COMPARISONS OF REGIONAL FIXED PRICE AND GENERAL EQUILIBRIUM MODELS

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Introduction

Impacts of rural development strategies frequently are evaluated using quick and simple fixed price multiplier analysis to estimate aggregate employment and income effects for states and relatively large regions. Employment and income effects, for example, of strategies such as alternative crop and livestock enterprises in agriculture, rural industrialization, and increased value-added activities are estimated using multipliers from a standard fixed price input-output model. Because there are no resource constraints and no fixed period of adjustment embodied in the fixed price multiplier approach, this method may be useful in estimating long-term impacts for small regions where full mobility of factors appears to be appropriate. In evaluating relatively short-term impacts (two to five years) for large regions, however, a regional general equilibrium approach appears to be more appropriate because it captures both price effects and quantity effects compared with the fixed price multiplier approach that captures only quantity effects.

Results of the fixed price multiplier analysis can grossly overestimate regional sector outputs and factor demands and underestimate factor and household incomes when compared to price-endogenous regional general equilibrium models. The latter depend upon model assumptions, particularly the price elasticities of factor supply.

The main drawbacks in using regional general equilibrium models, however, have not been the assumptions typically imposed on such general equilibrium (GE) models (Dervis, deMelo, and Robinson, 1982) but upon the perceived nature of the mobility of regional resources (particularly labor), the perceived closure of regional commodity markets (i.e., distinction between tradables and nontradables), and the lack of appropriate regional data. Many of the data problems in regional GE modeling for the U.S. are being mitigated by development of databases such as IMPLAN (IMpact Analysis for PLANing) and by persistent

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regionalization of data as exemplified by Rose, Stevens, and Davis (1988) and by Koh (1991). The functioning of regional factor and commodity markets for states and large regions awaits further research, but the assumptions of the fixed price multiplier models must be challenged. Results of model comparisons in this research should stimulate the need for knowing more about regional markets, particularly the price elasticity of regional labor supply.

What follows in this report is an analytical comparison of key regional variables under fixed price multiplier analysis and general equilibrium analysis, a brief review of the empirical GE literature, presentation of an empirical GE model for the state of Oklahoma (most of the model specification is relegated to an appendix), and results and analysis of model comparisons for a 10 percent quantity increase of agricultural exports for Oklahoma.

Fixed Price Multiplier Versus GE Results

Assume an exogenous increase in the export quantity for a tradable commodity. The differences in assumptions and model structure between the fixed price approach and the GE approach create differences in commodity market responses, including differences in sector output and regional output prices. The multiplier approach has a tendency to overestimate output responses; this tendency, in part, comes from the treatment of prices as constants.

Overestimation of output for some commodities by the fixed price model can be explained by Figure 1. Let E_0 be the initial equilibrium with P_0 and Q_0 as equilibrium price and quantity for a commodity. Under the fixed price multiplier approach, supply is treated as infinitely elastic, while positively sloped supply curves are associated with the regional GE model for at least some commodities, particularly the nontradable commodities. If demand changes (as represented by a shift from D_0 to D_1), the new equilibrium under fixed price multiplier analysis will be E_1^f. The price remains at P_0 with a new equilibrium quantity of Q_1^f. In the regional GE framework for nontradables, however, price increases to P_1^g and equilibrium quantity is Q_1^g, which is less than Q_1^f.

This difference in output response basically originates from a Hecksher-Ohlin assumption about factor mobility: factors are mobile between sectors and immobile between regions. This assumption may be too strong for regional versus national economic analysis. In the short run, however, this assumption is useful, especially for large regions, in identifying market behavior for a regional economy under exogenous shocks. Increase in output of some sectors requires decreases in output in other sectors (because of factor mobility). Exports decrease for all sectors with the exception of the sector for which export increase is exogenous. Increases in output prices result in increases in regional import demand. Changes in trade volumes are based on increased intermediate demands governed by interindustry relationships and increased consumption originating from increased income.

Changes in the regional factor market are shown in Figure 2. Initial equilibrium for factor demand D_0 is at price P_0 for quantity X_0. Under the fixed price multiplier approach, factor supply again is treated as infinitely elastic; hence, with a shift in demand to D_1, quantity supplied is X_1^f. For the regional GE model, some factors are fixed, at least in the short run (land and capital). Hence, price increases to P_1^g with the shift in demand. What is less certain is the response of labor supply. Labor is assumed to be mobile between sectors, but how mobile is it between regions and how responsive is it to changes in wage rates? Even if it is assumed to be immobile between regions (which is not likely), persons within the region may be enticed to offer more labor at higher wage rates.

The more likely response is that for a rural development strategy such as emphasizing alternative higher income agricultural enterprises (i.e., fruit and vegetable production for wheat and beef production in Oklahoma), the regional labor supply will not be perfectly elastic but will have some upward slope such as S_2^g. If this is the case, the wage rate for the increased demand D_1 will be P_2^g and the quantity of labor supplied will be X_2^g. It thus becomes an empirical problem to estimate the price elasticity of labor supply for alternative agricultural enterprises.

Change in income from the exogenous change in export quantity is significantly more sensitive in the regional GE approach compared to the fixed price multiplier approach. The fixed price multiplier framework captures changes in factor income by changes in quantities of factors used in production. The regional GE framework captures changes in factor income caused by sectoral changes in factor use and changes in factor prices associated with given aggregate factor availability. This is shown in Figure 3.

Assume an economy with one input (X) and two goods (A and B). Initial equilibrium is depicted by point E_o in Figure 3. The distances from O_a to X_o and from O_b to X_o on the horizontal axis measure equilibrium quantities of X allocated to production of goods A and B, respectively. The equilibrium price of X is represented by P_o on the vertical axis. Factor income is measured by the rectangular area $O_aP_oP_oO_b$. If the price of B increases for some reason, the value of the marginal product of X will increase for the production of B (MVP_b to MVP_b'). For simplicity, assume that this will not affect the price of A. Under fixed price multiplier analysis, new equilibrium quantities of X used in production of A and B will be O_aX_o and $O_bX_1^f$, respectively. The initial equilibrium price, P_o, is valid for the new equilibrium. This implies that the availability of factor X increases by the distance from X_0 to X_1^f at the equilibrium price. Consequently, the change in factor income under this approach is only a quantity effect and equal to the area $X_0X_1^fE_1^fE_0$.

On the other hand, in the regional GE model the assumption is that the total amount of X available is fixed at O_aO_b. The change in price of B will bring a new equilibrium price for X of P_1 and new equilibrium quantities of X allocated to A and B of $O_aX_1^g$ and $O_bX_1^g$, respectively. The rectangular area $P_1P_0P_0P_1$ is the change in factor income for X.

The regional GE results on factor prices and factor incomes are important in explaining rural development strategies to rural residents. If the fixed price multiplier result is assumed, telling rural persons whose resources already are employed fully that a proposed rural development strategy is not going to change the rate of return (price) on their resources but only is going to expand the resource base of their region probably will be met with considerable skepticism and disinterest.

General Equilibrium Models

General equilibrium implies that all individual economic agents (and all subsets of the agents) in the system are in equilibrium. To define equilibrium, assumptions are required about the behavior of agents and their initial conditions or constraints. A simple conceptual GE model without production is the pure exchange model with two consumers and two goods represented by the Edgeworth box diagram. The behavioral assumption is utility maximization for the two agents, and the constraint assumption is the amount of goods each person owns initially. GE for this exchange economy is the point where the indifference curves for the two persons are tangent to each other and where the offer curves originating from the initial point intersect with each other. GE prices are represented by the slope of the straight line tangent to both indifference curves. At this GE price ratio, exchanges are made between the two agents in such a way that the exchange brings utility maximization for both with given initial amounts of goods to each. Under the convexity assumption for consumption sets, this equilibrium will be unique to the given setting. But this model does not include production activities.

A basic economic system with n commodities (denoted by a vector y) and m primary factors (vector x) is represented in Figure 4. Government and trade are not included in this basic structure. The number of producers and consumers is not specified. A set of firms produces n commodities combining m factors and n intermediate goods with given technology. Households consume n goods with given utility structure under the constraints imposed by incomes generated from selling factors of production they own. A total of n + m markets exists in the economy. Factor markets generate household incomes that are factor costs to firms. Commodity market prices determine household expenditures and revenues for the firms. The n + m equilibrium prices (denoted by vectors of P_y^* and P_x^*) that clear all markets with equilibrium quantities of Q_y^* and Q_x^* define the GE for the system.

Ginsburgh and Robinson (1984) distinguish two broad families of empirical GE models: computable general equilibrium (CGE) models and activity general equilibrium (AGE) models. CGE models search for a price vector that clears all markets in the system specified by a set of behavioral rules for economic agents with given factor endowments and technology. Competitive markets generally are assumed. A solution vector that makes the excess demand function values for all commodities and all factors simultaneously equal to zero is considered to be the GE solution. The first order conditions for the economic agents' objective functions should be satisfied simultaneously under the assumptions of well-behaved production and utility functions. CGE models usually involve a number of nonlinear equations, but no inequality constraint or explicit objective function is required.

AGE models are cast in the format of mathematical programming with an explicit objective function to be optimized with a set of constraints (Ginsburgh and Robinson, 1984). A programming approach, as discussed in Hazell and Norton (1986), maximizes the value of consumption or consumer surplus subject to various feasibility conditions specified by technology, resource availability, and marginal cost pricing. Under competitive markets, resources are employed fully, and shadow prices for activities and resources are the GE commodity prices and factor returns.

Shoven and Whalley (1984) provide a comparative analysis of 18 CGE models applied to tax and international trade policy. Devarjan, Lewis, and Robinson (1986) list 48 references to empirical CGE models applied to 22 countries. Thorbecke (1985), calling the CGE model the second generation consistency model compared with the fixed coefficient first generation consistency model, gives an in-depth evaluation of three early CGE models applied to developing countries. More recently, Decaluwé and Martens (1989) compare the basic structure of 73 empirical applications of CGE models for 26 developing countries, 67 of which were made in the 1980s. CGE models have been applied in the United States for tax and trade policy evaluation since the early 1980s (Shoven and Whalley, 1988). In 1990 a CGE model for the U.S. with emphasis on the agricultural sector was developed at the USDA (Robinson, Kilkenny, and Hanson, 1990). Hertel views the relatively recent appearance of CGE analysis in U.S. agricultural economics as a belated arrival.

Because general equilibrium relies on basic characteristics of markets, the structure of CGE models used to evaluate different policies need not be too different. The differences come from the degree of elaboration in model specification for different components of the model, including the level and manner of disaggregation for sectors, factors, and households. Moreover, most CGE models have some components of income distribution because consumption demand and savings are specified as functions of income, and income depends on the level of endogenous production.

