shock or an implementation of economic policy the whole system responds to obtain a new equilibrium. The CGE model also incorporates the activity of institution agents and captures the transaction flow of income.

Structure of the CGE model is described in four sections. Section 4.2.1 describes the operation of production using production functions and profit maximizing behavior to decide how much to produce what inputs to use given output and input prices. This section also describes the decisions of producer on how much to import of intermediate inputs versus domestic inputs given relative prices. Section 4.2.2 introduces the operation of commodity markets in which supply and demand interact to create the market clearing prices. Factor markets and distribution of factor compensations are presented in Section 4.2.3. Transfers and flows of income among institutions are described in section 4.2.4. Finally, section 4.2.5 presents the macro balances between incomes and expenditures.

4.2.1. INDUSTRY SECTORS

Production Function

The industrial sectors use two sets of inputs, namely, primary factors (labor, capital and land) and intermediate inputs (outputs of other industrial sectors). Production is described as a multi-level process to allow different elasticities of substitution between sets of factors (Schreiner et al, 1999). In this research, production is described at two levels. The first level follows the Leontief technology that does not allow substitution between the composite of primary factors and the composite of intermediate inputs. In the second level, primary factors follow a Cobb-Douglas relationship to produce value added. The intermediate inputs were used at a fixed proportion of output but the ratio of imported to regionally produced inputs follow a constant elasticity of substitution (CES) relationship.

The first level is presented by a Leontief production function, which characterizes non-substitutability between intermediate and primary inputs. Inputs are a fixed proportion of output. Output of an industrial sector i is the following:

$$X_i = \min(\frac{VA_i}{a_{oi}}, \frac{INT_{ji}}{a_{ji}}) \tag{4.1}$$

where VA_i is total value-added (composite primary factor input) used by sector i

INT_{ji} is intermediate input from sector j used by sector i

In Leontief technology, production cost is minimized, profit is maximized, when firms select levels of inputs such that

$$X_i = \frac{VA_i}{a_{oi}} = \frac{INT_{ji}}{a_{ji}} \tag{4.2}$$

where a_{oi} is the amount of value-added used to produce one unit of output of industry i, and a_{ji} is the amount of commodity j used to produce one unit of output of industry i. These parameters are identical with input-output coefficients in the input-output model.

There are two groups of inputs: factor inputs (primary factors), and intermediate inputs. The second level of production allows substitutions of inputs in each group.

Factor Inputs and Their demands

The second level of production is presented by the Cobb-Douglas production function. Value-added is a function of primary factors (labor, capital, and land) such that:

$$VA_i = \Phi_i^{VA} LAB_i^{\alpha_i^L} * CAP_i^{\alpha_i^K} * LAND_i^{\alpha_i^T} . \tag{4.3}$$

where Φ_i^{VA} is an efficiency parameter, and α_i^L, α_i^K, and α_i^T are share parameters for labor, capital and land, respectively. The share parameters satisfy the condition $\alpha_i^L + \alpha_i^K + \alpha_i^T = 1$ to ensure the feature of constant return to scale.

Rearranging equation (4.2) and substituting into (4.3) yields

$$X_i = \frac{\Phi_i^{VA}}{a_{oi}} LAB_i^{\alpha_i^L} * CAP_i^{\alpha_i^K} * LAND_i^{\alpha_i^T} \tag{4.4}$$

or

$$X_i = \Phi_i^X LAB_i^{\alpha_i^L} * CAP_i^{\alpha_i^K} * LAND_i^{\alpha_i^T} \tag{4.5}$$

where $\Phi_i^X = \dfrac{\Phi_i^{VA}}{a_{oi}}$.

Producers decide the level of primary factor to use in order to maximize profit. The profit of industrial sector i is described as follows:

$$\Pi_i = PN_i * X_i - PL * LAB_i - PK_i * CAP_i - PT_i * LAND_i .$$

where PL is wage rate, PK is capital rent, and PT is land rent. Wage rate (PL) is assumed equal in all sectors while capital rent (PK) and land rent (PT) are specific to each sector in the short-run. In the long-run, capital is assumed mobile and in equilibrium when its rent is equal among all sectors.

The profit function does not incorporate cost of intermediate inputs, so costs of these inputs are excluded from calculating profit by multiply output X_i by the net-price (PN_i), instead of output price (PX_i).

Net-price (PN_i) is the value of one unit of output after compensating for intermediate inputs and indirect business tax. In other words, this is the value of each unit of output available to compensate primary factors or value-added:

$$PN_i = \left(1 - \sum_j a_{ji} P_j - ibt_i\right) * PX_i \tag{4.6}$$

where P_j is price of composite commodity j, and PX_i is output price.

The optimal level of primary factors is the result of the first order condition (FOC) of profit maximization. Taking the derivative of π_i with respect to each factor and setting equal to zero yields:

$$\frac{\partial \pi_i}{\partial LAB_i} = PN_i \frac{\partial X_i}{\partial LAB_i} - PL = \alpha_i^L PN_i \frac{X_i}{LAB_i} = 0 \tag{4.7}$$

$$\frac{\partial \pi_i}{\partial CAP_i} = PN_i \frac{\partial X_i}{\partial CAP_i} - PK_i = \alpha_i^L PN_i \frac{X_i}{CAP_i} = 0 \tag{4.8}$$

$$\frac{\partial \pi_i}{\partial LAND_i} = PN_i \frac{\partial X_i}{\partial LAND_i} - PT = \alpha_i^L PN_i \frac{X_i}{LAND_i} = 0 \tag{4.9}$$

Rearranging equation (4.7), (4.8), (4.9) yields the optimal factor (labor, capital and land) levels as a function of its price, net price, output level and production parameters as follows:

$$LAB_i = \frac{\alpha_i^L PN_i * X_i}{PL} \tag{4.10}$$

$$CAP_i = \frac{\alpha_i^K PN_i * X_i}{PK_i} \tag{4.11}$$

$$LAND_i = \frac{\alpha_i^T PN_i * X_i}{PT_i}. \tag{4.12}$$

Intermediate Inputs and Their Demands

Composite intermediate input is used in fixed proportion to output in the Leontief function. However, the commodities used as intermediate inputs are purchased locally or imported. Commodities from different regions are assumed to be imperfect substitutes for locally purchased commodities and are specified as a constant elasticity of substitution function (CES).

Arrow et al. (1961) defined the general form of the CES as follows:

$$y = \Phi\left[\delta X_1^{-\rho} + (1-\delta)X_2^{-\rho}\right]^{-1/\rho} \tag{4.13}$$

where $\Phi > 0$. A change of Φ changes the output for any given set of inputs, so it is called an *efficiency parameter.* $0 < \delta < 1$ is a functional distribution of income or inputs so is called *distribution parameter.* ρ is related to the elasticity of substitution so it is termed a *substitution parameter.* ρ must satisfy the condition $\rho + 1 > 0$ to ensure diminishing returns of the CES equation (4.13).

The elasticity of substitution between inputs X_2 and X_1 is defined as:

$$\sigma = \frac{\Delta \frac{X_2}{X_1}}{\Delta TRS} * \frac{TRS}{\frac{X_2}{X_1}} \tag{4.14}$$

where TRS is the technical rate of substitution between the two inputs and equal to

$-\frac{\partial f / x_1}{\partial f / x_2}$.

Varian (1992) (P.13) suggested the convenient formula to calculate σ as follows:

$$\sigma = \frac{d\ln\left(\frac{X_2}{X_1}\right)}{d\ln|TRS|}. \tag{4.15}$$

Elasticity of substitution for the CES function is derived as follows:

$$\frac{\partial y}{\partial x_1} = \Phi\left(-\tfrac{1}{\rho}\right)(-\rho)\delta X_1^{-\rho-1}\left[\delta X_1^{-\rho} + (1-\delta)X_2^{-\rho}\right]^{-1/\rho-1}$$

$$\frac{\partial y}{\partial x_1} = \Phi\delta X_1^{-\rho-1}\left[\delta X_1^{-\rho} + (1-\delta)X_2^{-\rho}\right]^{-1/\rho-1} \tag{4.16}$$

$$\frac{\partial y}{\partial x_2} = \Phi\left(-\tfrac{1}{\rho}\right)(-\rho)(1-\delta)X_2^{-\rho-1}\left[\delta X_1^{-\rho} + (1-\delta)X_2^{-\rho}\right]^{-1/\rho-1}$$

$$\frac{\partial y}{\partial x_2} = \Phi(1-\delta)X_2^{-\rho-1}\left[\delta X_1^{-\rho} + (1-\delta)X_2^{-\rho}\right]^{-1/\rho-1} \tag{4.17}$$

$$TRS = -\frac{\Phi\delta X_1^{-\rho-1}\left[\delta X_1^{-\rho} + (1-\delta)X_2^{-\rho}\right]^{-1/\rho-1}}{\Phi(1-\delta)X_2^{-\rho-1}\left[\delta X_1^{-\rho} + (1-\delta)X_2^{-\rho}\right]^{-1/\rho-1}}$$

$$TRS = -\left(\frac{\delta}{1-\delta}\right)\left(\frac{X_1}{X_2}\right)^{-\rho-1} = -\left(\frac{\delta}{1-\delta}\right)\left(\frac{X_2}{X_1}\right)^{1+\rho}. \tag{4.18}$$

Rearranging (4.18) yields

$$\frac{X_2}{X_1} = \left[\left(\frac{1-\delta}{\delta}\right)|TRS|\right]^{\frac{1}{1+\rho}} \tag{4.19}$$

Taking the log of both sides of (4.19) yields:

$$\ln\left(\tfrac{X_2}{X^1}\right) = \frac{1}{1+\rho}\left\{\ln\left(\tfrac{1-\delta}{\delta}\right) + \ln|TRS|\right\}.$$

Applying formula (4.15) yields the elasticity of substitution as:

$$\sigma = \frac{1}{1+\rho} \tag{4.20}$$

The admissible value of $-1 < \rho < \infty$ allows the value of σ to be from 0 to ∞.

The smallest admissible value of ρ is –1, implies the infinite elasticity of substitution. In this case the isoquants are strait-line. For values of ρ between –1 and 0 gives an elasticity of substitution σ larger than unity. The case of $\rho = 0$ gives a unitary elasticity of substitution; therefore, the CES leads to the Cobb-Douglas function. For $0 < \rho < \infty$ gives $\sigma < 1$. When $\rho \to \infty$ the elasticity of substitution approaches zero, there is no substitution between inputs, and the CES leads to the Leontief function (fixed proportions).

The relationship between the levels of regionally produced and imported commodity j that industry i uses as intermediate input ($INTR_{ji}$ and $INTM_{ji}$) follows the CES relationship:

$$INT_{ji} = \Phi_{ji}^{INT}\left[\delta_{ji}^{INT} INTM_{ji}^{-\rho_j^{INT}} + (1-\delta_{ji}^{INT}) INTR_{ji}^{-\rho_j^{INT}}\right]^{-\frac{1}{\rho_j^{INT}}} \tag{4.21}$$

where Φ_{ji}^{INT} >0 is the efficiency parameter, 0< δ_{ji}^{INT} <1 is the share parameter, and $-1 < \rho_j^{INT} < \infty$ is the substitution parameter of commodity j.

The elasticity of substitution of this function $\sigma_j^{INT} = \dfrac{1}{1+\rho_j^{INT}}$ is constant, independent with levels of regionally produced intermediate input ($INTR_{ji}$) and imported intermediate input ($INTM_{ji}$), but depends on the degree of substitution between the two kinds (from two sources) of commodity.

Producers decide how much intermediate input to purchase from each source based on the objective of minimizing production cost:

$$\text{Minimize } PM_j * INTM_{ji} + PR_j * INTR_{Ji}$$

$$\text{subject to } INT_{ji} = \Phi_{ji}^{INT}\left[\delta_{ji}^{INT} INTM_{ji}^{-\rho_j^{INT}} + (1-\delta_{ji}^{INT}) INTR_{ji}^{-\rho_j^{INT}}\right]^{-\frac{1}{\rho_j^{INT}}}.$$

The Lagrangian function of this constrained optimization problem is:

$$L = PM_j * INTM_{ji} + PR_j * INTR_{ji} + \lambda\left(INT_{ji} - \Phi_{ji}^{INT}\left[\delta_{ji}^{INT} INTM_{ji}^{-\rho_j^{INT}} + (1-\delta_{ji}^{INT}) INTR_{ji}^{-\rho_j^{INT}}\right]^{-\frac{1}{\rho_j^{INT}}}\right).$$

Taking the derivative of L with respect to $INTM_{ji}$ and setting equal to zero yields:

$$\frac{\partial L}{\partial INTM_{ji}} = PM_j - \lambda\Phi_{ji}^{INT}\delta_{ji}^{INT} INTM_{ji}^{-\rho_j^{INT}-1}\left[\delta_{ji}^{INT} INTM_{ji}^{-\rho_j^{INT}} + (1-\delta_{ji}^{INT}) INTR_{ji}^{-\rho_j^{INT}}\right]^{-\frac{1}{\rho_j^{INT}}-1} = 0$$

$$\Rightarrow PM_j = \lambda\Phi_{ji}^{INT}\delta_{ji}^{INT} INTM_{ji}^{-\rho_j^{INT}-1}\left[\delta_{ji}^{INT} INTM_{ji}^{-\rho_j^{INT}} + (1-\delta_{ji}^{INT}) INTR_{ji}^{-\rho_j^{INT}}\right]^{-\frac{1}{\rho_j^{INT}}-1} . \quad (4.22)$$

Similarly, taking the derivative of L with respect to $INTR_{ji}$ and setting equal to zero yields:

$$\frac{\partial L}{\partial INTR_{ji}} = PR_j - \lambda\Phi_{ji}^{INT}(1-\delta_{ji}^{INT})INTR_{ji}^{-\rho_j^{INT}-1}\left[\delta_{ji}^{INT}INTM_{ji}^{-\rho_j^{INT}} + (1-\delta_{ji}^{INT})INTR_{ji}^{-\rho_j^{INT}}\right]^{-\frac{1}{\rho_j^{INT}}-1} = 0$$

$$\Rightarrow PR_j = \lambda\Phi_{ji}^{INT}(1-\delta_{ji}^{INT})INTR_{ji}^{-\rho_j^{INT}-1}\left[\delta_{ji}^{INT}INTM_{ji}^{-\rho_j^{INT}} + (1-\delta_{ji}^{INT})INTR_{ji}^{-\rho_j^{INT}}\right]^{-\frac{1}{\rho_j^{INT}}-1}. \quad (4.23)$$

Dividing (4.22) by (4.23) yields:

$$\frac{PM_j}{PR_j} = \frac{\delta_{ji}^{INT}}{1-\delta_{ji}^{INT}} * \left(\frac{INTM_{ji}}{INTR_{ji}}\right)^{-\rho_j^{INT}-1}. \quad (4.24)$$

Rearranging (4.24) yields the relationship between regionally produced intermediate input ($INTM_{ji}$) and imported intermediate input ($INTR_{ji}$) that minimizes intermediate inputs cost:

$$\frac{INTM_{ji}}{INTR_{ji}} = \left[\frac{1-\delta_{ji}^{INT}}{\delta_{ji}^{INT}} * \frac{PM_j}{PR_j}\right]^{-\frac{1}{1+\rho_j^{INT}}} \quad (4.25)$$

or

$$\frac{INTM_{ji}}{INTR_{ji}} = \left[\frac{1-\delta_{ji}^{INT}}{\delta_{ji}^{INT}} * \frac{PM_j}{PR_j}\right]^{-\sigma_j^{INT}} \quad (4.26)$$

where $\sigma_j^{INT} = \frac{1}{1+\rho_j^{INT}}$ is the elasticity of substitution.

Equation (4.26) identifies the optimal level of intermediate input used by industrial sector i in order to maximize profit.

4.2.2. COMMODITY MARKETS

The regional economy exhibits more openness than the national economy. Commodity trade includes regional markets, markets from other regions and international markets. Regionally produced commodities are sold in the regional market as well as in the out-of-region markets. Finally, the regional demand for commodities are satisfied from regionally produced or imported goods.

4.2.2.1. Supply of Commodities

Supply of commodities comes from (1) regional industrial sectors (producers), (2) imported from out-of-region markets and (3) a small portion provided by institutions such as governments and sales inventory. The regional industrial sectors generally provide the largest proportion of commodity supply.

<u>Regional Industry Output</u>

Each industrial sector produces a commodity (X_i) that is sold in regional markets or exported to markets out-of-region. Exported and regionally sold products are assumed to be market differentiated. The relationship between exported (E_i) and locally sold (R_i) levels is assumed to follow a constant elasticity of transformation (CET) function:

$$X_i = \Phi_i^X \left[\delta_i^X E_i^{\rho_i^X} + (1-\delta_i^X) R_i^{\rho_i^X}\right]^{\frac{1}{\rho_i^X}}. \tag{4.27}$$

Similar to the CES function, Φ_i^X>0 is the efficiency parameter, 0<δ_i^X<1 is the share parameter, and ρ_i^X is the substitution parameter. The elasticity of transformation (substitution between the two markets) is constant ($\sigma_i^X = \frac{1}{\rho_i^X - 1}$); and does not vary with locally sold (R_i) and exported (E_i) levels.

The industrial sector allocates its output between the two markets in order to maximize revenue subject to the CET function (4.27):

$$\text{Minimize } PE_i * E_i + PR_i * R_i$$

$$\text{subject to } X_i = \Phi_i^X \left[\delta_i^X E_i^{\rho_i^X} + (1-\delta_i^X) R_i^{\rho_i^X}\right]^{\frac{1}{\rho_i^X}}.$$

The Lagrangian equation for this optimization problem is the following:

$$L = PE_i * E_i + PR_i * R_i + \lambda \left\{ X_i - \Phi_i^X \left[\delta_i^X E_i^{\rho_i^X} + (1-\delta_i^X) R_i^{\rho_i^X}\right]^{\frac{1}{\rho_i^X}} \right\}.$$

The first-order conditions are:

$$\frac{\partial L}{\partial E_i} = PE_i - \lambda \Phi_i^X \left(\tfrac{1}{\rho_i^X}\right) \rho_i^X \delta_i^X E_i^{\rho_i^X - 1} \left[\delta_i^X E_i^{\rho_i^X} + (1-\delta_i^X) R_i^{\rho_i^X}\right]^{\frac{1}{\rho_i^X} - 1} = 0$$

$$PE_i = \lambda \Phi_i^X \delta_i^X E_i^{\rho_i^X - 1} \left[\delta_i^X E_i^{\rho_i^X} + (1-\delta_i^X) R_i^{\rho_i^X}\right]^{\frac{1}{\rho_i^X} - 1} \tag{4.28}$$

$$\frac{\partial L}{\partial R_i} = PR_i - \lambda \Phi_i^X \left(\tfrac{1}{\rho_i^X}\right) \rho_i^X \left(1-\delta_i^X\right) R_i^{\rho_i^X - 1} \left[\delta_i^X E_i^{\rho_i^X} + (1-\delta_i^X) R_i^{\rho_i^X}\right]^{\frac{1}{\rho_i^X} - 1} = 0$$

$$PR_i = \lambda \Phi_i^X \left(1-\delta_i^X\right) R_i^{\rho_i^X - 1} \left[\delta_i^X E_i^{\rho_i^X} + (1-\delta_i^X) R_i^{\rho_i^X}\right]^{\frac{1}{\rho_i^X} - 1}. \tag{4.29}$$

Dividing (4.28) by (4.29) yields

$$\frac{PE_i}{PR_i} = \frac{\delta_i^X}{1-\delta_i^X} * \left(\frac{E_i}{R_i}\right)^{\rho_i^X - 1}. \tag{4.30}$$

Rearranging (4.30) provides the relationship of exported (R_i) and regionally sold (E_i) levels.

$$\frac{E_i}{R_i} = \left(\frac{1-\delta_i^X}{\delta_i^X} * \frac{PE_i}{PR_i} \right)^{\frac{1}{\rho_i^X - 1}}. \tag{4.31}$$

Imported Commodities

Producers from out-of-region sell their output to the region via trade activities. These kinds of goods are considered as "imported commodities" in the CGE model. Imported and regionally produced commodities are assumed differentiated (imperfect substitutes).

In the benchmark data (process of construction of the SAM), the composite commodity is differentiated as imported or regionally produced commodities by applying a regional purchase coefficient (RPC). For each commodity, the same regional purchase coefficient (RPC) is used for all sources of demand. In the CGE model, the relationship between these two sources of commodities is assumed by the constant elasticity of substitution (CES) function.

Commodities Provided by Institutions

Institutions also provide small portions of commodities to markets (for instance, households and governments provide services, inventory sells commodities stored in the previous period). Inventory is the largest provider of this source of supply. The market share of this source is very small, about 0.1 to 3.0 percent of market supply. This institutional source of commodities supply is treated as exogenous in the CGE model.

4.2.2.2. Demands for Commodity

Commodity demands are within region (regional markets) or from out-of-region (export markets). Regional demands are for intermediate inputs, households and other institutional agents (governments, capital formation, and inventory). Demands for intermediate input were discussed in section 4.2.1. This section examines demands by households and other institutions.

Commodities Demanded by Households

Households use their income to pay taxes to governments, spend for hired labor, keep for future use (saving), and purchase commodities. The amount of income used for purchasing commodities is called "household expenditure." (1) Households decide the quantity of each commodity to purchase, depending on the availability of their budget, in order to maximize utility. (2) Households choose regionally produced or imported commodities, or both. To incorporate these two sources of household consumption, the CGE model differentiates household consumption in two levels.

The First Level

In this CGE model, a Linear Expenditure System (LES) for household expenditure is used. The LES is derived from maximizing the Stone-Geary utility function subject to the household expenditure (HE_h) constraint:

$$\text{Maximize } U_h = \sum_{i=1}^{n} \beta_{ih} \ln(Q_{ih} - \gamma_{ih})$$

$$\text{subject to: } HE_h = \sum_{i=1}^{n} P_i Q_{ih},$$

where γ_{ih} = Subsistence minima of commodity i as perceived by consumer h,

β_{ih} = Marginal budget share for commodity i, $\sum_i \beta_i = 1$,

Q_{ih} = Quantity of good i consumed by household h,

P_i = Price of good i, and

HE_h = Expenditure of household h.

The Lagrangian function of this maximization problem is the following:

$$L_h = \sum_{i=1}^{n} \beta_{ih} \ln(Q_{ih} - \gamma_{ih}) - \lambda\left(HE_h - \sum_{i=1}^{n} P_i Q_{ih} \right).$$

Solving the first order conditions results in:

$$\frac{\beta_{ih}}{Q_{ih} - \gamma_{ih}} = \lambda P_i \tag{4.32}$$

$$HE_h - \sum_{i=1}^{n} P_i Q_{ih} = 0. \tag{4.33}$$

Summing (4.33) over n commodities i and rearranging yields, (recalling $\sum_i \beta_i = 1$):

$$\lambda = \frac{1}{\sum_i P_i Q_{ih} - \sum_i P_i \gamma_{ih}} = \frac{1}{HE_{ih} - \sum_i P_i \gamma_{ih}} \tag{4.34}$$

Substituting (4.34) into (4.32) and rearranging yields

$$Q_{ih} = \gamma_{ih} + \left(\frac{\beta_{ih}}{P_i} \right)\left(HE_h - \sum_{j=1} P_j \gamma_{jh} \right). \tag{4.35}$$

The estimated values for γ_{ih} from other research is needed to identify the demand functions. Assuming average budget share equal to marginal budget share results in $\gamma_{ih} = 0$ for all commodities and equation (4.35) simplifies to:

$$Q_{ih} = \beta_{ih} \frac{HE_h}{P_i}. \tag{4.36}$$

The Second Level

The optimum quantity of composite commodity, Q_{ih}, decided by households from maximizing utility subject to the budget constraint, HE_h, can be purchased regionally or imported. Households determined the amounts purchased regionally, QR_{ih}, and imported, QM_{ih}, by minimizing total purchase cost, subject to the CES relationship between commodities from the two markets:

$$\text{Minimize } PM_i * QM_{ih} + PR_h * QR_{ih}$$

$$\text{subject to } Q_{ih} = \Phi_{ih}^{Q}\left[\delta_{ih}^{Q} QM_{ih}^{-\rho_i^h} + (1-\delta_{ih}^{Q}) QR_{ih}^{-\rho_i^Q}\right]^{-\frac{1}{\rho_i^Q}}.$$

Applying the same process as for intermediate inputs (section 4.2.1), the optimal solution yields the following relationship:

$$\frac{QM_{ih}}{QR_{ih}} = \left[\frac{1-\delta_{ih}^{Q}}{\delta_{ih}^{Q}} * \frac{PM_i}{PR_i}\right]^{-\frac{1}{1+\rho_i^Q}}. \tag{4.37}$$

<u>Commodities Demanded by Other Institutions</u>

Composite commodity consumed by other institutions (governments, capital formation and inventory) is assumed exogenous in this study. However, the ratio of regionally produced to imported commodity is changed depending on relative regional and imported prices, and the degree of substitution of the commodities from the two sources. Like intermediate inputs and commodities consumed by households, the relationship is a CES function. Using the same procedure as in the previous section yields the following:

$$\frac{QXM_{ik}}{QXR_{ik}} = \left[\frac{1-\delta_{ik}^{QX}}{\delta_{ik}^{QX}} * \frac{PM_i}{PR_i}\right]^{-\frac{1}{1+\rho_i^{QX}}} . \qquad (4.38).$$

QX is the composite quantity of commodity consumed by institution (exogenous). QXM is the imported amount and QXR is the regionally produced amount. The index k presents institution that consisting of federal government, state/local government, and capital formation.

Commodity consumed by inventory (Q_i^{INVT}) is assumed proportionate to regional industry output:

$$Q_i^{INVT} = invtexr * X_i \qquad (4.39)$$

where $invtexr$ is the rate of inventory expenditure.

4.2.2.3. Commodity Prices

In a perfectly competitive market, both producers and consumer are price takers. The price of each commodity is determined by demand and supply of its market. Regional producers of i sell their output in regional market at price level PR_i, export output to out-of-region market at price level PE_i. Local consumers (consisting of local households and institutions who buy final goods and regional producers who buy commodities for intermediate inputs) pay for regionally produced commodities at price level PR_i and imported commodity at price level PM_i in local market. PR_i (commodity price in local market) is set by demand and supply in the region (treated as endogenous variable) while PE_i and PM_i is determined by factors from outside (exogenous variables). The CGE model in this research assumed the region is a "small country" in the trade model. That means imported and exported quantities for the region do not affect out-of-region prices.

Composite Commodity Price

The total quantity of commodity locally produced consumed is the quantity supplied to regional market by industrial sectors (R_i) plus quantity sold by institutions ($INSTSELL0_i$). The total quantity of imported commodity i (M_i) is the sum of total imported intermediate inputs used by industrial sectors ($TINTM_i$), total imported commodity consumed by households (TQM_i), and total imported commodity consumed by other institutions ($TQXM_i$):

$$M_i = TINTM_i + TQM_i + TQXM_i \tag{4.41}$$

where $TINTM_i = \sum_j INTM_{ij}$ is total of imported intermediate input i used by production sectors,

$TQM_i = \sum_h QM_{ih}$ is total of imported commodity i consumed by households, and

$TQXM_i = \sum_k QXM_{ik}$ is total of imported commodity i consumed by institutions.

Price of composite commodity is a weighted average price over the quantity of commodity locally produced and consumed in the region, and the quantity of imported commodity:

$$P_i = \frac{PR_i * (R_i + INSTSELL0_i) + PM_i * M_i}{R_i + INSTSELL0_i + M_i}. \tag{4.42}$$

where $INSTSELL0_i$ is commodity and services provided by institutions, other terms are as previously defined:

Composite Output Price

Commodities produced by industrial sectors are sold in regional markets (R_i) and exported out-of-region (E_i). Price of composite output (PX_i) is a weighted average over quantity of regionally sold and exported industry output:

$$PX_i = \frac{PR_i * R_i + PE_i * E_i}{R_i + E_i}. \tag{4.43}$$

4.2.2.4. Commodity Market Equilibrium

The basic feature of the CGE models is that all markets are in equilibrium. The commodity market is in equilibrium when quantity supplied is equal to quantity demanded. For each commodity, the equilibrium condition follows as:

$$X_i + M_i + INSTSELL0_i = TINT_i + TQ_i + TQX_i + E_i. \qquad (4.44).$$

The left-hand side of equation (4.44) is the quantity supplied and consists of commodity (X_i) produced by industrial sector, commodity imported (M_i), and commodity and services provided by institutions ($INSTSELL0_i$).

The right-hand side of equation (4.44) is the quantity demanded of composite commodity (included regionally produced and imported) and consists of commodity used by industrial sector ($TINT_i$) as intermediate inputs, commodity consumed by households (TQ_i), commodity consumed by institutions (TQX_i); and exported commodity (E_i). These quantities are calculated as following:

$$TINT_i = \sum_j INT_{ij} \, ,$$

$$TQ_i = \sum_h Q_{ih} \, , \text{ and}$$

$$TQX_i = \sum_k QX_{ik}$$

4.2.3 FACTOR MARKETS AND FACTOR INCOME DISTRIBUTION

In the CGE model, the factor markets are assumed perfectly competitive. Both firms (factor demanders) and households (factor suppliers) are price takers (Schreiner et al. 1999). The demand for factors was presented in section 4.2.1. This section is about supply of factors and distribution of factor incomes.

4.2.3.1. Labor Market

Households provide labor for industries and governments, and in return, receive labor income. The supply of labor depends on the choices of individuals between number of hours to work and number of hours spent for "leisure." The individuals choose the number of work hours in order to maximize utility of consumption and leisure subject to the full income constraint. This constrained optimization yields the number of hours worked, up to the marginal rate of substitution of leisure, and for consumption is equal to wage rate (Nicholson, 1995). This theory of labor supply is called endogenous labor supply. In this research, the change in endogenous labor supply is small because of the stability of wage rate, so it is ignored.

Labor is assumed mobile. That means labor can move between industrial sectors and can migrate from outside into region or migrate out of the region. The total labor supply is initial labor provided by local households plus in-migrated labor minus out-migrated labor. In this study, because of one labor market, labor either in-migrates or out-migrates, but not both.

The largest portion of labor supply is used by industrial sectors. Additionally, institutions such as governments and households also use labor. The labor used by government and household is treated as exogenous, so called exogenous demand for labor. The balance of the labor market is as follows:

$$LS0 + LMIG = LDI + LDE \tag{4.45}$$

where $LS0$ is total initial labor provided by households, $LMIG$ is migrated labor, LDI is labor demanded by industrial sectors, $LDI = \sum_i LAB_i$, and LDE is exogenous demand for labor (used by governments and households).

$$LDE = \sum_h LDH_h + \sum_g LDG_g \tag{4.46}$$

where LDH_h is labor used by households and LDG_g is labor used by government.

Labor Migration

Labor migration occurs when there is a gap between regional (PL) and out-of-region ($PLROW$) wage rates. The magnitude of labor migration depends on the elasticity of labor migration as follows:

$$LMIG = LS0 * \varepsilon^{L} \log\left(\frac{PL}{PLROW}\right) \qquad (4.47)$$

where ε^{L} is the elasticity of labor migration.

Migrated labor is classified into household income group by the following formula:

$$LMIGH_{h} = ldist_{h} * LMIG \qquad (4.48)$$

where $ldist_{h}$ is the proportion of labor supply by household group.

Labor Income

Labor income is total labor demanded multiplied by wage rate:

$$LY = PL * \left(\sum_{i} LAB_{i} + \sum_{h} LDH_{h} + \sum_{g} LDG_{g}\right) \qquad (4.49)$$

where PL is wage rate. Because of one labor market, the equilibrium wage rate is equal for all sectors.

A portion of labor compensation is distributed to government as labor taxes, i.e. social security. Labor tax is proportionate ($ltax_{g}$) to labor income. The remainder is net labor income (NLY) that is distributed directly to households and is their main source of income:

$$NLY = LY\left(1 - \sum_g ltax_g\right) \tag{4.50}$$

where $ltax_g$ is labor tax rate.

Households receive labor income based on the amount of labor provided. So, the proportion of labor income received by each household group is used to identify labor supply by household income group. This proportion is employed in equation (4.48).

4.2.3.2. Capital Market

Capital is used by industrial sectors only. In the short-run, capital is assumed fixed in each industrial sector. In the initial stage, the capital market is in equilibrium at quantity of capital demanded by each industrial sector CAP_i and equal to initial capital stock $KS0_i$:

$$CAP_i = KS0_i \tag{4.51}$$

In the long-run capital is mobile from sector to sector depends on the difference of capital rent between sectors until reaching an equilibrium. In the equilibrium capital rent in all sectors are equal to PKL.

$$PKL = \frac{\sum_i PK_i * CAP_i}{\sum_i KS0_i}. \tag{4.52}$$

Capital can also "migrate" into the region from outside or move out of the region. The capital migration ($KMIG$) depends on the ration of regional capital rent (PKL) to out-of-region capital rent ($PKROW$) and the elasticity of capital migration (ε^K):

$$KMIG = \sum_i KS0_i * \varepsilon^K * \log\left(\frac{PKL}{PKROW}\right). \tag{4.53}$$

The capital market is in equilibrium when total capital demanded equals total capital supplied:

$$\sum_i CAP_i = \sum_i KS0_i + KMIG. \tag{4.54}$$

Capital Income

In the short-run, capital income for each industrial sector is capital used (equal to capital stock) multiplied by its rent. Total capital income is the sum of capital income across all sectors:

$$KY = \sum_i PK_i * CAP_i. \tag{4.55}$$

With capital mobile across sectors and regions (long-run), total capital income is total capital used multiplied by the overall capital rent:

$$KY = PKL * \sum_i CAP_i. \tag{4.56}$$

Capital Income Distribution

Enterprises and households own capital stock. Enterprise ownership is in the corporations. Household ownership is in the self-employed businesses. The capital income distributed to owners is based on the proportion of resources they hold. Capital owned by enterprises ($ENTK$) and capital owned by households (HK) are as follows:

$$ENTK = entkshr * \sum_i CAP_i \tag{4.57}$$

$$HK_h = hkshr_h * \sum_i CAP_i \tag{4.58}$$

where $entkshr$, and $hkshr_h$ are capital shares by enterprises and households, respectively.

Capital income distributed to enterprises and households is equal to quantity of capital owned multiplied by the overall capital rent ($PK1$). In the short-run:

$$PK1 = \frac{\sum_i PK_i * CAP_i}{\sum_i CAP_i}. \tag{4.59}$$

In the long-run:

$$PK1 = PKL. \tag{4.60}$$

Beside proportions distributed to capital owners, capital income is distributed to the capital account as retained earnings (rents and depreciation), and to government as capital tax. When capital to government is negative this means a government subsidy for capital:

$$CAPK = capkshr * \sum_i CAP_i \tag{4.61}$$

$$GOVK_g = govkshr_g * \sum_i CAP_i \tag{4.62}$$

where $capkshr$ and $govkshr$ are shares to capital account and governments, respectively.

