APPLICATION OF GENERAL EQUILIBRIUM MODELING FOR MEASURING REGIONAL ECONOMIC AND WELFARE IMPACTS OF QUALITY CHANGES IN SPORT FISHING IN OKLAHOMA

BY

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IN OKLAHOMA

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CHAPTER I

INTRODUCTION

Problem Statement

The myriad of ponds, lakes, streams and rivers throughout the United States provide a multitude of diverse and rewarding fishing experiences for the nation's recreational anglers. The popularity of sport fishing has grown steadily over the past several decades. One in five Americans now go fishing each year. In Oklahoma, the number of anglers increased by 14 percent from 1980 to 1990, compared to a 20 percent increase over the same period nationally. Pursuit of the social, psychological and physical benefits of sport fishing has given rise to an industry focused on supplying the goods and services necessary to meet angler demand as well as ensuring satisfying recreational experiences (Fedler and Nickum, 1994b).

People are spending more leisure time in outdoor recreation activities and sport fishing is one of the most popular forms of outdoor recreation. People are demanding more recreation activities because of more leisure time within the working week and year, more income, and increased mobility. Other factors such as the growth in the overall population, changing age structure, rising education level, concentrated populations in urban centers, and increased value of recreation also contribute to a growing demand for outdoor recreation in general and sport fishing in particular.

Recreational anglers' expenditures have become a significant source of income for some regional economies. Angler expenditures include spending at sporting goods stores, bait shops, specialties fishing stores, hotels and motels, fishing lodges and camps, guide services, retail food stores, and restaurants. These expenditures have direct and trickle down effects to the earnings and welfare of a region's residents. Fedler and Nickum have estimated the fixed price multiplier impact associated with the $387.3 million angler expenditures in Oklahoma as determined from the 1991 National Survey (Fedler and Nickum, 1994b). This impact translates into $208.2 million in job earnings, 11,610 in employment (number of jobs), and $793.5 million in output for all Oklahoma sectors.

Measuring Value of Recreation

Many outdoor recreation opportunities, such as sport fishing, are provided by governments on public lands. Keeping a balance between the supply and demand for recreation thus is a public policy concern. Measuring recreation supply is difficult. The lack of adequate supply measures make it difficult to discuss the key issues associated with recreation policy in the aggregate (Harrington 1987).

Measurement of recreation resource scarcity should include the following properties: (a) the measurement should be expressed in terms of physical units if possible; (b) the measurement should recognize the role consumers play in providing inputs as well as consuming outputs; and (c) the measurement should also account for the nonpecuniary nature of costs. As a nonmarket good, nonmonetary costs and benefits usually play a much larger role for recreation than for market goods. Examples of nonmonetary costs are travel time and the cost of congestion.

Recreationalists are frequently both consumers of the good and participants in the production process. As consumers, their trips and catches are part of their satisfaction (utility) derived from fishing, while as producers they make the necessary trip purchases and equipment expenditures to produce recreation which is then applied to the fish stock and making that catch. Thus 'fishing trips' appear as part of both production and consumption (Cunningham et al. 1985).

Valuing recreation is necessary for incorporating benefits into resource planning and decision making. The travel cost models, hedonic travel cost models, and discrete choice models are examples of valuation models based on inferences from market data. Among them, the travel cost method is used most frequently for measuring recreation demand.

Following Neoclassical demand theory for market goods, demand equations express quantity of a particular commodity consumed as a function of the commodity's own price, prices of related commodities, household income, and other variables which affect preferences or tastes such as education, gender, etc. The same relationships apply to nonmarket goods.. The sport fishing 'quantity' is measured by number of trips or visits. Travel cost per trip or visit represents the price that is important in determining number of trips or visits.

The basis for deriving measures of the economic value of changes in resource allocation is their effects on human welfare. The 'economic value' and 'welfare change' terms can be used interchangeably because the benefits and costs are valued in terms of their effects' on individual well being. Changes in resource allocations should be made only if the results are worth more in terms of individuals' welfare than what is given up by diverting resources from other uses (Freeman, 1993).

According to Cunningham et at. (1985), recreation is now generally recognized as having five phases: planning, travel to the site, the recreational experience, travel back, and recollection. All of these may confer pleasure, to a greater or lesser extent. The values from planning and recollection are less likely to be measurable, but travel and the activity itself reveal preference of the consumer through actual expenditures and frequency of participation. Moreover, these expenditures may have wider importance to the general economy, such as creating jobs.

Cunningham et al. (1985) have listed the values or benefits of recreation (fishing) as primary, secondary, and non-consumptive. *Primary benefits* accrue to those taking part in the activity and are reflected in the amount consumers spend on the goods. *Secondary benefits* are categorized into: (a) benefits that recreation gives rise to economic development in the area or locality around the site, based on the extra expenditure made on the activity and the multiplier effect, and (b) benefits that property rights in proximity to the site may be enhanced because of the existence of the recreation. A group of *non-consumptive benefits* has no direct expenditure effect. These benefits include: (a) option value, i.e., knowing the recreational experience is available for optional future use, (b) existence value, i.e., feeling pleasure from knowing that a recreation activity is being maintained and protected, and (c) bequest value, i.e., satisfaction of knowing that the recreation resource and associated natural environments will be available to future generations. In addition to these benefits, society as a whole may be better off in terms of human welfare from the externalities of recreation, particularly if it results in higher output or labor productivity or lower crime levels.

Welfare changes have been defined in terms of the area under the appropriate Hicks-compensated demand curve for market goods or marginal willingness-to-pay curve for nonmarket goods and services (Freeman, 1993). Conceptually, there are two basic approaches: (a) 'equivalent variation' (EV) measure, i.e., estimating in money terms the amount that anglers would be willing to pay so as to remain as well off with the fishery as they would be without it, that is their preparedness to pay to forego the disappearance of the fishery (willingness to pay, WTP), and (b) 'compensating variation' (CV) measure, i.e., estimating in money terms the amount that anglers would require as compensation to remain as well off without as they are with it, that is their preparedness to surrender their rights to the fishery (willingness to surrender, WTS or willingness to accept compensation, WAC). The techniques to establish demand curves for sport fishing include travel cost methods (HCK), hedonic travel cost methods (Brown, 1982), and varying parameter travel cost methods (Vaughan and Russel, 1982b).

Conflict In Use of Natural Resource Systems

That most sport fishing expenditures occur in rural areas is a boon for rural development. It is, however, also important to understanding how an individual industry, in particular agriculture, is affected. Agriculture is the basic industry for many rural areas. In Oklahoma, agriculture continues to be of great importance to the state's economy. Agriculture represented five percent or $3.3 billion of $64.8 billion of the State's gross state product (GSP) in 1992. Scifres and Osborn estimated that 15.4 percent of the State's GSP was associated with agriculture after the inclusion of the multiplier impacts of cash receipts to agriculture. Agriculture and sport fishing activities compete for factor use, in particular land, water, and labor. The overall implication of expansion of sport fishing activities versus agriculture is an important policy concern.

The natural resource systems provide valuable services to support sport fishing activities. The characteristics of the natural resource systems that determine economic value can be affected by air and water pollution and by resource management decisions such as the allocation of water flows between diversionary uses and various instream uses (Freeman, 1993). Agricultural production involves the flows of large amounts of water. Boosting agricultural production by applying more fertilizer and other chemical products could substantially affect the quality of water in natural resource systems. This result may negatively impact the quality of natural resources for sport fishing purposes, which in turn may diminish recreational activities.

Questions such as: "what is the optimal amount of pollution? what policy instruments can be most helpful?" could arise when pollution problems are present. A model to determine the conditions that characterize a socially efficient, or Pareto-optimal, allocation of resources in the presence of pollution needs to be developed. This study applies a marketlike policy instrument, a pollution or resource quality tax, to determine resource allocations and to evaluate the damages from pollution which are measured by a change in welfare.

The General Equilibrium Result

The problem is to maximize the utility of any individual, subject to the constraints of indicated outputs. The control variables are consumption of each commodity by each individual, and the production and input use by each firm. The nature of the problem suggests that partial equilibrium analyses are not sufficient to address the linkages of sport fishing with quality change to the state economy. As a quality tax is imposed in a regional economy in equilibrium, all economic actors in the region react and adjust to a new equilibrium. Prices, incomes, and production resources, which are endogenous to the region, would change to reach the new equilibrium. Although the analysis of externalities and optimal taxes often has proceeded in a partial-equilibrium framework, the general-equilibrium approach allows accounting for important interdependencies. The potential adjustments in all related markets and institutions in the region economy, which may be important for policy, would not be included in a partial-equilibrium analysis. This study employs a regional general equilibrium analysis for tracing out the commodity and factor market implications for sport fishing in Oklahoma. Welfare measures, CV and EV, are used in this study. The welfare measures in the general equilibrium model account for welfare effects induced by reactions across sectors and institutions in the region economy.

A general equilibrium model (GEM) is a framework for analyzing the linkages between industries and factors. A GEM provides an analytical framework in which widely different policies may be examined. Once the basic model has been specified and implemented with data, various policies may be studied with only minor modifications. One of the virtues of the GEM is its ability to trace the consequences of large changes in a particular sector throughout the entire economy. It shares this property with input-output analysis but permits a more flexible treatment of prices in the consumer economy and a less rigid structure on production. GEMs allow interregional labor and capital movement. Labor has the opportunity to move for higher wage rates and capital for higher rents which contribute to increased household earnings. The fundamental general equilibrium method links the production structure, incomes of various population groups and the pattern of household demands in a class of models known as Computable General Equilibrium models (CGE).

A CGE model simulates the working of a market economy in which prices and quantities adjust to clear markets for products and factors. The model specifies the behavior of optimizing consumers and producers in the market economy. It also includes the government as an explicit agent and captures all transactions in circular flow of income (Robinson et al. 1990).

In the Walrasian neoclassical general equilibrium approach, the main equations are derived from constrained optimization of the neoclassical production and utility functions.

Producers choose inputs to minimize costs of given outputs to non-increasing returns to scale industry production functions. Consumers are assumed to choose their purchases to maximize utility subject to budget constraints. Production factors are paid according to their marginal productivity. At the equilibrium level the model's solution provides a set of prices that clear all commodity and factor markets and make all the individual agents' optimizations feasible and mutually consistent (Bandara 1991).

Objective of the Study

The objective of this study is to develop a CGE model for Oklahoma that facilitates analysis and evaluation of welfare change from expansion or reduction in sport fishing activities because of changes in the natural resource system. A quality tax is imposed to reflect the change in the natural resource system. The CGE framework is employed to obtain a general equilibrium result in the region economy. Emphasized in the model is the evaluation of how variations in sport fishing activities affect state agricultural and food processing outputs and the resulting welfare change. The model distinguishes between nonmarket goods and market goods, domestic goods and imported goods, and regional supply and export. The change of welfare of different income class size household groups will be investigated.

Specific objectives of the study are as follows:

1. To provide a theoretical background and review of literature related to sport fishing and the conflict in use of natural resource systems.

2. To construct a social accounting matrix (SAM) for Oklahoma that includes market goods and nonmarket goods (sport fishing), different income levels of households, different skills of labor, regional supply and export, and other features.
3. To develop an Oklahoma CGE model based on the SAM that facilitates evaluation of welfare change from a change in the quality of the natural resource system.
4. To simulate measures of welfare change and equilibrium results from expansion or reduction of sport fishing and the potential interdependence with sources of sectoral pollution in the natural resource system.
5. To draw policy implications and suggest further research.

Organization of the Study

Theoretical background and review of literature are presented in Chapter II. Chapter III is the proposed methodology. Chapter IV describes data sources and presents the data in the form of an Oklahoma SAM and a computable general equilibrium model. Simulation and results of a change in the natural resource system on sport fishing and subsequent welfare variables are presented in Chapter V. The last chapter presents policy implications and conclusions.

CHAPTER II

THEORETICAL BACKGROUND

Quality of Sport Fishing Activities

Sport Fishing Recreation and Environmental Quality

Pollution is widely regarded as a major environmental problem. Improvements in natural resource quality such as cleaner air, cleaner water, or less pesticide affect individuals' well-being or welfare. The benefits of better environmental quality are hardly disputable: health, aesthetics, and recreational benefits, for example, contribute to increased welfare. But improving environmental quality is not costless. Government policies to improve or maintain environmental quality can have negative welfare consequences through impacts on product and factor prices, in addition to the obvious clean-up burden to taxpayers. Government environmental policies are usually evaluated within a benefit-cost welfare analysis framework where costs/benefits are usually measured in terms of reductions/increases in the utility or welfare of individuals. In this study, welfare measures are incorporated into a regional CGE model to consider adjustments in all related markets and institutions.

According to the U.S. Council on Environmental Quality (CEQ), total incremental expenditure on water pollution abatement in 1979 was $12.7 billion (1979 dollars). The expenditure is roughly equal to the spending on auto part replacements or 90 percent of the sales of health care and hospital supply industry in 1979. The expenditure was about equally divided between public polluters and industrial resources. CEQ projected that by 1988 incremental expenditures on water pollution abatement will have doubled (in 1979 dollars) to $24.4 billion per year (Vaughan and Russel, 1982a).

Table 2.1 shows the National Benefits of Meeting 1985 Water Quality Objectives estimated by Freeman and reported in Vaughan and Russel (1982a). Freeman's "most likely point estimate" of $13.9 billion in 1979 dollars is 9.4 percent higher than CEQ's cost estimate for the same year. Although the wide ranges in Freeman's results suggest high uncertainty, they do point out the importance of recreational benefits of water quality: recreation accounts for over half of the total annual benefits, i.e., $7.6 billion of $13.9 billion in 1979 (Vaughan and Russel, 1982a).

Biological and Human Behavior Aspects of Quality of Sport Fishing

The benefits accruing to sport fishing anglers from reduction in the discharge of water pollutants include: (1) the increase of total availability of fishable natural water bodies, (2) increasing the relative amount of water yielding higher quality fishing, and (3) improvement in aesthetic quality of the fishing experience. These recreational benefits usually exceed gross expenditures by users. Gross expenditure measures the amount that might be directed elsewhere if the recreation facility is to be abolished.

TABLE 2.1.

NATIONAL BENEFITS OF MEETING 1985 WATER QUALITY OBJECTIVES (BILLIONS OF 1979 DOLLARS PER YEAR)

Category	Range	Most likely point estimate
Recreation		
Fresh water fishing	0.7 - 4.5	1.1
Marine sports fishing	2.3 - 5.7	3.3
Boating	1.4 - 3.2	2.3
Swimming	0.2 - 2.3	0.6
Waterfowl hunting	0.1 - 0.3	0.2
Subtotal	*4.6 -16.0*	*7.6*
Nonusable Benefits		
Aesthetics, ecology, property values	1.1 - 5.7	2.3
Diversion Uses		
Drinking water - health	0.0 - 5.7	1.1
Municipal treatment	0.7 - 1.4	1.0
Households	0.1 - 0.6	0.3
Industrial supplies	0.4 - 0.9	0.7
Subtotal	*1.2 - 5.2*	*3.1*
Commercial Fisheries	0.4 - 1.4	0.9
Grand Total	***7.5 -28.0***	***13.9***

Source: A. Myrick Freeman III, "The Benefits of Air and Water Pollution Control: A Review and Synthesis of Recent Estimates," unpublished report to the Council on Environmental Quality, December 1979; tables 12 and 13; pp. 160, 171, 174 in W.J. Vaughan and C.S. Russell (1982a) Ch. I pp. 7

Stevens (1966) noted that the problem of relating changes in water quality through pollution to changes in sport fishery recreational values involved biological as well as human behavior.

Biological aspect. One of the biological aspects is the total biological production within the fishery, or biomass. The production of biomass is determined by physiological, ecological, and physical factors, and intensity of fishing in previous periods. Water quality is an important physical determinant of total biomass. Given levels of water quality and biomass, a biological production function (Figure 2.1) can be envisioned between an input (sport fishing trips) and an output (yield of fish taken in sport fishing). The total yield represents the total physical product (TPP), and sport fishing success per trip is the marginal physical product (MPP).

Reduced water quality may be evidenced through lethal effects when dissolved oxygen levels become too low to support aquatic life, or when water temperature or concentration of toxic substances exceeds the tolerance levels of the species. Sublethal effects may also be important. Avoidance reactions to low oxygen levels may prevent an anadromous fish species from entering a fishery (Whitemore et al., 1960). Declining water quality through lower dissolved oxygen levels, or higher toxicity and temperature would shift the biological production function downward, implying downward shifts in both the yield of fish (TPP), and success (MPP).

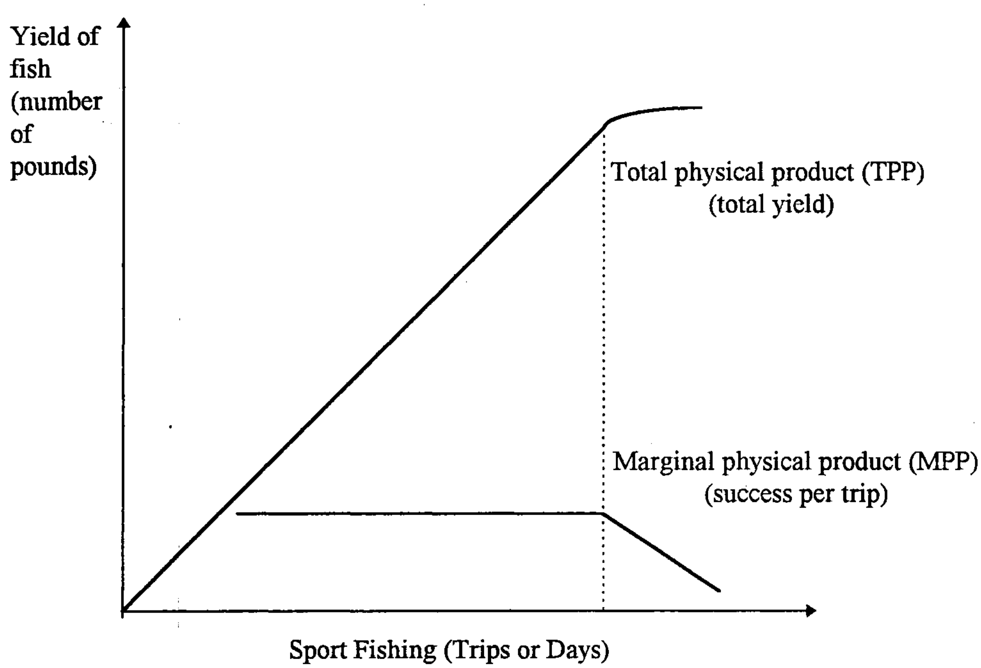

Figure 2.1. Biological Production Function for Sport Fishing (Source: Stevens, 1966 pp.170)

Behavioral aspect. The human behavioral relationships involved in sport fishing can be approached in the context of demand theory. The well known travel cost method (TCM) indicates that transfer costs, income, and distance are among the relevant determinants of the quantities of outdoor recreation. The quality of the recreational experience is also an important demand determinant. Among the quality considerations are attractiveness, degree of access, roads, lodging, camping, and dining facilities en route to the fishery. Each of these factors is limited in usefullness by a substantial degree of subjectivity in terms of individual valuations. The level of success per trip, however, has the distinct advantage of being subject to objective measurement.

The relationship between the level of sport fishing success and the number of sport fishing trips is called the behavioral "success-trip" relationship. Stevens (1966) shows the linkage between the human behavioral aspects of sport fishing and the biological production function. It relates a particular level of water quality to the aggregate quantity of sport fishing (Figure 2.2). The behavioral success-trip function and the marginal product of the biological production function jointly establish equilibrium levels of angling success and number of trips.

Figure 2.2. is the relationships between biological success and behavioral success-trip functions. Even though this is a static solution, both functions are influenced by dynamic shifters. The biological success function is subject to volatile day-to-day shifts, seasonal shifts, and secular shifts that depend on ecological factors and the level of management of the fishery. The behavioral success-trip function may be shifted by

changes in population, income, tastes and preferences, leisure, and angling success at alternative fisheries.

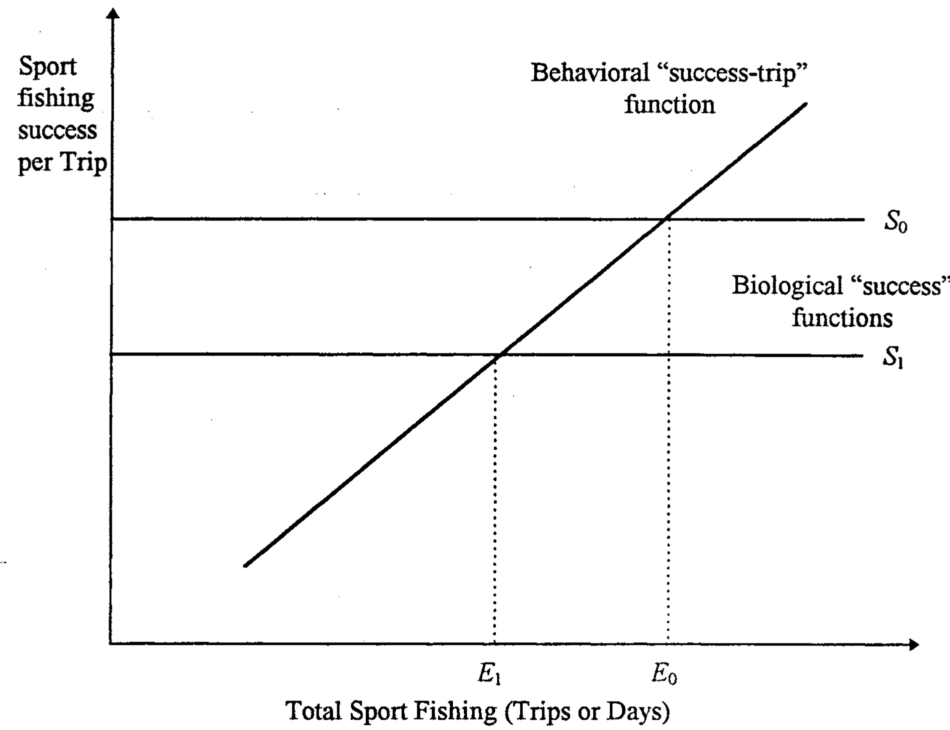

Figure 2.2. Determination of the Impact of Changes in Water Quality on Total Sport Fishing Trip (Source: Stevens, 1966 pp.171)

The bioeconomic model facilitates determination of the impact of water pollution on the aggregate level of sport fishing trip. A reduction in water quality inhibits the production of biomass and causes the yield and angling success functions to be shifted downward. The lowering of the biological success function from S_0 to S_1 indicates a reduction in total sport fishing trips from E_0 to E_1.

There is, however, evidence that for sport fishing the size or number of fish caught is only one of many factors influencing recreational value. Moeller and Engelken (1972) found in personal interviews that anglers consider characteristics of the natural environment such as water quality, natural beauty, and privacy while fishing to be more important than the size or number of fish caught. Hampton and Lackey (1976) similarly found that for Virginia anglers at fee sites, aesthetic factors were considered to be more important than the size or number of fish caught. Changes in water quality affects the value of the product "fishing", not the product "fish".

The human behavioral aspects in sport fishing can be investigated under the framework of consumer demand theory. The travel cost models, hedonic travel cost models, and discrete choice models are examples of valuation models based on inferences from market data. Among them, the travel cost technique is the most frequently used method for measuring recreation demand. Travel cost per trip or visit represents the price that is important in determining number of trips or visits.

Economic Efficiency in the Presence of Pollution

Individuals derive satisfaction from recreation sites, specifically sport fishing sites, as visitor experiences or primary benefits, secondary benefits, and nonconsumptive benefits. The experiences are measured as units of participation such as number of trips or visits, days per trip, and number of days. The nonconsumptive benefits will be difficult to measure satisfactorily as most persons will be free-riders to the benefits. These benefits include: option value, existence value, and bequest value.

In the production of trips, participants as well as site operators provide inputs. Participants provide leisure time, travel, and equipment. At the site, operators provide additional inputs such as lodging facilities, boat ramps, and guide services. As consumers as well as producers of recreation experiences, participants include quality of trips in their utility function. The change in sport fishing quality in this study is considered due to the effect of pollution.

The production of commodities by firms (for example agriculture) generates an externality (water pollution) that adversely affects each consumer. The pollution generated by a firm is considered as a factor of production that can be substituted for other inputs, such as labor, capital, and land. The externality is considered a pure public good. What one person "consumes" does not affect the amount available for consumption by others. The disutility suffered by any consumer also depends in part on his consumption of sport fishing recreation.

Fisher (1981, Ch.6)[1] shows the derivation of the problem of maximizing individual utility, subject to restrictions that no one else is made worse off and that the indicated outputs are feasible. The control variables are the consumption of each commodity by each individual and the production and input (including pollution) use by each firm. The polluting firms are subject to a tax, which then the optimal tax, i.e., the tax required to make the competitive allocation Pareto-optimal, can be derived.

The problem is stated as follows:

(2.1) Maximize $u^1 (x_{11}, \ldots\ldots, x_{n1}, w)$

subject to

(2.2) $u^j (x_{1j}, \ldots\ldots, x_{nj}, w) \geq u^{j*}$ $\qquad (j=2,\ldots.,m)$

(2.3) $f^k(y_{1k}, \ldots\ldots, y_{nk}, w_k) = 0$ $\qquad (k=1,\ldots.,h)$

---

[1] Fisher (1981) provides further discussion.

and

$$(2.4)\quad \sum_{j=1}^{m} x_{ij} - \sum_{k=1}^{h} y_{ik} \leq r_i \qquad (i = 1,......,n)$$

where u^j is individual j's utility function, x_{ij} is the amount of good or resource i consumed by individual j, y_{ik} is the amount of good or resource i produced or used by firm f, r_i is the amount of resource i available, w_k is the pollution emitted by firm k, $w = \sum_k w_k$ is the total pollution, and f^k is firm k's production function.

The objective of maximizing utility for consumer 1 contains an externality, w. The first constraint (equation 2.2) states that the utility of each consumer, other than the one whose utility is being maximized, must be at least equal to some prespecified level (u^{j*} for consumer j). Equation 2.3 is the set of production functions with w as one of the production factors. The third constraint (equation 2.4) is a general equilibrium condition. It states that no more of a commodity can be consumed, or a resource used, in the aggregate, than is available to the economy.

The objective and constraints can be combined in the Lagrangian expression:

$$(2.5)\quad L = u^1(.) + \sum_{j=2}^{m} \lambda_j \left[-u^{j*} + u^j(.)\right] - \sum_{k=1}^{h} \mu_k f^k(.) + \sum_{i=1}^{n} \omega_i \left(r_i - \sum_{j=1}^{m} x_{ij} + \sum_{k=1}^{h} y_{ik} \right)$$

Differentiating with respect to the x_{ij}, y_{ik}, and w_k, the first order conditions for a maximum are:

$$(2.6)\quad \lambda_j u_i^j - \omega_i = 0 \qquad \text{(all } i,j\text{)}$$

$$(2.7)\quad -\mu_k f_i^k + \omega_i = 0 \qquad \text{(all } i,k\text{)}$$

(2.8) $u_w^1 + \sum_{j=2}^{m} \lambda_j u_w^j - \mu_k f_{w_k}^k = 0$ (all k)

Equation 2.8 suggests that each firm should emit or employ pollution only to the point where the value of the marginal product of pollution, $\mu_k f_{w_k}^k$, is equal to the marginal cost or the value of the weighted sum of the marginal disutilities, $u_w^1 + \sum_{j=2}^{m} \lambda_j u_w^j$. Since neither the disutilities nor the weights are observable, further analysis is needed.

Let $x_{\bar{i}}$ be a good consumed by everyone. The value of the marginal damage from pollution (equation 2.6), $\lambda_j = \omega_{\bar{i}} / u_{\bar{i}}^j$, becomes $\omega_{\bar{i}} \sum_j u_w^j / u_{\bar{i}}^j$. Along an indifference curve, between two goods (w_i and $x_{\bar{i}}$) the ratio of the marginal utilities is equal to the marginal rate of substitution ($u_w^j / u_{\bar{i}}^j = -dx_{\bar{i}j} / dw$). Thus, the value of the damage is equal to $\omega_{\bar{i}} \sum_j \left(-dx_{\bar{i}j} / dw\right)$ or the value of $x_{\bar{i}}$ needed to offset an increment of pollution. If we let $x_{\bar{i}}$ be the numeraire in the system, then the observable value of damage is the amount of $x_{\bar{i}}$ needed, i.e.,

(2.9) $\lambda_j = \sum_j \left(-dx_{\bar{i}j} / dw\right)$

<u>Consumer</u>. The consumer's problem is to maximize utility subject to a budget constraint. The expenditures are $\sum_{i=1}^{n'} p_i x_{ij}$ where p_i is the price of x_i, and $n'<n$. Income is $\sum_{i=n'}^{n} p_i x_{ij}$, where $x_{n'j}$ to x_{nj} are services sold by the consumer, i.e., labor. The budget constraint then is $\sum_{i=1}^{n'} p_i x_{ij} \leq \sum_{i=n'}^{n} p_i x_{ij} + t^j$, where t^j is compensation for pollution suffered. The Lagrangian expression is:

(2.10) $L_j = u^j(.) + \alpha_j\left(t^j - \sum_i p_i x_{ij}\right).$

Solving the first order condition yields:

(2.11) $u_i^j + \alpha\left(t_i^j - p_i\right) = 0$

Industry. The firm's problem is to maximize profits subject to a production constraint. The firm's profit function includes a term, $t_k w_k$, representing tax payments at a per unit rate t_k for the pollution emitted. The Lagrangian expression is:

(2.12) $L_k = \sum_{i=1}^{n} p_i y_{ik} - t_k w_k - \beta_k f^k(.)$

Solving the first order condition yields:

(2.13) $p_i - \beta_k f_i^k = 0$

(2.14) $-t_k - \beta_k f_{w_k}^k = 0$

Comparing these conditions, i.e. equations (2.11), (2.13), and (2.14), with the corresponding ones for determining a Pareto optimum, i.e., equations (2.6), (2.7), and (2.8), the following must hold:

(2.15a) $p_i = \omega_i$, (2.15b) $\lambda_j = 1/\alpha_j$, (2.15c) $\mu_k = \beta_k$ and

(2.16a) $t_i^j = 0$, (2.16b) $t_k = -u_w^1 - \sum_{j=2}^{m} \lambda_j u_w^j$

The interesting results are in equation 2.16b. It shows the pollution tax is the same for all firms and is equal to the value of the marginal damage from pollution at the Pareto-optimal pollution level.

Subtituting equation 2.16b into observable value of damage (equation 2.9), the tax can also be expressed as:

$$(2.17)\quad t_k = \sum_j dx_{\bar{i}j} / dw$$

Equation 2.16a suggests that compensation must not vary with changes in the consumption levels. More specifically, if consumers increase their trips to polluted sport fishing they should neither be compensated for increasing their consumption nor taxed to prevent it.

Welfare Measurement of Quality Change

Theoretical Considerations

Freeman (1993) identified four channels through which environmental quality changes affect individuals' welfare: (1) changes in the prices they pay for goods bought in markets, (2) changes in the prices they receive for their factors of production, (3) changes in the quantities or qualities of nonmarketed goods, and (4) changes in the risks individuals face.

To illustrate a change in welfare in this section, we utilize a change in price. The "willingness to pay" concept is central to measurement of welfare changes due to price changes. The Hicksian-compensated demand gives an unambiguous measure of willingness-to-pay for infinitesimal changes in price. For non-infinitesimal changes in prices, the "willingness to pay" concept is still valid but alternative measurements exist (Freeman, 1993).

Suppose the price of a product x_1 drops from P_0 to P_1 (Figure 2.3). Five alternatives can be used to measure or approximate the "willingness to pay". The five measures are: (1) Ordinary Consumer's Surplus, (2) Compensating Variation (CV), (3) Equivalent Variation (EV), (4) Compensating Surplus (CS), and (5) Equivalent Surplus (ES) (Freeman, 1993).

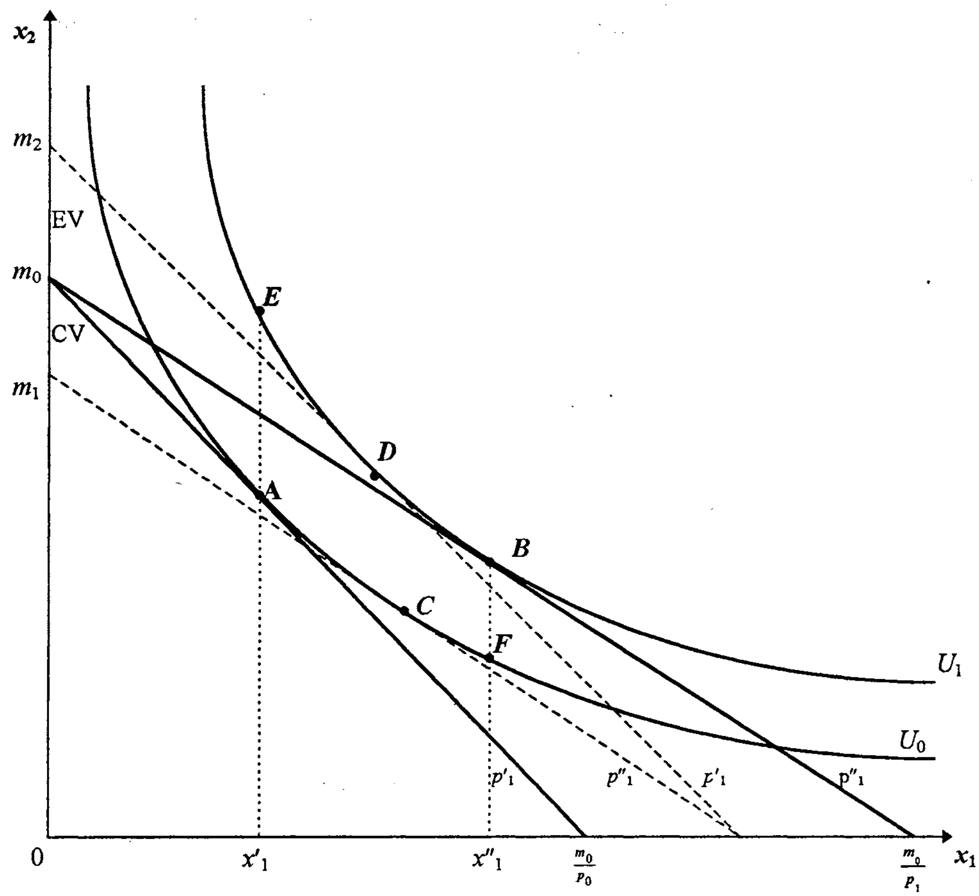

Figure 2.3. Measures of the Welfare Gain from a Price Decrease (Source: Freeman, 1993 p.47 and Hanley and Spash, 1993 p.33)

Ordinary consumer's surplus is measured by the area under a Marshallian ordinary demand curve above the horizontal price line. This measure can not be defined in terms of the underlying utility function which is both an advantage and a disadvantage. It is an advantage because it is measurable from an ordinary demand curve which is easily observable. However, because it is not defined in terms of the underlying utility function, it is only an approximation of a welfare change. The price and income effects reflected by an ordinary demand function are bundled together. Thus, the effect of a price change will involve both price and income effects.

The other four measures (CV, EV, CS, and ES) are theoretical refinements of the ordinary consumer's surplus (Hicks, 1943). Welfare changes, or "willingness to pay" are defined in terms of the area under the appropriate Hicks-compensated demand curve for a market good or marginal willingness-to-pay curve for a non-market good. Unlike ordinary demand functions, where the price and income effects can not be separated, compensated demand functions focus only on price effects. Figure 2.3 shows CV, EV, CS, and ES graphically. The welfare measures can be defined in terms of good x_2. The unit of x_2 is normalized to the price of one so that it can also represent income. For a given budget constraint (money income) of m_0, the consumer may purchase m_0 of x_2 and $\frac{m_0}{P_0}$ of x_1 before the price change and $\frac{m_0}{P_1}$ after the change. The consumer's initial position is at point A on indiference curve U_0.

The CV is the maximum amount that an individual would be willing to pay for the opportunity to consume at the new price set. Given the new price set with consumption at point B, the individual's income could be reduced by the amount of CV and that person would still be as well off at point C as at point A with the original price set and money income. CV is the vertical distance between the budget line where B locates and the budget line where C locates.

The EV is the minimum lump sum payment the individual would have to receive to induce that person to voluntarily forego the opportunity to purchase at the new price set. Given the original price at point A, the individual could reach utility level U_1 at point D with income increase equal to EV. EV is the vertical distance between the budget line where A locates and the budget line where D locates.

In addition to the compensating and equivalent variation measures, there are two surplus measures: compensating and equivalent surplus (CS and ES). These surplus measures are useful where a choice concerns goods with are not continuously divisible, which is the case for many public goods.

CS is closely related to CV. In Figure 2.3, the consumer moves from point A to B in response to the price change, increasing consumption of x_1 from x'_1 to x''_1. As in the case of CV, compensating change in income is then made to move the consumer back to the original utility level. However, unlike the case of CV, the consumer is not allowed to adjust the quantity of x_1 as his/her income falls. That is, the consumer must remain at x''_1 as his/her income is lowered. Consequently, less income needs to be removed to bring the consumer back to the original level of utility since the consumer is "forced" to consume at x''_1. In Figure 2.3, the consumer ends up at point F after the compensation. The CS is the vertical distance between the indifference curves at the new quantity x''_1 (B to F). Similarly, ES is closely related to EV but with its restriction on adjustment of the consumption of x_1. In Figure 2.3 ES is the vertical distance from A to E. This study will employ CV and EV to measure welfare changes.

Consumer Surplus from the Control of Water Pollution in Sport Fishing: Previous Studies

Vaughan and Russel (1982b) noted that the overlapping literature of water resources, recreation, and environmental economics stresses the need for values to attach to largely nonmarket interactions of people and environment, such as recreational boating, fishing, and swimming. Such values are useful for public resource administrators who must decide on policies and implement specific projects directly affecting the allocation of natural resources between recreational and nonrecreational (market) uses (Vaughan and Russel, 1982b).

The travel cost model is based on the insight that individuals' frequencies of visitation to a site in response to changes in entry price are similar to the visitation frequencies observed across different levels of travel cost incurred by individuals in moving between their places of residence and the recreational site. By manipulation of the expenditure function, Bowes and Loomis (1980) show that there is an exact theoretical relationship between the consumer surplus produced by the travel cost method and the consumer surplus defined as the area under the Hicks-compensated demand function for the site's services. The consumer surplus measured by the travel cost method is equivalent to that measured using entry prices.

The existing water pollution shifts the supply curve leftward from S_0 to S_1 (Figure 2.4) by decreasing the availability of the underlying resource, fishable water. Thus, less units of recreational fishing will be produced with water pollution. Demand curve D_0 represents price-quantity relationship at initial water quality level S_0. Assuming other shift factors constant, water pollution causes demand curve shifts downward to D_1. At zero increase in price (P_0) anglers would 'supply' themselves at Q_0 days, it is represented by supply function S_0. Incremental reductions in angler success due to poorer water quality cause incremental reductions in sport fishing trips. Anglers are willing to supply themselves with lesser quantity of trips (Q_1 days) when angling success reduces because of water pollution. If the leftward shift of the supply function could be avoided by preventing water pollution, the area of Q_0AQ_1 would be the total consumer surplus.

Stevens (1966) studied three sport fisheries at Yaquina Bay, i.e., bottomfish, salmon, and clam. By charging $1.50 per angler day for bottomfish and salmon angling, and $1.00 per day for access to the clam beds, the revenues could be maximized. At these price increases, total revenue would equal $22,747 per year (point Q_0 in Figure 2.4). This number represents maximum total 'rent' that anglers would be willing to pay for the opportunity of fishing or digging clam. As one measure of the net economic value of fishery, it could be interpreted as the benefits of preventing the destruction of the fishery by water pollution. The estimated success elasticity for salmon is 0.375 (one day time period), 0.584 (one week time period), and 0.999 (one year time period), and for bottomfish is 0.09 (one day time period). The success elasticity is used to estimate a revised demand equation. Assuming 50 percent reduction in angling success, bottomfish anglers would be willing to supply themselves with only 16,186 trips (represented by S_1 in

Figure 2.4) with an equilibrium price of $0.78 per trip. The consumer surplus were estimated to be $5,279 per year.

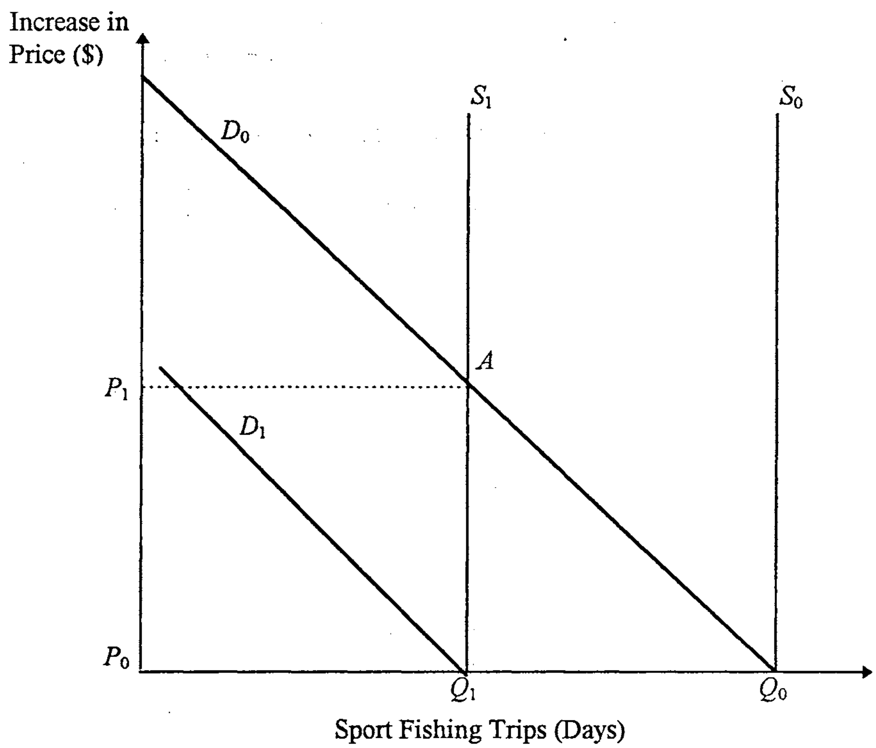

Figure 2.4. Consumer Surplus from Water Quality Control in Sport Fishing (Source: Stevens, 1966 pp.179)

Ward and Cohen estimated demand systems for sport fishing quantities and qualities of two New Mexico trout fishing waters, based on a Quality Generalized Quadratic Utility Index . The estimated quality parameters, represented by fish size and fish catch, are 0.14 and 0.40. The results suggest that increasing catch rate generates more angler utility than increasing size. Applying the CV as welfare measure, they found that increasing quality has a highly variable effect on demand and welfare depending on zone-of-origin. The low expenditure anglers experience only a $7.48 gain in welfare from a 10 percent quality improvement compared to $152.90 gain in welfare for high expenditure anglers. Thus, expenditure is a major determinant of welfare received from a given quality change.

Regional Computable General Equilibrium Model

Computable General Equilibrium (CGE) models have become important policy analysis tools over the past three decades. Numerous models have been applied to a wide range of policy issues. The issues include income distribution, trade policy, development strategy, taxes, long term growth and structural change, etc. both in developed and less developed countries (LDCs) (Dixon and Parmeter 1994). According to Dixon and Parmenter (1994), and Bandara (1991), the 'boom' in CGE modeling of developing economies is the result of: (a) a growing realization that CGE models, unlike a number of other types of economic models, allow the simulation of policy alternatives in a way which is readily understood and perceived to be both relevant and useful by policy makers in these countries, and (b) vast progress in the development of computer software which is user friendly, readily transferable between countries and computer systems, which has taken much of the tedious work and cost out of model building. Thus, it increases enormously the ability of handling the models in detailed analysis. Dixon and Parmenter (1994) pointed out that the Australian CGE models, for example, are disaggregated into 120 industries, 56 regions, 280 occupations, and hundreds of family types.