Tax policy is the most widely applied area of research for CGE models. Following Harberger's (1962) two sector model for tax policy analysis, Shoven and Whalley (1972) analyze effects of changes in capital income tax on labor income with two income groups (capital and labor). In agricultural areas, Hertel and Tsigas (1988) have used a 1977-based U.S. CGE model to analyze impacts of eliminating the farm/nonfarm disparity in tax rates. Shoven and Whalley (1984) and Pereira provide surveys of the tax models.

One of the most comprehensive CGE models is for Australia with 114 commodities. The model, by Dixon *et al.* (1982), shows that a 25 percent increase in all import tax rates will lead to a 0.21 percent decrease in total employment. The USDA/ERS CGE model of the U.S. developed by Robinson, Kilkenny, and Hanson (1990) recently was used in analyzing the impacts of alternative world trade environments on the U.S. agriculture (Hanson, Robinson, and Tokaric, 1990).

Even though national CGE models increasingly are being used in diversified fields of economic analysis, regional applications are limited. Jones and Whalley (1985) have evaluated differential regional impacts of Canadian tariff policy with respect to U.S.—Canadian trade. Using a two domestic region and three commodity interregional CGE model, they conclude that unilateral abolition of Canadian tariffs will have negative welfare effects for western Canada and that only with restricted assumptions will there be a small gain in welfare for eastern Canada. Harrigan and McGregor (1989) analyze the different general equilibrium results caused by alternative macroeconomic closure rules using a one sector, two region model for Malaysia. Fisher and Despotakis (1989) estimate the impacts of alternative energy taxes on the California economy using a regional CGE model. Morgan, Mutti, and Partridge (1989) investigate how alternative tax policies affect interregional factor mobility in the U.S.

The main reasons for infrequent regional applications seem to be twofold. First, policy instruments available to regional governments are limited when compared with central governments. Price, monetary, trade, and income distribution policies generally are not applicable at the regional level. Thus, the usefulness of the CGE model at the regional level is limited.

Regional GE models, however, can be used to evaluate impacts of central government policy or other exogenous shocks on specific regional economies. Because of differences in economic structure and factor endowments across regions, impacts of central government policies may vary significantly across regions. General equilibrium analysis is desirable when evaluating adjustments of regional economies through factor and commodity market interactions.

Second, regional CGE models lack appropriate data. As Dervis, deMelo, and Robinson (1982) suggest, constructing a consistent database for an economy-wide model is a nightmare. But the problem is more severe for regional models. For national models, income and input-output accounts are used widely as the database for the production side. Consumer expenditure surveys with national income accounts are utilized as data sources for the demand side. These same data may be utilized for regional models, but with more difficulties in the reconciliation process. Many of the data problems in regional CGE modeling for the U.S. have been mitigated by the development of IMPLAN and by the contributions of Rose, Stevens, and Davis (1988) and others.

The basic structure of a regional CGE model for this study is represented in Figure 5. Variables in rectangles are exogenous, while those in ovals are endogenous. Arrows show the direction of flow of causal relationships. The plus (+) or minus (-) signs indicate how the affected variable moves relative to the causal variable. In other words, the plus sign indicates that the partial derivative of the affected variable with respect to the causal variable is positive.

A regional economy is assumed to produce and consume two distinct groups of commodities with respect to the rest of the world: tradables and nontradables. Most commodities produced by the agriculture, mining, and manufacturing sectors are tradables. Outputs of the construction, wholesale trade, retail trade, and service sectors are relatively close to nontradables. The dimensions of the two vector variables sum to n, reflecting an n-commodity space. The prices of tradables are exogenous, while the prices of nontradables are determined by the interaction of supply and demand within the region.

Suppose the price of a tradable commodity increases as a result of government policy. The initial first round effect is positive on production and negative on consumption of the commodity. But interindustry relationships, and interdependencies between factor and commodity markets are important in analyzing the multidimensional income distribution effects of the commodity policy. Stimulated production of the commodity initially shifts factor demands (land, capital, and labor with various types of skills) and the demands for both tradables and nontradables for intermediate use. Factor prices rise with limited interregional factor mobility in the short run. Increases in factor prices imply negative feedback effects on production of both groups of commodities and positive effects on regional incomes. Changes in factor prices influence income distribution and consumption demand for commodities. This change in commodity demands will affect production activities. As part of this process, tax revenues for governments are determined with given tax rates (not included in the figure for simplicity). The magnitude of all changes depends on the corresponding elasticities.

Under the assumption of smallness of a region relative to the national economy, demand functions for tradables are perfectly elastic. (Otherwise downward sloping demand curves can be incorporated in the model.) Changes in regional output do not affect national prices of tradables. Therefore, the level of production in the region has no feedback effect on own price for tradable commodities, but it plays a significant role in the determination of factor prices and prices of nontradables. For nontradables, prices are endogenous to the regional economic system. Prices adjust to eliminate the excess demand for nontradables in contrast to the market clearing by adjustment in trade for tradable commodities. This type of adjustment mechanism requires price differentials for nontradables and factors between regions. Mobility of resources will reduce price differentials in the longer time horizon.

The assumptions on tradables and nontradables are relaxed in model specification by introducing the concept of composite goods, which incorporates sectorwise elasticities of substitution between imported goods and regionally produced goods.

For CGE modeling, the social accounting matrix (SAM) is utilized as a basic data framework. A SAM is a snapshot description of an economy representing the full circular flow of commodities and money during a certain time period, i.e., the base year. It has the same accounts for columns and rows, implying that a SAM is always square. Entries down a column are expenditures by the column heading account to each of the corresponding row heading accounts, i.e., an entry in ith row and jth column represents the amount of money paid by jth column account to ith row account. Therefore, the row sum and the column sum of each account are always the same. In this way, a SAM provides consistent information on overall structure of an economy by organizing data on production, income, and consumption in the base year.

In constructing a CGE model, it is considered that the economic system represented by the SAM is in general equilibrium. A CGE model is a system of equations representing theoretically consistent economic relationships between variables and can reproduce the base year SAM with values for the exogenous variables prevailing in the base year. In this sense, the basic structure of a CGE model depends on the structure of the SAM.

The Oklahoma CGE Model

The structure of applied general equilibrium models is similar, with differences between models in the degree of complexity and emphasis on the policy issue in question (Shoven and Whalley, 1984). This is not surprising because the usual assumptions behind the models most often include competitive markets with full information and profit or utility maximization behavior of economic agents. Based on these assumptions, the models are structured to allow prices of outputs and inputs to adjust until equilibria in all markets are attained. Such microfoundations in a multisectoral framework are standard and accepted, especially for static analysis (Dewatripont and Michel, 1987). The Oklahoma CGE model follows a variant of that developed by Dervis, deMelo, and Robinson (1982). The model is presented in the appendix. The empirical basis of the model is discussed here.

Several steps are involved in the empirical implementation of the model in this study. The first step is to construct the regional SAM. Because of limited data and a lack of consistency among certain data sets, most of the time required for this study is devoted to this step. The second step is to determine the parameters for the regional CGE model. All of the parameters, with a few exceptions, are calibrated from the base year SAM in an *ex post* fashion. In some cases, however, parameter values are determined first and the real variable values for the benchmark SAM are estimated based on these initial parameters. The third step is transforming the model into a computer program and obtaining the base solution which is the exact reproduction of the base SAM. The last step is performing the simulation experiments with the model based on selected exogenous variables.

In constructing the regional SAM based on published data, some of the values in the SAM had to be estimated. This is true even for national SAMs, especially when the structure of the SAM focuses on income distribution. A set of guidelines is established when estimation is inevitable. If regional data are unavailable or if multiple data sets are inconsistent, the following guidelines are established

- Adopt or make approximations from available national data;
- Determine aggregate values first and then progress to disaggregation using the aggregate values as control totals; and
- Final values must balance for all accounts in the SAM.

Major submatrices of the SAM including the use matrix and final demands—household demand, government demand, investment demand, and exports and imports—are derived from IMPLAN developed by the USDA. Other parts of the SAM are constructed by organizing data from various sources, including the Census Bureau of the U.S. Department of Commerce and Rose, Stevens, and Davis (1988) on income distribution.

IMPLAN is an input-output database available in microcomputer software form. This study used micro IMPLAN release 89-03 (version 2.0) containing 1982 data.[1] IMPLAN permits construction of regional input-output accounts with 528 sector detail for a single county or combination of counties of the U.S.

Fundamental characteristics of the IMPLAN database are centered on the assumption of U.S. production technology and the estimation of regional purchase coefficients. The basic assumption used in the construction of IMPLAN database is that production technology is homogeneous across all regions of the U.S. for all sectors. This assumption allows the generation of regional input-output tables from the national table with exogenous estimates of regional industry output. For example, the regional make matrix is generated by multiplying regional total industry output (exogenous data) by the national byproduct matrix. The regional use matrix is derived by dividing each column element of the national absorption matrix by regional total industry output.

The key parameter used to estimate interregional commodity flow is the regional purchase coefficient (RPC) which represents the proportion of locally produced commodities (net commodity supply) used to meet local demand (regional commodity demand). For the tradable commodities (IMPLAN sectors 1 to 445), the RPCs are estimated using a regression analysis using the Multiregional Input-Output Accounts (MRIOA) data provided by the U.S. Department of Human Services. The RPCs for the remaining sectors are based on the MRIOA data (Alward *et al.,* 1989, pp. G.1-G.4). Incorporating these RPCs into the above regional input-output matrices, IMPLAN generates detailed data on production, intermediate demand, consumption, investment, exports, and imports for each of the 528 sectors with limited additional exogenous data. Exogenous estimates used include gross regional final demand, government demand, foreign trade, and inventory changes (Alward *et al.,* 1989).

The SAM for this study is presented in Table 1. It has nine economic sectors; factors characterized by five types of labor, one type of land, and one type of capital; three geographic institutions represented as urban, rural agriculture, and rural nonagriculture; three household accounts categorized by low, medium, and high income classes; a government account; a condensed capital account; and a rest-of-the-world account.

The SAM summarizes the overall performance and structure of the Oklahoma economy in 1982. Each entry of the matrix is expressed in terms of millions of 1982 dollars. With normalized prices, the entries

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[1] A new version of IMPLAN containing 1985 updates became available in early 1991.

also can be interpreted as quantities. Individual aggregate accounts are discussed below.