4.2.3.3. Land Market

Land is assumed immobile and fixed in each industrial sector in both the short-run and long-run. That means the supply of land is perfectly inelastic. Therefore, the land market attains equilibrium when land used ($LAND_i$) is equal to initial quantity of land ($TS0_i$):

$$LAND_i = TS0_i. \tag{4.63}$$

Land Income

Land is immobile. Therefore, land rent may different between sectors. Land income is the sum of the quantity of land used by sector multiplied by the corresponding land rent:

$$TY = \sum PT_i * LAND_i. \tag{4.64}$$

Net land income (NTY) is the remaining land income after paying the tax:

$$NTY = \left(1 - \sum_g ttax_g\right) * TY \tag{4.65}$$

where $ttax_g$ are land tax rate.

Land Income Distribution

Households are presumed the only owners of land; therefore, all net land income is distributed to household groups (HTY_h) based on share of land resource:

$$HTY_h = htshr_h * TY \tag{4.66}$$

where $htshr_h$ are household shares of land.

4.2.4. INTER-INSTITUTION TRANSFERS

Monetary flows between industrial sectors and households through regional and out-of-region commodity markets, and factor markets via purchasing and selling is called market-transfers. The monetary transfers between institutional agents without trade activities are called non-market-transfers. Actually, these transfers are the redistribution of income within institutional agents.

4.2.4.1. Enterprise Income Distribution

In section 4.2.3.2, capital compensation was distributed to households and enterprises (capital owners) after paying taxes. The owners of enterprises are corporations that eventually make distributions to households. Like other agents in the economy, a portion of enterprise income goes to governments as corporate income taxation. In addition, enterprise income is distributed to the capital account as depreciation, retained earning and capital payments to capital (stock) owners outside of the region.

Enterprise income ($ENTY$) is the enterprise share of capital ($ENTK$) multiplied by overall capital price ($PK1$):

$$ENTY = PK1 * ENTK . \tag{4.67}$$

The distribution of enterprise income is assumed at fixed shares, so the monetary shares of gross enterprise income to institutions are as follows:

$$HENTY_h = heshr_h * ENTY \tag{4.68}$$

$$GENTY_g = geshr_g * ENTY \tag{4.69}$$

$$CENTY = ceshr * ENTY \tag{4.70}$$

where $HENTY_h$, $GENTY_g$, and $CENTY$ are gross enterprise income distributions to household groups, government and capital account, respectively. And $heshr_h$, $geshr_g$, and $ceshr$ are corresponding fixed shares.

4.2.4.2. Investment Expenses

Like enterprise income, investment paid taxes to governments at fixed rate:

$$INVTAX = invtaxrate_g * INVEST \tag{4.71}$$

and shared income to household groups. Investment also distributed income to inventory activity. All of these distributions are assumed exogenous. Investment income distributed to households ($INV2HH0_h$), and investment expenditure for inventory ($INV2INVT0$).

4.2.4.3. Government Transfer Payments

In addition to purchasing final goods and services, government expenditures include transfer payments to other institutions. These transfer payments consist of payments to households ($GOV2HH0_{hg}$) as program payment and social security, grants of Federal government to state and local governments ($GO2GOV0_{gg}$), and distribution to capital account as government saving ($GOVSAV_g$). The first two transfer payments are assumed fixed (exogenous). The last is the residual of government revenue after paying for all government expenses.

4.2.4.4. Household Transfer Payments

Households pay income tax to governments at a fixed rate ($htax_{hg}$) and may keep a part of their income to spend in the future as savings. Household savings are assumed at a fixed rate (hs_h).

4.2.5. INSTITUTION INCOMES AND EXPENDITURES

4.2.5.1. Household Income and Expenditures

Factor payments are the main source of household income. Households also receive income from enterprises, investment, payments from governments, inter-household transfers and net remittances from the rest-of-the-world. Gross household income (GHY_h) for each household group is as follows:

$$\begin{aligned} GHY_h &= hlshr_h * LY + PK1 * HHK_h + htshr_h * TY + HENTY_h \\ &+ \sum_i PX_i * HSELL_{hi} + \sum_g GOV2HH_{hg} + INV2HH0_h + REMIT_h \end{aligned} \tag{4.72}$$

where $hlshr_h$ is household shares of labor income; $htshr_h$ is household shares of net land income, $PK1 * HHK_1$ is household income from capital, $HENTY_h$ is households enterprise income, $GOV2HH_{hg}$ is government transfers to household, $INV2HH0_h$ is household income from investment, and $REMIT_h$ is net remittance to households from rest-of-the- world.

Disposable household income (DHY) is the remainder of GHY after paying taxes:

$$DHY_h = \left(1 - \sum_g htax_{hg}\right) * GHY_h. \tag{4.73}$$

where $htax_{hg}$ is the household tax rate.

Household expenditure (HE_h) is the amount of gross income remaining after paying taxes and saving and is used for commodity consumption:

$$HE_h = \left(1 - \sum_g htax_{hg} - hs_h\right) * GHY_h. \tag{4.74}$$

4.2.5.2. Government Revenues and Expenditures

The main sources of government revenue ($GOVR_g$) are taxes from economic agents. These consist of indirect business tax from industrial sectors, primary factor taxes, household income taxes, corporation tax, and investment tax. Governments also receive payments from out-of-region ($ROW2GOV_g$) that known as foreign borrowing. Local governments may also receive grants from the Federal government ($GOV2GOV_{gg_1}$).

Governments use budgets to purchase final goods as discussed in section 4.2.2.2 and make transfer payments to other institutions as discussed in section 4.2.4.3. The remainder of government revenue ($GOVR_g$), after deducting government expenditure and transfer payments, is government saving ($GOVSAV_g$).

4.2.6. ADJUSTMENT FOR HOUSEHOLD INCOME

The model allows labor and capital to be mobile. If the household moves out-of-region the ownership of not only labor but also capital and land ownership are reallocated to out-of-region. Thus, compensation for capital and land flow out-of-region. It is assumed that immigrated households bring no factors other than labor into the region. The immigrated households with only labor compensation are assumed belong to the low-income household group. This assumption seems realistic for this study because the additional laborers are required mainly for the Hog Production, and Meat Packing sectors where low wages predominate.

When labor and capital are mobile, it is necessary to make adjustments to ensure that resource ownership of regional households is accounted precisely.

The proportion of out-migrated labor ($aLMIG_h$) to initial total labor supply by households ($\sum_h LS0_h$) is:

$$aLMIGH_h = \frac{\sqrt{LMIGH_h^{\ 2}} - LMIGH_h}{\sum_h LS0_h} * 0.5 \qquad (4.75)$$

Equation (4.77) operates as a conditional formula such that $aLMIGH_h = \frac{|LMIGH_h|}{\sum_h LS0_h}$ if labor out-migrates and $aLMIG_h = 0$ if labor in-migrates or does not migrates.

Similarly, the proportion of out-migrated capital ($aKMIG$) to total initial capital stock ($\sum_i KS0_i$) is:

$$aKMIG = \frac{\sqrt{KMIG^2} - KMIG}{\sum_h KS0_h} * 0.5 \qquad (4.76)$$

where $KMIG$ is migrated capital defined by equation (4.53).

Formula (4.76) operates similar to formula (4.75). That means it only accounts for out-migrated capital.

4.2.6.1. Regional Household Income

Household income consists of labor, capital, and land compensation; household share of enterprise income; and transfers from governments, share of income from investment, and rest-of-world remittances.

Regional Household Labor Income

Labor income of regional households in the new equilibrium stage (HLY_h) is defined for the original households remaining in the region at the new period. The amount of this income is the following:

$$HLY_h = \left(1 - \sum_g ltax_g\right) * PL * \left[LS0_h - \left(\sqrt{LMIGH_h^2} - LMIGH_h\right) * 0.5\right] \qquad (4.77)$$

where $LMIGH_h$ is out-migrated labor classified by income group.

If labor out-migrated, HLY_h calculated from (4.77) is net labor income of the households remaining in the region. If labor in-migrated, HLY_h accounts for net labor income of original households, only. It does not include income of in-migrated households.

Regional Household Capital Income

Initial stock owned by households is HK_h, from (4.58). If there is capital out-migration, the household share of capital income is calculated as follows:

$$HKY_h = (1 - aKMIG) * PK1 * HK_h + aKMIG * PKROW * HK_h \ . \qquad (4.78)$$

The first term of the right hand side is compensation for capital stock remaining in the region (evaluated by regional capital rent), and the second term is compensation for out-migrated capital stock (evaluated by out-of-region capital rent). The rational of this formula is that even though capital migrated out-of-region, the capital owners remain in the region.

If capital is in-migrated, the capital owners are out-of-region, so variable HK_h accounts for initial capital stock only. In this case capital migration adjustment variable ($aKMIG$) is equal to zero.

If labor and capital are simultaneously mobile, household capital income (HKY_h) is calculated as:

$$HKY_h = (1 - aLMIG_h) * \{(1 - aKMIG) * PK1 * HK_h + aKMIG * PKROW * HK_h\}. \tag{4.79}$$

Regional Household Enterprise Income

Enterprise income is proportional to the capital stock ownership equation (4.57). Therefore, when capital out-migrates the household enterprise income reduces proportionally. When labor and capital are mobile the regional household enterprise income is calculated as follows:

$$HENTY_h = (1 - aLMIGH_h) * (1 - aKMIG) * heshr_h * PK1 * ENTK \tag{4.80}$$

Regional Household Land Income

When households move out-of-region, their proportion of income from land flows out of the region. The land income of households remaining in the region is calculated as follows:

$$HTY_h = (1 - aLMIGH_h) * htshr_h * TY \tag{4.81}$$

Other Income of Regional Households

Household income from other sources is also adjusted as follows:

$$HOY_h = (1 - aLMIG_h) * \begin{pmatrix} \sum_i PX_i * HSELL_i + INV2H_h \\ + \sum_g GOV2H_{hg} + REMIT_h \end{pmatrix} \tag{4.82}$$

Gross Regional Household Income

Finally, Gross Regional Household Income ($GRHY_h$) is the sum of all sources of income and defined as:

$$GRHY_h = HLY_h + HKY_h + HENTY_h + HTY_h + HOY_h . \tag{4.83}$$

Regional Household Expenditure

Regional household expenditure is calculated similar to equation (4.76)

$$RHE_h = \left(1 - \sum_g htax_{hg} - hs_h\right) * GRHY_h . \tag{4.84}$$

4.2.6.2. Out-migrated Household Income

Out-migrated households take with them their share of labor, capital and land compensation.

The income of out-migrated households is as follows:

$$\begin{aligned} OMHY = PLROW * \left(\sqrt{LMIGH_h^2} - LMIGH_h\right) * 0.5 \\ + aLMIGH_h * \left(HKY_h + HENTY_h + HTY_h\right). \end{aligned} \tag{4.85}$$

4.2.6.3. In-migrated Household Income

Labor compensation is the only income associated with in-migrated households. Therefore, labor income is also a gross household income ($GIMHY$):

$$GIMHY = \left(1 - \sum_{g} ltax_g\right) * PL * \left(\sqrt{LMIG^2} - LMIG\right) * 0.5. \tag{4.86}$$

Similar to other household groups, expenditure of in-migrated households is as follows:

$$IMHE = (1 - htax - hs) * GIMHY. \tag{4.87}$$

4.3. MEASURES OF REGIONAL WELFARE

The purpose of CGE analysis is to measure the impact of policy or policy change on the region and household welfare. The often-used measures of regional welfare are Gross Regional Product (GRP), Regional Expenditure (RE), Compensating Variation (CV), and Equivalent Variation (EV).

GROSS REGIONAL PRODUCT

The Gross Regional Product (GRP) is the most comprehensive measure of regional change. This is the total payment to resources used in the regional production process as plus indirect business taxes paid to governments:

$$GRP = LY + KY + TY + \sum_{i} ibt_i * PR_i * X_i \tag{4.88}$$

where ibt_i is indirect business tax rates. Other terms are defined in other sections.

REGIONAL EXPENDITURE

The Regional Expenditure (RE) is defined as total expenditures of households, governments, businesses for capital formation, and inventory:

$$RE = \sum_h HE_h + \sum_i P_i * QX_i . \quad (4.89)$$

Revenue from exports is excluded but expenditures for imports included. The premise is that expenditure on goods and services is a measure of welfare.

HOUSEHOLD INCOME

Household income is a widely used measure of household welfare. After the policy change there are three groups of households classified as (1) initial regional households remaining in the region, (2) initial regional households migrating out-of-region, and (3) in-migrated households to the region. Income of these groups are measured by equations (4.84), (4.85), and (4.86), respectively.

Implementing policy changes the economy from one situation to another. Compensating Variation (CV) and Equivalent Variation (EV) are two widely accepted measures of the change of individual preferences between two situations (Schreiner et al., 1999).

COMPENSATING VARIATION (CV)

Compensating Variation (CV) is the amount of money which, when taken away from an individual after an economic change, leaves the person just as well off as before. CV is based on the new prices. CV of household group h is calculated as follows:

$$CV_h = HE_h^1 - HE_h^0 * \prod_i \left(\frac{P_i^1}{P_i^0} \right)^{\beta_{ih}} \tag{4.90}$$

where HE_h^1 is the new household expenditure, HE_h^0 is the initial household expenditure, P_i^1 is the new composite price for commodity i, P_i^0 is the initial composite price for commodity i, β_{ih} is the budget share for commodity i.

EQUIVALENT VARIATION (EV)

Equivalent Variation (EV) is amount of money, which when given to the individual, if an economic change does not happen, makes the individual just as well off as if the change had occurred:

$$EV_h = HE_h^1 * \prod_i \left(\frac{P_i^0}{P_i^1} \right)^{\beta_{ih}} - HE_h^0 \tag{4.91}$$

all terms are as defined for equation (4.90).

4.4. IMPLEMENTING THE CGE MODEL

The CGE model begins with the Social Accounting Matrix (SAM) as data for the initial equilibrium. The data in SAM are measured in monetary units. All prices at the initial stage are set equal to one, therefore the quantity measures are equal to their monetary values. The structure of SAM was described in chapter 3.

Behavior of the economy agents was discussed in section 4.3, and transformed into equations. In other words, these equations describe the activities of economic agents. The CGE model is a set of simultaneous equations (Robinson et al., 190) that incorporate all of the function of the model. The CGE model also includes equations that account for incomes and expenditures of institutions. Solutions to the simultaneous equation system are equilibrium prices and quantities for all markets in the economy.

4.4.1. EQUATIONS OF THE CGE MODEL

This section summarizes equations that are included in the CGE model. Table 4.1 lists the indices used in equations of CGE model. Table 4.2 lists the endogenous variables. Table 4.3 lists the exogenous variables. Table 4.4 lists the parameters. The endogenous variables are named by capital letters while the exogenous variables are named by capital letters and ended by number zero. The names of parameters are all lower letters.

TABLE 4.1 DEFINITIONS OF INDICES USED IN THE CGE MODEL

Indices	Definition
i, j	Industrial sectors
cr	Crop sectors
ncr	Non-crop sectors. $cr+ncr=i$
f	Factor of production: labor, capital, land
fl	Factor of production w/o land
f	Institutions
f	Governments: Federal, state and local
f	Household groups: Low, Med, Hig
h_l	Low-income household. $h_l + h_{mh} = h$
h_{mh}	Medium and High income household

TABLE 4.2 DEFINITIONS OF ENDOGENOUS VARIABLES

Variable	Description	Number of variables
Production block		
X_i	Industry output	11
LAB_i	Labor demand	11
CAP_i	Capital demand	11
$LAND_{cr}$	Land demand	2
VA_i	Value added	11
INT_{ji}	Composite intermediate inputs	121
$INTR_{ji}$	Regionally produced intermediate inputs	121
$INTM_{ji}$	Imported intermediate inputs	121
E_i	Exported regional commodity	11
R_i	Regionally produced and consumed commodity	11
Commodity markets		
Q_{ih}	Composite commodity consumed by households	33
QR_{ih}	Regional commodity consumed by households	33
QM_{ih}	Imported commodity consumed by households	33
$QGOV_{ig}$	Composite commodity consumed by governments	22
$QGOVR_{ig}$	Regional commodity consumed by governments	22
$QGOVM_{ig}$	Imported commodity consumed by governments	22

TABLE 4.2 DEFINITIONS OF ENDOGENOUS VARIABLES

(CONTINUED)

Variable	Description	Number of variables
$QINV_i$	Composite investment commodity	11
$QINVR_i$	Regional investment commodity	11
$QINVM_i$	Imported investment commodity	11
$QINVT_i$	Inventory commodity	11
M_i	Imported commodity	11
Factor markets		
$LMIG$	Migrated labor	1
$LMIGH_h$	Migrated labor by household group	3
$aLMIGH_h$	Adjustment factor for out-migrated labor	3
LY	Labor income	1
$KMIG$	Migrated capital	1
$aKMIG$	Adjustment factor for out-migrated capital	1
$adjK$	Adjustment factor for migrated capital	1
KY	Capital income	1
TY	Land income	1
Institutional Accounts		
$ENTK$	Enterprise capital stock	1
$ENTY$	Enterprise income	1
$HENTY_h$	Household enterprise income	3
HKY_h	Household capital income	3

TABLE 4.2 DEFINITIONS OF ENDOGENOUS VARIABLES

(CONTINUED)

Variable	Description	Number of variables
HLY_h	Household labor income	3
$IMHLY$	In-migrated household labor income	1
HTY_h	Household land income	3
HOY_h	Other household income	3
GHY_h	Gross household income	3
HE_h	Household expenditure	3
SAV	Saving	1
$GOVR_g$	Government Revenue	2
$INVEST$	Investment	1
$RGRP$	Real Gross Regional Product	1
$GOVSAV_g$	Government saving	2
$ROWSAV$	Saving from rest-of-world	1
$K2ROW$	Capital compensation to rest-of-world	1
Prices		
PN_i	Net price (Value-added price)	11
P_i	Price of composite commodity	11
PX_i	Output price	11
PR_i	Regional price	11
PL	Wage rate	1
PK_i	Capital rent for each sector (in the short-run)	11
$PK1$	Overall capital rent	1
PKL	Capital rent in the long-run	1
PT_{cr}	Land rent	2

TABLE 4.3 DEFINITIONS OF EXOGENOUS VARIABLES

Variable	Description	Number of variables
$QGOV0_{ig}$	Composite commodity consumed by government	22
$QINV0_i$	Composite investment commodity	11
$LS0_h$	Initial labor supply	3
$KS0_i$	Initial capital supply	11
$ENTK0$	Initial enterprise capital stock	1
$HK0_h$	Initial household capital stock	3
$INV2H0_h$	Household income from investment	3
$HSELL0_{hi}$	Household commodity sales	33
$GOV2H0_{hg}$	Government transfer to household	6
$REMIT0_h$	Household remittance from rest-of-world	3
$INSTSELL0_i$	Institutional commodity sales	11
$GOVSELL0_{gi}$	Government commodity sales	22
$CAPSELL0_i$	Commodity sales by capital account	11
$GOV2GOV0_{gg}$	Government to government transfer	4
$ROW2GOV0_g$	ROW to government	2
$ROW2INVT0$	ROW to inventory	1
$PE0_i$	Export price	11
$PM0_i$	Import price	11
$PLROW0$	Out-of-region wage rate	1
$PKROW0$	Out-of-region capital rent	1

TABLE 4.4 DEFINITIONS OF PARAMETERS

Parameters	Description	Number of variables
α_i^L	Labor share in CD function	11
α_i^K	Capital share in CD function	11
α_{cr}^T	Land share in CD function	2
Φ_i^{VA}	Shift parameter in CD function	11
a_{0i}	Value-added coefficient in Leontief function	11
a_{ji}	Intermediate input coefficient in Leontief function	121
Φ_{ji}^{INT}	Shift parameter in CES function for intermediate input	121
δ_{ji}^{INT}	Share parameter in CES function for intermediate input	121
ρ_j^{INT}	Elasticity parameter in CES function for intermediate input	11
Φ_i^X	Shift parameter in CET function for output	11
δ_i^X	Share parameter in CET function for output	11
ρ_i^X	Elasticity parameter in CET function for output	11
β_{ih}	Commodity budget share	33
Φ_{ih}^Q	Shift parameter in CES func. for comm. consumed by hh	33
δ_{ih}^Q	Share parameter in CES fun. for comm. consumed by hh	33
ρ_{ih}^Q	Elasticity parameter in CES func. for comm. consumed by hh	33
Φ_{ig}^{GOV}	Shift parameter in CES func. for comm. consumed by gov.	22
δ_{ig}^{GOV}	Share para in CES func. for comm. consumed by government	22
ρ_{ig}^{GOV}	Elasticity para in CES func. for comm. consumed by gov	22

TABLE 4.4 DEFINITIONS OF PARAMETERS

(CONTINUED)

Parameters	Description	Number of variables
Φ_i^{INV}	Shift parameter in CES func. for invest. commodity	11
δ_i^{INV}	Share parameter in CES func. for invest. commodity	11
ρ_i^{INV}	Elasticity parameter in CES func. for invest. commodity	11
$invtexr$	Inventory expenditure rate	1
ε^L	Labor migration elasticity	1
$ldist_h$	Proportion of labor supply by household group	3
ε^K	Capital migration elasticity	1
$entkshr$	Enterprise share of capital	1
$heshr$	Household share of enterprise capital	2
$ltax_g$	Labor tax	2
$htshr_h$	Household share of land income	2
$htax_{gh}$	Household tax	6
hs_h	Household saving rate	3
$capkshr$	Capital account share of capital	1
$ceshr$	Capital account share of enterprise income	1
$ktax_g$	Capital tax rate	2
$ttax_g$	Land tax rate	2
$ibt2gov_g$	Government share of indirect business tax	2
$ibtax_i$	Indirect business tax rate	11
$etax_g$	Enterprise tax rate	2
$invtax_g$	Investment tax rate	2

The values of exogenous variables are assigned to the initial corresponding values in the SAM and do not change during the simulation process. Almost all of the values of parameters are be calculated based on data of SAM. This calculating process is called calibration. The estimated values of elasticities of substitution obtained from other research are used in addition to SAM data to calibrate parameters of CES and CET functions. The set of simultaneous equations of the CGE model is listed from Tables 4.5 to 4.10.

Equations of Production Block

Table 4.5 gives equations corresponding with sectors production. Equations with indices are actually blocks of equations that include number of equations equal to the number of elements of the corresponding index. For instance, equation 1 goes with index i (industrial sector), consists of 11 (number of industrial sectors) equations. The last column lists the number of equations of each "block of equations".

Equations 1-4 are optimal factors levels derived from first order conditions of profit maximization problem. These equations identify the optimal amounts of primary factor inputs used in the production process in order to maximize producers' profit. Equation 2a is the optimal level of capital in the short-run when capital is fixed in each sector and therefore capital rents are different between sector. In the long-run capital is mobile within sector until capital rent is equal across sectors. The optimal capital level for this case is equation 2b. Equation 3 describes the optimal level of land. This equation is applied only for crop sectors (Feed Grains, and Other Crops) because these are the only two sectors using land as an input.

TABLE 4.5 EQUATIONS OF PRODUCTION BLOCK

	Equation	No. of equation
1	$LAB_i = \frac{\alpha_i^L * PN_i * X_i}{PL}$	11
2a	$CAP_i = \frac{\alpha_i^K * PN_i * X_i}{PK_i}$ (for the short-run)	11
2b	$CAP_i = \frac{\alpha_i^K * PN_i * X_i}{PKL}$ (for the long-run)	11
3	$LAND_{cr} = \frac{\alpha_{cr}^T * PN_{cr} * X_{cr}}{PT_{cr}}$	2
4a	$VA_{ncr} = \Phi_{ncr}^{VA} * LAB_{ncr}^{\alpha_{ncr}^L} * CAP_{ncr}^{\alpha_{ncr}^K}$	9
4b	$VA_{cr} = \Phi_{cr}^{VA} * LAB_{cr}^{\alpha_{cr}^L} * CAP_{cr}^{\alpha_{cr}^K} * LAND_{cr}^{\alpha_{cr}^T}$	2
5	$VA_i = a_{0i} X_i$	11
6	$INT_{ji} = a_{ji} X_i$	121
7	$INT_{ji} = \Phi_{ji}^{INT} \left[\delta_{ji}^{INT} INTM_{ji}^{-\rho_j^{INT}} + (1-\delta_{ji}^{INT}) INTR_{ji}^{-\rho_j^{INT}} \right]^{-\frac{1}{\rho_j^{INT}}}$	121
8	$INTM_{ji} = INTR_{ji} \left[\frac{1-\delta_{ji}^{INT}}{\delta_{ji}^{INT}} * \frac{PM_j}{PR_j} \right]^{-\frac{1}{1+\rho_j^{INT}}}$	121
9	$X_i = \Phi_i^X \left[\delta_i^X E_i^{\rho_i^X} + (1-\delta_i^X) R_i^{\rho_i^X} \right]^{\frac{1}{\rho_i^X}}$	11
10	$E_i = R_i \left(\frac{1-\delta_i^X}{\delta_i^X} * \frac{PE_i}{PR_i} \right)^{\frac{1}{\rho_i^X - 1}}$	11

Equation 4 is the Cobb-Douglas production function for value added. This is a production function for the second level of the production process. This equation is divided by two cases: 4a for non-crop sectors, and 4b for crop sectors. The Cobb-Douglas function is a special case of the CES function. Following the Cobb-Douglas relationship, the elasticity of substitution among inputs is constant and equal to unity.

Equation 5 defines the relationship of value-added to output in the first level. This relationship follows the Leontief technology that is the level of value-added is a fixed proportion of output. Similarly, equation 6 defines the Leontief relationship between composite intermediate input and output. Level of intermediate input is also a fixed proportion of output.

Equation 7 defines the CES relationship between regional and imported intermediate input. Equation 8 identifies the optimal ratio of imported to regional intermediate input that minimizes composite input cost. This ratio depends on the ratio of import price (PM) to regional commodity price (PR) and on the parameters of the CES function.

Equations 9 and 10 define the components of output for regional market and export market. The level of output sold in the regional market (R) and the export market (E) follow the CET relationship defined by equation 9. Equation 10 identifies the relationship between R and E that maximizes producer revenue.

Equations of Commodity Markets

Table 4.6 lists equations defining behavior of households and other institutional agents in commodity consumption. Final demand for composite commodity consists of regional commodity and imported commodity. The levels of two sources of commodity follow the CES relationship.

Equations 11 to 13 identify commodity demand by household. Equation 11 is the simple LES household demand function for final goods based on the Stone-Geary utility function and subject to household expenditure (*HE*) constraint. Equation 12 and 13 identify optimal quantities of regional commodity and imported commodity that minimizes expenditure.

Government final demand for commodity is exogenous and equal to initial quantity (equation 14). Commodity demanded by investment is proportionate to capital demanded. This quantity is identified by equation 17. Quantity used for inventory is at fixed proportion of industry output (equation 20).

Another source of demand in commodity markets is demand for intermediate inputs from producers, which were defined by equations 6, 7 and 8 in Table 4.5. Aggregated imported commodity is defined by equation 21.

TABLE 4.6 EQUATIONS OF COMMODITY MARKETS

	Equation	No. of equation
11	$Q_{ih} = \beta_{ih} \dfrac{HE_h}{P_i}$	33
12	$Q_{ih} = \Phi_{ih}^{Q}\left[\delta_{ih}^{Q} QM_{ih}^{-\rho_i^h} + (1-\delta_{ih}^{Q}) QR_{ih}^{-\rho_i^Q}\right]^{-\frac{1}{\rho_i^Q}}$	33
13	$QM_{ih} = QR_{ih}\left[\dfrac{1-\delta_{ih}^{Q}}{\delta_{ih}^{Q}} * \dfrac{PM_i}{PR_i}\right]^{-\frac{1}{1+\rho_i^Q}}$	33
14	$QGOV_{ig} = QGOV0_{ig}$	22
15	$QGOV_{ig} = \Phi_{ig}^{QGOV}\left[\delta_{ig}^{GOV} GOVM_{ig}^{-\rho_i^{GOV}} + (1-\delta_{ig}^{GOV}) GOVR_{ig}^{-\rho_i^{GOV}}\right]^{-\frac{1}{\rho_i^{GOV}}}$	22
16	$QGOVM_{ig} = QGOVR_{ig}\left[\dfrac{1-\delta_{ig}^{GOV}}{\delta_{ig}^{GOV}} * \dfrac{PM_i}{PR_i}\right]^{-\frac{1}{1+\rho_i^{GOV}}}$	22
17	$QINV_i = adjK * QINV0_i$	11
18	$QINV_i = \Phi_i^{INV}\left[\delta_i^{INV} QINVM_i^{-\rho_i^{INV}} + (1-\delta_i^{INV}) QINVR_i^{-\rho_i^{INV}}\right]^{-\frac{1}{\rho_i^{INV}}}$	11
19	$QINVM_i = QINVR_i\left[\dfrac{1-\delta_i^{INV}}{\delta_i^{INV}} * \dfrac{PM_i}{PR_i}\right]^{-\frac{1}{1+\rho_i^{INV}}}$	11
20	$QINVT_i = invtexr * X_i$	11
21	$M_i = \sum_j INTM_{ij} + \sum_h QM_{ih} + \sum_g QGOVM_{ig} + QINVM_i$	11

Equations of Factor Markets

Table 4.7 lists the equations that describe the supply of primary factors of production and their corresponding income. Equation 22 identifies labor migration. Proportions of out-migration between household incomes groups are assume equal to the proportions of initial labor supply by these groups. Equation 23 classifies migrated labor into household-income groups. Equation 24 calculates the ratio of out-migrated labor to total initial labor supply. Notice that this ratio keeps track of out-migrated labor only.

Equations 26-27 account for capital migration. Capital migration is equal to zero in the short-run (equation 26a). In the long-run capital migration is identified by equation 26b. Similar to labor migration, equation 27 calculates the proportion of out-migrated capital to total initial capital supply. The proportion of new total capital supply to the initial total capital supply ($adjK$) is calculated by equation 28. This variable ($adjK$) is used to calculate the commodity demanded by investment (equation 17 in Table 4.6). Again, calculation of capital income is separated into two cases. In the short-run, capital income is calculated based on individual capital rent of each sector (equation 29a). In the long-run, capital income is calculated base on the overall capital rent (equation 29a).

Land income is calculated by equation 30 that is the sum of the quantity of land used by crop sector multiplied by the corresponding land rent. Notice that land rents are different between sectors because land is immobile.

TABLE 4.7 EQUATIONS OF FACTOR MARKETS

	Equation	No. of equation
22	$LMIG = LS0 * \varepsilon^L \log\left(\frac{PL}{PLROW0}\right)$	1
23	$LMIGH_h = ldist_h * LMIG$	3
24	$aLMIGH_h = \frac{\sqrt{LMIGH_h^2} - LMIGH_h}{\sum_h LS0_h} * 0.5$	3
25	$LY = PL * \left(\sum_i LAB_i + \sum_h LDH0_h + \sum_g LDG0_g\right)$	1
26a	$KMIG = 0$ (for the short-run)	1
26b	$KMIG = \sum_i KS0_i * \varepsilon^K * \log\left(\frac{PKL}{PKROW0}\right)$ (for the long-run)	1
27	$aKMIG = \frac{\sqrt{KMIG^2} - KMIG}{\sum_h KS0_h} * 0.5$	1
28	$adjK = \frac{\left(\sum_i KS0_i + KMIG\right)}{\sum_i KS0_i}$	1
29a	$KY = \sum_i PK_i * CAP_i$ (for the short-run)	1
29b	$KY = PKL * \sum_i CAP_i$ (for the long-run)	1
30	$TY = \sum_{cr} PT_{cr} * LAND_{cr}$	1

Equations of Institutional Accounts

This part of the model captures the distribution of factor compensations into the institutional accounts under factor mobility. Equations used to calculate the institutional accounts are listed in Table 4.8.

Notice that the term "household" used from equations 33 to 38 is identical with the initial regional households that still reside in the region. These equations do not include in-migrated households.

Equations 31 and 32 calculate enterprise capital stock and enterprise income. These calculations are based on the total current capital used by the industrial sectors. These values are used to calculate the enterprise tax to governments and retained earnings going to the saving account. Enterprise tax and retained earning are proportionate to enterprise income.

The household share of enterprise income is based on the initial proportion but is adjusted for labor and capital out-migration (equation 33). Even though capital may migrated out-of-region, the capital ownership is assumed to remained in the region. Therefore, income compensation from out-migrated capital remains in the regions with the initial owner. The ownership of in-migrated capital belongs to people out-of-region, therefore, it is not counted as regional household income. Equation 34 calculates household capital income adjusted for labor and capital migration. Equations 35, 37, and 38 calculate household labor income, household land income, and other household income, respectively. The rational for the above calculations was discussed in section 4.2.6.1.

TABLE 4.8 EQUATIONS OF INSTITUTIONAL ACCOUNTS

	Equation	No. of equation
31	$ENTK = entkshr * \sum_i CAP_i$	1
32	$ENTY = PK1 * ENTK$	1
33	$HENTY_h = (1 - aLMIGH_h) * (1 - aKMIG) * heshr_h * PK1 * ENTK0$	3
34	$HKY_h = (1 - aKMIG) * PK1 * HK0_h + aKMIG * PKROW * HK0_h$	3
35	$HLY_h = \left(1 - \sum_g ltax_g\right) * PL * \left[LS0_h - \left(\sqrt{LMIGH_h^2} - LMIGH_h\right) * 0.5\right]$	3
36	$IMHLY = \left(1 - \sum_g ltax_g\right) * PL * \left(\sqrt{LMIG^2} - LMIG\right) * 0.5$	1
37	$HTY_h = (1 - aLMIGH_h) * htshr_h * TY$	3
38	$HOY_h = (1 - aLMIG_h) * \left(\begin{array}{l} INV2HH0_h + \sum_g GOV2HH0_{hg} \\ + REMIT0_h + \sum_i PX_i * HSEL0_i \end{array}\right)$	3
39a	$GHY_{h_l} = HLY_{h_l} + IMHLY + HKY_{h_l} + HENTY_{h_l} + HTY_{h_l} + HOY_{h_l}$	1
39b	$GHY_{h_{ml}} = HLY_{h_{ml}} + HKY_{h_{ml}} + HENTY_{h_{ml}} + HTY_{h_{ml}} + HOY_{h_{ml}}$	2
40	$HE_h = \left(1 - \sum_g htax_{hg} - hs_h\right) * GHY_h - (1 - aLMIGH_h) * PL * LH0_h$	3
41	$SAV = \sum_i PX_i * CAPSELL0_i + capkshr * KY + hs_h * GHY_h + \sum_g GOVSAV_g + ceshr * ENTY + ROWSAV$	1

TABLE 4.8 EQUATIONS OF INSTITUTIONAL ACCOUNTS

(CONTINUE)

Equation		No. of equation
42	$GOVR_g = \sum_i GOVSELL0_{gi} + ltax_g * LY + ktax_g * KY + ttax_g * TY + ibt2gov_g * \sum_i (ibtax_i * PX_i * X_i) + \sum_h (htax_{gh} * GHY_h) + \sum_{g_1} GOV2GOV_{gg_1} + etax_g * ENTY + invtax_g * INVEST + ROW2GOV0_g$	2
43	$\left(1 - \sum_g invtax_g - cap2invtr\right) * INVEST = \sum P_i * QINV_i + \sum_h (1 - aLMIGH_h) * INV2H0_h$	1
44	$RGRP = \sum_i \left(\sum_h Q_{ih} + \sum_g QGOV_{ig} + QINV_i + QINVT_i + E_i - M_i \right)$	1

Gross household income (equation 39) is the sum of all sources of household income (calculated by equations 33 to 38, except for equation 36). Labor income is the only income of in-migrated households and calculated by equation 36. In-migrated households were assigned to the low-income group. Therefore, labor income of in-migrated households is added to gross household income of the low-income group (equation 39a). Household expenditure is the remainder of gross household income after deducting household tax, saving and pay for labor used by household. This amount is used to purchase final goods (equation 11).