Two popular programs for CGE modeling are GAMS (Brooke et al, 1992) and GEMPACK (Codsi and Pearson, 1988). Computer software and hardware improvements have reduced the computational constraints on the implementation of CGE models.

In analyzing welfare change due to policy implementation, the use of CV and EV has gained in application among economists. Ahluwalia and Lysy (1979), Shoven and Whalley (1984), Ballard, et al. (1985), and de Melo and Tarr (1992) are to name a few. Most of the studies, however, focus on national level rather than regional level.

Lee (1993) developed a regional CGE model for Oklahoma to measure welfare change from a ten percent decrease in agricultural export commodity prices. The finding was a total welfare loss of $123.7 million across all household income groups in Oklahoma. The more significant welfare change was for the high income groups with a $83.5 million loss. The welfare loss of the medium income groups was $51.3 million, and the low income groups gained $11.1 million.

Welfare Measures of Sport Fishing

There have been numerous studies on estimating the benefits and costs of recreational sport fishing. Schreiner (1993) reported benefit-cost (B/C) ratios for the Mountain Fork River trout fishery in Southeastern Oklahoma. The B/C ratio by season and annual increased for 1992 over 1991. The B/C ratio for 1992 was 21:1 excluding opportunity costs represented by the previous natural fishery and 9:1 including opportunity costs compared to 16:1 and 7:1, respectively, for 1991. Seasonal B/C ratios in 1992 ranged from 16:1 for winter to 29:1 for spring. The same as in 1991, the B/C ratios in 1992 were the highest for spring and summer and the lowest in winter and fall.

Few studies have incorporated the linkages of recreational activities to the regional economy as a whole by means of regional general equilibrium. Lee (1993) studied the general equilibrium impacts of the trout fishery in Southeastern Oklahoma. He employed CV and EV to measure the welfare changes from decreased demand for Mountain Fork River trips without the trout fishery. He found that the existence of the trout fishery resulted in a total welfare gain of about $608,537 to all households in McCurtain County, Oklahoma. Anglers from outside the county contributed $558,080 or 92 percent of the total county household welfare gain.

The current study utilizes sport fishing expenditures for Oklahoma as reported by the Sport Fishing Institute (Fedler and Nickum, 1994b) and the 1991 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (USDI and USDC, 1993) as the basis for a general equilibrium result to measure the welfare change from decreasing trip expenditures due to water pollution. The expenditures are grouped according to commodities purchased by industry sector. These expenditures by sector are the inputs of a sport fishing trip production function, while the total expenditures for trips forms the basis for consumer demands. In the social accounting matrix (SAM), sport fishing is treated as one of the endogenous sectors. The CV and EV welfare measures are then applied to trace the impacts of decreasing trip demands in sport fishing on the economy of the region.

Production Technology and Factor Substitutability

Production is a principle structural component of CGE models. The functional form used to represent production technology often implies the degree of substitutability between factors. The most widely applied production functional forms in CGE models are the Cobb-Douglas (CD) and the Constant Elasticities of Substitution (CES). In a review by Decaluw'e and Martens, 59 out of 73 models used either CD or CES forms. In Bandara's review of 61 CGE models for LDCs (Bandara, 1991), the functional forms used were Leontief, CD, CES, or Constant Ratios of Elasticities of Substitution Homothetic (CRESH). In some cases, the production functions were generalized to all inputs. However, the use of multi-level 'nested' production functions was more common.

Nested production functions allow flexibility in modeling behavioral features at different levels of production. At the first level, the Leontief functional form is appropriate for modeling the behavior of non-substitutability between primary and intermediate inputs. CES, CD, or CRESH functional forms are appropriate at the second level to capture the substitutability among primary factors (including labor, capital, and land) and among intermediate inputs (including domestic and imported goods). At the third level, the substitutability between different skills of labor can be modeled with either CD, CES, or CRESH functional forms (Shoven and Whalley, 1992).

The most common assumptions about factor substitutability are zero elasticity of substitution implied by the Leontief form and unitary elasticity of substitution implied by the CD form. However, Arrow et al (1961) found evidence that elasticity of substitution may not be zero or unity or the same across sectors. CES allows elasticity of substitution different from zero or unity and encompasses the Leontief and CD as special cases. For use in modeling production processes with more than two factors, however, CES suffers the severe limitation that substitution elasticity between any pair of factors is equal. Perhaps less seriously, CES assumes substitution elasticity remains constant as factors vary. CRESH relaxes these limitations and encompasses the CES, and thus also the CD and Leontief, as special cases. CRESH, however, is more difficult to incorporate in CGE models due to its more complex mathematical form and non-linearities.

Product Differentiation

Most recent multisector CGE models assume national product differentiation. The assumption is often referred to as the "Armington" assumption because Armington (1969) first explored the nature of the import demand function when domestically produced and imported goods are imperfect substitutes in use.

The assumption of imperfect substitution is needed because sectoral disaggregation in the presence of few primary factors of production lead to extreme specialization if domestically and foreign-produced goods are perfect substitutes (de Melo and Tarr 1992). Modelers have overcome the specialization problem by dropping the law of one price, that is, by allowing domestically produced and foreign produced goods to be imperfect substitutes in use.

Following Armington, through constant elasticity of substitution (CES) functions, the domestic and imported inputs of production imperfectly and smoothly substitute for each other. In general equilibrium models, the idea of product differentiation for imports can be extended to exports, naturally and symmetrically. The concept of constant elasticity of transformation (CET) was introduced by Powell and Gruen (1968). The CET reflects substitution possibilities in production between the domestic and export products.

Factor Migration

In CGE, two modes of market behavior for primary factors may be modeled. In a "shortrun" version, capital is assumed to be sectorally fixed, and the final equilibrium will have sectorally differentiated rental rates. In a "longrun" version, all factors are mobile and average factor returns adjust to clear factor markets with full employment (Robinson, Kilkenny and Hanson, 1990).

Armstrong and Taylor (1985) have noted that interregional movements of factors play an important role in theories of regional growth and development. Factor migration is viewed as a factor flow from one region to another searching for interregional equilibrium.

Few studies have incorporated labor migration in the general equilibrium model. Dervis et. al. (1982) and Adelman and Robinson (1978) constructed a national model that allowed labor mobility between rural and urban regions. In modeling the national economy, de Melo and Tarr (1992) derived an endogenous labor supply by incorporating leisure as a commodity in the utility function. Lee (1992), in a regional CGE model, endogenized labor supply by allowing labor and leisure choice, and labor migration.

An approach to specify long run equilibrium, capital is allowed to migrate between regions. Capital, thus, behaves similar to labor. It outmigrates from the region if the capital rent in the rest-of-country is higher than in the region. In-migration will occur when rest-of-country capital rent is lower. Rickman (1992) modeled the U.S. economy and included labor migration as well as capital migration.

Quality Tax in Sport Fishing

The concern with natural resources and taxation has given rise to a number of CGE models. Natural resources have economy-wide effects and a general equilibrium model is the appropriate tool for analyzing questions of this kind. Similarly, taxes affect relative prices in the economy, so that a price-endogenous, multisectoral approach is called for in this case (Devarajan, 1988).

Miller and Blair (1985) incorporated environmental pollution generation and abatement in the input-output framework. Several other studies have extended pollution analysis from input-output models to CGE models (Hollenbeck, 1979; Jorgenson and Wilcoxen, 1990; and Robinson et.al., 1993).

This study traces the impacts of water pollution on sport fishing trips and the region economy by imposing a quality tax. Reduced water quality (i.e., an increase in chemical discharge) reduces fish populations which reduce fish caught per trip and thus a decrease in quality of sport fishing and a reduction in number of sport fishing trips in Oklahoma.

CHAPTER III

REGIONAL COMPUTABLE GENERAL EQUILIBRIUM: SAM STRUCTURE AND MODEL SPECIFICATION

SAM Structure of CGE Model

In Computable General Equilibrium (CGE) modeling, a Social Accounting Matrix (SAM) is assumed to represent equilibrium of the economy at a point in time. A SAM is a tabular 'snapshot' of the economy for a particular year. It is a double entry bookkeeping account presented in a single matrix form. It describes circular transactions and incomes flows among the components of the economy, i.e., production sectors, factors of production or value added, institutions, capital account, and rest of the world. A table entry's row represents receipts or incomes to the row account. A table entry's column represents expenditures out of the column account. For each account, the row sum and column sum must balance. Thus all flows in the economy are accounted for with no leakage.

Figure 3.1. captures the SAM structure for the Oklahoma economy. The production side of the economy is aggregated into 14 sectors of market goods. There are two sectors of nonmarket goods, namely, Oklahoma resident and nonresident sport fishing. Thus a total of 16 production sectors are modeled.

EXPENDITURES \ RECEIPTS	INDUSTRY	FACTOR			INSTITUTION			CAPITAL	REST OF WORLD	TOTAL
		Labor	Capital	Land	Enterprise	HH Low (<20,000) / HH Medium (20-40,000) / HH High (>40,000)	Government State/Local / Federal			
	1..........16	1.....5	1.....14							
INDUSTRY 1 : 16	Inter-industry Transactions					Household Consumption Demand	Government Demand	Investment Demand	Commodity Exports	Total Outputs
FACTOR Labor 1.Mgmt/Professional 2.Tech/Sales/Adm Support 3.Services 4.Farm/Forest/Fish 5.Prod/Craft/Repair Capital Land	Value Added					**Labor Employed by HH**	**Labor Employed by Gov't**			**Factor Income**
INSTITUTION Enterprise			Enterprise Income							Entr Income
Household Low <20,000 Medium 20,000-40,000 High >40,000		Household Labor Income	Agr Capital Income	Agr Land Income	Profit Distri-bution		Government Transfer to Households		Net Remit-tances from ROW	HH Income
Government State/Local Federal	Indirect Bu-siness Taxes	Labor Inc Tax	Agr Cap Inc Tax	Agr Land Inc Tax	Enterprise Tax	Household Income Taxes			Net ROW Gov't Transfer	Gov't Rev
CAPITAL			Ag Cap Depr		Depr+Retained Earnings	Household Saving			Net Transfers (ROW Savings)	Tot Saving
REST OF WORLD 1 : 16	Import Demand					Household Import Demand	Government Import Demand	Investment Import Demand		Total Outflows
TOTAL	Total Outlays	Factor Expenditure			Enterprise Expenditure	Household Expenditure	Government Expenditure	Total Investment	Total Inflows	

Figure 3.1. SAM Structure of Oklahoma Model

Value-added inputs are labor, capital, and land, with labor further sub-divided into five skill types (or occupational categories). There are three institutional accounts: enterprise, household, and government. The household sector is sub-divided into low, medium, and high income classes. The government sector is sub-divided into state/local, and federal. Capital account captures financial transactions. The last account is rest-of-world.

The SAM for Oklahoma in this study uses 1991 IMpact analysis for PLANning (IMPLAN) data as the base year, which is consistent with 1991 angler trip expenditure data.[2] The 1991 SAM is used as a benchmark equilibrium. Using the calibration technique, the CGE model which represents the economy should reproduce the benchmark SAM.

Model Specification

This section presents model specification in equation form. Variables are presented in uppercase letters. Exogenous variables are differentiated from endogenous variables by using "0" as the last part of the name of exogenous variables. Greek and lower case Latin letters indicate parameters or policy variables.

The model includes market goods (*M*) and nonmarket goods (*NM*). Nonmarket goods are differentiated into sport fishing resident trips (*NR*) and nonresident trips (*NE*). Variable subscripts "*i*" and "*j*" indicate sectors. For variables representing flows from one sector to another, the first subscript of double subscript indicates sector origin, while the

[2] Data sources and methods are presented in Chapter IV.

second indicates sector destination. Index "*h*" represents household groups: *low*, *medium*, and *high* income level. Index "*s*" (and "*t*" when reference is to labor skill other than "*s*") represents five different labor skills: L_1, L_2, L_3, L_4, and L_5. Appendix A lists the description of variables, indices, and model equations.

Factor Markets and Supply of Commodities

Structure of Production

Production is characterized by three-level nesting to allow flexibility in modeling behavioral features at different levels of production. At the first level, the Leontief input-output production function allows the behavior of non-substitutability or fixed coefficients for a composite of primary and a composite of intermediate inputs. The second level is the production technology for primary factors, and intermediate inputs. Primary factors are described by a neoclassical production function represented by the C-D (Cobb-Douglas) functional form to capture smooth substitution among primary factors (labor, capital, and land). Intermediate goods are represented by the Leontief production function although substitution among domestic and imported intermediate inputs is represented by the CES (constant elasticity of substitution) production function. At the third level, a CES production function allows substitution between different skills of labor. Figure 3.2 summarizes the structure of production and functional forms in the model.

At the first level, a Leontief production function is used to relate gross output of industries with composite value-added (VA_i) and intermediate inputs (V_{ji}):

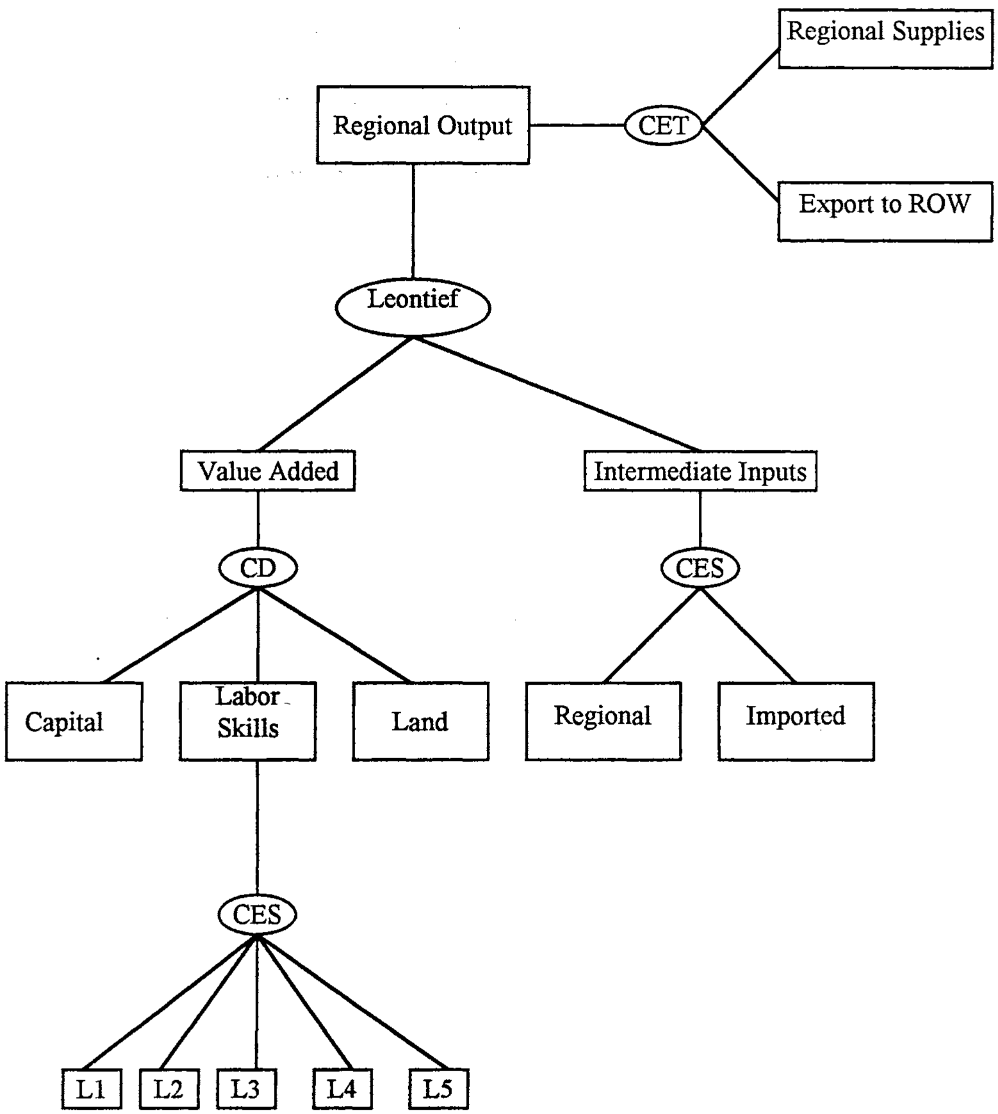

Figure 3.2. Allocation of Production Model Structure

$$(3.1)\quad X_i = \min\left[\frac{VA_i}{a_{0i}}, \frac{V_{1i}}{a_{1i}}, \ldots, \frac{V_{mi}}{a_{mi}}\right] \qquad i \in M, NM;\ j \in M(1.....m)$$

where X_i = gross output of sector i,
VA_i = composite value added in industry i,
V_{ji} = composite intermediate input j in industry i,
a_{0i} = composite value added per unit of output i, and
a_{ji} = the usage of intermediate input j per unit of good i.

Alternatively:

$$(3.2)\quad VA_i = a_{0i} X_i \text{ and } V_{ji} = a_{ji} X_i$$

Value Added and Factor Demand

At the second level, value-added is produced by three factors: labor (L), capital (K), and land (T). The relationship is expressed as a Cobb-Douglas production function which assumes linear homogeneity and unitary-elasticity substitutability among the three primary factors. With the Cobb-Douglas production function, factor shares are also partial elasticities of output.

$$(3.3)\quad VA_i = \phi_i^{VA} LAB_i^{\alpha_i^L} CAP_i^{\alpha_i^K} LAND_i^{\alpha_i^T}, \qquad i \in M;\ (\alpha_i^L + \alpha_i^K + \alpha_i^T = 1)$$

where ϕ_i^{VA} = value added efficiency parameter for industry i ($\phi_i^{VA} > 0$),
α_i^L = labor share parameter ($0 < \alpha_i^L < 1$),
α_i^K = capital share parameter ($0 < \alpha_i^K < 1$),
α_i^T = land share parameter ($0 < \alpha_i^T < 1$),
LAB_i = labor used by industry i,
CAP_i = capital used by industry i, and
$LAND_i$ = land used by industry i.

Firms are assumed to choose VA_i (composite value added) and V_{ji} (composite intermediate goods) to maximize the following profit function:

(3.4) $\Pi_i = PN_i X_i - PLM_i LAB_i - PK_i CAP_i - PT_i LAND_i$

where PN_i is the net price of commodity i, PLM_i, PK_i, and PT_i are unit costs of labor, capital, and land, respectively. Net price is final commodity price net of costs of intermediate inputs and taxes. In the long run, industries face the same unit costs for land and capital. Industries also face the same unit costs for labor in each skill category. PLM_i is a weighted average unit labor cost weighted by proportion of skill labor type required by individual industries. Thus PLM_i is industry specific aggregate labor price.

The first order condition of equation (3.4) with respect to capital can be written as:

(3.5) $$\frac{\partial X_i}{\partial CAP_i} = \frac{PK_i}{PN_i}$$

Equation (3.5) gives the marginal product of capital. The marginal product of CAP_i multiplied by the amount of CAP_i used gives the contribution of capital in the sectoral output, X_i. Thus, dividing the net contribution of capital by X_i yields the share of CAP_i. Using equation (3.5), the factor share of capital can be written as:

(3.6) $$\alpha_i^K = \frac{PK_i CAP_i}{PN_i X_i}$$

Rearranging terms in equation (3.6) yields the demand for capital in industry i:

(3.7) $$CAP_i = \frac{\alpha_i^K PN_i X_i}{PK_i}$$

Similarly, the demand for labor is:

(3.8) $$LAB_i = \frac{\alpha_i^L PN_i X_i}{PLM_i}$$

The demand for land is:

$$(3.9)\quad LAND_i = \frac{\alpha_i^T PN_i X_i}{PT_i}.$$

The third level represents substitution among five labor skills. A CES (constant elasticity of substitution) production function is assumed. The CES allows elasticities of substitution among labor skills to differ among industries but requires the elasticity of substitution among any two categories of labor in one industry to be the same.

$$(3.10)\quad LAB_i = \phi_i^{LAB}\left[\sum_s \delta_{is}^{LAB} LD_{is}^{\rho_i^{LAB}}\right]^{1/\rho_i^{LAB}}, \qquad \sigma_i^{LAB} = \frac{1}{1-\rho_i^{LAB}}, \qquad i \in M;\ s = L_1,..,L_5$$

where ϕ_i^{LAB} = the labor efficiency parameter for industry i ($\phi_i^{LAB} > 0$),
δ_{is}^{LAB} = labor's share parameter ($0 < \delta_{is}^{LAB} < 1$), ($\Sigma_s \delta_{is}^{LAB} = 1$),
LD_{is} = quantity demanded of skilled labor type s in industry i,
σ_i^{LAB} = the elasticity of substitution among labor skills in industry i,
ρ_i^{LAB} = the substitution parameter among labor skills in industry i ($\rho_i^{LAB} \neq 0$).

The derived demand for labor of skill level s in industry i is based on cost minimization to satisfy aggregate labor requirement in the industry. The cost minimizing problem is to choose LD_{is} to minimize the total wage bill $\Sigma_s PLS_s LD_{is}$

subject to $$LAB_i = \phi_i^{LAB}\left[\sum_s \delta_{is}^{LAB} LD_{is}^{\rho_i^{LAB}}\right]^{1/\rho_i^{LAB}}$$

where s=1,..,5 and PLS_s is wage rate of skill labor type s.

Following Dixon, Bowles and Kendrick (1980), the first-order conditions are:

$$(3.11)\quad PLS_s = \phi_i^{LAB}\left[\sum_t \delta_{it}^{LAB} LD_{it}^{\rho_i^{LAB}}\right]^{(1-\rho_i^{LAB})/\rho_i^{LAB}} \delta_{is}^{LAB} LD_{is}^{-(1-\rho_i^{LAB})} \qquad s,\ t = 1,\ldots\ldots,5$$

and

$$(3.12)\quad LAB_i = \phi_i^{LAB}\left[\sum_s \delta_{is}^{LAB} LD_{is}^{\rho_i^{LAB}}\right]^{1/\rho_i^{LAB}}$$

From equation (3.11) the ratio of wages for two labor skills of type *s* and *t* can be expressed as:

$$(3.13)\quad \frac{PLS_t}{PLS_s} = \frac{\delta_{it}^{LAB} LD_{it}^{-(1-\rho_i^{LAB})}}{\delta_{is}^{LAB} LD_{is}^{-(1-\rho_i^{LAB})}}$$

i.e.

$$(3.14)\quad LD_{is} = \left(\frac{PLS_s \delta_{it}^{LAB}}{PLS_t \delta_{is}^{LAB}}\right)^{1/(1+\rho_i^{LAB})} LD_{it}$$

Substituting equation (3.14) into equation (3.10) yields:

$$(3.15)\quad LAB_i = \phi_i^{LAB}\left[\sum_t \delta_{is}^{LAB}\left(\frac{PLS_s \delta_{it}^{LAB}}{PLS_t \delta_{is}^{LAB}}\right)^{\rho_i^{LAB}/(1-\rho_i^{LAB})} LD_{it}\right]^{1/\rho_i^{LAB}}$$

so that the demand for labor of type *s* in industry *i* has the form:

$$(3.16)\quad LD_{is} = \frac{LAB_i}{\phi_i^{LAB}}\left[\sum_t \delta_{it}^{LAB}\left(\frac{PLS_s\ \delta_{it}^{LAB}}{PLS_t\ \delta_{is}^{LAB}}\right)^{\rho_i^{LAB}/(1-\rho_i^{LAB})}\right]^{1/\rho_i^{LAB}}$$

Intermediate Input Demand

Intermediate inputs are obtained from region and nonregion sources. The choice between region and nonregion produced intermediate inputs is based on their relative prices and their substitutability as specified by the elasticity of substitution. A CES function is used to allow substitution between regionally produced and imported goods:

$$(3.17)\quad V_{ji} = \phi^V_{ji}\left[\delta^V_{ji} VM_{ji}^{\rho^V_j} + \left(1-\delta^V_{ji}\right) VR_{ji}^{\rho^V_j}\right]^{-1/\rho^V_j}, \quad \sigma^V_j = \frac{1}{1-\rho^V_j}, \qquad i \in M, NM;\ j \in M$$

where ϕ^V_{ji} = the intermediate input efficiency parameter ($\phi^V_{ji} > 0$),
δ^V_{ji} = the share parameter ($0 < \delta^V_{ji} < 1$),
VM_{ji} = imported intermediate purchases by sector i from sector j,
VR_{ji} = regional intermediate purchases by sector i from sector j,
σ^V_j = elasticity of substitution, and
ρ^V_j = the substitution parameter ($-1 < \rho^V_j \neq 0$).

The intermediate input demand functions for regionally produced and imported goods are derived from the following cost minimization problem:

Minimize $\quad PM0_j VM_{ji} + PR_j VR_{ji}$

subject to $\quad V_{ji} = \phi^V_{ji}\left[\delta^V_{ji} VM_{ji}^{\rho^V_j} + \left(1-\delta^V_{ji}\right) VR_{ji}^{\rho^V_j}\right]^{-1/\rho^V_j}$

where $PM0_j$ = the prices of intermediate imported goods of sector j, and
PR_j = the prices of intermediate regional goods of sector j.

Solving the first order condition yields:

$$(3.18)\quad \frac{VR_{ji}}{VM_{ji}} = \left[\left(\frac{1-\delta^V_{ji}}{\delta^V_{ji}}\right)\left(\frac{PM0_j}{PR_j}\right)\right]^{\sigma^V_j}.$$

Output Market

Introduced by Powell and Gruen (1968), the constant elasticity of transformation (CET) function implements the idea of product differentiation. Each industry in the region produces a composite commodity that can be transformed into an export or a commodity sold in the regional market. Price ratio and elasticity of transformation determine the levels of output exported and sold in the region. The following equation shows the substitution possibilities in production for the regional and export markets:

$$(3.19)\quad X_i = \phi_i^X\left[\delta_i^X EXP_i^{\rho_i^X} + \left(1-\delta_i^X\right)R_i^{\rho_i^X}\right]^{-1/\rho_i^X}, \qquad \sigma_i^X = \frac{1}{\rho_i^X - 1}, \qquad i\in M$$

where X_i = output of industry i,
ϕ_i^X = the output efficiency parameter ($\phi_i^X > 0$),
δ_i^X = the share parameter ($0<\delta_i^X<1$),
EXP_i = supply of sector i for export,
R_i = supply of sector i for regional sales,
σ_i^X = elasticity of transformation,
ρ_i^X = the substitution parameter ($-1 < \rho_i^X \neq 0$).

Each firm producing market goods allocates its output between the regional and export markets to maximize profits. The firm maximizes revenue subject to the CET function for X_i, and for given prices in the regional and export markets:

Maximize $\quad PE0_i EXP_i + PR_i R_i$

subject to $\quad X_i = \phi_i^X\left[\delta_i^X EXP_i^{\rho_i^X} + \left(1-\delta_i^X\right)R_i^{\rho_i^X}\right]^{-1/\rho_i^X}$

where $PE0_i$ = price of exported goods, and
PR_i = price of regional goods.

Solving the first order condition yields:

$$(3.20)\quad \frac{R_i}{EXP_i} = \left[\left(\frac{1-\delta_i^X}{\delta_i^X}\right)\left(\frac{PE0_i}{PR_i}\right)\right]^{-\sigma_i^X} \qquad i\in M$$

For nonmarket goods, sport fishing resident trips are only consumed in the region and nonresident trips are all exported. The export demand for nonresident trips is a function of price and price elasticity of export demand, ε_i.

$$(3.21)\quad R_i = X_i, \qquad EXP_i = 0, \qquad i\in NR$$

$$(3.22)\quad R_i = 0, \qquad EXP_i = E0_i P_i^{\varepsilon_i}, \qquad i\in NE$$

Income and Expenditure

Factor Income

Factor income is the result of value added by industrial sector. It is determined from regional resources and factor prices under market equilibrium conditions. It includes labor income (*YL*), capital income (*YK*), and land income (*YT*).

Labor Income. Total labor income is the sum of the product of labor demanded and the wage rate. Labor by skill is demanded by industry and institution including household and government. Labor income by skill is:

$$(3.23)\ YLS_s = PLS_s\left(\sum_i LD_{is} + \sum_h LHH0_{sh} + LSL0_s + LFED0_s\right)$$

where $LHH0_{sh}$, $LSL0_s$, and $LFED0_s$ are, respectively, labor employed by household, state and local government, and federal government, while other variables are as defined previously. Only high income households employ labor directly, therefore $\sum_h LHH0_{sh}$ = $LHHH0_s$, where $LHHH0_s$ is labor employed by high income households.

Total labor income is the summation across labor skills:

$$(3.24)\ YL = \sum_s YLS_s$$

Capital income. Total capital income is the sum of the product of capital demanded and the rent of capital. Equation (3.25) is total capital income:

$$(3.25)\ YK = \sum_i PK_i CAP_i, \qquad i \in M$$

where PK_i is capital rent and CAP_i is quantity of capital demanded by sector i.

Land income. Total land income is the sum of the product of land demanded and the land rent. Total land income is:

$$(3.26)\quad YT = \sum_i PT_i LAND_i \qquad i \in M$$

where PT_i is land rent, and $LAND_i$ is quantity of land demanded by sector i. In the current analysis, only agricultural land is identified and all agricultural land is used by sector one.

Factor income net of factor taxes, depreciation and retained earnings. Factor incomes are subject to government taxes, capital depreciation, and enterprise retained earnings. Labor, capital, land, and enterprise incomes net of taxes, depreciation, and retained earnings are defined as follows:

Labor income net of labor income tax (*NYL*) is:

$$(3.27)\quad NYL = YL(1 - sstax)$$

where *YL* is labor income, and *sstax* is labor income tax rate.

Capital income available for distribution to households is total supply of capital multiplied by capital rent. Capital is differentiated between agricultural (*YAGK*) and nonagricultural capital because agricultural capital income net of capital income tax and depreciation (*NYAGK*) is distributed directly to households:

$$(3.28)\quad YAGK = PK_{ag} CAP_{ag}\text{, and}$$

$$(3.29)\quad NYAGK = YAGK(1 - ktax - depr),$$

where *ktax* is capital income tax rate, and *depr* is agricultural capital depreciation rate. Enterprise income is the nonagricultural capital income:

$$(3.30)\quad YENT = YK - YAGK,$$

The enterprise income net of depreciation and retained earnings (*NYENT*) is distributed to households via enterprise profits:

(3.31) $NYENT = YENT(1 - ktax - retr)$, where *ktax* is capital income tax rate and *retr* is enterprise depreciation and retained earnings.

Land income available for distribution to households is land supplied multiplied by land rent net of land income tax (*NYT*). Similar to agricultural capital, land income net of land income tax is distributed directly to households:

(3.32) $NYT = YT(1 - ttax)$, where *ttax* is land income tax rate.

Household Income

Sources of household income are factor income including profit distribution by enterprises, transfers from other households, government transfers, and net remittances from rest-of-world. Factor income is the main source of household income.

Household labor income. Labor income, *YL*, in equation 3.24 is for all households residing in the region labor market[3]. From the household point of view, labor income is the product of labor supplied by household by wage rate. Overall wage rates paid to household groups differ because skill endowments vary. Thus, labor income by household group in the region is expressed as:

(3.33) $YLH_h = PLH_h LSupH_h$

[3] This study has not allowed for commuter labor. Because the region is large (state of Oklahoma), commuting across regional boundaries is minimal relative to the total size of the labor market.

where PLH_h is overall regional wage rate paid to household group and $LSupH_h$ is regional labor supplied by household group. $LSupH_h$ will be discussed in a later section of this chapter.

The total regional household labor income is:

(3.34) $YL = \sum_h YLH_h$.

At equilibrium, equations 3.24 and 3.34 are equal where labor demand must equal labor supply at equilibrium wage rate.

However, because the model allows labor migration[4] out of the region, labor supplied within the region under a new equilibrium is a proportion of the initial labor supplied by household groups. This proportion is used as an adjustment factor and is needed to account for factor returns (capital and land) that flow out-of-region with migrating households. The specific adjustment factor for each household group ($adjL_h$) is the following:

(3.35) $adjL_h = \dfrac{LSupH0_h + LMigH_h}{LSupH0_h}$

where $LSupH0_h$ is initial equilibrium stock of labor by household group, and $LMigH_h$ is labor migration by household group. Specification of labor migration will be presented in later discussion.

Household disposable income. Factor incomes are distributed to households after factor income taxes, depreciation, and retained earnings. Because no provision is made for changes in ownership of capital and land, the adjustment factor in equation (3.35) is

[4] The more general case of labor in-migration as well as out-migration was not modelled in this study. Labor in-migration requires establishing an additional household group.

applied to account for returns to capital and land that remain with households in the region. Regional factor income by household group adjusted for migration under new equilibrium is:

$$(3.36)\quad YFH_h = l_h NYL + adjL_h\left(k_h NYAGK + e_h NYENT + t_h NYT\right)$$

where l_h = labor income distribution coefficients to household groups,
k_h = agricultural capital income distribution coefficients to household groups,
t_h = land income distribution coefficients to household groups,
e_h = enterprise profit distribution coefficients to household groups, and other parameters and variables are as defined previously.

In addition to factor income (YFH_h), total income of household group h (YH_h) remaining in the region includes State and Local government transfer ($TRSL0_h$), Federal government transfer ($TRFED0_h$) and net remittances from rest-of-world ($REMIT0_h$). The government transfer and remittances need to be adjusted to only account for households remaining in the region.

$$(3.37)\quad YH_h = YFH_h + adjL_h\left(TRSL0_h + TRFED0_h + REMIT0_h\right)$$

Each household group pays income taxes to the government and saves a proportion of its income. Disposable income for household group h is denoted DYH_h and is calculated as after tax household incomes:

$$(3.38)\quad DYH_h = YH_h\left(1 - hhtax_h\right)$$

where $hhtax_h$ is the income tax rate of household group h.

Savings are fixed in proportion to household income. The proportion is mps_h: the marginal saving propensity. Equation (3.39) shows the saving of household group h:

$$(3.39)\quad HSAV_h = mps_h YH_h.$$

Regional Household Consumption Demand

Regional household commodity expenditure is disposable income less savings and payment for labor employed by households:

$$(3.40)\quad HEXP_h = DYH_h - HSAV_h - \sum_s PLS_s LHH0_{sh}$$

Households in the region consume market and nonmarket goods. The regional consumption by households is nested in two levels. At the first level, households maximize utility in the consumption of a composite of market and nonmarket goods, and the demand for leisure (or supply of labor) subject to budget constraints and prices. Linear expenditure system (LES) for consumption demand allows cross-price effects in demand. The LES is derived from the Stone-Geary utility function with consideration of leisure (See Lee, 1992 for fuller derivation). Demand for commodities is:

$$(3.41)\quad Q_{ih} = \gamma_{ih} + \left(\frac{\beta_{ih}}{(1-\beta_{0h})P_i}\right)\left(HEXP_h - \sum_{j=1}^{n} P_j \gamma_{jh}\right) \qquad i,j \in M,NR$$

where Q_{ih} = consumption demand for composite good i of household group h,
γ_{ih}, γ_{jh} = minimum subsistence requirement for good i, or j of household group h,
β_{ih} = marginal budget share for commodity i of household group h,
β_{0h} = marginal budget share for leisure of household group h,
$HEXP_h$ = expenditure of household group h, and
P_i, P_j = composite price of commodity i, or j.

Demand for leisure is:

$$(3.42)\quad Q_{0h} = \gamma_{0h} + \left(\frac{\beta_{0h}}{(1-\beta_{0h})w}\right)\left(HEXP_h - \sum_{j=1}^{n} P_j \gamma_{jh}\right)$$

where w is the wage rate. This equation is not directly used in the model but is used for deriving the labor supply equation presented in a later section (See Lee, 1992 for derivation).

At the second level, households choose optimal combinations of imported and locally produced goods according to relative prices and pre-specified elasticities of substitution. Regional and imported goods are imperfect substitutes due to product differentiation. In addition to imported market goods, the imported nonmarket goods include sport fishing trips that households have at alternative sites outside the region. The substitution possibilities (or degree of product differentiation) are represented by the parameters of the CES function. This formulation corresponds to the well-known Armington specification. The shares in the composition of regional and imported goods are determined by cost minimization.

(3.43) $Q_{ih} = \phi_i^Q \left(\delta_i^Q QM_{ih}^{\rho_i^Q} + \left(1-\delta_i^Q\right) QR_{ih}^{\rho_i^Q}\right)^{\frac{1}{\rho_i^Q}}, \qquad \sigma_i^Q = \frac{1}{1-\rho_i^Q}, \qquad i,j \in M,NR$

where
ϕ_i^Q = the household consumption efficiency parameter ($\phi_i^Q > 0$),
δ_i^Q = the share parameter ($0 < \delta_i^Q < 1$),
QM_{ih} = household demand for imports,
QR_{ih} = household demand for regional products,
σ_i^Q = elasticity of substitution, and
ρ_i^Q = the substitution parameter ($-1 < \rho_i^Q \neq 0$).

It is assumed that there is no regional nonmarket good demand for nonresident trips:

(3.44) $Q_{ih} = 0, \qquad i \in NE$

Consumers minimize cost or maximize utility subject to their budget by optimizing purchases from regionally produced and imported goods:

Minimize $\qquad PM0_i QM_{ih} + PR_i QR_{ih}$

subject to $\quad Q_{ih} = \phi_i^Q \left(\delta_i^Q QM_{ih}^{\rho_i^Q} + \left(1-\delta_i^Q\right) QR_{ih}^{\rho_i^Q} \right)^{\frac{1}{\rho_i^Q}}$

where $PM0_i$ = the price of imported goods of sector i.

Solving the first order condition yields:

$$(3.45)\quad \frac{QR_{ih}}{QM_{ih}} = \left[\left(\frac{1-\delta_i^Q}{\delta_i^Q} \right) \left(\frac{PM0_i}{PR_i} \right) \right]^{-\sigma_i^Q}$$

Total demand for regional products and imports are:

$$(3.46)\quad TQR_i = \sum_h QR_{ih}, \text{ and } TQM_i = \sum_h QM_{ih}.$$

Total demand for composite goods is:

$$(3.47)\quad TQ_i = \sum_h Q_{ih}$$

Household Labor Supply

Taking demand for leisure into account, labor supply by household is defined as:

$$(3.48)\quad LSupH_h = MAXHOURS0_h - \left(\frac{\beta_{0h}}{PLH_h} \right) \left(\frac{HEXP_h - \sum_{j=1}^{n} P_j \gamma_{jh}}{1-\beta_{0h}} \right)$$

where $MAXHOURS0_h = T_h - \gamma_{0h}$. T_h is the time endowment, which is twenty four hours minus the time necessary for sleeping and other minimal maintenance tasks, and γ_{0h} is minimum subsistence requirement for leisure. The other variables are as defined in previous section.

Because labor demand is classified in terms of skill levels, labor supply must also be expressed in terms of skill level when equating supply and demand at equilibrium. The following is used to bridge labor supply by household and labor supply by skills. Labor supply by household and by skill type, $LSupHS_{hs}$, is computed by assuming that the share of skilled labor in each household type is the same as in the base, i.e. $\frac{LSupHS0_{hs}}{LSupH0_h}$:

$$(3.49)\quad LSupHS_{hs} = LSupH_h \frac{LSupHS0_{hs}}{LSupH0_h}$$

Labor supply by skill is computed by summing $LSupHS_{hs}$ over all households:

$$(3.50)\quad LSupS_s = \sum_h LSupHS_{hs}$$

Government Income and Expenditure

State and Local, and Federal government are considered separately. Governments consume market goods only, and, like households, optimize the allocation of expenditures between imported and regional commodities given relative prices and substitution possibilities. Governments also collect taxes and provide transfers to households.

More specifically, government revenue is accumulated from indirect business taxes, factor taxes, enterprise taxation, household income taxes, and transfers from rest-of-world. Its expenditures include commodity consumption, payment to labor, and transfers to households.

State and Local Government

The State and Local government revenue (YSL) and expenditure ($SLEXP$) are presented in equations (3.51) and (3.52).

$$(3.51)\quad \begin{aligned} YSL = {} & sl^{IBT}\left(\sum_i ibtax_i PR_i X_i\right) + sl^{SST}(sstaxYL) + sl^{KTT}(ktaxYK) + sl^{TTT}(ttaxYT) \\ & + sl^{HHT}\left(\sum_h hhtax_h YH_h\right) + SLBOR0 \end{aligned}$$

where sl^{IBT} = state/local proportion of government tax revenues from indirect business tax,

sl^{SST} = state/local proportion of government tax revenues from labor tax,

sl^{KTT} = state/local proportion of government tax revenues from capital tax,

sl^{TTT} = state/local proportion of government tax revenues from land tax,

sl^{HHT} = state/local proportion of government tax revenues from household income tax,

$ibtax_i$ = indirect business tax of industry i,

$SLBOR0$ = state/local government transfer and net borrowing, and other parameters and variables are as defined previously.

$$(3.52)\quad SLEXP = \sum_i P_i QSL_i + \sum_h adjL_h TRSL0_h + \sum_s PLS_s LSL0_s, \qquad i \in M$$

where $QSL_i = QSL0_i$ are exogenously determined commodity purchases, and other variables are as defined previously.

$$(3.53)\quad QSL_i = \phi_i^{SL}\left(\delta_i^{SL} QSLM_i^{\rho_i^{SL}} + \left(1-\delta_i^{SL}\right) QSLR_i^{\rho_i^{SL}}\right)^{\frac{1}{\rho_i^{SL}}}, \quad \sigma_i^{SL} = \frac{1}{1-\rho_i^{SL}}, \qquad i \in M$$

where ϕ_i^{SL} = the state and local government efficiency parameter ($\phi_i^{SL} > 0$),

δ_i^{SL} = the share parameter ($0 < \delta_i^{SL} < 1$),

$QSLM_i$ = state and local government demand for imports,

$QSLR_i$ = state and local government demand for regional products,

σ_i^{SL} = elasticity of substitution, and

ρ_i^{SL} = the substitution parameter ($-1 < \rho_i^{SL} \neq 0$).