Sectoral output totaled $94 billion in 1982. A total of $46 billion of intermediate inputs is used, and the GSP (or value added including indirect taxes) is $48 billion. Of the total production, $39 billion is exported. Total commodity demand in the region is $88 billion dollars, of which $36 billion is met by imports. This implies that the state is a net material exporter. Shares of total exports of the agricultural and mining sectors are 5.7 percent and 26.7 percent, respectively. Had the petroleum refining industry been included in the mining sector, the share of the two natural resource based industries would have been higher.

The value added by labor is $27 billion, comprising 56.1 percent of total GSP. Capital (including land) and indirect tax shares are 34.2 percent and 9.7 percent, respectively. The factor shares represented by the U.S. SAM for the same year are 60.4 percent for labor, 31.7 percent for capital, and 7.9 percent for indirect taxes (Robinson *et al.*, 1990). Comparing the two sets of factor shares, labor share for Oklahoma is smaller than the national average. The considerably smaller labor share and hence larger capital share for Oklahoma compared to the nation also is observed in the GSP data series provided by the Bureau of Economic Analysis, U.S. Department of Commerce (Renshaw, Trott, and Freidenberg, 1988).[2]

Household income distributed to geographic institutions is $21 billion for urban (67 percent), $0.6 billion for rural agriculture (2 percent), and $10 billion dollars for rural nonagriculture (31 percent). The income from rural agriculture for low income households is negative. This can be interpreted as a result of instability of farm proprietary income and of the intrinsic nature of small family farms.[3]

Aggregate savings including depreciation and retained earnings is about $13 billion, $7 billion of which is invested and $6 billion of which can be considered as financial outflow. Total household consumption is

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[2] According to the BEA data series, Oklahoma labor and capital shares are about 53 percent and 27 percent, respectively, from 1982 to 1986. The U.S. counterpart shares are about 60 percent and 22 percent. The share of proprietary income is about 26 percent to 27 percent for Oklahoma and 9 percent to 10 percent for the U.S. for the same period.

[3] In 1982, only 7,232 of 72,523 farms in Oklahoma (or 10 percent) had more than $40,000 of sales per farm. The share of these farms of total sales of agricultural output is 80.3 percent. On the other hand, the estimated value of farm machinery and equipment owned by these farms is about 50 percent of the state total, indicating relatively high capital cost to small farms (UADC, 1984a. pp. 88-103). Farm income data for the U.S. show that annual returns to farm operators for farms with less than $40,000 of sales is negative from 1980 to 1983 (USDA, 1984, pp. 81-83).

about \$28 billion; \$4 billion dollars is spent by low income households, \$11 billion by medium income households, and \$12 billion by high income households.

The model parameter estimation process is related to the structure of the SAM construction. In most applied CGE models, parameter values for the equations are determined in a nonstochastic manner called *calibration*. The calibration procedure is the process of solving the model equations for parameters using benchmark or base year values of endogenous and exogenous variables.

Suppose a n-dimensional vector function exists as the following:

(1) $Y = F(X; a, \beta, e)$

where:

- Y = A vector of n endogenous variables;
- X = A vector of exogenous variables;
- a = A vector of known parameters selected from available knowledge;
- β = A vector of unknown parameters; and
- e = A vector of stochastic disturbances.

Using the implicit function theorem, equation (1) can be expressed as:

(2) $\beta = G(X, Y; a, e)$

As discussed before, in a SAM-based CGE model the base year SAM is assumed to be a representation of general equilibrium which satisfies equation (1). Moreover, it is assumed that e is a zero vector under the situation that there is only one observed general equilibrium data set. These two assumptions enable a solution to equation (2) as long as equation (1) is linear in the parameters and values for X and Y are provided by a base SAM. This procedure of calibration ensures parameter values whereby the model can reproduce the base year equilibrium.

The calibration approach has certain intrinsic weaknesses. First, the number of parameter vectors that can be determined by this approach can not exceed one for each vector equation in the model as implied by equations (1) and (2). For example, if there are two or more unknown parameters in equation (1), equation (2) cannot be solved for any of the parameters. This is the reason why the functional forms of utility (or demand) and production in most empirical CGE applications are restricted to Cobb-Douglas, Stone-Geary, or CES, etc., whether they are single staged or nested multiple stage functions.

If the number of unknown parameter vectors exceeds one, the general practice is to assume some subjective alternative values for the parameter vectors which are not determined by use of the calibration procedure and to analyze the effects of the different values for those parameters on model performance. This sensitivity analysis is used widely for determining parameters whose values are considered to be pivotal to model results even when the unknown parameter vector in equation (1) is one and thus there is no problem in solving equation (2). An important drawback of the calibration approach, however, is that it lacks the formal statistical measures to determine the degree of reliability of calibrated parameters and thus the SAM-based model itself.

Even with these weaknesses, most empirical CGE models, with some exceptions (Jorgenson, 1984; Jorgenson and Slesnick, 1985), follow the calibration approach. The basic reason for their use is that multisector general equilibrium models require a large number of parameters, but available numerical information on the parameters consistent with the models is limited and alternatives such as econometric estimation involve other problems of data, structure, time, and budget.

The proponents of the calibration approach such as Mansur and Whalley (1984) and Diewert (1985) emphasize the difficulties in econometric parameter estimation:

- Identification of the problem in relation to the number of parameters to be estimated and degrees of freedom;
- Incompatibility of units used in the CGE model and the equations in the estimation process; and
- Although econometric estimation allows the incorporation of flexible functional forms into the model, these functions may not be globally well-behaved and may make the model more complicated.

Considering that the basic purpose of CGE analysis is counterfactual simulation, the calibration approach may not cause serious problems in regional modeling. The current Oklahoma model follows the calibration procedure.

Every equation in the current regional CGE model, except the equations for composite commodity and import demand (see appendix equations), satisfies the condition that the number of unknown parameter vectors does not exceed one. The joint solution of the two equations in the CES functional form have three (equation A-52) and two (equation A-53) unknown parameter vectors. Therefore, at least one of the parameter vectors must be provided exogenously. The approach followed is to assume specific values for the elasticity of substitution parameters and then to calibrate the other parameters.

In selecting the elasticity of substitution parameter values, it is assumed that the elasticities for tradables are greater than unity, while the elasticities for nontradables are less than unity. For initial conditions, the values of 4.0 and 0.5 are selected as elasticities of substitution for tradables and nontradables, respectively, in this study, even though simulations based on different elasticities are presented in Koh (1991).

The elasticity of export demand is an important parameter that determines the performance of an economic system and is not calculated from the SAM. The elasticity of demand for Oklahoma products for each production sector is not available. The elasticity of import demand for the U.S., however, provides important information about the Oklahoma export demand parameters. Akhtar (1980) estimates price elasticities of total import demand for the U.S. of 0.17 using 1960 through 1976 annual data, 0.13 using 1952 through 1976 annual data, and 0.4 using 1970 through 1976 quarterly data.

Kreinin (1973) estimates price elasticities for U.S. imports by major commodity groups using 1964 through 1970 data. The results show that for most of the commodity groups the estimates are concentrated in the 0.5 to 1.0 range. Exceptions are processed fruits and vegetables (1.13), sugar and confectionery (1.14), manufactured animal feeds (3.41), cotton products (1.17), and paint and paint materials (1.56). The elasticity estimates by Deyak *et al.* (1989) for five industry groups using 1958 through 1983 quarterly data are 0.76 for manufactured foods, 0.84 for semimanufactures, 1.00 for finished manufactures, 0.27 for crude foods, and 0.53 for crude materials.

Elasticities estimated from international trade data are only indicative of elasticities for regional trade. Regional trade is expected to be more price responsive. It is believed, however, that responsiveness to exogenous price changes in agriculture and energy are fairly consistent for all regions. For other sectors, the existence of nonprice competition (including brand names, distribution channels, etc.) will limit the responsiveness of demand to price changes.

Based on these considerations, the elasticity values used in model simulations were 0.7 for tradable goods and 0.3 for nontradable goods. Model results based on other sets of elasticity values are compared in Koh (1991).

The first multisector general equilibrium model by Johansen (1960) is solved by log-linearization of all equations in the endogenous variables. Many AGE models have been solved by use of optimization techniques. Most CGE models, however, are solved directly for the endogenous variables using a variety of solution algorithms. Dervis, deMelo, and Robinson classify these algorithms into three categories: fixed-point-theorem-based approach, tatonnement-process-based approach, and Jacobean algorithms. They also discuss the advantages and disadvantages of the algorithms (Dervis *et al.*, 1982, pp. 491-496).

This study uses the GAMS (general algebraic modeling system) algorithm to solve the regional model. GAMS is a mathematical programming software program designed to solve both linear and nonlinear problems. For nonlinear problems, the GAMS/MINOS solution algorithm, which belongs to the third category listed above, is used. Because of the characteristic GAMS syntax of optimization, an objective function is required. All equations in the model become constraints. None of the equations in the model, however, has an inequality sign. Therefore, any equation in the model is eligible to be the objective function as long as it is a scalar equation.

Condon, Dahl, and Devarajan (1987) and Robinson, Kilkenny, and Hanson (1990) use GAMS in solving their CGE models for the Cameroon and for the U.S., respectively. Detailed programming procedures are provided in Jefferson and Boisvert (1989) and Brooke, Kendrick, and Meeraus (1988).

With base year exogenous variable values, the solution values for the endogenous variables will be the same as those in the base year SAM. The program for this study that reproduces the base Oklahoma SAM is available from the authors. The objective function chosen is minimization of the sum of a set of slack variables. Two slack vectors, SLACK1 and SLACK2, are introduced in the production function equations and also are expressed in the objective function. This technique (trick) is recommended by Brooke *et al.* (1988) to address the infeasibility problem that frequently occurs during the iteration process for nonlinear programming models. Both of the slacks are declared to be positive variables. If the sum of the slacks is zero (so both must be equal to zero) at the equilibrium solution, the solution will be optimal in that the objective function is minimized satisfying all of the equations in the model, and the introduction of the slacks does not affect any solution values in the model.

Comparisons of Model Results

Comparative static analyses of the Oklahoma CGE model are reported in this section, assuming an exogenous shock of a 10 percent increase in the quantity of agricultural exports. Comparisons are made between the CGE results and the fixed price SAM multiplier results. CGE results are shown based on labor supply elasticity parameterized from 0 to 1000. Factor supplies for capital and land are fixed in the CGE model. Elasticity of substitution between imported and regional goods is assumed to be 2.0 for the tradable goods and 0.5 for the nontradable goods. Elasticity of export demand is assumed to be -0.7 for the tradable goods and -0.3 for the nontradable goods. Results of all simulations are compared to the base SAM. Hence, a value for an endogenous variable of 1.1 is interpreted as a 110 percent of the base result for the same variable, whereas a value of 0.9 is interpreted as a 90 percent-of-the-base result.