Saving account is calculated by equation 41. Government revenue is calculated by equation 42. Total expense for investment is calculated by equation 43. Real Gross

Regional Product (RGRP) is defined as total quantity of commodities traded in regional market plus exported commodity net of import quantity (equation 44). RGRP will be used as the objective function of the CGE model. The solution of the model is to maximize the value of RGRP.

Price Equations

Commodity prices are defined is set by the interaction between demand and supply to clear commodity markets. Similarly, rents of primary factor inputs are set by the interaction between demand and supply of factors to clear factor markets.

TABLE 4.9 PRICE EQUATIONS

	Equation		No. of equation
45	$PN_i = \left(1 - \sum_j a_{ji} P_j - ibt_i\right) * PX_i$		11
46	$P_i = \dfrac{PR_i * (R_i + INSTSELL0_i) + PM0_i * M_i}{R_i + INSTSELL0_i + M_i}$		11
47	$PX_i = \dfrac{PR_i * R_i + PE0_i * E_i}{R_i + E_i}$		11
48a	$PK1 = \dfrac{\sum_i PK_i * CAP_i}{\sum_i CAP_i}$	(for the short-run)	1
48b	$PK1 = PKL$	(for the long-run)	1

Price equations of composite commodities and outputs are listed in Table 4.9. Equation 45 calculates the net price of output. Composite commodity price (P) is calculated by equation 46. It is the weighted average price of regionally produced and imported commodities. Similarly, composite output price (*PX*) is the weighted average price of regionally sold and exported output that is calculated by equation 47. Equation 48a calculates overall capital rent (*PK1*) in the short-run. Equation 48b calculates overall capital rent (*PK1*) in the long-run.

Equilibrium Equations

Table 4.10 lists equations to bring the system into equilibrium status. Equation 49 equilibrates supply and demand of commodity markets. Equations 50-52 are equilibrium equations of factor markets.

Equations 53-55 capture the three major macro balances: Government deficit, saving-investment, and balance of trade, respectively. In equation 53 the variable $GOVSAV_g$ plays the equilibrating role. The difference between government revenue and government expenditure captured by this variable. Equation 54 equates saving and investment. The equilibrating variable for this equation is $ROWSAV$ in the saving equation (equation 41 in Table 4.8). Regional balance of payment is shown by equation 55.

TABLE 4.10 EQUILIBRIUM EQUATIONS

	Equation	No. of equation
49	$X_i + M_i + INSTSELL0_i = \sum_j INT_{ij} + \sum_h Q_{ih} + \sum_g QGOV_{ig} + QINV_i + QINVT_i + E_i$	11
50	$\sum_i LAB_i + \sum_h LH0_h + \sum_g LGOV0_g = \sum_h LS0_h + LMIG$	1
51a	$CAP_i = KS0_i$ (for the short-run)	11
51b	$\sum_i CAP_i = \sum_i KS0_i + KMIG$ (for the long-run)	1
52	$LAND_{cr} = T0_{cr}$	2
53	$GOVR_g = \sum_i P_i * QGOV0_i + PL * LGOV0_g + \sum_{g_1} GOV2GOV0_{g_1g} + \sum_h (1 - aLMIGH_h) * GOV2HH0_{hg} + GOVSAV_g$	2
54	$SAV = INVEST$	1
55	$\sum_i PM0_i * M_i + K2ROW = \sum_i PE0_i * E_i + \sum_h REMIT0_h + \sum_g ROW2GOV0_g + ROWSAV + ROWINVT0$	1

Counting Equations and Variables

The CGE model is seen as a set of simultaneous nonlinear equations. To ensure the existence of a solution and that solution is unique the number of equations should equal the number of endogenous variables.

Counting the number of variables listed in Table 4.2 yields 757 variables for the short-run and 747 variables for the long-run. The difference in the number of variables between the two production periods is caused by how capital rents are determined. In the short-run, capital rents are determined for each production sector (11 variables). In the long-run, capital rent is equated to the overall rent (1 variable). Counting number of equations listed from Tables 4.5 to 4.10 yields 757 equations in the short-run and 747 equations in the long-run. In the short-run, equation 51a (consisting of 11 equations) is employed to ensure capital in each production sector is fixed. In the long-run equation 51b (consisting of one equation) is employed to ensure the condition that total capital demanded equals to total capital supplied and allows capital to be mobile between sectors. The different number of variables in equations 51a and 51b causes the difference in total number of equations in the short-run versus long-run CGE model.

4.4.2. CALIBRATION OF THE CGE MODEL PARAMETERS

Parameters described are section 4.4.1 (Table 4.4) are calculated directly from a SAM or taken from other studies. This calculation process is called calibration. The calibration is not a statistical process because it is based on "single value" data. The calibration is based on the SAM of Texas County 1993 plus additional values of elasticity of substitution from de Melo and Tarr (1992).

In calibrating the CGE model the base year of the model (1993) is used. The quantity units are defined so that all prices for the base year are equal to one. Therefore, the flows in SAM are measured in nominal magnitudes that are equal to real magnitudes. Given the base-year value for the variables, the parameters are derived by solving equations in reverse (Robinson et al., 1990).

4.4.2.1. Production Functions

Rearranging equation 4.2 yields parameters of the Leontief function:

$$a_{oi} = \frac{VA_i}{X_i}, \text{ and } a_{ji} = \frac{INT_{ji}}{X_i}. \tag{4.92}$$

Values of these parameters are calibrated by using data in SAM. X_i is the value of total industry output (TIO) in the second column of Table 3.7; VA_i (value added) is total of the last 3 columns of Table 3.9; INT_{ji} is the sum of the corresponding upper and lower parts of Table 3.8. Results of the calibrated parameters are presented in Table 4.11.

Formulas to calibrate parameters of the Cobb-Douglas production function are obtained by rearranging the functions of optimal level of primary factors (labor, capital, and land) (equations 4.10, 4.11, and 4.12, respectively).

$$\alpha_i^L = \frac{PL_i * LAB_i}{PN_i * X_i} \tag{4.93}$$

$$\alpha_i^K = \frac{PK_i * CAP_i}{PN_i * X_i} \tag{4.94}$$

$$\alpha_i^T = \frac{PT_i * LAND_i}{PN_i * X_i} \tag{4.95}$$

Similarly, rearranging equations (4.5) and (4.3) to calibrate Φ_i^X, and Φ_i^{VA} efficiency parameter of the Cobb-Douglas function:

$$\Phi_i^X = \frac{X_i}{LAB_i^{\alpha_i^L} * CAP_i^{\alpha_i^K} * LAND_i^{\alpha_i^T}} \tag{4.96}$$

$$\Phi_i^{VA} = \frac{VA_i}{LAB_i^{\alpha_i^L} * CAP_i^{\alpha_i^K} * LAND_i^{\alpha_i^T}} \tag{4.97}$$

TABLE 4.11 CALIBRATED PARAMETERS OF THE LEONTIEF PRODUCTION FUNCTIONS

Commodity (j)	Industry (i)										
	Hog Prod	Other Livestock	Feed Grains	Other Crops	Oil & Gas	Construct.	Meat Pack.	Prep Feeds	Other Prep. Foods	Other Manuf	Services
a_{oi}	0.027	0.079	0.121	0.072	0.409	0.295	0.088	0.092	0.345	0.276	0.586
a_{ji}											
Hog Prod	0.251	0.000	0.002	0.001	0.000	0.000	0.772	0.000	0.000	0.000	0.000
Other Livestock	0.003	0.115	0.039	0.015	0.000	0.000	0.000	0.000	0.087	0.000	0.000
Feed Grains	0.163	0.164	0.043	0.000	0.000	0.000	0.000	0.105	0.006	0.000	0.000
Other Crops	0.116	0.148	0.030	0.077	0.000	0.000	0.000	0.077	0.069	0.006	0.001
Oil & Gas	0.008	0.004	0.025	0.021	0.401	0.038	0.003	0.005	0.005	0.021	0.007
Construction	0.017	0.022	0.060	0.051	0.017	0.005	0.002	0.004	0.011	0.030	0.042
Meat Packing	0.000	0.001	0.000	0.000	0.000	0.000	0.014	0.000	0.027	0.001	0.001
Prepared Feeds	0.098	0.173	0.000	0.007	0.000	0.000	0.000	0.054	0.000	0.000	0.000
Other Pre Foods	0.011	0.023	0.000	0.004	0.000	0.000	0.003	0.291	0.164	0.001	0.009
Other Manuf.	0.033	0.039	0.279	0.230	0.048	0.317	0.021	0.143	0.124	0.465	0.046
Services	0.267	0.221	0.380	0.511	0.089	0.343	0.089	0.222	0.157	0.191	0.221
$\sum_j a_{ji}$	0.969	0.911	0.858	0.917	0.555	0.703	0.904	0.902	0.651	0.714	0.327

a_{oi} is I-O coefficient of value-added, a_{ji} is I-O coefficient of intermediate input

Notice that:

(1) PN_i is the value of one unit of output to compensate for value-added (see section 4.6). Therefore, $PN_i * X_i$ is identical with VA_i, and

(2) All prices (except net-price) are equal to one at initial equilibrium. Therefore, α's are calibrated, simply, by dividing the value of each primary factor by total value added. Data for this calibration is from the last three columns of Table 3.9. The numerators are the values of each column and the denominator is the sum of the three columns. Table 4.12 presents results of calibration.

TABLE 4.12 CALIBRATED PARAMETERS OF THE COBB-DOUGLAS PRODUCTION FUNCTION

Industry (i)	Parameters				
	α_i^L	α_i^K	α_i^T	Φ_i^X	Φ_i^{VA}
Hogs Products	0.005	0.995		38.301	1.033
Other Livestock	0.005	0.995		13.131	1.033
Feed Grains	0.002	0.188	0.810	13.519	1.641
Other Crops	0.002	0.188	0.810	22.754	1.641
Oil Gas and Products	0.474	0.526		4.881	1.997
Construction	0.563	0.437		6.729	1.984
Meat Packing Plants	0.850	0.150		17.321	1.525
Prepared Feeds	0.769	0.231		18.668	1.717
Other Prepared Foods	0.511	0.489		5.790	2.000
Other Manufacturing	0.895	0.105		5.073	1.398
Services	0.656	0.344		3.248	1.903

To calibrate parameters of the CES function (4.13), data from the SAM and an estimate of the elasticity of substitution, σ_j^V, are needed.

The substitution parameter, ρ_j^V, is calculated directly from equation (4.20):

$$\rho_j^V = 1 - \frac{1}{\sigma_j^V} \tag{4.98}$$

Equation (4.25) is used to calibrate the share parameter, δ_{ji}^V, as:

$$\delta_{ji}^V = \left[1 + \frac{PM_j}{PR_j} * \left(\frac{INTR_{ji}}{INTM_{ji}} \right)^{1+\rho_j^V} \right]^{-1} . \tag{4.99}$$

because PM_j and PR_j are equal to one at initial equilibrium, equation (4.99) becomes:

$$\delta_{ji}^V = \left[1 + \left(\frac{INTM_{ji}}{INTR_{ji}} \right)^{1+\rho_j^V} \right]^{-1} \tag{4.100}$$

The efficiency parameter is calibrated by rearranging equation (4.21):

$$\Phi_{ji}^V = \frac{INT_{ji}}{\left[\delta_{ji}^V INTM_{ji}^{-\rho_j^V} + (1 - \delta_{ji}^V) INTR_{ji}^{-\rho_j^V} \right]^{-\frac{1}{\rho_j^V}}} \tag{4.103}$$

Elasticity of substitution parameters were obtained from de Melo and Tarr (1992), and $INTR_{ji}$ and $INTM_{ji}$ are from the SAM (Table 3.8.) Results of calibration are presented in Table 4.13.

TABLE 4.13 CALIBRATED PARAMETERS OF CES FUNCTIONS FOR INTERMEDIATE INPUTS

Industry (i)	Commodity (j)										
	Hog Prod	Other Lives-tock	Feed Grains	Other Crops	Oil & Gas	Cons-truct.	Meat Pack.	Prep Feeds	Other Prep. Foods	Other Manuf	Ser-vices
σ_j	1.42	1.42	1.42	1.42	0.50	0.50	3.55	3.55	3.55	3.55	2.00
ρ_j	-0.30	-0.30	-0.30	-0.30	1.00	1.00	-0.72	-0.72	-0.72	-0.72	-0.50
Share parameters (δ^V_{ji})											
Hog Prod	0.083	0.103	0.571	0.571	0.012	0.500	0.333	0.729	0.769	0.638	0.000
Other Livestock	0.000	0.077	0.834	0.913	0.049	0.031	0.543	0.781	0.857	0.624	0.498
Feed Grains	0.058	0.077	0.834	0.913	0.049	0.031	0.000	0.000	0.000	0.624	0.498
Other Crops	0.058	0.077	0.000	0.913	0.049	0.031	0.000	0.780	0.857	0.624	0.498
Oil & Gas	0.000	0.000	0.000	0.000	0.049	0.031	0.543	0.000	0.858	0.624	0.498
Cons-truction	0.000	0.000	0.000	0.000	0.049	0.031	0.000	0.000	0.000	0.624	0.498
Meat Packing	0.355	0.355	0.000	0.000	0.012	0.988	0.000	0.000	0.769	0.638	0.000
Prepared Feeds	0.000	0.103	0.877	0.891	0.813	0.000	0.333	0.729	0.769	0.638	0.546
Other Pre Foods	0.058	0.077	0.834	0.913	0.049	0.031	0.543	0.000	0.857	0.624	0.498
Other Manuf.	0.055	0.078	0.000	0.913	0.049	0.031	0.543	0.754	0.857	0.624	0.498
Services	0.059	0.077	0.000	0.913	0.049	0.031	0.543	0.780	0.857	0.624	0.498

TABLE 4.13 CALIBRATED PARAMETERS OF CES FUNCTIONS FOR INTERMEDIATE INPUTS (CONTINUED)

Industry (i)	Commodity (j)										
	Hog Prod	Other Lives-tock	Feed Grains	Other Crops	Oil & Gas	Cons-truct.	Meat Pack.	Prep Feeds	Other Prep. Foods	Other Manuf	Ser-vices
Efficiency parameters (Φ^{V}_{ji})											
Hog Prod	1.240	1.296	1.972	1.972	1.220	2.000	1.701	1.536	1.434	1.779	0.000
Other Livestock	0.000	1.225	1.470	1.251	1.430	1.345	1.974	1.406	1.239	1.815	2.000
Feed Grains	1.169	1.225	1.470	1.251	1.430	1.345	0.000	0.000	0.000	1.815	2.000
Other Crops	1.169	1.225	0.000	1.251	1.430	1.345	0.000	1.406	1.239	1.815	2.000
Oil & Gas	0.000	0.000	0.000	0.000	1.430	1.345	1.975	0.000	1.237	1.815	2.000
Cons-truction	0.000	0.000	0.000	0.000	1.430	1.345	0.000	0.000	0.000	1.815	2.000
Meat Packing	1.885	1.885	0.000	0.000	1.219	1.220	0.000	0.000	1.434	1.779	0.000
Prepared Feeds	0.000	1.296	1.352	1.314	1.780	0.000	1.701	1.536	1.434	1.779	1.983
Other Pre Foods	1.171	1.225	1.470	1.251	1.430	1.345	1.974	0.000	1.239	1.815	2.000
Other Manuf.	1.162	1.225	0.000	1.251	1.430	1.345	1.974	1.472	1.239	1.815	2.000
Services	1.173	1.225	0.000	1.251	1.430	1.345	1.974	1.406	1.239	1.815	2.000

4.4.2.2. Commodity Markets

Parameters of CET Function

The substitution parameter is calculated directly from constant elasticity of transformation function:

$$\rho_j^X = 1 + \frac{1}{\sigma_j^X} \tag{4.101}$$

Rearranging equation (4.31) and setting export price (PE) and regional commodity price (PR) equal to 1 yields the share parameter, δ_i^X:

$$\delta_i^X = \left[1 + \left(\frac{R_i}{E_i}\right)^{\rho_i^X - 1}\right]^{-1}. \tag{4.102}$$

The efficiency parameter, Φ_i^X, is derived by rearranging equation (4.27):

$$\Phi_i^X = \frac{X_i}{\left[\delta_i^X E_i^{\rho_i^X} + (1-\delta_i^X) R_i^{\rho_i^X}\right]^{\frac{1}{\rho_i^X}}} \tag{4.103}$$

The elasticities of transformation are from from research of Melo and Tarr (1992), and R_i and E_i are from the third and fourth columns of Table 3.7, respectively. Results of calibration are given in Table 4.14.

TABLE 4.14 CALIBRATED PARAMETERS OF CET FUNCTIONS

OF INDUSTRY OUTPUTS

Industry output	Parameters			
	σ_i^X (a)	ρ_i^X	δ_i^X	Φ_i^X
Hogs Products	3.9	1.256	0.436	2.063
Other Livestock	3.9	1.256	0.370	2.259
Feed Grains	3.9	1.256	0.461	2.023
Other Crops	3.9	1.256	0.373	2.250
Oil Gas and Products	2.9	1.345	0.523	2.006
Construction	2.9	1.345	0.911	6.023
Meat Packing Plants	2.9	1.345	0.688	2.439
Prepared Feeds	2.9	1.345	0.319	2.404
Other Prepared Foods	2.9	1.345	0.267	2.709
Other Manufacture	2.9	1.345	0.645	2.252
Services	0.7	2.429	0.993	7.734

(a) From de Melo and Tarr (1992)

Parameters of Household Expenditures

Household expenditures, HE_h, are from the SAM: \$64.23 million, \$85.65 million, and \$157.19 million for low, medium and high-income households, respectively. The values of Q_{ih} are obtained by adding the corresponding upper and lower parts of columns "LOW", "MED", and "HIG" of Table 3.10.

Rearranging equation (4.36) yields formula for calibrating parameters β_{ih}

$$\beta_{ih} = \frac{Q_{ih}P_i}{HE_h} \tag{4.104}$$

where $P_i = 1.0$. Results of the calibrated parameters are presented in Table 4.15.

TABLE 4.15 CALIBRATED PARAMETERS (β_{ih}) OF HOUSEHOLD COMMODITY DEMAND FUNCTIONS

Commodity	Households		
	Low-income	Med-income	High-income
Hogs Products			
Other Livestock	0.00039	0.00049	0.00045
Feed Grains	0.00001	0.00003	0.00003
Other Crops	0.00067	0.00046	0.00053
Oil Gas and Products	0.02802	0.02123	0.02506
Construction			
Meat Packing Plants	0.00702	0.00447	0.00536
Prepared Feeds	0.00025	0.00016	0.00019
Other Prepared Foods	0.06578	0.04682	0.05308
Other Manufacture	0.11472	0.12944	0.12393
Services	0.78315	0.79691	0.79137

Using the same elasticities of substitution as for intermediate inputs, the substitution parameters of the CES function are:

$$\rho_i^Q = \frac{1}{\sigma_i^Q} - 1 \tag{4.105}$$

The calibrated share and efficiency parameters of the CES function for the household consumed commodities are:

$$\delta_{ih}^Q = \left[1 + \left(\frac{QM_{ih}}{QR_{ih}} \right)^{1+\rho_i^Q} \right]^{-1} \tag{4.106}$$

and

$$\Phi_{ih}^{Q} = \frac{Q_{ih}}{\left[\delta_{ih}^{Q} QM_{ih}^{-\rho_i^Q} + (1-\delta_{ih}^{Q}) QR_{ih}^{-\rho_i^Q}\right]^{-\frac{1}{\rho_i^Q}}}. \tag{4.107}$$

Using the same elasticity of substitution parameters (de Melo and Tarr) as for intermediate inputs, and QR_{ih}, QM_{ih} from Table 3.10, the parameters of equations (4.106) and (4.107) are calibrated. Results are presented in Table 4.16.

TABLE 4.16 CALIBRATED PARAMETERS OF CES HOUSEHOLD DEMAND FUNCTIONS

Commodity	Low-income Household		Med-income household		High-income Household	
	Φ_{ih}^{Q}	δ_{ih}^{Q}	Φ_{ih}^{Q}	δ_{ih}^{Q}	Φ_{ih}^{Q}	δ_{ih}^{Q}
Hogs Products						
Other Livestock	1.0419	0.0137	1.0418	0.0136	1.0418	0.0136
Feed Grains	1.9849	0.4484	1.4701	0.8336	1.4698	0.8337
All Other Crops	1.9161	0.6231	1.9161	0.6231	1.9161	0.6231
Oil Gas and Products	1.4298	0.0485	1.4298	0.0485	1.4298	0.0485
Construction						
Meat Packing Plants	1.9743	0.5430	1.9743	0.5430	1.9743	0.5430
Prepared Feeds	1.4056	0.7806	1.4060	0.7805	1.4059	0.7805
Other Prepared Foods	1.2389	0.8570	1.2389	0.8570	1.2389	0.8570
Other Manufacture	1.8148	0.6244	1.8148	0.6244	1.8148	0.6244
Services	2.0000	0.4984	2.0000	0.4984	2.0000	0.4984

Parameters of Government and Capital Formation Expenditures

Similar procedures are used to derive and calibrate the CES parameters for commodities consumed by governments and for investment:

TABLE 4.17 CALIBRATED PARAMETERS OF CES DEMAND FUNCTIONS OF INSTITUTIONS

Commodity	Federal Gov		State/local Gov		Capital Form	
	Φ_i^Q	δ_i^Q	Φ_i^Q	δ_i^Q	Φ_i^Q	δ_i^Q
Hogs Products						
Other Livestock						
Feed Grains						
All Other Crops						
Oil Gas and Products					1.4295	0.0485
Construction	1.2233	0.0126	1.0050	0.0000	1.3451	0.0307
Meat Packing Plants						
Prepared Feeds						
Other Prep. Foods						
Other Manufacture					1.8148	0.6244
Services	1.9277	0.4032	1.3371	0.1479	2.0000	0.4984

$$\rho_i^{QX} = \frac{1}{\sigma_i^{QX}} - 1 \qquad (4.108)$$

$$\delta_{ik}^{QX} = \left[1 + \left(\frac{QXM_{ik}}{QXR_{ik}} \right)^{1+\rho_i^{QX}} \right]^{-1} \qquad (4.109)$$

$$\Phi_{ik}^{QX} = \frac{QX_{ik}}{\left[\delta_{ik}^{QX} QXM_{ik}^{-\rho_i^{QX}} + (1-\delta_{kh}^{QX}) QXR_{ik}^{-\rho_i^{QX}} \right]^{-\frac{1}{\rho_i^{QX}}}} \qquad (4.110)$$

Using data for QX_{ik}, QXM_{ik}, and QXR_{ik} are from Table 3.10. Elasticities of substitution are the same as for commodities consumed by households. Results presented in Table 4.17.

4.4.2.3. Institutional Accounts

At the initial state, $LMIG = 0$. Therefore, $LS0 = LDI$ (equation 4.45). In the Texas county SAM, the initial labor equilibrium is 121.582 million. Because $PL = 1$, labor income, LY, is equal to initial labor supply ($121.582 million).

The labor tax rates are 0.132 and 0.0272 for federal, and state/local government, respectively.

Value of net labor income, NLY, is $102.23 million.

Proportions of net labor income received by low, medium and high-income household groups are 0.073, 0.427, and 0.50, respectively.

Capital tax paid to local government is $3.841 million. $11 million was received form federal government as subsidy (Table 3.11).

Local government tax rate is 3.33 percent. The rate of subsidy from the Federal government is 9.55 percent.

Large portions of capital income are distributed to enterprises and households. The amount of capital income distributed to enterprises (*ENTK*) is \$29.658 million and to household groups is \$6.987 million, \$27.726 million, and \$34.8 million to low, medium, and high-income groups, respectively. The corresponding capital shares are as follow: 0.257, 0.061, 0.240, and 0.302.

In the Texas SAM, total land income is \$3.163 million. The land tax rate for local government is 5.37 percent. There is no tax for federal government. Thus, net land income is \$2.993 million.

Land income distributions are \$0.157 million, \$1.581 million, and \$1.254 million to low, medium, and high-income groups, respectively. The percentage shares of net land income are 5.26%, 52.83%, and 41.91%.

At initial stage, *PKL* is equal to 1. Therefore, enterprise income (*ENTY*) is identical to enterprise capital stock (*ENTK*), \$29.658 million (Table 3.11).

Inter-institution transfers are presented in Table 3.12. Corporation tax rates ($etax_g$) are 0.3185, and 0.0456 for Federal, and State/Local governments. Household shares of gross enterprise income (h_h) are 0.0012, 0.0103, and 0.0032 for low, medium, and high-income, respectively. The share of gross enterprise income to capital account is 0.6212.

The federal government did not receive investment tax, while the investment tax paid to local government was at the rate of 0.2295. Gross investment incomes distributed to household groups are \$11.79 million, \$7.57 million, and \$4.10 million for low, medium and high-income groups, respectively. The share of gross investment income to inventory is $18.91 million.

In the Texas County's SAM of the base year 1993, Federal government grants to local government was $10.655 million; distributed to capital account, $30.76 million; and paid (transferred) $25.652 million, $52.638 million, and $13.72 million to low, medium, and high-income household groups. Local government made transfer payments to households, only. These payments were $0.268 million, $1.556 million, and $0.539 million to low, medium, and high-income household groups, respectively.

Households paid taxes to governments. The calibrated tax rates ($htax_g$) of low-income households are 0.0183 for Federal government and 0.0112 for state/local government. Similarly, medium-income household rates are 0.077 and 0.026; and high-income household rates are 0.14 and 0.0435. Households may keep a part of income to spend in the future as saving. All household groups have no saving, so the saving rate (hs_h) of all household groups are zero.

4.4.3. IMPLEMENTING THE CGE MODEL IN GAMS

The calibration process and solving for solution of the simultaneous equations of the CGE model are implemented by using General Algebraic Modeling System (GAMS). Constructing the GAMS program follows the syntax of GAMS software. Information about GAMS is obtained from the web site "http:/www.gams.com".

The GAMS program to implement the CGE model of this research is printed in the appendix. The program is designed to read data directly from the SAM and perform the calibration process. The calibrated parameters are then used directly in the set of simultaneous equations to solve for the general equilibrium of the model. The structure of this program is presented in Table 4.18.

TABLE 4.18 STRUCTURE OF THE GAMS PROGRAM FOR IMPLEMENTING THE CGE MODEL

I) Sets

- 1) Specified sets
- 2) Sub sets

II) Parameters

- 1) Parameter declaration
  - a) Exogenous parameters
  - b) Calibrated parameters
- 2) Parameter assignment
  - a) Read data from external file
  - b) Assign value to exogenous parameters
  - c) Calibrate parameters

III) Variables and Equations

- 1) Variable declaration
- 2) Equation declaration
- 3) Equation definition
- 4) Variable initialization

IV) Model definition and solving model

V) Calculating result and writing output to external files

For convenience in checking the computation and validation of the model, the last section of the program writes the final result into the external file in the form of a tab delimiter. This file can be read by Excel and is easy to make additional computation, printout, and copy and paste to word processor when writing reports.

4.4.4. VALIDATION OF THE CGE MODEL

The SAM of the base year captures the monetary flows of the region that is already in equilibrium. The CGE model uses data from the base year SAM to calibrate parameters of the equations of the model. The CGE model is validated when the solution of the model is identical with the SAM of the base year (Robinson et al., 1990).

We let the CGE program read the SAM for Texas County, 1993 and solve the CGE model. The solution of the CGE model is identical with the original SAM. This identity implies that the CGE model implemented by GAMS program is valid and can be used to construct simulated CGE models as described in Chapter V.

CHAPTER V

SIMULATED CGE MODEL FOR TEXAS COUNTY, OKLAHOMA

5.1. SPECIFICATION OF SIMULATED CGE MODEL

The input-output model and CGE model are often used to identify the impacts of the changes of final demands of commodity on the economy. Such types of models are so called demand-side models. Another application of the input-output model is the supply-side input-output model. The supply-side model is used in cases where there is investment in new industry in the region or changes in supply of resources that affects the supply of commodity. The input-output model can be used in case the output of one industrial sector is predetermined. The model in this case is called a mixed exogenous/ endogenous variables model (Miller, and Blair, 1985).

5.1.1. GENERAL INFORMATION

The primary objective of this study is to determine the impacts of the investment of Seaboard Farms in Texas County, Oklahoma. Prior to the investment of Seaboard Farms, the output of hog production and meat packing plants was relatively low in comparison to other industrial sectors. With the investment of Seaboard Farms, the output of meat packing plants increased 29 times from 1993 to 1997 and output of hog production increased 78 times (Table 5.1), based on the actual data. The scenario is the investment of new industry in the region. To capture the impacts of Seaboard Farms the CGE model incorporates production attributes of Seaboard Farms. The CGE model used in this case is a supply-side model with mixed exogenous/endogenous variables in which output of Meat Packing is exogenous, outputs of other sector are endogenous.

TABLE 5.1 INDEX OF CHANGE IN INDUSTRY INPUTS AND OUTPUTS OF TEXAS COUNTY FROM 1993 TO 1997 (BASE YEAR 1993 = 1.0)

	Industrial sectors										
	Hog Prod	Other Lives-tocks	Feed Grains	Other Crops	Oil & Gas	Cons-truct.	Meat Pack.	Prep Feeds	Other Prep. Foods	Other Manuf	Ser-vices
Intermediate Inputs (INT)											
Regional	47.74	0.71	1.24	1.07	0.54	0.84	36.13	26.00	69.58	1.31	1.11
Imported	139.12	0.79	1.82	1.46	2.61	1.38	12.62	26.00	62.04	1.69	1.58
Total INT	78.02	0.77	1.58	1.30	1.14	1.19	29.49	26.00	64.45	1.58	1.35
Primary Factor Inputs (Value-added, VA)											
Labor	78.51	0.57	0.72	0.76	1.03	2.36	29.49	26.00	28.98	1.46	1.21
Capital	78.02	0.57	0.72	0.76	2.15	1.01	29.49	26.00	16.55	7.91	1.47
Land			0.72	0.76							
Total VA	78.02	0.57	0.72	0.76	1.62	1.77	29.49	26.00	22.90	2.13	1.30
Industry Outputs (X)											
Reg. sold	29.08	2.33	1.15	2.16	0.60	1.31	11.04	3.51	29.03	1.49	1.29
Exported	48.29	0.55	1.62	1.13	2.38	45.15	33.60	28.48	51.30	3.08	1.15
Total Output	78.02	0.75	1.46	1.25	1.37	1.37	29.49	26.00	50.18	1.73	1.28

The Seaboard Farms web site states that it is a regionally dominant pork processor that includes the nation's largest vertically integrated system. According to sources in Guymon, Seaboard Farms account for 99 percent of the meat processing in Texas County. Seaboard is a vertically integrated system; it raises hogs and 100 percent of the hog production is processed in Texas County meat packing plants. About 99 percent of meat processing in Texas County is hog. Seaboard Farms is thus effectively the only owner of Hog Product and Meat Packing in Texas County.[1]

5.1.2. PRODUCTION INFORMATION

5.1.2.1 Intermediate Inputs

According to informed sources in Texas County, the proportions of regionally purchased intermediate inputs by Seaboard is estimated at 70 percent for animals, 40 percent for feed, 100 percent for services, 90 percent for energy/utilities, and 10 percent for construction. These values are the regional purchase coefficients (RPC) for the hog complex sectors.

5.1.2.2. Industry Output

All Hog Product output is processed in the region (there is no exporting of hogs). Practically all Meat Packing output is exported out of the region, leaving only a small portion for local consumption.

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[1] This information was based on confidential interviews with local sources who are considered expert on agricultural markets in Texas County.

5.1.2.3. Factor Markets

The regional economy is more open than the national economy. Labor easily migrates between regions. The unemployment of Texas County is low, 3.7 percent (North Central Regional Center for Rural Development), so the labor supply for additional labor demand is mostly met from outside the region. The report of the North Central Regional Center for Rural Development states that Seaboard Farms demanded 5,500 new jobs. However, with the increased employment, the actual overall wage rate for the region was lowered. This implies close to a perfectly elastic labor supply.

Since the Hog Product and Meat Packing sectors receive a capital subsidy from governments, therefore, the capital market of these two sectors is separated from capital markets of other sectors. To incorporate this characteristic the industrial sectors are classified into two groups. The hog group consists of two sectors; Hog Product and Meat Packing. The non-hog group consists of the nine other sectors.

In general, capital is fixed for each industrial sector in the short-run. However, the government subsidized capital for the hog sectors, therefore, capital stock for these sectors increased in both the short-run and long-run. The subsidized capital is assumed sufficient to increase output to the pre-specified level, therefore, this capital market is assumed to be perfectly elastic. Because the two sectors of the hog complex are assumed to be owned by Seaboard Farms, capital in this market is allocated between the Hog Product and Meat Packing such that the rents are always equal.

Capital in the non-hog sectors is fixed in the short-run. In the long-run, capital is assumed mobile between the non-hog sectors until capital rents are equal. Capital is assumed to migrate between regions in the long-run. The magnitude of capital migration depends on the difference between regional price of capital and price of capital out-of-region. It also depends on the elasticity of capital migration.