State and Local government minimizes expenditure on product i by considering region and out-of-region sources:

Minimize $\quad PM0_i QSLM_i + PR_i QSLR_i$

subject to $$QSL_i = \phi_i^{SL}\left(\delta_i^{SL} QSLM_i^{\rho_i^{SL}} + \left(1-\delta_i^{SL}\right) QSLR_i^{\rho_i^{SL}}\right)^{\frac{1}{\rho_i^{SL}}}$$

where $PM0_i$ are the prices of imported goods. Solving the first order condition yields:

$$(3.54)\quad \frac{QSLR_i}{QSLM_i} = \left[\left(\frac{1-\delta_i^{SL}}{\delta_i^{SL}}\right)\left(\frac{PM0_i}{PR_i}\right)\right]^{-\sigma_i^{SL}}.$$

Federal Government

Federal government revenue (*YFED*) and expenditure (*FEDEXP*) are calculated using equations (3.55) and (3.56).

$$(3.55)\quad \begin{aligned} YFED = {} & fed^{IBT}\left(\sum_i ibtax_i PR_i X_i\right) + fed^{SST}\left(sstaxYL\right) + fed^{KTT}\left(ktaxYK\right) + \\ & fed^{TTT}\left(ttaxYT\right) + fed^{HHT}\left(\sum_h hhtax_h YH_h\right) + FEDBOR0 \end{aligned}$$

where fed^{IBT} = federal government's share of indirect business tax revenue,
fed^{SST} = federal government's share of labor tax revenue,
fed^{KTT} = federal government's share of capital tax revenue,
fed^{TTT} = federal government's share of land tax revenue,
fed^{HHT} = federal government's share of household income tax revenue,
$FEDBOR0$ = federal government transfer and net borrowing, and other parameters and variables are as defined previously.

$$(3.56)\quad FEDEXP = \sum_i P_i QFED_i + \sum_h adjL_h TRFED0_h + \sum_s PLS_s LFED0_s, \qquad i \in M$$

where $QFED_i = QFED0_i$ are exogenously determined commodity purchases, and other variables are as defined earlier.

$$(3.57)\quad QFED_i = \phi_i^{FED}\left(\delta_i^{FED} QFEDM_i^{\rho_i^{FED}} + \left(1-\delta_i^{FED}\right) QFEDR_i^{\rho_i^{FED}}\right)^{\frac{1}{\rho_i^{FED}}} \qquad i \in M$$

$$\sigma_i^{FED} = \frac{1}{1-\rho_i^{FED}}$$

where ϕ_i^{FED} = the federal government efficiency parameter ($\phi_i^{FED} > 0$),
δ_i^{FED} = the share parameter ($0 < \delta_i^{FED} < 1$),
$QFEDM_i$ = federal government demand for imports,
$QFEDR_i$ = federal government demand for regional products,
σ_i^{FED} = elasticity of substitution, and

ρ_i^{FED} = the substitution parameter ($-1 < \rho_i^{FED} \neq 0$).

Federal government also minimizes expenditures on good *i* by optimizing purchases of regionally produced and imported goods:

Minimize $PM0_i QFEDM_i + PR_i QFEDR_i$

subject to $QFED_i = \phi_i^{FED}\left(\delta_i^{FED} QFEDM_i^{\rho_i^{FED}} + \left(1-\delta_i^{FED}\right) QFEDR_i^{\rho_i^{FED}}\right)^{\frac{1}{\rho_i^{FED}}}$

Solving the first order condition yields:

$$(3.58)\quad \frac{QFEDR_i}{QFEDM_i} = \left[\left(\frac{1-\delta_i^{FED}}{\delta_i^{FED}}\right)\left(\frac{PM0_i}{PR_i}\right)\right]^{-\sigma_i^{FED}}$$

Savings and Investments

Total saving composed of household savings, depreciation and retained earnings, and savings from rest-of-world is defined as:

$$(3.59)\quad SAV = \sum_h HSAV_h + deprYAGK + retr(YENT) + ROWSAV0$$

where *YAGK* is agriculture capital income, *depr* is agricultural capital depreciation rate, *YENT* is enterprise income, *retr* is rate of depreciation and retained earnings from enterprise income, and *ROWSAV0* is exogenous savings from rest-of-world.

The capital expenditures include regional and imported investment demands. The investment demand substitution follows a CES function:

$$(3.60)\quad QINV_i = \phi_i^{INV}\left(\delta_i^{INV} QINVM_i^{\rho_i^{INV}} + \left(1-\delta_i^{INV}\right) QINVR_i^{\rho_i^{INV}}\right)^{\frac{1}{\rho_i^{INV}}}, \sigma_i^{INV} = \frac{1}{1-\rho_i^{INV}}, i \in M$$

where ϕ_i^{INV} = the investment efficiency parameter ($\phi_i^{INV} > 0$),

δ_i^{INV} = the share parameter ($0<\delta_i^{INV}<1$),
$QINVM_i$ = investment demand for imports,
$QINVR_i$ = investment demand for regional products,
σ_i^{INV} = elasticity of substitution, and
ρ_i^{INV} = the substitution parameter ($-1 < \rho_i^{INV} \neq 0$).

$QINV_i = QINV0_i$ is exogenously determined.

The levels of regional and imported investment goods depend on their price ratios and elasticities of substitution:

Minimize $PM0_i QINVM_i + PR_i QINVR_i$

subject to $QINV_i = \phi_i^{INV}\left(\delta_i^{INV} QINVM_i^{\rho_i^{INV}} + \left(1-\delta_i^{INV}\right)QINVR_i^{\rho_i^{INV}}\right)^{\frac{1}{\rho_i^{INV}}}$

Solving the first order condition yields:

$$(3.61)\quad \frac{QINVR_i}{QINVM_i} = \left[\left(\frac{1-\delta_i^{INV}}{\delta_i^{INV}}\right)\left(\frac{PM0_i}{PR_i}\right)\right]^{-\sigma_j^{INV}}$$

The sum of investment demand for each sector multiplied by its composite price is the total investment:

$$(3.62)\quad INV = \sum_i P_i QINV_i, \qquad i \in M$$

Prices

Composite labor price faced by industry is a weighted average of skilled labor wage rate. The weight used is the share of skilled labor categories required in each industry:

$$(3.63)\quad PLM_i = \frac{\sum_s PLS_s LD_{is}}{\sum_s LD_{is}} \qquad i \in M$$

To compute price of labor by household, note that $LSupHS_{hs}/LSupH_h$ is the share of skilled labor type s in the household h. These shares are used as weights to compute a weighted average price of skilled labor for each household type. In general, each household type has a different labor price because of different endowments of skilled labor. Thus the composite price of labor paid to household type h is:

$$(3.64)\quad PLH_h = \sum_s PLS_s \frac{LSupHS_{hs}}{LSupH_h}$$

Overall economy-wide aggregate wage rate is a weighted average of the skill specific wage rate. Note that $LDemS_s$ is demand for labor for type s by industry, $LDemS_s = \sum_i LD_{is}$, and $LExo0_s$ is exogenous demand for type s. Exogenous demand for labor is made up of demand for labor from government and high income households.

$$(3.65)\quad PL = \frac{\sum_s PLS_s (LDemS_s + LExo0_s)}{\sum_s (LDemS_s + LExo0_s)}$$

Net price for commodity i is calculated as follows:

$$(3.66)\quad PN_i = PR_i \sum_i a_{ji} P_j - ibtax_i PR_i \qquad i,j \in M,NM$$

where PR_i is regional price of sector i, a_{ji} is the usage of intermediate input sector j per unit of good i, P_j is composite price of sector j, $ibtax_i$ is indirect business tax of sector i.

Composite price of a commodity is a weighted average of regional and import prices:

(3.67) $P_i = \frac{PR_i R_i + PM0_i M_i}{R_i + M_i}$ $i \in M,NR$

Composite price of nonresident trips is the cost of intermediate inputs:

(3.68) $P_i = \frac{\sum_j P_j V_{ji}}{\sum_j V_{ji}}$ $i \in NE; j \in M$

Market Equilibrium

Domestic and composite prices adjust to clear all factor and commodity markets. Labor is imperfectly mobile responding to real wage differentials in a neoclassical migration model. In a "short run" version, capital is assumed to be sectorally fixed, and the final equilibrium will have sectorally differentiated rental rates. In a "long run" version, capital is mobile and average capital return adjusts to clear the regional capital market. Flow of factor returns to resources owned by migrating households is assumed to be carried out of the region by the households in the same proportion as the original factor endowments.

Commodity Markets

Commodity markets for market goods clear by equating regional outputs plus imports to total intermediate demands plus total final demands including exports.

(3.69) $X_i + M_i = TV_i + TQ_i + QSL_i + QFED_i + QINV_i + EXP_i$ $i \in M$

(3.70) $M_i = TVM_i + TQM_i + QSLM_i + QFEDM_i + QINVM_i$ $i \in M$

Equilibrium conditions for nonmarket goods are:

(3.71) $X_i + M_i = TQR_i + TQM_i \qquad i \in NR$

(3.72) $X_i = EXP_i \qquad i \in NE$

Labor

The labor market is in equilibrium when the quantity supplied equals the quantity demanded in each skill category.

(3.73) $LSupS_s + LMIG_s = LDemS_s + LExo0_s$

(3.74) $LExo0_s = LHHH0_s + LSL0_s + LFED0_s$,

where $LDemS_s$ is industry demand for labor of type s, $LExo0_s$ is exogenous demand for labor which is made up of $LHHH0_s$, $LSL0_s$ and $LFed0_s$ representing demand for labor from high income households, state/local government and federal government, respectively. Labor supply, $LSupS_s$, is as previously defined in equation (3.50).

Labor migration. Skilled labor migration is based on the difference between regional and out-of-region wage rate for the skill category:

(3.75) $LMIG_s = LSupS0_s \left(\dfrac{PLS_s}{PL_s^{ROC0}} \right)^{\eta_s^L}$

where $LSupS0_s$ is initial labor supply by skill, PL_s^{ROC0} is rest-of-world exogenous wage rate by skill, the η_s^L is labor migration elasticity of response by skill and $LSHS0_{hs}$ is initial labor supply by household and skill.

Labor migration by household is calculated from labor migration by skills. It is assumed that the share of household types for migrating labor of a certain skill level is the same as the existing labor supply in the region:

$$(3.76)\quad LMigH_h = \sum_s LMIG_s \frac{LSupHS_{hs}}{LSupS_s}$$

where $LSupHS_{hs}$ is labor supply by household and by skill type. $LSupHS_{hs}$ and $LSupS_s$ are as discussed previously.

Capital

When capital immobility is assumed, the capital market is in equilibrium when quantity demanded of capital from each industry equals the initial stock of capital in each industry. Capital migration is disallowed and capital prices in each industry adjust to equate supply and demand. Thus:

$$(3.77)\quad CAP_i = KS0_i$$

When capital mobility is assumed, the capital market is in equilibrium when total capital supply, which is the initial amount of capital plus capital migration, equals total capital demand:

$$(3.78)\quad KMIG + \sum_i KS0_i = \sum_i CAP_i$$

In addition, under capital mobility, the price paid for capital is assumed to be uniform across industries. In other words, there is only one capital price. This is enforced in the model by setting all nonagricultural capital price equal to agricultural capital price, thus:

(3.79) $PK_{nonag} = PK_{ag}$

Capital migration. The long run model is represented by allowing capital to migrate between sector and region. Capital migration is based on the difference between the regional and the out-of-region rental price of capital:

$$KMIG = \sum_i K0_i \left(\frac{PK}{PK^{ROC0}} \right)^{\eta^K} \qquad i \in M \tag{3.80}$$

where PK^{ROC0} is rest-of-world rent of capital, η^K is capital migration elasticity of response, PK is capital rent which is uniform across industries.

Land

The land market is in equilibrium when land use is equal to the initial quantity of land:

(3.81) $LAND_i = TS0_i$

Welfare Measure

The change in welfare in the region is measured by compensating variation (CV), and equivalent variation (EV) consistent with the linear expenditure demand system. The CV measure estimates in money terms the amount households would require as compensation to remain as well off after an exogenous shock as they are before the shock. The EV measure estimates in money terms the amount households would pay to avoid the shock. The CV measure is based on new prices and the EV measure is based on initial prices.

Compensating Variation

$$(3.82)\quad CV_h = \left(\frac{1}{1-\beta_{0h}}\right) *$$

$$\left[\left(HEXP_h - \sum_j P_j \gamma_{jh}\right) - \left(adjL_h HEXP0_h - \sum_j P0_j \gamma_{jh}\right) \prod_i \left(\frac{P_i}{P0_i}\right)^{\beta_{ih}} \left(\frac{PL}{PL0}\right)^{\beta_{0h}}\right],$$

$$i,j \in M,\ NR$$

$$(3.83)\quad TCV = \sum_h CV_h .$$

Equivalent Variation

$$(3.84)\quad EV_h = \left(\frac{1}{1-\beta_{0h}}\right) *$$

$$\left[\left(HEXP_h - \sum_j P_j \gamma_{jh}\right) \prod_i \left(\frac{P0_i}{P_i}\right)^{\beta_{ih}} \left(\frac{PL0}{PL}\right)^{\beta_{0h}} - \left(adjL_h HEXP0_h\right) - \sum_j P0_j \gamma_j\right],$$

$$i,j \in M,\ NR$$

$$(3.85)\quad TEV = \sum_h EV_h .$$

CHAPTER IV

DATA AND PROCEDURES

This chapter describes the data sources and procedures used for construction of the social accounting matrix (SAM). Also discussed are methods used in calibrating and solving the CGE model.

Data Sources

The main source of data for the SAM was obtained from micro IMPLAN (IMpact Analysis for PLANning) for 1991 originally developed by the USDA Forest Service (Olson, Lindall, and Maki, 1993).

The regional non-survey IMPLAN I/O model is derived from a national model. Regional Purchase Coefficients (RPCs) are used to determine local (domestic) content of purchased goods and services. An RPC represents the locally produced proportion of the amount of a good or service required to meet a particular industry's intermediate demands and final demands. By developing RPCs, gross regional trade flows (gross exports and imports) on commodities are estimated. For example, an RPC value of 0.8 for the commodity 'fish' means that 80 percent of the demand by fish processors, wholesalers, foreign exports, and all other demands for fish are met by local producers. The other 20 percent (1.0 - RPC) of the demand is imported (Olson, Lindall, and Maki, 1993, p.28).

This study uses the 1991 IMPLAN data base for Oklahoma. RPCs derived from a data set developed at Boston College are used (Olson, Lindall, and Maki, 1993). These RPCs (i.e., trade flow assumptions) replace the original values developed from the Jack Faucett study for "Non-shippable" commodities only. The non-shippable commodities are basically the service sectors and include IMPLAN sectors 433-528.[5]

Angler trip expenditure data for 1991 was supplied by the Sport Fishing Institute (Fedler and Nickum, 1994b). The data are based on the 1991 National Survey of Fishing, Hunting, and Wildlife Associated Recreation conducted by the U.S. Fish and Wildlife Service. Angler information was collected for three types of fishing: (1) freshwater, excluding Great Lakes; (2) Great Lakes; and (3) saltwater (Fedler and Nickum, 1994b). Oklahoma has only freshwater fishing. Micro-IMPLAN Recreation Economic Impact Estimation System (MI-REC) was used to bridge the trip expenditure data to the IMPLAN sectors. The MI-REC system (Stynes and Propst, 1992) consists of a set of utilities and customized procedures for estimating the economic impacts of recreation and tourism projects. MI-REC is designed to be used with Micro-IMPLAN. Other supporting data were collected from various secondary sources.

[5] IMPLAN NEWS, Issue No. 14 July, 1995

Production Sector Aggregation

The IMPLAN 528 sectors were aggregated into 38 industries corresponding to the Standard Industrial Classification (SIC) code. These are listed in Appendix Table B.1. The 38 industries follow industry aggregation of Regional Input-Output Modeling System (RIMS) II (USDC, 1992). To reduce the size of the model, this study further aggregated the 38 sectors into 14 sectors (Table 4.1). The IMPLAN sectors not included in the aggregation of production sectors are listed in Table 4.2.

TABLE 4.1

SECTOR AGGREGATION FOR PRODUCTION ACCOUNT

Production Account	RIMS Sector Number	IMPLAN Sector Number
1 Ag, forestry, fishery products and services	1-2	1-27
2 Mining (coal, misc, stone clay)	3,5,16	28-37,40-47,218,230-253
3 Crude petr, natural gas, petroleum refining	4,13	38-39,186-214
4 Construction	6-7	48-57
5 Food and kindred products and tobbaco	8	58-107
6 Textile mill products and apparel	9-10	108-132
7 Paper, allied products, printing, publishing	11-12	161-185
8 Other manufactures	14-15,17-24	133-160,215-217,219-229,254-432
9 Transportation, communication, utilility	25-27	433-446,513-514
10 Trade (wholesale, retail)	28-29	447-453,455
11 Finance, insurance, real estate	30-32	456-462
12 Hotels, lodging places & amusements	33	463,483-489
13 Eating & drinking places	36	454
14 Other services	34-35,37-38	464-482,490-515

Intermediate Demand

Aggregated regional interindustry transaction matrix in *Lister Report #402* shows the industry purchase of goods and services from local industries. The row sum of *interindustry transaction* is the locally produced regional intermediate demand by industry. The data sources for imported intermediate inputs demanded by regional industries are *Lister Report #112* (*Regional Competitive Import to Intermediate Demands*) and *Lister Report #109* (*Regional Non-competitive Imports to Intermediate Demands*). Total intermediate demand by industry is included in Table 4.5 (discussed later).

TABLE 4.2

IMPLAN DATABASE SECTORS NOT IN THE PRODUCTION ACCOUNT AGGREGATION*

Sector Description	IMPLAN Database Sector Number
Noncomparable Imports	516
Scrap	517
Used and Secondhand Goods	518
Federal Government	519-521
State and Local Government	522-523
Rest of World Industry	524
Households Industry-Low Income	525
Households Industry-Medium Income	526
Households Industry-High Income	527
Inventory Valuation Adjustment	528

*Adopted from Lee (1992, p.73)

Value Added

The value added in the SAM summarizes factor shares which are under 'industry' column headings and 'factor' row headings in the SAM. Factor account includes five labor skills, capital, and land. Labor skill categories were aggregated from 59 job lists compiled by the U.S. Bureau of the Census in Rose, et al., 1988 (Appendix Table B.2).

IMPLAN does not provide value added information consistent with most SAM accounts for factor use of labor, capital, and land. IMPLAN total value added *in Lister Report #404A* includes employee compensation, proprietary income, other property income, and indirect business taxes (Table 4.3). For this study, indirect business taxes were subtracted from total value added and entered into the SAM entries corresponding to the appropriate government rows and industry columns. This study distributed indirect business taxes to State/Local and Federal government across industry at the same proportion as the data reported in *IMPLAN SAM 1990*[6], i.e., 73.63 percent (State/Local) and 26.37 percent (Federal).

The remaining total value added were distributed to factor accounts. This study followed Koh (1991) who adopted the USDA/ERS CGE model for agricultural sector factor shares developed by Robinson, Kilkenny, and Hanson (1990). These factor share distributions for agriculture are 23.94 percent for labor, 33.94 percent for capital and, 42.12 percent for land.

Non-agricultural sector factor shares are treated differently. Employee compensation was all attributed to labor. Other property income was all attributed to capital. Proprietary income was divided between payments to labor and payments to capital. The 1990 SAM generated by IMPLAN provides a detailed breakdown of value added and this was used to conclude that payment to labor and capital from proprietary income was, respectively, 31.4 percent and 69.6 percent.

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[6] IMPLAN SAM 1990 is generated by combining Oklahoma 1990 SAM data and Oklahoma 1990 IMPLAN database.

Labor income in each sector was distributed to five skill levels. Appendix Table B.3. bridges the sector industries defined by RIMS II and Rose, et al. A wage and salary matrix for 1982 by 59 job classifications and 41 industries is presented by Rose, et al. (1988, Table 5.1, p.49-54, reproduced in this study as Appendix Table B.4). The wage/salary income data was used to produce labor income allocation by industry and labor skill classified in this study (Appendix Table B.5).

TABLE 4.3

REGIONAL FINAL PAYMENTS TO FACTORS IN OKLAHOMA, 1991

INDUSTRY	Employee Compen-sation ($M)	Indirect Business Tax ($M)	Proprietary Income ($M)	Other Property Income ($M)	Total Value Added ($M)
1 Ag, forestry, fishery products and services	239.415	71.740	832.561	73.537	1217.252
2 Mining (coal, misc, stone clay)	367.012	14.669	24.325	990.852	1396.859
3 Crude petr, natural gas, petroleum refining	1481.438	4199.412	75.837	5857.123	11613.809
4 Construction	1710.747	11.116	619.864	398.134	2739.860
5 Food and kindred products and tobbaco	375.115	5.725	3.286	315.697	699.824
6 Textile mill products and apparel	118.242	1.314	-0.217	43.286	162.625
7 Paper, allied products, printing, publishing	400.544	7.108	25.591	391.294	824.537
8 Other manufactures	3503.309	108.832	153.372	1861.513	5627.025
9 Transportation, communication, utilility	2651.327	370.816	245.402	2295.351	5562.895
10 Trade (wholesale, retail)	3992.322	1478.676	615.277	655.880	6742.155
11 Finance, insurance, real estate	1537.948	1494.240	90.874	4773.972	7897.034
12 Hotels, lodging places & amusements	281.940	96.083	97.514	69.991	545.528
13 Eating & drinking places	723.538	128.029	49.495	163.968	1065.029
14 Other services	5600.673	88.947	1874.839	1153.619	8718.078
Total	*22983.570*	*8076.705*	*4708.020*	*19044.216*	*54812.510*

Employee Compensation: Total payroll costs (wages and salaries and benefits) paid by local industries.

Indirect Business Taxes: Sales, excise and other taxes paid during normal operation of industry. This does not include taxes paid based on net income

Proprietary Income: Income from self employment.

Other Property Income: Includes corporate income, rental income, interest, and corporate transfer payments.

Total Value Added: The value added to intermediate cost of goods and services. The sum of the above four factors.

Employment: Number of jobs (annual average) required by a given industry - includes self employed.

Labor Employed by Households

IMPLAN shows that households themselves employ labor. Such labor is usually services provided by lower income households to higher income households. Modification was made to IMPLAN results by allocating all such labor to high income households. The labor employed by high income households was classified as labor skill 3 (service occupations).

Labor Employed by Governments

Labor employed by State/Local government, and Federal government was distributed to five labor skills. The distribution follows sector "Public Administration" in wage/salary income distribution matrix in Appendix Table B.4.

Regional Consumption Demand

Regionally Produced Commodity Demand

Regional consumption demand is reported in *Lister Report #403A* (Table 4.4). The report includes household personal consumption and government consumption. Households are classified as low, medium, and high income households with 1991 yearly income of under $20,000, $20,000 to $40,000, and over $40,000, respectively. State/Local and Federal form the government accounts.

TABLE 4.4

REGIONAL CONSUMPTION DEMAND BY INDUSTRY
IN OKLAHOMA, 1991 ($M)

INDUSTRY	Household Personal Consumption			Government				
				Federal			State/Local	
	Low	Medium	High	Pur/Non-Mil	Pur/Mil	CCC	Pur/Non-Ed	Pur-Ed
1 Ag, forestry, fishery products and servic	74.124	86.422	44.299	0.096	0.511	0.000	9.990	5.809
2 Mining (coal, misc, stone clay)	4.650	16.679	12.045	0.001	0.049	0.000	2.771	1.450
3 Crude petr, natural gas, petroleum refini	297.772	570.728	263.871	0.012	199.304	0.000	35.995	53.947
4 Construction	0.000	0.000	0.000	5.027	343.333	0.000	936.686	224.127
5 Food and kindred products and tobbaco	224.183	364.023	149.423	0.038	1.832	0.000	8.724	26.057
6 Textile mill products and apparel	89.534	155.074	93.184	0.000	0.328	0.000	4.863	0.567
7 Paper, allied products, printing, publishi	32.302	48.883	22.192	0.032	0.102	0.000	8.027	13.135
8 Other manufactures	141.082	290.864	151.004	0.831	50.081	0.000	46.502	33.382
9 Transportation, communication, utilility	818.913	987.983	531.062	0.500	105.667	0.000	119.894	101.643
10 Trade (wholesale, retail)	1391.417	2414.943	1224.045	0.119	12.872	0.000	36.695	32.086
11 Finance, insurance, real estate	1641.975	2574.428	1214.218	0.267	0.326	0.000	98.642	9.771
12 Hotels, lodging places & amusements	138.623	250.123	147.447	0.014	0.204	0.000	9.779	6.077
13 Eating & drinking places	533.944	655.469	331.735	0.000	13.542	0.000	21.121	0.580
14 Other services	2830.767	3614.157	2030.851	10.237	255.510	0.000	182.975	133.374
Total	*8219.284*	*12029.776*	*6215.377*	*17.172*	*983.661*	*0.000*	*1522.663*	*642.003*

Household Personal Consumption: Purchase of commodities by individuals for personal use by low, medium and high income households.
Pur/Non-Mil: Purchase of commodities by Federal agencies other than defense agencies.
Pur/Mil: Purchase of commodities by Federal defense agencies.
CCC: Net purchase or sales (negative numbers) by Federal Commodity Credit Corporation
Pur/Non-ed: Purchase of commodities by non-educational state and local government agencies.
Pur/Ed: Purchase of commodities by educational state and local government agencies.

Aggregation Lister Report #403B contains regional investment and trade demand (Table 4.5). Investment demand is the summation of inventory additions and capital formation. Domestic and foreign exports by industry are the commodity exports outside the region. It also includes total regional final demand for each industry.

Imported Commodity Demand

Domestic and foreign imports are generated from *IMPLAN Lister Report #113A: Regional Competitive Imports to Consumption Demand and Lister Report #110A: Regional Non-competitive Imports to Consumption Demand.* The reports differentiate household and government consumption for each commodity. *IMPLAN Lister Report #110B and 113B* presents regional non-competitive and regional competitive imports, respectively, for investment and trade demand. Imported investment demand is the summation of inventory additions and capital formation. Import summary is reported in *IMPLAN Lister Report # 404B* (Table 4.6).

TABLE 4.5

REGIONAL INVESTMENT AND TRADE DEMAND IN OKLAHOMA, 1991 ($M)

INDUSTRY	Investment		Trade		Total		
	Inventory Additions	Capital Formation	Domestic Exports	Foreign Exports	Intermediate Demand	Final Demand	Commodity Output
1 Ag, forestry, fishery products and services	3.024	0.534	2401.585	764.828	1290.077	3391.222	4681.299
2 Mining (coal, misc, stone clay)	0.137	3.620	1903.251	52.306	245.901	1996.956	2242.858
3 Crude petr, natural gas, petroleum refining	4.041	7.890	18571.401	263.111	2158.322	20268.069	22426.392
4 Construction	0.000	3591.834	65.896	0.000	3917.752	5166.903	9084.656
5 Food and kindred products and tobbaco	1.816	0.033	1965.423	120.695	344.048	2862.245	3206.293
6 Textile mill products and apparel	0.699	0.129	77.668	7.068	71.093	429.114	500.207
7 Paper, allied products, printing, publishing	0.112	0.579	1393.128	42.528	503.049	1561.020	2064.068
8 Other manufactures	13.744	1238.543	7142.624	3141.587	1735.928	12250.244	13986.172
9 Transportation, communication, utilility	0.842	63.670	3324.044	663.810	3403.290	6718.029	10121.319
10 Trade (wholesale, retail)	0.000	228.859	405.737	601.747	1722.057	6348.519	8070.574
11 Finance, insurance, real estate	0.000	35.302	1969.096	267.209	2341.437	7811.233	10152.671
12 Hotels, lodging places & amusements	0.000	0.073	58.014	24.275	153.437	634.626	788.063
13 Eating & drinking places	0.000	0.000	163.326	3.299	405.065	1723.015	2128.080
14 Other services	0.094	22.053	2432.568	190.013	4205.829	11702.599	15908.429
Total	*24.508*	*5193.120*	*41873.759*	*6142.476*	*22497.283*	*82863.795*	*105361.081*

Investment - Inventory Additions: Net addition (purchase) to inventory.
Investment - Capital Formation: Commodity purchases by private industry and households for capital formation.
Trade - Domestic Exports: Commodity export from the region to the rest of the US.
Trade - Foreign Exports: Commodity export from the region to the rest of the world (outside of the US).
Intermediate demand: Sum of industry purchase of goods and services.
Total Final Demand: Sum of all purchases for final use or consumption.
Commodity Output: Sum of commodities produced in the region.

Institutional Income

Factor Income

The row-sum of value added matrix plus the value of labor employed by households and governments are the row and column control totals for factor income. Factor income was then adjusted for taxes, capital depreciation, and retained earnings before allocation to households. Information from the USDA/ERS CGE model for the U.S. (Robinson, et al, 1990), and Koh (1991) was used to establish employee social security tax rates for the Oklahoma SAM. This study applied a 13.40 percent social security tax rate to labor compensation. The capital tax rate of 13.30 percent was adopted from the USDA/ERS model. Land tax was taken as 15.98 percent. The rate of depreciation and retained earning, also from the USDA/ERS model, was equal to 38.5 percent.

TABLE 4.6

REGIONAL TRADE FINAL PAYMENT IN OKLAHOMA, 1991 ($M)

INDUSTRY	Competitive Imports	Non-competitive Imports	Total Domestic Imports	Foreign Imports	Total Imports	Total Domestic Final Payment	Total Final Payment	Total Industry Outlays
1 Ag, forestry, fishery products and services	1397.282	0.132	1371.765	25.649	1397.414	2589.017	2614.666	4681.299
2 Mining (coal, misc, stone clay)	527.258	0.973	474.641	53.590	528.231	1871.500	1925.090	2242.858
3 Crude petr, natural gas, petroleum refining	7594.522	0.883	893.293	6702.113	7595.405	12507.098	19209.217	22426.392
4 Construction .	3277.183	3.438	3103.977	176.643	3280.620	5843.838	6020.481	9084.656
5 Food and kindred products and tobbaco	1183.719	33.870	1134.208	83.380	1217.589	1834.032	1917.413	3206.293
6 Textile mill products and apparel	251.093	0.535	227.529	24.099	251.628	390.154	414.252	500.207
7 Paper, allied products, printing, publishing	838.010	0.315	759.524	78.801	838.325	1584.061	1662.862	2064.068
8 Other manufactures	5305.900	33.468	4489.217	850.150	5339.367	10116.243	10966.392	13986.173
9 Transportation, communication, utilility	2283.758	97.218	1108.260	1272.715	2380.975	6671.155	7943.870	10121.319
10 Trade (wholesale, retail)	440.004	1.741	430.585	11.161	441.745	7172.739	7183.900	8070.574
11 Finance, insurance, real estate	834.149	8.515	828.575	14.088	842.663	8725.609	8739.697	10152.671
12 Hotels, lodging places & amusements	94.880	0.851	94.054	1.676	95.730	639.583	641.258	788.063
13 Eating & drinking places	506.478	8.614	456.942	58.150	515.092	1521.971	1580.121	2128.080
14 Other services	2853.351	26.631	2696.186	183.796	2879.981	11414.264	11598.059	15908.430
Total	*27387.586*	*217.181*	*18068.757*	*9536.010*	*27604.765*	*72881.262*	*82417.279*	*105361.083*

Competitive Imports: Total for all commodities imported which are also locally produced by each industry sector.

Non-Competitive Imports: Total of commodities imported which are not locally produced by each industry sector.

Total Domestic Imports: Total of commodities imported from the rest of the United States by industry.

Foreign Imports: Total of commodities imported from the rest of the world outside of the US by industry.

Total Imports: All imports of commodities, foreign and domestic by industry.

Total Domestic Final Payments: Sum of value added and total domestic imports -i.e., payments other than for intermediate goods and services and foreign imports.

Total Final Payments; All payments by each industry other than for local intermediate goods and services. The sum of total value added and total imports.

Labor, agricultural capital, and land returns after tax were distributed directly to households as factor income. Total labor income is the sum of the product of quantity of household labor supplied by skill and the price of labor by skill. An aggregate wage rate paid to households by income class differs because skill endowments by household income class size vary. The distribution of labor income to low, medium, and high income households is the same as the distribution of employee compensation to three income household classes presented in IMPLAN 1990 SAM.

Agricultural capital returns and land returns were equally distributed by household income class size following the study by Lee (1993), i.e., 3 percent, 45 percent, and 52 percent, respectively, to low, medium, and high income households.

Enterprise income equals non-agricultural capital returns net of capital tax. The proportion of enterprise income distributed to households and the rate of enterprise depreciation and retained earnings are the same as in IMPLAN 1990 SAM.

Government Transfers

Regional Economic Information System (REIS), Bureau of Economic Analysis (BEA) reports the dollar amount of total government transfers by source (State/Local government and Federal government) for Oklahoma (USDC, 1991c). Total transfers of $9,433,541,000 in 1991 were allocated to low, medium, and high income households in the same proportions as reported by IMPLAN 1990 SAM.

Total Household Income

REIS, BEA provides total personal household income for Oklahoma. The total of $49,530,955,000 in 1991 was used as a control total. Utilizing data from Consumer Expenditure Survey (CES) 1990-91, a control total for each household income class size was estimated. Table 4.7 shows the adjusted total household income by income class size (in millions of dollars) , i.e., $9,837; $23,829; and $15,865 for low, medium, and high household income class size, respectively.

TABLE 4.7

ADJUSTED HOUSEHOLD TOTAL INCOME BY INCOME CLASS SIZE, 1991

		Household Income Class Size			
Item	Unit	Low	Medium	High	Total
Income before taxes (I)	Avg/consumer ($)	10,087	28,937	67,251	30,649
Annual expenditures (E)	Avg/consumer ($)	16,001	27,592	49,908	27,883
Ratio (E/I) or (r)	Percent	159	95	74	91
Total consumption (this study) (c)	Million $	13,345	19,432	10,069	42,846
Adjusted total income (c/r)	Million $	8,413	20,379	13,568	42,360
Total income adjustment (this study)	Million $	9,837	23,829	15,865	49,531

Source: Consumer Expenditure Survey, 1990-91, US Dept of Labor 1993, IMPLAN 1991, and REIS, BEA 1994

To balance the SAM, remittances, household saving, government borrowing and ROW saving were calculated as residuals.

Angler Trip Expenditure

Sport Fishing Institute Trip Expenditure Data

The information collected in the National Survey of Fishing, Hunting and Wildlife Associated Recreation focused on the participation, characteristics and expenditures of U.S. residents 16 years of age and older. Unlike the previous surveys completed in 1980 and 1985 where anglers were contacted once at the end of year, anglers in 1991 were contacted three times over the course of the year. Respondents were asked to provide fishing participation and expenditure information (Fedler and Nickum, 1994).

The National Survey estimated that 803,700 US anglers fished in Oklahoma during 1991, with 10,790,000 angler trips, and 12,079,000 angler days. Among the anglers, 623,300 were state residents with 9,410,900 trips, and 10,394,000 days (Table 4.8). An additional 180,400 anglers were nonresidents with 1,379,000 trips and 1,686,000 days of fishing. Table 4.9 shows the expenditure profiles of resident trips (in-state and out-of-state) and nonresident trips. The 1991 total angler expenditures of $387,326,000 in Oklahoma are distributed as *trip related*, *equipment*, and *other*; and equaled $196,226,000, $59,506,000, and $131,594,000, respectively (Table 4.10). Appendix Table B.6 presents the corresponding expenditure items as in Table 4.10 but classified as RIMS II sectors.

TABLE 4.8

RESIDENT AND NONRESIDENT ANGLERS AND TRIPS IN OKLAHOMA, 1991

Description	Unit	Resident	Nonresident	Total
Total anglers	1000 anglers	623.3	180.4	803.7
Total trips				
In-state	1000 trips	9410.9	1379.0	10789.9
Out-of-state	1000 trips	368.7	NA	368.7
Total days of fishing	1000 days	10394.0	1686.0	12080.0
Days per trip	number	1.10	1.22	1.12

Source: USDC, 1991 National Survey of Fishing, Hunting, and Wildlife Associated Recreation: Oklahoma

TABLE 4.9

RESIDENT AND NONRESIDENT TRIP EXPENDITURE PROFILES
IN OKLAHOMA, 1991

Item	Resident				Nonresident	
	In-State		Out-of-State			
	($1,000)	(%)	($1,000)	(%)	($1,000)	(%)
Trip Related Expenditure						
Food and lodging	69,314.83	43.09	23,064.87	47.84	14,560.66	41.16
Transportation	44,063.05	27.39	12,897.05	26.75	14,051.52	39.73
Privilage and other fees	3,130.85	1.95	6,546.05	13.58	952.65	2.69
Boat etc	26,650.34	16.57	4,200.86	8.71	4,163.21	11.77
Bait	13,910.97	8.65	959.43	1.99	1,072.92	3.03
Ice	3,784.03	2.35	546.47	1.13	570.77	1.61

MI-REC Recreation Economic Impact Estimation System

The MI-REC system has been developed in conjunction with efforts to evaluate economic impacts associated with water-based recreation. Expenditures by visitors to recreation resources can be used to estimate the economic impacts of recreation or tourism. Before visitor spending profiles can be used in Micro-IMPLAN, they must be "bridged" to the economic sectors in the model. This "bridging" process requires average expenditures for each item to be proportioned among production, transportation and trade sectors through the use of the Personal Consumption Expenditure (PCE) data. This proportioning results in a "bridge table" whose rows are the economic sectors contained in the Micro-IMPLAN model and whose columns are expenditure categories (Stynes and Propst, 1992). Appendix Table B.6 is the "bridge table" which is aggregated to the RIMS II 38 sectors.

TABLE 4.10

ANGLER TRIP AND EQUIPMENT EXPENDITURES FOR 1991 IN OKLAHOMA

INDUSTRY	EXPENDITURES ($1,000)
TRIP RELATED EXPENDITURES	*196,226*
Food & drink	71,614
Lodging	12,224
Public transportation	2,789
Private transportation	55,352
Boat fuel	15,502
Guide fees	430
Package fees	718
Public land use fees	1,361
Private land use fees	568
Boat launching fees	371
Boat storage, repair	14,934
Equipment rental	1,008
Bait	15,001
Ice	4,354
EQUIPMENT EXPENDITURES	*59,506*
Rods, poles, components	14,465
Reels	11,833
Lines	5,321
Artificial lures	13,912
Leaders, hooks, sinkers	4,834
Tackle boxes	1,387
Creels, stringer, nets	1,066
Minnow traps, seines	605
Electronic devices	4,980
Ice fishing equipment	0
Spear fishing equipment	96
Other purchases	1,007
OTHER EXPENDITURES	*131,594*
Camping equipment	6,161
Binoculars	95
Special clothing	2,923
Processing, taxidermy	1,781
Magazines	1,999
Contributions to org.	1,780
Other purchases	1,885
Bass boat	38,433
Other motor boat	21,495
Non-motor boat	635
Motors, boat accessories	9,418
Pickup, camper, trailer	35,467
Cabin	0
Trail bike, snowmobile	0
Other (ice chest)	430
Land leasing	1,579
Fishing licenses	7,513
Special licenses, fees	0
TOTAL	*387,326*

Source: Feedler, A.J. and D.M. Nickum. 1994. The 1991 Economic Impact of Sport Fishing in Oklahoma. Sport Fishing Institute, Washington, D.C.

Bridging Sport Fishing Expenditure to MI-REC

Sport fishing expenditure and MI-REC bridge table (Appendix Table B.8) are constructed based on the expenditure data (Appendix Table B.6) and IMPLAN bridge table (Appendix Table B.7). The expenditures were distributed across 38 sectors.

Incorporating Sport Fishing Expenditures into Oklahoma SAM

Sector allocation of trip related expenditures by Oklahoma resident and nonresident anglers is presented in Table 4.11. Oklahoma residents spent $160,854 thousand in-state and $48,038 thousand out-of-state. The trip related expenditures for nonresidents of Oklahoma were $35,372 thousand. The total sport fishing expenditures, which include trip related, equipment, and other expenditures, made in Oklahoma by resident and nonresident anglers is presented in Appendix Table B.9. Out of the total expenditures of $387,326 thousand, residents of Oklahoma spent $321,990 thousand, while nonresidents of Oklahoma spent $65,336 thousand.

TABLE 4.11

OKLAHOMA RESIDENT AND NONRESIDENT TRIP RELATED EXPENDITURES BY INDUSTRY, 1991

Industry	Total Trip Related Expenditures ($1,000)			
	Resident		Non-resident	Total Spending in Oklahoma
	In-State (a)	Out-of-State (b)	(c)	(a)+(c)
1 Ag, forestry, fishery products and services	2476.932	616.056	416.694	2893.627
2 Mining (coal, misc, stone clay)	6.479	1.888	2.066	8.545
3 Crude petr, natural gas, petroleum refining	32023.275	8133.257	8763.371	40786.646
4 Construction	0.000	0.000	0.000	0.000
5 Food and kindred products and tobbaco	27166.682	8345.053	5457.619	32624.300
6 Textile mill products and apparel	3.665	1.068	1.169	4.834
7 Paper, allied products, printing, publishing	0.000	0.000	0.000	0.000
8 Other manufactures	8034.370	1470.499	1511.519	9545.889
9 Transportation, communication, utilility	11608.962	2831.443	2415.644	14024.606
10 Trade (wholesale, retail)	43252.568	9704.225	8462.920	51715.488
11 Finance, insurance, real estate	0.000	0.000	0.000	0.000
12 Hotels, lodging places & amusements	13443.826	9527.665	3082.850	16526.676
13 Eating & drinking places	18599.564	6171.367	3907.127	22506.691
14 Other services	4237.482	1234.978	1351.216	5588.697
Total	*160853.805*	*48037.500*	*35372.195*	*196226.000*

The information about trip spending by household income level is extracted from sport fishing survey data. Only anglers responding to the income question when interviewed were considered in aggregating trip expenditures by income classes. Because the allocation of sport fishing expenditures were based on the trip related expenditures only, the equipment and other expenditures were treated in the same way. The survey results show that expenditures were 24.41 percent, 36.24 percent, and 39.35 percent made by low, medium, and high income households, respectively. The study by Lee (1993) in McCurtain County showed 23.35 percent, 38.15 percent, and 38.50 percent of trip expenditures, respectively, made by low, medium, and high income households.

The sport fishing expenditures by sector form the intermediate inputs in the sport fishing production function. The total expenditures form the demand for the nonmarket good of sport fishing trips by household group. In the SAM, sport fishing is treated as additional producing sectors of nonmarket goods but with market good input expenditures. The addition of nonmarket sport fishing expenditures, i.e., resident trip, and nonresident trip, increased the total number of sectors in the model to 16 sectors.

Oklahoma SAM

The Oklahoma SAM summarizes the performance and structure of the state's economy in 1991 (Table 4.12). The entry in each cell is in terms of 1991 millions of dollars.