Results of selected variables are presented in Table 2 from the model simulations. The first five columns present the CGE results when the elasticity of labor supply ranges from completely inelastic (e = 0) to almost infinitely elastic (e = 1000). The assumptions for capital and land in the CGE results are those of fixed quantities (zero elasticity). The last column shows the results for the fixed price multiplier analysis which assumes infinitely elastic labor supply as well as for capital and land.

Although not shown in Table 2, regional and composite prices increase in all sectors for the CGE models. Excluding agriculture, the composite price generally increases more for the nontradables than the tradables, which shows the result of less opportunity to substitute imports for domestic production. All commodity price effects decrease significantly as the elasticity of labor supply increases. All commodity prices remained unchanged for the fixed price multiplier results.

Sector outputs decrease for all tradables except agriculture and increase for all nontradables at the lower labor supply elasticities. Only at the higher labor supply elasticities did any of the tradables show sector output increases, and processed manufacturing (Manufacturing-1) shows decreased output throughout. Sector outputs all increase for the fixed price multiplier result, as expected, because of the fixed coefficient relationships in production between agriculture and all other sectors.

The results of most interest are the effects on factor supplies, wage rates, capital (and land) rents, factor incomes, and institutional and household incomes. These results are presented in Table 2.

Factor supplies are not limited in fixed price multiplier analysis. Land supply is presumed to increase 6.8 percent, and total capital (all sectors) is expected to increase 0.5 percent. Labor category 4 (farming, forestry, and fishing occupations) increases 5.2 percent. For the CGE models, capital and land are fixed by sector, but labor is allowed to increase according to the elasticity of labor supply. Because the sector production functions allow factor input substitutions, labor can substitute for land and capital which are assumed fixed in the CGE model. Thus, labor category 4 increases 7.8 percent when the elasticity of labor supply is 0.5 and increases 19.2 percent when the elasticity approaches infinity. All other labor categories increase less than the fixed price multiplier results, although the rates tend to converge as the elasticity of labor supply increases. Although the CGE model permits substitution among labor skills, this model result is less significant because the same elasticity of labor supply is assumed for each labor skill.

Wage rates all increase at low elasticities of labor supply but converge to 1.0 at the highest elasticity which is comparable to the infinite elastic result for the fixed price multiplier. When the elasticity of labor supply is zero (fixed labor supply), the wage rate increases over 30 percent for labor category 4. This increase in wage rate reduces to 11.1 percent with a elasticity of labor supply equal to 1.0.

Rental price of capital shows the same result as the wage rate (with one exception). Rental price is highest at fixed supplies for all resources and decreases as the elasticity of labor supply increases. The rental price on capital for all elasticities remains greater than the rental price under the fixed price multiplier result, however, except for Manufacturing-1. Agriculture and Manufacturing-1 evidently are in competition for certain labor skill categories which results in lower sector output for Manufacturing-1 (not shown here) and a reduced rental price for the fixed capital in that sector.

Rental prices of capital and land increase significantly (40.1 percent) when all resources are fixed in supply, and the quantity of agricultural exports increases 10 percent. The rental prices of capital and land decrease as the responsiveness of labor supply increases, but they remain at a 25.5 percent higher level when the wage rate adjusts to the level of the fixed price multiplier result.

Factor income results are the product of multiplying factor supply changes by the corresponding factor price changes. Thus, labor income for category 4 and land and capital income are higher for the CGE results compared to the fixed price multiplier results. Factor incomes for the remaining labor categories in the CGE results for the highest elasticity of labor supply are less than or equal to the fixed price multiplier, even though the wage rates are equal. This results from the smaller increase in labor supply for the CGE model compared to the fixed price multiplier result.

Institutional income is equal to or higher for all CGE results compared to the fixed price multiplier results. The increase in rural farm income is 3.5 to 5.6 times greater for the CGE than the fixed price multiplier income increase, depending on the elasticity of labor supply. The increase in rental price of capital and land (because of constrained supply and because of a quantity increase in agricultural exports) increases agricultural income significantly more than the fixed price multiplier analysis (where factor supplies are permitted to increase but prices are constant).

Household incomes, except for the low income households, increase more under the CGE results compared to the fixed price multiplier results. Because small farms show negative returns in the base SAM, this result means a smaller increase for low income households in the aggregate when compared to the fixed price multiplier result.

Conclusions

Fixed price multiplier analysis is a quick way to estimate the impacts of exogenous changes (shocks) on rural regions. Availability of employment and income multipliers at great sector detail and for specific geographic divisions has given professionals a sense of precision of expected impacts that is not warranted. The time frame of the analysis or the structure of the regional economy may not be conducive to the rigid assumptions of fixed price multiplier analysis.

In Koh's study of the boom and bust cycles of the Oklahoma economy from 1977 to 1986, a fixed price multiplier analysis proved inadequate. Policy makers can be misled by fixed price multiplier analysis into thinking that certain actions of a structural nature can bring rapid results. Policies advising investments in value-added activities, promotion of international trade development, or creation of infrastructure necessary for development of alternative crop and livestock enterprises are structural in nature and should be evaluated for long-term development results. Expectations of a certain level of direct employment created through these strategies and a further significant multiplier effect in the short run are not realistic. Creating capacities in a regional economy requires time, and more complete evaluations are necessary to determine if policies used in the process have positive benefits.

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Table 1—Social Accounting Matrix for Oklahoma, 1982 (millions of 1982 dollars)

	Agri-culture	Mining	Con-struction	Mfg-1	Mfg-2	Transportation, Communication, Utilities	Trade	Finance, Insurance, Real Estate	Services
Production Sectors									
Agriculture	1064.4	0.4	0.0	600.5	3.5	0.0	0.4	0.3	59.5
Mining	3.1	2413.8	42.1	3.9	4247.7	1289.6	0.0	0.1	34.3
Construction	44.4	25.3	8.9	19.3	177.0	297.9	56.8	246.5	261.3
Manufacturing-1	462.2	40.3	495.9	903.0	314.2	28.6	108.5	69.2	882.4
Manufacturing-2	437.8	2357.5	1813.9	339.7	5952.7	770.5	223.0	59.7	983.7
TCU	143.9	677.7	192.7	172.3	1290.4	1590.5	427.9	184.5	726.4
Trade	208.3	380.1	646.9	193.3	731.8	98.9	106.2	25.9	401.1
FIRE	338.7	1505.1	77.7	47.7	284.1	157.8	413.7	980.3	685.1
Services	243.3	988.9	564.3	211.4	1019.6	396.9	1071.6	617.8	1552.1
Factor Accounts									
Labor-1	34.5	705.0	339.5	145.9	1010.7	409.4	800.7	394.1	4715.5
Labor-2	13.8	340.9	173.9	131.7	687.7	560.3	1794.8	788.2	2243.6
Labor-3	3.3	25.5	9.3	10.0	45.8	27.5	42.7	26.4	1859.5
Labor-4	115.7	0.7	1.3	3.0	0.7	0.6	1.8	2.7	27.6
Labor-5	15.9	2047.6	1608.3	398.9	2231.8	890.7	978.1	27.6	876.8
Capital	259.8	5845.0	87.0	268.1	1030.7	2196.5	758.2	3587.5	1859.1
Land	322.3								
Institutions									
Urban									
Rural Agriculture									
Rural Nonagriculture									
Households									
Low									
Medium									
High									
Government	72.5	1500.8	70.8	26.4	424.2	350.4	1062.4	908.7	187.2
Condensed Capital									
Rest of World	676.5	1314.9	612.1	5212.7	12868.0	2445.0	1460.7	3246.9	5706.7
Column Totals	4460.7	20169.5	6744.6	8687.7	32320.6	11511.1	9307.6	11166.4	23061.8

Table 1 (cont.)—Social Accounting Matrix for Oklahoma, 1982 (millions of 1982 dollars)

	Labor 1	Labor-2	Labor-3	Labor-4	Labor-5	Capital	Land	Urban	Agriculture
Production Sectors									
Agriculture									
Mining									
Construction									
Manufacturing-1									
Manufacturing-2									
TCU									
Trade									
FIRE									
Services									
Factor Accounts									
Labor-1									
Labor-2									
Labor-3									
Labor-4									
Labor-5									
Capital									
Land									
Institutions									
Urban	5284.6	4145.0	1260.1	34.6	5341.3	4496.8	30.6		
Rural Agriculture	27.5	11.0	2.6	92.1	12.6	94.6	240.2		
Rural Nonagriculture	2362.9	1886.0	576.3	11.6	1909.4	0.0			
Households									
Low								388.5	-14.2
Medium								7214.6	351.2
High								12989.8	272.6
Government	932.5	734.1	223.4	16.8	989.2	1080.6	51.5		
Condensed Capital						8310.5			
Rest of World									
Column Totals	8607.5	6776.1	2062.4	155.1	9130.8	15891.9	322.3	20592.8	609.6

Table 1 (cont.)—Social Accounting Matrix for Oklahoma, 1982 (millions of 1982 dollars)

	Nonagriculture	Low	Medium	High	Government	Condensed Capital	Rest of World	Row Totals
Production Sectors								
Agriculture		37.7	94.6	91.4	250.7	28.9	2228.4	4460.7
Mining		0.1	0.2	0.2	1.5	1652.8	10480.1	20169.5
Construction		0.0	0.0	0.0	911.5	2999.0	1696.6	6744.6
Manufacturing-1		580.7	1610.1	1529.7	471.8	92.7	1098.5	8687.7
Manufacturing-2		475.6	1686.3	1766.5	1424.0	1794.7	12235.0	32320.6
TCU		418.4	973.1	995.1	408.5	84.5	3225.1	11511.1
Trade		683.6	1987.3	2163.5	99.5	311.1	1270.2	9307.6
FIRE		719.6	2156.9	2621.3	224.5	102.4	851.5	11166.4
Services		1112.4	2986.3	3277.3	2900.1	0.8	6119.0	23061.8
Factor Accounts								
Labor-1							52.2	8607.5
Labor-2							41.1	6776.1
Labor-3							12.5	2062.4
Labor-4							0.9	155.1
Labor-5							55.3	9130.8
Capital								15891.9
Land								322.3
Institutions								
Urban								20592.8
Rural Agriculture								609.6
Rural Nonagriculture							9534.0	
Households								
Low	200.8		600.0	1200.0	1562.8			3937.9
Medium	3231.7			500.0	2501.5			13798.9
High	6101.5				1009.7			20373.6
Government		79.1	1207.0	3585.7				13503.3
Condensed Capital		-169.3	497.1	2642.9	1608.2			12889.4
Rest of World						5822.6		39366.3
Column Totals	9534.0	3937.9	13798.9	20373.6	13503.3	12889.4	39366.3	304982