5.2. CONSTRUCTING THE SIMULATED CGE MODEL

Constructing the CGE model that incorporates all properties of the scenario described in section 5.1 consists of two tasks: modifying the SAM, and modifying equations of the model.

5.2.1. MODIFYING THE SAM

The SAM for Texas County base year 1993 was modified to accommodate the model simulation. Intermediate inputs of the two hog complex sectors were reallocated such that the proportions of the regionally purchased inputs were equal to regional purchase coefficients (RPC) as provided in section 5.1.2.1.

5.2.2. MODIFYING EQUATIONS OF THE CGE MODEL

The modifications discussed in this section refer to the equations and variables defined in section 4.4.1 of chapter IV.

To incorporate the characteristics of the industrial sectors as described in section 5.1, additional sets and endogenous variables are added to the simulation model as listed in Table 5.2. Some equations were modified for this purpose. The modified equations are presented in Tables 5.3 and 5.4.

TABLE 5.2 NEW INDICES AND ENDOGENOUS VARIABLES

OF THE SIMULATED CGE MODEL

Indices/Variables	Descriptions	Number of Variables
Sets		
Hog	Hog sectors: Hog Production, Meat Packing	
Non-hog	Non-hog sectors: Other industrial sectors	
Parameter		
outrate	Determined output of Meat Packing sector	
Endogenous Variables		
PKL1	Long-run capital rent for hog sectors	1
KMIG1	Migrated capital of non-hog sectors	1
KMIG2	Migrated capital of hog sectors	1

Because capital is divided into two markets, three additional variables are required to measure capital rents and capital migration. *PK1* measures capital rent for the hog sectors in both short-run and long-run. The old variable *PKL* is used to measure the long-run capital rent of the non-hog sectors. *KMIG1* captures migrated capital for the non-hog sectors and *KMIG2* captures migrated capital for hog sectors. The old variable *KMIG* captures the total of *KMIG1* and *KMIG2*. The new parameter *outrate* is used to identify the specific level of output for the Meat Packing sector in the simulated model.

Modified equations for the production block are presented in Table 5.3.

TABLE 5.3 MODIFIED EQUATIONS OF PRODUCTION BLOCK

	Equation		Number of equations
2a	$CAP_i = \frac{\alpha_i^K * PN_i * X_i}{PK_i}$	for $i \in$ *non-hog* for the short-run	9
2b	$CAP_i = \frac{\alpha_i^K * PN_i * X_i}{PKL}$	for $i \in$ *non-hog* for the long-run	9
2c	$CAP_i = \frac{\alpha_i^K * PN_i * X_i}{PKL1}$	for i $\in$ *hog*	2
9	$X_i = \Phi_i^X \left[\delta_i^X E_i^{\rho_i^X} + (1-\delta_i^X) R_i^{\rho_i^X}\right]^{\frac{1}{\rho_i^X}}$	for $i \in$ *non-hog* for the long-run	9
10a	$E_i = R_i \left(\frac{1-\delta_i^X}{\delta_i^X} * \frac{PE_i}{PR_i}\right)^{\frac{1}{\rho_i^X - 1}}$	for $i \in$ *non-hog* for the long-run	9
10b	$E_i = 0$	for i = "Hog Product"	1
10c	$R_i = X_i$	for i = "Hog Product"	1
10d	$E_i = X_i - R_i$	for i = "Meat Packing"	1
10e	$X_i = outrate * X0_i$	for i = "Meat Packing"	1

Capital Demand

Equations 2a and 2b in the basic model are applied for the non-hog sectors in the simulated model to describe the capital demand of these sectors in the short-run and the long-run, respectively. The two hog sectors (Hog Product, and Meat Packing) are assumed to belong to one owner (Seaboard Farms). Therefore, capital can be allocated freely in this capital market equating capital rent between these two sectors as level *PKL1* in both short-run and long-run. Equation 2c captures this characteristic of capital demand in the hog complex.

Commodity supply

The relationship between regionally supplied output (R_i) and exported output (E_i) of the non-hog group is defined by a constant elasticity of transformation (CET) function and specified by equations 9 and 10a. These equations are the same as equations 9 and 10 in the basic model.

Output of Hog Product is processed locally (no exports). Therefore, all of the output is supplied to the regional market. That means R=X. This characteristic is described by equations 10b and 10c.

The Meat Packing sector operates like export processing plants. All of its output is exported, leaving only a small portion for local consumption (depending on regional demand), regardless of price. Equation 10d describes this characteristic.

Equation 10e is used to specify the output level of Meat Packing. In this equation, $X0_{MP}$ is the initial output level of Meat Packing plants and *outrate* as the multiplier for this output. The value for *outrate* is set before running the program for pushing the output of Meat Packing to a specified level. In the short-run simulated model, the value of *outrate* is set equal to 10 to make output of Meat Packing increase 10 times. In the same manner, *outrate* is set to 30 in the long-run model.

Table 5.4 lists the modified equations for overall capital rent and equilibrium conditions for capital markets.

Because the two capital markets operate independently, the formula to calculate overall capital rent is adjusted. Variable *PK1* in equations 48a and 48b is a weighted average of capital rent of the two capital markets for the short-run and the long-run, respectively.

TABLE 5.4 MODIFIED PRICE AND EQUILIBRIUM EQUATIONS

	Equation		Number of equations
48a	$PK1 = \dfrac{PKL1 * \sum_{hog} CAP_{hog} + \sum_{nonhog} PK_{nonhog} * CAP_{nonhog}}{\sum_i CAP_i}$	for the SR	1
48b	$PK1 = \dfrac{PKL1 * \sum_{hog} CAP_{hog} + PKL * \sum_{nonhog} CAP_{nonhog}}{\sum_i CAP_i}$	for the LR	1
51a	$CAP_i = KS0_i$	for $i \in$ *non-hog* for the short-run	
51b	$\sum_i CAP_i = \sum_i KS0_i + KMIG1$	for $i \in$ *non-hog* for the long-run	
51c	$\sum_i CAP_i = \sum_i KS0_i + KMIG2$	for $i \in$ *hog*	

Supply of Labor

The additional labor supply is provided by migrated labor specified by equation (4.47):

$$LMIG = LS0 * \varepsilon^{L} \log\left(\frac{PL}{PLROW}\right) \tag{4.47}$$

where ε^{L} is an elasticity of labor migration. The larger the value of ε^{L}, the flatter the labor supply curve (Figure 5.1). As suggested in section 5.1.2.4, labor migration was easy, thus ε^{L} is set to a very large value (100 thousand).

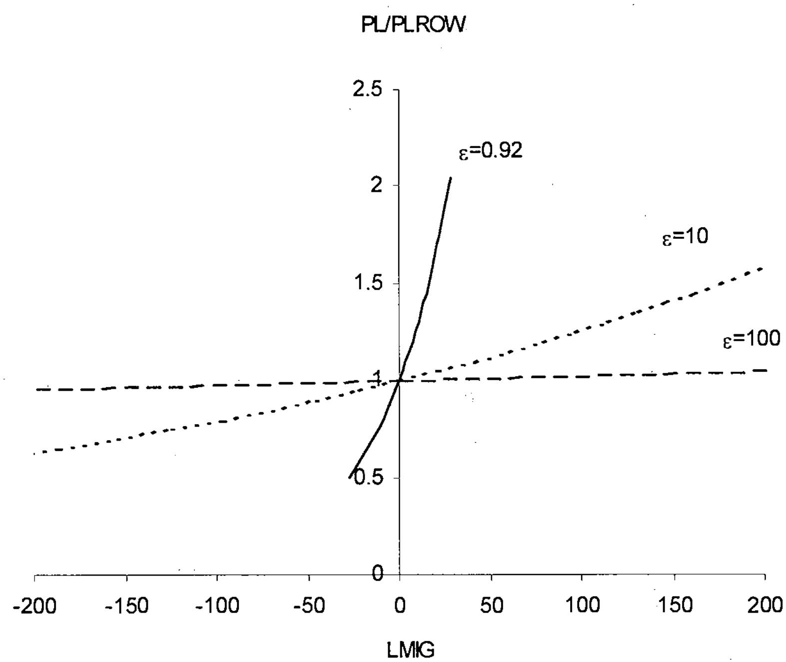

Figure 5.1. Labor Migration

Labor Equilibrium

The labor equilibrium is identified by equation (5.2) in both the long-run and short-run:

$$\sum_i LAB_i = LS0 + LMIG \tag{5.2}$$

where $LMIG$ is labor migration assumed to be perfectly elastic.

Supply of Capital

Similar to labor, capital migration is defined as:

$$KMIG = \sum_i KS0_i * \varepsilon^K * \log\left(\frac{PKL}{PKROW}\right) \tag{4.51}$$

The ε^K_{hog} for hog complex is equal to 100 while ε^K_{nonhog} for non-hog group is 0.92 as reported by Plaut (1981).

Capital Equilibrium

In the short-run, capital for the non-hog sectors is fixed for each sector. This condition is set by equation 51a. In the long-run, total capital demanded by the non-hog sectors is equal to total initial capital plus migrated capital (*KMIG1*). This condition is set by equation 51b, where *KMIG1* is capital migration for the non-hog sectors and depends on the ratio of regional capital rent (PL) to out-of-region capital rent ($PKROW$), specified by $\frac{PK}{PKROW}$. The elasticity of capital migration for the non-hog group is 0.92.

Capital equilibrium for the hog sectors is specified by equation 51c for the both long-run and short-run. In equation 51c, variable *KMIG2* is capital subsidized for the hog complex and is assumed perfectly elastic.

5.3. RESULTS OF THE SIMULATED MODEL

When all attributes of the scenario were incorporated into the model as described in section 5.2, the model was simulated in the two production periods: (1) the short-run in which capital of the non-hog sectors is fixed, and output of meat packing plants increases 10 times; and (2) the long-run in which capital in the two capital markets is variable and output of Meat Packing increases 30 times output in year 1993. This output is equal to the volume for 1997.

5.3.1. THE SIMULATED MODEL IN THE SHORT-RUN

5.3.1.1. Changes in Production System and Commodity Markets

<u>Industry Inputs and Outputs</u>

The indices of change in inputs and outputs by industrial sector are presented in Table 5.5. Increasing output of the Meat Packing sector requires more inputs. Because the first level of production follows Leontief technology, composite commodity inputs increase by the same proportion as output. Increasing Meat Packing by 10 times increases composite primary factors by the same proportion. Output of the Hog Product sector is the main intermediate input of the Meat Packing sector (input-output coefficient is 0.77, see Table 4.11), therefore, demand for output of the Hog Product sector increases significantly because of the expansion of Meat Packing.

TABLE 5.5 INDEX OF CHANGE IN INDUSTRY INPUTS AND OUTPUTS, SHORT-RUN (BASE YEAR 1993=1.0)

	Industrial sectors										
	Hog Prod	Other Lives-tocks	Feed Grains	Other Crops	Oil & Gas	Cons-truct.	Meat Pack.	Prep Feeds	Other Prep. Foods	Other Manuf	Ser-vices
Intermediate Inputs (INT)											
Reg. INT	11.39	0.98	0.98	0.98	1.00	1.00	9.98	0.91	0.95	1.01	1.04
Imp. INT	11.87	1.01	1.01	1.01	1.02	1.03	10.06	0.95	1.00	1.03	1.07
Total INT	11.54	1.00	1.00	1.00	1.01	1.02	10.00	0.94	0.99	1.02	1.06
Primary Factor Inputs (Value-added, VA)											
Labor	11.54	0.93	1.22	1.16	1.01	1.04	10.00	0.93	0.97	1.02	1.09
Capital	11.54	1.00	1.00	1.00	1.00	1.00	10.00	1.00	1.00	1.00	1.00
Land			1.00	1.00							
Total VA	11.54	1.00	1.00	1.00	1.01	1.02	10.00	0.94	0.99	1.02	1.06
Industry Outputs (X)											
Reg. Sold	11.54	1.00	1.19	1.43	1.03	1.02	1.23	1.01	1.03	1.02	1.06
Exported		1.00	0.89	0.94	0.98	0.99	11.95	0.94	0.98	1.01	1.04
Total	11.54	1.00	1.00	1.00	1.01	1.02	10.00	0.94	0.99	1.02	1.06

Because labor supply is perfectly elastic and capital of non-hog sectors is fixed (in the short-run), the impact of expansion of the Meat Packing sector on other sectors is mostly driven by the change in demand for their output. The output of Hog Product expands 11.54 times because of the large increase in the expansion of the Meat Packing.

The two percent and six percent increases in output of Other Manufacture, and Services sectors, respectively, are explained in the same manner. Meat Packing sector input-output coefficients of these two sectors are 0.317 and 0.343, respectively. The impact on other sectors is relatively small because their output used by the Meat Packing sector is small (from 0 to 0.014).

The Cobb-Douglas constant return to scale production function is used to describe the relationship of primary factor inputs to output (equation 4.3). Because factor prices remain 1.0 in the hog complex factor markets, the factors (labor and capital) of these sectors (Hog Product, and Meat Packing) change at the same proportion. Also, because capital and land are fixed for the non-hog sectors, the level of use remains at 1.0.

Prices

Increased output of the Meat Packing causes regional prices (PR) of all other commodities to increase ranging from 0.1 to 11.4 percent, as shown in Table 5.6. The composite commodity prices (P) also increase. Seaboard Farms operate as an export-processing plant such that almost all of the output is exported from the region. Regional price of the Meat Packing product still increased 29.6 percent because supply of Meat Packing in regional market does not increase.

Labor in-migration is 10.47 percent of initial labor in response to the increased demand for labor. Because labor supply is assumed perfectly elastic the wage rate remained at its initial level.

TABLE 5.6 INDEX OF PRICES IN THE SHORT-RUN

PRICES	Industrial sectors										
	Hog Prod	Other Lives-tocks	Feed Grains	Other Crops	Oil & Gas	Cons-truct.	Meat Pack.	Prep Feeds	Other Prep. Foods	Other Manuf	Ser-vices
Regional Price	1.007	1.001	1.078	1.114	1.017	1.010	1.296	1.024	1.015	1.005	1.023
Import price	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Commodity Price	1.005	1.001	1.008	1.005	1.014	1.008	1.110	1.000	1.000	1.001	1.012
Export Price	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Output Price	1.007	1.000	1.033	1.019	1.010	1.010	1.007	1.003	1.001	1.004	1.022
Capital rent	1.000	0.934	1.216	1.157	1.012	1.037	1.000	0.927	0.972	1.024	1.087
Wage rate	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Land rent			1.216	1.157							

To increase output of Meat Packing 10 times the hog complex demanded an additional $1.67 million capital stock. Because capital for the two hog sectors is unlimited, capital rent remains unchanged. Capital of the other sectors was fixed in the short-run, therefore, capital rents for these sectors change. For the sectors that increased output, capital rent increase, and vise versa.

Land use by the two agricultural sectors, Feed Grains and Other Crops is fixed. Therefore land rent increased 22 and 16 percent, respectively, because of increases in output.

5.3.1.2. Changes in Regional Welfare

The measure of regional welfare are presented in Table 5.7. Gross regional product (GRP) increased from $271.01 million to $290.5 million (7.21%). Regional expenditure (RE) increased from $367.11 million to $379.45 million (3.36%). The indirect business tax increased 8.33%. Employment increased 10.47%

TABLE 5.7 MEASURE OF REGIONAL WELFARE IN THE SHORT-RUN (MILLION DOLLARS)

Measures	Initial value	New value	Change (%)
Gross Regional Product	271.01	290.54	7.21
Regional Expenditure	367.11	379.45	3.36
Employment	121.91	134.68	10.47
Export	589.54	637.33	8.11
Tax	30.58	33.13	8.33

Measures of income and expenditure of regional and immigrated households (in thousand dollars) are presented in Table 5.8. The last three columns measure the percentage change of regional household income. Because the wage rate is stable, the household labor income does not change. Household incomes from capital and enterprise increases 1.67 percent because of increased overall capital rent. Household income from land rent increased 19.33 percent. The change in household income by income class is different because of differences in shares of factor ownership. Low income households had the smallest income increase (0.24%) because the largest sources of income are labor and transfers which are unchanged. Medium income and high income households had changes of 0.77% and 0.50%, respectively. Their shares of capital and land rents are higher than for low income households. The total income of in-migrated households is $10.73 million.

TABLE 5.8 HOUSEHOLD WELFARE IN THE SHORT-RUN

(THOUSAND DOLLARS)

Measures	Monetary value			Change (%)		
	Low-income household	Med-income household	High-income household	LOW	MED	HIGH
Gross regional hh income	66,403.82	105,870.38	176,414.64	0.24	0.77	0.50
Labor income	7,505.99	43,769.68	51,229.92	0.00	0.00	0.00
Land income	184.35	1,852.49	1,469.73	19.33	19.33	19.33
Capital income	7,103.64	28,187.70	35,381.86	1.67	1.67	1.67
Enterprise income	35.54	310.63	96.93	1.67	1.67	1.67
Other source	51,574.30	31,749.89	88,236.20	0.03	0.12	0.06
Household welfare (CV)/*	-527.85	-239.13	-873.23	-0.82	-0.28	-0.55
Income of in-migrated hh	10,733.87					
Expend. of in-migrated hh	10,416.94					

/* the last three column is percent of initial household expenditure.

Because commodity prices increased more than income, the regional households lost welfare. The household welfare measures (CV and EV) show that the welfare loss of high-income household group is highest ($873 thousand), welfare loss of the low-income group is next ($528 thousand), and welfare loss of the medium-income group is lowest ($239 thousand).

5.3.2. THE SIMULATED MODEL IN THE LONG-RUN

The long-run model was simulated such that the output of Meat Packing increases 30 times and capital is allowed to move between sectors of the non-hog group until rents in all of these sectors are equal. Capital migration elasticity for this capital market was set equal to 0.92 (Plaut, 1981). The capital market for the hog complex is perfectly elastic. All of the industrial sectors share the same labor market in which labor supply is perfectly elastic.

5.3.2.1. Changes in Production System and Commodity Markets

In the long-run there is sufficient time for industrial sectors to adjust their production plans corresponding to the change of economic conditions to maximize profit. The Meat Packing sector expanded output to 30 times, thus causing large impacts on other sectors. The impacts caused by changing demand of intermediate inputs and increasing in-migration labor increased the demand for all final goods.

Industry Inputs and Outputs

As shown in Table 5.9, Hog Product expanded to 35 times because its output was demanded largely by expansion of the Meat Packing sector of 30 times. The expansion of the Hog Product sector demands more output of Feed Grains and Other Crops sectors. The crops sectors can not freely respond to the increased demand for their output because land for these sectors is fixed; therefore, output prices for these sectors increase. Composite price of Feed Grains and Other Crops are 1.016 and 1.019, respectively (Table 5.11). These increased prices reduce the production of Other Livestock sector because

Feed Grains and Other Crops are its main intermediate inputs. Output of Other Livestock decreases 47 percent. Decreasing output of Other Livestock reduces demand for Prepared Feeds, therefore output of this sector decreases 13 percent.

TABLE 5.9 INDEX OF CHANGE IN INDUSTRY INPUTS AND OUTPUTS IN THE LONG-RUN (BASE YEAR 1993=1.0)

	Industry Sectors										
	Hog Prod	Other Lives-tocks	Feed Grains	Other Crops	Oil & Gas	Cons-truct.	Meat Pack.	Prep Feeds	Other Prep. Foods	Other Manuf	Ser-vices
Intermediate Inputs (INT)											
Reg. INT	34.41	0.53	1.10	1.15	1.42	0.97	29.98	0.91	8.01	1.05	1.16
Imp. INT	36.42	0.53	1.08	1.13	1.39	0.96	30.06	0.86	8.03	1.04	1.14
Total INT	35.04	0.53	1.09	1.14	1.41	0.96	30.00	0.87	8.02	1.04	1.15
Primary Factor Inputs (Value-added, VA)											
Labor	35.04	0.45	1.42	1.85	1.44	0.94	30.00	0.78	5.70	1.07	1.19
Capital	35.04	0.47	1.48	1.93	1.50	0.98	30.00	0.82	5.95	1.12	1.24
Land			1.00	1.00							
Total VA	35.04	0.53	1.09	1.14	1.41	0.96	30.00	0.87	8.02	1.04	1.15
Industry Outputs (X)											
Reg. sold	35.04	0.55	1.35	2.08	1.30	0.96	3.21	0.86	3.53	1.04	1.15
Exported		0.53	0.94	1.00	1.55	0.99	35.96	0.87	8.23	1.06	1.16
Total	35.04	0.53	1.09	1.14	1.41	0.96	30.00	0.87	8.02	1.04	1.15

The large immigrated labor (24.77 percent of initial labor supply) in the long-run increases demand for final commodities in the region. This change plus the change of intermediate input demands increases the long-run regional impacts significantly greater than the short-run impacts.

Table 5.10 shows the changes of demand for regional commodities in the short-run and the long-run. Other Prepared Foods, Other Manufacture, and Services are main commodities mainly consumed by households (see the corresponding budget share β, see Table 4.15). Household demand for Other Prepared Foods increases to 3.08 times while that of Other Manufacture, and Services increases 8.9 percent and 9.8 percent, respectively. The high increased demand for Other Prepared Foods is caused by the low composite commodity price and the high input-output coefficient with Prepared Feeds.

TABLE 5.10 INDEX OF CHANGE IN DEMAND FOR REGIONAL COMMODITY (BASE YEAR 1993=1.0)

Commodity	Short-run			Long-run		
	Intermediate Input	Final demand		Intermediate Input	Final demand	
		Household	Institution		Household	Institution
Hog Prod	10.183			30.651		
Other Livestock	1.001	1.035	1.000	0.559	1.058	0.775
Feed Grains	1.157	0.959	1.000	1.282	0.982	1.000
Other Crops	1.353	0.939	1.000	1.928	0.897	1.014
Oil & Gas	1.026	1.028	1.000	1.348	1.150	1.020
Construction	1.035		1.009	0.913		1.005
Meat Packing	2.289	0.488	2.450	6.237	0.883	5.673
Prepared Feeds	1.005	0.964	1.000	0.858	1.112	1.000
Other Prep. Foods	1.025	0.994	1.000	3.253	3.083	1.000
Other Manufacture	1.026	1.021	1.002	1.018	1.089	1.012
Services	1.116	1.003	1.001	1.209	1.098	1.008

In addition to demand for intermediate goods by industrial sectors, demand for final goods by households plays an important role in the economic development. The large amount of labor in-migration (24.77 percent) to the region requires more consumption of Other Prepared Foods (3.08 times in long-run versus 1 time in short-run). This sector expands production 8.02 times to provide more commodity demanded by Prepared Feeds and immigrated households. This expansion increases commodity supply, but also decreases its price.

Prices

Table 5.11 presents equilibrium prices for the economy in the long-run. The wage rate is the same for all sectors of the region is equal to one because of the assumed perfect supply elasticity. Capital rent for the hog complex is also one because supply is assumed perfectly elastic. Capital market for non-hog group was in equilibrium at a rent (0.957) lower than the initial level, causing capital to migrate out-of-region. Land rent for the two crop sectors (Feed Grains and Other Crops) increased more than 50 percent because land supply was fixed while outputs of these sectors increased.

The output of Other Prepared Foods increased 8.02 times in response to the increment of demand for this commodity. The expansion of output shifts the supply curve to the right, decreases regional market price of this commodity to 0.79. Similarly, demand for oil and gas of in-migrated households plus the increased intermediate demand increases pushes output Oil and Gas Product 147 percent. The expansion of output decreases the price of Oil and Gas Product by 5 percent. Decreasing price of Other

Manufacture, and Services sectors may be caused by the expansion of their outputs. Commodity prices of other sectors are relatively stable.

TABLE 5.11 INDEX OF PRICES IN THE LONG-RUN

PRICES	Industrial sectors										
	Hog Prod	Other Lives-tocks	Feed Grains	Other Crops	Oil & Gas	Cons-truct.	Meat Pack.	Prep Feeds	Other Prep. Foods	Other Manuf	Ser-vices
Region Price	1.003	1.010	1.098	1.207	0.941	0.990	1.076	0.997	0.747	0.995	0.988
Import price	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Comm Price	1.002	1.010	1.016	1.019	0.952	0.991	1.048	1.000	0.998	0.999	0.993
Export Price	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Output Price	1.003	1.001	1.043	1.045	0.969	0.990	1.002	1.000	0.994	0.996	0.988
Capital rent	1.000	0.957	0.957	0.957	0.957	0.957	1.000	0.957	0.957	0.957	0.957
Wage rate	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Land rent			1.496	1.890							

The expansion of the hog sectors requires additional capital of $5.37 million. Capital in the non-hog market migrated out. The equilibrium capital rent was 0.957, lower than capital rent from out-of-region (exogenously set to 1) thus capital migrated out of-the-region. The out-migrated capital was $4.62 million.

5.3.2.2. Changes in Regional Welfare

Change in regional welfare are presented in Table 5.12. Gross Regional Product (GRP) increased from $271.01 million to $302.12 million, 11.5 percent. Regional Expenditure (RE) increased from $367.11 million to $390.67 million (6.42 percent). Employment increased 24.77%. Indirect business tax increased 9.55% These increments are more than the increments in the short-run because of a greater expansion of the economy. Export decreased 9.24% because of the decrease output of Other Livestock.

TABLE 5.12 MEASURE OF REGIONAL WELFARE IN THE LONG-RUN (MILLION DOLLARS)

Measures	Initial value	New value	Change (%)
Gross Regional Product	271.01	302.12	11.48
Regional Expenditure	367.11	390.67	6.42
Employment	121.91	152.11	24.77
Export	589.54	535.07	-9.24
Tax	30.58	33.50	9.55

Measures of the changes of household welfare are presented in Table 5.13. Similar to the short-run, labor income of regional households does not change because of the stable wage rate. Regional household land income increased 64.8 percent, however this increment has little impact on household income because it share is relatively small. In contrast with the short-run, the decreasing capital rent (4.3 percent) in the long-run reduces household income from capital and investment. Even though the expansion of Meat Packing sector is large (30 times) the gross income of regional households (of all household groups) does not increase (slight decrease, less than one percent). The same to disposable incomes and regional household expenditures. On the other side, the income of immigrated households is $25.39 million.

TABLE 5.13 HOUSEHOLD WELFARE IN THE LONG-RUN

(THOUSAND DOLLARS)

Measures	Monetary value			Change (%)		
	Low-income household	Medium-income household	High-income household	LOW	MED	HIGH
Gross regional hh income	66,058.15	104,938.00	174,934.68	-0.28	-0.12	-0.34
Labor income	7,505.99	43,769.68	51,229.92	0.00	0.00	0.00
Land income	254.62	2,558.62	2,029.95	64.82	64.82	64.82
Capital income	6,713.34	26,638.95	33,437.84	-3.92	-3.92	-3.92
Enterprise income	32.18	281.25	87.76	-7.95	-7.95	-7.95
Other source	51,552.02	31,689.50	88,149.20	-0.02	-0.07	-0.03
Household welfare (CV)/*	261.74	472.60	532.97	0.41	0.55	0.34
Income of in-migrated hh	25,391.34					
Expend. of in-migrated hh	24,641.63					

/* the last three column is percent of initial household expenditure.

Measures of household welfare (CV and EV) are positive even though household incomes decrease marginally. The increment of regional welfare is caused by decreasing composite commodity prices. The high-income household group receives largest welfare gain ($536 thousand), the medium-income household is next ($475 thousand), and the welfare gain of low-income households is smallest ($263 thousand). However, the total welfare gain of all regional household groups ($1.28 million) is relatively small in comparison with the income of in-migrated households ($25.39 million).

5.4. COMPARING RESULTS OF SIMULATED MODEL AND EMPIRICAL DATA

The SAM of Texas County in 1997 was constructed using IMPLAN to compare with the results of simulated model of this study. Data of production activities were converted to an index value by dividing by the corresponding values of year 1993. The index number is known as "time of year 1993." Results of converted data of year 1997 were presented in Table 5.1.

Results of the simulated model in the short-run were presented in Table 5.5. Similarly, long-run simulated results were presented in Table 5.9.

Comparing the changes of outputs and resources used by Meat Packing sector of the long-run model and the actual data of Texas County in year 1997 we find that the increased output and production material are consistant. The stability of production of Feed Grains, Other Crop, Oil and Gas Product, Other Manufacture, and Services predicted by the simulated model are consistent with the actual data. The contraction of Other Livestock sector shown by simulated model agrees with the actual data.

The simulated model also predicts the expansion of Hog Product sector caused by increased production of Meat Packing. However, the magnitude of expansion predicted by the simulated model is about half of the actual value given by IMPLAN.

The main difference between results of the simulated model and the actual data are in two sectors: Other Prepared Foods, and Prepared Feeds. The simulated model predicted that output of Other Prepared Foods sector would expanded 8.02 times while actual data shows that output of this sector expanded up to 50.18 times. Simulated model shows that Prepared Feeds sector reduced 23 percent while actual data shows that this sector expanded up to 26 times.

Consequently, the consistency of the results of the simulated model with actual data are much more than the inconsistency allow us to believe on the ability of CGE model to predict the response of the regional economy caused by the changes in the system. Based on this conclusion, we consider that the large expansion of Prepared Feeds and Other Prepared Foods may be caused by factors not included in the simulated model. The greater expansion of Hog Product that was not predicted by the simulated model may be caused by the increased demand of the large expansion of the sector Other Prepared Foods.

CHAPTER VI

SUMMARY AND CONCLUSIONS

6.1. REVIEW OF PROBLEM AND PURPOSE OF STUDY

In 1987, the population of Texas County, Oklahoma, decreased and the unemployment rate increased because of the closure of Swift Beef Packing Plant and the slow down of the oil and gas industry. In hopes of reversing population and unemployment trends, the policy makers of Oklahoma and Texas County implemented development policies to create incentives for industrial recruitment in the county. Responding to this policy, Seaboard Farms purchased land in Texas County and opened a pork processing plant in Guymon and a pork production operation in Texas County in 1993. The outputs of Meat Parking and Hog Product have dramatically increased. The expansion of production of one sector may affect other sectors and the income and expenditures of people in the region.

The general objectives of this research were to identify the changes in Texas County economy that resulted from the operation of Seaboard Farms. The specific objectives are (1) to determine the change in gross regional welfare, employment and demand for goods and services, (2) to measure the changes of regional household incomes and distribution of income between household groups, and (3) to measure the change of regional household welfare.

6.2 PROCEDURES

The actual data of Texas County shows that output of the Meat Packing sector increased up to 30-fold and the output of Hog Product increased up to 78-fold from 1993 to 1997. The main reason for this expansion was the investments that attracted Seaboard Farms to Texas County. However, the changes may also be caused by other factors such as the investment of other industries, or other production conditions not specified. The Regional CGE model was used to isolate the impacts of Seaboard Farms from other factors that affected the Texas County economy.

The Regional CGE model was developed based on the Social Accounting Matrix (SAM) of Texas County of base year 1993 generated by IMPLAN database and software. The 528 industrial sectors (classified by IMPLAN) were aggregated into 11 sectors. The institution agents were classified as households, governments, enterprises, capital account, and inventory. The households were classified into three groups based on household income: Low-income households with annual income less than 15 thousand dollars; Medium-income households with annual income from 15 thousand dollars to 50 thousand dollars; and High-income households with annual income more than 50 thousand dollars. Governments were disaggregated into Federal Government, and State/local government. The IMPLAN value-added was converted into conventional primary factors of production (Labor, Capital, and Land). Labor was aggregated into one labor skill. Land is used by only two sectors (Feed Grains, and Other Crops). The composite commodities demanded by industrial sectors and institutions were disaggregated into regionally produced commodities and imported commodities based on Regional Purchase Coefficients (RPC). For each commodity, the same Regional

Purchase Coefficients (RPC) were used to disaggregate both the intermediate inputs used by industrial sectors and the final goods consumed by institutions.

The features of the basic Regional CGE model are as follows: (1) Production functions of industrial sectors consisting of two levels to allow different elasticities of substitution between inputs. The Leontief technology was employed at the first level that does not allow composite input substitution. The Cobb-Douglas production function was employed at the second level to describe the relationship between Value-added and primary factor inputs. The elasticity of substitution between factors in this relationship is equal to one. (2) The commodity outputs were assumed differentiated between regional supply and export by the constant elasticity of transformation (CET) function. (3) The regionally produced commodities and imported commodities were assumed imperfect substitutes and followed the constant elasticity of substitution (CES) relationship. (4) Household commodities consumption was constructed at two levels. The first level follows the simple Linear Expenditure System (LES) to specify the household demand for composite commodities. The second level follows the constant elasticity of substitution (CES) relationship to specify the regional and imported commodity quantities. (5) Composite commodities consumed by governments were fixed; however, the regional and imported commodity quantities were specified by the constant elasticity of substitution (CES) relationship. (6) Quantities of composite investment commodities were proportionate to the capital used by industrial sectors, and the regional and imported commodity quantities were specified by the constant elasticity of substitution (CES) relationship. (7) Inventory commodities were proportionate to the industry output. (8) Labor was assumed to be mobile between sectors and between regions. The change of labor supply was assumed to be caused by labor migration that was perfectly elastic. (9) Capital was fixed between industrial sectors in the short-run and was mobile between industrial sectors and migrated in or out-of-region depending on the ratio of regional capital rent to out-of-region capital rent in the long-run. (10) Land was fixed within sectors in both the short-run and long-run. (11) Trade between region and out-of-region were assumed to follow the rule of "small country". That means the amount of traded commodities were insufficient to change the commodity prices of out-of-region markets. (12) Households received factor compensations proportionately to the fixed shares of factor ownerships, and received fixed transfer payment from governments. (13) Governments received taxes at fixed rates.

The simulated regional CGE model was used to identify the impacts of Seaboard Farm on Texas County economy. The simulated regional CGE model was constructed based on the basic regional CGE model with modifications as follows: (1) Output of Hog Product sector and Meat Packing sector did not follow the constant elasticity of transformation (CET) relationship. All output of Hog Product was locally processed. Output of Meat Packing sector was exported after leaving a small amount for regional consumption. (2) Commodities purchased by Seaboard Farms follow its own contracts, therefore, the proportion of regionally produced commodities used by Seaboard Farms were specified by its own Regional Purchase Coefficients (RPC). (3) Capital was divided into two markets. Capital for the hog complex was mobile in both the short-run and long-run, and supply of its capital market was perfectly elastic. Capital for non-hog sectors was fixed in the short-run, and mobile between sectors in the long-run. Elasticity of capital migration for non-hog capital market was 0.92.

The mixed exogenous/endogenous variables CGE model was used to simulate the operation of Seaboard Farms such that the output of Meat Packing sector was specified at a level of 10 times its initial level in the short-run and 30 times its initial level in the long-run. The long-run output level is the actual output of Meat Packing sector in 1997. Output of other sectors, commodity consumption, commodity prices and factor prices were endogenously specified by the equilibriums conditions of the model.