TABLE 4.12

OKLAHOMA SOCIAL ACCOUNTING MATRIX, 1991 ($MILLION)

EXPENDITURES \ RECEIPTS	INDUSTRY 1	2	3	4	5	6	7	8	9	10	11	12	13
INDUSTRY													
1 Ag, forestry, fishery products and services	745.9	0.4	0.2	31.6	402.2	2.5	0.4	3.1	5.2	2.0	46.1	5.4	10.3
2 Mining (coal, misc, stone clay)	1.6	70.9	11.7	50.0	30.3	0.1	2.2	38.9	15.3	0.2	0.3	0.3	4.8
3 Crude petr, natural gas, petroleum refining	221.8	47.7	160.9	529.3	56.5	4.0	62.3	211.9	561.8	35.8	7.9	2.0	6.3
4 Construction	48.0	5.3	2927.9	8.0	7.8	0.5	3.1	60.3	107.7	15.0	277.2	2.9	6.1
5 Food and kindred products and tobbaco	47.1	0.0	0.8	0.1	151.8	0.0	0.1	0.6	2.5	0.0	0.0	1.9	105.3
6 Textile mill products and apparel	1.0	0.1	0.0	4.4	0.2	33.3	0.3	20.2	0.9	0.3	0.2	0.6	0.1
7 Paper, allied products, printing, publishing	2.6	12.6	7.2	3.8	95.9	3.8	40.8	103.8	28.2	60.1	22.7	10.3	18.1
8 Other manufactures	33.6	11.7	9.0	477.9	31.6	2.1	22.4	860.4	68.7	9.9	7.1	2.2	3.9
9 Transportation, communication, utilility	203.9	96.5	36.4	394.5	212.7	12.4	105.0	530.3	641.4	194.7	121.9	27.2	80.5
10 Trade (wholesale, retail)	131.9	18.2	11.8	495.8	140.1	8.4	44.6	536.2	72.7	14.8	6.3	1.7	57.1
11 Finance, insurance, real estate	393.4	17.2	20.9	138.5	31.6	5.7	22.4	133.3	184.3	155.4	487.1	19.9	77.8
12 Hotels, lodging places & amusements	8.1	0.8	0.3	6.7	3.2	0.2	2.9	17.0	48.0	7.0	5.0	21.2	2.9
13 Eating & drinking places	2.3	2.9	1.5	27.3	9.0	1.9	10.5	47.4	83.5	57.1	46.6	3.8	9.6
14 Other services	196.0	29.3	26.4	782.5	102.5	9.9	74.6	394.3	314.7	312.0	343.9	44.6	159.2
15 Resident trip													
16 Nonresident trip													
Total	2037.3	313.8	3215.0	2950.4	1275.2	84.8	391.7	2957.6	2134.9	864.2	1372.2	143.9	542.2
FACTORS													
Labor													
1.Mgmt/Professional	51.6	84.7	360.1	303.4	70.5	13.2	113.4	924.2	533.8	906.1	594.0	183.8	325.7
2.Tech/Sales/Adm Support	20.7	40.9	273.5	155.4	61.7	13.9	105.3	589.7	771.4	2095.8	911.0	47.1	67.9
3.Services	5.0	3.1	21.2	8.3	8.5	1.0	3.7	39.7	44.0	53.1	30.1	43.1	322.1
4.Farm/Forest/Fish	173.2	0.1	0.4	1.2	0.2	0.0	0.1	4.3	0.9	2.0	2.2	6.3	0.1
5.Prod/Craft/Repairs	23.7	245.9	850.0	1437.2	235.3	90.0	186.1	1993.6	1378.3	1128.5	29.2	32.3	23.2
Subtotal	*274.2*	*374.7*	*1505.3*	*1905.4*	*376.1*	*118.2*	*408.6*	*3551.5*	*2728.4*	*4185.6*	*1566.5*	*312.6*	*739.1*
Capital	388.8	1007.5	5909.1	823.3	318.0	43.1	408.8	1966.7	2463.7	1077.9	4836.3	136.9	197.9
Land	482.5												
Total	*1145.5*	*1382.2*	*7414.4*	*2728.7*	*694.1*	*161.3*	*817.4*	*5518.2*	*5192.1*	*5263.5*	*6402.8*	*449.4*	*937.0*

TABLE 4.12 (Continued)

OKLAHOMA SOCIAL ACCOUNTING MATRIX, 1991 ($MILLION)

EXPENDITURES \ RECEIPTS	INDUSTRY 1	2	3	4	5	6	7	8	9	10	11	12	13
INSTITUTION													
Enterprise													
Household													
Low													
Med													
High													
Subtotal													
Government													
St&Loc	52.8	10.8	3092.0	8.2	4.2	1.0	5.2	80.1	273.0	1088.7	1100.2	70.7	94.3
Fed	18.9	3.9	1107.4	2.9	1.5	0.3	1.9	28.7	97.8	389.9	394.0	25.3	33.8
Subtotal	*71.7*	*14.7*	*4199.4*	*11.1*	*5.7*	*1.3*	*7.1*	*108.8*	*370.8*	*1478.7*	*1494.2*	*96.1*	*128.0*
Total	*71.7*	*14.7*	*4199.4*	*11.1*	*5.7*	*1.3*	*7.1*	*108.8*	*370.8*	*1478.7*	*1494.2*	*96.1*	*128.0*
CAPITAL													
ROW													
1 Ag, forestry, fishery products and services	499.3	0.1	0.7	20.7	281.0	4.8	0.7	7.9	1.4	1.5	32.8	3.9	6.8
2 Mining (coal, misc, stone clay)	10.3	360.9	91.5	642.1	17.6	0.2	11.8	205.6	162.8	1.0	0.1	0.1	0.4
3 Crude petr, natural gas, petroleum refining	180.1	58.6	6639.6	571.4	71.4	24.4	47.5	616.0	1206.4	1.4	1.3	1.4	2.9
4 Construction	7.2	0.8	793.1	0.8	1.2	0.1	0.5	9.1	17.2	2.3	48.4	0.4	0.9
5 Food and kindred products and tobbaco	147.1	0.0	1.5	0.1	344.7	0.0	1.4	0.5	14.9	4.0	0.0	2.6	282.6
6 Textile mill products and apparel	9.3	0.4	0.3	25.3	2.9	191.4	29.8	128.7	1.9	0.7	1.6	1.7	0.2
7 Paper, allied products, printing, publishing	12.8	13.6	7.9	27.5	128.8	1.9	585.0	60.1	30.5	65.5	51.4	2.5	19.8
8 Other manufactures	105.6	37.5	21.6	1456.1	169.0	13.9	61.7	3701.8	176.0	24.0	21.4	7.0	32.9
9 Transportation, communication, utilility	61.2	25.7	9.6	168.2	56.6	3.2	36.5	170.7	382.0	58.7	58.5	7.0	22.0
10 Trade (wholesale, retail)	37.1	5.2	3.3	121.7	40.8	2.4	12.6	153.5	22.3	4.1	1.8	0.5	16.5
11 Finance, insurance, real estate	298.2	12.1	16.5	94.8	21.0	3.7	15.9	87.1	150.2	123.4	451.1	15.7	56.5
12 Hotels, lodging places & amusements	3.0	0.7	0.2	7.2	2.1	0.1	2.8	16.5	84.7	5.0	4.3	28.3	6.4
13 Eating & drinking places	0.3	0.4	0.2	4.1	1.3	0.3	1.5	6.7	13.9	8.5	7.1	0.6	1.4
14 Other services	55.2	16.2	11.5	254.5	92.7	6.5	40.0	237.1	159.4	164.0	203.5	26.7	71.5
15 Resident trip													
16 Nonresident trip													
Total	*1426.7*	*532.2*	*7597.6*	*3394.4*	*1231.2*	*252.8*	*847.9*	*5401.5*	*2423.5*	*464.2*	*883.4*	*98.6*	*520.8*
GRAND TOTAL	4681.3	2242.9	22426.4	9084.7	3206.3	500.2	2064.1	13986.2	10121.3	8070.6	10152.7	788.1	2128.1

TABLE 4.12 (Continued)

OKLAHOMA SOCIAL ACCOUNTING MATRIX, 1991 ($MILLION)

EXPENDITURES \ RECEIPTS	Industry				FACTOR								
	14	15	16	*Total*	Labor						Capital	Land	*Total*
					1	2	3	4	5	*Subtotal*			
INDUSTRY													
1 Ag, forestry, fishery products and services	34.8	1.6	0.3	***1292.0***									
2 Mining (coal, misc, stone clay)	19.4	0.0	0.0	***245.9***									
3 Crude petr, natural gas, petroleum refining	250.1	16.1	4.4	***2178.8***									
4 Construction	447.9	0.0	0.0	***3917.8***									
5 Food and kindred products and tobbaco	33.8	6.0	1.2	***351.2***									
6 Textile mill products and apparel	9.5	0.0	0.0	***71.1***									
7 Paper, allied products, printing, publishing	93.1	0.0	0.0	***503.0***									
8 Other manufactures	195.5	0.7	0.1	***1736.7***									
9 Transportation, communication, utilility	745.8	6.6	1.4	***3411.3***									
10 Trade (wholesale, retail)	182.5	37.7	7.3	***1767.1***									
11 Finance, insurance, real estate	653.8	0.0	0.0	***2341.4***									
12 Hotels, lodging places & amusements	30.1	6.9	1.6	***162.0***									
13 Eating & drinking places	101.7	16.3	3.4	***424.8***									
14 Other services	1415.8	3.3	1.1	***4210.2***									
15 Resident trip													
16 Nonresident trip													
Total	4213.9	95.2	20.8	***22613.2***									
FACTORS													
Labor													
1.Mgmt/Professional	3222.1			***7686.6***									
2.Tech/Sales/Adm Support	1227.9			***6382.2***									
3.Services	745.6			***1328.5***									
4.Farm/Forest/Fish	8.4			***199.4***									
5.Prod/Craft/Repairs	985.5			***8638.8***									
Subtotal	*6189.5*			***24235.5***									
Capital	2439.6			***22017.8***									
Land				***482.5***									
Total	*8629.1*			***46735.8***									

TABLE 4.12. (Continued)

OKLAHOMA SOCIAL ACCOUNTING MATRIX, 1991 ($MILLION)

EXPENDITURES \ RECEIPTS	Industry				FACTOR								
	14	15	16	*Total*	Labor						Capital	Land	*Total*
					1	2	3	4	5	*Subtotal*			
INSTITUTION													
Enterprise											*21651.7*		*21651.7*
Household													
Low					855.8	669.0	236.5	18.6	764.3	*2544.2*	6.0	12.9	*2563.2*
Med					2650.1	2071.7	732.2	57.5	2366.7	*7878.3*	84.3	182.3	*8144.9*
High					5340.2	4174.6	1475.4	115.9	4769.1	*15875.2*	97.1	210.1	*16182.5*
Subtotal					*8846.1*	*6915.3*	*2444.1*	*192.1*	*7900.1*	*26297.7*	*187.4*	*405.4*	*26890.5*
Government													
St&Loc	65.5			*5946.8*	220.6	172.5	61.0	4.8	197.0	*655.9*	9.8	26.1	*691.9*
Fed	23.5			*2129.9*	1148.2	897.6	317.2	24.9	1025.4	*3413.2*	19.1	51.0	*3483.4*
Subtotal	*88.9*			*8076.7*	*1368.8*	*1070.0*	*378.2*	*29.7*	*1222.4*	*4069.2*	*29.0*	*77.1*	*4175.2*
Total	*88.9*			*8076.7*	*10214.9*	*7985.4*	*2822.3*	*221.8*	*9122.6*	*30366.9*	*21868.1*	*482.5*	*52717.5*
CAPITAL											149.7		*149.7*
ROW													
1 Ag, forestry, fishery products and services	25.5	0.9		*888.1*									
2 Mining (coal, misc, stone clay)	40.5	0.0		*1545.1*									
3 Crude petr, natural gas, petroleum refining	161.2	15.9		*9599.7*									
4 Construction	70.9	0.0		*953.0*									
5 Food and kindred products and tobbaco	104.4	21.2		*924.9*									
6 Textile mill products and apparel	18.7	0.0		*413.0*									
7 Paper, allied products, printing, publishing	264.7	0.0		*1272.0*									
8 Other manufactures	761.6	7.4		*6597.5*									
9 Transportation, communication, utilility	269.3	5.0		*1334.4*									
10 Trade (wholesale, retail)	46.0	5.6		*473.4*									
11 Finance, insurance, real estate	541.0	0.0		*1887.0*									
12 Hotels, lodging places & amusements	31.5	6.5		*199.4*									
13 Eating & drinking places	15.1	2.3		*63.8*									
14 Other services	626.1	0.9		*1965.9*									
15 Resident trip													
16 Nonresident trip													
Total	*2976.4*	*65.7*		*28117.0*									
GRAND TOTAL	**15908.4**	**160.9**	**20.8**	***105542.7***	**10214.9**	**7985.4**	**2822.3**	**221.8**	**9122.6**	***30366.9***	**22017.8**	**482.5**	***52867.2***

TABLE 4.12. (Continued)

OKLAHOMA SOCIAL ACCOUNTING MATRIX, 1991 ($MILLION)

EXPENDITURES \ RECEIPTS	INSTITUTION									CAPITAL	ROW	GRAND TOTAL
	Enterprise	HH Low (<20,000)	HH Med (20-40,000)	HH High (>40,000)	*Sub-total*	Government			*Total*			
						St&Local	Federal	Subtotal				
INDUSTRY												
1 Ag, forestry, fishery products and services		73.7	85.8	43.7	*203.2*	15.8	0.6	*16.4*	*219.6*	3.6	3166.1	**4681.3**
2 Mining (coal, misc, stone clay)		4.6	16.7	12.0	*33.4*	4.2	0.0	*4.3*	*37.6*	3.8	1955.6	**2242.9**
3 Crude petr, natural gas, petroleum refining		294.4	564.4	257.4	*1116.3*	89.9	199.3	*289.3*	*1405.5*	11.9	18830.1	**22426.4**
4 Construction		0.0	0.0	0.0	*0.0*	1160.8	348.4	*1509.2*	*1509.2*	3591.8	65.9	**9084.7**
5 Food and kindred products and tobbaco		222.8	361.7	147.1	*731.6*	34.8	1.9	*36.7*	*768.3*	1.8	2084.9	**3206.3**
6 Textile mill products and apparel		89.5	155.1	93.2	*337.8*	5.4	0.3	*5.8*	*343.5*	0.8	84.7	**500.2**
7 Paper, allied products, printing, publishing		32.3	48.9	22.2	*103.4*	21.2	0.1	*21.3*	*124.7*	0.7	1435.7	**2064.1**
8 Other manufactures		141.0	290.5	150.8	*582.3*	79.9	50.9	*130.8*	*713.1*	1252.3	10284.1	**13986.2**
9 Transportation, communication, utilility		817.3	985.6	528.4	*2331.3*	221.5	106.2	*327.7*	*2659.0*	64.5	3986.5	**10121.3**
10 Trade (wholesale, retail)		1382.2	2401.3	1209.2	*4992.7*	68.8	13.0	*81.8*	*5074.5*	228.9	1000.2	**8070.6**
11 Finance, insurance, real estate		1642.0	2574.4	1214.2	*5430.6*	108.4	0.6	*109.0*	*5539.6*	35.3	2236.3	**10152.7**
12 Hotels, lodging places & amusements		137.0	247.6	144.7	*529.3*	15.9	0.2	*16.1*	*545.3*	0.1	80.7	**788.1**
13 Eating & drinking places		530.0	649.6	325.3	*1504.9*	21.7	13.5	*35.2*	*1540.1*	0.0	163.2	**2128.1**
14 Other services		2830.0	3612.9	2029.6	*8472.5*	316.3	265.7	*582.1*	*9054.6*	22.1	2621.5	**15908.4**
15 Resident trip		39.3	58.3	63.3	*160.9*				*160.9*			**160.9**
16 Nonresident trip											20.8	**20.8**
Total		*8236.1*	*12052.9*	*6241.1*	*26530.1*	*2164.7*	*1000.8*	*3165.5*	*29695.6*	*5217.6*	*48016.2*	*105542.7*
FACTORS												
Labor												
1.Mgmt/Professional						1740.9	787.4	*2528.3*	*2528.3*			**10214.9**
2.Tech/Sales/Adm Support						1103.8	499.3	*1603.1*	*1603.1*			**7985.4**
3.Services				95.0	*95.0*	963.1	435.6	*1398.8*	*1493.8*			**2822.3**
4.Farm/Forest/Fish						15.4	7.0	*22.4*	*22.4*			**221.8**
5.Prod/Craft/Repairs						333.1	150.7	*483.8*	*483.8*			**9122.6**
Subtotal				*95.0*	*95.0*	*4156.4*	*1880.0*	*6036.3*	*6131.4*			**30366.9**
Capital												**22017.8**
Land												**482.5**
Total				*95.0*	*95.0*	*4156.4*	*1880.0*	*6036.3*	*6131.4*			*52867.2*

TABLE 4.12. (Continued)

OKLAHOMA SOCIAL ACCOUNTING MATRIX, 1991 ($MILLION)

EXPENDITURES \ RECEIPTS	INSTITUTION									CAPITAL	ROW	GRAND TOTAL
	Enterprise	HH Low (<20,000)	HH Med (20-40,000)	HH High (>40,000)	*Sub-total*	Government St&Local	Government Federal	Government Subtotal	*Total*			
INSTITUTION												
Enterprise												**21651.7**
Household												
Low	815.4					1001.9	4257.1	*5258.9*	*6074.3*		1199.9	**9837.3**
Med	1399.5					751.3	2187.7	*2939.0*	*4338.5*		11345.3	**23828.7**
High	3958.6					297.8	937.8	*1235.6*	*5194.2*		-5511.8	**15864.9**
Subtotal	*6173.5*					*2051.0*	*7382.6*	*9433.5*	*15607.0*		*7033.4*	***49531.0***
Government												
St&Loc	983.2	65.7	400.0	504.0	*969.7*				*1952.9*		710.9	**9302.4**
Fed	1916.2	298.3	1816.1	2288.2	*4402.5*				*6318.8*		-1204.0	**10728.1**
Subtotal	*2899.4*	*364.0*	*2216.1*	*2792.1*	*5372.2*				*8271.6*		*-493.1*	***20030.5***
Total	***9072.9***	***364.0***	***2216.1***	***2792.1***	***5372.2***	***2051.0***	***7382.6***	***9433.5***	***23878.6***		***6540.4***	***88313.8***
CAPITAL	12578.9	-3871.7	2180.9	2908.7	*1217.9*				*13796.8*		-6727.4	**7219.1**
ROW												
1 Ag, forestry, fishery products and services		42.9	51.8	28.8	*123.5*	10.7	0.6	*11.3*	***134.8***	4.5		**1027.4**
2 Mining (coal, misc, stone clay)		7.2	15.6	8.4	*31.2*	6.4	1.1	*7.5*	***38.7***	6.0		**1589.8**
3 Crude petr, natural gas, petroleum refining		323.0	405.1	204.0	*932.1*	96.3	8.6	*104.9*	***1037.0***	570.7		**11207.5**
4 Construction		0.0	0.0	0.0	*0.0*	65.0	22.2	*87.1*	***87.1***	123.1		**1163.2**
5 Food and kindred products and tobbaco		865.1	1200.5	515.8	*2581.4*	53.7	5.5	*59.2*	***2640.6***	5.1		**3570.6**
6 Textile mill products and apparel		222.8	343.1	194.3	*760.2*	10.4	0.7	*11.1*	***771.4***	12.2		**1196.5**
7 Paper, allied products, printing, publishing		219.8	301.1	145.1	*666.0*	114.4	0.3	*114.8*	***780.7***	0.9		**2053.6**
8 Other manufactures		804.2	1390.6	756.1	*2950.8*	216.4	260.6	*477.0*	***3427.9***	1163.7		**11189.1**
9 Transportation, communication, utilility		443.8	523.3	294.4	*1261.4*	108.9	61.6	*170.5*	***1431.9***	32.4		**2798.6**
10 Trade (wholesale, retail)		170.5	267.8	135.5	*573.9*	18.4	3.6	*22.0*	***595.9***	49.7		**1119.0**
11 Finance, insurance, real estate		1040.7	1586.9	779.8	*3407.4*	78.8	0.2	*79.0*	***3486.4***	29.1		**5402.5**
12 Hotels, lodging places & amusements		140.3	226.4	125.3	*492.0*	16.9	0.2	*17.1*	***509.1***	0.0		**708.5**
13 Eating & drinking places		73.8	90.0	43.8	*207.6*	3.1	1.9	*5.0*	***212.6***	0.0		**276.4**
14 Other services		743.2	959.2	577.7	*2280.1*	131.0	97.6	*228.6*	***2508.6***	4.1		**4478.6**
15 Resident trip		11.7	17.4	18.9	*48.0*				***48.0***			**48.0**
16 Nonresident trip												
Total		*5108.9*	*7378.8*	*3828.0*	*16315.7*	*930.4*	*464.7*	*1395.1*	*17710.8*	*2001.5*		*47829.2*
GRAND TOTAL	**21651.7**	**9837.3**	**23828.7**	**15864.9**	**49531.0**	**9302.4**	**10728.1**	**20030.5**	**91213.2**	**7219.1**	**47829.2**	

Total sectoral output was $105.5 billion, and total exports were $48 billion. Total commodity final demand in the region was $47.4 billion, of which $17.7 billion was fulfilled by imports. The intermediate inputs used and produced in the region were $22.6 billion, while imported intermediate inputs were $28.1 billion. Total GSP (value added plus indirect business taxes) from the production sectors plus household and government employment compensation was $60.9 billion. Labor share of GSP was 50 percent or $30.4 billion, which was contributed by Managerial and Professional Specialty occupations ($10.2 billion), Technical, Sales and Administrative Support occupations ($8.0 billion), Service occupations ($2.8 billion), Farming, Forestry, and Fishing occupations ($0.2 billion), and Precision Production, Crafts, and Repair occupations, Operators, Fabricators, and Laborers ($9.1 billion).

Total angler trip expenditures in Oklahoma were $160,854 thousand for residents (industry 15) and $35,372 thousand for nonresidents (industry 16). Resident anglers spent $1,616, $16,101, $5,991, $657, $6,631, $37,680, $6,930 $16,286 and $3,291 thousand for regionally produced goods and services from sectors: Agriculture, Petroleum, Food, Other Manufactures, Transportation, Trade, Hotel, Eating, and Other Services, respectively. They spent $861, $15,922, $21,176, $7,377, $4,978, $5,572, $6,513, $2,313, and $947 thousand for imported goods and services from sectors: Agriculture, Petroleum, Food, Other Manufactures, Transportation, Trade, Hotel, Eating, and Other Services, respectively. They also spent relatively small values for goods and services from the other industries. The total trip expenditures made by low, medium, and high income households were $39,260, $58,301, $63,293 thousand, respectively.

Nonresident angler total expenditures were $20,754 thousand, which $272, $1,202, $124, $1,380, $7,321, $1,583, $3,421, and $1,055 thousand were from regionally produced sectors: Agriculture, Petroleum, Food, Other Manufactures, Transportation, Trade, Hotel, Eating, and Other Services, respectively. The total expenditures of $20,754 were considered as exported trip demand. The rest of nonresident expenditures of $14,762 thousand was not included in the SAM because it was for imports from other regions.

Factor income, government transfers, and remittances from rest of world make up a total household income of $49.53 billion. The total household income was adopted from REIS, BEA data and was used as a control total. Total household income by income class size was $9.84, $23.83, and $15.86 billion, respectively, for low, medium, and high. The total government revenue of $20.03 billion was from State/Local revenue ($9.3 billion), and Federal revenue ($10.7 billion). Aggregate savings including depreciation and retained earning were $13.8 billion. However, there was a net resource transfer out of the state of $6.7 billion because the estimated gross capital formation amounted to only $7.2 billion.

Parameters in the Model

Endogenous and Exogenous Parameters

Parameter values for the equations in the model were calibrated to base year data. Additional exogenous parameter values including elasticities of substitution, elasticities of transformation, income elasticities, migration elasticity, Frisch parameters, etc., to complete the calibration were obtained from other studies. Table 4.13 presents exogenous parameters and their sources used in this study. Because a complete set of exogenous parameters needed in this study by individual industry are not available, common parameters by industry grouping were used. Parameters for 'agriculture' are for Agriculture (industries 1). Parameters for 'mining' are for Mining and Petroleum (industries 2-3). Parameters for 'manufacturing' are for Construction, Food, Textile, Printing, and Other Manufactures (industries 4-8). Parameters for 'services' are for Transportation, Trade, Finance, Hotel, Eating and Drinking Establishment, and Other Services (industries 9-14).

Calibration

Calibration procedure is the process of solving the model equations for parameters using benchmark or base year values of endogenous and exogenous variables (Koh, 1991). In this section, calibration of parameters in the model is discussed. The calibration method assumes that in the base year the economy is in equilibrium. Thus, calibration ensures the base year solution of the model reproduces the initial equilibrium.

Calibration of Cobb-Douglas production function. First order conditions of profit maximization in equation 3.4 in Chapter 3 yields factor demand equations. The exponent (α_i) of each factor is calibrated with the initial equilibrium data set. Once the exponent is calculated, equation 3.3 is used to calibrate the shift parameter (ϕ).

TABLE 4.13

EXOGENOUS PARAMETER ESTIMATES AND THE SOURCES

Parameter	Parameter Value	Source
Elasticity of Substitution (σ^V, σ^Q, σ^{SL}, σ^{Fed}, σ^{INV}, σ^{SK})		de Melo and Tarr (1992)
Agriculture *(Industry: 1)*	1.42	
Mining *(Industry 2 and 3)*	0.50	
Manufacturing *(Industry 4-8)*	3.55	
Services *(Industry 9-14)*	2.00	
Resident Trip*	2.00	
Labor Skill**	1.50	
Elasticity of Transformation (σ^X)		de Melo and Tarr (1992)
Agriculture *(Industry: 1)*	3.90	
Mining *(Industry 2-3)*	2.90	
Manufacturing *(Industry 4-8)*	2.90	
Services *(Industry 9-14)*	0.70	
Income Elasticity of Household Consumption		
Agriculture *(Industry: 1)*	0.30	de Melo and Tarr (1992)
Mining *(Industry 2-4)*	0.89	de Melo and Tarr (1992)
Manufacturing *(Industry 4-8)*	1.06	de Melo and Tarr (1992)
Services *(Industry 9-14)*	1.05	de Melo and Tarr (1992)
Resident Trip	0.82	Choi (1993)
Price Elasticity of Export Demand (ε)	-0.58	Choi (1993)
Income Elasticity of Labor Supply		Abbot and Ashenfelter (1979)
Low Household	-0.12	
Medium Household	-0.18	
High Household	-0.24	
Frisch Parameter		Lluch, Powell, and Williams (1977)
Low Household	-1.80	
Medium Household	-1.60	
High Household	-1.40	
Labor Migration Elasticity (η^L)	0.92	Rickman (1992)
Capital Migration Elasticity (η^K)	0.92	Rickman (1992)

*) Elasticity of Substitution for Resident Trip is assumed to be the same as Services
**) Elasticity of Substitution for Labor Skill is assumed to be 1.50
Source: Lee (1993) p.76

Calibration of CES and CET functions. CES and CET functions are calibrated in the same manner. The CES function in equation 3.17 is used to represent all functions. The first order condition resulting from cost minimization in equation 3.18 can be rearranged as:

$$(4.1)\quad \frac{1-\delta_j^v}{\delta_j^v} = \left[\left(\frac{VR_{ji}}{VM_{ji}}\right)\left(\frac{PR_j}{PM0_j}\right)\right]^{1/\sigma_j^v}$$

Using initial values for *VR*, *VM*, *PR*, and *PM*, and an exogenous value for the elasticity of substitution (or transformation) ,σ, the value of the share parameter, δ, can be obtained. In turn, δ is utilized to calculate the shift parameter (ϕ).

Calibration of labor CES equation. Calibration of the labor CES equation is slightly more complex because it has five inputs instead of two as in the other CES or CET functions used in the model. Because wages are normalized to one in the base year, Equation 3.13 from the labor cost minimization problem can be expressed as:

$$(4.2)\quad 1 = \frac{\delta_{it}^{LAB}}{\delta_{is}^{LAB}} \frac{LD_{is}^{-(1-\rho_i^{LAB})}}{LD_{it}^{-(1-\rho_i^{LAB})}}$$

From equation 4.2:

$$(4.3)\quad \delta_{it}^{LAB} = \delta_{is}^{LAB}\left(\frac{LD_{is}}{LD_{it}}\right)^{(1-\rho_i^{LAB})}$$

Summing equation 4.3 over the five labor skills yields:

$$(4.4)\quad \sum_{it}\delta_{it}^{LAB} = \sum_{it}\delta_{is}^{LAB}\left(\frac{LD_{is}}{LD_{it}}\right)^{(1-\rho_i^{LAB})}$$

Because the share parameters sum to one, equation 4.4 gives:

(4.5) $1 = \delta_{is}^{LAB} \sum_{it} \left(\frac{LD_{is}}{LD_{it}} \right)^{(1-\rho_i^{LAB})}$

thus

(4.6) $\delta_{is}^{LAB} = 1 \Big/ \sum_{it} \left(\frac{LD_{is}}{LD_{it}} \right)^{(1-\rho_i^{LAB})}$

The share parameters can be computed using base year values for labor demands and assumed values for the elasticities of substitution. After the share parameters are computed, they are substituted into equation 3.10 to calculate the efficiency parameter:

(4.7) $\phi_i^{LAB} = LAB_i \Big/ \left(\sum_s \delta_{is}^{LAB} LD_{is}^{\rho_i^{LAB}} \right)^{1/\rho_i^{LAB}}$

Calibration of LES function. Labor supply function is shown in equation 3.46. The elasticity of labor with respect to income is:

(4.8) $\varepsilon_h^{LY} = \frac{-\beta_{0h} HEXP_h}{(1-\beta_{0h}) PLH_h LSupH_h}$

The value of the marginal budget share for leisure for household group h, β_{0h}, can be obtained when $HEXP_h$, PLH_h, and $LSupH_h$ are supplied with base year SAM data, and exogenous labor supply elasticity is known (see Table 4.13).

Equation 3.39 is commodity demand LES function. The same derivation as above is used to obtain the value of the marginal budget share for commodity i of household group h, β_{ih}. The elasticity of demand for commodity i with respect to income is:

(4.9) $\varepsilon_{ih}^{Y} = \frac{\beta_{ih} HEXP_h}{(1-\beta_{0h}) P_i Q_{ih}}$ $\qquad (\Sigma_i \beta_{ih} = 1)$

With $HEXP_h$, P_i, and Q_{ih} obtained from SAM data, ε_{ih}^{Y} exogenously defined (see Table 4.13), and β_{0h} calculated from equation 4.8., then β_{ih} is known.

Once the values for β_{0h} and β_{ih} are obtained, they are substituted into equation 3.39 to determine the minimum subsistence requirement for good i of household group h, γ_{ih}:

$$(4.10)\quad \gamma_{ih} = Q_{ih} + \left(\frac{\beta_{ih}}{(1-\beta_{0h})P_i}\right)\left(\frac{HEXP_h}{Frisch}\right)$$

The *Frisch* parameter is exogenously given.

Model Solution

The CGE model is a simultaneous equilibrium system derived from micro and macro economic theories. Once the parameters are calibrated, the model equations are solved simultaneously for the endogenous variables given values of the exogenous variables. A variety of solution algorithms are available. Dervis et.al. (1982) have classified solution algorithms and have discussed strengths and weaknesses of each class.

The model in this study is implemented using GAMS (General Algebraic Modeling System). GAMS software is designed to make the construction and solution of large and complex mathematical programming models more straightforward for programmers and model users. Because it can make concise algebraic statements of models in a language that is easily read by both modelers and computers, GAMS can substantially improve the productivity of modelers and greatly expand the extent and usefulness of mathematical programming applications in policy analysis and decision making (Brooke, Kendrick, and Meeraus, 1992). GAMS by itself does not have solvers. It calls programming packages (such as MINOS, ZOOM, etc.) to solve the model it generates (see Brooke, et.al., 1992, pp.105 for the list of solvers available with GAMS). For the model in this study, the solver MINOS was used. MINOS is a solver suitable for non-linear programming problems with non-linearity both in the objective function and in the constraints.

The model equations are presented to MINOS as a set of equality constraints. Because a unique solution to this simultaneous equation system is expected, a feasible solution of an optimization problem using any objective function and this set of equality constraints is also (1) an optimal solution and (2) the solution of the given simultaneous equation system.

Following Koh (1991), two sets of positive slack variables were introduced in one of the constraints. The objective is specified as minimizing the sum of the slack variables. An optimal objective function value of zero is expected in this case.

A listing of the GAMS program of the model used in this study is presented in Appendix C.

A list of selected variables from the solution of the model shows that it exactly replicates the base SAM (Table 4.14). It shows all production levels and household income levels identical to the initial values in the SAM. All commodity prices are unity because the base prices were normalized. With these results, the model is likely to be valid and correctly specified and should be ready for implementation in the various simulations.

TABLE 4.14

COMPARISON BETWEEN CGE SOLUTION AND THE BASE SAM FOR SELECTED ENDOGENOUS VARIABLES

Endogenous Variables		Base SAM	CGE Solution
Regional Outputs by sector ($million)		*X0*	*X*
1Agr	Ag, forestry, fishery products and services	4681.299100	4681.299249
2Min	Mining (coal, misc, stone clay)	2242.857900	2242.857900
3Ptr	Crude petr, natural gas, petroleum refining	22426.390000	22426.390000
4Cnst	Construction	9084.656900	9084.656893
5Food	Food and kindred products and tobbaco	3206.292900	3206.292899
6Text	Textile mill products and apparel	500.207000	500.206986
7Pprt	Paper, allied products, printing, publishing	2064.067700	2064.067689
8Oman	Other manufactures	13986.170000	13986.170000
9Trd	Transportation, communication, utilility	10121.320000	10121.320000
10Tran	Trade (wholesale, retail)	8070.573200	8070.573216
11Fin	Finance, insurance, real estate	10152.670000	10152.670000
12Htl	Hotels, lodging places & amusements	788.062700	788.062699
13Eat	Eating & drinking places	2128.079800	2128.079788
14Ser	Other services	15908.430000	15908.430000
15Rest	Resident trip	160.853800	160.853782
16Nres	Nonresident trip	20.754300	20.754300
Imports by sector ($million)		*M0*	*M*
1Agr	Ag, forestry, fishery products and services	1027.402290	1027.402295
2Min	Mining (coal, misc, stone clay)	1589.766600	1589.766588
3Ptr	Crude petr, natural gas, petroleum refining	11207.460000	11207.460000
4Cnst	Construction	1163.217910	1163.217910
5Food	Food and kindred products and tobbaco	3570.574720	3570.574725
6Text	Textile mill products and apparel	1196.488590	1196.488590
7Pprt	Paper, allied products, printing, publishing	2053.633720	2053.633718
8Oman	Other manufactures	11189.090000	11189.090000
9Trd	Transportation, communication, utilility	2798.629100	2798.629106
10Tran	Trade (wholesale, retail)	1118.988220	1118.988220
11Fin	Finance, insurance, real estate	5402.522820	5402.522841
12Htl	Hotels, lodging places & amusements	708.470320	708.470322
13Eat	Eating & drinking places	276.372070	276.372070
14Ser	Other services	4478.588740	4478.588754
15Rest	Resident trip	48.037500	48.037507
Exports by sector ($million)		*E0*	*EXP*
1Agr	Ag, forestry, fishery products and services	3166.141590	3166.141704
2Min	Mining (coal, misc, stone clay)	1955.556180	1955.556179
3Ptr	Crude petr, natural gas, petroleum refining	18830.120000	18830.120000
4Cnst	Construction	65.896900	65.896898
5Food	Food and kindred products and tobbaco	2084.915460	2084.915460

TABLE 4.14. (Continued)

COMPARISON BETWEEN CGE SOLUTION AND THE BASE SAM FOR SELECTED ENDOGENOUS VARIABLES

Endogenous Variables		Base SAM	CGE Solution
Exports by sector ($million)		*E0*	*EXP*
6Text	Textile mill products and apparel	84.735340	84.735340
7Pprt	Paper, allied products, printing, publishing	1435.655740	1435.655732
8Oman	Other manufactures	10284.090000	10284.090000
9Trd	Transportation, communication, utilility	3986.474060	3986.474053
10Tran	Trade (wholesale, retail)	1000.159840	1000.159845
11Fin	Finance, insurance, real estate	2236.306000	2236.306022
12Htl	Hotels, lodging places & amusements	80.705150	80.705150
13Eat	Eating & drinking places	163.204490	163.204488
14Ser	Other services	2621.527740	2621.527742
16Nres	Nonresident trip	20.754300	20.754300
Institution Income ($million)			
Enterprise (YENT)		18752.360000	18752.340000
Household (YH)			
	Low	9837.348537	9837.348537
	Medium	23828.680000	23828.680000
	High	15864.920000	15864.920000
Government			
	State and Local (YSL)	9302.400822	9302.400822
	Federal (YFED)	10728.100000	10728.100000
Gross State Product (GSP) $million		60943.880000	60943.880000
Price of regionally produce goods (PR)			
1Agr	Ag, forestry, fishery products and services	1.000000	1.000000
2Min	Mining (coal, misc, stone clay)	1.000000	1.000000
3Ptr	Crude petr, natural gas, petroleum refining	1.000000	1.000000
4Cnst	Construction	1.000000	1.000000
5Food	Food and kindred products and tobbaco	1.000000	1.000000
6Text	Textile mill products and apparel	1.000000	1.000000
7Pprt	Paper, allied products, printing, publishing	1.000000	1.000000
8Oman	Other manufactures	1.000000	1.000000
9Trd	Transportation, communication, utilility	1.000000	1.000000
10Tran	Trade (wholesale, retail)	1.000000	1.000000
11Fin	Finance, insurance, real estate	1.000000	1.000000
12Htl	Hotels, lodging places & amusements	1.000000	1.000000
13Eat	Eating & drinking places	1.000000	1.000000
14Ser	Other services	1.000000	1.000000
15Rest	Resident trip	1.000000	1.000000
16Nres	Nonresident trip	1.000000	1.000000

CHAPTER V

SIMULATION RESULTS

This chapter presents model results and analysis of alternative policy simulations. The policy alternatives are based primarily on two levels of quality tax (10 percent and 50 percent) which affects sport fishing. Model experiments focus on trip demands. The assumption is that if quality of sport fishing decreases, the trip demand shifts to the left. Quality of sport fishing is hypothesized to be associated with number of fish caught per trip. The number of fish caught per trip is hypothesized to be associated with fish population which, in turn, is hypothesized to be associated with water quality. Hence, a decrease in water quality (i.e., an increase in chemical discharge) reduces fish populations which reduces fish caught per trip and thus a decrease in quality of sport fishing and a reduction in number of trips in Oklahoma. Residents and nonresidents have alternative sites at which they can replace their desire for sport fishing.

The change in welfare by imposing a quality tax on sport fishing is measured by means of compensating variation (CV) and equivalent variation (EV). Because CV and EV provide similar results, the discussion concentrates only on the CV measure. The CV, Marshallian and Hicks-compensated demand curves are shown in Figure 5.1.

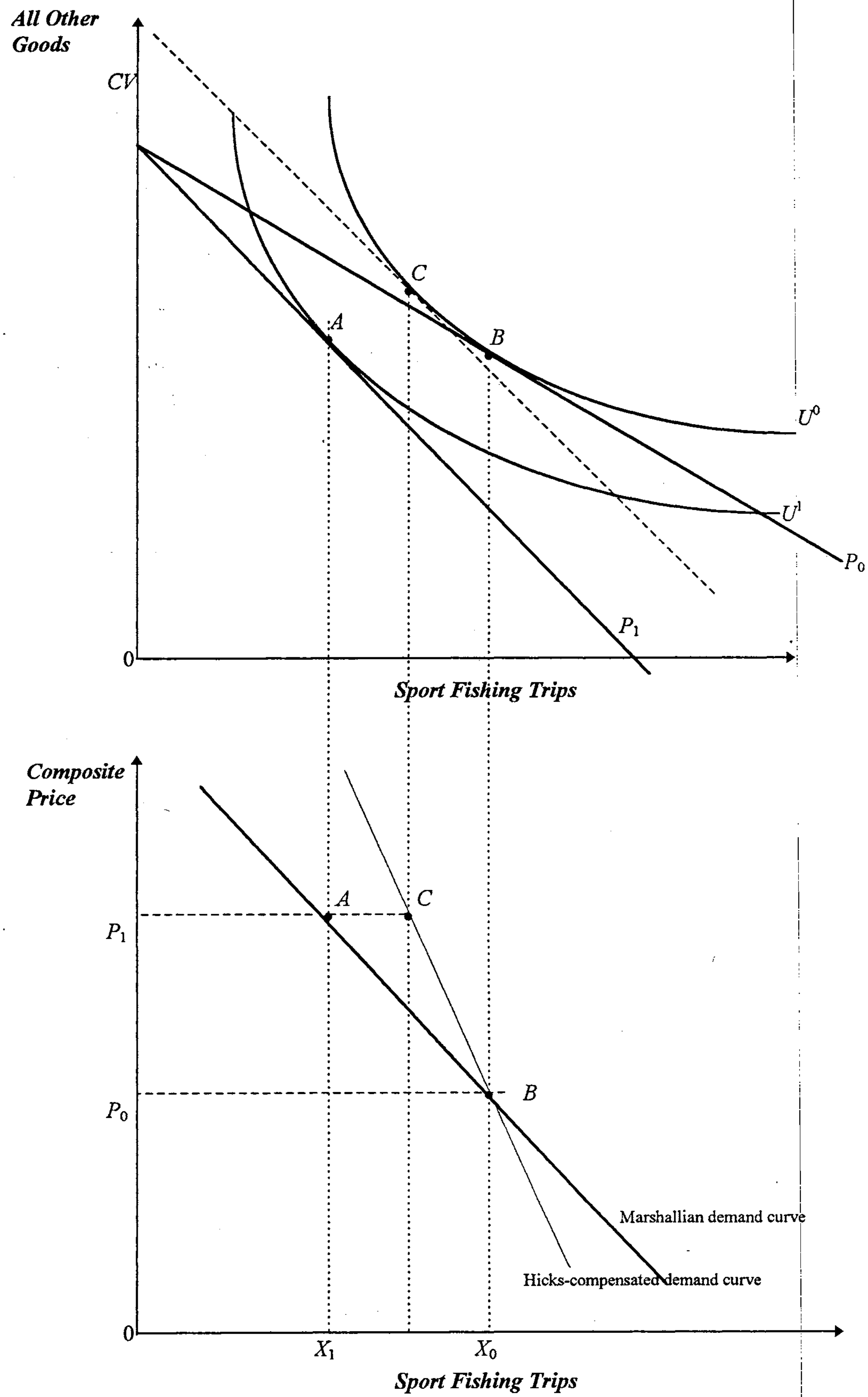

Figure 5.1. The CV, EV, Marshallian Demand and Hicks-Compensated Demand Curves

The price increase on sport fishing from P_0 to P_1 decreases demand for trips from X_0 to X_1 and decreases utility from U_0 to U_1. To remain as well off as before the price change, the CV is the amount of money required to compensate consumers. The CV measure of welfare change is the area to the left of the Hicks-compensated demand curve that passes through the initial position.

Specification of Model Simulations

Simulations varied by the following assumptions: variations in the level of quality tax imposed on sport fishing, pollution assessment tax on potential polluting industries, and short run and long run equilibrium results. The equilibrium results of selected variables and welfare change are presented and analyzed in this chapter. Results of all simulations are compared to the base SAM results. Thus, 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.

Model Scenarios

The following Group scenarios are discussed:

Group I: "Quality Tax (*qTax*)"

Scenario I-1: Short run and 10 percent *qTax* on sport fishing.

Scenario I-2: Long run and 10 percent *qTax* on sport fishing.

Scenario I-3: Short run and 50 percent *qTax* on sport fishing.

Scenario I-4: Long run and 50 percent *qTax* on sport fishing.

Group II: "Quality Tax (*qTax*) and Pollution Assessment Tax (*pTax*)"

Scenario II-1: Short run, 10 percent *qTax* on sport fishing, and *pTax* assessed to Agriculture.

Scenario II-2: Long run, 10 percent *qTax* on sport fishing, and *pTax* assessed to Agriculture.

Scenario II-3: Short run, 50 percent *qTax* on sport fishing, and *pTax* assessed to Agriculture.

Scenario II-4: Long run, 50 percent *qTax* on sport fishing, and *pTax* assessed to Agriculture.

Scenario II-5: Short run, 10 percent *qTax* on sport fishing, and *pTax* assessed to Food processing.

Scenario II-6: Long run, 10 percent *qTax* on sport fishing, and *pTax* assessed to Food processing.

Scenario II-7: Short run, 50 percent *qTax* on sport fishing, and *pTax* assessed to Food processing.

Scenario II-8: Long run, 50 percent *qTax* on sport fishing, and *pTax* assessed to Food processing.

Group III: "Long Term Pollution Assessment Tax"

Scenario III-1: Long run, Low tax assessed to Agriculture.

Scenario III-2: Long run, High tax assessed to Agriculture.

Scenario III-3: Long run, Low tax assessed to Food processing.

Scenario III-4: Long run, High tax assessed to Food processing.

Modification of the Model

Short run vs long run model. In a "short run" version of the model, capital is assumed to be sectorally fixed, and the final equilibrium will have sectorally differentiated rental rates. Capital flows in or out of the region are not allowed. Labor is assumed mobile between sectors and between regions. In a "long run" version, capital is mobile and average capital return adjusts to clear the regional capital market. Capital flows in or out of the region as needed. As discussed in Chapter III, under capital mobility, capital rent is equal among all sectors. Equations 3.77-3.79 imply the short run and long run equilibrium results.