Table 2—Comparisons of a 10 Percent Increase in Quantity of Agricultural Exports on Selected Variables When Factor Supply Elasticities are Varied

Variable	Elasticity of Labor Supply					
	0.00	0.50	1.00	5.00	1000.00	∞
	<------------------- General Equilibrium					---------------------->Fixed Price
Factor Supply						
Labor 1	1.000	1.002	1.003	1.003	1.004	1.004
Labor 2	1.000	1.002	1.003	1.004	1.004	1.005
Labor 3	1.000	1.002	1.003	1.003	1.003	1.004
Labor 4	1.000	1.078	1.111	1.168	1.192	1.052
Labor 5	1.000	1.001	1.001	1.002	1.002	1.004
Capital	1.000	1.000	1.000	1.000	1.000	1.005
Land	1.000	1.000	1.000	1.000	1.000	1.068
Wage Rate						
Labor 1	1.010	1.004	1.003	1.001	1.000	1.000
Labor 2	1.010	1.005	1.003	1.001	1.000	1.000
Labor 3	1.011	1.004	1.003	1.001	1.000	1.000
Labor 4	1.303	1.163	1.111	1.032	1.000	1.000
Labor 5	1.005	1.002	1.001	1.000	1.000	1.000
Rental Price of Capital						
Agriculture (including land)	1.401	1.337	1.312	1.271	1.255	1.000
Mining	1.000	1.000	1.000	1.000	1.000	1.000
Construction	1.006	1.003	1.002	1.001	1.001	1.000
Manufacturing-1	0.990	0.992	0.993	0.994	0.995	1.000
Manufacturing-2	1.004	1.002	1.002	1.001	1.001	1.000
Transportation, Communication, Utilities	1.008	1.006	1.005	1.004	1.004	1.000
Trade	1.012	1.008	1.007	1.005	1.005	1.000
Finance, Insurance, Real Estate	1.015	1.012	1.011	1.010	1.009	1.000
Services	1.010	1.006	1.005	1.003	1.003	1.000
Factor Income						
Labor 1	1.010	1.006	1.005	1.004	1.004	1.004
Labor 2	1.010	1.007	1.006	1.004	1.004	1.005
Labor 3	1.011	1.007	1.005	1.004	1.003	1.004
Labor 4	1.301	1.253	1.234	1.203	1.191	1.052
Labor 5	1.005	1.003	1.003	1.002	1.002	1.004

Table 2 (cont.)—Comparisons of a 10 Percent Increase in Quantity of Agricultural Exports on Selected Variables When Factor Supply Elasticities are Varied

Variable	Elasticity of Labor Supply					
	0.00	0.50	1.00	5.00	1000.00	∞
	<---------- General Equilibrium				----------	>Fixed Price
Factor Income (cont.)						
Capital	1.013	1.010	1.009	1.008	1.007	1.005
Land	1.401	1.337	1.312	1.271	1.255	1.068
Institutional Income						
Urban	1.011	1.007	1.006	1.005	1.005	1.004
Rural Farm	1.206	1.173	1.160	1.139	1.131	1.037
Rural Nonfarm	1.010	1.007	1.006	1.004	1.004	1.004
Household Income						
Low	1.001	1.001	1.001	1.000	1.000	1.005
Medium	1.014	1.010	1.009	1.008	1.007	1.005
High	1.012	1.009	1.008	1.006	1.006	1.005

Figure 1—Commodity Market Equilibrium for Fixed Price Multiplier Model and Regional GE Model

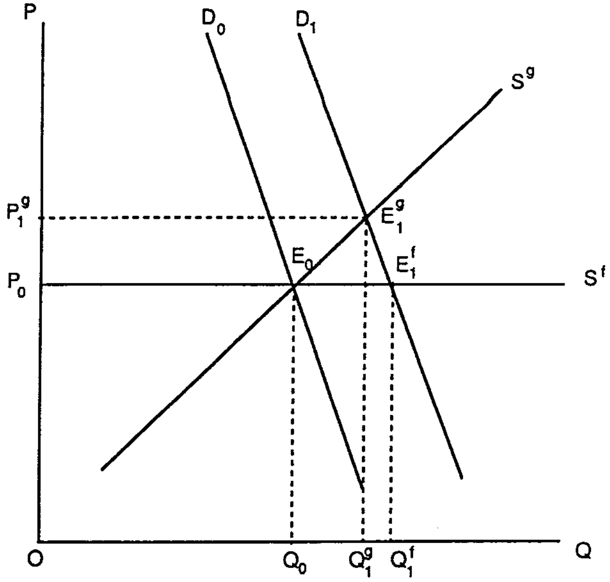


Figure 2—Factor Market Equilibrium for Fixed Multiplier Model and Regional GE Model

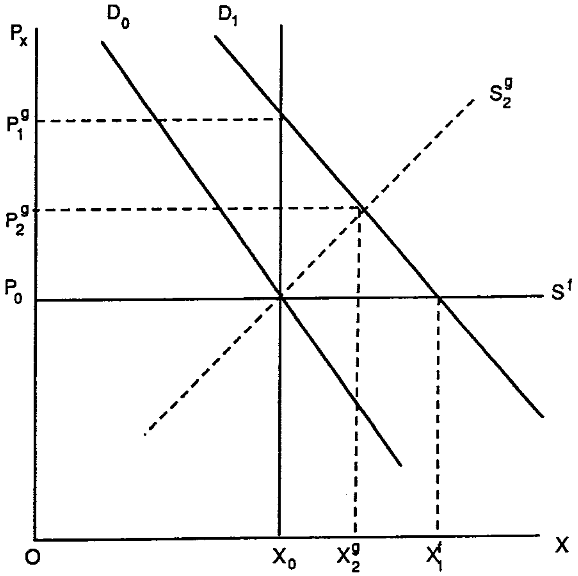


Figure 3—Factor Market Equilibrium for Fixed Price Multiplier Model and Regional GE Model.

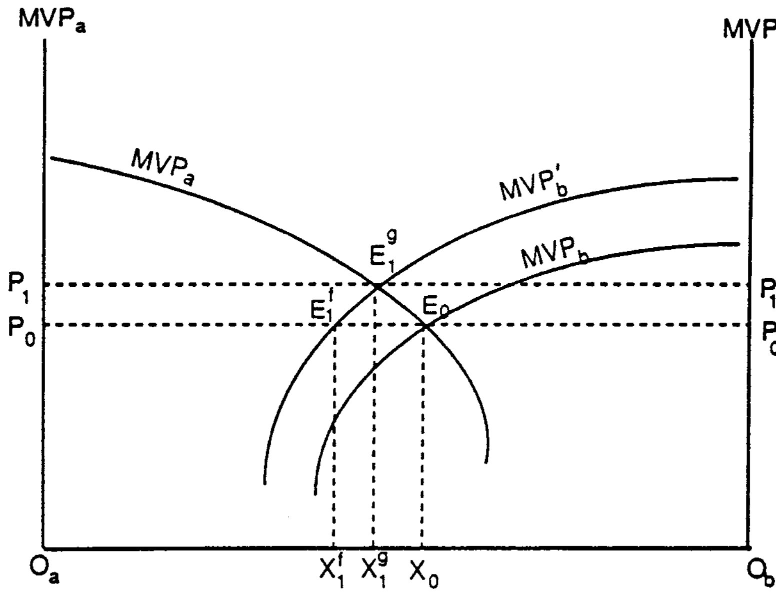


Figure 4—Basic General Equilibrium of an Economy

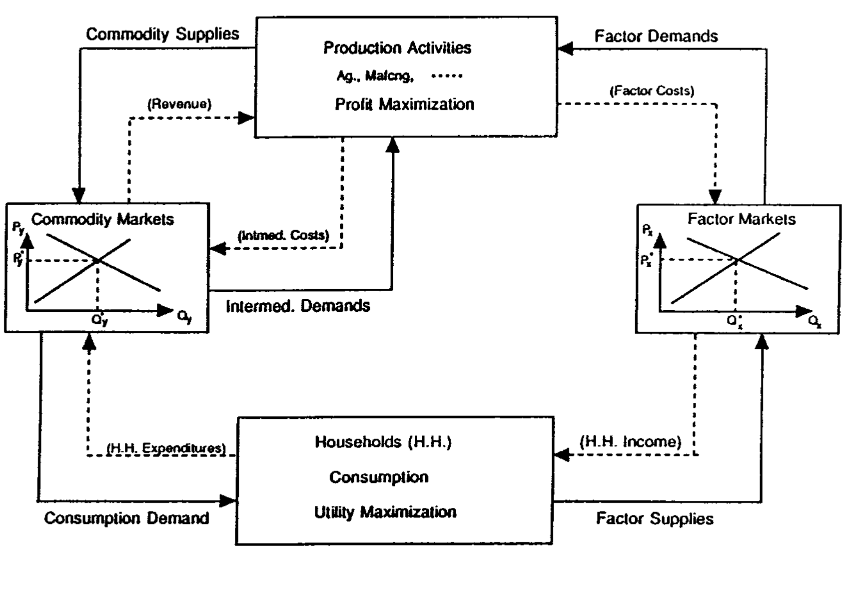
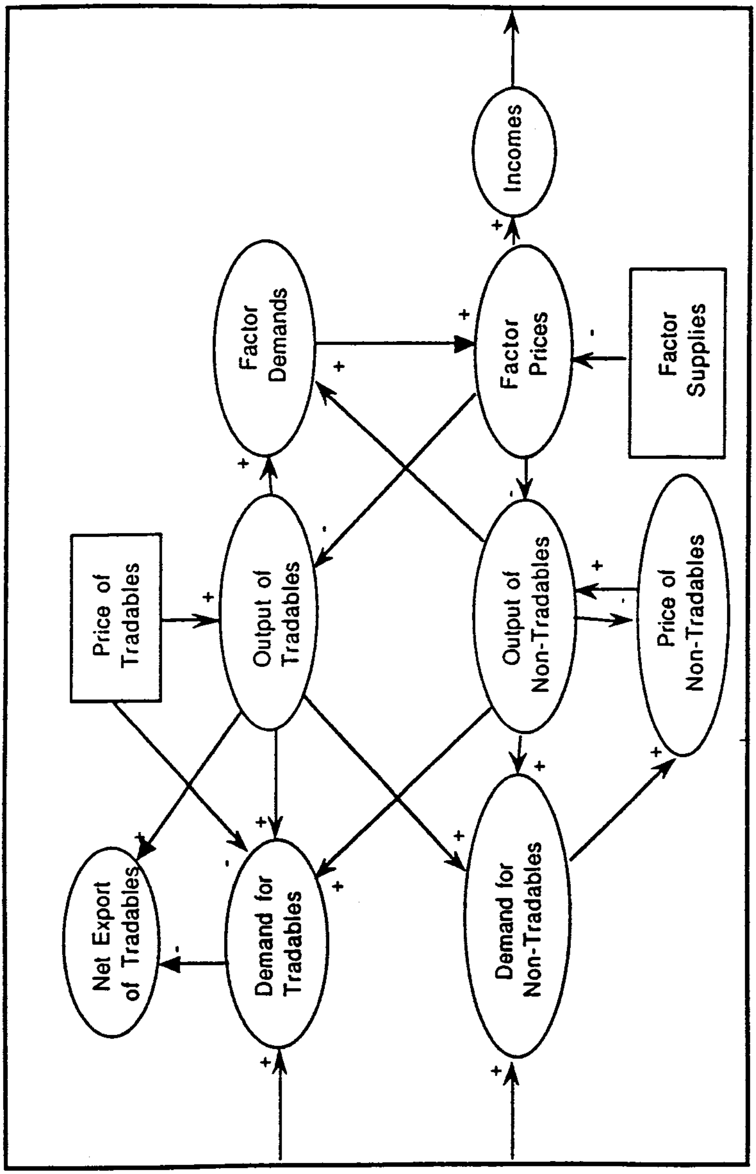