6.3 SUMMARY OF RESULTS

In The Short-Run

The expansion of Meat Packing sector to 10 times its initial output caused the output of Hog Product sector to expand to 11.54 times. The changes of output of other industrial sectors were small (from 1 to 6 percent) because capital was not allowed to be adjusted. Laborers from outside in-migrated to the region and equaled 10.47 percent of the initial region labor supply. These households earned $10.73 million labor income. The expenditure of in-migrated households was $10.41 million. Because commodity prices increased most commodities demanded by households decreased except for necessary goods such as Oil and Gas, Other Livestock, Other Manufacture, and Services increased from 0.3 to 3.5 percent. These increments caused by the consumption of in-migration of laborers.

The Gross Regional Product (GRP) increased 7.21 percent. The Regional Expenditure (RE) increased 3.36 percent. The indirect business tax increased 8.33percent. Export increase 8.11 percent. Employment increased 10.47%.

The incomes of regional households increased very little (less than 1 percent) because the wage rate does not increase. On the other side, the commodity prices increased from 0.1 to 11 percent (while incomes did not increase) causing $1.64 million loss of total welfare of regional households. The welfare losses (measured by Compensating Variation, CV) corresponding to household income groups are $527,000, $239,000, and $872,000 for low-income, medium-income and high-income group, respectively.

In The Long-Run

The expansion of Meat Packing sector (30 times its initial output) and the flexibility of capital adjustment of industrial sectors in the long-run caused changes in the economy different from the changes in the short-run. The output of Hog Product sector expanded 35 times because demand for its output increased significantly by the expansion of Meat Packing. On the other side, output of other livestock sector significantly decreased (47%) because of the competition with Hog Product sector on intermediate inputs (Feeds Grains, and Other Crops). The output of Prepared Feed sector reduced 13% because demand for its output was decreased because of the reduction of the output of Other Livestock sector. Outputs of other sectors expanded because of the increased demands for their outputs as intermediate inputs and as final goods.

The laborers from outside in-migrating to the region increased 24.77 percent of initial region labor supply, and earned $25.39 million in labor income. The larger number of new laborers in-migrated into the region significantly increased demand for final goods. For instance, household demand for Other Prepared Foods was 3.08 times (compared with 0.99 in the short-run) causing this sector to expand 8 times. Household demand for Oil and Gas increased 35 percent (compared with 3 percent in the short-run), causing this sector to expand 41 percent.

The Gross Regional Product (GRP) increased 11.48 percent. The Regional Revenue (RE) increased 6.42 percent. The indirect business tax increased 9.55 percent. Employment increased 24.77 percent. Export decreased 9.24 percent.

The incomes of regional households slightly decreased (less than 1 percent) because of the decrease in capital rent (4.3 percent). However, the prices of commodities such as Oil and Gas Product, Prepared Foods, and Services slightly decreased causing the increment of regional household welfare to increase $1.28 million. The welfare gains (measure by Compensating Variation, CV) corresponding to household income groups are $261,000, $472,000, and $533,000 for low-income, medium-income and high-income group, respectively.

6.4 CONCLUSIONS

Based on the results of simulated models, some conclusions are drawn as follows:

(1) The operation of Seaboard Farms increased the measures of regional welfare such as Gross Regional Product (GRP) and Regional Expenditure (RE) and indirect business tax in both production periods (long-run and short-run).

(2) Employment in the region increased and labor easily in-migrated from out-of-region. The operation of Seaboard does not increase incomes of regional households in both periods.

(3) In the short-run, the commodity price increases causes loss of household welfare. In the long-run, commodity price decreases because of the adjustment of industrial

sector gains causes the regional household welfare to increase. Household welfare increased the most for high-income, somewhat less for medium-income, and least for low-income.

(4) Income of in-migrated households is higher than the welfare increments of regional households. However, almost all of this income was spent in the region, and in turn, contributed to the development of the regional economy.

(5) Given that environmental impacts were not included, the estimated welfare gain is a points of comparison for future studies.

6.5. LIMITATIONS AND FURTHER STUDY

(1) The study based on the data generated by IMPLAN that some parameters such as regional purchase coefficient (RPC) included in IMPLAN were employed to generate data for the regional level. Therefore the data generated by this process may not be realistic for the region. In addition, the elasticity of substitution parameters at the national level were employed to calibrate parameters estimated by the model. This may be another source of error.

(2) It is possible that concentrated hog production may cause impacts on the environment, positive and negative. However, this factor was not included in the model because of insufficient data. Because of the absence of environment factors, there may be an over-estimate of the positive impacts of Seaboard Farms on the regional economy.

(3) The in-migration of new laborers into the region may be a burden of the regional community such as pressure on elementary school, crime and other social problems

may increase when population is more crowded. This impact was not included in the model. There may also be positive impacts such as improved cultural diversity.

(4) Amount of traded some commodities in some sectors may be sufficient to affect exported commodity prices. The model did not incorporate this situation.

(5) By using Cobb-Douglas production functions, the elasticities of substitution of all industrial sectors are set equal to one. This constrains producers to change the ratio of factor inputs when relative factor prices change.

For further study, an attempt should be made to have additional data at regional level to make the following modifications of the model:

(a) Use the necessary regional information in addition with the IMPLAN data to generate the SAM that more closely approximates the monetary flows of the regional economy.

(b) Incorporate environmental factors into the CGE model.

(c) Include the export demand equations of commodities that may affect export prices.

(d) Use constant elasticity of substitution production function with corresponding elasticity of substitution for each industrial sector instead of the Cobb-Douglas function.

(e) Concern about the impacts of in-migrated households on the regional communities should be addressed.

(f) Sensitivity analysis could be conducted to better evaluate the estimates of this initial study.

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APPENDIX A

SAM OF TEXAS COUNTY, OKLAHOMA, 1993

SAM OF TEXAS, OK 1993
(Thousand dollars)

	1. Industry								
	01HP	02OL	03FG	04OC	05OG	06CN	07MP	08PF	09OP
1. Industry									
01 Hogs Products									
02 Other Livestock									
03 Feed Grains									
04 All Other Crops									
05 Oil Gas and Prod									
06 Construction									
07 Meat Packing									
08 Prepared Feeds									
09 Other Prep Foods									
10 Other Manuf									
11 Services									
subtotal									
2. Commodity									
01 Hogs Products	1,176.2	0.0	37.5	16.5	0.0	0.0	581.4	0.0	0.5
02 Other Livestock	12.9	64,202.4	742.0	308.1	0.0	0.0	0.1	1.8	105.7
03 Feed Grains	315.6	8,648.2	76.9	0.0	0.0	0.0	0.0	67.8	0.7
04 All Other Crops	224.9	2,893.7	20.4	55.4	0.0	0.0	0.0	41.8	2.9
05 Oil Gas and Pro	36.3	1,796.6	397.5	358.8	17,421.8	1,616.1	3.3	17.9	4.9
06 Construction	40.1	10,807.1	999.7	912.4	788.8	216.1	0.2	44.8	11.7
07 Meat Packing	0.3	246.7	0.0	0.0	0.1	0.0	14.9	1.9	12.1
08 Prepared Feeds	13.8	1,086.8	0.0	1.7	0.0	0.0	0.0	17.7	0.0
09 Other Prep Foo	0.8	22.6	0.0	0.2	0.0	0.0	0.1	45.2	0.4
10 Other Manuf	18.9	3,194.1	774.3	687.4	361.0	2,328.1	2.6	188.6	21.9
11 Services	1,289.8	63,887.4	3,755.5	5,421.6	2,378.0	8,986.8	95.9	1,011.8	98.9
subtotal	*3,129.5*	*156,785.5*	*6,803.6*	*7,762.1*	*20,949.7*	*13,147.1*	*698.4*	*1,439.2*	*259.7*
3. Factors									
Labor	0.7	233.4	4.0	2.6	10,332.5	8,634.4	80.6	791.7	220.4
Capital	129.6	44,860.0	447.7	286.1	11,455.0	6,706.2	14.2	237.8	210.9

SAM OF TEXAS, OK 1993
(Thousand dollars)

	1. Industry								
	01HP	02OL	03FG	04OC	05OG	06CN	07MP	08PF	09OP
Land	0.0	0.0	1,929.5	1,233.0	0.0	0.0	0.0	0.0	0.0
Ind Bus Taxes	19.4	5,850.0	395.4	228.2	1,884.7	122.5	8.4	67.4	4.0
subtotal	*149.6*	*50,943.4*	*2,776.6*	*1,749.8*	*23,672.2*	*15,463.1*	*103.2*	*1,096.9*	*435.3*
4. Institution									
Enterprises									
Low-Income hh									
Med-Income hh									
High-Income hh									
Fed gov									
St&Local gov									
Capital									
Inventory									
subtotal									
5. Import									
01 Hogs Products	38.6	0.0	0.7	0.3	0.0	0.0	249.2	0.0	0.0
02 Other Livestock	0.6	1,898.1	21.9	9.1	0.0	0.0	0.0	0.1	3.1
03 Feed Grains	473.4	85,369.5	758.7	0.0	0.0	0.0	0.0	1,104.7	7.1
04 All Other Crops	337.4	81,815.5	577.1	1,566.9	0.0	0.0	0.0	824.2	83.2
05 Oil Gas and Pro	4.0	405.8	89.8	81.0	3,934.9	365.0	0.4	37.2	1.1
06 Construction	40.1	1,924.0	178.0	162.4	140.4	38.5	1.9	0.0	2.1
07 Meat Packing	0.0	455.2	0.0	0.0	0.2	0.0	0.0	0.2	22.3
08 Prepared Feeds	461.5	98,190.2	0.0	154.6	0.0	0.0	0.0	590.7	0.0
09 Other Prep Foo	53.7	12,980.0	0.0	85.3	10.0	0.0	3.6	3,217.3	204.3
10 Other Manuf	141.8	19,396.4	4,701.7	4,174.4	2,191.8	14,137.4	19.5	1,414.4	133.1
11 Services	0.0	63,071.8	3,707.5	5,352.4	2,347.7	8,872.1	0.0	1,469.2	97.6
subtotal	*1,551.0*	*365,506.2*	*10,035.4*	*11,586.4*	*8,625.0*	*23,413.0*	*274.6*	*8,658.0*	*553.9*
COLUMN TOTAL	*4,830.1*	*573,235.1*	*19,615.6*	*21,098.3*	*53,246.9*	*52,023.2*	*1,076.1*	*11,194.1*	*1,248.9*

SAM OF TEXAS, OK 1993
(Thousand dollars)

			Total	**2. Commodity**					
	10OM	11SV	**Industry**	01HP	02OL	03FG	04OC	05OG	06CN
1. Industry									
01 Hogs Products				1,296.8	0.0	0.0	0.0	0.0	0.0
02 Other Livestock				0.0	64,237.0	0.0	0.0	0.0	0.0
03 Feed Grains				0.0	0.0	6,920.3	0.0	0.0	0.0
04 All Other Crops				0.0	0.0	0.0	2,448.3	0.0	0.0
05 Oil Gas and Pro				0.0	0.0	0.0	0.0	30,106.6	0.0
06 Construction				0.0	0.0	0.0	0.0	0.0	51,961.1
07 Meat Packing				0.0	0.0	0.0	0.0	0.0	0.0
08 Prepared Feeds				0.0	0.0	0.0	0.0	0.0	0.0
09 Other Prep Foo				0.0	0.0	0.0	0.0	0.0	0.0
10 Other Manuf				0.0	0.0	0.0	0.0	0.0	0.0
11 Services				0.0	0.0	0.0	0.0	0.0	0.0
subtotal				*1,296.8*	*64,237.0*	*6,920.3*	*2,448.3*	*30,106.6*	*51,961.1*
2. Commodity									
01 Hogs Products	0.3	0.1	1,812.4						
02 Other Livestock	4.2	54.2	65,431.3						
03 Feed Grains	0.0	0.0	9,109.2						
04 All Other Crops	4.1	5.6	3,248.8						
05 Oil Gas and Pro	336.9	1,498.1	23,488.0						
06 Construction	493.4	9,023.3	23,337.5						
07 Meat Packing	4.8	81.7	362.5						
08 Prepared Feeds	0.0	0.1	1,120.1						
09 Other Prep Foo	0.1	3.9	*73.0*						
10 Other Manuf	1,290.3	1,641.6	*10,508.8*						
11 Services	1,883.3	27,831.4	*116,640.4*						
subtotal	*4,017.3*	*40,139.8*	*255,131.9*						
3. Factors									
Labor	4,844.2	96,438.1	*121,582.5*						
Capital	565.3	50,503.3	*115,416.0*						

SAM OF TEXAS, OK 1993
(Thousand dollars)

	10OM	11SV	**Total Industry**	**2. Commodity** 01HP	02OL	03FG	04OC	05OG	06CN
Land	0.0	0.0	*3,162.5*						
Ind Bus Taxes	197.4	21,786.9	*30,564.2*						
subtotal	*5,606.9*	*168,728.3*	*270,725.2*						
4. Institution									
Enterprises				0.0	0.0	0.0	0.0	0.0	0.0
Low-Income hh				0.0	0.0	0.0	0.0	0.0	0.0
Med-Income hh				0.0	0.0	0.0	0.0	0.0	0.0
High-Income hh				0.0	0.0	0.0	0.0	0.0	0.0
Fed gov				0.0	0.0	0.0	0.0	26.2	0.0
St&Local gov				0.0	0.0	0.0	0.0	13.6	0.0
Capital				0.0	0.0	0.0	0.0	0.0	0.0
Inventory				515.6	1,347.8	2,190.1	856.5	205.2	0.0
subtotal				*515.6*	*1,347.8*	*2,190.1*	*856.5*	*245.0*	*0.0*
5. Import									
01 Hogs Products	0.0	0.0	*288.8*						
02 Other Livestock	0.1	1.6	*1,934.7*						
03 Feed Grains	0.0	0.0	*87,713.4*						
04 All Other Crops	115.0	157.9	*85,477.1*						
05 Oil Gas and Pro	76.1	338.4	*5,333.6*						
06 Construction	87.8	1,606.4	*4,181.6*						
07 Meat Packing	8.9	150.7	*637.4*						
08 Prepared Feeds	0.1	6.4	*99,403.4*						
09 Other Prep Foo	25.9	2,214.9	*18,795.0*						
10 Other Manuf	7,835.3	9,968.7	*64,114.4*						
11 Services	1,859.2	27,476.1	*114,253.5*						
subtotal	*10,008.4*	*41,921.0*	*482,132.8*						
COLUMN TOTAL	*19,632.6*	*250,789.1*		*1,812.4*	*65,584.7*	*9,110.5*	*3,304.8*	*30,351.6*	*51,961.1*

SAM OF TEXAS, OK 1993
(Thousand dollars)

	07MP	08PF	09OP	10OM	11SV	**Total Commod**	**3. Factors** Labor	Capital
1. Industry								
01 Hogs Products	0.0	0.0	0.0	0.0	0.0	*1,296.8*		
02 Other Livestock	0.0	0.0	0.0	0.0	0.0	*64,237.0*		
03 Feed Grains	0.0	0.0	0.0	0.0	0.0	*6,920.3*		
04 All Other Crops	0.0	0.0	0.0	0.0	0.0	*2,448.3*		
05 Oil Gas and Pro	0.0	0.0	0.0	0.0	0.0	*30,106.6*		
06 Construction	0.0	0.0	0.0	0.0	0.0	*51,961.1*		
07 Meat Packing	978.0	0.0	0.0	0.0	0.0	*978.0*		
08 Prepared Feeds	0.0	1,112.8	0.0	0.0	0.0	*1,112.8*		
09 Other Prep Foo	0.0	0.0	63.0	0.0	0.0	*63.0*		
10 Other Manuf	0.0	0.0	0.0	16,683.9	0.0	*16,683.9*		
11 Services	0.0	0.0	0.0	0.0	243,003.6	*243,003.6*		
subtotal	*978.0*	*1,112.8*	*63.0*	*16,683.9*	*243,003.6*	*418,811.2*		
2. Commodity								
01 Hogs Products								
02 Other Livestock								
03 Feed Grains								
04 All Other Crops								
05 Oil Gas and Pro								
06 Construction								
07 Meat Packing								
08 Prepared Feeds								
09 Other Prep Foo								
10 Other Manuf								
11 Services								
subtotal								
3. Factors								
Labor								
Capital								

SAM OF TEXAS, OK 1993
(Thousand dollars)

	07MP	08PF	09OP	10OM	11SV	**Total Commod**	**3. Factors** Labor	Capital
Land								
Ind Bus Taxes								
subtotal								
4. Institution								
Enterprises	0.0	0.0	0.0	0.0	0.0	*0.0*	0.0	29,657.7
Low-Income hh	0.0	0.0	0.0	0.0	631.6	*631.6*	7,485.8	6,987.3
Med-Income hh	0.0	0.0	0.0	0.0	1,711.8	*1,711.8*	43,652.0	27,726.1
High-Income hh	0.0	0.0	0.0	0.0	2,465.9	*2,465.9*	51,092.2	34,802.4
Fed gov	0.0	0.0	0.0	0.0	34.7	*60.9*	16,048.9	-11,005.7
St&Local gov	0.0	0.0	35.2	24.6	9,967.0	*10,040.4*	3,303.5	3,841.1
Capital	0.0	0.0	0.0	0.0	1,632.6	*1,632.6*	0.0	23,009.8
Inventory	0.0	8.1	4.1	70.6	243.9	*5,441.8*	0.0	0.0
subtotal	*0.0*	*8.1*	*39.3*	*95.1*	*16,687.5*	*21,985.0*	*121,582.5*	*115,018.6*
5. Import								
01 Hogs Products								
02 Other Livestock								
03 Feed Grains								
04 All Other Crops								
05 Oil Gas and Pro								
06 Construction								
07 Meat Packing								
08 Prepared Feeds								
09 Other Prep Foo								
10 Other Manuf								
11 Services								
subtotal							*0.0*	*397.4*
COLUMN TOTAL	*978.0*	*1,120.8*	*102.3*	*16,779.0*	*259,691.1*		*121,582.5*	*115,416.0*

SAM OF TEXAS, OK 1993
(Thousand dollars)

	Land	IBTax	**Total Factors**	**4. Institution** Enterprise	LOW hh	MED hh	HIG hh	Fed gov	S/L gov
1. Industry									
01 Hogs Products									
02 Other Livestock									
03 Feed Grains									
04 All Other Crops									
05 Oil Gas and Pro									
06 Construction									
07 Meat Packing									
08 Prepared Feeds									
09 Other Prep Foo									
10 Other Manuf									
11 Services									
subtotal									
2. Commodity									
01 Hogs Products				0.0	0.0	0.0	0.0	0.0	0.0
02 Other Livestock				0.0	25.3	41.5	70.9	0.0	8.1
03 Feed Grains				0.0	0.3	0.2	0.5	0.0	0.3
04 All Other Crops				0.0	14.1	12.9	27.4	0.0	1.6
05 Oil Gas and Pro				0.0	1,468.0	1,483.6	3,213.3	0.0	658.8
06 Construction				0.0	0.0	0.0	0.0	351.6	9,140.9
07 Meat Packing				0.0	158.4	134.5	296.2	0.0	24.7
08 Prepared Feeds				0.0	0.2	0.2	0.3	0.0	0.0
09 Other Prep Foo				0.0	7.3	7.0	14.5	0.0	0.6
10 Other Manuf				0.0	1,041.8	1,567.7	2,754.4	0.0	533.9
11 Services				0.0	25,310.2	34,347.9	62,595.2	1,017.1	17,911.2
subtotal				*0.0*	*28,025.4*	*37,595.3*	*68,972.7*	*1,368.6*	*28,280.2*
3. Factors									
Labor									
Capital									

SAM OF TEXAS, OK 1993
(Thousand dollars)

			Total	4. Institution					
	Land	IBTax	**Factors**	Enterprise	LOW hh	MED hh	HIG hh	Fed gov	S/L gov
Land									
Ind Bus Taxes									
subtotal									
4. Institution									
Enterprises	0.0	0.0	*29,657.7*	0.0	0.0	0.0	0.0	0.0	0.0
Low-Income hh	157.3	0.0	*14,630.5*	35.0	0.0	0.0	0.0	25,652.3	267.7
Med-Income hh	1,581.1	0.0	*72,959.1*	305.5	0.0	0.0	0.0	13,719.9	1,556.2
High-Income hh	1,254.4	0.0	*87,149.0*	95.3	0.0	0.0	0.0	52,637.8	538.6
Fed gov	169.7	6,668.2	*11,881.1*	9,445.8	1,211.0	14,725.0	13,497.0	0.0	0.0
St&Local gov	0.0	23,896.1	*31,040.7*	1,353.5	743.0	4,565.0	4,613.0	10,654.8	0.0
Capital	0.0	0.0	*23,009.8*	18,422.6	0.0	0.0	0.0	30,760.5	0.0
Inventory	0.0	0.0	*0.0*	0.0	0.0	0.0	0.0	0.0	0.0
subtotal	*3,162.5*	*30,564.2*	*270,327.9*	*29,657.7*	*1,954.0*	*19,290.0*	*18,110.0*	*133,425.3*	*2,362.6*
5. Import									
01 Hogs Products				0.0	0.0	0.0	0.0	0.0	0.0
02 Other Livestock				0.0	0.1	0.1	0.2	0.0	0.0
03 Feed Grains				0.0	0.2	2.2	4.7	0.0	0.0
04 All Other Crops				0.0	28.8	26.2	55.8	0.0	0.0
05 Oil Gas and Pro				0.0	331.6	335.1	725.8	0.0	0.0
06 Construction				0.0	0.0	0.0	0.0	39.8	22.8
07 Meat Packing				0.0	292.2	248.2	546.4	0.0	0.0
08 Prepared Feeds				0.0	15.6	13.5	29.3	0.0	0.0
09 Other Prep Foo				0.0	4,217.6	4,002.9	8,328.7	0.0	0.0
10 Other Manuf				0.0	6,326.1	9,519.5	16,726.0	0.0	0.0
11 Services				0.0	24,987.0	33,909.4	61,796.1	464.1	540.0
subtotal	*0.0*	*0.0*	*397.4*	*0.0*	*36,199.1*	*48,057.0*	*88,213.0*	*503.8*	*562.8*
COLUMN TOTAL	*3,162.5*	*30,564.2*		*29,657.7*	*66,178.5*	*104,942.3*	*175,295.6*	*135,297.7*	*31,205.6*

SAM OF TEXAS, OK 1993
(Thousand dollars)

	Invest	Inventory	Total Instit	Exports	ROW TOTAL
1. Industry					
01 Hogs Products				3,533.3	*4,830.1*
02 Other Livestock				508,998.2	*573,235.1*
03 Feed Grains				12,695.2	*19,615.6*
04 All Other Crops				18,650.0	*21,098.3*
05 Oil Gas and Pro				23,140.3	*53,246.9*
06 Construction				62.1	*52,023.2*
07 Meat Packing				98.1	*1,076.1*
08 Prepared Feeds				10,081.3	*11,194.1*
09 Other Prep Foo				1,185.8	*1,248.9*
10 Other Manuf				2,948.7	*19,632.6*
11 Services				7,785.5	*250,789.1*
subtotal				*589,178.7*	
2. Commodity					
01 Hogs Products	0.0	0.0	*0.0*		*1,812.4*
02 Other Livestock	0.0	7.6	*153.4*		*65,584.7*
03 Feed Grains	0.0	0.0	*1.3*		*9,110.5*
04 All Other Crops	0.0	0.1	*56.0*		*3,304.8*
05 Oil Gas and Pro	12.9	27.2	*6,863.6*		*30,351.6*
06 Construction	19,131.2	0.0	*28,623.6*		*51,961.1*
07 Meat Packing	0.0	1.7	*615.5*		*978.0*
08 Prepared Feeds	0.0	0.0	*0.7*		*1,120.8*
09 Other Prep Foo	0.0	0.0	*29.3*		*102.3*
10 Other Manuf	356.5	16.0	*6,270.2*		*16,779.0*
11 Services	1,437.0	432.2	*143,050.7*		*259,691.1*
subtotal	*20,937.5*	*484.6*	*185,664.3*		
3. Factors					
Labor					*121,582.5*
Capital					*115,416.0*

SAM OF TEXAS, OK 1993
(Thousand dollars)

	Invest	Inventory	**Total Instit**	**ROW Exports**	**TOTAL**
Land					*3,162.5*
Ind Bus Taxes					*30,564.2*
subtotal					
4. Institution					
Enterprises	0.0	0.0	*0.0*	0.0	*29,657.7*
Low-Income hh	11,790.3	0.0	*37,745.3*	13,171.1	*66,178.5*
Med-Income hh	4,101.8	0.0	*19,683.4*	10,588.0	*104,942.3*
High-Income hh	7,571.6	0.0	*60,843.4*	24,837.3	*175,295.6*
Fed gov	0.0	0.0	*38,878.8*	84,477.0	*135,297.7*
St&Local gov	20,937.5	0.0	*42,866.8*	-52,742.4	*31,205.6*
Capital	0.0	0.0	*49,183.0*	17,413.6	*91,239.0*
Inventory	18,908.0	0.0	*18,908.0*	-23,332.0	*1,017.8*
subtotal	*63,309.2*	*0.0*	*268,108.7*	74,412.5	
5. Import					
01 Hogs Products	0.0	0.0	*0.0*		*288.8*
02 Other Livestock	0.0	0.0	*0.3*		*1,935.0*
03 Feed Grains	0.0	0.0	*7.1*		*87,720.5*
04 All Other Crops	0.0	0.1	*111.0*		*85,588.1*
05 Oil Gas and Pro	2.9	6.1	*1,401.4*		*6,735.0*
06 Construction	3,405.9	0.0	*3,468.5*		*7,650.1*
07 Meat Packing	0.0	3.1	*1,089.9*		*1,727.3*
08 Prepared Feeds	0.0	0.0	*58.3*		*99,461.7*
09 Other Prep Foo	0.0	0.0	*16,549.1*		*35,344.1*
10 Other Manuf	2,164.7	97.1	*34,833.5*		*98,947.9*
11 Services	1,418.7	426.7	*123,541.9*		*237,795.4*
subtotal	*6,992.2*	*533.2*	*181,061.1*		
COLUMN TOTAL	*91,238.9*	*1,017.8*			