Group I. "Quality tax is imposed on sport fishing." Water pollution affecting quality of sport fishing is represented by incorporating a quality tax into the model. The quality tax raises the price of resident and nonresident trips. Thus with pollution the regional prices become:

(5.1) $PRX_i = PR_i \qquad i \in M$

(5.2) $PRX_i = PR_i + qTax, \qquad i \in NR$

where $qTax$ is the quality tax per unit of sport fishing (trip).

Composite price is a weighted average of domestic price and price of imports.

(5.3) $$PX_i = \frac{PRX_i R_i + PM0_i M_i}{R_i + M_i} \qquad i \in M,NR$$

The quality tax affects nonresident trips through the export demand function:

(5.4) $E_i = E0_i (P_i + qTax)^{\varepsilon_i} \qquad i \in NE$

Group II. "Quality tax on sport fishing and pollution assessment tax on producing sector(s)." Total cost from the quality tax ($QTAXCOST$) is calculated as follows:

(5.5) $QTAXCOST = qTax(X_{NR} + X_{NE})$

where X_{NR} and X_{NE} are resident and nonresident trips, respectively.

We assume that a pollution tax is charged to potential polluting sectors such that the total revenue collected from the pollution tax is equal to the total quality tax. Net price of value added production is reduced by $pTax_i$ which is non-zero for polluting industries. Thus the net price function in equation 3.66 is modified to:

$$(5.6) \qquad PN_i = PR_i \sum_i \left(a_{ji} P_j - ibtax_i PR_i - pTax_i\right)$$

The share of total quality tax paid by each polluting industry is pre-determined and is denoted as sh_i, thus the following equates total quality tax and total pollution tax:

$$(5.7) \qquad \sum_i sh_i pTax_i X_i = QTAXCOST$$

where the summation is over all the polluting industries. The pollution tax rates $pTax_i$ are endogenously determined by the model. The agricultural industry's share of the pollution tax is denoted by sh_{ag}, while the food processing industry's share is denoted by sh_{food}. Variable sh_{ag} is set to one for Scenarios II-1 to II-4; sh_{food} is set to one for Scenarios II-5 to II-8.

Group III. "Long term pollution assessment tax in producing sector(s)." The assumption is that in the long run the quality of the natural resource system has been restored but the pollution assessment tax is needed to maintain quality of the natural resource system. Thus sport fishing quality is the same as in the initial equilibrium, therefore no quality tax is assessed. The long term pollution assessment tax rate is exogenously defined. A pollution tax, $pTax_i$, is charged to potential polluting sectors such that the total revenue collected from the pollution tax is equal to the total quality tax obtained from the corresponding result in Group I. Equation 5.6 is applied in these scenarios except that the $pTax_i$ is now defined exogenously.

The first solution of the model is the basic model in which the quality tax is set to zero. The solution is used to validate the model, that is to confirm that the model is correctly specified and any unintentional errors have been removed. Furthermore, because the solution reproduces the base SAM, those results can be used as a benchmark equilibrium to which the results of the simulations can be compared.

Simulation Results

Quality Tax

Results of the four scenarios in Group I are presented and analyzed in this section. A 10 percent and 50 percent quality tax were imposed on the price (cost) of resident and nonresident in-state trips. Short run and long run equilibrium results are estimated for each tax level. The tax has the effect of increasing the cost of in-state relative to out-of-state trips for residents and nonresidents. Table 5.1. presents the results on selected impact variables.

The regional price of resident and nonresident trips increases because of the quality tax. However, the increase is slightly less than the tax because endogenous regional prices are lower overall and reduce cost of regional trips marginally. The trip prices are slightly higher in the long run models (SI-2 and SI-4) compared to the short run models (SI-1 and SII-2) which in turn decreases marginally (by 1,000) the number of resident in-state and total trips. This is to be expected because capital is mobile in the long run and with capital flowing out of the region, wages and prices increase slightly.

TABLE 5.1

IMPACTS ON SELECTED VARIABLES FROM IMPOSING A QUALITY TAX ON SPORT FISHING IN OKLAHOMA, 1991

Impact Variable	Base	Group I			
		10% tax		50% tax	
		Short run	Long run	Short run	Long run
		SI-1	SI-2	SI-3	SI-4
Resident Trips					
Prices (index)					
Regional price	1.000000	1.099883	1.099935	1.499559	1.499756
Out-of-region price	1.000000	1.000000	1.000000	1.000000	1.000000
Composite price	1.000000	1.073374	1.073411	1.298861	1.298947
Number of trips (1,000)					
In-state	9411	7877	7876	4427	4426
Out-of-state	369	411	411	585	585
Total	*9780*	*8288*	*8287*	*5012*	*5011*
Non-Resident Trips					
Regional price (index)	1.000000	1.099857	1.099921	1.499463	1.499704
No. of trips (1,000)	1379	1187	1187	728	728
Resource Use					
Labor					
Total Labor (index)	1.000000	0.999842	0.999843	0.999401	0.999405
Overall Wage Rate (index)	1.000000	0.999828	0.999829	0.999348	0.999353
Skill 1 - Managerial	1.000000	0.999829	0.999830	0.999351	0.999356
Skill 2 - Technical	1.000000	0.999799	0.999803	0.999242	0.999257
Skill 3 - Services	1.000000	0.999789	0.999796	0.999202	0.999228
Skill 4 - Farming	1.000000	0.999941	0.999877	0.999775	0.999537
Skill 5 - Production	1.000000	0.999860	0.999859	0.999470	0.999467
Capital					
Quantity (index)	1.000000	1.000000	0.999891	1.000000	0.999595
Overal Capital Rent (index)	1.000000	0.999790	0.999882	0.999427	0.999559
Agriculture	1.000000	1.000043	0.999882	1.000170	0.999559
Mining	1.000000	1.000110	0.999882	1.000417	0.999559
Petroleum	1.000000	0.999689	0.999882	0.998840	0.999559
Construction	1.000000	0.999858	0.999882	0.999464	0.999559
Food Processing	1.000000	0.999470	0.999882	0.998022	0.999559
Textile	1.000000	0.999917	0.999882	0.999689	0.999559
Printing	1.000000	1.000106	0.999882	1.000406	0.999559
Other Manufactures	1.000000	1.000186	0.999882	1.000703	0.999559
Transportation	1.000000	0.999751	0.999882	0.999069	0.999559
Trade	1.000000	0.999269	0.999882	0.997266	0.999559
Finance	1.000000	0.999861	0.999882	0.999478	0.999559
Hotels	1.000000	0.998855	0.999882	0.995721	0.999559
Eating Places	1.000000	0.998847	0.999882	0.995687	0.999559
Other Services	1.000000	0.999767	0.999882	0.999126	0.999559
Land					
Quantity (index)	1.000000	1.000000	1.000000	1.000000	1.000000
Land Rent (index)	1.000000	1.000043	0.999879	1.000170	0.999555
Resource Migration					
Labor					
Number of Jobs	0	-216	-214	-816	-810
Percent of Base (%)	NA	-0.016	-0.016	-0.060	-0.060
Capital					
Percent of Base (%)	NA	0	-0.011	0	-0.041

The total number of resident trips decreases with the quality tax and subsequent increase in composite price. For the short run analysis, the 7.3 percent increase in composite price at the 10 percent quality tax reduces resident in-state trips from 9,411,000 to 7,877,000 (16.3 percent) and increases resident out-of-state trips from 369,000 to 411,000 (11.4 percent). The number of total trips decreases from 9,780,000 to 8,288,000 (15.3 percent).

Total trips decrease because the composite price (weighted in-state and out-of-state prices) increases thus shifting demand to other commodities. The proportion of in-state to out-of-state trips changes because the price ratio changes. Out-of-state price is assumed to remain constant. The elasticity of substitution between in-state and out-of-state trips is set at 2.0.

With a quality tax of 50 percent, composite price increases by about 30 percent and total resident trips decreases by 48.7 percent (from 9,780,000 to 5,012,000). Resident in-state trips decrease by 53.0 percent (from 9,411,000 to 4,427,000) and out-of-state resident trips increase by 58.6 percent (from 369,000 to 585,000). The results of the 50 percent quality tax compared to the 10 percent quality tax shows the nonlinear response of the model.

There is little difference between the short run and long run results in terms of resident trips. Composite price increases slightly for reasons explained above which results in a modest 1,000 total trip reduction in the long run over the short run.

Nonresident trip (export demand) is driven by the price elasticity of demand and the quality tax. With a 10 percent unit cost quality tax, regional price increases slightly less than 10 percent and number of trips decreases from 1,379,000 to 1,187,000 (13.9 percent). With a 50 percent quality tax, number of trips decreases from 1,379,000 to 728,000 (47.2 percent). These results show the potential loss in regional exports from changes in the natural resource system and the subsequent change in quality of sport fishing. A slightly higher long run regional price changes nonresident trips by less than 200 trips for the same level of quality tax (SI-1 Vs SI-2, and SI-3 Vs SI-4).

Regional labor demand (number of jobs plus work time) decreases marginally with the quality tax. Overall regional wage rate decreases marginally which encourages labor out-migration. The latter depends upon the out-of-region wage rate (assumed constant) and the labor migration elasticity. The labor migration elasticities are assumed to be the same across labor skill, i.e., 0.92. Wage rates in labor skills managerial (skill 1), farming (skill 4), and production (skill 5) decrease slightly less than the overall average wage, whereas wage rates for labor skills technical (skill 2) and services (skill 3) decrease slightly more than the overall average. Long run wage rates decrease marginally less compared to short run wage rates. This is expected, however, because of capital out-migration in the long run and the capital and labor substitutions.

The change in overall wage rate is slightly more than the change in total labor use. This is the net result of at least three factors: (1) a slight inelasticity of labor migration which means that the change in overall wage rate leads to a smaller than proportional change in labor supply, (2) a negative income elasticity of labor supply, which means that with a lower wage rate (and subsequent income) households supply more labor, and (3) a lower overall wage rate increases industry demand for labor in the region. The net result is a slightly lower decrease in regional labor use compared to the reduction in overall wage rate. The reductions in labor use and wage rates are greater with the 50 percent quality tax compared to the 10 percent quality tax. This result is simply because of a greater reduced aggregate demand in the region.

Labor out-migration is about 216 jobs with the 10 percent quality tax and about 816 jobs with the 50 percent quality tax. The long run results are slightly less at 214 and 810, respectively. This is expected because of the mobility of capital in the long run and the labor-capital substitutions. Labor out-migration as a percent of the base number of jobs is 0.016 percent for the 10 percent quality tax and 0.06 percent for the 50 percent quality tax.

Long run equilibrium results from a quality tax in sport fishing leads to reduced capital and land rents. The decrease in capital rent causes capital to migrate for a higher return. Capital reduces by 0.011 percent with the 10 percent quality tax, and by 0.040 percent with the 50 percent quality tax. The capital migration elasticity was set at 0.92.

In the short run, capital is fixed by sector and hence capital rents vary by sector. Capital rents increase for agriculture, mining, printing and other manufacturing and decrease for all other sectors. The overall reduction in capital rent is less for the long run simulations compared to the short run simulations. This is expected because of capital out-migration in the long run.

Agricultural land supply is fixed in the short and long run. Land rent increases in the short run and decreases in the long run. With labor out-migration in the short run, land substitutes for labor and the increased demand for land marginally increases land rent.

Differences in the changes in wage rates, capital rents, and land rent will have differing effects on factor incomes of household groups because of differences in resource endowments of the various groups. In the short run, the overall capital rent decreases more than the overall wage rate. Land rent increases. In the long run, wage rates decrease more than land and capital rates.

Impacts on selected institutional and welfare variables from imposing a unit quality tax on sport fishing are presented in Table 5.2. In the short run equilibrium, the quality tax cost to resident anglers for in-state trips is the equivalent of $14,791,000 ($23.73 per angler) at 10 percent quality tax, and $56,688,000 ($90.95 per angler) at 50 percent quality tax. Anglers are not actually assessed this tax. As shown in Figure 5.1., increase in price from P_0 to P_1 because of quality tax reduces number of trips from X_0 to X_1 at the original cost (price) per trip. A quality tax on the original price is used to measure the decrease in demand for trips. The quality tax per trip for 10 percent is $1.71 and for 50 percent is $8.54.

Nonresident anglers pay the equivalent of $1,962,000 quality tax ($10.87 per angler) and $8,204,000 tax ($45.47 per angler), in short run equilibrium, with the 10 percent and 50 percent quality tax, respectively. The quality tax per trip for 10 percent is $1.50 and for 50 percent is $7.52. When compared to the short run results, the long run equilibrium results do not show significant differences.

TABLE 5.2

IMPACTS ON SELECTED INSTITUTIONAL AND WELFARE VARIABLES FROM IMPOSING A QUALITY TAX ON SPORT FISHING IN OKLAHOMA, 1991

Institution	Base	Group I			
		10% tax		50% tax	
		Short run	Long run	Short run	Long run
		SI-1	SI-2	SI-3	SI-4
Households					
Quality Tax ($1,000)					
Resident Anglers ($1,000)	0	14791	14798	56688	56702
Per Angler ($)	0	23.73	23.74	90.95	90.97
Nonresident Anglers ($1,000)	0	1962	1963	8204	8207
Per Angler ($)	0	10.87	10.88	45.47	45.49
Total Anglers ($1,000)	0	16753	16761	64891	64909
Per Angler ($)	0	20.84	20.85	80.74	80.76
Welfare Change - Households					
Total ($1,000)					
Low income (<$20,000)	NA	-3156	-3549	-12383	-13855
Medium income ($20,000-$40,000)	NA	-4766	-5378	-18596	-20885
High income (>$40,000)	NA	-7252	-7629	-27936	-29330
Total	*NA*	*-15174*	*-16556*	*-58914*	*-64070*
Per Household (index)					
Low income (<$20,000)	1.000000	0.999679	0.999639	0.998740	0.998591
Medium income ($20,000-$40,000)	1.000000	0.999800	0.999774	0.999219	0.999123
High income (>$40,000)	1.000000	0.999543	0.999519	0.998238	0.998150
Total	*1.000000*	*0.999694*	*0.999666*	*0.998810*	*0.998706*
Income Change Per Household (index)					
Low income (<$20,000)	1.000000	0.999945	0.999944	0.999793	0.999790
Medium income ($20,000-$40,000)	1.000000	0.999943	0.999942	0.999788	0.999783
High income (>$40,000)	1.000000	0.999868	0.999864	0.999513	0.999503
Total	*1.000000*	*0.999919*	*0.999917*	*0.999701*	*0.999695*
Governments					
State/Local					
Revenues (index)	1.000000	0.999757	0.999705	0.999090	0.998900
Expenditures (index)	1.000000	0.999857	0.999864	0.999460	0.999486
Net ($1,000)	0	-937	-1476	-3442	-5448
Federal					
Revenues (index)	1.000000	0.999719	0.999702	0.998952	0.998886
Expenditures (index)	1.000000	0.999849	0.999852	0.999429	0.999441
Net ($1,000)	0	-1390	-1610	-5110	-5950
Region					
Gross State Product Change					
Total ($1,000)	NA	-13450	-14910	-50280	-55670
Percent	NA	-0.022	-0.024	-0.083	-0.091
Welfare Change ($1,000)					
Households	NA	-15174	-16556	-58914	-64070
Resource Migration	NA				
Labor					
Wage Compensation	NA	-4815	-4782	-18233	-18083
Other Resource Compensation	NA	-3577	-5781	-13490	-13376
Capital					
Capital Compensation	NA	0	-2395	0	-8927
Total	*NA*	*-8392*	*-12958*	*-31723*	*-40386*

Households remaining in-state have a welfare loss equal to $15,174,000 and $16,556,000 for the short run and long run models, respectively, with the 10 percent quality tax and a loss equal to $58,914,000 and $64,070,000 for the short run and long run models, respectively, with the 50 percent quality tax. Welfare loss includes price effects as well as income effects. Hence, the effects of changes in price of resident trips (as well as all other prices) and the losses through reduced factor incomes (reduced wage rate and land and capital rents) are included in the CV measure. High income households show the highest total welfare loss. Low income households have the lowest total welfare loss. The welfare change per household shows that high income households have the highest loss, while medium income households have the lowest loss.

The income loss per household is less than the welfare loss per household. In the case of a 10 percent quality tax and the short run, the overall income loss per household is 0.013 percent whereas the welfare loss per household is 0.031 percent. Low income households have less of a welfare loss compared to the high income households. This is the result of low income households benefiting more from lower commodity prices and losing less from lower factor income compared to higher income households.

Government revenues and expenditures decrease with a unit quality tax imposed on resident and nonresident trips. Main sources of government revenues are taxes. The decrease in factor income and household income lead to a decrease in government revenue. Government spending includes commodity purchases, transfers to households, and government employment. Expenditures decrease because commodity prices and wage rates decrease, and transfers to households decrease marginally because of out-migration.

The decrease in revenues, however, is more than the decrease in expenditures. Therefore, the net revenue change is negative. At the 50 percent quality tax, the government net losses are more than three times higher than at the 10 percent quality tax. Overall results show that losses with the long run equilibrium are higher than with the short run equilibrium. Federal government net losses are higher than State/Local government net losses in all scenarios.

Regional impact may be measured by change in gross state product (GSP), change in welfare of households, and loss of resources to the region. Total GSP decreases because of the quality tax. Short run equilibrium GSP decreases by $13,450,000 (0.022 percent) with a 10 percent unit quality tax, and by $50,280,000 (0.083 percent) with a 50 percent unit quality tax. Long run equilibrium results show slightly higher losses.

Out-migration of labor compensated at the out-of-region wage rate equals $4,815,000, $4,782,00, $18,233,000 and $18,083,000 for SI-1, SI-2, SI-3, and SI-4, respectively. Migrating labor is expected to retain proportional ownership of other household resources (capital and land) and hence returns to these resources are expected to flow out of the state. The value of the compensation for these resources equals $3,577,000, $5,781,000, $13,490,000, and $13,376,000 for SI-1, SI-2, SI-3, and SI-4, respectively.

Long run models show capital out-flow from the region with a compensation equal to $2,395,000 under a 10 percent quality tax (SI-2), and $8,927,000 under a 50 percent quality tax (SI-4).

Change in GSP is one measure of the regional loss due to the quality tax. A second measure of regional loss may be defined as regional household welfare change and resource migration. Welfare change of households is as explained previously. Loss to the region from migration of resources plus out-flow of compensation to resource owners who migrate equals $8,392,000, $12,958,000, $31,723,000, and $40,486,000 for scenarios SI-1, SI-2, SI-3, and SI-4, respectively.

Quality and Pollution Assessment Taxes

Group II scenario includes eight models: two potential polluting industries, two levels of quality tax for each industry, and short run and long run equilibrium models. A 10 percent and 50 percent quality tax are imposed on the price (cost) of resident and nonresident in-state trips. Simultaneously, a pollution tax is assessed to potential polluting industries. This study assumed that the agricultural and the food processing sectors were potential polluters of sport fishing streams. A pollution tax is charged to the potential polluting sectors such that the total revenue collected from the pollution tax is equal to the total quality tax imposed on sport fishing trips. The quality tax has the effect of increasing the cost of in-state relative to out-of-state sport fishing trips for residents and nonresidents, and the pollution tax has the effect of decreasing net price for agriculture and food processing productions.

Impacts on selected variables from imposing a unit cost quality tax and pollution tax assessment on net price of agriculture and food processing are presented in Table 5.3. The overall impact is a significant reduction in aggregate demand for the state, significant increase in out-migration of resources, substantial loses in household welfare, and substantial decreases in gross state product.

TABLE 5.3

IMPACTS ON SELECTED VARIABLES FROM IMPOSING A QUALITY TAX ON SPORT FISHING AND ASSESSING POLLUTION TAX ON POTENTIAL POLLUTING INDUSTRY IN OKLAHOMA, 1991

Impact Variable	Base	Group II							
		Agriculture				Food Processing			
		10% tax		50% tax		10% tax		50% tax	
		Short run	Long run	Short run	Long run	Short run	Long run	Short run	Long run
		SII-1	SII-2	SII-3	SII-4	SII-5	SII-6	SII-7	SII-8
Resident Trips									
Prices (index)									
Regional price	1.000000	1.099767	1.099784	1.499109	1.499162	1.099735	1.099790	1.498984	1.499201
Out-of-region price	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
Composite price	1.000000	1.073294	1.073305	1.298663	1.298686	1.073271	1.073309	1.298608	1.288703
Number of trips (1,000)									
In-state	9411	7875	7873	4423	4419	7874	7869	4419	4410
Out-of-state	369	410	410	584	583	410	410	583	582
Total	*9780*	*8286*	*8283*	*5007*	*5002*	*8284*	*8279*	*5002*	*4992*
Non-Resident Trips									
Regional price (index)	1.000000	1.099712	1.099726	1.498899	1.498968	1.099582	1.099572	1.498382	1.498329
No. of trips (1,000)	1379	1187	1187	728	728	1187	1187	729	729
Selected Sector Results									
Total Sector Output (index)									
Weighted regional price	1.000000	0.999904	0.999881	0.999832	0.999742	0.999726	0.999599	0.999137	0.998646
Weighted output	1.000000	0.999684	0.999230	0.998792	0.997005	0.999390	0.998624	0.997620	0.994590
Agricultural Sector									
Prices (index)									
Regional price	1.000000	1.000423	1.001440	1.001694	1.005853	0.998614	0.998020	0.994505	0.992109
Composite price	1.000000	1.000252	1.000858	1.001009	1.003481	0.999174	0.998821	0.996730	0.995317
Quantity (index)	1.000000	0.997226	0.990320	0.989023	0.961741	0.999203	0.994391	0.996805	0.977445
Food Processing									
Prices (index)									
Regional price	1.000000	0.999817	0.999972	0.999305	0.999923	1.002480	1.004913	1.010178	1.020710
Composite price	1.000000	0.999956	0.999993	0.999834	0.999982	1.000589	1.001161	1.002377	1.004719
Quantity (index)	1.000000	0.999605	0.998193	0.998482	0.992884	0.986713	0.974455	0.947268	0.898471
Resource Use									
Labor									
Total Labor (index)	1.000000	0.998422	0.998018	0.993871	0.992255	0.998979	0.998175	0.995989	0.992776
Overall Wage Rate (index)	1.000000	0.999544	0.999381	0.998246	0.997599	0.999244	0.998897	0.997052	0.995665
Capital									
Quantity (index)	1.000000	1.000000	0.999445	1.000000	0.997839	1.000000	0.999075	1.000000	0.996356
Overal Capital Rent (index)	1.000000	0.999238	0.999397	0.997055	0.997654	0.998839	0.998996	0.995477	0.996047
Land									
Quantity (index)	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
Land Rent (index)	1.000000	0.984430	0.980937	0.939643	0.925806	0.995051	0.988324	0.980329	0.953637
Resource Migration									
Labor									
Number of Jobs	0	-583	-790	-2249	-3076	-953	-1393	-3719	-5486
Percent of Base (%)	NA	-0.042	-0.057	-0.162	-0.222	-0.070	-0.102	-0.272	-0.400
Capital									
Percent of Base (%)	NA	0	-0.056	0	-0.216	0	-0.092	0	-0.364

Differences in results for sport fishing resident and nonresident trips between Group I scenarios and Group II scenarios are minimal. Differences are because of lower commodity prices, lower income levels, and lower aggregate regional demand for Group II scenarios relative to Group I scenarios. This results in marginally lower resident and nonresident regional trip prices, lower resident in-state trips, and lower resident total trips for Group II scenarios. The decrease in number of trips ranges from 2,000 in comparing short run with 10 percent quality tax (SI-1 compared to SII-1) to 19,000 in comparing long run with 50 percent quality tax (SI-4 compared to SII-8). There is little difference between the two groups of scenarios when comparing nonresident (export demand) trips.

Impact of the pollution assessment tax falls most heavily on the sectors assessed the cost. Group II scenarios SII-1, SII-2, SII-3, and SII-4 (Table 5.3) show the results of the tax assessed to agriculture. Regional and composite prices for agriculture increase. The composite price increases less than the regional price because the external price remains constant. The regional price for agriculture is able to increase with the pollution assessment because use of agricultural output as inputs to other sectors and for regional consumption shows imperfect substitution of agricultural imports for domestic agricultural output. Increased agricultural composite price, however, reduces quantity demanded of regional agricultural output. Long run regional agricultural price increases by 0.14 percent with the 10 percent quality tax and by 0.59 percent with the 50 percent quality tax. Agricultural output decreases by 0.97 percent and by 3.83 percent, respectively, for the same scenarios. The decrease in agricultural output is the result of the increased price effect both on in-state demand and export demand for agricultural output.

When the pollution tax is assessed to food processing, price increases by 0.25 percent in the long run model for the 10 percent quality tax on sport fishing and by 2.07 percent for the 50 percent quality tax on sport fishing. For the same scenarios, output of the food processing sector decreases by 2.56 percent and 10.15 percent, respectively. The impact of the pollution tax is much greater on the food processing sector when compared to the impact on the agricultural sector. The principle reason for this is that the agricultural sector is much larger than the food processing sector but the assumed tax cost is the same. The assessed pollution cost is based on the unit quality tax rate per sport fishing trip and the number of sport fishing trips, not on the output level of agriculture or food processing. This, of course, is a limitation on the current modeling effort. A pollution tax should be assessed on the basis of the amount of pollutants produced by industry that affects the natural resource system and the consequent effect on fish populations.

Imposing the pollution assessment tax in addition to a quality tax on sport fishing trips decreases regional labor demand as well as the overall wage rate as expected when compared to the impact of the quality tax alone. These results are most significant when comparing out-migration of labor. With a 10 percent quality tax, the short run model shows a job loss of 216 compared to a job loss of 583 for the same 10 percent quality tax but also with a pollution assessment tax in agriculture equal to the cost of the quality tax. The long run model results are a loss of 214 jobs compared to 790 jobs. Clearly, the pollution assessment tax on agriculture has decreased regional output and demand for labor, and thus increased labor out-migration. Assessing the pollution tax to food processing shows a greater reduction in labor demand and wage rate compared to assessing the pollution tax to agriculture. More specifically, the long run models show an increase in out-migration from 790 in agriculture to 953 for food processing with the 10 percent quality tax. With the 50 percent quality tax, labor out-migration is 3,076 when assessing the pollution tax to agriculture versus a labor out-migration of 5,486 when assessing the pollution tax to food processing. The latter result represents a 0.4 percent reduction in the total state labor force.

The pollution tax reduces capital and land rents in the long run equilibrium. Under the 10 percent quality tax scenario, capital rent is reduced by 0.06 percent when the pollution tax is assessed to agriculture. With the 50 percent quality tax scenario, capital rent is reduced by 0.24 percent. When the pollution tax is assessed to food processing, the same comparisons are 0.10 percent and 0.40 percent. Allowing capital mobility, the decrease in in-state capital rent causes capital out-migration, where the capital rent is assumed to be constant. The capital base reduces by 0.06 and 0.22 percent when the pollution tax is assessed to agriculture (scenarios SII-2 and SII-4, respectively), and 0.09 and 0.36 percent when the pollution tax is assessed to food processing (scenarios SII-6 and SII-8, respectively).

Table 5.4 presents the impacts on selected institutional welfare variables from imposing a unit cost quality tax in sport fishing simultaneously with assessing a pollution tax in agriculture and food processing. The impact of the quality tax on resident and nonresident anglers is very similar for Group I and Group II scenarios. The total quality tax and tax per angler are slightly less because the price per trip and total number of trips are less.

TABLE 5.4

IMPACTS ON SELECTED INSTITUTIONAL AND WELFARE VARIABLES FROM IMPOSING A QUALITY TAX ON SPORT FISHING AND ASSESSING POLLUTION TAX ON POTENTIAL POLLUTING INDUSTRY IN OKLAHOMA, 1991

Institution	Base	Agriculture				Food Processing			
		10% tax		50% tax		10% tax		50% tax	
		Short run	Long run	Short run	Long run	Short run	Long run	Short run	Long run
		SII-1	SII-2	SII-3	SII-4	SII-5	SII-6	SII-7	SII-8
Households									
Quality Tax ($1,000)									
Resident Anglers ($1,000)	0	14769	14768	56564	56519	14761	14761	56498	56414
Per Angler ($)	0	23.69	23.69	90.75	90.68	23.68	23.68	90.64	90.51
Nonresident Anglers ($1,000)	0	1959	1959	8196	8197	1957	1956	8189	8189
Per Angler ($)	0	10.86	10.86	45.43	45.44	10.85	10.84	45.40	45.39
Total Anglers ($1,000)	0	16728	16727	64760	64716	16717	16717	64687	64603
Per Angler ($)	0	20.81	20.81	80.58	80.52	20.80	20.80	80.49	80.38
Welfare Change - Households									
Total ($1,000)									
Low income (<$20,000)	NA	-2752	-3641	-10782	-14207	-2831	-4418	-11111	-17349
Medium income ($20,000-$40,000)	NA	-7113	-9019	-27630	-35024	-5257	-8715	-20565	-34175
High income (>$40,000)	NA	-12316	-15317	-47555	-59345	-12950	-18738	-50287	-73185
Total	*NA*	*-22180*	*-27977*	*-85967*	*-108576*	*-21039*	*-31871*	*-81962*	*-124710*
Per Household (index)									
Low income (<$20,000)	1.000000	0.999720	0.999630	0.998902	0.998553	0.999712	0.999551	0.998867	0.998229
Medium income ($20,000-$40,000)	1.000000	0.999701	0.999621	0.998839	0.998527	0.999779	0.999634	0.999135	0.998560
High income (>$40,000)	1.000000	0.999223	0.999034	0.996998	0.996251	0.999183	0.998818	0.996822	0.995368
Total	*1.000000*	*0.999769*	*0.999098*	*0.999690*	*0.998766*	*0.999575*	*0.999356*	*0.998341*	*0.997472*
Income Change Per Household (index)									
Low income (<$20,000)	1.000000	0.999823	0.999750	0.999318	0.999029	0.999721	0.999572	0.998915	0.998318
Medium income ($20,000-$40,000)	1.000000	0.999676	0.999572	0.998749	0.998337	0.999664	0.999453	0.998689	0.997848
High income (>$40,000)	1.000000	0.999341	0.999094	0.997467	0.996486	0.999150	0.998644	0.996693	0.994673
Total	*1.000000*	*0.999598*	*0.999454*	*0.998451*	*0.997882*	*0.999511*	*0.999218*	*0.998094*	*0.996924*
Governments									
State/Local									
Revenues (index)	1.000000	1.001188	1.001188	1.001188	1.001188	1.001188	1.001188	1.001188	1.001188
Expenditures (index)	1.000000	0.999639	0.999521	0.998611	0.998140	0.999415	0.999165	0.997719	0.997719
Net ($1,000)	0	14407	11805	55873	45636	14845	11920	57493	57493
Federal									
Revenues (index)	1.000000	0.999083	0.999083	0.999083	0.999083	0.999083	0.999083	0.999083	0.999083
Expenditures (index)	1.000000	0.999607	0.999470	0.998484	0.997935	0.999353	0.999061	0.997479	0.997479
Net ($1,000)	0	-5620	-8400	-21600	-32540	-6960	-11750	-27040	-27040
Region									
Gross State Product Change									
Total ($1,000)	NA	-47400	-69140	-182460	-268520	-67240	-107220	-261820	-421170
Percent	NA	-0.078	-0.113	-0.299	-0.441	-0.110	-0.176	-0.430	-0.691
Welfare Change ($1,000)									
Households	NA	-22180	-27977	-85967	-108576	-21039	-31871	-81962	-124710
Resource Migration	NA								
Labor									
Wage Compensation	NA	-12752	-17310	-49206	-67392	-21140	-30833	-82495	-121430
Other Resource Compensation	NA	-9240	-12813	-35564	-49721	-15307	-22811	-59508	-89479
Capital									
Capital Compensation	NA	0	-12220	0	-47575	0	-20358	0	-80241
Total	*NA*	*-21992*	*-42343*	*-84770*	*-164688*	*-36446*	*-74002*	*-142003*	*-291149*

Households remaining in-state have a welfare loss ranging from $21,039,000 to $31,871,000 with the 10 percent quality tax and from $81,962,000 to $124,710,000, with the 50 percent quality tax depending on sector assessed and whether short run or long run. Assessing the pollution tax to food processing compared to agriculture generates the least welfare loss in the short run, but the greatest welfare loss in the long run. Assessing the pollution tax in addition to the quality tax increases substantially welfare loss.

As with Group I scenarios, Group II scenarios show that high income households have the greatest total welfare loss and low income households have the lowest. With pollution tax assessed to agriculture, the per household welfare loss is highest for high income households and lowest for the low income households. However, when the pollution tax is assessed to food processing, the high income households have the highest per household welfare loss while the medium income households have the lowest. Income loss per household is consistent across both sectors in that the high income households have the greatest loss and low income households have the lowest.

The pollution tax assessed to industries is assumed collected by State/Local (S/L) government. This addition to revenue is presumed to be used to restore the quality of sport fishing. Total S/L government net revenue is positive but less than the amount collected as the pollution tax (and equal to the quality tax). Taking out the pollution tax revenue, the S/L government net losses with 50 percent quality tax are nearly four times the losses with the 10 percent quality tax. State/Local government losses with the long run equilibrium are twice that of the short run equilibrium. Federal government revenue losses with the long run equilibrium are about 150 percent higher than the short run equilibrium losses. Federal government losses are much greater than S/L government losses excluding the pollution tax revenue.

Decreases in GSP are substantially more with Group II scenarios compared to Group I. The pollution tax assessment has a substantial effect on decreasing GSP. The long run result from a 50 percent quality tax assessed to agriculture reduces GSP by $268,000,000 (Scenario SII-4) versus a reduction in GSP of $56,000,000 (Scenario SI-4) for the quality tax alone. The comparable amount for food processing is a reduction in GSP of $421,000,000.

Much of the loss in GSP is because of out-migration of labor and capital because of lower returns within the state compared to returns outside of the state. The out-migration of labor compensated at the external wage rate equals $67,000,000 for the 50 percent quality tax assessed to agriculture (Scenario SII-4) and $121,000,000 if assessed to food processing (Scenario SII-8). Other resource compensation associated with the migration of labor (households) equals $50,000,000 and $90,000,000, respectively. This later compensation is included in GSP but flows out of the region as factor payments because resource ownership no longer resides in the state.

Capital out-migration compensated at the external capital rent equals $48,000,000 for the 50 percent quality tax assessed to agriculture (Scenario SII-4) and $80,000,000 if assessed to food processing (Scenario SII-8). Total loss of resources to the region is about $165,000,000 for the agriculture scenario (SII-4) and $291,000,000 for the food processing scenario (SII-8). This represents resources not spent within the region but available to households that migrated from the region or accrued to households outside of the region because of higher capital returns.

Other reductions in GSP relate to lower returns to labor, capital, and land because of the effects of the quality tax on sport fishing trips and the pollution tax assessments to agriculture and food processing. These reductions in factor returns have a further multiplier effect through regional spending, all of which is captured in the general equilibrium model and are in the final GSP measurement.

Long Term Pollution Assessment Tax

Group III scenarios start from the premise that the quality tax cost generated from the long run models in Group I scenarios is the long term pollution assessment tax that should be charged to the potential polluting sectors. The logic of the argument may be stated in the following way. The reduced quality of sport fishing is reflected by the decrease in trip demand. In terms of reducing the number of trips, this is the equivalent of adding a quality tax of *qTax* per trip on the original trip price. The pollution assessment tax may be considered like a pollution abatement tax with the revenue used to restore the natural resource system to its original state. In the example applied here, it is not known if the quality tax would be exactly equal to an abatement tax that is sufficient to restore the original state of the natural resource system. The assumption here is that it is exactly the right amount.

A second alternative to consider is that the revenue from the pollution assessment tax could be used by the Oklahoma Department of Wildlife Conservation to create a substitute fishery that would leave anglers as well off as before the deterioration of the natural resource system because of pollution. An example of this is the cold water trout fishery established on the Mountain Fork River in southeastern Oklahoma when the natural fishery was destroyed because of the Broken Bow retention dam (see Choi, 1993). Anglers in this case are better off with the replacement fishery than with the original fishery.

A third alternative to consider is to use the pollution tax assessment to compensate anglers for the reduced quality of fishing in Oklahoma. Anglers may use this compensation to "purchase" more out-of-state sport fishing trips or any other recreation activity (or consumer good) which restores their lost utility from lower quality sport fishing in Oklahoma.

The total cost of the long run 10 percent unit quality tax from SI-2 (Table 5.2) is $16,761,000 and from the 50 percent unit quality tax (SI-4) is $64,909,000. Four long run equilibrium scenarios are created from these results and are presented in Table 5.5 as Group III scenarios. Scenarios SIII-1 and SIII-2 are pollution assessment taxes in agriculture. Scenario SIII-1 is a low tax rate corresponding to the 10 percent quality tax and is computed as the tax per unit of output in the base result needed to generate $16,761,000 revenue. This tax rate is 0.00358 per unit of agricultural output. Scenario SIII-2 is a high tax rate corresponding to the 50 percent quality tax. This tax rate is the amount needed to generate $64,909,000 revenue and equals 0.01387. Scenarios SIII-3 and SIII-4 are the corresponding low and high tax rates for the food processing sector and equal 0.00523 and 0.02024, respectively. These tax rates are the needed increases in net price per unit of base output (see equation 5.6) to generate the corresponding tax revenue. Therefore, multiplying the tax rate by 100 gives the tax rate as a percentage of output price for agriculture or food processing. The impacts of these tax rates on selected variables are presented in Table 5.5.

The regional and composite prices of resident and nonresident sport fishing trips differ from the base price only because of the overall decrease in prices due to the pollution tax assessments in agriculture and food processing and the corresponding decrease in regional aggregate demand. The net effect of the marginal decrease in resident trip price is a marginal decrease in total number of trips. The effect of a marginal decrease in nonresident price (export price) is a marginal increase in nonresident (export) trips. The high tax in agriculture increases number of nonresident trips by 2,000 and the high tax in food processing increases the number of nonresident trips by 3,000.

The effect on sector prices and sector outputs are very similar to the long run effects of Group II scenarios except prices and outputs did not decrease as much. This is to be expected because only the impacts of pollution tax assessments are included in Group III scenarios. The differences, however, are very marginal.

The resource use effects are very different between the Group I scenarios and Group II scenarios even though the quality tax cost in sport fishing trip demand of Group I scenarios is equal to the pollution tax assessment in Group III scenarios. In the latter, wage rates decrease more, labor demand decreases more, capital and land rents decrease more, and labor and capital migration increase more. In fact, labor migration more than doubles when the pollution tax is assessed to agriculture and it more than doubles again when assessed to food processing rather than agriculture.

TABLE 5.5

IMPACTS ON SELECTED VARIABLES FROM LONG TERM POLLUTION TAX ASSESSMENT ON POTENTIAL POLLUTING INDUSTRY IN OKLAHOMA, 1991

Impact Variable	Base	Group III			
		Agriculture		Food Processing	
		Low tax	High tax	Low tax	High tax
		SIII-1	SIII-2	SIII-3	SIII-4
Resident Trips					
Prices (index)					
Regional price	1.000000	0.999850	0.999427	0.999858	0.999491
Out-of-region price	1.000000	1.000000	1.000000	1.000000	1.000000
Composite price	1.000000	0.999884	0.999559	0.999891	0.999608
Number of trips (1,000)					
In-state	9411	9407	9396	9402	9378
Out-of-state	369	368	367	368	367
Total	*9780*	*9775*	*9764*	*9770*	*9745*
Non-Resident Trips					
Regional price (index)	1.000000	0.999807	0.999263	0.999659	0.998750
No. of trips (1,000)	1379	1379	1381	1380	1382
Selected Sector Results					
Total Sector Output (index)					
Weighted regional price	1.000000	0.999805	0.999261	0.999533	0.998304
Weighted output	1.000000	0.999467	0.997945	0.998884	0.995869
Agricultural Sector					
Prices (index)					
Regional price	1.000000	1.001495	1.005885	0.998136	0.996080
Composite price	1.000000	1.000891	1.003500	0.998891	0.995893
Quantity (index)	1.000000	0.990415	0.963158	0.994529	0.979582
Food Processing					
Prices (index)					
Regional price	1.000000	1.000036	1.000159	1.004853	1.018873
Composite price	1.000000	1.000009	1.000038	1.001147	1.004319
Quantity (index)	1.000000	0.998684	0.994864	0.975555	0.909552
Resource Use					
Labor					
Total Labor (index)	1.000000	0.998203	0.993145	0.998382	0.994015
Overall Wage Rate (index)	1.000000	0.999552	0.998245	0.999068	0.996308
Capital					
Quantity (index)	1.000000	0.999558	0.998309	0.999204	0.997059
Capital Rent (index)	1.000000	0.999515	0.998095	0.999114	0.996484
Land					
Quantity (index)	1.000000	1.000000	1.000000	1.000000	1.000000
Land Rent (index)	1.000000	0.981061	0.926277	0.988446	0.954092
Resource Migration					
Labor					
Number of Jobs	0	-570	-2183	-1150	-4247
Percent of Base (%)	NA	-0.041	-0.156	-0.084	-0.309
Capital					
Percent of Base (%)	NA	-0.044	-0.169	-0.080	-0.294

Impacts on selected institutional and welfare variables from long term pollution tax assessment are presented in Table 5.6. Comparisons will basically be made with Group I scenarios of Table 5.2. Group III scenarios have no quality tax on sport fishing because of the assumption that the quality of the fisheries has been restored. Only the long term effect of pollution tax assessment to agriculture and food processing is measured on institutional and welfare variables in Group III scenarios.

The welfare loss of households remaining in-state was substantially lower, in general, for Group III scenarios compared to Group I scenarios, especially for low income households. The exception was for high income households for food processing. In this case, welfare loss for high income households was greater. However, total household welfare loss was less in Group III scenarios compared to Group I scenarios. The pollution tax assessed to agriculture generated lower losses in welfare compared to the tax assessed to food processing.

As in Group II scenarios, the exogenous tax assessed to potential polluting industries is collected by State/Local (S/L) government. The net increase in S/L government revenue over S/L government expenditure is less than the revenue from pollution tax assessment because of the overall decrease in output of the regional economy. The low tax generates about $16,761,000 S/L government revenue and the high tax generates about $64,909,000. The losses of Federal government revenue over expenditure are substantial because of the overall decrease in output of the regional economy.

TABLE 5.6

IMPACTS ON SELECTED INSTITUTIONAL AND WELFARE VARIABLES FROM LONG TERM POLLUTION TAX ASSESSMENT ON POTENTIAL POLLUTING INDUSTRY IN OKLAHOMA, 1991

Institution	Base	Agriculture		Food Processing	
		Low tax	High tax	Low tax	High tax
		SIII-1	SIII-2	SIII-3	SIII-4
Households					
Welfare Change - Households					
Total ($1,000)					
Low income (<$20,000)	NA	-92	-355	-849	-3199
Medium income ($20,000-$40,000)	NA	-3607	-13658	-3260	-12112
High income (>$40,000)	NA	-7617	-28985	-10847	-39964
Total	*NA*	*-11315*	*-42998*	*-14956*	*-55275*
Per Household (index)					
Low income (<$20,000)	1.000000	0.999991	0.999964	0.999914	0.999674
Medium income ($20,000-$40,000)	1.000000	0.999849	0.999426	0.999863	0.999490
High income (>$40,000)	1.000000	0.999520	0.998170	0.999316	0.997473
Total	*1.000000*	*0.999771*	*0.999131*	*0.999698*	*0.998881*
Income Change Per Household (index)					
Low income (<$20,000)	1.000000	0.999808	0.999266	0.999637	0.998662
Medium income ($20,000-$40,000)	1.000000	0.999634	0.998606	0.999523	0.998242
High income (>$40,000)	1.000000	0.999237	0.997091	0.998809	0.995609
Total	*1.000000*	*0.999542*	*0.998252*	*0.999317*	*0.997482*
Governments					
State/Local					
Revenues (index)	1.000000	1.001074	1.003999	1.000724	1.002528
Expenditures (index)	1.000000	0.999661	0.998703	0.999318	0.997484
Net ($1,000)	0	13150	49272	13076	46923
Federal					
Revenues (index)	1.000000	0.998995	0.996160	0.998306	0.993756
Expenditures (index)	1.000000	0.999621	0.998549	0.999228	0.997152
Net ($1,000)	0	-6710	-25630	-9890	-36440
Region					
Gross State Product Change					
Total ($1,000)	NA	-53700	-205180	-90060	-332200
Percent	NA	-0.088	-0.337	-0.148	-0.545
Welfare Change ($1,000)					
Households	NA	-11315	-42998	-14956	-55275
Resource Migration					
Labor					
Wage Compensation	NA	-12403	-47506	-25415	-93861
Other Resource Compensation	NA	-8975	-34314	-18398	-65846
Capital					
Capital Compensation	NA	-9727	-37224	-17523	-64746
Total	*NA*	*-31105*	*-119044*	*-61336*	*-224454*

GSP decreases substantially more with the exogenous pollution tax assessments of Group III scenarios compared to the quality tax of Group I scenarios. Assessing the exogenous tax to food processing results in higher decreases in GSP compared to assessing the tax to agriculture.