Figure 5—Causal Relationships Between Selected Variables of a Regional Economy



APPENDIX—MODEL SPECIFICATION AND ASSUMPTIONS

Production

Consider a multisectoral economic system. Each of n production sectors produces only one homogeneous commodity using intermediate and primary inputs. Technology allows neither substitution between intermediate and primary factors nor between intermediate inputs. Input substitution is possible, however, between the primary factors of labor, capital, and land.

One type of capital and one type of land exist, but s types of labor skill categories exist, where substitution among different labor skills is allowed.

The production function is described in a three stage process. First, the relationship between intermediate and primary inputs is described by a Leontief production function:

$$\text{(A-1)}\ X_i = \min\left(\frac{INT_{ij}}{a_{ij}}, \frac{VAD_i}{v_i}\right) \text{ for } i,j = 1, \ldots, n$$

where:

X_i = Industry output of sector i;
INT_{ij} = Amount of commodity j used in industry i;
a_{ij} = Direct requirement of commodity j to produce one unit of output in industry i;
VAD_i = Value added in industry i; and
v_i = Value added per unit of output in industry i.

This specification implies that the sectoral output X_i can be measured either by the level of intermediate goods used or value added, because the profit-maximizing behavior will provide the equality represented in equation (A-2):

$$\text{(A2)}\ \frac{INT_{ij}}{a_{ij}} = \frac{VAD_i}{v_i} = X_i$$

The coefficients of a_{ij} and v_i determine the first level of production technology. With fixed values for those parameters, the model is characterized as static.

The second stage describes substitutability between primary factors of labor, capital, and land. The third stage describes substitution among different labor skill categories. Let value added and labor aggregation for sector i be represented by equations (A-3) and (A-4), respectively:

$$(\overline{A3})\ VAD_i = g_i(AGGLAB, CAP, LND)$$

$$(\overline{A4})\ AGGLAB = h_i(LAB_1, LAB_2, \dots, LAB_s)$$

Value added has arguments of aggregated labor, capital, and land, whereas labor aggregation is a function of different labor skills. Combining equations (A-3) and (A-4) gives:

$$(A\text{-}5)\ VAD_i = g_i[h_i(LAB_1, \dots, LAB_s), CAP, LND]$$

With a specific functional form for equation (A-5), the value-added function is defined completely and, consequently, the production function is complete with the support of equation (A-2).

The Oklahoma model uses Cobb-Douglas production functions. Based on equations (A-2) and (A-5), output in sector i is:

$$(A\text{-}6)\ X_i = q_i(\prod_s LAB_{is}^{a_{is}})CAP_i^{a_{ik}} LND_i^{a_{il}}$$

The production function shift parameter q_i reflects the combined effects of equations (A-4) and (A-5). It is related inversely to the value-added coefficient v_i in equation (A-2) , implying smaller v_i leads to larger q_i.

Determining Production Function Parameters

It is assumed that each production sector exhibits constant returns to scale at the competitive equilibrium. Thus, the production function specified in equation (A-6) is homogeneous of degree one in primary factors. Parameter values of the production function are determined by use of the homogeneity property. The number of parameters of equation (A-6) is the same as the number of primary factors plus the number of labor categories. One of the parameters is a shift parameter and the others are partial elasticities of production.

Consider a constant returns to scale production function:

$$(A\text{-}7)\ y = f(x_1, x_2, \dots, x_n)$$

where:

y = Output; and
x_i = Inputs.

If y is homogeneous of degree one, and if the price of each x_i, Px_i, equals its value of marginal product, then the sum of the partial elasticities for all inputs will sum to one by Euler's theorem:

$$\text{(A-8)} \sum_i \left(\frac{\partial y}{\partial x_i} \frac{x_i}{y} \right) = 1$$

First order conditions for competitive production holds that the marginal product of each input should be equal to the ratio of input to output price at equilibrium:

$$\text{(A-9)} \frac{\partial y}{\partial x_i} = \frac{P_{x_i}}{Py} \text{ for all } i = 1, \dots, n$$

Substitution of equation (A-9) into equation (A-8) yields:

$$\text{(A-10)} \sum_i \frac{P_{x_i} x_i}{P_y y} = 1$$

Equations (A-8) and (A-10) imply that the partial elasticity of each input in the Cobb-Douglas production function is equal to the share of the output going to the corresponding input. Therefore, the parameter values for the exponents in equation (A-6) are derived from the value-added matrix in the SAM. Given these parameter values, q_i can be calculated using the base year values for the variables in the equation.

Output Price

Most commodity prices are exogenous for small and completely open regions. There are three possibilities, however, where it is more appropriate to treat commodity prices endogenously: (1) existence of nontradable commodities, (2) highly specialized regional production, and (3) existence of product differentiation between regions. The first means a change in output in the region influences the regional price only and there exists a commodity price differential between the region and the rest of the nation. The second case suggests that the national price is affected by the regional output, thus implying the small region assumption does not fit for the commodity. The last case causes *cross hauling* (export and import occurs at the same time for the same commodity group) in regional trade which will be discussed in relation to import demand.

Net price or value-added price of commodity i is expressed as the regional price minus intermediate input costs and indirect tax:

$$(A\text{-}11)\ NPX_i = RP_i - \sum_j a_{ij}P_j - idtx_iRP_i$$

where:

NPX_i = Net price of commodity i;
RP_i = Regional price of commodity i produced in the region;
P_j = Composite good price of commodity j; and
$idtx_i$ = Indirect tax rate for sector i.

Under Walrasian general equilibrium, relative prices are assumed to be the only force that determines the flow of commodities and factors. Therefore, all prices are expressed in terms of relative value with respect to a base year price of one, whether they are exogenized or endogenized prices.

Intermediate Inputs

The Leontief input-output technology assumed in equation (A-2) determines demand for intermediate input i ($INTD_i$):

$$(A\text{-}12)\ INTD_i = \sum_j a_{ij} X_j$$

The coefficients a_{ij} are derived from transposing the use matrix in the SAM such that

$$\sum_j a_{ij} = 1 \text{ for all i.}$$

Because the transposed use matrix has production sectors as rows and commodities as columns, $INTD_i$ in equation (A-12) expresses the sum of the demand for commodity i by all production sectors.

Factor Markets

Labor Market and Wage Rate

With given production technology and value-added prices, primary input demand is determined by profit-maximizing behavior for each production sector. The profit function for sector i is defined as:

$$(A\text{-}13)\ PRFT_i = NPX_i\ X_i - \sum_s (WAGE_s\ LAB_{is}) - LNDRNT_iLND_i - CAPRNT_i\ CAP_i$$

where:

$WAGE_s$	=	Wage rate for labor skill category s;
$LNDRNT_i$	=	Rental price of land used in sector i; and
$CAPRNT_i$	=	Rental price of capital stock used in sector i.

Notice that the wage rate in the above equation implies intersectoral labor mobility. Thus, the wage for each labor skill category must be equalized across the production sectors. Taking the first derivative of the profit function with respect to each labor skill and setting its value equal to zero for the local maximum gives demand for labor skill s by industry i:

$$NPX_i \frac{\partial X_i}{\partial LAB_{is}} = WAGE_s$$

or specifically

$$\text{(A-14)}\ LAB_{is} = \frac{a_{is}\, NPX_i\, X_i}{WAGE_s}$$

Aggregate demand for labor skill s is the sum of the demand by all industries:

$$\text{(A-15)}\ LAB_s = \sum_i LAB_{is}$$

Labor supply is a function of wage rate and an exogenously determined supply elasticity:

$$\text{(A-16)}\ LABS_s = L_s\, WAGE_s^{l_s}$$

In this study the labor supply elasticity, l_s, is varied parametrically to show the impacts of an externally induced shock.

The labor market equilibrium is determined by equating the endogenously determined labor demand and supply:

$$\text{(A-17)}\ LAB_s - LABS_s = 0$$

A key assumption of the above approach is that full employment always is attained by the adjustment of the wage rate with the labor supply for a given time period.

In contrast to the above neoclassical closure rule, the wage rate can be treated exogenously following the Keynesian closure rule. In this case, the unemployment level is endogenized:

$$(A\text{-}18)\ LAB_{is} = \frac{a_{ls}\ NPX_i\ X_i}{\overline{WAGE_s}}$$

$$(A\text{-}19)\ UNEMP_s = LABS_s - \sum_i LAB_{is}$$

where:

$UNEMP_s$ = The unemployment level for labor skill s.

The current model follows the neoclassical rule.

Land Market

Demand for land and capital can be derived in the same manner as labor demand. Equation (A-20) represents a specific demand function for land by industry i (LND_i):

$$(A\text{-}20)\ LND_i = \frac{a_{il}\ NPX_i\ X_i}{LNDRNT_i}$$

Assuming that land is mobile across production sectors, the rental price of land will be the same in each sector. The current study assumes that land is used only in agricultural production. Thus, the production function parameter a_{il} is zero for nonagricultural sectors. The market-clearing equilibrium condition is given by:

$$(A\text{-}21)\ \sum_i LND_i - \overline{LND} = 0$$

where:

$\overline{LND}$ = The region specific fixed supply of land.