APPENDIX B

GAMS PROGRAMS FOR THE CGE MODEL

```
* Filename: CGE_GAMS.TXT
* Main program for CGE model of Texas County, Oklahoma.
*
*-----------------------------------------------------
* using data TEXAS 1993
* Simulated model, two markets for capital
*-----------------------------------------------------

$TITLE CGE MODEL FOR TEXAS COUNTY 1993
$OFFSYMLIST OFFSYMXREF OFFUPPER

* -- SET DECLARATION
SETS
i   Industry sectors   /01HP  Hogs Products
                        02OL  All Other Livestock
                        03FG  Feed Grains
                        04OC  All Other Crops
                        05OG  Oil Gas and Products
                        06CN  Construction
                        07MP  Meat Packing Plants
                        08PF  Prepared Feeds
                        09OP  All Other Prepared Foods
                        10OM  All Other Manufacturing
                        11SV  Services /

cr(i)   Crop sectors   /03FG  Feed Grains
                        04OC  All Other Crops /

ncr(i)  Non-crop sectors  /01HP Hogs Products
                           02OL All Other Livestock
                           05OG Oil Gas and Products
                           06CN Construction
                           07MP Meat Packing Plants
                           08PF Prepared Feeds
                           09OP All Other Prepared Foods
                           10OM All Other Manufacturing
                           11SV Services /

hog(i)  Hog complex sectors  /01HP  Hogs Products
                              07MP  Meat Packing Plants      /

non_hog(i)  Non-hog sectors  /02OL   All Other Livestock
                              03FG   Feed Grains
                              04OC   All Other Crops
                              05OG   Oil Gas and Products
                              06CN   Construction
                              08PF   Prepared Feeds
                              09OP   All Other Prepared Foods
                              10OM   All Other Manufacturing
                              11SV   Services                 /

ied(i)        Sectors with export demand equation
iedn(i)       Sectors without export demand equation
```

```
fa                    /L    Labor
                       K    Capital
                       T    Land
                       IBT  Indirect business tax /

f(fa)                 /L    Labor
                       K    Capital
                       T    Land    /

fl(f)   Factors no land / L, K/

n       Institutions   /ENT       Enterprises (Corporations)
                        LOW       Households-Low Income
                        MED       Households-Medium Income
                        HIG       Households-High Income
                        FEG       Federal Government
                        SLG       State-Local Govt
                        CAP       Capital
                        INVT      Inventory         /

g(n)       Governments    /FEG, SLG/
h(n)       Households     /LOW, MED, HIG /
hl(h)      Low hh         /LOW/
hmh(h)     med hig hh     /Med, HIG/;

ALIAS(i,j);
ALIAS(j,j1);
ALIAS(n,n1);
ALIAS(h,h1);
ALIAS(g,g1);

* -- PARAMETER DECLARATION

PARAMETERS

*@Price block
  PL0            Wage rate
  PLROW0         Wage rate of rest-of-world
  PKROW0         Cap rate of rest-of-world
  PK0(i)         cap rate
  PK10           average capital rate
  PKL0           long run capital rate
  PT0(cr)        Land rent
  PE0(i)         Export price
  PM0(i)         Import price
  PR0(i)         Reg price
  P0(i)          Composite price
  PN0            Net output price or value-added price of sector i
  PX0(i)         Composite price face for producers

*@Production block
  L0(i)          Labor demand
  K0(i)          capital demand
  T0(i)          Land demand
  LH0(h)         Labor employed by household group
  LGOV0(g)       Labor employed by gov
  LExo0          Exogenous employment
```

```
  LS0(h)          Labor supply by hh
  TLS0            Total labor supply
  KS0             Supply of pri capital
  TKS0            Total pri capital supply
  TS0             Supply of land
  VA0(i)          Value added
  INTR0(j,i)      Reg int good demand
  INTM0(j,i)      Imported int good demand
  INT0(j,i)       Composite intermediate good demand
  TINT0(i)        Composite intermediate good total demand
  TINTR0(i)       Reg int good total demand
  TINTM0(i)       Imported int good total demand
  TotINT0(i)      Total intermediate good used by industry
  IBT0(i)         Indirect business taxes
  R0(i)           Reg supply of reg product by industry
  E0(i)           Export of reg product
  X0(i)           Sector output
  M0(i)           Import
  instsell0(i) Institution sell

*@Income block
  LY0             Labor income
  NLY0(h)         Net labor income
  KY0             capital income
  NKY0            Net capital income
  TY0             Land income
  NTY0(h)         Net Land income
  FY2H0(h,f)      Factor income distributed to hh
  FY2GOV0(g,fa)   Factor income distributed to gov
  FY2ENT0(f)      Factor income distributed to enterprise
  FY2CAP0(f)      Factor income distributed to cap
  K2ROW0           Capital compensation to ROW
  ENTK0           initial stock of enterprise capital
  HK0(h)          initial stock of hh capital
  ENTY0           Gross Enterprise income
  HENTY0(h)       Enterprise income distributed to hh
  GENTY0(g)       Enterprise income distributed to gov
  CENTY0          Enterprise income distributed to capital account
  HSELL0(h,i)     hh sell commodity
  GOVSELL0(g,i)   gov sell commodity
  CAPSELL0(i)     calpital sell commodity
  INVTSELL0(i)    inventory sell commodity
  GOV2GOV0(g,gl)  Inter-Gov transfer
  GOV2H0(h,g)     Gov transfer to hh
  GOV2ENT0(g)     Gov subsidy for enterprise
  H2H0(h,hl)      Inter-hh transfer
  ENT2H0(h)       Enterprise income distrib to hhs
  INV2H0(h)       Investment income distrib to hhs
  HTAX0(g,h)      hh tax
  ENTTAX0(g)      Enterprise tax
  INVTAX0(g)      Investment tax
  HSAV0(h)        Household saving
  GOVSAV0(g)      Gov saving
  RETENT0         Retain earning from interprise
  INV2INVT0       Investment to intervantion
  REMIT0(h)       Remittance from outside the region to household
  ROW2GOV0(g)     ROW to gov
```

```
  ROWSAV0         Saving from ROW
  ROWENT0         Enterprise income from ROW
  ROWINVT0        ROW intervention
  GHY0(h)         Household income
  DHY0(h)         Disposable hh income
  SAV0            Total saving (cap account)
  INVEST0         Investment
  ROWSAV0         Saving from rest-of-world
  GOVR0(g)        Government revenue
  GRP0            Gross regional product
  YINVT0          Inventory income
  IBTX0(g)        Indirect business tax by gov
  RE0             Initial regional expenditure
  RGRP0           Initial real GRP
  isellshr(n,i)   institution share of sell
  instshr_f(n,fa) institution share of factor income
  k2rowrate       portion of K compensation to ROW
  cap2invtr       capital to inventory
  cap2hr(h)       capital to hh rate
  invexpr(i)      cap good expenditure rate
  invtexr(i)      intervention good expenditure rate

*@Expenditure block
  INSTEXPD0(n)    Total institution expenditure
  HEXP0(h)        Household expend
  QR0(i,h)        Demand for reg consump good
  QM0(i,h)        Demand for imp consump good
  Q0(i,h)         Demand for comp consump good
  TQR0(i)         Total Demand for reg consump good
  TQM0(i)         Total Demand for imp consump good
  TQ0(i)          Total Demand for comp consump good
  QGOVR0(i,g)     government demand for reg good
  QGOVM0(i,g)     government demand for imported good
  QGOV0(i,g)      government demand for comp good
  TQGOVR0(i)      Total government demand for reg good
  TQGOVM0(i)      Total government demand for imported good
  TQGOV0(i)       Total government demand for comp good
  GOVEXP0(g)      government expenditure
  QInvR0(i)       Invest demand for reg good
  QInvM0(i)       Invest demand for imported good
  QInv0(i)        Invest demand for comp good
  QInvtR0(i)      Intervention demand for reg good
  QInvtM0(i)      Intervention demand for imported good
  QInvt0(i)       Intervention demand for comp good
```

```
*The following variables are defined as  "logical variables". A logical
*variable takes the value of 1 if the condition stated is true and "0"
*if not.

*--------------------------------------------------------
* Regional      x  x  0  0     0=zero, x=not zero
* Import        x  0  x  0
*
* NZV           T  F  F  F     T=True, F=False
* ZVR           F  F  T  F
* ZVM           F  T  F  T
*--------------------------------------------------------

  ZINTM(i,J)
  ZINTR(i,J)
  NZINT(i,J)
  ZQM(i,h)
  ZQR(i,h)
  NZQ(i,h)
  ZGOVM(i,g)
  ZGOVR(i,g)
  NZGOV(i,g)
  ZInvM(i)
  ZInvR(i)
  NZInv(i)
  ZInvtM(i)
  ZInvtR(i)
  NZInvt(i)
  ZE(i)      sector without export
  NZE(i)     sector with export

*#####-- DECLARATION OF PARAMETERS TO BE CALIBRATED.

PARAMETERS

*@Production block
  a0(i)           composite value added req per unit of output i
  a1(i)           industry input-output coefficient
  a(j,i)          req of interm good j per unit of good i
  Alpha(i,f)      value added share param
  Ava(i)          value added shift param
  RHOint(i)       interm input subs param
  DELTAint(j,i)   interm input share param
  Aint(j,i)       interm input shift param
  RHOx(i)         output transformation param
  DELTAx(i)       output share param
  Ax(i)           output shift param
  RHOe(i)         elasticity of export demand
  Ae(i)           export demand shift parameter

*@Income block
  ltax(g)         factor income tax rate for labor
  ktax(g)         capital tax rate
  ttax(g)         factor income tax rate for land
  retr            rate of retained earnings fr ent inc
  etax(g)         enterprise tax rate
  invtaxrate(g)   investment tax rate
```

```
  htax(g,h)       income tax rate for hh
  htrrate(h,h1)   Household Income Transfer Coefficient
  inv2hrate(h)    rate of investment to hh
  hs(h)           hh saving rate
  ibtax(i)        indirect business tax
  ibt2gov(g)      rate of ibt to gov
  beta(i,h)       param calc fr elast of comm demand wrt inc
  h_entshr(h)     share of ent income dist to hh
  g_entshr(g)     share of ent income dist to gov
  c_entshr        share of ent income dist to capital account
  insttrrate(n,n1) rate of inter-institution transfer
  ldist(h)        distribution of net labor income

*@Expenditure block
  RHOq(i)         consumer demand subs param
  DELTAq(i,h)     consumer demand share param
  Aq(i,h)         consumer demand constant eff param
  RHOgov(i)       gov demand subs param
  DELTAgov(i,g)   gov demand share param
  Agov(i,g)       gov demand constant eff param
  RHOinv(i)       inv demand subs param
  DELTAinv(i)     inv demand share param
  Ainv(i)         inv demand constant eff param
  RHOinvt(i)      intervention demand subs param
  DELTAinvt(i)    intervention demand share param
  Ainvt(i)        intervention demand constant eff param
  ;

* DATA ASSIGNMENT
* Read data from external file

$include "h:\dxe_cge\tx93c.dat";

* --- Econometric parameters

TABLE ParamA(*,i) Elasticity of substitution
           01HP     02OL     03FG     04OC     05OG     06CN
SIGMAxc    1.42     1.42     1.42     1.42     0.50     0.50
SIGMAint   1.42     1.42     1.42     1.42     0.50     0.50
SIGMAx     3.90     3.90     3.90     3.90     2.90     2.90
SIGMAq     1.42     1.42     1.42     1.42     0.50     0.50
SIGMAgov   1.42     1.42     1.42     1.42     0.50     0.50
SIGMAinv   1.42     1.42     1.42     1.42     0.50     0.50
SIGMAinvt  1.42     1.42     1.42     1.42     0.50     0.50
*SIGMAe     0.00     3.00     3.0      3.0
SIGMAe

+          07MP     08PF     09OP     10OM     11SV
SIGMAxc    3.55     3.55     3.55     3.55     2.00
SIGMAint   3.55     3.55     3.55     3.55     2.00
SIGMAx     2.90     2.90     2.90     2.90     0.70
SIGMAq     3.55     3.55     3.55     3.55     2.00
SIGMAgov   3.55     3.55     3.55     3.55     2.00
SIGMAinv   3.55     3.55     3.55     3.55     2.00
SIGMAinvt  3.55     3.55     3.55     3.55     2.00
*SIGMAe     0.00     3.00     3.00
SIGMAe;
```

```
SCALAR KMOBIL      Capital MOBILITY            /    0.0    /;
SCALAR Small     Small number for lower bounds / 0.0000001   /;
Scalar Etal Labor imgration elasticity /0.92/;
Scalar Etak Cap imgration elasticity for non_hog /0.92/;
Scalar Etak1 Cap imgration elasticity hog /0.92/;
Scalar out_rate /1/;

* --- ASSIGN PARAMETER VALUES

*@Price block
  PL0       =1;
  PLROW0    =1;
  PKROW0    =1;
  PK0(i)    =1;
  PT0(cr)   =1;
  PE0(i)    =1;
  PM0(i)    =1;
  PR0(i)    =1;
  PX0(i)    =1;
  P0(i)     =1;
  PKL0      =1;
  PK10      =1;

* -- Production block
  L0(i)         =FI("L",i);
  K0(i)         =FI("K",i);
  T0(i)         =FI("T",i);
  VA0(i)        =sum(f,FI(f,i));
  INTR0(j,i)    =CI(j,i);
  INTM0(j,i)    =MI(j,i);
  INT0(j,i)     =INTM0(j,i)+INTR0(j,i);
  TINTR0(i)     =sum(j,INTR0(i,j));
  TINTM0(i)     =sum(j,INTM0(i,j));

  TINT0(i)      =TINTM0(i)+TINTR0(i);
  TotINT0(i)    =sum(j,INTR0(j,i))+sum(j1,INTM0(j1,i));
  IBT0(i)       =FI("IBT",i);
  IBTX0(g)      =NF(g,"IBT");
  LH0(h)        =0;
  LGOV0(g)      =0;
  LExo0         =sum(h,LH0(h))+sum(g,LGOV0(g));
  FY2H0(h,f)    =NF(h,f);
  TLS0          = (Sum(i,FI("L",i)) + LExo0);
  ldist(h)      = FY2H0(h,"L")/sum(h1,FY2H0(h1,"L"));
  LS0(h)        =TLS0*ldist(h);
  KS0(i)        =K0(i);
  TS0(i)        =T0(i);
  TKS0          =sum(i,KS0(i)) ;

* -- Income block
  LY0              =sum(i,FI("L",i))+sum(h,LH0(h))+sum(g,LGOV0(g));
  KY0              =Sum(i,K0(i));
  TY0              =Sum(i,T0(i));
  INSTSELL0(i)     =sum(n,NC(n,i));
  HSELL0(h,i)      =NC(h,i);
  GOVSELL0(g,i)    =NC(g,i);
```

```
CAPSELL0(i)       =NC("CAP",i);
INVTSELL0(i)      =NC("INVT",i);
FY2GOV0(g,fa)     =NF(g,fa);
FY2ENT0(f)        =NF("ENT",f);
FY2CAP0(f)        =NF("CAP",f);
K2ROW0            =MF("K");
GOV2H0(h,g)       =NN(h,g);
GOV2ENT0(g)       =NN("ENT",g);
H2H0(h,h1)        =NN(h,h1);
ENT2H0(h)         =NN(h,"ENT");
INV2H0(h)         =NN(h,"CAP");
HTAX0(g,h)        =NN(g,h);
GOV2GOV0(g,g1)    =NN(g,g1);
ENTTAX0(g)        =NN(g,"ENT");
INVTAX0(g)        =NN(g,"CAP");
INV2INVT0         =NN("INVT","CAP");
HSAV0(h)          =NN("CAP",h);
GOVSAV0(g)        =NN("CAP",g);
RETENT0           =NN("CAP","ENT");
REMIT0(h)         =NX(h);
ROW2GOV0(g)       =NX(g);
ROWSAV0           =NX("CAP");
ROWINVT0          =NX("INVT");
ROWENT0           =NX("ENT");
GHY0(h)           =sum(i,HSELL0(h,i))+sum(f,FY2H0(h,f))
                   +sum(h1,H2H0(h,h1))+sum(g,GOV2H0(h,g))
                   +ENT2H0(h)+INV2H0(h)+REMIT0(h);
DHY0(h)           =GHY0(h)-sum(g,NN(g,h));
SAV0              =sum(i,CAPSELL0(i))+sum(f,FY2CAP0(f))+RETENT0
                   +sum(h,HSAV0(h))+sum(g,GOVSAV0(g))+ROWSAV0;
ENTY0             =sum(f,FY2ENT0(f));
GOVR0(g)          =sum(i,GOVSELL0(g,i))+sum(f,FY2GOV0(g,f))
                   +sum(h,HTAX0(g,h))+IBTX0(g)+sum(g1,GOV2GOV0(g,g1))
                   +ENTTAX0(g)+INVTAX0(g)+ROW2GOV0(g);
HEXP0(h)          =DHY0(h)-HSAV0(h)-sum(h1,H2H0(h1,h));
IBT0(i)           = FI("IBT",i);
GRP0              =LY0+KY0+TY0+sum(i,IBT0(i));
YINVT0            =sum(i,INVTSELL0(i))+INV2INVT0+ROWINVT0;

* -- Expenditure block
QR0(i,h)       =CN(i,h);
QM0(i,h)       =MN(i,h);
Q0(i,h)        =QM0(i,h)+QR0(i,h);
TQR0(i)        =sum(h,QR0(i,h));
TQM0(i)        =sum(h,QM0(i,h));
TQ0(i)         =sum(h,Q0(i,h));
QGOVR0(i,g)    =CN(i,g);
QGOVM0(i,g)    =MN(i,g);
QGOV0(i,g)     =QGOVM0(i,g)+QGOVR0(i,g);
TQGOVR0(i)     =Sum(g,QGOVR0(i,g));
TQGOVM0(i)     =Sum(g,QGOVM0(i,g));
TQGOV0(i)      =TQGOVR0(i)+TQGOVM0(i);
GOVEXP0(g)     =sum(i,QGOVR0(i,g))+sum(i,QGOVR0(i,g));
QINVR0(i)      =CN(i,"CAP");
QINVM0(i)      =MN(i,"CAP");
QINV0(i)       =QINVM0(i)+QINVR0(i);
QINVTR0(i)     =CN(i,"INVT");
```

```
  QINVTM0(i)     =MN(i,"INVT");
  QINVT0(i)      =QINVTM0(i)+QINVTR0(i);
  R0(i)          =sum(j,IC(i,j));
  M0(i)          =TINTM0(i)+sum(h,QM0(i,h))+sum(g,QGOVM0(i,g))+QinvM0(i)
                  +QinvtM0(i);
  X0(i)          =sum(j,CI(j,i))+sum(fa,FI(fa,i))+sum(j,MI(j,i));
  E0(i)          =IX(i);
  RE0            =sum(h,HEXP0(h))+sum(i,sum(g,QGOV0(i,g))
                  +QINV0(i)+QINVT0(i));
  INVEST0        = sum(i,QINV0(i))+sum(h,INV2H0(h))+sum(g,INVTAX0(g))
                   +INV2INVT0;
  RGRP0          = sum(i,sum(h,Q0(i,h))+sum(g,QGOV0(i,g))+QINV0(i)
                   +QINVT0(i)+E0(i)-M0(i));

*--------------------------------------------------------
* Regional       x  x  0  0     0=zero, x=not zero
* Import         x  0  x  0

* NZV            T  F  F  F     T=True, F=False
* ZVR            F  F  T  F
* ZVM            F  T  F  T
*--------------------------------------------------------
  ZINTM(i,j)     =(INTM0(i,j) eq 0);
  ZINTR(i,j)     =(INTR0(i,j) eq 0) and (INTM0(i,j) ne 0);
  NZINT(i,j)     =(INTR0(i,j) ne 0) and (INTM0(i,j) ne 0);
  ZQM(i,h)       =(QM0(i,h) eq 0);
  ZQR(i,h)       =(QR0(i,h) eq 0) and (QM0(i,h) ne 0);
  NZQ(i,h)       =(QR0(i,h) ne 0) and (QM0(i,h) ne 0);
  ZGOVM(i,g)     =(QGOVM0(i,g) eq 0);
  ZGOVR(i,g)     =(QGOVR0(i,g) eq 0)and (QGOVM0(i,g) ne 0);
  NZGOV(i,g)     =(QGOVR0(i,g) ne 0) and (QGOVM0(i,g) ne 0);
  ZInvM(i)       =(QInvM0(i) eq 0);
  ZInvR(i)       =(QInvR0(i) eq 0) and (QInvM0(i) ne 0);
  NZInv(i)       =(QInvR0(i) ne 0) and (QInvM0(i) ne 0);
  ZInvtM(i)      =(QInvtM0(i) eq 0);
  ZInvtR(i)      =(QInvtR0(i) eq 0) and (QInvtM0(i) ne 0);
  NZInvt(i)      =(QInvtR0(i) ne 0) and (QInvtM0(i) ne 0);
  NZE(i)         = (E0(i) ne 0);
  ZE(i)          = (E0(i) eq 0);
  RHOe(i)        =ParamA("SIGMAe",i);
  Ae(i)          =E0(i);
  ied(i)         = yes$RHOe(i);
  iedn(i)        = not ied(i);

*#############################################################*
*                                                             *
*                   PARAMETER CALIBRATION                     *
*                                                             *
*#############################################################*

*#####-- CALIBRATION

*@Production block

  a0(i)             =VA0(i)/X0(i);
  a1(i)             =TotINT0(i)/X0(i);
  a(j,i)            =INT0(j,i)/X0(i);
```

```
  alpha(cr,"L")      =FI("L",cr)/VA0(cr);
  alpha(cr,"K")      =FI("K",cr)/VA0(cr);
  alpha(cr,"T")      =FI("T",cr)/VA0(cr);
  alpha(ncr,"L")     =FI("L",ncr)/VA0(ncr);
  alpha(ncr,"K")     =FI("K",ncr)/VA0(ncr);
  Ava(cr)            =VA0(cr)/Prod(f,FI(f,cr)**alpha(cr,f));
  Ava(ncr)           =VA0(ncr)/PROD(fl,FI(fl,ncr)**alpha(ncr,fl));

* Intermediate input
  RHOint(i)=1/ParamA("SIGMAint",i)-1;
  DELTAint(j,i)$NZINT(j,i) = 1/((INTR0(j,i)/INTM0(j,i))
                              **(1+RHOint(j))+1);
  Aint(j,i)$NZINT(j,i) = INT0(j,i)/(DELTAint(j,i)*INTM0(j,i)
                         **(-RHOint(j))+(1-DELTAint(j,i))
                         *INTR0(j,i)**(-RHOint(j)))**(-1/RHOint(j));
* Market outlet for regional output
  RHOx(i)             =1/ParamA("SIGMAx",i)+1;
  DELTAx(i)$NZE(i)  =1/((E0(i)/R0(i))**(RHOx(i)-1)+1);
  Ax(i)$NZE(i)        =X0(i)/(DELTAx(i)*E0(i)**RHOx(i)+
                       (1-DELTAx(i))*R0(i)**RHOx(i))**(1/RHOx(i));
*@Income block
  ltax(g)            =FY2GOV0(g,"L")/LY0;
  ktax(g)            =FY2GOV0(g,"K")/KY0;
  ttax(g)            =FY2GOV0(g,"T")/TY0;
  retr               =RETENT0/ENTY0;
  etax(g)            =ENTTAX0(g)/ENTY0;
  invtaxrate(g)      =INVTAX0(g)/SAV0;
  htax(g,h)          =HTAX0(g,h)/GHY0(h);
  htrrate(h,h1)      =H2H0(h,h1)/GHY0(h1);
  inv2hrate(h)       =INV2H0(h)/SAV0;
  hs(h)              =HSAV0(h)/GHY0(h);
  ibtax(i)           =IBT0(i)/X0(i);
  ibt2gov(g)         =FY2GOV0(g,"IBT")/sum(g1,FY2GOV0(g1,"IBT"));
  instexpd0(n)       =sum(i,CN(i,n))+sum(n1,NN(n1,n))+ sum(i,MN(i,n));
  insttrrate(n,n1)=NN(n,n1)/instexpd0(n1);
  isellshr(n,i)$(INSTSELL0(i) ne 0) = NC(n,i)/INSTSELL0(i);
  isellshr(n,i)$(INSTSELL0(i) eq 0) = 0;
  instshr_f(n,fa) =NF(n,fa)/sum(i,FI(fa,i));
  k2rowrate          =K2ROW0/sum(i,FI("K",i));
  cap2invtr          =INV2INVT0/SAV0;
  cap2hr(h)          =INV2H0(h)/SAV0;
  invexpr(i)         =QINV0(i)/SAV0;
  invtexr(i)         =QINVT0(i)/X0(i);
  h_entshr(h)        =ENT2H0(h)/ENTY0;
  g_entshr(g)        =ENTTAX0(g)/ENTY0;
  c_entshr           =RETENT0/ENTY0;

*@Expenditure block
* ---- hh expenditure
  beta(i,h)          =Q0(i,h)*P0(i)/HEXP0(h);
  RHOq(i)            =1/ParamA("SIGMAq",i)-1;
  DELTAq(i,h)$NZQ(i,h) =1/((QR0(i,h)/QM0(i,h))**(1+RHOq(i))+1);
  Aq(i,h)$NZQ(i,h)       =Q0(i,h)/(DELTAq(i,h)*QM0(i,h)**(-RHOq(i))
                          +(1-DELTAq(i,h))*QR0(i,h)**(-RHOq(i)))**(-
1/RHOq(i));
* ---- gov expenditure
  RHOgov(i)              =1/ParamA("SIGMAgov",i)-1;
```

```
  DELTAgov(i,g)$NZGOV(i,g)=1/((QGOVR0(i,g)/QGOVM0(i,g))
                              **(1+RHOgov(i))+1);
  Agov(i,g)$NZGOV(i,g)=QGOV0(i,g)/(DELTAgov(i,g)*QGOVM0(i,g)
                        **(-RHOgov(i))+(1-DELTAgov(i,g))*QGOVR0(i,g)
                        **(-RHOgov(i)))**(-1/RHOgov(i));
* ---- investment expenditure
  RHOinv(i)             = 1/ParamA("SIGMAinv",i)-1;
  DELTAinv(i)$NZINV(i)= 1/((QINVR0(i)/QINVM0(i))**(1+RHOinv(i))+1);
  Ainv(i)$NZINV(i)  = QINV0(i)/(DELTAinv(i)*QINVM0(i)**(-RHOinv(i))
                      +(1-DELTAinv(i))*QINVR0(i)**(-RHOinv(i)))
                      **(-1/RHOinv(i));
PN0(i)       =(1-ibtax(i))*PX0(i)-sum(j,A(j,i)*P0(j));
NLY0(h)      =LY0*instshr_f(h,"L");
NKY0         =KY0 *(PK10-sum(g,ktax(g)));
NTY0(h)      =TY0*instshr_f(h,"T");
ENTK0        =FY2ENT0("K");
HK0(h)       =NF(h,"K");
HENTY0(h)    =h_entshr(h)*ENTY0;
GENTY0(g)    =g_entshr(g)*ENTY0;
CENTY0       =c_entshr*ENTY0;

*###########################################################*
*                                                           *
*      VARIABLE DECLARATION                                 *
*                                                           *
*###########################################################*

VARIABLES

*@Price block
  PL                 Wage rate
  PK(i)              Capital rate
  PK1                Average Capital rate
  PKL                Long run Capital rate for non_hog
  PKL1               Long run Capital rate for hog
  PKhog              Capital rate for hog complex
  PT(cr)             Land rent
  PN(i)              Net price
  PR(i)              Regional price
  P(i)               Composite price
  PX(i)              Composite price faced by consumers
  PE(i)              Export price
*@Production block
  LAB(i)             Labor demand
  CAP(i)             Capital demand
  LAND(cr)           Land demand
  LMIG               Labor migration
  LMIGH(h)           Labor migration of hh group
  KMIG               Capital migration
  KMIG1              Capital migration for non_hog
  KMIG2              Capital migration for hog
  VA(i)              Value added
  INT(j,i)           Composite intermediate good demand
  INTM(j,i)          Imported int good demand
  INTR(j,i)          Reg int good demand
  R(i)               Regional supply
  X(i)               Output
```

```
  E(i)                Export
  M(i)                Import

*@Income block
  LY                  Labor income (original hhs)
  KY                  capital income (original capital stock)
  TY                  Land income
  ENTK                ent cap stock
  HKY(h)              capital compensation to hh
  K2ROW               K compensation to ROW
  ENTY                Gross Enterprise income
  HENTY(h)            hh income from enterprise
  HLY(h)              labor compensation to regional hh
  HTY(h)              land compensation to regional hh
  HOY(h)              other hh income
  IMHLY               immigrated labor income
  GHY(h)              hh income including immigrated hh
  GOVR(g)             gov revenue
  INVEST              investment expenses
  SAV                 Total saving
  RGRP                real GRP
  GOVSAV(g)           gov saving
  ROWSAV              foreign saving
  aLMIG               adjustment for labor out-migration
  aLMIGH(h)           adjustment for labor out-migration classify by hh
  aKMIG               adjustment for cap out-migration
  adjL(h)             adjust for labor migration
  adjK                adjust for capital migration
*### Expenditure block
  HEXP                household expenditure
  Q(i,h)              Demand for comp consump good
  QM(i,h)             Demand for imp consump good
  QR(i,h)             Demand for reg consump good
  QGOV(i,g)           gov demand for comp good
  QGOVM(i,g)          gov demand for imported good
  QGOVR(i,g)          gov demand for reg good
  QINV(i)             Invest demand for comp good
  QINVM(i)            Invest demand for imported good
  QINVR(i)            Invest demand for reg good
  QINVT(i)            Intervention demand for comp good

POSITIVE VARIABLE PL, PK, PKL, PKL1, PKhog, PT, PR, P, LAB, CAP, LAND,
VA, V, VR, VM, X, R, E, Q, QR, QM, QGOV, QGOVR, QGOVM, QINV, QINVR,
QINVM, QINVT, LY, adjL, KY, TY, ENTK, ENTY, RETENT, GHY, HEXP, M ;

*############################################################*
*                                                            *
*      EQUATION DECLARATION                                  *
*                                                            *
*############################################################*

EQUATIONS

*@Price block
  NETprice(i)       net price
  Price(i)          composite commodity  price
  Price1(i)         composite output  price
```

```
  Price2(i)        export fix price
  PK_eq            Average capital rate in sohrt-run
  PK1_eq           Average capital rate in long-run

**@Production block
  Ldemand(i)         labor demand
  KdemandSR(non_hog) capital demand short-run
  KdemandLR(non_hog) capital demand long-run
  KdemandLR1(hog)    capital demand long-run
  Tdemand(cr)        land demand
  VAdemand(i)        value added demand
  Vdemand(j,i)       intermediate demand
  VAprod1(ncr)       value added prod fc
  VAprod2(cr)        value added prod fc
  Vces(j,i)          ces fc for int demand
  VRdem(j,i)         demand for reg int good
  VRdem1(j,i)
  VRDem2(j,i)
  VMdem1(j,i)
  VMDem2(j,i)
  Xcet(non_hog)      cet fc for reg product
  Rsupply(non_hog)   reg supply of reg product
  Rsupply1           reg supply of reg product
  Rsupply2           reg supply of reg product
  Rsupply3           reg supply of reg product
  Rsupply4           reg supply of reg product
  Edemand            export demand
  LMIGrat            labor migration
  LMIGrat1(h)        labor migration of low income hh group
  aLMIG_eq(h)        adjustment for labor out-migration
  KMIGrat            capital migration
  KMIGrat1           capital migration
  KMIGrat2           capital migration
  KMIGrat3           capital migration
  aKMIG_eq           adjustment for cap out-migration
  adjK_eq            adjustment for cap out-migration

**@Income block
  LYincome          labor income
  KYincomeSR        capital income
  KyincomeLR        capital income
  TYincome          land income
  HKY_eq(h)         hh capital income
  ENTK_eq           ent cap stock
  ENTY_eq           enterprise income
  HENTY_eq(h)       household income from enterprise
  HKY_eq(h)         capital compensation to hh
  HLY_eq(h)         labor compensation to hh
  HTY_eq(h)         land compensation to hh
  HOY_eq(h)         other hh income
  GHY_eq(h)         household income
  GHY_eq1(h)        household income
  IMHLY_eq          immigrated hh labor income
  SAV_eq            total savings
  GOVR_eq(g)        gov revenue
  INVEST_eq         investment expenses
  RGRP_eq           real GRP
```

```
**@Expenditure block
  HEXPend(h)          household expenditure
  Qdemand(i,h)        commodity demand by hh
  Qces                ces fc for consumption
  QRdem               cons demand for reg goods
  QRdem1
  QRdem2
  QMdem1
  QMdem2
  QGOVces             ces for st and loc gov demand
  QGOVdemand          st and loc gov cons
  QGOVRdem            st and loc gov reg cons
  QGOVRDem1
  QGOVRDem2
  QGOVMDem1
  QGOVMDem2
  QINVces             ces for invest demand
  QINVdem             invest cons
  QINVRdem            invest reg cons
  QInvRdem1
  QInvRdem2
  QInvMdem1
  QInvMdem2
  QINVTdem            interventioncons
  Mimports(i)         import

**@Equilibrium
  COMMequil(i)        comm market equilibrium
  Lequil              labor market equilibrium
  Kequil(non_hog)     cap market equilibrium
  Kequil1             cap market equilibrium
  Kequil2             cap market equilibrium
  Tequil(cr)          land market equilibrium
  GOVBL_eq(g)         gov budget balance
  SI_BL_eq            sav invest balance
  TRADEBL_eq          trade balance
;

*##########################################################*
*                                                          *
*      EQUATION DEFINITION                                 *
*                                                          *
*##########################################################*

*@Production block
Ldemand(i)..  LAB(i) =e= alpha(i,"L")*PN(i)*X(i)/PL;
KdemandSR(non_hog)$(Not Kmobil).. CAP(non_hog) =e= alpha(non_hog,"K")
                             *PN(non_hog)*X(non_hog)/PK(non_hog);
KdemandLR(non_hog)$(Kmobil).. CAP(non_hog) =e= alpha(non_hog,"K")
                             *PN(non_hog)*X(non_hog)/PKL;
KdemandLR1(hog).. CAP(hog) =e= alpha(hog,"K")
                          *PN(hog)*X(hog)/PKL1;
Tdemand(cr)..     LAND(cr) =e= alpha(cr,"T") *PN(cr)*X(cr)/PT(cr);
VAdemand(i)..     VA(i)    =e= a0(i)*X(i);
VAprod1(ncr)..    VA(ncr)  =e=
Ava(ncr)*LAB(ncr)**alpha(ncr,"L")*CAP(ncr)**
                          alpha(ncr,"K");
```

```
VAprod2(cr)..      VA(cr)    =e= Ava(cr)*LAB(cr)**alpha(cr,"L")*CAP(cr)**
                                  alpha(cr,"K")*LAND(cr)**alpha(cr,"T");
Vdemand(j,i)..     INT(j,i) =e= a(j,i)*X(i);
Vces(j,i) $NZINT(j,i).. INT(j,i)=e=Aint(j,i)*(DELTAint(j,i)
                            *INTM(j,i) **(-RHOint(j))+(1-DELTAint(j,i))
                            *INTR(j,i)**(-RHOint(j)))**(-1/RHOint(j));
VRdem(j,i)$NZINT(j,i).. INTM(j,i) =e= INTR(j,i)*((1-DELTAint(j,i))
                          /DELTAint(j,i)*PM0(j)/PR(j))
                          **(-1/(1+RHOint(j)));
VRdem1(j,i)$ZINTM(j,i)..  INTR(j,i) =e= INT(j,i);
VMdem1(j,i)$ZINTM(j,i)..  INTM(j,i) =e= 0;
VRdem2(j,i)$ZINTR(j,i)..  INTR(j,i) =e= 0;
VMdem2(j,i)$ZINTR(j,i)..  INTM(j,i) =e= INT(j,i);
Xcet(non_hog).. X(non_hog)=e=Ax(non_hog)*(DELTAx(non_hog)
                       *E(non_hog)**RHOx(non_hog)
                       +(1-DELTAx(non_hog))*R(non_hog)**RHOx(non_hog))
                       **(1/RHOx(non_hog));
Rsupply(non_hog).. E(non_hog)=e=R(non_hog)*((1-DELTAx(non_hog))
                          /DELTAx(non_hog)*PE(non_hog)/PR(non_hog))
                          **(1/(RHOx(non_hog)-1));
Rsupply1..  E("01HP") =e= 0;
Rsupply2..  R("01HP") =e= X("01HP");
Rsupply3..  X("07MP") =e= X0("07MP")*out_rate;
Rsupply4..  E("07MP") =e= X("07MP")-R("07MP");
Edemand(ied).. E(ied) =e= Ae(ied)*(PE(ied)/PE0(ied))**(-RHOe(ied));
Mimports(i)..  M(i)   =e= sum(j,INTM(i,j))+sum(h,QM(i,h))
                          +sum(g,QGOVM(i,g))+QINVM(i);
** Commodity markets
Qdemand(i,h)..        Q(i,h)=e=beta(i,h)*HEXP(h)/P(i);
Qces(i,h)$NZQ(i,h).. Q(i,h)=e=Aq(i,h)*(DELTAq(i,h)*QM(i,h)**(-RHOq(i))
                             +(1-DELTAq(i,h))*QR(i,h)**(-RHOq(i)))