Resource migration out-of-region may be considered as an important loss to the region. The loss in labor compensation is $12,403,000 and $25,415,000 for scenarios SIII-1 and SIII-3, respectively, with low tax assessment. With high tax assessment the labor compensation losses are $47,506,000 and $93,861,000 for scenarios SIII-2 and SIII-4, respectively.

Loss in other resource compensation is $8,975,000 (SIII-1) and $18,398,000 (SIII-3) with low tax assessment. With high tax assessment the other resource compensation loss is $34,314,000 (SIII-2) and $65,846,000 (SIII-4). Tax assessment encourages capital migration with a compensation of $9,727,000 (SIII-1) and $17,523,000 (SIII-3) for low tax and $37,224,000 (SIII-2) and $64,746,000 (SIII-4) for high tax.

The important distinction between Group I scenarios and Group III scenarios are the differences in welfare losses of households compared to GSP losses. Group I scenarios with the quality tax show greater household welfare losses compared to Group III scenarios with the pollution tax assessments. However, Group III scenarios show a greater loss in GSP compared to Group I scenarios.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary

Recreational angler expenditures have become a significant source of income for some regional economies. Angler expenditures include spending at sporting goods stores, bait shops, specialties fishing stores, hotels and motels, fishing lodges and camps, guide services, retail food stores, and restaurants. These expenditures have direct and trickle down effects to earnings and welfare of a region's residents.

That most sport fishing expenditures occur in rural areas is potentially a boon for rural development. It is, however, also important to understanding how an individual industry, in particular agriculture, is affected. Agriculture is the basic industry for many rural areas. Agriculture and sport fishing activities compete for factor use, in particular land, water, and labor. The overall implication of expansion of sport fishing activities versus agriculture or other related industry is an important policy concern.

Natural resource systems provide valuable services in support of sport fishing activities. The characteristics of the natural resource systems that determine economic value can be affected by air and water pollution and by resource management decisions such as the allocation of water flows between diversionary uses and various instream uses. Agricultural production involves the flows of large amounts of water. Boosting agricultural production by applying more fertilizer and other chemical products could substantially affect the quality of water in natural resource systems. This result may negatively impact the quality of natural resource systems for sport fishing purposes, which in turn may diminish recreational activities.

Objective of the Study

The objective of this study is to develop a computable general equilibrium (CGE) model for Oklahoma that facilitates analysis and evaluation of welfare change from expansion or reduction from sport fishing activities because of changes in the natural resource system. A quality tax on sport fishing is imposed to reflect changes in the natural resource system. An off-setting pollution tax is assessed potential polluting industries to measure comparable pollution costs. The CGE framework is employed to obtain general equilibrium results in the region economy. The model distinguishes between market and nonmarket goods, domestic and imported goods, and regional domestic supply and export. Evaluation of the results is in terms of changes in welfare of households by income class size, changes in gross state product (GSP), migration of labor and capital resources, and other impact variables.

Procedure

To achieve the objective, a CGE model for Oklahoma was specified. A social accounting matrix (SAM) for Oklahoma was constructed based on 1991 data sets. The data sources included IMPLAN, and results of a national survey on angler expenditures published by the Sport Fishing Institute. The production side of the economy was aggregated into 14 sectors of market goods. There were two sectors of nonmarket goods, namely, Oklahoma resident and nonresident sport fishing. Thus a total of 16 production sectors were modeled. Value-added inputs were labor, capital, and land, with labor further sub-divided into five skill types (or occupational categories). Production was characterized by three-level nesting to allow flexibility in modeling behavioral features at different levels of production. At the first level, the Leontief input-output production function was used for a composite of primary and a composite of intermediate inputs. The second level is the production technology for primary factors, and intermediate inputs. Primary factors are described by a neoclassical production function represented by the Cobb-Douglas (C-D) functional form to capture smooth substitution among primary factors of labor, capital, and land. Intermediate goods are represented by the Leontief production function although substitution between domestic and imported intermediate inputs is represented by the constant elasticity of substitution (CES) production function. At the third level, a CES production function allowed substitution between different skills of labor. Maximizing behavior was represented by a set of factor demand equations, a set of intermediate input demand equations, and a set of labor demand by skill equations.

The output supply produced by industry in the region may be transformed into an export or sold in the regional market. A constant elasticity of transformation (CET) function was adopted to determine the levels of output exported and sold in the region. Each firm producing market goods maximizes profits subject to the CET function for output, given prices in the regional and export markets. For nonmarket goods, sport fishing resident trips were only consumed in the region and nonresident trips were all exported. The export demand for nonresident trips was a function of price and price elasticity of export demand.

There were three institutional accounts: enterprise, household, and government. The household sector was sub-divided into low, medium, and high income classes. Household preferences, including the labor-leisure choice, were assumed to be represented by a Stone-Geary utility maximizing function subject to full income. This results in a demand system of the linear expenditure system form (LES). Household labor supply was endogenously defined by the labor-leisure choice and labor migration.

Total income by household group included factor income (labor, capital, and land), state/local government transfer, federal government transfer, and net remittances from rest of world. Households in the region consumed market and nonmarket goods. There was no regional nonmarket good demand for nonresident trips. The regional consumption by households was nested in two levels. At the first level, with the LES function, households maximized utility in the consumption of a composite of market and nonmarket goods and the demand for leisure (or supply of labor) subject to budget constraints and prices. At the second level, households chose optimal combinations of imported and locally produced goods according to pre-specified constant elasticities of substitution and relative prices in the CES functional form

The government sector was sub-divided into state/local, and federal. Capital account captured financial transactions. The last account was rest of world. Governments consumed market goods only, and, like households, optimized the allocation of expenditures between imported and regional commodities given relative prices and substitution possibilities. The level of consumption was exogenously given. Governments also collected taxes and provided transfers to households. Total savings included household savings, depreciation and retained earnings, and exogenous savings from rest of world. Capital expenditures included regional and imported investment good demands. The investment demand substitution between regional and imported goods followed a CES functional form.

The change in household welfare in the region was measured by compensating variation (CV) consistent with the linear expenditure demand system. The CV measure estimates in money terms the amount households would require as compensation to remain as well off after an exogenous shock as they are before the shock. The change in resident and nonresident sport fishing trips because of changes in the natural resource system was measured and analyzed.

The model was calibrated to the 1991 base SAM of Oklahoma. The Oklahoma economy was assumed to be in equilibrium at the base SAM. This assured that changes in the solution by imposing policy experiments were measured relative to the base SAM. The CGE model was then used to examine different policy simulations.

The policy alternatives were based primarily on two levels of quality tax (10 percent and 50 percent) which affected sport fishing in short run and long run equilibrium. Model experiments focused on trip demands. Three groups of scenarios were carried out in the study: (1) quality tax imposed on sport fishing, (2) quality tax imposed on sport fishing and pollution tax assessed to potential polluting industries, and (3) long term pollution assessment tax on potential polluting industries.

Results

Quality tax imposed on sport fishing. The regional price of resident and nonresident trips increases because of the quality tax. The total number of resident trips decreases because of the quality tax and subsequent increase in composite price. For the short run analysis, the 10 percent quality tax increases composite price by 7.3 percent, reduces resident in-state trips from 9,411,000 to 7,877,000 (16.3 percent), and increases resident out-of-state trips from 369,000 to 411,000 (11.4 percent). The number of total trips decreases from 9,780,000 to 8,288,000 (15.3 percent).

With a quality tax of 50 percent, composite price increases by about 30 percent, total resident trips decreases by 48.7 percent (from 9,780,000 to 5,012,000), resident in-state trips decrease by 53.0 percent (from 9,411,000 to 4,427,000), and out-of-state resident trips increase by 58.6 percent (from 369,000 to 585,000).

With a 10 percent unit cost quality tax regional price for nonresident trips increases slightly less than 10 percent and number of trips decreases from 1,379,000 to

1,187,000 (13.9 percent). With a 50 percent quality tax, number of trips decreases from 1,379,000 to 728,000 (47.2 percent).

Regional labor demand (number of jobs plus work time) decreases marginally with the quality tax. Wage rates in labor skills managerial (skill 1), farming (skill 4), and production (skill 5) decrease slightly less than the overall average wage, whereas wage rates for labor skills technical (skill 2) and services (skill 3) decrease slightly more than the overall average. Long run wage rates decrease marginally less compared to short run wage rates.

The change in overall wage rate is slightly more than the change in total labor use. The reductions in labor use and wage rates are greater with the 50 percent quality tax compared to the 10 percent quality tax. Labor out-migration is about 216 jobs with the 10 percent quality tax and about 816 jobs with the 50 percent quality tax. The long run results are slightly less at 214 and 810, respectively. Labor out-migration as a percent of the base number of jobs is 0.016 percent for the 10 percent quality tax and 0.06 percent for the 50 percent quality tax.

In the short run, capital is fixed by sector and hence capital rents vary by sector. Capital rents increase for agriculture, mining, printing and other manufacturing and decrease for all other sectors. Long run equilibrium results in capital out-migration equal to 0.011 percent of the base amount with the 10 percent quality tax, and by 0.041 percent with the 50 percent quality tax. The overall reduction in capital rent is less for the long run simulations compared to the short run simulations. Agricultural land supply is fixed in the short run and long run. Land rent increases in the short run and decreases in the long run compared to the base.

In the short run equilibrium, the quality tax cost to resident anglers for in-state trips is the equivalent of $14,791,000 ($23.73 per angler) at the 10 percent quality tax, and $56,688,000 ($90.95 per angler) at the 50 percent quality tax. The increase cost per trip for the 10 percent quality tax is $1.71 and $8.54 for the 50 percent quality tax. Nonresident anglers pay the equivalent of $1,962,000 quality tax ($10.87 per angler) and $8,204,000 tax ($45.47 per angler), in short run equilibrium, with the 10 percent and 50 percent quality tax, respectively. The increased cost per trip for 10 percent quality tax is $1.50 and $7.52 for the 50 percent quality tax.

Households remaining in-state have a welfare loss equal to $15,174,000 and $16,556,000 for the short run and long run models, respectively, with the 10 percent quality tax and a loss equal to $58,914,000 and $64,070,000 for the short run and long run models, respectively, with the 50 percent quality tax. The income loss per household is less than the welfare loss per household. In the case of a 10 percent quality tax and the short run, the overall income loss per household is 0.013 percent of the base amount whereas the welfare loss per household is 0.031 percent.

Government revenues and expenditures decrease with a unit quality tax imposed on resident and nonresident trips. At the 50 percent quality tax, the government net losses are more than three times higher than at the 10 percent quality tax. Overall results show that losses with the long run equilibrium are higher than with the short run equilibrium.

Federal government net losses are higher than State/Local government net losses in all scenarios.

GSP decreases because of the quality tax. Short run equilibrium GSP decreases by $13,450,000 (0.022 percent) with a 10 percent unit quality tax, and by $50,280,000 (0.083 percent) with a 50 percent unit quality tax. Long run equilibrium results show slightly higher changes.

Out-migration of labor compensated at the out-of-region wage rate ranges from $4,815,000 to $18,233,000 depending on level of quality tax and whether short run or long run equilibrium. The value of the compensation for resources owned by migrating households ranges from $3,577,000 to $13,490,000, depending again on the scenario.

Long run models show capital out-flow from the region with a compensation equal to $2,395,000 under a 10 percent quality tax, and $8,927,000 under a 50 percent quality tax.

Quality tax assessed to sport fishing and pollution assessed to agriculture and food processing. The overall impact is a significant reduction in aggregate demand for the state, significant increase in out-migration of resources, substantial loses in household welfare, and substantial decreases in gross state product.

Long run regional agricultural price increased by 0.14 percent with the 10 percent quality tax and by 0.59 percent with the 50 percent quality tax. Agricultural output decreased by 0.97 percent and by 3.83 percent, respectively, for the same scenarios. When the pollution tax was assessed to food processing, price increased by 0.25 percent in the long run model for the 10 percent quality tax and by 2.07 percent for the 50 percent quality tax. For the same scenarios, output of the food processing sector decreased by 2.56 percent and 10.15 percent, respectively. The impact of the pollution tax was much greater on the food processing sector compared to the impact on the agricultural sector.

With a 10 percent quality tax, the short run model showed a job loss of 216 compared to a job loss of 583 for the same 10 percent quality tax but also with a pollution assessment tax in agriculture equal to the cost of the quality tax. The long run model results were a loss of 214 jobs compared to 790 jobs. The long run models showed an increase in out-migration from 790 in agriculture to 953 for food processing with the 10 percent quality tax. With the 50 percent quality tax, labor out-migration was 3,076 when assessing the pollution tax to agriculture versus a labor out-migration of 5,486 when assessing the pollution tax to food processing. The latter result represents a 0.4 percent reduction in the total state labor force.

The pollution tax reduced capital and land rents in the long run equilibrium. Under the 10 percent quality tax scenario, capital rent was reduced by 0.06 percent when the pollution tax was assessed to agriculture. With the 50 percent quality tax scenario, capital rent was reduced by 0.24 percent. When the pollution tax was assessed to food processing, the same comparisons were 0.10 percent and 0.40 percent. The capital base was reduced by 0.06 with the 10 percent quality tax and by 0.22 percent with the 50 percent quality tax when the pollution tax was assessed to agriculture, and by 0.09 and 0.36 percent when the pollution tax was assessed to food processing for the same scenarios.

Households remaining in-state had a welfare loss ranging from $21,039,000 to $31,891,000 with the 10 percent quality tax and from $81,962,000 to $124,710,000, with the 50 percent quality tax depending on scenario.

With the short run equilibrium, GSP decreased by 0.08 and 0.11 percent with a 10 percent unit quality tax assessed to agriculture and food processing, respectively. The results were 0.30 and 0.43 percent with a 50 percent unit quality tax for the same two industries. Long run equilibrium results showed higher changes ranging from 0.11 to 0.69 percent depending on quality tax level and potential polluting industry.

Long term pollution assessment tax on agriculture and food processing. The regional and composite prices of resident and nonresident trips differed from the base price only because of the overall decrease in prices due to the pollution tax assessments in agriculture and food processing and the corresponding decrease in regional aggregate demand. The net effect of the marginal decrease in resident trip price was a marginal decrease in total number of trips.

The effect on sector prices and sector outputs for the potential polluting sectors were very similar to the long run effects of the Group II scenarios. The resource use effects were very different between the Group I scenarios and Group III scenarios even though the quality tax cost in sport fishing trip demand of the Group I scenarios was equal to the pollution tax assessment in the Group III scenarios. In the latter, wage rates decreased more, labor demand decreased more, capital and land rents decreased more, and labor and capital migration increased more. In fact, labor migration more than doubled when the pollution tax was assessed to agriculture and it more than doubled again when assessed to the food processing sector rather than agriculture.

The welfare loss of households remaining in-state was substantially lower in general for Group III scenarios compared to Group I scenarios, especially for low income households, with the exception of high income households for food processing. In this case, welfare loss for high income households was greater. However, total household welfare loss was less in Group III scenarios compared to Group I scenarios. The pollution tax assessed to agriculture generated lower losses in welfare compared to the tax assessed to food processing.

The net increase in S/L government revenue over S/L government expenditure was less than the revenue from the pollution tax assessment. The low tax generated about $16,761,000 S/L government revenue and the high tax generated about $64,909,000.

GSP decreased substantially more with the exogenous pollution tax assessments of Group III scenarios compared to the quality tax of Group I scenarios. Assessing the exogenous tax to food processing resulted in higher decreases in GSP compared to assessing the tax to agriculture.

Resource out-migration may be considered an important loss to the region. The loss in labor compensation for low tax rate ranged from $12,403,000 for agriculture to $25,415,000 for food processing. With the high tax assessment, labor compensation losses ranged from $47,506,000 for agriculture to $93,861,000 for food processing.

Loss in other resource compensation ranged from $8,975,000 to $18,398,000 with low tax assessment depending on sector assessed. With the high tax assessment the other resource compensation losses ranged from $37,224,000 to $64,746,000. Low tax assessment encouraged capital migration with a compensation ranging from $9,727,000 to $17,523,000 depending on sector assessed and from $37,224,000 to $64,746,000 for the high tax assessment.

The important distinction between Group I scenarios and Group III scenarios were the differences in welfare losses of households compared to GSP losses. Group I scenarios with the quality tax showed greater household welfare losses compared to Group III scenarios with the pollution tax assessments. However, Group III scenarios showed a greater loss in GSP compared to Group I scenarios.

Conclusions

It was shown using the CGE framework that significant impacts occur in the Oklahoma economy as a result of imposing a quality tax and/or assessing a pollution tax. In particular, new equilibria in prices emerge leading to a reallocation of resources toward sectors where there is scope for import substitution and export expansion. Reduced commodity prices and factor rents reduces incomes. It was shown in the model results that household incomes and government revenues were reduced with the existence of pollution. More specifically, imposing a quality tax on sport fishing increased regional trip prices which in turn increased composite prices causing significant reductions in resident and nonresident trips in Oklahoma. The long term tax assessment on polluting industries is a burden to the industries. The changes in net prices to the potential polluting industries include increased output prices of those industries because of the increase in production cost, and reduced in wage rates and capital rents. The model results explained above are potential losses to the Oklahoma economy. Such losses include labor and capital out-migration, decrease in household welfare, and decrease of gross state product.

Limitations of the Study

The results and conclusions of the study are limited by the accuracy of the data and assumptions used. The first concern is the adoption of exogenous parameters in the study. Exogenous parameters were obtained from previous research which mainly represented national economies. This regional study, dissaggregated into fourteen sectors of market goods and two sectors of nonmarket goods, used common exogenous parameters instead of sector specific parameters. Moreover, labor migration by skill and capital migration was assumed to have the same elasticity. Future empirical research on the estimation of dissaggregated parameters for regional general equilibrium model is desired.

The SAM generated from IMPLAN is not as detailed as needed in this study. Complete data and information to build an Oklahoma SAM was not available. Therefore, adjustments were made to balance the Oklahoma SAM.

The study experiment on the impact of a quality change on sport fishing was represented by imposing a unit tax, by means of increasing the price per trip. Industries assessed the pollution costs were taxed such that the costs were equallized. This method of imposing a pollution cost may not be desirable but it was the best option available because of data limitations. Future studies need to estimate the level of pollution by specific industry which causes the quality change in the natural resource system. Once the empirical estimation is available, an optimal tax may be estimated and applied to the model.

This study considered only trip expenditures, while sport fishing expenditures also include equipment and other expenditures. The reason for not including equipment and other expenditures is that such expenditures relate to purchases of durable goods and not necessarily to anlger trips. Hence, results of this study are not directly comparable to the study by Fedler and Nickum. Further research to include all sport fishing expenditures is desirable.

Theoretical assumptions behind the regional general equilibrium model in this study need further analysis and perhaps model modification. For example, when labor is differentiated by skill, the question of whether labor or households migrate is a critical assumption. This study assumed labor by skill migrated.

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APPENDIX A

INDICES, VARIABLES, AND EQUATIONS

APPENDIX TABLE A.1.

DEFINITIONS OF INDICES, VARIABLES, AND PARAMETERS

Indices	Description	
I,J	*Sectors: 1Agr, 2Min, 3Ptr, 4Cnst, 5Food, 6Text, 7Pprt, 8Oman, 9Tran, 10Trd, 11Fin, 12Htl, 13Eat, 14Ser, 15Rest, and 16Nres.*	
F	*Factors of production: Lab (L), Cap (K), and Land (L).*	
S	*Labor skill: Managerial (L_1), Technical (L_2), Services (L_3), Farming (L_4), Production (L_5).*	
H	*Households: Low, Med, and High.*	
G	*governments: SL, and FED.*	
M	*Set of market goods: 1Agr, 2Min, 3Ptr, 4Cnst, 5Food, 6Text, 7Pprt, 8Oman, 9Tran, 10Trd, 11Fin, 12Htl, 13Eat, and 14Ser..*	
NM	*Set of nonmarket goods: 15Rest, and 16Nres.*	
NR	*Nonmarket good: Resident trip (15Rest).*	
NE	*Nonmarket good: Nonresident trip (16Nres).*	
CI,CJ	*Sectors: 1Agr, 2Min, 3Ptr, 4Cnst, 5Food, 6Text, 7Pprt, 8Oman, 9Tran, 10Trd, 11Fin, 12Htl, 13Eat, 14Ser, and 15Rest.*	
n	*Number of sectors* = 16.	
m	*Number of market good sectors* = 14.	
nr	*Number of nonmarket good consumed in the region* = 1.	
ne	*Number of nonmarket good exported* = 1.	
h	*Number of household income size* = 3.	
s	*Number of labor skill* = 5.	
Variables	**Description**	**No of Variables**
PRODUCTION BLOCK		
X_i	*Composite good supply*	*n*
VA_i	*Value added*	*m*
L_i	*Labor demand*	*m*
K_i	*Capital demand*	*m*
T_i	*Land demand*	*m*
LD_{is}	*Labor demand by skill*	*m* x *s*
$LDemS_s$	*Industry demand for labor skill*	*s*
V_{ji}	*Intermediate demand*	*n* x *m*
VM_i	*Imported intermediate input demand*	*n* x *m*
VR_{ji}	*Regional intermediate input demand*	*n* x *m*
TVM_i	*Total imported intermediate input demand*	*m*
TVR_i	*Total regional intermediate input demand*	*m*
TV_i	*Total composite intermediate input demand*	*m*
EXP_i	*Export of regional products*	*n*
R_i	*Regional supply of regional products*	*n*
INCOME BLOCK		
$LHHH0_s$	*Labor employed by households*	*s*
$LSL0_s$	*Labor employed by State/Local government*	*s*
$LFED0_s$	*Labor employed by Federal government*	*s*
$LExo0_s$	*Exogenous demand for labor*	*s*
KS0	*Supply of private capital*	1
TS0	*Supply of land*	1
YLS_s	*Labor income by skill*	*s*
YL	*Total labor income*	1
YK	*Capital income*	1
YAGK	*Agricultural capital income*	1

APPENDIX TABLE A.1. (Continued)

DEFINITIONS OF INDICES, VARIABLES, AND PARAMETERS

Variables	Description	No of Variables
YENT	*Nonagricultural capital or enterprise income*	1
YT	*Land income*	1
NYL	*Labor income net tax*	1
NYAGK	*Agricultural capital income net tax and depreciation*	1
NYENT	*Enterprise income net tax, depreciation, and retained earnings*	1
NYT	*Land income net tax*	1
YLH_h	*Household labor income*	*h*
YFH_h	*Household factor income*	*h*
YH_h	*Household income*	*h*
DYH_h	*Disposable household income*	*h*
$HSAV_h$	*Household saving*	*h*
$LSupH_h$	*Labor supply by household*	*h*
$LSupH0_h$	*Initial labor supply by household*	*h*
$LSupHS_{hs}$	*Labor supply by household and by skill*	*h* x *s*
$LSupHS0_{hs}$	*Initial labor supply by household and by skill*	*h* x *s*
$LSupS_s$	*Labor supply by skill*	*s*
$LSupS0_s$	*Initial labor supply by skill*	*s*
$LMIG_s$	*Labor migration by skill*	*s*
$LMigH_h$	*Labor migration by household*	*h*
KMIG	*Capital migration*	1
$TRSL0_h$	*State/Local gov transfer payment to households*	*h*
$TRFed0_h$	*Federal Government transfer payment to households*	*h*
$REMIT0_h$	*Net remittance from rest-of-country to households*	*h*
YSL	*State/Local Government revenue/income*	1
YFED	*Federal Government revenue/income*	1
GSP	*Gross State Product*	1
EXPENDITURE BLOCK		
$HEXP_h$	*Household expenditure*	*h*
Q_{ih}	*Composite demand for private consumption*	*h* x *n*
QR_{ih}	*Regional demand for consumption*	*h* x *n*
QM_{ih}	*Imported demand for consumption*	*h* x *n*
TQ_i	*Total demand for composite consumption*	*n*
TQR_i	*Total regional demand for consumption*	*n*
TQM_i	*Total imported demand for consumption*	*n*
SLEXP	*State/Local Government expenditure*	1
$QSLR_i$	*State/Local Government demand for regional good*	*m*
$QSLM_i$	*State/Local Government demand for imported good*	*m*
$QSL0_i$	*Commodity demand by State/Local Government*	*m*
FEDEXP	*Federal Government expenditure*	1
$QFEDR_i$	*Federal Government demand for regional good*	*m*
$QFEDM_i$	*Federal Government demand for imported good*	*m*
$FEDQ0_i$	*Commodity demand by Federal Government*	*m*
SAV	*Total savings*	1
INV	*Total investment*	1
$QINVR_i$	*Investment demand for regional good*	*m*
$QINVM_i$	*Investment demand for imported good*	*m*
$QINV0_i$	*Investment demand*	*m*

APPENDIX TABLE A.1. (Continued)

DEFINITIONS OF INDICES, VARIABLES, AND PARAMETERS

Variables	Description	No of Variables
M_i	*Import*	n
EXP_i	*Export*	n
PRICE BLOCK		
PLM_i	*Composite wage rate paid by industry*	m
PLH_h	*Composite wage rate paid to household*	h
PL	*Aggregate wage rate*	1
PN_i	*Net price*	n
P_i	*Price of composite good*	n
PR_i	*Regional sales price*	n
PE_i	*Regional price of exports*	n
$PM0_i$	*Import price*	n
PLS_s	*Wage rate by labor skill*	s
PL_s^{ROC0}	*Wage rate of rest-of country*	s
PK_i	*Price of a unit of capital*	m
PT_i	*Land rent*	m
Total number of variables = $13n+19m+11s+(mxs)+3(nxm)+13h+2(hxs)+3(hxn)+19$		

Parameters	Description	No of Parameters
a_{0i}	*Value added requirement per unit of output*	m
a_{ji}	*Intermediate input requirement per unit of output*	n x m
ϕ_i^{VA}	*Production (value added) function shift parameter*	m
α_i^L,	*Labor share parameter in production function*	m
α_i^K,	*Capital share parameter in production function*	m
α_i^T,	*Land share parameter in production function*	m
ϕ_i^{LAB}	*Labor demand function shift parameter*	m
δ_{is}^{LAB}	*CES function share parameter for labor skill*	m
σ_i^{LAB}	*Elasticity of transformation*	m
ρ_i^{LAB}	*CES function exponent for labor demand by skill*	m
ϕ_{ji}^V	*Intermediate input demand efficiency parameter*	m
δ_{ji}^V	*CES intermediate input demand function share parameter*	m^2
σ_i^V	*Elasticity of substitution for intermediate demand*	m
ρ_i^V	*CES function exponent for intermediate demand*	m
ϕ_i^X	*Supply function shift parameter*	m
δ_i^X	*CET function share parameter*	m
σ_i^X	*Elasticity of transformation*	m
ρ_i^X	*CET function exponent*	m
η_s^L	*Labor migration elasticity*	s
η^K	*Capital migration elasticity*	1
ε^{trip}	*Elasticity of export demand*	1
$adjL_h$	*Labor adjustment coefficient by household groups*	h
depr	*Depreciation rate of agricultural capital*	1
retr	*Depreciation rate and retained earnings of enterprise income*	1
sstax	*Labor income tax rate*	1
ktax	*Capital income tax rate*	1
ttax	*Land income tax rate*	1
$hhtax_h$	*Household income tax rate*	h
$ibtax_i$	*Indirect business tax*	m

APPENDIX TABLE A.1. (Continued)

DEFINITIONS OF INDICES, VARIABLES, AND PARAMETERS

Parameters	Description	No of Parameters
mps_h	*Household saving rate*	h
l_h	*Labor income distribution coefficient to household groups*	h
k_h	*Capital income distribution coefficient to household groups*	h
t_h	*Land income distribution coefficient to household groups*	h
e_h	*Enterprise profit distribution coefficient to household groups*	h
γ_{ih}	*Minimum requirement of commodity consumption*	n
β_{0h}	*Marginal budget share for leisure*	h
β_{ih}	*Marginal budget share for commodity*	$h \times n$
ϕ_i^Q	*CES household demand function shift parameter*	n
δ_i^Q	*CES household demand function share parameter*	n
σ_i^Q	*Elasticity of substitution for household commodity demand*	n
ρ_i^Q	*CES household demand function exponent*	n
sl^{IBT}	*State/Local gov proportion for indirect business tax*	1
sl^{SST}	*State/Local gov proportion for labor tax*	1
sl^{KTT}	*State/Local government proportion for capital tax*	1
sl^{TTT}	*State/Local government proportion for land tax*	1
sl^{HHT}	*State/Local gov proportion for household income tax*	1
ϕ_i^{SL}	*CES State/Local gov demand function shift parameter*	m
δ_i^{SL}	*CES State/Local gov demand function share parameter*	m
σ_i^{SL}	*Elasticity of subs for State/Local gov comm demand*	m
ρ_i^{SL}	*CES State/Local gov demand function exponent*	m
fed^{IBT}	*Federal government proportion for indirect business tax*	1
fed^{SST}	*Federal government proportion for labor tax*	1
fed^{KTT}	*Federal government proportion for capital tax*	1
fed^{TTT}	*Federal government proportion for land tax*	1
fed^{HHT}	*Federal government proportion for household income tax*	1
ϕ_i^{FED}	*CES Federal gov demand function shift parameter*	m
δ_i^{FED}	*CES Federal gov demand function share parameter*	m
σ_i^{FED}	*Elasticity of substitution for Federal gov commodity demand*	m
ρ_i^{FED}	*CES Federal gov demand function exponent*	m
ϕ_i^{INV}	*CES investment gov demand function shift parameter*	m
δ_i^{INV}	*CES investment gov demand function share parameter*	m
σ_i^{INV}	*Elasticity of subs for investment gov commodity demand*	m
ρ_i^{INV}	*CES investment gov demand function exponent*	m
$qTax$	*Quality tax*	1
$pTax_i$	*Pollution assessment tax*	n
Total number of parameters = $6n+29m+s+(nxm)+m^2+2(hxn)+2h+18$		

APPENDIX TABLE A.2.

OKLAHOMA MARKET AND NONMARKET GOODS GENERAL EQUILIBRIUM MODEL

Equation	Description	No of Equations	Endogenous Variables	Exogenous Variables	Parameters
PRODUCTION BLOCK					
1. $LAB_i = \dfrac{\alpha_i^L PN_i X_i}{PL}$, $i \in M$	*Labor demand*	*m*	LAB_i PN_i PL X_i		α_i^L
2. $CAP_i = \dfrac{\alpha_i^K PN_i X_i}{PK_i}$, $i \in M$	*Capital demand*	*m*	CAP_i PN_i PK_i X_i		α_i^K
3. $LAND_i = \dfrac{\alpha_i^T PN_i X_i}{PT_i}$, $i \in M$	*Land demand*	*m*	$LAND_i$ PN_i PT_i X_i		α_i^T
4. $VA_i = a_{0i} X_i$, $i \in M$	*Value added*	*m*	VA_i X_i		a_{0i}
5. $V_{ji} = a_{ji} X_i$, $i \in M, NM; j \in M$	*Intermediate demand*	*n* x *m*	V_{ji} X_i		a_{ji}
6. $VA_i = \phi_i^{VA} LAB_i^{\alpha_i^L} CAP_i^{\alpha_i^K} LAND_i^{\alpha_i^T}$, $i \in M$	*Value added production function*	*m*	VA_i LAB_i CAP_i $LAND_i$		ϕ_i^{VA} α_i^L α_i^K α_i^T
7. $LAB_i = \phi_i^{LAB}\left[\sum_s \delta_{is}^{LAB} LD_{is}^{\rho_i^{LAB}}\right]^{\frac{1}{\rho_i^{LAB}}}$, $\sigma_i^{LAB} = \dfrac{1}{1-\rho_i^{LAB}}$, $i \in M$	*CES function for labor demand*	*m*	LAB_i LD_{is}		ϕ_i^{LAB} δ_{is}^{LAB} ρ_i^{LAB} σ_i^{LAB}

APPENDIX TABLE A.2. (Continued)

OKLAHOMA MARKET AND NONMARKET GOODS GENERAL EQUILIBRIUM MODEL

Equation	Description	No of Equations	Endogenous Variables	Exogenous Variables	Parameters
8. $LD_{is} = \frac{LAB_i}{\phi_i^{LAB}} \left[\sum_s \delta_{it}^{LAB} \left(\frac{PLS_s}{PLS_t} \frac{\delta_{it}^{LAB}}{\delta_{is}^{LAB}} \right)^{\rho_i^{LAB} / (1-\rho_i^{LAB})} \right]^{\frac{1}{\rho_i^{LAB}}}$, $i \in M$	*Labor demand by skill*	$m \times s$	LAB_i LD_{is} PLS_s		ϕ_i^{LAB} δ_{is}^{LAB} ρ_i^{LAB}
9. $V_{ji} = \phi_{ji}^V \left[\delta_{ji}^V VM_{ji}^{\rho_j^V} + \left(1-\delta_{ji}^V\right) VR_{ji}^{\rho_j^V} \right]^{\frac{1}{\rho_j^V}}, \sigma_j^V = \frac{1}{1-\rho_j^V}$, $i \in M, NM;\ j \in M$,	*Domestic and import substitution*	$n \times m$	V_{ji} VM_{ji} VR_{ji}		ϕ_{ji}^V δ_{ji}^V ρ_j^V σ_j^V
10. $TV_i = \sum_j V_{ij}$, $i \in M, NM; j \in M$	*Total intermediate demand*	n	TV_i V_{ij}		
11. $VR_{ji} = VM_{ji} \left[\left(\frac{1-\delta_{ji}^V}{\delta_{ji}^V} \right) \left(\frac{PM0_j}{PR_j} \right) \right]^{\sigma_j^V}$, $i \in M, NR; j \in M$	*Intermediate regional demand*	$m^2 + (nr \times m)$	VM_{ji} VR_{ji} PR_j	$PM0_j$	δ_{ji}^V σ_j^V
12. $VR_{ji} = V_{ji}$, $i \in NE; j \in M$	*Intermediate regional demand*	$m \times ne$	V_{ji} VR_{ji}		
13. $VM_{ji} = 0$, $i \in NE\ j \in M$	*Intermediate imported demand*	$m \times ne$	VM_{ji}		
14. $TVR_i = \sum_j VR_{ji}$, $i \in M, NM; j \in M$	*Total intermediate regional demand*	n	TVR_i VR_{ji}		

APPENDIX TABLE A.2. (Continued)

OKLAHOMA MARKET AND NONMARKET GOODS GENERAL EQUILIBRIUM MODEL

Equation	Description	No of Equations	Endogenous Variables	Exogenous Variables	Parameters
15. $TVM_i = \sum_j VM_{ji}$, $i \in M, NM; j \in M$	*Total intermediate imported demand*	*n*	TVM_i VM_{ji}		
16. $X_i = \phi_i^x \left[\delta_i^x EXP_i^{\rho_i^x} + \left(1-\delta_i^x\right) R_i^{\rho_i^x} \right]^{\frac{1}{\rho_i^x}}$, $\sigma_i^X = \frac{1}{\rho_i^X - 1}$, $i \in M$	*Regional supply*	*m*	X_i EXP_i R_i		ϕ_i^x δ_i^x ρ_i^x σ_i^x
17. $R_i = EXP_i \left[\left(\frac{1-\delta_i^x}{\delta_i^x} \right) \left(\frac{PE0_i}{PR_i} \right) \right]^{-\sigma_i^x}$, $i \in M$	*Regional supply for regional demand (market goods)*	*m*	R_i EXP_i PR_i	$PE0_i$	ϕ_i^x δ_i^x σ_i^x
18. $R_i = X_i$, $i \in NR$	*Regional supply for regional demand (nonmarket goods for resident)*	*nr*	R_i X_i		
19. $R_i = 0$, $i \in NE$	*Regional supply for regional demand (nonmarket good for nonresident)*	*ne*	R_i		
20. $EXP_i = 0$, $i \in NR$	*Export (nonmarket good for resident)*	*nr*		EXP_i	
21. $EXP_i = E0_i P_i^{\varepsilon^{trip}}$, $i \in NE$	*Export (nonmarket good for nonresident)*	*ne*		EXP_i P_i	$E0_i$ ε^{trip}

APPENDIX TABLE A.2. (Continued)

OKLAHOMA MARKET AND NONMARKET GOODS GENERAL EQUILIBRIUM MODEL

Equation	Description	No of Equations	Endogenous Variables	Exogenous Variables	Parameters
INCOME BLOCK					
22. $YLS_s = PLS_s \sum_i LD_{is} + \sum_h LHH0_{sh} + LSL0_s + LFED0_s,\ i \in M$	*Labor skill income*	s	$YLS_s\ PLS_s\ LD_{is}$	$LHH0_{sh}\ LSL0_s\ LFed0_s$	
23. $YL = \sum_s YLS_s$	*Total labor income*	1	$YL\ YLS_s$		
24. $YK = \sum_i (CAP_i PK_i)\ ,\ i \in M$	*Capital income*	1	$YK\ CAP_i\ PK_i$		
25. $YAGK = PK_{ag} CAP_{ag}$	*Agricultural capital income*	1	$YAGK\ CAP_{ag}\ PK_{ag}$		
26. $YENT = YK - YAGK$	*Enterprise income*	1	$YENT\ YK\ YAGK$		
27. $YT = \sum_i (LAND_i PT_i),\ i \in M$	*Land income*	1	$YT\ LAND_i\ PT_i$		
28. $NYL = YL(1 - sstax)$	*Labor income net tax*	1	$NYL\ YL$		*sstax*
29. $NYAGK = YAGK(1 - ktax - depr)$	*Agricultural capital income net tax and depreciation*	1	$NYAGK\ YAGK$		*ktax depr*
30. $NYENT = YENT(1 - ktax - retr)$	*Enterprise income net tax, depreciation, and retained earnings*	1	$NYENT\ YENT$		*ktax retr*
31. $NYT = YT(1 - ttax),$	*Land income net tax*	1	$NYT\ YT$		*ttax*
32. $YLH_h = PLH_h LSupH_h$	*Household labor income*	h	$YLH_h\ PLH_h\ LSupH_h$		

APPENDIX TABLE A.2. (Continued)

OKLAHOMA MARKET AND NONMARKET GOODS GENERAL EQUILIBRIUM MODEL

Equation	Description	No of Equations	Endogenous Variables	Exogenous Variables	Parameters
33. $YL = \sum_h YLH_h$	*Total household labor income*	1	$YL\ YLH_h$		
34. $adjL_h = \dfrac{LSupH0_h + LMigH_h}{LSupH0_h}$	*Household adjustment factor*	h	$LMigH_h$	$LSupH0_h$	$adjL_h$
35. $YFH_h = l_h NYL + adjL_h(k_h NYAGK + e_h NYENT + t_h NYT)$	*Household factor income*	h	$YFH_h\ NYL\ NYAGK\ NYENT\ NYT$		$l_h\ k_h\ e_h\ t_h\ adjL_h$
36. $YH_h = YFH_h + adjL_h(TRSL0_h + TRFED0_h + REMIT0_h)$	*Household income*	h	$YH_h\ YFH_h$	$TRSL0_h\ TRFed0_h\ REMIT0_h$	$adjL_h$
37. $DYH_h = YH_h(1 - hhtax_h)$	*Disposable income*	h	$DYH_h\ YH_h$		$hhtax_h$
38. $HSAV_h = mps_h YH_h$	*Household saving*	h	$HSAV_h\ YH_h$		mps_h
39. $GSP = YL + YK + YT + \sum_i ibtax_i X_i$, $i \in M$	*Gross state product*	1	$GSP\ YL\ YK\ YT\ X_i$		$ibtax_i$
EXPENDITURE BLOCK					
40. $HEXP_h = DYH_h - HSAV_h - \sum_s PLS_s LHH0_{sh}$	*Household expenditure*	h	$HEXP_h\ DYH_h\ HSAV_h\ PLS_s$	$LHH0_h$	
41. $Q_{ih} = \gamma_{ih} + \left(\dfrac{\beta_{ih}}{(1-\beta_{0h})P_i}\right)\left(HEXP_h - \sum_j P_j \gamma_{jh}\right)$, $i,j \in M, NR$	*Composite demand for hh consumption*	$h(m+nr)$	$Q_{ih}\ P_i\ HEXP_h\ P_j$		$\gamma_{ih}\ \beta_{ih}\ \beta_{0h}\ \gamma_{jh}$

APPENDIX TABLE A.2. (Continued)

OKLAHOMA MARKET AND NONMARKET GOODS GENERAL EQUILIBRIUM MODEL

Equation	Description	No of Equations	Endogenous Variables	Exogenous Variables	Parameters
42. $Q_{ih} = \phi_i^Q\left[\delta_i^Q QM_{ih}^{\rho_i^Q} + \left(1-\delta_i^Q\right) QR_{ih}^{\rho_i^Q}\right]^{\frac{1}{\rho_i^Q}}$, $\sigma_i^Q = \frac{1}{1-\rho_i^Q}$, $i \in M, NR$	*Domestic and import hh demand substitution*	$h(m+nr)$	Q_{ih} QM_{ih} QR_{ih}		ϕ_i^Q δ_i^Q ρ_i^Q σ_i^Q
43. $Q_{ih} = 0$, $i \in NE$	*Composite demand for hh consumption (nonmarket good: for nonresident)*	$h \times ne$	Q_{ih}		
44. $QR_{ih} = QM_{ih}\left[\left(\frac{1-\delta_i^Q}{\delta_i^Q}\right)\left(\frac{PM0_i}{PR_i}\right)\right]^{\frac{1}{1-\rho_i^Q}}$, $i \in M, NR$	*Regional hh demand for consumption*	$h(m+nr)$	QR_{ih} QM_{ih} PRX_i	$PM0_j$	δ_i^Q ρ_i^Q
45. $TQ_i = \sum_h Q_{ih}$, $i \in M, NR$	*Total household demand*	$m+nr$	TQ_i Q_{ih}		
46. $TQR_i = \sum_h QR_{ih}$, $i \in M, NR$	*Total household regional demand*	$m+nr$	TQR_i QR_{ih}		
47. $TQM_i = \sum_h QM_{ih}$, $i \in M, NM$	*Total household imported demand*	$m+nr$	TQM_i QM_{ih}		
48. $LSupH_h = MAXHOURS0_h - \left(\frac{\beta_{0h}}{PLH_h}\right)\left(\frac{HEXP_h - \sum_{j=1}^{n} P_j \gamma_{jh}}{1-\beta_{0h}}\right)$, $j \in M, NR$	*Household labor supply*	h	$LSupH_h$ PLH_h P_j $HEXP_h$	$MAXHOURS0_h$	β_{0h} γ_{jh}