Capital Market

Equalizing the marginal value product of capital with the rental price of capital stock for each production sector maximizes profit. Let $CAPRNT_i$ be the rental price of capital stock in sector i. Demand for capital in the model is specified by:

$$(A\text{-}22)\ CAP_i - \frac{a_{ik} NPX_i X_i}{CAPRNT_i} = 0$$

Market equilibrium conditions in the model may differ depending on the assumption about sectoral mobility of capital stock. Two extreme assumptions are perfect mobility and complete immobility represented by equations (A-23) and (A-24), respectively, where $\overline{CAP}$ is total capital stock for the economy and $\overline{CAP_i}$ is capital stock in sector i, both exogenously given:

$$(A\text{-}23)\ \overline{CAP} - \sum_i CAP_i = 0$$

$$(A\text{-}24)\ CAP_i - \overline{CAP_i} = 0$$

The assumption of capital mobility depends on the length of time allowed for the system to attain a new equilibrium after an external shock. Thus, region-specific but intersectoral capital mobility in equation (A-23) may be used for evaluating a policy impact when a relatively longer time period is required for adjustment. The sector-specific capital market represented in equation (A-24) may be relevant otherwise. The current Oklahoma model follows the second approach.

Income Determination and Distribution

Functional Income Determination

Functional incomes for the resources in Oklahoma are derived from two sources: regional production activities and out-of-region activities. Some workers in the region may be employed by producers located outside the region. Some resources from outside the region may be used in regional production.

Capturing region-specific resources and activities is important in relation to the feedback effect from consumption to production. This is true especially when the region under concern is small and interregional resource flow and consumption demand must be investigated in relation to central place theory.[4]

Because of data availability and the large size of the region, the current Oklahoma model ignores this type of interregional resource use. Only labor income generated from outside the region is considered, and it is regarded as fixed at the base year level. Therefore, the assumption for this treatment is that only regional resources are used in regional production, but there exists a fixed amount of labor income transferred from outside the region.

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[4] For central place theory, see Flood and Schreiner and Marshall.

As indicated by factor market equilibrium conditions, functional income is determined by endogenous factor prices and exogenous endowments. Let income for labor skill s be denoted by $YLAB_s$, transfer income by $TRLABY_s$, and total labor income by TOTYLAB:

$$(A\text{-}29)\ YLAB_s = WAGE_s\, LAB_s + TRLABY_s$$

$$(A\text{-}30)\ TOTYLAB = \sum_s YLAB_s$$

Similarly, land income, YLND, is determined by the rental price of land multiplied by the quantity of land used by all industries:

$$(A\text{-}31)\ YLND = \sum_i LND_i\, LNDRNT$$

Capital income, YCAP, is treated as the residual of total revenue net of intermediate cost and indirect tax and minus payments for labor and land:

$$(A\text{-}32)\ YCAP = \sum_i NPX_i\, X_i - \sum_s (YLAB_s - TRLABY_s) - YLND$$

If competitive equilibrium exists, the economic profit must be zero. Therefore, by Euler's theorem, the result of equation (A-32) must be identical to that of equation (A-33) because the production function is homogeneous of degree one and $CAPRNT_i$ represents marginal productivity of capital employed by sector i:

$$(A\text{-}33)\ YCAP = \sum_i CAP_i\, CAPRNT_i$$

Institutional and Household Income Distribution

Functional income is determined by factor demand, based on production technology and profit-maximizing behavior, and factor endowment. Institutional and household income, however, are determined by the ownership of those factors by each institution and household group. Sector and geographic institutions are defined for this study and include agriculture, rural nonagriculture, and urban.

It is impossible to know how much labor by skill, land, and capital stock are owned by each institution. Nonetheless, it may be considered that institutional income distribution presented in the benchmark SAM represents the structure of factor ownership in the region. With the assumption that ownership structure remains unchanged in the short run, factor income (row sum of factor account) can be translated into institutional income. Institutional income then can be translated into household income. For example, institutional income distribution coefficients are derived from the base year SAM by dividing each element of the institutional income distribution matrix by its column sum. These coefficients represent the share of each factor income distributed across the institution. Similarly, household income distribution coefficients are derived and used to allocate the institutional income (row sum of institutional accounts) across the household income group.

Based on the above approach, institutional income is determined by the sum of factor income plus government transfers to each institution. Incomes from each factor are reduced by any corresponding factor tax. Depreciation and retained earnings are subtracted from capital income.

Institutional income is defined as:

$$\text{(A-34)}\ YINST_t = \sum_s b_{ts}\, YLAB_s\, (1\text{-}sstx_s) + w_t\, YCAP\, (1 - ktx - dprt) + z_t\, YLND\, (1\text{-}ltx) + TRINST_t$$

where:

$YINS_t$	=	Institutional income; and
b_{ts}, w_t, and z_t	=	Institutional income distribution coefficients for labor, capital, and land income, respectively.

These are partitioned matrices of the whole income distribution coefficient matrix where $sstx_s$, ktx, and ltx denote the tax rate for Social Security payments, capital income tax, and land income tax; dprt is the rate of depreciation and retained earnings; and $TRINST_t$ denotes exogenous transfers from government.

Household income is derived from three sources: distribution from institutional income, transfers from government, and interhousehold transfers. The former two are treated as taxable income and the latter is added to calculate disposable income:

$$\text{(A-35)}\ TXHHY_h = \sum_t d_{ht}\, YINST_t + TRGHH_h$$

$$\text{(A-36)}\ HHY_h = TXHHY_h\, (1 - hhtx_h) + TRHHR_h$$

where:

$TXHHY_h$	=	Taxable income of household group h;
d_{ht}	=	Household income distribution coefficients which map institutional income onto household income;
$TRGHH_h$	=	Exogenous government payments to household group h;
HHY_h	=	Disposable income to household group h;
$hhtx_h$	=	Income tax rate to household group h; and
$TRHHR_h$	=	Interhousehold transfer income (row sum of interhousehold income matrix of the SAM).

Government Revenue and Household Saving

Government revenue is the sum of the various taxes: indirect tax, Social Security tax, capital income tax, land income tax, and household income tax. Federal, state, and local governments are aggregated into one single account. Government revenue, YGVT, is:

$$\text{(A-37)}\quad YGVT = \sum_i idtxRP_iX_i + \sum_s sstx_sYLAB_s + ktxYCAP + ltx\,YLND + \sum_h hhtx_h\,TXHHY_h$$

For household saving, it is assumed that each household group saves a fixed proportion of its disposable income for future consumption. Therefore, the marginal savings rate equals the average savings rate in the short run.

The savings rate is calibrated from the SAM as a proportion of saving from total income rather than disposable income:

$$\text{(A-38)}\quad HHSAV_h = mps_h\,(TXHHY_h + TRHHR_h)$$

Given savings and the household expenditure for commodity consumption, HHE_h, is simply the residual of disposable income less savings and interhousehold transfers:

$$\text{(A-39)}\quad HHE_h = HHY_h - HHSAV_h - TRHHC_h$$

where:

$TRHHC_h$ = A column sum of the interhousehold transfer matrix.

Commodity Markets

Consumer Demand

Consumer demand functions are derived from utility theory. The fundamental basis of utility theory is that if consumer preferences satisfy the axioms of complete ordering, transitivity, continuity, and strong monotonicity then there exists a single valued continuous utility function that represents those preferences (Varian, 1984). Further, the diminishing marginal rate of substitution is assumed such that the second derivative of the utility function with respect to consumption is negative.

Due to the ordinal character of describing preferences, any function that is monotonically increasing at a decreasing rate can be used as the utility function. Hence, any strictly increasing transformation of a utility function also is regarded as a utility function representing exactly the same preferences.

In this study, the Stone-Geary utility function that leads to a linear expenditure system is used. The demand system derived from the Stone-Geary utility function satisfies the general properties required; homogeneity of degree zero in all prices and income, symmetry of the cross-substitution effects, adding-up condition, and negativity of direct substitution effect. The commodity demand functions used in this model are derived below.

Consider a Cobb-Douglas type utility function that describes the utility level determined by the quantity of each good consumed above some fixed minimum level:

$$\text{(A-40)}\ U_h = \prod_i (D_{ih} - g_{ih})^{b_{ih}}$$

where:

U_h = Utility level of household group h;
D_{ih} = Amount of commodity i consumed by household group h; and
g_{ih} and b_{ih} = Parameters.

Notice the restrictions on the parameters: $0 \leq g_{ih} \leq D_{ih}$ because g_{ih} is a minimum level of consumption and b_{ih} is nonnegative to satisfy the properties of the utility function. The Stone-Geary utility function is derived following log-transformation of the above equation:

$$\text{(A-41)}\ U_h = \sum_i b_{ih} \log (D_{ih} - g_{ih})$$

Given a fixed amount of income that can be allocated to consumption, HHE_h, household group h faces the following constrained maximization problem:

Maximize $U_h(D_{ih})$

Subject to $HHE_h - \sum_i P_i D_{ih} = 0$

The first order conditions for the corresponding Lagrangian will yield:

$$(A\text{-}42)\ \frac{b_{ih}}{D_{ih} - g_{ih}} = l_h P_i$$

$$(A\text{-}43)\ \sum_i P_i D_{ih} - HHE_h = 0$$

Solving equation (A-42) for b_{ih}, summing b_{ih} across i=1, ... , n and solving for the Lagrangian multipliers yields:

$$(A\text{-}44)\ l_h = \frac{1}{HHE_h - \sum_i P_i g_{ih}}$$

Substitution of (A-44) into (A-42) yields:

$$(A\text{-}45)\ P_i D_{ih} = P_i g_{ih} + b_{ih}\,(HHE_h - \sum_j P_j g_{jh})$$

The term $P_i D_{ih}$ represents the expenditure on commodity i by household group h. b_{ih} is known to be the corresponding marginal expenditure share. The first derivative of the expenditure function with respect to total expenditure (HHE_h) is b_{ih}. Dividing through the above equation by P_i gives the linear expenditure system (LES) expressed as:

$$(A\text{-}46)\ D_{ih} = g_{ih} + \frac{b_{ih}}{P_i}(HHE_h - \sum_j P_j g_{jh})$$

To compute the consumption demand using equation (A-46), values are needed for g_{ih} and b_{ih} in addition to data on prices and total consumption expenditure by each household group. g_{ih} is not estimated directly from empirical data. Marginal budget shares b_{ih} can not be calculated from only one period data set for the base year. With a full set of expenditure elasticities and a single own or cross price elasticity, equation (A-46) could be implemented using the Frisch parameter (Pyles, 1989).