                             **(-1/RHOq(i));
QRdem(i,h)$NZQ(i,h).. QM(i,h)=e=QR(i,h)*((1-DELTAq(i,h))/DELTAq(i,h)
                               *PM0(i)/PR(i))**(-1/(1+RHOq(i)));
QRdem1(i,h)$ZQM(i,h).. QR(i,h)=e=Q(i,h);
QMdem1(i,h)$ZQM(i,h).. QM(i,h)=e=0;
QRdem2(i,h)$ZQR(i,h).. QR(i,h)=e=0;
QMdem2(i,h)$ZQR(i,h).. QM(i,h)=e=Q(i,h);
QGOVdemand(i,g)..      QGOV(i,g)=e=QGOV0(i,g);
QGOVces(i,g)$NZGOV(i,g).. QGOV(i,g)=e=Agov(i,g)*(DELTAgov(i,g)
                            *QGOVM(i,g)**(-RHOgov(i))+(1-DELTAgov(i,g))
                            *QGOVR(i,g)**(-RHOgov(i)))**(-1/RHOgov(i));
QGOVRdem(i,g)$NZGOV(i,g).. QGOVM(i,g) =e=QGOVR(i,g)*((1-DELTAgov(i,g))
                             /DELTAgov(i,g)*PM0(i)/PR(i))
                             **(-1/(1+RHOgov(i)));
QGOVRdem1(i,g)$ZGOVM(i,g)..   QGOVR(i,g) =e= QGOV(i,g);
QGOVMdem1(i,g)$ZGOVM(i,g)..   QGOVM(i,g) =e= 0;
QGOVRdem2(i,g)$ZGOVR(i,g)..   QGOVR(i,g) =e= 0;
QGOVMdem2(i,g)$ZGOVR(i,g)..   QGOVM(i,g) =e= QGOV(i,g);
QINVdem(i)..          QINV(i)=e= adjK*QINV0(i);
QINVces(i)$NZInv(i).. QINV(i)=e= Ainv(i)*(DELTAinv(i)*QINVM(i)
                         **(-RHOinv(i))+(1-DELTAinv(i))*QINVR(i)
                         **(-RHOinv(i)))**(-1/RHOinv(i));
QINVRdem(i)$NZInv(i)..  QINVM(i) =e= QINVR(i)*((1-DELTAinv(i))
                         /DELTAinv(i)*PM0(i)/PR(i))
                         **(-1/(1+RHOinv(i)));
QinvRdem1(i)$ZINVM(i)..   QinvR(i) =e= Qinv(i);
```

```
QinvMdem1(i)$ZINVM(i)..    QinvM(i) =e= 0;
QinvRdem2(i)$ZINVR(i)..    QinvR(i) =e= 0;
QinvMdem2(i)$ZINVR(i)..    QinvM(i) =e= Qinv(i);
QINVTdem(i)..              QINVT(i) =e= invtexr(i)*X(i);

* Factor markets
LMIGrat..       LMIG       =e= etaL*sum(h,LS0(h))*LOG(PL/PLROW0);
LMIGrat1(h)..   LMIGH(h)   =e= ldist(h)*LMIG;
LYincome..      LY         =e= PL*(sum(i,LAB(i))+sum(h,LH0(h))
                                +sum(g,LGOV0(g)));
KYincomeSR$(not kmobil).. KY =e= PKL1*sum(hog,CAP(hog))
                            +sum(non_hog,PK(non_hog)*CAP(non_hog));
KYincomeLR$(kmobil)..      KY =e= PKL1*sum(hog,CAP(hog))
                                  +PKL*sum(non_hog, CAP(non_hog));
KMIGrat$(KMobil)..         KMIG1 =e= etaK*(SUM(non_hog,K0(non_hog))
                                     *LOG(PKL/PKROW0));
KMIGrat1$(not KMobil)..    KMIG1 =e= 0;
KMIGrat2..       KMIG2 =e= etaK1*(SUM(hog,K0(hog))*LOG(PKL1/PKROW0));
KMIGrat3..       KMIG  =e= KMIG1+KMIG2;
TYincome..       TY    =e= sum(cr,PT(cr)*LAND(cr));
aLMIG_eq(h)..    aLMIGH(h) =e= (SQRT(LMIGH(h)*LMIGH(h))
                               -LMIGH(h))*0.5/sum(h1,LS0(h1));
aKMIG_eq..  aKMIG =e= (SQRT(KMIG1*KMIG1)-KMIG1)*0.5/sum(i,KS0(i));
adjK_eq..   adjK  =e= (sum(i,KS0(i))+KMIG)/sum(i,KS0(i));

* Institution accounts
ENTK_eq..       ENTK =e= sum(i,CAP(i))*instshr_f("ENT","K");
ENTY_eq..       ENTY =e= PK1*ENTK;
HENTY_eq(h)..  HENTY(h)=e=(1-aLMIGH(h))*(1-aKMIG)*h_entshr(h)*PK1*ENTK0;
HKY_eq(h)..    HKY(h)   =e=(1-aLMIGH(h))*((1-aKMIG)*PK1+
                          aKMIG*PKROW0)*HK0(h);
HLY_eq(h)..    HLY(h)=e=(1-sum(g,ltax(g)))*PL*(LS0(h)
                        -(SQRT(LMIGH(h)*LMIGH(h))-LMIGH(h))*0.5);
IMHLY_eq..     IMHLY =e=(1-sum(g,ltax(g)))*PL
                      *(SQRT(LMIG*LMIG)+LMIG)*0.5;
HTY_eq(h)..    HTY(h)=e=(1-aLMIGH(h))*TY*instshr_f(h,"T");
HOY_eq(h)..    HOY(h)=e=(1-aLMIGH(h))*(INV2H0(h)+REMIT0(h)
                     + sum(g,GOV2H0(h,g)))+sum(i,PX(i)*HSELL0(h,i));
GHY_eq(hl)..   GHY(hl)=e=HLY(hl)+IMHLY+HKY(hl)
                      +HTY(hl)+HENTY(hl)+HOY(hl);
GHY_eq1(hmh).. GHY(hmh)=e=HLY(hmh)+HKY(hmh)+HTY(hmh)
                        +HENTY(hmh)+HOY(hmh);
HEXPend(h)..    HEXP(h)=e=GHY(h)*(1-sum(h1,htrrate(h1,h))
                       -sum(g,htax(g,h))-hs(h))-(1-aLMIG)*PL*LH0(h);
SAV_eq..        SAV =e= sum(i,PX(i)*isellshr("CAP",i)*INSTSELL0(i))
                      + KY*instshr_f("CAP","K")+ sum(h,hs(h)*GHY(h))
                      + sum(g,GOVSAV(g))+ c_entshr *ENTY+ROWSAV;
GOVR_eq(g).. GOVR(g)=e=sum(i,PX(i)*isellshr(g,i)*INSTSELL0(i))
                      +ltax(g)*LY+ktax(g)*KY+ttax(g)*TY
                      +ibt2gov(g)*sum(i,ibtax(i)*PX(i)*X(i))
                      +sum(h,htax(g,h)*GHY(h))+sum(g1,GOV2GOV0(g,g1))
                      +etax(g)*ENTY+invtaxrate(g)*INVEST+ROW2GOV0(g);
INVEST_eq..  (1-sum(g,invtaxrate(g))-cap2invtr)*INVEST
              -sum(h,(1-aLMIGH(h))*INV2H0(h))=e= sum(i,P(i)*QINV(i));
RGRP_eq..    RGRP =e= sum(i,sum(h,Q(i,h))+sum(g,QGOV0(i,g))
                     +QINV(i)+QINVT(i)+E(i)-M(i));
```

```
*@Price block
NETprice(i)..    PN(i)       =e= PX(i)-sum(j,A(j,i)*P(j))-ibtax(i)*PX(i);
Price(i)..       P(i)        =e= (PR(i)*(R(i)+INSTSELL0(i))+PM0(i)*M(i))
                                 /(R(i)+M(i)+INSTSELL0(i));
Price1(i)..      PX(i)       =e= (PR(i)*R(i)+PE(i)*E(i))/(R(i)+E(i));
Price2(iedn)..   PE(iedn)    =e= 1;
PK_eq$(not KMobil)..   PK1 =e= (PKL1*sum(hog,CAP(hog))
                                 +sum(non_hog,PK(non_hog)*CAP(non_hog)))
                                 /sum(i,CAP(i));
PK1_eq$(KMobil).. PK1   =e= (PKL1*sum(hog,CAP(hog))
                             +PKL*sum(non_hog,CAP(non_hog)))
                             /sum(i,CAP(i));
**@Equilibrium
COMMequil(i).. X(i)+INSTSELL0(i)+M(i) =e= sum(j,INT(i,j))+sum(h,Q(i,h))
                   +sum(g,QGOV(i,g))+QINV(i)+QINVT(i)+E(i);
Lequil..         sum(i,LAB(i))+sum(h,LH0(h))+sum(g,LGOV0(g))
                   =e= sum(h,LS0(h))+LMIG;
Kequil(non_hog)$(not KMobil).. CAP(non_hog) =e= KS0(non_hog);
Kequil1$(KMobil).. Sum(non_hog,CAP(non_hog)) =e=
                   Sum(non_hog,KS0(non_hog))+KMIG1;
Kequil2..  Sum(hog,CAP(hog))=e= Sum(hog,KS0(hog))+KMIG2;
Tequil(cr)..  LAND(cr)=e= T0(cr);
GOVBL_eq(g).. GOVR(g) =e= sum(i,P(i)*QGOV0(i,g))+PL*LGOV0(g)
                +sum(g1,GOV2GOV0(g1,g))
                +sum(h,(1-aLMIGH(h))*GOV2H0(h,g))+GOVSAV(g);
SI_BL_eq..     SAV    =e= INVEST;
TRADEBL_eq..   sum(i,PM0(i)*M(i))+K2ROW =e=sum(i,PE(i)*E(i))
                +sum(h,REMIT0(h))+sum(g,ROW2GOV0(g))+ROWSAV+ROWINVT0;

* ======= end of equations declaration ==================

*#######################################################*
*                                                       *
*      VARIABLE BOUNDS                                  *
*                                                       *
*#######################################################*

  PL.LO                              = 0.000001;
  PT.LO(cr)                          = 0.000001;
  PK.LO(i)                           = 0.000001;
  PR.LO(i)                           = 0.000001;
  PN.LO(i)                           = 0.000001;
  P.LO(i)                            = 0.000001;
  R.LO(i)                            = 0.000001;
  PX.LO(i)                           = 0.000001;
  QM.LO(i,h)$(QM0(i,h) ne 0)         = 0.000001;
  QR.LO(i,h)$(QR0(i,h) ne 0)         = 0.000001;
  Q.LO(i,h)$(Q0(i,h) ne 0)           = 0.000001;
  QM.LO(i,h)$(QM0(i,h) eq 0)         = 0;
  QR.LO(i,h)$(QR0(i,h) eq 0)         = 0;
  Q.LO(i,h)$(Q0(i,h) eq 0)           = 0;
  QM.UP(i,h)$(QM0(i,h) eq 0)         = 0;
  QR.UP(i,h)$(QR0(i,h) eq 0)         = 0;
  Q.UP(i,h)$(Q0(i,h) eq 0)           = 0;
  QgovM.LO(i,g)$(QgovM0(i,g) ne 0)   = 0.000001;
  QgovR.LO(i,g)$(QgovR0(i,g) ne 0)   = 0.000001;
  Qgov.LO(i,g)$(Qgov0(i,g) ne 0)     = 0.000001;
```

```
  QgovM.LO(i,g)$(QgovM0(i,g) eq 0)   = 0;
  QgovR.LO(i,g)$(QgovR0(i,g) eq 0)   = 0;
  Qgov.LO(i,g)$(Qgov0(i,g) eq 0)     = 0;
  QgovM.UP(i,g)$(QgovM0(i,g) eq 0)   = 0;
  QgovR.UP(i,g)$(QgovR0(i,g) eq 0)   = 0;
  Qgov.UP(i,g)$(Qgov0(i,g) eq 0)     = 0;
  QinvM.LO(i)$(QinvM0(i) ne 0)       = 0.000001;
  QinvR.LO(i)$(QinvR0(i) ne 0)       = 0.000001;
  Qinv.LO(i)$(Qinv0(i) ne 0)         = 0.000001;
  QinvM.LO(i)$(QinvM0(i) eq 0)       = 0;
  QinvR.LO(i)$(QinvR0(i) eq 0)       = 0;
  Qinv.LO(i)$(Qinv0(i) eq 0)         = 0;
  QinvM.UP(i)$(QinvM0(i) eq 0)       = 0;
  QinvR.UP(i)$(QinvR0(i) eq 0)       = 0;
  Qinv.UP(i)$(Qinv0(i) eq 0)         = 0;
  VR.LO(i,j)$(INTR0(i,j) ne 0)       = 0.000001;
  VM.LO(i,j)$(INTM0(i,j) ne 0)       = 0.000001;
  V.LO(i,j)$(INT0(i,j) ne 0)         = 0.000001;
  VR.LO(i,j)$(INTR0(i,j) eq 0)       = 0;
  VM.LO(i,j)$(INTM0(i,j) eq 0)       = 0;
  V.LO(i,j)$(INT0(i,j) eq 0)         = 0;
  VR.UP(i,j)$(INTR0(i,j) eq 0)       = 0;
  VM.UP(i,j)$(INTM0(i,j) eq 0)       = 0;
  V.UP(i,j)$(INT0(i,j) eq 0)         = 0;

OPTIONS ITERLIM=50000, LIMROW=0, LIMCOL=0, SOLPRINT=ON, reslim=50000;
*-- MODEL DEFINITION AND SOLVE STATEMENT

MODEL TEXAS / all/;

scalar count;
scalar z1 /0/;
scalar z2 /0/;

*** Solve for BASIC Model

* set variable to initial value
$include "h:\dxe_cge\init.txt";
kmobil=0;
SOLVE TEXAS MAXIMIZING RGRP USING NLP;
$include "h:\dxe_cge\calcul.txt";
file out /h:\dxe_cge\output.txt/;
out.pc=6;
put out;
$include "h:\dxe_cge\writeout.txt";
putclose out;

** SIMULATION ------------------------------
*** Solve SHORT-RUN SIMULATED Model
kmobil=0;
etaL=100000000;
etaK1=100000000;
etaK=0.92;
For (count=1 to 10,
  Out_rate=count;
  SOLVE TEXAS MAXIMIZING RGRP USING NLP;
);
```

```
$include "h:\dxe_cge\calcul.txt"
file out1 /h:\dxe_cge\output1.txt/;
out1.pc=6;
put out1;
z1=0; z2=0;
$include "h:\dxe_cge\writeout.txt";
putclose out1;

*** Solve LONG-RUN SIMULATED Model
* set variable to initial value
$include "h:\dxe_cge\init.txt";
kmobil=1;
etaL=100000000;
etaK1=100000000;
etaK=0.92;
For (count=1 to 10,
  Out_rate=count*3;
  SOLVE TEXAS MAXIMIZING RGRP USING NLP;
);
$include "h:\dxe_cge\calcul.txt";
file out2 /h:\dxe_cge\output2.txt/;
out2.pc=6;
put out2;
z1=0; z2=0;
$include "h:\dxe_cge\writeout.txt";
putclose out2;

*** NOTE
* output files:
* output.txt  : basic model
* output1.txt : simulated SR model
* output2.txt : simulated LR model

**** END OF MAIN PROGRAM *****
```

```
* Filename: init.txt
* Purpose: Assign initial values to endogenous variables
*
*@Price block
  PL.L        =1;
  PKL.L       =1;
  PKL1.L      =1;
  PK.L(i)     =PK0(i);
  PK1.L       =PK10;
  PKhog.L     =1;
  PT.L(cr)    =PT0(cr);
  PR.L(i)     =PR0(i);
  P.L(i)      =P0(i);
  PX.L(i)     =PX0(i);
  PE.L(i)     =PE0(i);
  PN.L(i)     =PN0(i);
*@Production block
  LAB.L(i)    =L0(i);
  CAP.L(i)    =K0(i);
  LAND.L(cr)  =T0(cr);
  LMIG.L      =0;
  KMIG.L      =0;
  VA.L(i)     =VA0(i);
  INTM.L(j,i)=INTM0(j,i);
  INTR.L(j,i)=INTR0(j,i);
  INT.L(j,i) =INT0(j,i);
  R.L(i)      =R0(i);
  X.L(i)      =X0(i);
  E.L(i)      =E0(i);
  M.L(i)      =M0(i);
*@Income block
  LY.L        =LY0;
  KY.L        =KY0;
  TY.L        =TY0;
  aLMIG.L     =0;
  aKMIG.L     =0;
  adjL.L(h)   =1;
  ENTY.L      =ENTY0;
  ENTK.L      =ENTK0;
  HKY.L(h)    =HK0(h);
  K2ROW.L     =K2ROW0;
  GHY.L(h)    =GHY0(h);
  SAV.L       =SAV0;
  RETENT.L    =RETENT0;
  INVEST.L    =INVEST0;
  ROWSAV.L    =ROWSAV0;
  HEXP.L(h)   =HEXP0(h);
  GOVR.L(g)   =GOVR0(g);
  GOVSAV.L(g)=GOVSAV0(g);
  RGRP.L      =RGRP0;
*@Expenditure block
  Q.L(i,h)    =Q0(i,h);
  QR.L(i,h)   =QR0(i,h);
  QM.L(i,h)   =QM0(i,h);
  QGOV.L(i,g)=QGOV0(i,g);
  QGOVM.L(i,g)=QGOVM0(i,g);
  QGOVR.L(i,g)=QGOVR0(i,g);
```

```
  QINVM.L(i)  =QINVM0(i);
  QINVR.L(i)  =QINVR0(i);
  QINV.L(i)   =QINV0(i);
  QINVT.L(i)  =QINVT0(i);

* EOF init.txt -------------*
```

```
* Filename: Calcul.txt
* Purpose: - Put calibrated parameters into array
*          - Make additional calculation
*
PARAMETER CALIB_PAR Calibrated parameters;
CALIB_PAR("a0",i) = a0(i);
CALIB_PAR("a1",i) = a1(i);
CALIB_PAR("Ava",i) = Ava(i);
CALIB_PAR("DELTAx",i) = DELTAx(i);
CALIB_PAR("Ax",i) = Ax(i);
CALIB_PAR("ibtax",i) = ibtax(i);
CALIB_PAR("DELTAinv",i) = DELTAinv(i);
CALIB_PAR("Ainv",i) = Ainv(i);

PARAMETER CALIB_PAR1 Calibrated parameters;
CALIB_PAR1(i,f) = alpha(i,f);

PARAMETER CALIB_PAR2 Calibrated parameters;
CALIB_PAR2("a",j,i) = a(j,i);
CALIB_PAR2("DELTAint",j,i) = DELTAint(j,i);
CALIB_PAR2("Aint",j,i) = Aint(j,i);

PARAMETER CALIB_PAR3 Calibrated parameters;
CALIB_PAR3("DELTAq",i,h) = DELTAq(i,h);
CALIB_PAR3("Aq",i,h) = Aq(i,h);
CALIB_PAR3("Beta",i,h) = beta(i,h);

PARAMETER CALIB_PAR4 Calibrated parameters;
CALIB_PAR4("DELTAgov",i,g) = DELTAgov(i,g);
CALIB_PAR4("Agov",i,g) = Agov(i,g);

PARAMETER CALIB_PAR5 Tax rate Calibrated parameters;
CALIB_PAR5("Labor tax",g) = ltax(g);
CALIB_PAR5("Cap tax",g) = ktax(g);
CALIB_PAR5("Land tax",g) = ttax(g);
CALIB_PAR5("Ent tax",g) = etax(g);
CALIB_PAR5("Inv tax",g) = invtaxrate(g);
CALIB_PAR5("HLow tax",g) = htax(g,"LOW");
CALIB_PAR5("HMed tax",g) = htax(g,"MED");
CALIB_PAR5("HHig tax",g) = htax(g,"HIG");
CALIB_PAR5("IBT 2 gov",g) = ibt2gov(g);
CALIB_PAR5("g ENT shr",g) = g_entshr(g);

PARAMETER CALIB_PAR6 othe rates Calibrated parameters;
CALIB_PAR6("h ENT shr",h) = h_entshr(h);
CALIB_PAR6("HLow 2 h",h) = htrrate("LOW",h);
CALIB_PAR6("HMed 2 h",h) = htrrate("MED",h);
CALIB_PAR6("HHig 2 h",h) = htrrate("HIG",h);
CALIB_PAR6("Inv 2 h",h) = inv2hrate(h);
CALIB_PAR6("H sav",h) = hs(h);
CALIB_PAR6("RETENT_KY","LOW") = retr;
CALIB_PAR6("c ENT shr","LOW") = c_entshr;
```

```
* Variable to be calculated after running model

PARAMETERS

  TCAP              Total Capital Demand
  TLAB              Total Labor Demand
  TLAND             Total land Demand
  TINTM(i)          Imported int good total demand
  TINTR(i)          Reg int good total demand
  TINT(i)           Composite intermediate good total demand
  NLY(h)            Net labor income
  NKY               Net capital income
  NTY(h)            Net Land income
  GRHY(h)           Gross regional hh income
  GENTY(g)          Enterprise income distributed to gov
  CENTY             Enterprise income distributed to capital account
  DRHY(h)           Disposable regional hh income
  DHY(h)            Disposable hh income (staying in the region +
inmigra)
  RHSAV(h)          Regional household saving
  HSAV(h)           Household saving (staying +inmigrat)
  HK(h)             Household Capital stock
  IBTX(g)           Indirect business tax
  INVESTTX(g)       Investmene tax
  INV2INVT          Investment to inventory
  YLS0(h)           labor income of initial regional hh
  RHY(h)            Regional hh income
  RHE(h)            Regional hh expenditure for commodity demand
  OMHY(h)           Income of out-migration hh
  OMGR(g)           Gov revenue from out-migrating hh
  GIMHY             income of immigrating hh
  IMHE              regional expenditure of immigrated hh
  Qimm(i)           Composite commodity consumed by immigrated hh
  QimmR(i)          Regional commodity consumed by immigrated hh
  QimmM(i)          Imported commodity consumed by immigrated hh
  TMP(i)            temporary variable
  Qrh(i,h)          Composite commodity consumed by regional hh
  QrhR(i,h)         Regional commodity consumed by regional hh
  QrhM(i,h)         Imported commodity consumed by regional hh
  GRP               Gross region product
  IGRP              index of change in GRP
  RE                regional expenditure
  IRE               index of change in RE
  GOVEXP(g)         government sependiture
  CV(h)             Compensating variation
  EV(h)             Equivalent variation
;

TLAB      = Sum(i,LAB.L(i));
TCAP      = Sum(i,CAP.L(i));
TLAND     = Sum(cr,LAND.L(cr));
TINT(i)   = sum(j,INT.L(i,j));
TINTR(i)  = sum(j,INTR.L(i,j));
TINTM(i)  = sum(j,INTM.L(i,j));
IBTX(g)   = Sum(i,ibtax(i)*PR.L(i)*X.L(i))*ibt2gov(g);
If (LMIG.l >0,
    NLY(hl)=HLY.l(hl)+IMHLY.l;
```

```
    NLY(hmh)=HLY.l(hmh);
else
  NLY(h)    = LY.L*instshr_f(h,"L");
);
NTY(h)      = TY.L*instshr_f(h,"T");
HK(h)       = (1-aLMIGH.l(h))*HK0(h);
DHY(h)      = GHY.L(h)*(1-sum(g,htax(g,h)));
HSAV(h)     = hs(h) *GHY.L(h) ;
GENTY(g)    = g_entshr(g)*ENTY.L;
CENTY       = c_entshr*ENTY.L;
INVESTTX(g) = invtaxrate(g)*SAV.L;
INV2INVT     = SAV.L*insttrrate("INVT","CAP");
NKY      = KY.L*(PK1.L-sum(g,ktax(g)));
YLS0(h)  = HLY.l(h)+PLROW0*(SQRT(LMIGH.l(h)*LMIGH.l(h))-LMIGH.l(h))*0.5;
GRHY(h)  = HLY.l(h)+HKY.l(h)+HTY.l(h)+HENTY.l(h)+HOY.l(h);
RHE(h)   = (1-sum(h1,htrrate(h1,h))-sum(g,htax(g,h))-hs(h))*GRHY(h)
           -PL.l*(1-aLMIGH.l(h))*LH0(h);
DRHY(h)  = GRHY(h)*(1-sum(g,htax(g,h)));
RHSAV(h)= hs(h) *GRHY(h) ;
OMHY(h)  = PLROW0*(SQRT(LMIGH.L(h)*LMIGH.L(h))-LMIGH.L(h))*0.5
           +aKMIG.L*HKY.l(h)+aLMIGH.L(h)*HTY.l(h)
           +aLMIGH.L(h)*HENTY.l(h);
OMGR(g)  = sum(h,htax(g,h)*aLMIG.L*(HKY.l(h)+HTY.l(h)+HENTY.l(h)));
GIMHY    = IMHLY.l;
IMHE     = (1-sum(g,htax(g,"LOW"))-hs("LOW"))*GIMHY;
Qimm(i)  = beta(i,"LOW")*IMHE/P.l(i);
TMP(i)$NZQ(i,"LOW")=((1-DELTAq(i,"LOW"))/DELTAq(i,"LOW")
                      *PM0(i)/PR.l(i))**(-1/(1+RHOq(i)));
QimmM(i)$NZQ(i,"LOW")  = TMP(i)/(1+TMP(i))*Qimm(i);
QimmM(i)$ZQM(i,"LOW")  = 0;
QimmM(i)$ZQR(i,"LOW")  = Qimm(i);
QimmR(i)     = Qimm(i)-QimmM(i);
Qrh(i,hl)    = Q.l(i,hl)-Qimm(i);
QrhR(i,hl)   = QR.l(i,hl)-QimmR(i);
QrhM(i,hl)   = QM.l(i,hl)-QimmM(i);
Qrh(i,hmh)   = Q.l(i,hmh);
QrhR(i,hmh)= QR.l(i,hmh);
QrhM(i,hmh)= QM.l(i,hmh);
GRP          = LY.L + KY.L + TY.L + sum(g,IBTX(g));
IGRP         = (GRP-GRP0)/GRP0;
RE           = sum(h,HEXP.L(h))+sum(i,P.L(i)*sum(g,QGOV0(i,g))
               +QINV0(i)+QINVT0(i));
IRE          = (RE-RE0)/RE0;
GOVEXP(g)    = sum(i,P.l(i)*QGOV0(i,g))+PL.L*LGOV0(g)
               + sum(g1,GOV2GOV0(g1,g))
               + sum(h,(1-aLMIGH.l(h))*GOV2H0(h,g));
CV(h)  = RHE(h)-HEXP0(h)*prod(i,P.l(i)**beta(i,h));
EV(h)  = RHE(h)*prod(i,(1/P.l(i))**beta(i,h))-HEXP0(h);

PARAMETER B_PRICE price of basic model;
B_PRICE(i,"PR") = PR.L(i);
B_PRICE(i,"P")  = P.L(i);
B_PRICE(i,"PN") = PN.L(i);
B_PRICE(i,"PK") = PK.L(i);
B_PRICE("01HP","PK1") = PK1.L;
B_PRICE("01HP","PKL") = PKL.L;
B_PRICE("01HP","PL")  = PL.L;
```

```
B_PRICE(cr,"PT") = PT.L(cr);
B_PRICE(i,"PX")  = PX.L(i);
B_PRICE(i,"PE")  = PE0(i);

PARAMETER B_FI primary factors (VA);
B_FI("L",i)  = LAB.L(i);
B_FI("T",cr) = LAND.L(cr);
B_FI("K",i)  = CAP.L(i);
B_FI("IBT",i)=ibtax(i)*PR.L(i)*X.L(i)

PARAMETER B_CI_INT total intermediate input;
B_CI_INT(j,i) = INT.L(j,i);

PARAMETER B_CI_INTR CI regionally produced intermediate input;
B_CI_INTR(j,i) = INTR.L(j,i);

PARAMETER B_CI_INTM MI imported intermediate input;
B_CI_INTM(j,i) = INTM.L(j,i);

PARAMETER B_Total Total value;
B_total("VA",i)    = VA.L(i);
B_total("TINT",i)  = TINT(i);
B_total("TINTR",i)= TINTR(i);
B_total("TINTM",i)= TINTM(i);
B_total("X",i)     = X.L(i);
B_total("R",i)     = R.L(i);
B_total("E",i)     = E.L(i);
B_total("INSTSELL",i) = INSTSELL0(i);

PARAMETER B_Q final demand for composite comm;
B_Q(i,h)      = Q.L(i,h);
B_Q(i,g)      = QGOV.L(i,g);
B_Q(i,"ENT") = 0;
B_Q(i,"CAP") = QINV.L(i);
B_Q(i,"INVT")= QINVT.L(i);

PARAMETER B_QR CN region final demand comm;
B_QR(i,h)      = QR.L(i,h);
B_QR(i,"FEG") = QGOVR.L(i,"FEG");
B_QR(i,"SLG") = QGOVR.L(i,"SLG");
B_QR(i,"CAP") = QINVR.L(i);
B_QR(i,"INVT")= QINVT.L(i);

PARAMETER B_QM MN imported final demand comm;
B_QM(i,h)       = QM.L(i,h);
B_QM(i,"FEG")  = QGOVM.L(i,"FEG");
B_QM(i,"SLG")  = QGOVM.L(i,"SLG");
B_QM(i,"CAP")  = QINVM.L(i);
*B_QM(i,"INVT")= QINVTM.L(i);

PARAMETER B_NC Institution sale;
B_NC(n,i)       = NC(n,i);

PARAMETER B_NF Factor income distribution;
B_NF(h,"L")     = NLY(h);
B_NF(h,"T")     = NTY(h);
B_NF(h,"K")     = HKY.l(h);
```

```
B_NF(g,"L")          = LY.L*ltax(g);
B_NF(g,"T")          = TY.L*ttax(g);
B_NF(g,"K")          = KY.L*ktax(g);
B_NF(g,"IBT")        = IBTX(g);
B_NF("ENT","K")      = ENTY.L-sum(g,GOV2ENT0(g));
B_NF("CAP","K")      = KY.L*FY2CAP0("K")/KY0;

PARAMETER B_NN Inter-Institution transfer;
B_NN("ENT",g)        = GOV2ENT0(g);
B_NN(h,h1)           = H2H0(h,h1);
B_NN(g,h)            = GHY.L(h)*htax(g,h);
B_NN("CAP",h)        = HSAV(h);
B_NN(h,g)            = adjL.L(h)*GOV2H0(h,g);
B_NN(g,g1)           = GOV2GOV0(g,g1);
B_NN("CAP",g)        = GOVSAV.l(g);
B_NN(h,"ENT")        = HENTY.l(h);
B_NN(g,"ENT")        = GENTY(g);
B_NN("CAP","ENT")    = CENTY;
B_NN(h,"CAP")        = SAV.L*inv2hrate(h);
B_NN(g,"CAP")        = INVESTTX(g);
B_NN("INVT","CAP")  = INV2INVT;

PARAMETER B_NX Institutional Export;
B_NX(h)              = REMIT0(h);
B_NX(g)              = ROW2GOV0(g);
B_NX("CAP")          = ROWSAV.l;
B_NX("INVT")         = ROWINVT0;
B_NX("ENT")          = ROWENT0;
MF("K")              = K2ROW.L;

PARAMETER B_Q1 hh demand for composite comm;
B_Q1(i,h)            = Qrh(i,h);
B_Q1(i,"IMH")        = Qimm(i);

PARAMETER B_QR1 hh demand for regional composite comm;
B_QR1(i,h)           = QrhR(i,h);
B_QR1(i,"IMH")       = QimmR(i);

PARAMETER B_QM1 hh demand for imported composite comm;
B_QM1(i,h)           = QrhM(i,h);
B_QM1(i,"IMH")       = QimmM(i);

* EOF calcul.txt -------------*
```

```
* Filename: writeout.txt
* Purpose: Write output of CGE to external file
*
Put "CALIBRATED PARAMETERS" //;
put ""; loop(i, put i.tl); put /;
Put "a0"; loop(i, put CALIB_PAR("a0",i):0:6); put /;
Put "a1"; loop(i, put CALIB_PAR("a1",i):0:6); put /;
Put "Ava"; loop(i, put CALIB_PAR("Ava",i):0:6); put /;
Put "DELTAx"; loop(i, put CALIB_PAR("DELTAx",i):0:6); put /;
Put "Ax"; loop(i, put CALIB_PAR("Ax",i):0:6); put /;
Put "DELTAinv"; loop(i, put CALIB_PAR("DELTAinv",i):0:6); put /;
Put "Ainv"; loop(i, put CALIB_PAR("Ainv",i):0:6); put /;
Put "ibtax"; loop(i, put CALIB_PAR("ibtax",i):0:6); put //;
put "Parameters of CD functions" //;
put " " ;
loop(i, put i.tl);
loop(f, put / f.tl ;
          loop(i, put CALIB_PAR1(i,f):0:6);
); put //;
put "a(i,j) req of interm good j per unit of good i" //;
put " " ;
loop(j, put j.tl);
loop(i, put / i.tl ;
          loop(j, put CALIB_PAR2("a",i,j):0:6);
); put //;
put "DELTAint(j,i) interm input share param" //;
put " " ;
loop(i, put i.tl);
loop(j, put / j.tl ;
          loop(i, put CALIB_PAR2("DELTAint",j,i):0:6);
); put //;
put "Aint(j,i) interm input shift param" //;
put " " ;
loop(i, put i.tl);
loop(j, put / j.tl ;
          loop(i, put CALIB_PAR2("Aint",j,i):0:6);
); put //;

put "DELTAq(i,h) consumer demand share param" //;
put " " ;
loop(i, put i.tl);
loop(h, put / h.tl ;
          loop(i, put CALIB_PAR3("DELTAq",i,h):0:6);
); put //;
put "Aq(i,h) consumer demand constant eff param" //;
put " " ;
loop(i, put i.tl);
loop(h, put / h.tl ;
          loop(i, put CALIB_PAR3("Aq",i,h):0:6);
); put //;
put "Beta(i,h) param calc fr elast of comm demand wrt inc" //;
put " " ;
loop(i, put i.tl);
loop(h, put / h.tl ;
          loop(i, put CALIB_PAR3("Beta",i,h):0:6);
); put //;
put "DELTAgov(i,g) gov demand share param" //;
```

```
put " " ;
loop(i, put i.tl);
loop(g, put / g.tl ;
          loop(i, put CALIB_PAR4("DELTAgov",i,g):0:6);
); put //;
put "Agov(i,g) gov demand constant eff param" //;
put " " ;
loop(i, put i.tl);
loop(g, put / g.tl ;
          loop(i, put CALIB_PAR4("Agov",i,g):0:6);
); put //;
put "Parameters related to gov" //;
put "" ;
loop(g, put g.tl); put /;
put "Labor tax";
loop(g, put CALIB_PAR5("Labor tax",g):0:6); put /;
put "Cap tax";
loop(g, put CALIB_PAR5("Cap tax",g):0:6); put /;
put "Land tax";
loop(g, put CALIB_PAR5("Land tax",g):0:6); put /;
put "Ent tax";
loop(g, put CALIB_PAR5("Ent tax",g):0:6); put /;
put "Inv tax";
loop(g, put CALIB_PAR5("Inv tax",g):0:6); put /;
put "HLow tax";
loop(g, put CALIB_PAR5("HLow tax",g):0:6); put /;
put "HMed tax";
loop(g, put CALIB_PAR5("HMed tax",g):0:6); put /;
put "HHig tax";
loop(g, put CALIB_PAR5("HHig tax",g):0:6); put /;
put "IBT 2 gov";
loop(g, put CALIB_PAR5("IBT 2 gov",g):0:6); put /;
put "g ENT shr";
loop(g, put CALIB_PAR5("g ENT shr",g):0:6); put //;

put "Parameters related to h" //;
put "" ;
loop(h, put h.tl); put /;
put "h ENT shr";
loop(h, put CALIB_PAR6("h ENT shr",h):0:6); put /;
put "HLow 2 h";
loop(h, put CALIB_PAR6("HLow 2 h",h):0:6); put /;
put "HMed 2 h";
loop(h, put CALIB_PAR6("HMed 2 h",h):0:6); put /;
put "HHig 2 h";
loop(h, put CALIB_PAR6("HHig 2 h",h):0:6); put /;
put "Inv 2 h";
loop(h, put CALIB_PAR6("Inv 2 h",h):0:6); put /;
put "H sav";
loop(h, put CALIB_PAR6("H sav",h):0:6); put /;
put "RETENT_KY";
put CALIB_PAR6("RETENT_KY","LOW"):0:6; put /;
put "c ENT shr";
put CALIB_PAR6("c ENT shr","LOW"):0:6; put ////;

put "OUTPUT OF FINAL MODEL" ///;
put "Equilibrium prices" ///;
```

```
put "PRICES";
loop(i, put i.tl);
put /;
put "PR";
loop(i, put b_price(i,"PR"):0:4);
put /;
put "P";
loop(i, put b_price(i,"P"):0:4);
put /;
put "PN";
loop(i, put b_price(i,"PN"):0:4);
put /;
put "PK";
loop(i, put b_price(i,"PK"):0:4);
put /;
put "PK1";
loop(i, put b_price(i,"PK1"):0:4);
put /;
put "PKL";
loop(i, put b_price(i,"PKL"):0:4);
put /;
put "PL";
loop(i, put b_price(i,"PL"):0:4);
put /;
put "PT";
loop(i, put b_price(i,"PT"):0:4);
put /;
put "PX";
loop(i, put b_price(i,"PX"):0:4);
put /;
put "PE";
loop(i, put b_price(i,"PE"):0:4);
put /;
Put "Domestically commodity make (IC)" //;
put " " ; loop(i, put i.tl);
loop(i, put / i.tl ; z1=z1+1;
    loop(j, z2=z2+1;if(z1=z2, put R.L(i):0:4; else put 0;));
    z2=0;
); put //;

Put "Exported commodity(IX)" //;
loop(i, put i.tl E.L(i):0:4 /);
put /;

put "Primary Factor Input (FI)" //;
put " " ;
loop(i, put i.tl);
loop(fa, put / fa.tl ;
          loop(i, put b_fi(fa,i):0:4);
); put //;

put "Total intermediate input" //;
put " " ;
loop(i, put i.tl);
loop(j, put / j.tl ;
          loop(i, put b_CI_INT(j,i):0:4);
); put //;
```

```
put "Regionally produced intermediate input (CI)" //;
put " " ;
loop(i, put i.tl);
loop(j, put / j.tl ;
          loop(i, put b_CI_INTR(j,i):0:4);
); put //;
put "Imported intermediate input (MI)" //;
put " " ;
loop(i, put i.tl);
loop(j, put / j.tl ;
          loop(i, put b_CI_INTM(j,i):0:4);
); put //;

put "Total value" //;
put " " ; loop(i, put i.tl); put /;
put "VA";
loop(i, put B_total("VA",i):0:4); put /;
put "TINT";
loop(i, put B_total("TINT",i):0:4); put /;
put "TINTR";
loop(i, put B_total("TINTR",i):0:4); put /;
put "TINTM";
loop(i, put B_total("TINTM",i):0:4); put /;
put "X";
loop(i, put B_total("X",i):0:4); put /;
put "R";
loop(i, put B_total("R",i):0:4); put /;
put "E";
loop(i, put B_total("E",i):0:4); put /;
put "INSTSELL";
loop(i, put B_total("INSTSELL",i):0:4); put //;

put "Final demand for composite commodity" //;
put " " ;
loop(n, put n.tl);
loop(i, put / i.tl ;
          loop(n, put B_Q(i,n):0:4);
); put //;

put "Final demand for regionally produced commodity (CN)" //;
put " " ;
loop(n, put n.tl);
loop(i, put / i.tl ;
          loop(n, put B_QR(i,n):0:4);
); put //;
put "Final demand for imported commodity(MN)" //;
put " " ;
loop(n, put n.tl);
loop(i, put / i.tl ;
          loop(n, put B_QM(i,n):0:4);
); put //;

put "Institution sale commodity (NC)" //;
put " " ;
loop(i, put i.tl);
loop(n, put / n.tl ;
          loop(i, put B_NC(n,i):0:4);
```

```
); put //;

put "Factor income distribution(NF)" //;
put " " ;
loop(fa, put fa.tl);
loop(n, put / n.tl ;
          loop(fa, put B_NF(n,fa):0:4);
); put //;

put "Inter-Institution transfer (NN)" //;
put " " ;
loop(n, put n.tl);
loop(n1, put / n1.tl ;
          loop(n, put B_NN(n1,n):0:4);
); put //;

put "Institutional Export(NX)" //;
loop(n, put n.tl B_NX(n):0:4 /;) ;
put /;

put "Factor services import(MF)" //;
loop(fa, put fa.tl MF(fa):0:4 /;) ;
put ///;

put "Total Labor Demand (TLAB)"  ,"" ,"" ,"","", tlab:0:4; put /;
put "Total Capital Demand (TCAP)"  ,"" ,"" ,"","",  tcap:0:4; put /;
put "Total Land Demand (TLAND)"  ,"" ,"" ,"","",  tland:0:4; put /;
put "Labor migration (LMIG)"   ,"" ,"" ,"","", lmig.l:0:4 /;
put "Capital migration (KMIG)"   ,"" ,"" ,"","", kmig.l:0:4 /;
put "Old gross region product (GRP0)"   ,"" ,"" ,"","", grp0:0:4 /;
put "New gross region product (GRP)"   ,"" ,"" ,"","", grp:0:4 /;
put "index of change in GRP (IGRP)"   ,"" ,"" ,"","", igrp:0:6 /;
put "Old regional expenditure (RE0)"   ,"" ,"" ,"","", re0:0:4 /;
put "New regional expenditure (RE)"   ,"" ,"" ,"","", re:0:4 /;
put "index of change in RE (IRE)"   ,"" ,"" ,"","", ire:0:6 /;
put "Net capital income (NKY)"   ,"" ,"" ,"","", NKY:0:6 /;
put "Enterprise income distributed to capital account (CENTY)"   ,"" ,""
,"","", CENTY:0:6 /;
put "Investment to inventory (INV2INVT)"   ,"" ,"" ,"","", INV2INVT:0:6
/;
put /;
put "","","","","",""; loop(h, put h.tl); put /;
put "Labor migration separated by hh group (LMIGH)","","","","","";
if (lmig.l > 0,
     put lmig.l:0:4; put /;
else
   loop(h, put lmigh.l(h):0:4);
   put /;
);
put "Labor compensation to hh remaining in region
(RHLY)","","","","","";
loop(h, put hly.l(h):0:4 ); put /;
put "Capital compensation to hh remaining in region
(RHKY)","","","","","";
loop(h, put hky.l(h):0:4 ); put /;
put "net land compensation to hh remaining in region
(RHTY)","","","","","" ;
```

```
loop(h, put hty.l(h):0:4 ); put /;
put "Enterprise income distributed to hh (RHENTY)","","","","","" ;
loop(h, put henty.l(h):0:4 ); put /;
put "other source of income to hh remaining in region (RHOY)"
,"","","","","";
loop(h, put hoy.l(h):0:4 ); put /;
put "Regional gross hh income (GRHY)" ,"","","","","";
loop(h, put grhy(h):0:4 ); put /;
put "Regional hh expenditure for commodity demand (RHE)"
,"","","","","";
loop(h, put rhe(h):0:4 ); put /;
put "Regional hh Disposable income (DRHY)" ,"","","","","";
loop(h, put drhy(h):0:4 ); put /;
put "Regional hh Saving (RHSAV)" ,"","","","","";
loop(h, put rhsav(h):0:4 ); put /;
put "Compensating Variation (CV)" ,"","","","","";
loop(h, put CV(h):0:4 ); put /;
put "Equivalent Variation (EV)" ,"","","","","";
loop(h, put EV(h):0:4 ); put /;
put "Income of out-migration hh (OMHY)" ,"","","","","";
loop(h, put omhy(h):0:4 ); put /;
put "income of immigrating hh (GIMHY)" ,"","","","","";
put GIMHY:0:4 ; put /;
put "regional expenditure of immigrating hh (IMHE)","","","","","" ;
put IMHE:0:4 ; put /;
put "Net labor income (NLY)" ,"","","","","";
loop(h, put NLY(h):0:4 ); put /;
put "Net Land income (NTY)" ,"","","","","";
loop(h, put NTY(h):0:4 ); put /;
put "hh cap stock (HK)" ,"","","","","";
loop(h, put HK(h):0:4 ); put /;
put "Capital compensation to hh (HKY)" ,"","","","","";
loop(h, put HKY.l(h):0:4 ); put /;
put "Gross hh income (GHY)" ,"","","","","";
loop(h, put GHY.l(h):0:4 ); put /;
put "Enterprise income distributed to hh (HENTY)" ,"","","","","";
loop(h, put HENTY.l(h):0:4 ); put /;
put "Disposable hh income (staying in the region + inmigra)(DHY)"
,"","","","","";
loop(h, put DHY(h):0:4 ); put /;
put "Household saving (staying +inmigrat)(HSAV)" ,"","","","","";
loop(h, put HSAV(h):0:4 ); put /;
put "","","","","",""; loop(g, put g.tl:0:4); put /;
put "Gov revenue from out-migrating hh (OMGR)" ,"","","","","";
loop(g, put omgr(g):0:4 ); put /;
put "Investment tax (INVESTTX)" ,"","","","","";
loop(g, put INVESTTX(g):0:4 ); put /;
put "Enterprise income distributed to gov (GENTY)" ,"","","","","";
loop(g, put GENTY(g):0:4 ); put /;
put "Government Revenue (GOVR)" ,"","","","","";
loop(g, put GOVR.L(g):0:4 ); put /;
put "Government expenditure (GOVEXP)" ,"","","","","";
loop(g, put GOVEXP(g):0:4 ); put /;
put "Government Saving (GOVSAV)" ,"","","","","";
loop(g, put GOVSAV.L(g):0:4 ); put /;
put "Foreign Saving (ROWSAV)" ,"","","","";
put ROWSAV.L:0:4 ; put /;
```

```
put "K compensation to ROW (K2ROW)" ,"","","","";
put K2ROW.L:0:4 ; put ///;


put "hh Final demand for composite commodity" //;
put " " ;
loop(h, put h.tl);
put "IMH";
loop(i, put / i.tl ;
   loop(h, put B_Q1(i,h):0:4);
   put put B_Q1(i,"IMH"):0:4;
); put //;

put "hh final demand for regionally produced commodity" //;
put " " ;
loop(h, put h.tl);
put "IMH";
loop(i, put / i.tl ;
   loop(h, put B_QR1(i,h):0:4);
   put put B_QR1(i,"IMH"):0:4;
); put //;

put "hh final demand for imported commodity" //;
put " " ;
loop(h, put h.tl);
put "IMH";
loop(i, put / i.tl ;
   loop(h, put B_QM1(i,h):0:4);
   put put B_QM1(i,"IMH"):0:4;
); put //;

* EOF writeout.txt -------------*
```