APPENDIX TABLE A.2. (Continued)

OKLAHOMA MARKET AND NONMARKET GOODS GENERAL EQUILIBRIUM MODEL

Equation	Description	No of Equations	Endogenous Variables	Exogenous Variables	Parameters
49. $LSupHS_{hs} = LSupH_h \frac{LSupHS0_{hs}}{LSupH0_h}$	*Household labor supply by skill level*	$h \times s$	$LSupHS_{hs}$ $LSupH_h$	$LSupHS0_{hs}$ $LSupH0_h$	
50. $LSupS_s = \sum_h LSupHS_{hs}$	*Labor supply by skill*	s	$LSupS_s$ $LSupHS_{hs}$		
51. $YSL = sl^{IBT}\left(\sum_i ibtax_i PR_i X_i\right) sl^{SST}(sstaxYL) + sl^{KTT}(ktaxYK) + sl^{TTT}(ttaxYT) + sl^{HHT}\left(\sum_h hhtax_h YH_h\right) + SLBOR0,\ i \in M$	*State/Local government revenue*	1	YSL PR_i X_i YL YK YT YH_h	$SLBOR0$	sl^{IBT} $ibtax_i$ sl^{SST} $sstax$ sl^{KTT} $ktax$ sl^{TTT} $ttax$ sl^{HHT} $hhtax_h$
52. $SLEXP = \sum_i QSL_i P_i + \sum_h adjL_h TRSL0_h + \sum_s PLS_s LSL0_s,\ i \in M$	*State/Local government expenditures*	1	$SLEXP$ QSL_i P_i PLS_s QSL_i	$LSL0_s$, $TRSL0_h$	$adjL_h$
53. $QSL_i = QSL0_i,\ i \in M$	*State/Local gov commodity demand*	m	QSL_i	$QSL0_i$	
54. $QSL_i = \phi_i^{SL}\left[\delta_i^{SL} QSLM_i^{\rho_i^{SL}} + \left(1-\delta_i^{SL}\right) QSLR_i^{\rho_i^{SL}}\right]^{\frac{1}{\rho_i^{SL}}},\ \sigma_i^{SL} = \frac{1}{1-\rho_i^{SL}},\ i \in M$	*State/Local gov domestic and import demand substitution*	m	QSL_i $QSLM_i$ $QSLR_i$		ϕ_i^{SL} δ_i^{SL} ρ_i^{SL} σ_i^{SL}
55. $QSLR_i = QSLM_i\left[\left(\frac{1-\delta_i^{SL}}{\delta_i^{SL}}\right)\left(\frac{PM0_i}{PR_i}\right)\right]^{\frac{1}{1-\rho_i^{SL}}},\ i \in M$	*State/Local government demand for regional good*	m	$QSLR_i$ $QSLM_i$ PR_i	$PM0_i$	δ_i^{SL} ρ_i^{SL}

APPENDIX TABLE A.2. (Continued)

OKLAHOMA MARKET AND NONMARKET GOODS GENERAL EQUILIBRIUM MODEL

Equation	Description	No of Equations	Endogenous Variables	Exogenous Variables	Parameters
56. $YFED = fed^{IBT}\left(\sum_i ibtax_i PR_i X_i\right) fed^{SST}(sstaxYL) + fed^{KTT}(ktaxYK) + fed^{TTT}(ttaxYT) + fed^{HHT}\left(\sum_h hhtax_h YH_h\right) + FEDBOR0 \ , i \in M$					
	Federal government revenue	1	$YFED\ PR_i\ X_i\ YL\ YK\ YT\ YH_h$	$FEDBOR0$	$fed^{IBT}\ ibtax_i\ fed^{SST}\ sstax\ fed^{KTT}\ ktax\ fed^{TTT}\ ttax\ fed^{HHT}\ hhtax_h$
57. $FEDEXP = \sum_i QFED_i P_i + \sum_h adjL_h TRFED0_h + \sum_s PLS_s LFED0_s \ , i \in M$					
	Federal government expenditure	1	$FEDEXP\ QFED_i\ P_i\ PLS_s$	$LFED0_s\ TRFED0_h$	$adjL_h$
58. $QFED_i = QFED0_i \ , i \in M$	*Federal gov commodity demand*	*m*	$QFED_i$	$QFED0_h$	
59. $QFED_i = \phi_i^{FED}\left[\delta_i^{FED} QFEDM_i^{\rho_i^{FED}} + \left(1-\delta_i^{FED}\right) QFEDR_i^{\rho_i^{FED}}\right]^{\frac{1}{\rho_i^{FED}}},\ \sigma_i^{FED} = \frac{1}{1-\rho_i^{FED}},\ i \in M,$					
	Federal gov domestic and import demand substitution	*m*	$QFED_i\ QFEDM_i\ QFEDR_i$		$\phi_i^{FED}\ \delta_i^{FED}\ \rho_i^{FED}\ \sigma_i^{FED}$
60. $QFEDR_i = QFEDM_i\left[\left(\frac{1-\delta_i^{FED}}{\delta_i^{FED}}\right)\left(\frac{PM0_i}{PR_i}\right)\right]^{\frac{1}{1-\rho_i^{FED}}}\ i \in M$					
	Federal government demand for regional good	*m*	$QFEDR_i\ QFEDM_i\ PR_i$	$PM0_i$	$\delta_i^{FED}\ \rho_i^{FED}$
61. $SAV = \sum_h HSAV_h + deprYAGK + retrYENT + ROWSAV0$					
	Total Saving	1	$SAV\ HSAV_h\ YAGK\ YENT$	$ROWSAV0$	*depr retr*

APPENDIX TABLE A.2. (Continued)

OKLAHOMA MARKET AND NONMARKET GOODS GENERAL EQUILIBRIUM MODEL

Equation	Description	No of Equations	Endogenous Variables	Exogenous Variables	Parameters
62. $QINV_i = \phi_i^{INV}\left[\delta_i^{INV} QINVM_i^{\rho_i^{INV}} + \left(1-\delta_i^{INV}\right) QINVR_i^{\rho_i^{INV}}\right]^{\frac{1}{\rho_i^{INV}}}, \ \sigma_i^{INV} = \frac{1}{1-\rho_i^{INV}}, \ i \in M,$	*Investment demand substitution between region and import*	*m*	$QINV_i\ QINVM_i\ QINVR_i$		$\phi_i^{INV}\ \delta_i^{INV}\ \rho_i^{INV}\ \sigma_i^{INV}$
63. $QINV_i = QINV0_i \ , i \in M$	*Investment demand*	*m*	$QINV_i$	$QINV0_i$	
64. $QINVR_i = QINVM_i\left[\left(\frac{1-\delta_i^{INV}}{\delta_i^{INV}}\right)\left(\frac{PM0_i}{PR_i}\right)\right]^{\frac{1}{1-\rho_i^{INV}}} \quad i \in M$	*Investment demand for regional good*	*m*	$QINVR_i\ QINVM_i\ PR_i$	$PM0_i$	$\delta_i^{INV}\ \rho_i^{INV}$
65. $INV = \sum_i QINV_i P_i \ , i \in M$	*Total investment*	1		$INV\ QINV_i\ P_i$	
66. $M_i = TVM_i + TQM_i + QSLM_i + QFED_i + QINVM_i \ , i \in M$	*Import (market goods)*	*m*	$M_i\ TVM_i\ TQM_i\ QSLM_i$ $QFEDM_i\ QINVM_i$		
67. $M_i = TVM_i + TQM_i \ , i \in NR$	*Import (nonmarket good)*	*nr*	$M_i\ TVM_i\ TQM_i$		
PRICE BLOCK					
68. $PLM_i = \frac{\sum_s PLS_s LD_{is}}{\sum_s LD_{is}}$	*Composite wage rate by industry*	*m*	$PLM_i\ PLS_s LD_{is}$		
69. $PLH_h = \sum_s PLS_s \frac{LSupHS_{hs}}{LSupH_h}$	*Composite wage rate paid to hh*	*h*	$PLH_h\ PLS_s LSupHS_{hs} LSupH_h$		

APPENDIX TABLE A.2. (Continued)

OKLAHOMA MARKET AND NONMARKET GOODS GENERAL EQUILIBRIUM MODEL

Equation	Description	No of Equations	Endogenous Variables	Exogenous Variables	Parameters
70. $PL = \frac{\sum_s PLS_s(LDemS_s + LExo0_s)}{\sum_s (LDemS_s + LExo0_s)}$	*Aggregate wage rate*	1	$PLS_s\ LDemS_s$	$LExo0_s$	
71. $LDemS_s = \sum_i LD_{is}$, $i \in M$	*Demand for labor skill by industry*	*s*	$LDemS_s\ LD_{is}$		
72. $LExo0_s = LHH0_s + LSL0_s + LFED0_s$	*Exogenous demand for labor*	*s*		$LHHH0_s\ LSL0_s\ LFED0_s$	
73. $PN_i = PR_i - \sum_j a_{ji} P_j - ibtax_i PR_i$, $i \in M, NM; j \in M$	*Net price*	*n*	$PN_i\ PR_i\ P_i$		$a_{ij}\ ibtax_i$
74. $P_i = \frac{PR_i R_i + PM0_i M_i}{R_i + M_i}$, $i \in M, NR$	*Composite price*	*m+nr*	$P_i\ PR_i\ R_i\ M_i$	$PM0_i$	
75. $P_i = \frac{\sum_j P_j V_{ji}}{\sum_j V_{ji}}$, $i \in NE; j \in M$	*Composite price* (*nonmarket good for nonresident*)	*ne*	$P_i\ V_{ji}$		

APPENDIX TABLE A.2. (Continued)

OKLAHOMA MARKET AND NONMARKET GOODS GENERAL EQUILIBRIUM MODEL

Equation	Description	No of Equations	Endogenous Variables	Exogenous Variables	Parameters
MARKET EQUILIBRIUM					
76. $X_i + M_i = TV_i + TQ_i + QSL_i + QFED_i + QINV_i + EXP_i$, $i \in M$	*Commodity market equilibrium*	*m*	$X_i\ M_i\ TV_i\ TQ_i\ QSL_i\ QFED_i\ QINV_i\ EXP_i$		
77. $X_i + M_i = TQR_i + TQM_i$, $i \in NR$	*Nonmarket good equilibrium (for resident)*	*nr*	$X_i\ M_i\ TQR_i\ TQM_i$		
78. $X_i = EXP_i$, $i \in NE$	*Nonmarket good equilibrium (for nonresident)*	*ne*	$X_i\ EXP_i$		
79. $LSupS_s + LMIG_s = LDemS_s + LExo0_s$, $i \in M$	*Labor market equilibrium*	*s*	$LSupS_s\ LMIG_s\ LDemS_s$	$LExo0_s$	
80. $LMIG_s = LSupS0_s\left(\dfrac{PLS_s}{PL_s^{ROC0}}\right)^{\eta_s^L}$, $i \in M$	*Labor migration by skill*	*s*	$LMIG_s\ PLS_s$	$LSupS0_s, PL_s^{ROC0}$	η_s^L
81. $LMigH_h = \sum_s LMIG_s \dfrac{LSupHS_{hs}}{LSupS_s}$, $i \in M$	*Labor migration by skill*	*h*	$LMigH_h\ LMIG_s\ LSupHS_{hs}\ LSupS_s$		
82a. $CAP_i = KS0_i$, $i \in M$	*Capital market equilibrium (short run equilibrium)*	*m*	CAP_i	$KS0_i$	
82b. $\sum_i CAP_i = \sum_i KS0_i + KMIG$, $i \in M$	*Capital market equilibrium (long run equilibrium)*	1	$CAP_i\ KMIG$	$KS0_i$	

APPENDIX TABLE A.2. (Continued)

OKLAHOMA MARKET AND NONMARKET GOODS GENERAL EQUILIBRIUM MODEL

Equation	Description	No of Equations	Endogenous Variables	Exogenous Variables	Parameters
83. $KMIG = \sum_i K0_i \left(\frac{PK}{PK^{ROC0}}\right)^{\eta^K}$, $i \in M$	*Capital migration (long run equilibrium)*	1	*KMIG PK*	$K0_i PK^{ROC0}$	η^K
84. $LAND_i = TS0_i$, $i \in M$	*Land market equilibrium*	*m*	$LAND_i$	$TS0_i$	
Total equations = $4n+22m+6s+(mxs)+m^2(nrxm)+10h+(hxs)+2(mxne)+4nr+4ne+4(m+nr)+3h(mxnr)+(hxne)+20$					

WELFARE MEASURE

Compensating Variation:

$$CV_h = \left(\frac{1}{1-\beta_{0h}}\right)\left[\left(HEXP_h - \sum_j P_j \gamma_{jh}\right) - \left(adjL_h HEXP0_h - \sum_j P0_j \gamma_{jh}\right)\prod_i \left(\frac{P_i}{P0_i}\right)^{\beta_{ih}}\left(\frac{PL}{PL0}\right)^{\beta_{0h}}\right], \quad i,j \in M,\ NR, \qquad TCV = \sum_h CV_h$$

Equivalent Variation:

$$EV_h = \left(\frac{1}{1-\beta_{0h}}\right)\left[\left(HEXP_h - \sum_j P_j \gamma_{jh}\right)\prod_i \left(\frac{P0_i}{P_i}\right)^{\beta_{ih}}\left(\frac{PL0}{PL}\right)^{\beta_{0h}} - \left(adjL_h HEXP0_h\right) - \sum_j P0_j \gamma_j\right], \quad i,j \in M,\ NR, \qquad TEV = \sum_h EV_h$$

APPENDIX B

SUPPORTING DATA

APPENDIX TABLE B.1

RIMS SECTOR AGGREGATION FOR PRODUCTION ACCOUNT

Production Account	IMPLAN Database Sector Number	Standard Industrial Classification (SIC) 1987
Agriculture, forestry, and fisheries:		
1 Agricultural products and agricultural, forestry, and fisheries services	1-23, 26-27	01, 02, 07, 08, 09 (exc. 074, 081, 083, 097, 091)
2 Forestry and fishery products	24-25	081, 083, 097, 091
Mining:		
3 Coal mining	37	12
4 Crude petroleum and natural gas	38-39	131, 132
5 Miscellaneous mining	28-36, 40-47	10, 14
Construction:		
6 New construction	48-54	Part 15, 16, 17
7 Maintenance and repair construction	55-57	138, Part 15, 16, 17
Manufacturing:		
8 Food and kindred products and tobacco	58-107	20, 21
9 Textile mill products	108-123	22
10 Apparel	124-132	23
11 Paper and allied products	161-173	26
12 Printing and publishing	174-185	27
13 Chemicals and petroleum refining	186-214	28, 29
14 Rubber and leather products	215-217, 219-229	301, 302, 3052, 306, 308, 31
15 Lumber and wood products and furniture	133-142, 144-160	24 (exc.2451), 25
16 Stone, clay, and glass products	218, 230-253	3053, 32
17 Primary metal industries	254-272, 290-291	33, 3462, 3463
18 Fabricated metal products	273-289, 292-306, 396, 398	34 (exc.3462, 3463), 3761, 3795
19 Machinery, except electrical	307-323, 325-354, 382	35 (exc.3548), 3695
20 Electric and electronic equipment	324, 355-381, 383, 404, 410 411	3458, 36 (exc.3695), 3825, 3844, 3845
21 Motor vehicles and equipment	384-387	3711, 3713, 3714, 3715
22 Transportation equipment, except motor vehicles	143, 388-395, 397, 399	2451, 3716, 372-5, 3792, 3799
23 Instruments and related products	400-403, 405-409, 412-414	38 (exc.3825, 3844, 3845)
24 Miscellaneous manufacturing industries	415-432	39
Transportation and public utilities:*		
25 Transportation	433-440, 513	40, 41, 42, 44, 45, 46, 47, 4311
26 Communication	441-442	48
27 Electric, gas, water, and sanitary services	443-446, 514	49
Wholesale and retail trade:		
28 Wholesale trade	447	50, 51
29 Retail trade	448-453, 455	52-7, 59
Finance, insurance, and real estate:		
30 Finance	456-458	60, 61, 62, 67 (exc.6732)
31 Insurance	459-460	63, 64
32 Real estate	461-462	65
Services:		
33 Hotels and lodging places and amusements	463, 483-489	70, 78, 79
34 Personal services	464-468, 480-481	721-9
35 Business services	469-476, 482, 494, 506-509	73, 769, 811, 87
36 Eating and drinking places	454	58
37 Health services	490-493	80, 074
38 Miscellaneous services	477-479, 495-505, 510-512, 515	6732, 75, 82-86, 8922, part of 41 & 491

*Includes Federal Government Enterprises

Sources: Regional Multipliers: A User Handbook for Regional Input-Output Modeling System (RIMS II), USDC, BEA, 1992, and Micro IMPLAN User's Guide Version 91-F, USDA Forest Service, 1994.

APPENDIX TABLE B.2

LABOR SKILL CATEGORY AND LIST OF OCCUPATIONS

Skill 1	Managerial and Professional Specialty Occupations	
	1	Public Administrators and Officials
	2	Other Administrators and Officials
	3	Management Related
	4	Architect
	5	Engineers
	6	Surveyors and Mapping Scientists
	7	Other Scientists and Mathematicians
	8	Doctors and other Diagnoticians
	9	Other Health, including Nurses
	10	Elementary and Secondary Teachers
	11	Other Education Related
	12	Social Scientists and Urban Planners
	13	Social, Recreation and Religious
	14	Lawyers and Judges
	15	Artists, Entertainers, and Athletes
Skill 2	Technical, Sales, and Administrative Support Occupations	
	16	Health Technologies and Technicians
	17	Licensed Practical Nurses
	18	Other Technologists and Technicians
	19	Supervisors and Sales, Self-Employed
	20	Supervisors and Sales, Salaried
	21	Sales, Finance, and Business Services
	22	Sales Representative, Non-Retail
	23	Other Sales, Retail and Personal
	24	Cashiers
	25	Sales Related
	26	Supervisors and Administrative Support
	27	Computer Equipment Operators
	28	Secretarial Related
	29	Accountants and Auditors
	30	Other Financial Record Processing
	31	Mail and Message Distributing
	32	Shipping, Receiving, and other Clerks
	33	Other Administrative Support
Skill 3	Service Occupations	
	34	Private Household
	35	Guards
	36	Other Protective Services
	37	Food Preparation and Service
	38	Nursing and other Health Assistants
	39	Cleaning and Building Services
	40	Personal Services
Skill 4	Farming, Forestry, and Fishing Occupations	
	41	Farming, Forestry, and Fishing
Skill 5	Precision Production, Crafts, and Repair Occupations Operators, Fabricatiors, and Laborers	
	42	Auto Mechanics and Repairers
	43	Other Mechanics and Repairers
	44	Carpenters
	45	Other Construction Trades
	46	Extractive Occupations
	47	Supervisors and Production
	48	Precision and Production
	49	Plant and System Operators
	50	Machine Operators
	51	Fabrications and Assemblers
	52	Production Inspectors and Related
	53	Motor Vehicle Operators
	54	Other Transportation Operators
	55	Material Moving Equipment Operators
	56	Craft and Production
	57	Construction Labor
	58	Freight and Material Handlers
	59	Other Handlers and Miscellaneous

Source: Rose, A., B. Stevens, and G. Davis. (1988) Natural Resource Policy and Income Distribution.

APPENDIX TABLE B.3

RIMS II VERSUS ROSE, ET.AL. INDUSTRY ACCOUNT

INDUSTRY ACCOUNT	
RIMS II Classification	Rose, et al. Classification
1 Agricultural products and agricultural, forestry, and fisheries services	1 Agriculture, forestry, fisheries
2 Forestry and fishery products	1 Agriculture, forestry, fisheries
3 Coal mining	2 Mining
4 Crude petroleum and natural gas	10 Petroleum & coal
5 Miscellaneous mining	2 Mining
6 New construction	3 Construction
7 Maintenance and repair construction	3 Construction
8 Food and kindred products and tobacco	4 Food & kindred products
9 Textile mill products	5 Textile mill products
10 Apparel	6 Apparel
11 Paper and allied products	9 Paper & allied products
12 Printing and publishing	7 Printing & publishing
13 Chemicals and petroleum refining	8 Chemicals & allied products
14 Rubber and leather products	8 Chemicals & allied products
15 Lumber and wood products and furniture	11 Furniture, lumber, & wood
16 Stone, clay, and glass products	2 Mining
17 Primary metal industries	12 Primary metals
18 Fabricated metal products	13 Fabricated metals
19 Machinery, except electrical	14 Machinery, except electrical
20 Electric and electronic equipment	15 Electrical machinery equipment
21 Motor vehicles and equipment	16 Motor vehicle equipment
22 Transportation equipment, except motor vehicles	17 Other transport equipment
23 Instruments and related products	18 Miscellaneous manufacturing
24 Miscellaneous manufacturing industries	18 Miscellaneous manufacturing
25 Transportation	19 Railroads
	20 Trucking & warehousing
	21 Other transport service
26 Communication	22 Communications
27 Electric, gas, water, and sanitary services	23 Utilities
28 Wholesale trade	24 Wholesale trade
29 Retail trade	25 General merchandise stores
	26 Food, dairy stores
	27 Auto deal service stations
	29 Other retail trade
30 Finance	30 Banks & credit agencies
31 Insurance	31 Insurance real estate finance
32 Real estate	31 Insurance real estate finance
33 Hotels and lodging places and amusements	35 Recreation service
34 Personal services	34 Other personal services
35 Business services	33 Business services
	40 Legal & other services
36 Eating and drinking places	28 Eating & drinking places
37 Health services	36 Hospitals
	37 Health services
38 Miscellaneous services	32 Repair service
	38 Education services
	39 Social services
	41 Public administration

Source: Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System RIMS II, 1992, and Rose, et al., Natural Resource Policy and Income Distribution, 1988. Rose, et al. does not provide the SIC for their sectors.

APPENDIX TABLE B.4

US WAGE/SALARY INCOME DISTRIBUTION MATRIX FOR INDIVIDUALS (Millions of 1982 dollars)

	Occupation	Skill aggregation	Industry: Agric, Forestry, Fisheries	Mining	Construction	Food & Kindred Products	Textile Mill Products	Apparel	Printing & Publishing	Chemicals & Allied Products	Paper & Allied Products	Petroleum & Coal	Furniture, Lumber, & Wood	Primary Metals	Fabricated Metals	Machinery Except Electrical
	Corresponding RIMS Sector # ---->	V	1	3	6	8	9	10	12	13	11	4	15	17	18	19
1	Public Administrators & Officials	Skill 1	0.1	0.3	233.0	0.6	0.0	0.0	0.1	0.3	0.1	0.2	0.3	0.2	0.2	0.2
2	Other Administrators & Officials	Skill 1	884.5	2554.8	7412.0	3863.4	788.2	1015.3	3964.5	3819.5	1521.5	2474.3	1682.6	1620.7	3466.5	5987.1
3	Management Related	Skill 1	152.4	1016.5	1323.0	847.1	155.1	148.1	408.6	993.6	404.2	697.4	294.2	530.0	775.4	1555.4
4	Architect	Skill 1	400.3	4.4	126.7	3.4	1.4	0.6	1.6	7.3	0.3	2.3	5.1	1.9	3.9	7.8
5	Engineers	Skill 1	94.8	1778.1	2968.7	474.9	166.1	73.7	124.8	2080.4	499.2	1067.6	177.2	1048.6	1373.7	4688.9
6	Surveyors & Mapping Scientists	Skill 1	15.1	82.3	82.9	0.7	0.0	0.2	0.7	0.6	2.6	0.5	2.2	2.2	0.4	0.9
7	Oth Sci and Mathematicians	Skill 1	453.5	1358.2	143.5	302.6	45.0	15.2	89.4	1605.0	177.3	334.9	83.1	203.0	144.1	1060.6
8	Doctors & Ot Diagnoticians	Skill 1	1112.6	5.2	5.0	15.8	0.5	0.8	3.9	83.2	1.6	5.2	0.5	9.6	4.2	8.1
9	Ot Health, inc Nurses	Skill 1	9.6	5.2	7.7	29.8	11.2	1.6	9.7	50.0	14.5	16.9	3.6	32.5	20.8	37.3
10	Elementary & Secondary Teachers	Skill 1	10.9	7.9	7.6	7.4	15.5	15.1	7.0	11.2	2.8	9.1	1.8	4.7	5.3	52.6
11	Ot Education Related	Skill 1	6.6	13.9	9.9	5.5	3.2	1.8	30.8	21.0	4.0	7.2	2.2	3.9	5.2	23.8
12	Social Sci and Urban Planners	Skill 1	6.2	20.9	19.6	37.0	4.0	3.3	34.0	79.9	10.8	25.7	6.5	12.2	20.4	105.2
13	Social, Recreation & Religious	Skill 1	2.9	0.6	2.8	1.5	0.3	0.1	2.6	1.8	0.6	1.4	0.5	0.5	0.9	2.1
14	Lawyers and Judges	Skill 1	4.7	122.2	41.4	33.9	3.8	3.5	23.8	108.1	15.0	56.5	4.2	20.3	21.0	62.3
15	Artists, Entertainers, and Athletes	Skill 1	186.7	50.9	216.1	61.9	44.4	115.7	2789.8	132.4	73.6	95.7	55.4	38.4	82.7	367.7
16	Health Technologies & Technicians	Skill 2	52.3	5.2	2.4	4.7	1.3	0.2	1.6	38.5	2.5	5.5	0.5	6.5	3.8	4.7
17	Licensed Practical Nurses	Skill 2	0.7	0.9	0.9	1.2	0.9	0.2	0.5	2.3	0.8	0.6	0.2	1.4	2.1	2.9
18	Ot Technologists & Technicians	Skill 2	266.6	1035.3	1767.5	605.5	204.1	50.2	386.5	2101.3	435.9	748.7	155.8	646.8	909.8	2814.8
19	Supervisors and Sales, Self-Employed	Skill 2	2.7	0.7	9.4	4.3	0.6	2.0	5.2	1.1	0.7	2.6	9.7	0.9	2.8	3.7
20	Supervisors and Sales, Salaried	Skill 2	14.5	23.7	94.3	171.3	15.7	40.3	125.3	90.8	29.1	59.4	41.1	28.4	54.8	188.0
21	Sales, Finance, and Business Services	Skill 2	91.5	20.0	840.0	8.6	1.6	1.8	1955.6	10.3	2.2	8.7	4.8	3.4	6.6	10.9
22	Sales Representative, Non-Retail	Skill 2	175.1	331.4	46.7	1526.6	237.6	458.1	8.5	1810.9	689.9	728.3	473.1	492.0	916.8	1709.5
23	Other Sales, Retail and Personal	Skill 2	7.6	7.8	40.9	8.5	2.1	1.9	993.7	8.4	4.8	5.0	3.8	6.4	15.0	43.6
24	Cashiers	Skill 2	6.4	3.1	6.1	24.9	1.4	2.7	9.9	4.7	1.0	3.8	1.6	1.3	2.6	4.5
25	Sales Related	Skill 2	1.3	0.2	1.0	6.8	0.2	0.8	1.0	1.6	0.1	0.5	0.7	1.3	2.3	6.0
26	Supervisors and Admin Support	Skill 2	48.4	219.3	281.9	308.3	84.3	108.3	323.6	321.4	176.0	265.1	114.0	235.5	303.4	518.3
27	Computer Equipment Operators	Skill 2	12.6	96.6	67.2	100.8	29.0	27.1	127.4	104.7	48.4	87.0	29.7	64.9	84.7	251.4
28	Secretarial Related	Skill 2	218.2	666.7	1425.1	522.7	141.6	120.9	744.3	867.8	286.3	446.4	223.3	346.6	583.1	1167.7
29	Accountants and Auditors	Skill 2	186.4	237.5	821.5	332.8	52.3	95.1	318.5	212.6	102.6	177.6	130.7	114.3	246.5	371.7
30	Other Financial Record Processing	Skill 2	13.7	55.1	134.5	96.3	38.5	51.8	84.8	72.0	58.4	80.6	36.9	93.8	104.2	142.9
31	Mail and Message Distributing	Skill 2	6.7	31.6	35.8	41.6	9.4	11.4	353.4	57.9	20.5	34.9	11.8	26.5	27.3	55.5
32	Shipping, Receiving, and other Clerks	Skill 2	45.6	290.3	273.5	688.7	250.4	303.6	399.9	611.0	378.4	530.8	285.2	602.3	779.1	1468.0
33	Other Administrative Support	Skill 2	188.3	370.4	606.6	519.7	197.7	205.6	1124.2	587.3	278.4	432.3	180.6	358.5	456.9	944.1
34	Private Household	Skill 3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	Guards	Skill 3	31.5	102.2	97.5	118.1	49.4	23.5	41.3	132.4	59.2	96.3	83.4	145.7	101.3	135.3
36	Other Protective Services	Skill 3	181.8	8.9	10.2	10.4	3.0	0.2	1.4	22.1	9.7	11.8	11.0	19.6	15.8	14.9
37	Food Preparation and Service	Skill 3	11.1	11.5	7.7	95.5	2.3	1.8	6.0	10.6	4.3	5.8	2.5	5.1	4.4	13.8
38	Nursing and Other Health Assistants	Skill 3	6.1	1.3	2.7	5.1	0.6	0.9	0.8	3.6	1.0	2.4	0.9	2.9	1.6	3.4
39	Cleaning and Building Services	Skill 3	76.9	127.0	217.4	447.7	108.2	65.2	108.9	252.2	126.6	195.4	109.4	217.1	201.1	283.5
40	Personal Services	Skill 3	16.0	3.4	8.7	7.7	3.3	3.4	3.2	6.8	1.6	3.3	3.2	2.3	1.3	4.2
41	Farming, Forestry, and Fishing	Skill 4	11215.9	6.7	49.1	13.3	2.4	0.6	1.9	8.6	13.8	5.4	479.9	4.2	4.2	7.6
42	Auto Mechanics and Repairers	Skill 5	35.1	141.9	210.2	110.1	8.6	3.0	10.5	30.2	18.3	33.3	20.2	38.0	39.5	105.5
43	Other Mechanics and Repairers	Skill 5	272.4	2127.6	2888.4	1495.4	906.6	208.1	233.6	1350.1	1093.5	1140.5	558.0	1878.8	1233.9	2661.8
44	Carpenters	Skill 5	38.6	77.0	9715.1	26.3	17.1	4.5	10.3	51.5	26.4	38.3	323.4	58.7	61.6	48.0
45	Other Construction Trades	Skill 5	62.8	852.3	31278.0	268.4	100.6	27.6	69.8	645.8	356.0	418.2	230.9	943.3	736.4	647.5
46	Extractive Occupations	Skill 5	13.6	9954.8	70.3	3.5	5.1	0.8	1.0	18.9	2.8	28.1	4.0	23.9	8.4	15.7
47	Supervisors and Production	Skill 5	82.1	406.7	390.6	2791.5	991.4	944.2	1585.3	2709.4	1463.8	2428.8	1462.6	2625.7	2902.1	3805.8
48	Precision and Production	Skill 5	28.8	178.7	870.6	2976.8	156.8	644.8	626.7	350.1	295.4	916.9	1408.1	1212.0	2461.5	6330.4
49	Plant and System Operators	Skill 5	9.0	676.6	144.0	200.9	24.1	7.4	22.0	365.5	161.9	425.5	29.0	148.9	84.6	141.3
50	Machine Operators	Skill 5	153.5	311.6	503.8	3677.0	3914.7	6657.9	4708.9	3467.6	3690.9	5458.1	3012.9	4476.1	5002.8	5805.0
51	Fabrications and Assemblers	Skill 5	50.7	516.2	1162.4	560.9	106.2	161.1	193.6	656.4	348.9	978.9	1328.7	1174.1	3045.6	4753.1
52	Production Inspectors and Related	Skill 5	16.7	106.8	52.0	601.6	430.3	453.8	148.3	309.7	265.6	680.3	337.2	552.2	695.8	1195.1
53	Motor Vehicle Operators	Skill 5	354.8	1206.7	2134.0	2224.0	88.0	57.5	356.1	385.0	345.4	306.4	582.2	337.5	369.7	341.1
54	Other Transportation Operators	Skill 5	6.4	383.6	117.3	11.0	3.0	0.5	0.8	14.6	12.4	19.1	7.9	146.7	7.6	10.0
55	Material Moving Equipment Operators	Skill 5	131.3	2533.2	4321.2	963.8	222.3	148.8	169.2	531.5	674.5	515.6	683.9	1528.9	746.6	780.1
56	Craft and Production	Skill 5	5.1	339.9	728.4	92.3	15.8	8.1	55.9	34.2	73.8	49.6	35.6	167.6	80.4	73.1
57	Construction Labor	Skill 5	15.4	71.4	5009.6	9.2	2.2	0.9	2.7	11.7	9.5	10.2	12.3	17.2	10.5	10.0
58	Freight and Material Handlers	Skill 5	39.2	142.7	54.3	459.7	169.3	59.0	62.3	123.6	135.4	134.5	274.0	203.4	120.9	92.5
59	Other Handlers and Miscellaneous	Skill 5	221.6	366.2	39.4	2498.5	272.6	312.9	255.0	675.7	604.1	765.5	514.0	885.0	654.6	563.2
	Total		*17755.9*	*31072.1*	*79138.1*	*30327.5*	*10111.3*	*12673.5*	*23130.7*	*28066.7*	*15038.9*	*23080.9*	*15538.1*	*23374.4*	*29018.7*	*51510.1*

Source: Rose, Adam, Brandt Stevens, and Gregg Davis, 1988. Natural Resource Policy and Income Distribution (Table 5.1, p.49), and Regional Multipliers: A User Handbook for the Regional Input-Output Modeling Sustem RIMS II, 1992.

APPENDIX TABLE B.4 (Continued)

US WAGE/SALARY INCOME DISTRIBUTION MATRIX FOR INDIVIDUALS (Millions of 1982 dollars)

	Occupation	Skill aggregation	Industry: Elect Mach Equip	Motor Vehicle Equip	Other Transport Equipment	Misc Manufacturing	Railroads	Trucking & Warehousing	Other Transport Service	Communications	Utilities	Wholesale Trade	General Merchandise Stores	Food, Dairy Stores	Auto Deal Service Stations	Eating & Drinking Places
	Corresponding RIMS Sector # ---->	V	20	21	22	24	25	25	21	26	27	28	29	29	29	36
1	Public Administrators & Officials	Skill 1	0.6	0.2	0.1	0.0	0.2	1.5	25.0	0.4	0.4	1.2	0.6	0.9	0.4	0.3
2	Other Administrators & Officials	Skill 1	4491.5	1197.4	2231.6	4433.1	1141.1	2934.8	2917.2	4785.5	1895.7	21117.7	4510.4	4239.1	5052.1	7148.5
3	Management Related	Skill 1	1325.9	573.9	954.5	866.8	250.9	307.2	525.6	920.3	805.0	3954.9	1638.3	522.9	406.9	181.2
4	Architect	Skill 1	2.6	3.0	11.8	5.9	1.9	1.0	9.1	10.1	13.0	14.3	11.8	9.0	3.1	3.8
5	Engineers	Skill 1	5637.0	1461.7	5568.9	1929.6	218.6	68.8	455.8	2548.5	1951.8	1099.6	33.4	34.6	30.5	8.0
6	Surveyors & Mapping Scientists	Skill 1	1.2	0.5	1.5	1.2	4.7	0.5	6.4	0.7	23.2	0.8	0.0	8.0	1.0	0.0
7	Oth Sci and Mathematicians	Skill 1	567.2	151.9	625.5	411.0	58.9	25.4	106.1	395.1	383.7	664.9	68.8	26.1	24.3	7.3
8	Doctors & Ot Diagnosticians	Skill 1	8.4	8.2	12.1	20.1	1.9	1.9	6.1	16.9	7.7	17.5	7.0	3.3	8.8	0.9
9	Ot Health, inc Nurses	Skill 1	35.9	21.9	19.4	26.3	0.7	1.8	64.5	12.6	7.1	31.1	54.5	23.6	2.8	7.9
10	Elementary & Secondary Teachers	Skill 1	39.0	7.0	40.3	23.7	2.3	3.2	48.8	39.5	28.0	40.4	15.6	6.1	6.6	4.0
11	Ot Education Related	Skill 1	14.5	2.6	14.5	11.8	1.9	1.5	6.1	40.5	9.3	21.8	3.6	3.0	4.7	2.1
12	Social Sci and Urban Planners	Skill 1	85.8	13.3	34.6	54.3	6.4	3.5	17.4	105.9	32.1	155.5	8.2	7.3	8.1	3.6
13	Social, Recreation & Religious	Skill 1	1.4	0.5	1.0	3.4	0.6	0.5	3.2	3.1	3.7	6.7	2.4	1.3	1.0	0.8
14	Lawyers and Judges	Skill 1	60.2	29.1	32.9	41.8	32.3	11.2	38.4	76.4	70.2	81.2	26.6	8.1	6.7	6.5
15	Artists, Entertainers, and Athletes	Skill 1	351.3	102.2	236.2	350.0	19.0	13.6	63.6	2139.8	116.1	447.0	406.2	59.3	23.3	179.5
16	Health Technologies & Technicians	Skill 2	7.5	2.6	6.0	38.5	0.5	1.0	89.8	2.3	20.9	16.5	2.0	0.8	1.4	1.1
17	Licensed Practical Nurses	Skill 2	1.5	0.8	1.0	1.8	0.0	0.1	1.4	0.4	0.5	2.2	0.5	8.1	0.3	0.3
18	Ot Technologists & Technicians	Skill 2	3012.4	457.4	1491.1	1358.5	102.0	57.5	1140.3	2053.5	1022.2	1321.8	145.5	63.6	200.0	16.9
19	Supervisors and Sales, Self-Employed	Skill 2	1.9	1.3	1.0	14.3	0.0	4.6	4.2	0.7	0.8	887.3	140.3	1238.5	1180.9	41.1
20	Supervisors and Sales, Salaried	Skill 2	103.8	49.7	30.5	119.2	5.5	41.6	74.4	82.8	37.4	3418.2	3742.9	5386.9	3366.9	181.0
21	Sales, Finance, and Business Services	Skill 2	9.2	2.1	1.2	21.2	88.5	516.0	1306.2	1454.2	244.9	73.2	46.8	16.3	26.4	5.7
22	Sales Representative, Non-Retail	Skill 2	1010.0	258.7	196.4	1705.5	0.1	1.8	1.4	7.8	11.5	29799.5	2.0	8.3	5.6	0.0
23	Other Sales, Retail and Personal	Skill 2	29.0	40.1	9.7	15.3	1.3	26.9	19.4	39.4	5.9	1154.3	11409.3	1633.7	5770.7	223.2
24	Cashiers	Skill 2	5.2	2.8	3.4	6.1	5.5	16.1	84.9	28.9	37.4	156.6	1181.1	4419.3	317.1	661.9
25	Sales Related	Skill 2	3.8	1.2	0.6	3.3	0.3	0.1	1.1	1.2	1.4	48.3	28.9	24.3	4.5	1.3
26	Supervisors and Admin Support	Skill 2	445.9	174.7	230.3	355.6	116.9	218.3	863.6	2671.2	372.6	1494.9	619.4	385.2	141.8	44.6
27	Computer Equipment Operators	Skill 2	185.3	60.2	110.9	118.2	60.1	56.9	63.2	257.9	94.3	589.7	100.6	46.0	76.3	5.5
28	Secretarial Related	Skill 2	923.7	257.5	543.4	772.9	125.9	441.8	376.1	964.0	569.5	3326.4	389.6	198.0	553.3	85.4
29	Accountants and Auditors	Skill 2	253.3	74.7	104.4	309.2	49.5	283.3	196.0	271.8	228.7	2576.7	538.3	514.5	1000.1	153.2
30	Other Financial Record Processing	Skill 2	108.1	41.0	54.0	101.5	95.8	212.4	79.1	166.5	117.2	447.4	179.3	71.3	64.9	17.6
31	Mail and Message Distributing	Skill 2	50.3	15.5	25.3	55.3	32.1	181.2	6118.8	128.5	52.1	203.9	62.8	30.4	41.0	7.6
32	Shipping, Receiving, and other Clerks	Skill 2	1183.0	483.8	828.5	855.0	282.7	855.0	673.3	547.8	852.4	3104.0	1532.6	948.5	292.5	43.8
33	Other Administrative Support	Skill 2	878.2	279.6	502.2	698.6	527.0	555.9	1088.8	4935.8	939.3	3221.3	1691.5	546.4	590.2	85.1
34	Private Household	Skill 3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	Guards	Skill 3	143.1	107.9	128.1	98.5	87.6	65.5	137.1	51.5	124.0	148.9	418.8	70.4	26.6	32.4
36	Other Protective Services	Skill 3	14.2	18.5	49.0	11.3	9.8	9.6	24.0	6.8	16.2	19.6	40.8	7.0	1.9	0.4
37	Food Preparation and Service	Skill 3	10.8	4.5	7.3	9.6	10.5	3.9	37.9	10.1	3.6	66.7	235.3	351.2	19.3	7153.4
38	Nursing and Other Health Assistants	Skill 3	2.2	1.4	1.2	5.0	0.4	0.6	21.0	1.2	2.3	5.4	4.7	3.0	0.9	5.7
39	Cleaning and Building Services	Skill 3	212.0	176.2	112.2	235.9	44.9	85.4	234.3	117.7	256.6	432.3	314.2	250.6	166.9	237.7
40	Personal Services	Skill 3	3.3	1.7	2.1	5.8	9.8	3.4	345.4	9.2	3.6	20.8	54.9	11.1	2.7	41.4
41	Farming, Forestry, and Fishing	Skill 4	8.0	2.5	4.6	6.9	2.0	3.8	9.1	2.8	19.9	71.1	2.8	6.4	4.2	2.9
42	Auto Mechanics and Repairers	Skill 5	27.3	468.6	39.4	60.0	15.1	284.8	148.1	55.5	147.5	641.6	309.0	30.0	6327.9	3.2
43	Other Mechanics and Repairers	Skill 5	1864.0	1073.1	1792.5	1442.1	1163.8	1214.2	1771.8	8700.8	1734.1	5471.7	506.7	151.0	1679.2	36.4
44	Carpenters	Skill 5	31.7	27.7	307.6	70.6	64.2	10.7	25.0	11.3	72.1	119.2	32.3	20.6	16.8	13.0
45	Other Construction Trades	Skill 5	472.0	475.2	1141.7	503.1	471.8	42.2	173.9	253.7	2787.8	974.9	81.2	34.6	59.3	14.6
46	Extractive Occupations	Skill 5	5.7	3.4	9.0	13.5	2.1	2.1	7.5	2.4	11.8	29.6	0.5	1.3	2.1	0.0
47	Supervisors and Production	Skill 5	3087.7	1714.1	2065.9	2813.2	111.5	983.2	265.1	270.8	1960.4	4229.0	846.3	770.6	518.3	88.8
48	Precision and Production	Skill 5	3220.4	1116.5	2514.1	2141.5	484.0	84.6	140.9	78.4	240.0	1630.8	325.9	4518.2	276.4	75.0
49	Plant and System Operators	Skill 5	121.7	51.0	77.9	134.0	17.4	17.0	61.9	54.0	1787.2	174.2	22.1	18.5	19.9	2.7
50	Machine Operators	Skill 5	3826.0	2372.2	1689.8	4326.5	184.0	101.6	105.2	116.1	434.1	1847.0	37.1	134.8	234.3	28.6
51	Fabrications and Assemblers	Skill 5	5422.4	3615.7	2076.4	3024.9	258.6	68.7	72.2	69.6	252.2	928.1	35.4	89.4	100.0	8.8
52	Production Inspectors and Related	Skill 5	1468.8	786.1	802.3	991.2	134.8	73.5	36.6	59.4	147.7	654.7	22.9	40.6	13.8	1.6
53	Motor Vehicle Operators	Skill 5	165.2	252.7	111.5	749.6	122.9	12559.5	3399.7	70.5	878.3	7995.6	199.2	737.0	808.3	188.2
54	Other Transportation Operators	Skill 5	6.4	7.7	36.2	11.2	5004.9	23.7	1018.5	32.4	16.6	43.5	0.9	1.2	7.3	0.6
55	Material Moving Equipment Operators	Skill 5	482.3	592.5	275.7	717.0	209.1	459.8	253.8	33.9	398.6	1464.7	99.7	150.8	43.7	3.3
56	Craft and Production	Skill 5	27.4	13.6	51.9	43.5	27.0	16.4	13.3	7.0	68.8	83.7	6.8	73.2	58.4	1.2
57	Construction Labor	Skill 5	2.9	3.4	7.8	24.7	21.3	4.4	5.2	16.0	109.9	24.8	2.1	3.3	2.6	1.8
58	Freight and Material Handlers	Skill 5	164.8	65.3	27.2	169.4	22.8	993.1	394.5	18.9	461.7	856.0	636.5	4298.2	62.5	19.7
59	Other Handlers and Miscellaneous	Skill 5	484.5	277.8	225.7	1095.1	470.6	502.3	203.3	76.2	467.2	3157.7	308.8	963.8	3539.4	50.5
	Total		*42109.4*	*19006.4*	*27281.9*	*33433.1*	*12186.0*	*24460.9*	*25179.9*	*34828.2*	*22358.2*	*110386.5*	*33205.7*	*33206.1*	*33206.9*	*17141.6*

Source: Rose, Adam, Brandt Stevens, and Gregg Davis, 1988. Natural Resource Policy and Income Distribution (Table 5.1, p.45), and Regional Multipliers: A User Handbook for the Regional Input-Output Modeling Sustem RIMS II, 1992.