Under the situation where such information is not available, a simplified version of the Stone-Geary LES can be applied (Robinson, Kilkenny, and Hanson, 1990).

Rearranging equation (A-46) yields:

$$\text{(A-47)}\; g_{ih} - \frac{b_{ih}}{P_i}\sum_j P_j g_{jh} = \frac{HHE_h}{P_i}\left(\frac{P_i D_{ih}}{HHE_h} - b_{ih}\right)$$

The term $P_i D_{ih} / HHE_h$ is the share of expenditure on commodity i by household group h. If it is assumed that the average budget share equals the marginal budget share b_{ih}, the result is:

$$\text{(A-48)}\; \beta_{ih} = \frac{P_i D_{ih}}{HHE_h}$$

$$\text{(A-49)}\; g_{ih} - \frac{b_{ih}}{P_i}\sum_j P_j g_{jh} = 0$$

Because $0 < b_{ih} < 1$, the value of g is zero for each commodity and household.

From equation (A-46), the demand for good i by household group h reduces to equation (A-50):

$$\text{(A-50)}\; D_{ih} = \frac{b_{ih}\, HHE_h}{P_i}$$

Substituting equation (A-39) for HHE_h, we have commodity demand in terms of prices and income defined by equation (A-51):

$$\text{(A-51)}\; D_i = \sum_h b_{ih} \frac{HHY_h - HHSAV_h - TRHHC_h}{P_i}$$

The coefficients b_{ih} are readily available from the benchmark SAM. Even though the above equation is used in the current study, the assumption behind equation (A-50) is somewhat unrealistic because it implies that income elasticities of expenditure for all commodities are unity. Although the result is not appropriate for dynamic analysis, the assumption does not pose a serious problem for a comparative static analysis because different expenditure patterns for different household groups are embodied in the model.

Government Demand and Investment Demand

Demand for commodities by the government in this study is treated as exogenous in contrast to the endogenous treatment of government revenue. The model allows policy simulations with respect to alternative government expenditure patterns.

Investment demand for commodities is also exogenous to the system because the basic purpose of the current study is to evaluate the short-run impact of disturbances in commodity market prices on factor markets.

If the purpose is to evaluate the effect of changes in investment for a sector (e.g., investment by sector of destination), investment needs to be converted into commodity demands (by sector of origin). The general approach for the conversion is to use a capital composition matrix. (See Dervis, deMelo, and Robinson, 1982).

Import Demand and Composite Price

Conventional trade theory assumes homogeneity of commodities across imported and domestically produced goods. Therefore, imported goods are perfect substitutes for domestic goods. This approach leads to highly specialized regional production. The equilibrium solution for small open regions indicates that regions produce commodities in which they have comparative advantage under the assumption of infinite elasticity of substitution.

To allow regional production of commodities with comparative disadvantage, another extreme assumption is made that imported goods are perfect complements of regionally produced goods. This zero substitution elasticity, however, implies either that the price ratio between imported and regionally produced goods is constant for all commodities or that the rate of change in quantity demanded is equal for both goods whatever the relative price may be. Consequently, the region will import a fixed percent of total quantity demanded for each commodity.

A more realistic approach is to assume that the elasticity of substitution between imported and domestic products is greater than zero but less than infinity, following Armington (1969). The basic concept of the Armington model originally was developed to evaluate international trade. A commodity traded between n different countries must be treated as n different goods due to the heterogeneity in commodity characteristics. It is impossible to define commodities representing all attributes of each good traded. This assumption is more relevant than the other two extreme cases because of the generally observed cross-hauling, i.e., import and export of the same commodity at the same time, both internationally and regionally. With highly aggregated commodity or production activities, the Armington approach is particularly appropriate and widely used in CGE models.

Following the Armington approach, the concept of composite goods is introduced. Commodities in the regional market are treated as a mix of imported and regional products. The quantity of composite good demanded in the regional market is described by the following CES trade aggregation function:

$$(A\text{-}52)\; Q_i = y_i \left[d_i\, MQ_i^{-r_i} + (1-d_i)\, RQ_i^{-r_i} \right]^{-1/r_i}$$

where:

Q_i = Composite commodity demanded;
MQ_i = Imported commodities demanded;
RQ_i = Regional products demanded;
y_i = Constant shift parameter;
d_i = Share parameter; and
r_i = Parameter associated with elasticity of substitution.

The trade elasticity of substitution between imported and domestically produced goods (s_i) is represented by $1/(1+r_i)$.

Given equation (A-52), buyers in the regional market are faced with the following optimization problem:

Maximize $Q_i\,(MQ_i, RQ_i)$

Subject to $P_iQ_i - PM_i\, MQ_i - RP_i\, RQ_i = 0$

where:

P_i = Price of composite goods;
PM_i = Exogenous price of imported goods, i.e., national price.

Setting up the Lagrangian for this constrained maximization problem and solving for the first order conditions results in the following import demand equation as a function of relative price and elasticity of substitution:

$$(A\text{-}53)\; MQ_i = RQ_i \left(\frac{RP_i}{PM_i}\right)^{1/1+r_i} \left(\frac{d_i}{1-d_i}\right)^{1/1+r_i}$$

The regional market price of the composite good is a weighted average of the imported and domestic goods prices:

$$(A\text{-}54)\ P_i = \frac{RP_i\, RQ_i + PM_i\, MQ_i}{Q_i}$$

National prices (PM_i) are exogenous to a small region so that these prices are applied to all imported goods. In contrast, the regional prices (RP_i) are endogenous except for the sectors to which commodity market shocks are given. In sectors with exogenous RP_i, only quantities are allowed to adjust to attain the market equilibrium.

For implementation of the import demand function, the share parameter d_i and the shift parameter y_i are calculated from benchmark SAM data with exogenous estimates for the elasticity of substitution. The elasticity estimates are seldom available, however, especially at the regional level. Therefore, sensitivity analyses are conducted to find a set of reasonable values for s_i (and thus r_i) by assigning alternative values for the parameters and evaluating the model's performance.

In this process, the parameter values are not completely arbitrary because one can make use of the properties of the CES function according to the characteristics of commodity groups. It is fairly reasonable to assume that substitution is relatively easy for tradables, but not perfect. For a given Q_i the demand for imports and regional products depend on the relative price, and an interior solution is most likely. If import price were extremely high, however, then import demand would be close to zero. Therefore, indifference curves are expected to be convex to the origin but cut both axes. This implies that $1 < s_i$ or $-1 < r_i < 0$. Notice that if r_i is close to negative one, then s_i approaches infinity and the indifference curves become straight lines which makes a corner solution most likely.

On the other hand, for nontradables, substitution is assumed possible to only a limited degree. The relative price change does affect the demand, but there exists minimum levels of consumption for commodities from both sources for a given Q_i. Indifference curves are convex to the origin and are asymptotic to these minimum quantities determined by:

$$MQ_i = \left[\frac{\left(\frac{Q_i}{y_i}\right)^{-r_i}}{d_i}\right]^{-1/r_i}$$

and

$$RQ_i = \left[\frac{\left(\frac{Q_i}{y_i}\right)^{-r_i}}{(1-d_i)}\right]^{-1/r_i}$$

To satisfy this property, it is required that $0 < s_i < 1$ or $0 < r_i < \infty$ (see Henderson and Quandt, 1980, pp. 112-113). Notice that the indifference curves become right angled as the value for r_i increases, implying that substitution becomes more difficult.

Export Demand and Commodity Market Equilibrium

For a small region, the demand for regional products outside the region may be assumed to be perfectly elastic under the condition that no product differentiation exists. For the same reasons discussed in import demand, however, a region can not export commodities as much as it wants at a given price. This is true even for the tradable goods because of the existence of nonprice competition between regions.

The current study assumes downward-sloping export demand functions with constant price elasticity and different treatments for different commodity groups. For commodities with an exogenous price shock, there is no own price effect on exports. Exports of these sectors will be determined endogenously only by the change in supply. Therefore, it is required to set RP_i at PM_i for these sectors to endogenize exports:

(A-55) $RP_i = PM_i$

Notice that PM_i is exogenous national price. Endogenous export demand for the rest of the sectors is a function of regional price and defined by:

(A-56) $EXQ_i = EXQB_i \, RP_i^{e_i}$

where:

EXQ_i	=	Endogenous exports of commodity i;
$EXQB_i$	=	Base year exports; and
e_i	=	Price elasticity of exports.

At the regional level, price elasticity data are not available. It is fairly reasonable to assume, however, that the export demand will be relatively elastic for tradable goods and relatively inelastic for nontradables. Under this situation, the model will be simulated based on alternative elasticity assumptions. This sensitivity analysis seems to be useful to generate information for industry diversification policy.

Regional output must be equal to the sum of regional use and exports:

(A-57) $X_i = RQ_i + EXQ_i$

The commodity market equilibrium condition is given by:

(A-58) $X_i + MQ_i = D_i + GVTD_i + INVD_i + INTD_i + EXQ_i$

$GVTD_i$ and $INVD_i$ are government demand and investment demand which are exogenously determined.

State Aggregates

Gross State Product

GSP is estimated by before tax factor income generated from the production activities of the region plus indirect tax:

(A-59) $GSP = \sum_s (YLAB_s - TRLABY_s) + YCAP + YLND + \sum_i idtx_i X_i$

Financial Flows

For a national model, the balance of payments is related to the exchange rate using one of two basic approaches. If the balance of payments is exogenized, then the exchange rate will be endogenized. If the exchange rate is exogenized, then foreign savings will determine the balance of payments. No exchange rate, however, enters the financial flows between a region and the rest of the nation. This study treats net financial flows endogenously with endogenous saving and exogenous investment.

Financial flows are measured by two accounts in the SAM: capital and the rest of the world. For the capital account two channels of financial flows are observed: government and private. Any difference between government revenue and government expenditure measures the financial flows through the government channel. Because the government account comprises all government agencies (federal, state, and local), any government surplus (deficit) can be considered as money withdrawn from (injected into) the regional economic system; thus, it is a net financial outflow (inflow). Similarly, if savings exceed investment, it is a net outflow or vice versa.

Total net financial flow FINFL is determined by summing trade balance components, capital account components, and government account components:

$$(A\text{-}60)\ FINFL = \sum_i P_i GVTD_i + \sum_t TRINST + \sum_h TRGHH - YGVT + \sum_i RP_i EXQ_i - \sum_i PM_i MQ_i + \sum_i P_i INVD_i - dprt\ YCAP - \sum_h HHSAV_h$$