* Filename: tx93c.dat
* Purpose: Data of Texas 1993 modify for SEABOARD RPC

TABLE IC(i,j) Domestic Commodity Make

	01HP	02OL	03FG	04OC	05OG	06CN	07MP	08PF	09OP	10OM	11SV
01HP	3482.2758	0	0	0	0	0	0	0	0	0	0
02OL	0	64216.3649	0	0	0	0	0	0	0	0	0
03FG	0	0	6830.8819	0	0	0	0	0	0	0	0
04OC	0	0	0	2383.752	0	0	0	0	0	0	0
05OG	0	0	0	0	30095.5841	0	0	0	0	0	0
06CN	0	0	0	0	0	51912.6855	0	0	0	0	0
07MP	0	0	0	0	0	0	1046.0505	0	0	0	0
08PF	0	0	0	0	0	0	0	1116.8540	0	0	0
09OP	0	0	0	0	0	0	0	0	62.9704	0	0
10OM	0	0	0	0	0	0	0	0	0	16663.8532	0
11SV	0	0	0	0	0	0	0	0	0	0	243003.6113 ;

Parameters IX(i) Commodity Exports
/01HP 0
02OL 509018.6677
03FG 12530.6473
04OC 18159.4106
05OG 23131.8868
06CN 62.0421
07MP 4684.7850
08PF 10037.3275
09OP 1185.8873
10OM 2945.2044
11SV 7785.4495/;

TABLE CI(i,j) Domestic Commodity Use

	01HP	02OL	03FG	04OC	05OG	06CN	07MP	08PF	09OP	10OM	11SV
01HP	847.949	0	37.0042	16.0269	0	0	3095.9861	0	0.52	0.3396	0.05
02OL	9.2859	64202.695	732.3672	300.0139	0	0	0.3195	1.7637	105.7315	4.165	54.2202
03FG	227.5158	8648.0752	75.8626	0	0	0	0	67.5672	0.72	0	0
04OC	162.1585	2893.7404	20.1458	53.9627	0	0	0	41.6119	2.9401	4.0652	5.5901
05OG	26.1634	1796.5715	392.3092	349.3204	17415.433	1614.5839	17.7872	17.7864	4.8501	336.496	1498.06
06CN	28.8886	10807.0688	986.7248	888.432	788.5022	215.9286	1.1716	44.6504	11.6701	492.7884	9023.2501
07MP	0.2163	246.7305	0	0	0.12	0	79.2436	1.9032	12.0701	4.7943	81.6701
08PF	9.978	1086.8133	0	1.665	0	0	0	17.6469	0	0	0.07
09OP	0.5412	22.5686	0	0.1462	0.02	0	0.2665	45.1055	0.3603	0.05	3.8532
10OM	13.6332	3194.1429	764.2262	669.3328	360.8183	2325.9406	13.8463	187.8883	21.9202	1288.7529	1641.6202
11SV	929.8854	63887.4239	3706.8017	5278.9577	2377.1624	8978.4152	510.7165	1008.2254	98.8711	1881.0417	27831.381;

TABLE CN(i,n) Domestic Commodity Consumption (FinalDemand)

	ENT	LOW	HIG	MED	FEG	SLG	CAP	INVT
01HP	0	0	0	0	0	0	0	0.0000
02OL	0	25.2968	71.0149	41.5721	0.01	8.13	0	7.5700
03FG	0	0.2602	0.4807	0.2203	0	0.32	0	0.0000
04OC	0	14.1038	27.3883	12.8651	0	1.64	0	0.1800
05OG	0	1469.3917	3217.7742	1485.2872	0	658.76	12.85	33.3200
06CN	0	0	0	0	351.57	9140.86	19131.18	0.0000
07MP	0	158.5436	296.612	134.6668	0	24.73	0	4.7500
08PF	0	0.1702	0.3204	0.1502	0	0.04	0	0.0000
09OP	0	7.3431	14.502	6.9738	0	0.56	0	0.0000
10OM	0	1042.779	2758.2269	1569.4753	0	533.93	356.47	113.1100
11SV	0	25334.6835	62682.1855	34387.8402	1017.06	17911.19	1437.04	858.8600 ;

TABLE FI(fa,i) Value Added

	01HP	02OL	03FG	04OC	05OG	06CN	07MP	08PF	09OP	10OM	11SV
L	0.483	233.3602	3.9386	2.4829	10328.6998	8626.3433	429.1297	788.8597	220.43	4838.391	96438.1306
K	93.4283	44860.0064	441.8983	278.5625	11450.7902	6699.9802	75.569	236.9927	210.86	564.6421	50503.2903
T	0	0	1904.584	1200.5965	0	0	0	0	0	0	0
IBT	13.9649	5849.502	390.3108	222.1443	1884.0523	122.4058	44.681	67.11	3.9691	197.1433	21786.8794 ;

TABLE NC(n,i) Domestic Commodity Sales

	01HP	02OL	03FG	04OC	05OG	06CN	07MP	08PF	09OP	10OM	11SV
ENT	0	0	0	0	0	0	0	0	0	0	0
LOW	0	0	0	0	0	0	0	0	0	0	647.7899579
HIG	0	0	0	0	0	0	0	0	0	0	2528.979626
MED	0	0	0	0	0	0	0	0	0	0	1755.516529
FEG	0	0	0	0	26.87706237	0	0	0	0	0	35.53594142
SLG	0	0	0	0	13.97156217	0	0	0	35.21	49.63110305	10221.88022
CAP	0	0	0	0	0	0	0	0	0	0	1674.332543
INVT	515.6	1347.7908	2190.1401	856.6399	210.3114755	0	0	0	4.11	142.628797	250.0950844 ;

TABLE NF(n,fa) Factor Disbursements

	L	K	T	IBT
ENT	0	29657.69	0	0
LOW	7505.9925	6987.3	154.4883	0
HIG	51229.9598	34802.4	1231.6447	0
MED	43769.7103	27726.06	1552.4037	0
FEG	16092.2096	-11005.72	166.6537	6672.0846
SLG	3312.4467	3841.11	0	23910.0783
CAP	0	23009.76	0	0
INVT	0	0	0	0 ;

TABLE NN(n,n1) Inter-Institutional Transfers

	ENT	LOW	HIG	MED	FEG	SLG	CAP	INVT
ENT	0	0	0	0	0	0	0	0
LOW	34.96	0	0	0	25721.4412	268.4418	11767.2187	0
HIG	95.34	0	0	0	52779.7069	540.0822	7556.7817	0
MED	305.54	0	0	0	13756.8802	1560.4157	4093.7063	0
FEG	9445.77	1212.1728	13515.7512	14742.1432	0	0	0	0
SLG	1353.53	743.7196	4619.4088	4570.3147	10654.8	0	20896.4507	0
CAP	18422.55	0	0	0	30593.5968	0	0	0
INVT	0	0	0	0	0	0	18870.9127	0 ;

Parameters NX(n) Commodity and Factor Services Exports

/ENT	0
LOW	13154.9747
HIG	24774.2826
MED	10544.2403
FEG	84475.4070
SLG	-53010.6120
CAP	17414.5508
INVT	-23370.4389 /;

TABLE MI(i,j) Commodity Imports

	01HP	02OL	03FG	04OC	05OG	06CN	07MP	08PF	09OP	10OM	11SV
01HP	27.7999	0	0.7008	0.3018	0	0	1326.8508	0	0.01	0.01	0
02OL	0.4253	1897.8387	21.6529	8.8692	0	0	0.1065	0.0797	3.1296	0.1198	1.5998
03FG	341.2874	85369.6811	748.8888	0	0	0	0	1100.7558	7.1201	0	0
04OC	243.2335	81815.4783	569.6406	1525.6711	0	0	0	821.2831	83.1608	114.852	157.9099
05OG	2.9054	405.7703	88.6066	78.898	3933.4242	364.6698	1.9704	37.0874	1.1	75.9988	338.35
06CN	28.8886	1923.9716	175.6636	158.1659	140.3788	38.4441	10.3315	0	2.08	87.7347	1606.4
07MP	0.0216	455.18	0	0	0.2199	0	0	0.1594	22.2702	8.8394	150.6799
08PF	332.6838	98190.2673	0	150.4835	0	0	0	588.6056	0.03	0.0499	6.41
09OP	38.7003	12979.942	0	83.0457	9.9963	0	19.0651	3205.8118	204.3419	25.9089	2214.8768
10OM	102.2384	19396.3954	4640.7197	4064.5152	2191.0402	14124.2246	103.7942	1409.3513	133.0914	7825.9041	9968.6899
11SV	0	63071.8092	3659.4828	5211.5684	2346.8133	8863.7915	0	1463.9361	97.6111	1856.9705	27476.0793;

PARAMETERS MF(fa) Factor Services Imports

/L	0
K	397.41
T	0
IBT	0/;

TABLE MN(i,n) Commodity Importsand Remittances

	ENT	LOW	HIG	MED	FEG	SLG	CAP
01HP	0	0	0	0	0	0	0
02OL	0	0.0601	0.1602	0.1001	0	0	0
03FG	0	0.1902	4.7466	2.1825	0	0	0
04OC	0	28.7977	55.9173	26.2704	0	0	0
05OG	0	331.8711	726.7583	335.4701	0	0	2.9
06CN	0	0	0	0	39.75	22.84	3405.9
07MP	0	292.4928	547.1989	248.4388	0	0	0
08PF	0	15.5951	29.3006	13.4657	0	0	0
09OP	0	4221.6303	8340.2124	4007.5862	0	0	0
10OM	0	6332.2666	16749.267	9530.6228	0	0	2164.68
11SV	0	25011.239	61881.9513	33948.8275	464.07	540	1418.7 ;

APPENDIX C

OUTPUT OF THE CGE MODEL

TABLE C4. CALIBRATED PARAMETERS

Parameters of Leontief functions

	01HP	02OL	03FG	04OC	05OG	06CN	07MP	08PF	09OP	10OM	11SV
a0	0.026968	0.078665	0.121396	0.072123	0.409178	0.29488	0.088067	0.09197	0.345348	0.275538	0.585916
a1	0.969021	0.911131	0.858444	0.917063	0.555426	0.702765	0.904136	0.902013	0.651474	0.714409	0.32721
Ava	1.03276	1.032933	1.641084	1.641088	1.997346	1.984223	1.525378	1.716876	1.999508	1.397758	1.903049
DELTAx	0	0.370324	0.461186	0.372702	0.522671	0.910562	0.373554	0.319261	0.266536	0.645109	0.992721
Ax	0	2.258937	2.023447	2.249537	2.005966	6.022423	2.189962	2.40138	2.708716	2.252517	7.733568
DELTAinv	0	0	0	0	0.048464	0.030721	0	0	0	0.624362	0.498394
Ainv	0	0	0	0	1.429487	1.345119	0	0	0	1.814769	1.999979
ibtax	0.00401	0.010204	0.020159	0.010814	0.035396	0.002355	0.007797	0.006017	0.003178	0.010054	0.086873

Parameters of CD functions

	01HP	02OL	03FG	04OC	05OG	06CN	07MP	08PF	09OP	10OM	11SV
L	0.005143	0.005175	0.001676	0.001676	0.47424	0.562845	0.850269	0.76898	0.511095	0.895495	0.656303
K	0.994857	0.994825	0.188008	0.188009	0.52576	0.437155	0.149731	0.23102	0.488905	0.104505	0.343697
T	0	0	0.810316	0.810315	0	0	0	0	0	0	0

a(i,j) req of interm good j per unit of good i

	01HP	02OL	03FG	04OC	05OG	06CN	07MP	08PF	09OP	10OM	11SV
01HP	0.251488	0	0.001947	0.000795	0	0	0.771761	0	0.000424	0.000018	0
02OL	0.002789	0.115311	0.038944	0.015036	0	0	0.000074	0.000165	0.087169	0.000219	0.000223
03FG	0.163342	0.164013	0.042597	0	0	0	0	0.104743	0.006278	0	0
04OC	0.116416	0.147774	0.030462	0.076893	0	0	0	0.077361	0.068944	0.006064	0.000652
05OG	0.008348	0.003842	0.024839	0.020845	0.401087	0.038081	0.003448	0.00492	0.004764	0.021036	0.007323
06CN	0.016592	0.022209	0.060036	0.050946	0.017451	0.004894	0.002007	0.004003	0.01101	0.029605	0.042385
07MP	0.000068	0.001224	0	0	0.000006	0	0.013828	0.000185	0.027497	0.000695	0.000926
08PF	0.098402	0.173187	0	0.007406	0	0	0	0.054352	0.000024	0.000003	0.000026
09OP	0.011269	0.022683	0	0.00405	0.000188	0	0.003373	0.291453	0.163912	0.001324	0.008847
10OM	0.033275	0.039409	0.279159	0.230434	0.047943	0.316503	0.020528	0.143196	0.124123	0.464819	0.046295
11SV	0.267034	0.221478	0.38046	0.510658	0.088751	0.343286	0.089117	0.221635	0.15733	0.190627	0.220534

DELTAint(j,i) interm input share param

	01HP	02OL	03FG	04OC	05OG	06CN	07MP	08PF	09OP	10OM	11SV
01HP	0.082649	0	0.057684	0.057467	0	0	0.355102	0	0.058274	0.077092	0
02OL	0.102344	0.077286	0.077295	0.07729	0	0	0.315686	0.101477	0.077353	0.075925	0.077193
03FG	0.570911	0.833749	0.83375	0	0	0	0	0.877098	0.833922	0	0
04OC	0.570901	0.913209	0.913214	0.913208	0	0	0	0.890936	0.913232	0.913168	0.913159
05OG	0.012181	0.048536	0.048536	0.048537	0.048536	0.048537	0.012123	0.81301	0.048922	0.048534	0.048536
06CN	0.5	0.030721	0.03072	0.03072	0.030722	0.030725	0.987304	0	0.030789	0.030723	0.030721
07MP	0.343213	0.54302	0	0	0.54255	0	0	0.332132	0.543028	0.542978	0.543025
08PF	0.72866	0.780509	0	0.780527	0	0	0	0.728681	0	0	0.781158
09OP	0.769016	0.856931	0	0.856501	0.852015	0	0.769038	0.768711	0.856447	0.853291	0.856912
10OM	0.638197	0.624362	0.624361	0.624362	0.624361	0.624362	0.638171	0.638213	0.624353	0.624362	0.624362
11SV	0	0.498394	0.498394	0.498394	0.498394	0.498394	0	0.546483	0.498397	0.49839	0.498394

Aint(j,i) interm input shift param

	01HP	02OL	03FG	04OC	05OG	06CN	07MP	08PF	09OP	10OM	11SV
01HP	1.239676	0	1.169071	1.168452	0	0	1.884893	0	1.170746	1.224023	0
02OL	1.294869	1.224568	1.224595	1.22458	0	0	1.817689	1.292451	1.224757	1.22073	1.224307
03FG	1.971683	1.469601	1.469597	0	0	0	0	1.351922	1.46914	0	0
04OC	1.971691	1.251323	1.251308	1.251326	0	0	0	1.313588	1.251257	1.251438	1.251462
05OG	1.219391	1.429792	1.429793	1.429797	1.429792	1.429795	1.218867	1.779807	1.431408	1.429784	1.429793
06CN	2	1.34512	1.345116	1.345118	1.345126	1.345141	1.223922	0	1.345491	1.345135	1.34512
07MP	1.72967	1.974304	0	0	1.974849	0	0	1.699653	1.974294	1.974353	1.974298
08PF	1.535869	1.405892	0	1.405849	0	0	0	1.535812	0	0	1.404347
09OP	1.433608	1.238951	0	1.239806	1.248787	0	1.433556	1.434353	1.239914	1.24622	1.238989
10OM	1.779157	1.814771	1.814772	1.814771	1.814772	1.814771	1.779227	1.779117	1.814794	1.814771	1.814771
11SV	0	1.999979	1.999979	1.999979	1.999979	1.999979	0	1.982863	1.999979	1.999979	1.999979

DELTAq(i,h) consumer demand share param

	01HP	02OL	03FG	04OC	05OG	06CN	07MP	08PF	09OP	10OM	11SV
LOW	0	0.013991	0.445051	0.623096	0.048535	0	0.543021	0.781188	0.856917	0.624362	0.498394
MED	0	0.014122	0.834098	0.623109	0.048538	0	0.54302	0.780136	0.856903	0.624362	0.498394
HIG	0	0.013497	0.833777	0.623081	0.048536	0	0.543019	0.781094	0.856929	0.624362	0.498394

Aq(i,h) consumer demand constant eff param

	01HP	02OL	03FG	04OC	05OG	06CN	07MP	08PF	09OP	10OM	11SV
LOW	0	1.042882	1.982938	1.916112	1.429788	0	1.974303	1.404276	1.238978	1.81477	1.999979
MED	0	1.043271	1.468671	1.916096	1.429799	0	1.974304	1.406781	1.239007	1.81477	1.999979
HIG	0	1.041413	1.469526	1.916133	1.429791	0	1.974304	1.404499	1.238954	1.814771	1.999979

Beta(i,h) param calc fr elast of comm demand wrt inc

	01HP	02OL	03FG	04OC	05OG	06CN	07MP	08PF	09OP	10OM	11SV
LOW	0	0.000394	0.000007	0.000667	0.028019	0	0.007016	0.000245	0.065783	0.114721	0.783147
MED	0	0.000486	0.000028	0.000456	0.021233	0	0.004468	0.000159	0.046816	0.129444	0.79691
HIG	0	0.000452	0.000033	0.000529	0.02506	0	0.005361	0.000188	0.053078	0.123933	0.791366

DELTAgov(i,g) gov demand share param

	01HP	02OL	03FG	04OC	05OG	06CN	07MP	08PF	09OP	10OM	11SV
FEG	0	0	0	0	0	0.012622	0	0	0	0	0.403159
SLG	0	0	0	0	0	0.000006	0	0	0	0	0.147946

Agov(i,g) gov demand constant eff param

	01HP	02OL	03FG	04OC	05OG	06CN	07MP	08PF	09OP	10OM	11SV
FEG	0	0	0	0	0	1.223274	0	0	0	0	1.927688
SLG	0	0	0	0	0	1.004997	0	0	0	0	1.337105

Parameters related to gov

	FEG	SLG
Labor tax	0.132	0.027171
Cap tax	-0.095357	0.033281
Land tax	0.05367	0
Ent tax	0.318493	0.045638
Inv tax	0	0.229342
HLow tax	0.018299	0.011227
HMed tax	0.140315	0.0435
HHig tax	0.076996	0.026316
IBT 2 gov	0.218169	0.781831
g ENT shr	0.318493	0.045638

Parameters related to h

	LOW	MED	HIG
h ENT shr	0.001179	0.010302	0.003215
HLow 2 h	0	0	0
HMed 2 h	0	0	0
HHig 2 h	0	0	0
Inv 2 h	0.129147	0.044929	0.082937
H sav	0	0	0
RETENT_	0.621173		
c ENT shr	0.621173		

TABLE C1 OUTPUT OF THE BASIC MODEL

Total Labor Demand (TLAB)	121,910.2
Total Capital Demand (TCAP)	115,416.0
Total Land Demand (TLAND)	3,105.2
Labor migration (LMIG)	0.0
Capital migration (KMIG)	0.0
Old gross region product (GRP0)	271,013.6
New gross region product (GRP)	271,013.6
index of change in GRP (IGRP)	0.0
Old regional expenditure (RE0)	367,105.7
New regional expenditure (RE)	367,105.6
index of change in RE (IRE)	0.0
Net capital income (NKY)	122,580.6
Enterprise income distributed to capital account (CENTY)	18,422.5
Investment to inventory (INV2INVT)	18,870.9

	LOW	MED	HIG
Labor migration separated by hh group (LMIGH)	0.0	0.0	0.0
Labor compensation to hh remaining in region (RHLY)	7,506.0	43,769.7	51,229.9
Capital compensation to hh remaining in region (RHKY)	6,987.3	27,726.1	34,802.4
net land compensation to hh remaining in region (RHTY)	154.5	1,552.4	1,231.6
Enterprise income distributed to hh (RHENTY)	35.0	305.5	95.3
other source of income to hh remaining in region (RHOY)	51,559.9	31,710.8	88,179.8
Regional gross hh income (GRHY)	66,242.6	105,064.4	175,539.1
Regional hh expenditure for commodity demand (RHE)	64,286.7	85,752.0	157,404.0
Regional hh Disposable income (DRHY)	64,286.7	85,752.0	157,404.0
Regional hh Saving (RHSAV)	0.0	0.0	0.0
Compensating Variation (CV)	0.0	0.0	0.0
Equivalent Variation (EV)	0.0	0.0	0.0
Income of out-migration hh (OMHY)	0.0	0.0	0.0
income of immigrating hh (GIMHY)	0.0		
regional expenditure of immigrating hh (IMHE)	0.0		
Net labor income (NLY)	7,506.0	43,769.7	51,230.0
Net Land income (NTY)	154.5	1,552.4	1,231.6
hh cap stock (HK)	6,987.3	27,726.1	34,802.4
Capital compensation to hh (HKY)	6,987.3	27,726.1	34,802.4
Gross hh income (GHY)	66,242.6	105,064.4	175,539.1
Enterprise income distributed to hh (HENTY)	35.0	305.5	95.3
Disposable hh income (regional + inmigrated) (DHY)	64,286.7	85,752.0	157,404.0
Household saving (staying +inmigrat)(HSAV)	0.0	0.0	0.0

	FEG	SLG
Gov revenue from out-migrating hh (OMGR)	0.0	0.0
Investment tax (INVESTTX)	0.0	20,896.5
Enterprise income distributed to gov (GENTY)	9,445.8	1,353.5
Government Revenue (GOVR)	135,378.9	31,211.9
Government expenditure (GOVEXP)	104,785.3	31,211.9
Government Saving (GOVSAV)	30,593.6	0.0

Foreign Saving (ROWSAV)	17,414.6
K compensation to ROW (K2ROW)	397.4

TABLE C2 OUTPUT OF THE SHORT-RUN SIMULATED MODEL

Total Labor Demand (TLAB)	134,676.1
Total Capital Demand (TCAP)	117,081.1
Total Land Demand (TLAND)	3,105.2
Labor migration (LMIG)	12,765.8
Capital migration (KMIG)	1,665.1
Old gross region product (GRP0)	271,013.6
New gross region product (GRP)	290,541.2
index of change in GRP (IGRP)	0.1
Old regional expenditure (RE0)	367,105.7
New regional expenditure (RE)	379,454.8
index of change in RE (IRE)	0.0
Net capital income (NKY)	128,401.4
Enterprise income distributed to capital account (CENTY)	18,999.5
Investment to inventory (INV2INVT)	19,103.1

	LOW	MED	HIG
Labor migration separated by hh group (LMIGH)	12,765.8		
Labor compensation to hh remaining in region (RHLY)	7,506.0	43,769.7	51,229.9
Capital compensation to hh remaining in region (RHKY)	7,103.6	28,187.7	35,381.9
net land compensation to hh remaining in region (RHTY)	184.4	1,852.5	1,469.7
Enterprise income distributed to hh (RHENTY)	35.5	310.6	96.9
other source of income to hh remaining in region (RHOY)	51,574.3	31,749.9	88,236.2
Regional gross hh income (GRHY)	66,403.8	105,870.4	176,414.6
Regional hh expenditure for commodity demand (RHE)	64,443.2	86,409.8	158,189.0
Regional hh Disposable income (DRHY)	64,443.2	86,409.8	158,189.0
Regional hh Saving (RHSAV)	0.0	0.0	0.0
Compensating Variation (CV)	-527.8	-239.1	-873.2
Equivalent Variation (EV)	-522.3	-236.7	-864.1
Income of out-migration hh (OMHY)	0.0	0.0	0.0
income of immigrating hh (GIMHY)	10,733.9		
regional expenditure of immigrating hh (IMHE)	10,416.9		
Net labor income (NLY)	18,239.9	43,769.7	51,229.9
Net Land income (NTY)	184.4	1,852.5	1,469.7
hh cap stock (HK)	6,987.3	27,726.1	34,802.4
Capital compensation to hh (HKY)	7,103.6	28,187.7	35,381.9
Gross hh income (GHY)	77,137.7	105,870.4	176,414.6
Enterprise income distributed to hh (HENTY)	35.5	310.6	96.9
Disposable hh income (regional + inmigrated) (DHY)	74,860.1	86,409.8	158,189.0
Household saving (staying +inmigrat)(HSAV)	0.0	0.0	0.0

	FEG	SLG
Gov revenue from out-migrating hh (OMGR)	0.0	0.0
Investment tax (INVESTTX)	0.0	21,153.6
Enterprise income distributed to gov (GENTY)	9,741.6	1,395.9
Government Revenue (GOVR)	137,940.0	34,221.1
Government expenditure (GOVEXP)	104,806.5	31,523.6
Government Saving (GOVSAV)	33,133.5	2,697.5

Foreign Saving (ROWSAV)	11,963.4
K compensation to ROW (K2ROW)	1,850.7

TABLE C3 OUTPUT OF THE LONG-RUN SIMULATED MODEL

Total Labor Demand (TLAB)	152,108.3
Total Capital Demand (TCAP)	116,138.8
Total Land Demand (TLAND)	3,105.2
Labor migration (LMIG)	30,198.0
Capital migration (KMIG)	722.8
Old gross region product (GRP0)	271,013.6
New gross region product (GRP)	302,124.1
index of change in GRP (IGRP)	0.1
Old regional expenditure (RE0)	367,105.7
New regional expenditure (RE)	390,665.9
index of change in RE (IRE)	0.1
Net capital income (NKY)	113,758.0
Enterprise income distributed to capital account (CENTY)	17,780.6
Investment to inventory (INV2INVT)	18,853.8

	LOW	MED	HIG
Labor migration separated by hh group (LMIGH)	30,198.0		
Labor compensation to hh remaining in region (RHLY)	7,506.0	43,769.7	51,229.9
Capital compensation to hh remaining in region (RHKY)	6,713.3	26,639.0	33,437.8
net land compensation to hh remaining in region (RHTY)	254.6	2,558.6	2,030.0
Enterprise income distributed to hh (RHENTY)	32.2	281.3	87.8
other source of income to hh remaining in region (RHOY)	51,552.0	31,689.5	88,149.2
Regional gross hh income (GRHY)	66,058.1	104,938.0	174,934.7
Regional hh expenditure for commodity demand (RHE)	64,107.7	85,648.8	156,862.0
Regional hh Disposable income (DRHY)	64,107.7	85,648.8	156,862.0
Regional hh Saving (RHSAV)	0.0	0.0	0.0
Compensating Variation (CV)	261.7	472.6	533.0
Equivalent Variation (EV)	263.5	475.8	536.6
Income of out-migration hh (OMHY)	270.4	1,073.1	1,346.9
income of immigrating hh (GIMHY)	25,391.3		
regional expenditure of immigrating hh (IMHE)	24,641.6		
Net labor income (NLY)	32,897.3	43,769.7	51,229.9
Net Land income (NTY)	254.6	2,558.6	2,030.0
hh cap stock (HK)	6,987.3	27,726.1	34,802.4
Capital compensation to hh (HKY)	6,713.3	26,639.0	33,437.8
Gross hh income (GHY)	91,449.5	104,938.0	174,934.7
Enterprise income distributed to hh (HENTY)	32.2	281.3	87.8
Disposable hh income (regional + inmigrated) (DHY)	88,749.3	85,648.8	156,862.0
Household saving (staying +inmigrat)(HSAV)	0.0	0.0	0.0

	FEG	SLG
Gov revenue from out-migrating hh (OMGR)	0.0	0.0
Investment tax (INVESTTX)	0.0	20,877.5
Enterprise income distributed to gov (GENTY)	9,116.6	1,306.4
Government Revenue (GOVR)	140,539.1	34,177.0
Government expenditure (GOVEXP)	104,771.3	30,968.7
Government Saving (GOVSAV)	35,767.9	3,208.3

Foreign Saving (ROWSAV)	10,413.5
K compensation to ROW (K2ROW)	773.4

VITA

XE DO VAN

Candidate for the Degree of

Doctor of Philosophy

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