APPENDIX TABLE B.4 (Continued)

US WAGE/SALARY INCOME DISTRIBUTION MATRIX FOR INDIVIDUALS (Millions of 1982 dollars)

	Occupation	Skill aggregation	Industry: Eating & Drinking Places	Other Retail Trade	Banks & Credit Agencies	Ins. Real Estate Finance	Repair Service	Business Serv	Other Pers Serv	Recreation Service	Hospitals	Health Services	Education Services	Social Services	Legal & Other Services	Public Administration
	Corresponding RIMS Sector # --->	v	36	29	30	31	38	35	34	33	37	37	38	38	35	38
1	Public Administrators & Officials	Skill 1	0.3	0.2	0.5	2.2	1.9	0.1	1.0	0.9	1.2	0.0	0.8	0.9	0.2	28277.2
2	Other Administrators & Officials	Skill 1	7148.5	5378.8	5434.5	14726.7	9053.2	1506.1	6995.8	3202.6	1322.1	6888.9	1730.3	5480.3	989.1	14382.1
3	Management Related	Skill 1	181.2	817.4	4638.6	3345.7	5049.5	86.2	521.7	315.7	308.5	808.8	177.0	742.5	2180.6	30398.9
4	Architect	Skill 1	3.8	9.3	8.9	88.6	28.1	1.0	5.4	4.6	2.7	7.6	6.4	18.7	754.2	522.5
5	Engineers	Skill 1	8.0	52.8	24.7	323.5	1791.7	36.8	45.7	79.4	56.9	132.5	50.9	113.3	1816.9	10485.1
6	Surveyors & Mapping Scientists	Skill 1	0.0	0.2	0.4	11.5	9.1	0.2	0.9	0.7	0.1	1.9	1.1	5.9	210.3	299.6
7	Oth Sci and Mathematicians	Skill 1	7.3	78.5	238.0	886.7	2463.4	6.4	21.5	27.2	200.2	475.8	129.8	109.4	333.9	10398.3
8	Doctors & Ot Diagnosticians	Skill 1	0.9	77.2	5.5	66.6	58.1	0.3	15.2	31.0	2880.4	39963.3	88.3	115.1	25.8	1525.0
9	Ot Health, inc Nurses	Skill 1	7.9	749.0	10.1	82.0	413.8	0.4	132.8	17.9	6039.4	8655.4	178.6	380.0	12.2	1886.9
10	Elementary & Secondary Teachers	Skill 1	4.0	80.2	10.2	17.8	67.2	3.1	214.2	686.2	52.4	256.8	6410.0	2040.5	18.8	962.3
11	Ot Education Related	Skill 1	2.1	17.7	12.5	58.1	101.7	2.0	24.9	37.0	80.6	273.3	2292.3	5610.9	101.3	1853.0
12	Social Sci and Urban Planners	Skill 1	3.6	15.2	75.1	131.9	286.0	1.8	16.0	12.0	108.9	837.5	57.4	121.0	72.8	1805.2
13	Social, Recreation & Religious	Skill 1	0.8	4.4	6.4	53.8	51.0	0.2	39.6	84.2	205.8	1321.6	48.8	2872.5	18.3	8081.4
14	Lawyers and Judges	Skill 1	6.5	9.1	94.3	549.5	113.2	3.8	11.3	19.2	8.4	133.7	12.5	253.0	5142.7	11944.5
15	Artists, Entertainers, and Athletes	Skill 1	179.5	846.1	82.4	247.3	2779.3	12.0	751.6	2556.3	48.5	132.4	123.5	757.6	694.2	2299.8
16	Health Technologies & Technicians	Skill 2	1.1	10.2	2.4	18.2	41.8	0.5	5.9	2.8	1595.7	3520.0	31.7	35.8	7.7	443.2
17	Licensed Practical Nurses	Skill 2	8.3	0.9	1.4	6.8	120.0	0.1	120.3	1.0	893.8	2255.2	4.4	25.9	8.9	108.8
18	Ot Technologists & Technicians	Skill 2	16.9	152.0	293.7	1267.8	3788.2	98.5	137.7	155.4	168.6	407.7	403.5	206.1	1226.0	16236.5
19	Supervisors and Sales, Self-Employed	Skill 2	41.1	992.6	0.2	73.9	21.7	22.2	25.1	4.2	0.0	1.2	0.1	1.3	1.0	0.0
20	Supervisors and Sales, Salaried	Skill 2	181.0	3372.5	47.3	420.5	311.7	138.6	116.2	50.6	6.9	22.4	7.4	23.3	8.8	214.4
21	Sales, Finance, and Business Services	Skill 2	5.7	39.5	367.7	33519.9	3183.9	179.3	201.8	245.8	0.6	13.0	2.3	8.4	61.3	544.8
22	Sales Representative, Non-Retail	Skill 2	0.0	14.2	0.5	14.4	42.9	3.3	10.3	0.3	0.1	0.3	0.1	0.9	10.9	32.3
23	Other Sales, Retail and Personal	Skill 2	223.2	10199.7	6.2	192.7	219.9	143.9	830.0	172.8	15.4	88.6	19.5	185.4	21.2	355.9
24	Cashiers	Skill 2	661.9	519.8	68.1	66.1	29.7	26.0	149.3	231.7	27.8	15.7	25.3	14.4	2.5	234.6
25	Sales Related	Skill 2	1.3	42.3	3.0	29.3	88.2	0.4	3.8	0.8	8.3	0.7	1.4	6.3	1.1	13.5
26	Supervisors and Admin Support	Skill 2	44.6	294.1	1092.8	2201.3	984.9	40.5	150.1	87.6	250.2	624.7	71.9	248.4	150.6	12570.0
27	Computer Equipment Operators	Skill 2	5.5	64.5	310.3	419.9	641.1	8.2	24.8	14.4	61.8	109.9	35.3	45.1	54.4	1685.1
28	Secretarial Related	Skill 2	85.4	559.1	1417.0	5378.5	2595.7	184.5	399.9	277.0	876.3	3788.4	766.2	2244.1	1383.0	18126.2
29	Accountants and Auditors	Skill 2	153.2	833.7	985.3	1214.6	612.2	205.9	320.8	146.0	184.7	1002.6	74.4	358.8	339.6	2697.5
30	Other Financial Record Processing	Skill 2	17.6	77.5	288.8	502.8	141.4	12.0	45.2	17.2	88.0	164.2	18.5	41.3	18.3	934.0
31	Mail and Message Distributing	Skill 2	7.8	94.9	223.8	403.7	428.3	8.1	32.6	22.5	52.5	92.7	34.5	64.0	40.4	1067.2
32	Shipping, Receiving, and other Clerks	Skill 2	43.8	639.6	118.6	276.6	548.0	69.6	158.1	78.9	289.0	148.7	44.3	97.7	28.5	3398.2
33	Other Administrative Support	Skill 2	85.1	828.3	5503.1	5734.8	3110.8	149.1	1432.3	302.9	1090.1	4045.8	803.4	1145.3	325.8	28675.6
34	Private Household	Skill 3	0.0	0.0	0.0	8.0	0.0	0.0	1124.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	Guards	Skill 3	32.4	55.8	151.0	312.2	2766.1	8.3	203.3	264.8	137.9	94.4	99.2	127.9	38.0	4707.9
36	Other Protective Services	Skill 3	0.4	6.0	9.2	31.8	185.8	1.1	21.7	19.1	19.6	7.5	5.8	9.1	5.1	59562.9
37	Food Preparation and Service	Skill 3	7153.4	55.4	12.5	38.1	30.7	1.5	1022.0	455.4	230.5	970.8	275.3	339.7	2.7	503.2
38	Nursing and Other Health Assistants	Skill 3	5.7	55.6	2.5	15.1	169.8	0.2	270.9	6.2	1995.6	11545.4	21.3	174.0	3.5	588.7
39	Cleaning and Building Services	Skill 3	237.7	139.2	166.7	1274.2	2337.9	41.2	2443.5	380.8	626.6	1473.9	489.6	824.8	30.8	3230.2
40	Personal Services	Skill 3	41.4	17.4	4.1	71.1	76.4	2.8	4852.3	531.6	32.3	412.9	190.7	1099.3	10.3	630.4
41	Farming, Forestry, and Fishing	Skill 4	2.9	32.3	2.6	213.1	25.8	8.7	168.2	241.2	13.1	31.1	24.6	46.1	12.6	1107.7
42	Auto Mechanics and Repairers	Skill 5	3.2	47.3	2.5	17.8	54.9	4101.5	18.9	23.5	3.9	8.8	13.8	12.2	2.4	1303.6
43	Other Mechanics and Repairers	Skill 5	36.4	1079.8	37.7	319.5	1198.0	2950.3	276.8	414.2	131.3	137.7	103.1	79.4	39.5	6445.5
44	Carpenters	Skill 5	13.0	92.2	6.1	142.5	51.2	12.5	88.7	53.6	33.1	29.8	26.0	60.9	6.5	670.0
45	Other Construction Trades	Skill 5	14.6	571.3	21.3	512.0	457.6	112.7	196.6	92.8	141.8	111.9	81.5	157.2	34.5	2928.7
46	Extractive Occupations	Skill 5	0.0	3.0	0.4	3.5	7.3	1.6	0.7	1.5	0.1	0.6	0.3	0.4	1.9	43.0
47	Supervisors and Production	Skill 5	88.8	699.6	52.9	192.1	484.9	126.9	318.4	84.4	60.6	224.1	27.3	98.3	30.4	1514.7
48	Precision and Production	Skill 5	75.0	925.8	5.6	31.3	212.8	592.6	999.1	46.0	48.7	1563.4	33.2	51.8	22.5	1424.7
49	Plant and System Operators	Skill 5	2.7	10.2	14.1	145.7	30.2	5.2	121.5	15.1	95.5	43.4	24.5	20.2	27.6	639.2
50	Machine Operators	Skill 5	28.6	311.1	49.4	166.7	886.9	325.8	2382.2	220.9	218.0	589.6	52.8	142.8	36.5	1694.6
51	Fabrications and Assemblers	Skill 5	8.8	149.5	4.7	20.2	365.1	558.6	35.1	16.7	8.7	39.7	9.8	119.9	17.1	646.7
52	Production Inspectors and Related	Skill 5	1.6	38.6	7.0	22.0	111.2	8.6	85.3	3.9	2.5	10.9	3.9	31.1	8.3	398.7
53	Motor Vehicle Operators	Skill 5	188.2	1220.9	45.3	89.7	505.0	454.3	621.7	109.9	56.7	229.6	348.2	236.7	13.0	2524.1
54	Other Transportation Operators	Skill 5	0.6	3.0	0.8	3.4	9.1	2.6	8.9	10.0	0.6	2.0	0.7	3.8	2.3	204.7
55	Material Moving Equipment Operators	Skill 5	3.3	133.4	8.2	41.5	127.4	19.9	19.3	22.6	8.2	9.1	4.9	21.1	6.8	1082.3
56	Craft and Production	Skill 5	1.2	12.7	0.7	8.5	16.5	75.2	14.9	4.7	6.6	10.9	4.6	6.6	17.6	150.8
57	Construction Labor	Skill 5	1.8	7.2	0.8	19.2	15.5	2.3	11.0	6.0	1.9	2.1	1.7	11.9	2.1	178.0
58	Freight and Material Handlers	Skill 5	19.7	305.0	3.8	15.1	45.5	6.0	25.4	41.2	4.8	9.2	4.4	19.1	1.3	199.8
59	Other Handlers and Miscellaneous	Skill 5	50.5	364.2	11.0	161.0	400.7	338.3	239.7	77.4	21.8	71.1	19.8	136.9	16.4	1893.6
	Total		*17141.6*	*33207.0*	*21993.4*	*76193.0*	*49810.0*	*12749.4*	*28513.5*	*12030.3*	*20750.5*	*93821.2*	*15516.1*	*27204.3*	*16443.0*	*298733.3*

Source: Rose, Adam, Brandt Stevens, and Gregg Davis, 1988. Natural Resource Policy and Income Distribution (Table 5.1, p.49), and Regional Multipliers: A User Handbook for the Regional Input-Output Modeling Sustem RIMS II, 1992.

APPENDIX TABLE B.5

PROPORTION OF LABOR INCOME BY LABOR SKILL AND PRODUCTION ACCOUNT

Production Account	Labor Category					
	Skill 1	Skill 2	Skill 3	Skill 4	Skill 5	Total
Agriculture, forestry, and fisheries:						
1 Agricultural products and agricultural, forestry, and fisheries services	18.82	7.54	1.82	63.17	8.66	100.00
2 Forestry and fishery products	18.82	7.54	1.82	63.17	8.66	100.00
Mining:						
3 Coal mining	22.60	10.93	0.82	0.02	65.63	100.00
4 Crude petroleum and natural gas	20.77	15.67	1.36	0.02	62.16	100.00
5 Miscellaneous mining	22.60	10.93	0.82	0.02	65.63	100.00
Construction:						
6 New construction	15.92	8.16	0.43	0.06	75.42	100.00
7 Maintenance and repair construction	15.92	8.16	0.43	0.06	75.42	100.00
Manufacturing:						
8 Food and kindred products and tobacco	18.75	16.40	2.26	0.04	62.55	100.00
9 Textile mill products	12.25	12.55	1.65	0.02	73.53	100.00
10 Apparel	11.01	11.69	0.75	0.00	76.54	100.00
11 Paper and allied products	18.14	16.73	1.35	0.09	63.69	100.00
12 Printing and publishing	32.39	30.11	0.70	0.01	36.80	100.00
13 Chemicals and petroleum refining	32.05	24.60	1.52	0.03	41.80	100.00
14 Rubber and leather products	32.05	24.60	1.52	0.03	41.80	100.00
15 Lumber and wood products and furniture	14.93	10.96	1.35	3.09	69.67	100.00
16 Stone, clay, and glass products	22.60	10.93	0.82	0.02	65.63	100.00
17 Primary metal industries	15.10	12.97	1.68	0.02	70.24	100.00
18 Fabricated metal products	22.60	10.93	0.82	0.02	65.63	100.00
19 Machinery, except electrical	27.10	18.85	0.88	0.01	53.15	100.00
20 Electric and electronic equipment	29.98	19.50	0.92	0.02	49.59	100.00
21 Motor vehicles and equipment	18.80	11.59	1.63	0.01	67.96	100.00
22 Transportation equipment, except motor vehicles	35.87	15.17	1.10	0.02	47.84	100.00
23 Instruments and related products	24.46	19.59	1.10	0.02	54.83	100.00
24 Miscellaneous manufacturing industries	24.46	19.59	1.10	0.02	54.83	100.00
Transportation and public utilities:						
25 Transportation	15.17	27.64	1.82	0.02	55.34	100.00
26 Communication	31.83	39.09	0.56	0.01	28.50	100.00
27 Electric, gas, water, and sanitary services	23.92	20.61	1.82	0.09	53.56	100.00
Wholesale and retail trade:						
28 Wholesale trade	25.05	46.78	0.63	0.06	27.47	100.00
29 Retail trade	19.16	52.48	1.74	0.03	26.59	100.00
Finance, insurance, and real estate:						
30 Finance	48.39	48.79	1.57	0.01	1.24	100.00
31 Insurance	27.03	67.90	2.29	0.28	2.51	100.00
32 Real estate	27.03	67.90	2.29	0.28	2.51	100.00
Services:						
33 Hotels and lodging places and amusements	58.81	15.06	13.78	2.00	10.34	100.00
34 Personal services	30.86	14.60	34.85	0.59	19.09	100.00
35 Business services	48.07	17.03	0.50	0.07	34.33	100.00
36 Eating and drinking places	44.07	9.19	43.58	0.02	3.14	100.00
37 Health services	62.15	19.07	15.32	0.04	3.43	100.00
38 Miscellaneous services	45.32	26.41	20.05	0.31	7.91	100.00
TOTAL	27.23	21.80	4.46	3.52	42.99	100.00

APPENDIX TABLE B.6

THE RIMS II SECTORS RELATED TO ANGLER EXPENDITURES 1991 (Thousand dollars)

Industry	TRIP RELATED EXPENDITURES														
	Eating & drinking	Food & drinks (others)	Lodging	Public transportation	Private transportation	Boat fuel	Guide fees	Package fees	Public land use fees	Private land use fees	Boat launching fees	Boat storage, repair	Equipment rental	Bait	Ice
Agriculture, forestry, and fisheries:															
1 Agricultural products and agricultural, forestry, and fisheries services															
2 Forestry and fishery products															
Mining:															
3 Coal mining															
4 Crude petroleum and natural gas															
5 Miscellaneous mining															
Construction:															
6 New construction															
7 Maintenance and repair construction															
Manufacturing:															
8 Food and kindred products and tobacco		33842.4													2827.923
9 Textile mill products															
10 Apparel															
11 Paper and allied products															
12 Printing and publishing															
13 Chemicals and petroleum refining					41430.97	11603.25									
14 Rubber and leather products															
15 Lumber and wood products and furniture															
16 Stone, clay, and glass products															
17 Primary metal industries															
18 Fabricated metal products															
19 Machinery, except electrical															
20 Electric and electronic equipment															
21 Motor vehicles and equipment															
22 Transportation equipment, except motor vehicles															
23 Instruments and related products															
24 Miscellaneous manufacturing industries															
Transportation and public utilities:*															
25 Transportation				2789.00								14934			
26 Communication															
27 Electric, gas, water, and sanitary services															
Wholesale and retail trade:															
28 Wholesale trade		5281.762			3974.274	1113.044									639.1672
29 Retail trade		9781.04			9946.754	2785.709								15001	886.9098
Finance, insurance, and real estate:															
30 Finance															
31 Insurance															
32 Real estate															
Services:															
33 Hotels and lodging places and amusements			12224				430.00	718.00	1361.00	568.00	371.00		1008.00		
34 Personal services															
35 Business services															
36 Eating and drinking places	22708.8														
37 Health services															
38 Miscellaneous services															
39 Households															
TOTAL	22709	48905	12224	2789	55351	15502	430	718	1361	568	371	14934	1008	15001	4354

* Including Federal Government enterprises

Source: The 1991 Economic Impact of Sport Fishing in Oklahoma. Sport Fishing Institute, Washington, D.C. (in diskette), Feedler, A.J. and D.M. Nickum. 1994b. and Regional Multipliers: A User Handbook for Regional Input-Output Modeling System (RIMS II), USDC, BEA, 1992.

APPENDIX TABLE B.6 (Continued)

THE RIMS II SECTORS RELATED TO ANGLER EXPENDITURES 1991 (Thousand dollars)

Industry	EQUIPMENT EXPENDITURES											
	Rods, poles, components	Reels	Lines	Artificial lures	Leaders, hooks, sinkers	Tackle boxes	Creels, stringer, nets	Minnow traps, seines	Electronic devices	Ice fishing equipment	Spear fishing equipment	Other purchases
Agriculture, forestry, and fisheries:												
1 Agricultural products and agricultural, forestry, and fisheries services												
2 Forestry and fishery products												
Mining:												
3 Coal mining												
4 Crude petroleum and natural gas												
5 Miscellaneous mining												
Construction:												
6 New construction												
7 Maintenance and repair construction												
Manufacturing:												
8 Food and kindred products and tobacco												
9 Textile mill products			822.0945									
10 Apparel												
11 Paper and allied products												
12 Printing and publishing												
13 Chemicals and petroleum refining												
14 Rubber and leather products												
15 Lumber and wood products and furniture												
16 Stone, clay, and glass products												
17 Primary metal industries												
18 Fabricated metal products												
19 Machinery, except electrical												
20 Electric and electronic equipment												
21 Motor vehicles and equipment												
22 Transportation equipment, except motor vehicles												
23 Instruments and related products									769.41			
24 Miscellaneous manufacturing industries	2234.8425	1828.1985		2149.404	746.853	214.2915	164.697	93.4725		0	14.832	155.5815
Transportation and public utilities:*												
25 Transportation												
26 Communication												
27 Electric, gas, water, and sanitary services												
Wholesale and retail trade:												
28 Wholesale trade	4485.5965	3669.4133	1650.0421	4314.1112	1499.0234	430.1087	330.5666	187.6105	1544.298	0	29.7696	312.2707
29 Retail trade	7744.561	6335.3882	2848.8634	7448.4848	2588.1236	742.5998	570.7364	323.917	2666.292	0	51.3984	0
Finance, insurance, and real estate:												
30 Finance												
31 Insurance												
32 Real estate												
Services:												
33 Hotels and lodging places and amusements												
34 Personal services												
35 Business services												
36 Eating and drinking places												
37 Health services												
38 Miscellaneous services												
524 ROW Industry												
TOTAL	14465	11833	5321	13912	4834	1387	1066	605	4980	0	96	468

* Includes Federal Government enterprises

Source: The 1991 Economic Impact of Sport Fishing in Oklahoma. Sport Fishing Institute, Washington, D.C. (in diskette), Feedler, A.J. and D.M. Nickum. 1994b. and Regional Multipliers: A User Handbook for Regional Input-Output Modeling System (RIMS II), USDC, BEA, 1992.

APPENDIX TABLE B.6 (Continued)

THE RIMS II SECTORS RELATED TO ANGLER EXPENDITURES 1991 (Thousand dollars)

Industry	OTHER EXPENDITURES																	
	Camping equipment	Binoculars	Special clothing	Processing, taxidermy	Magazines	Contributions to org.	Other purchases	Bass boat	Other motor boat	Non-motor boat	Motors, boat accessories	Pickup, camper, trailer	Cabin	Trail bike, snowmobile	Other (ice chest)	Land leasing	Fishing licenses	Spesial licenses, fees
Agriculture, forestry, and fisheries:																		
1 Agricultural products and agricultural, forestry, and fisheries services																		
2 Forestry and fishery products																		
Mining:																		
3 Coal mining																		
4 Crude petroleum and natural gas																		
5 Miscellaneous mining																		
Construction:																		
6 New construction																		
7 Maintenance and repair construction																		
Manufacturing:																		
8 Food and kindred products and tobacco																		
9 Textile mill products																		
10 Apparel	3298.599		1567.02															
11 Paper and allied products																		
12 Printing and publishing					1124.837													
13 Chemicals and petroleum refining																		
14 Rubber and leather products																		
15 Lumber and wood products and furniture																		
16 Stone, clay, and glass products																		
17 Primary metal industries																		
18 Fabricated metal products																		
19 Machinery, except electrical																		
20 Electric and electronic equipment																		
21 Motor vehicles and equipment											25117.73							
22 Transportation equipment, except motor vehicles							24708.58	13819	408.2415	6054.832								
23 Instruments and related products		50.863																
24 Miscellaneous manufacturing industries						1009.229												
Transportation and public utilities:*																		
25 Transportation																		
26 Communication															270.556			
27 Electric, gas, water, and sanitary services																		
Wholesale and retail trade:																		
28 Wholesale trade	951.8745	14.6775	468.5569		254.2728		291.2325	7129.3	3987.323	117.7925	1747.039	4263.133			54.524			
29 Retail trade	1910.526	29.4595	887.4228		619.8899		584.5385	6595.1	3688.542	108.966		6086.137			104.92			
Finance, insurance, and real estate:																		
30 Finance																		
31 Insurance																		
32 Real estate											1616.129					1579		
Services:																		
33 Hotels and lodging places and amusements																		
34 Personal services																		
35 Business services				1781														
36 Eating and drinking places																		
37 Health services																		
38 Miscellaneous services						1780											7513	
TOTAL	6161	95	2923	1781	1999	2789	25584	27544	8084	6282	28481	10349	0	0	430	1579	7513	0

*Includes Federal Government enterprises

Source: Feedler, A.J. and D.M. Nickum. 1994b. The 1991 Economic Impact of Sport Fishing in Oklahoma. Sport Fishing Institute, Washington, D.C. (in diskette), and Regional Multipliers: A User Handbook for Regional Input-Output Modeling System (RIMS II), USDC, BEA, 1992.

APPENDIX TABLE B.7

IMPLAN BRIDGE TABLE FOR TRIP SPENDING IN CORPS OF ENGINEERS RECREATION SPENDING SURVEY

Industry	TRIP EXPENDITURE																					
	hotel	camping	food on site	food off site	gas & oil	auto rental / repairs	tires	auto / RV parts	boat rental	boat repairs	boat parts	boat launch / slip	boat fares	fish bait	ammunition	spec. & attr. fees	recreation fees	film purchase	film developing	footwear	men's clothing	women's clothing
Agriculture, forestry, and fisheries:																						
1 Agricultural products and agricultural, forestry, and fisheries services				0.0402										0.03		0.1103						
2 Forestry and fishery products				0.0018												0.0783						
Mining:																						
3 Coal mining																						
4 Crude petroleum and natural gas																						
5 Miscellaneous mining																						
Construction:																						
6 New construction																						
7 Maintenance and repair construction																						
Manufacturing:																						
8 Food and kindred products and tobacco				0.5922										0.03								
9 Textile mill products																					0.0262	0.0396
10 Apparel								0.0043													0.5075	0.3974
11 Paper and allied products														0.065								0.0178
12 Printing and publishing														0.015								0.0029
13 Chemicals and petroleum refining				0.0002	0.6638			0.0557						0.026								
14 Rubber and leather products							0.4082	0.0205						0.06						0.5111	0.0185	0.0342
15 Lumber and wood products and furniture																						
16 Stone, clay, and glass products								0.0076						0.06								
17 Primary metal industries																						
18 Fabricated metal products								0.0159			0.0056				0.5571							
19 Machinery, except electrical								0.0179			0.0542											
20 Electric and electronic equipment								0.2373			0.0009							0.133				
21 Motor vehicles and equipment								0.156														
22 Transportation equipment, except motor vehicles										1	0.6826											
23 Instruments and related products																		0.3757				
24 Miscellaneous manufacturing industries														0.238							0.0015	0.0029
Transportation and public utilities:*																						
25 Transportation			0.002	0.0226	0.0318		0.0169	0.039			0.0055	0.093	1	0.0089	0.0062		0.093	0.004			0.0034	0.0033
26 Communication																		0.0004				
27 Electric, gas, water, and sanitary services																						
Wholesale and retail trade:																						
28 Wholesale trade				0.1129	0.1527		0.0701	0.141			0.0363			0.092	0.0884			0.1076		0.0572	0.0407	0.0312
29 Retail trade				0.2302	0.1517		0.2319	0.3048			0.2149			0.3751	0.3483			0.3793	0.0471	0.4279	0.4019	0.4707
Finance, insurance, and real estate:																						
30 Finance																						
31 Insurance																						
32 Real estate																						
Services:																						
33 Hotels and lodging places and amusements	1	1	0.0074						1			0.9051				0.8114	0.9051					
34 Personal services																			0.9529			
35 Business services																						
36 Eating and drinking places			0.9912																			
37 Health services																						
38 Miscellaneous services						1	0.2729					0.0019					0.0019					
TOTAL	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

* Includes Federal Government enterprises

Source: Stynes and Propst. (1992). Micro-Implan Recreation Economic Impact Estimation System, Michigan State University., and Regional Multipliers: A User Handbook fro Regional Input-Output Modeling System (RIMS II), USDC, BEA, 1992.

APPENDIX TABLE B.7 (Continued)

IMPLAN BRIDGE TABLE FOR TRIP SPENDING IN CORPS OF ENGINEERS RECREATION SPENDING SURVEY

	DURABLE GOODS															
Industry	MotorBoats	Boat engines	Motorhomes	Other camping veh.	Trailers	Tents & camp equip.	Bikes & ORV's	Rods & reels	Rifles	Clothing	Boots & waders	Sporting Goods	Other equip & access.	Cameras & photo equip	Binoculars	Used (Dealers)
Agriculture, forestry, and fisheries:																
1 Agricultural products and agricultural, forestry, and fisheries services																
2 Forestry and fishery products																
Mining:																
3 Coal mining																
4 Crude petroleum and natural gas																
5 Miscellaneous mining																
Construction:																
6 New construction																
7 Maintenance and repair construction																
Manufacturing:																
8 Food and kindred products and tobacco																
9 Textile mill products													0.0031			
10 Apparel						0.4074				0.52			0.0043			
11 Paper and allied products																
12 Printing and publishing																
13 Chemicals and petroleum refining													0.0549			
14 Rubber and leather products	0.002						0.0057				0.5111		0.0203			
15 Lumber and wood products and furniture																
16 Stone, clay, and glass products													0.0074			
17 Primary metal industries																
18 Fabricated metal products	0.005					0.1499			0.5354				0.0191			
19 Machinery, except electrical	0.0484	0.5975											0.0176			
20 Electric and electronic equipment	0.0008												0.235			
21 Motor vehicles and equipment													0.1538			
22 Transportation equipment, except motor vehicles	0.6621		0.715	0.715	0.5283		0.4891									
23 Instruments and related products														0.5391	0.5921	
24 Miscellaneous manufacturing industries	0.003							0.5229				0.5079				
Transportation and public utilities:*																
25 Transportation	0.0088	0.0053	0.0027	0.0027	0.089	0.0068	0.0137	0.0106	0.0009	0.0022	0.0035	0.0085	0.0386	0.0023	0.0018	
26 Communication	0.0004										0.0002					
27 Electric, gas, water, and sanitary services																
Wholesale and retail trade:																
28 Wholesale trade	0.0349	0.0493	0.0062	0.0062	0.0345	0.0874	0.1048	0.0896	0.1155	0.023	0.0572	0.0864	0.1406	0.0663	0.0575	
29 Retail trade	0.2345	0.348	0.276	0.276	0.3482	0.3482	0.323	0.3771	0.3482	0.455	0.4288	0.3601	0.3054	0.3677	0.3486	0.25
Finance, insurance, and real estate:																
30 Finance																
31 Insurance																
32 Real estate																
Services:																
33 Hotels and lodging places and amusements																
34 Personal services																
35 Business services						0.0003	0.0638					0.0371		0.0246		
36 Eating and drinking places																
37 Health services																
38 Miscellaneous services																
518 Used and secondhand goods																0.75
TOTAL	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

* Includes Federal Government enterprises

Source: Stynes and Propst. (1992). Micro-Implan Recreation Economic Impact Estimation System, Michigan State University., and Regional Multipliers: A User Handbook fro Regional Input-Output Modeling System (RIMS II), USDC, BEA, 1992.

APPENDIX TABLE B.8

SPORT FISHING EXPENDITURE AND MI-REC BRIDGE TABLE

SPORTFISHING INSTITUTE*			MI-REC***						ADJUSTMENT	
Expenditure item	RIMS** sector #	Expenditure ($1,000)	Expenditure item	RIMS** sector #	Expenditure (%)	Per trip $	Per trip %	Expend adj ($1,000)	RIMS** sector #	Expenditure ($1,000)
TRIP EXPENDITURE										
Food and drink			Food and beverages:							
1. Eating & drinking	36	$22,708.80	1. Food on site	25	0.15%				25	$34.06
				33	0.74%				33	$168.05
				36	99.11%				36	$22,506.69
					100.00%					$22,708.80
2. Food & drinks (other)	8	$33,842.40	2. Food off site	1	4.02%				1	$1,965.99
	28	$5,281.76		2	0.18%				2	$88.03
	29	$9,781.04		8	59.21%				8	$28,956.77
		$48,905.20		13	0.02%				13	$9.78
				25	2.26%				25	$1,105.26
				28	11.29%				28	$5,521.40
				29	23.02%				29	$11,257.98
					100.00%					$48,905.20
			Lodging Expenses:							
Lodging	33	$12,224.00	1. Hotel	33	100.00%	$7.56	83.63%		33	$10,222.73
			2. Camping	33	100.00%	$1.48	16.37%		33	$2,001.27
						$9.04	100.00%			$12,224.00
Public transportation	25	$2,789.00	No comparable item						25	$2,789.00
			Auto/RV expenses:							
Private transportation	13	$41,430.97	1. Gas & oil	13	66.38%			$30,424.02	10	$4.83
	28	$3,974.27		25	3.18%			$1,457.49	13	$30,486.64
	29	$9,946.75		28	15.27%			$6,998.72	14	$1,598.71
		$55,352.00		29	15.17%			$6,952.88	16	$8.54
					100.00%	$12.23	82.80%	$45,833.10	18	$17.88
			2. Auto rental/repair	38	100.00%	$1.21	8.19%	$4,534.59	19	$20.12
			3. Tires	14	40.82%			$1,575.66	20	$266.79
				25	1.69%			$65.23	21	$175.39
				28	7.01%			$270.59	25	$1,566.57
				29	23.19%			$895.14	28	$7,427.83
				38	27.29%			$1,053.40	29	$8,190.70
					100.00%	$1.03	6.97%	$3,860.02	38	$5,587.99
			4. Auto parts	10	0.43%			$4.83		$55,352.00
				13	5.57%			$62.62		
				14	2.05%			$23.05		
				16	0.76%			$8.54		
				18	1.59%			$17.88		
				19	1.79%			$20.12		
				20	23.73%			$266.79		
				21	15.60%			$175.39		
				25	3.90%			$43.85		
				28	14.10%			$158.52		
				29	30.48%			$342.68		
					100.00%	$0.30	2.03%	$1,124.28		
						$14.77	100.00%	$55,352.00		

Sources: *) Fedler, A.J. and D.M. Nickum. 1994b. The 1991 Economic Impact of Sport Fishing in Oklahoma. Sport Fishing Institute, Washington, D.C. (in diskette).
**) Regional Multipliers: A User Handbook for Regional Input-Output Modeling System (RIMS II), USDC, BEA, 1992.
***) Stynes and Propst. 1992. Micro-Implan Recreation Economic Impact Estimation System, Michigan State University.

APPENDIX TABLE B.8 (Continued)

SPORT FISHING EXPENDITURE AND MI-REC BRIDGE TABLE

SPORTFISHING INSTITUTE*			MI-REC***						ADJUSTMENT	
Expenditure item	RIMS** sector #	Expenditure ($1,000)	Expenditure item	RIMS** sector #	Expenditure (%)	Per trip $	Per trip %	Expend adj ($1,000)	RIMS** sector #	Expenditure ($1,000)
TRIP EXPENDITURES										
Boat fuel	13	$11,603.25	Gas & oil	13	66.38%				13	$10,290.23
	28	$1,113.04		25	3.18%				25	$492.96
	29	$2,785.71		28	15.27%				28	$2,367.16
		$15,502.00		29	15.17%				29	$2,351.65
					100.00%					$15,502.00
Boat launching fees	33	$371.00	Boat launch/slip	25	9.30%				25	$34.50
				33	90.51%				33	$335.79
				38	0.19%				38	$0.70
					100.00%					$371.00
Boat storage, repair	25	$14,934.00	Boat repairs	22	100.00%				22	$7,467.00
									25	$7,467.00
										$14,934.00
Guide fees	33	$430.00	Recreation fees	25	9.30%				25	$286.16
Package fees	33	$718.00		33	90.70%				33	$2,790.84
Public land use fees	33	$1,361.00			100.00%					$3,077.00
Private land use fees	33	$568.00								
		$3,077.00								
Equipment rental	33	$1,008.00	Boat rental	33	100.00%				33	$1,008.00
Bait	29	$15,001.00	part of Fish bait	1	3.00%		5.60%		1	$839.61
				8	3.00%		5.60%		8	$839.61
				25	0.89%		1.66%		25	$249.08
				28	9.20%		17.16%		28	$2,574.80
				29	37.51%		69.98%		29	$10,497.90
					53.60%		100%			$15,001.00
Ice	8	$2,827.92							8	$2,827.92
	28	$639.17							28	$639.17
	29	$886.91							29	$886.91
		$4,354.00								$4,354.00
TOTAL TRIP EXPENDITURES										$196,226.00
EQUIPMENT EXPENDITURES										
Rods, poles, components	24	$7,744.56	Rods & reels	18	52.27%				24	$7,560.86
	28	$2,234.84		25	1.06%				25	$153.33
	29	$4,485.60		28	8.96%				28	$1,296.06
		$14,465.00		29	37.71%				29	$5,454.75
					100.00%					$14,465.00

Sources: *) Fedler, A.J. and D.M. Nickum. 1994b. The 1991 Economic Impact of Sport Fishing in Oklahoma. Sport Fishing Institute, Washington, D.C. (in diskette).

**) Regional Multipliers: A User Handbook for Regional Input-Output Modeling System (RIMS II), USDC, BEA, 1992.

***) Stynes and Propst. 1992. Micro-Implan Recreation Economic Impact Estimation System, Michigan State University.

APPENDIX TABLE B.8 (Continued)

SPORT FISHING EXPENDITURE AND MI-REC BRIDGE TABLE

SPORTFISHING INSTITUTE*			MI-REC***						ADJUSTMENT	
Expenditure item	RIMS** sector #	Expenditure ($1,000)	Expenditure item	RIMS** sector #	Expenditure (%)	Per trip $	Per trip %	Expend adj ($1,000)	RIMS** sector #	Expenditure ($1,000)
EQUIPMENT EXPENDITURES										
Reels	24	$6,335.39	Rods & reels	18	52.27%				24	$6,185.11
	28	$1,828.20		25	1.06%				25	$125.43
	29	$3,669.41		28	8.96%				28	$1,060.24
		$11,833.00		29	37.71%				29	$4,462.22
					100.00%					$11,833.00
Lines	9	$2,848.86	Rods & reels	18	52.27%				24	$2,781.29
	28	$822.09		25	1.06%				25	$56.40
	29	$1,650.04		28	8.96%				28	$476.76
		$5,321.00		29	37.71%				29	$2,006.55
					100.00%					$5,321.00
Artificial lures	24	$7,448.48	part of Fish bait	11	6.50%		6.91%		11	$962.00
	28	$2,149.40		12	1.50%		1.60%		12	$222.00
	29	$4,314.11		13	2.60%		2.77%		13	$384.80
		$13,912.00		14	6.00%		6.38%		14	$888.00
				16	6.00%		6.38%		16	$888.00
				24	23.80%		25.32%		24	$3,522.40
				25	0.89%		0.95%		25	$131.72
				28	9.20%		9.79%		28	$1,361.60
				29	37.51%		39.90%		29	$5,551.48
					94.00%		100.0%			$13,912.00
Leaders, hooks, sinkers	24	$2,588.12	Rods & reels	18	52.27%				24	$2,526.73
	28	$746.85		25	1.06%				25	$51.24
	29	$1,499.02		28	8.96%				28	$433.13
		$4,834.00		29	37.71%				29	$1,822.90
					100.00%					$4,834.00
Tackle boxes	24	$742.60	Rods & reels	18	52.27%				24	$724.98
	28	$214.29		25	1.06%				25	$14.70
	29	$430.11		28	8.96%				28	$124.28
		$1,387.00		29	37.71%				29	$523.04
					100.00%					$1,387.00
Creels, stringer, nets	24	$570.74	Rods & reels	18	52.27%				24	$557.20
	28	$164.70		25	1.06%				25	$11.30
	29	$330.57		28	8.96%				28	$95.51
		$1,066.00		29	37.71%				29	$401.99
					100.00%					$1,066.00

Sources: *) Fedler, A.J. and D.M. Nickum. 1994b. The 1991 Economic Impact of Sport Fishing in Oklahoma. Sport Fishing Institute, Washington, D.C. (in diskette).
**) Regional Multipliers: A User Handbook for Regional Input-Output Modeling System (RIMS II), USDC, BEA, 1992.
***) Stynes and Propst. 1992. Micro-Implan Recreation Economic Impact Estimation System, Michigan State University.

APPENDIX TABLE B.8 (Continued)

SPORT FISHING EXPENDITURE AND MI-REC BRIDGE TABLE

SPORTFISHING INSTITUTE*			MI-REC***						ADJUSTMENT	
Expenditure item	RIMS** sector #	Expenditure ($1,000)	Expenditure item	RIMS** sector #	Expenditure (%)	Per trip $	Per trip %	Expend adj ($1,000)	RIMS** sector #	Expenditure ($1,000)
EQUIPMENT EXPENDITURES										
Minnow traps, seines	24	$323.92	Rods & reels	18	52.27%				24	$316.23
	28	$93.47		25	1.06%				25	$6.41
	29	$187.61		28	8.96%				28	$54.21
		$605.00		29	37.71%				29	$228.15
					100.00%					$605.00
Electronic devices	23	$2,666.29	Rods & reels	18	52.27%				23	$2,603.05
	28	$769.41		25	1.06%				25	$52.79
	29	$1,544.30		28	8.96%				28	$446.21
		$4,980.00		29	37.71%				29	$1,877.96
					100.00%					$4,980.00
Spear fishing equipment	24	$51.40	Rods & reels	18	52.27%				24	$50.18
	28	$14.83		25	1.06%				25	$1.02
	29	$29.77		28	8.96%				28	$8.60
		$96.00		29	37.71%				29	$36.20
					100.00%					$96.00
Other purchases	24	$539.15	Rods & reels	18	52.27%				24	$526.36
	28	$155.58		25	1.06%				25	$10.67
	29	$312.27		28	8.96%				28	$90.23
		$1,007.00		29	37.71%				29	$379.74
					100.00%					$1,007.00
TOTAL EQUIPMENT EXPENDITURES										$59,506.00
OTHER EXPENDITURES										
Camping equipment	10	$3,298.60	Tents & camp equip	10	40.74%				10	$2,509.99
	28	$951.87		18	14.99%				18	$923.53
	29	$1,910.53		25	0.68%				25	$41.89
		$6,161.00		28	8.74%				28	$538.47
				29	34.82%				29	$2,145.26
				35	0.03%				35	$1.85
					100.00%					$6,161.00
Binoculars	23	$50.86	Binoculars	23	59.21%				23	$56.25
	28	$14.68		25	0.18%				25	$0.17
	29	$29.46		28	5.75%				28	$5.46
		$95.00		29	34.86%				29	$33.12
					100.00%					$95.00
Special clothing	10	$1,567.02	Clothing	10	51.98%				10	$1,519.38
	28	$468.56		25	0.22%				25	$6.43
	29	$887.42		28	2.30%				28	$67.23
		$2,923.00		29	45.50%				29	$1,329.97
					100.00%					$2,923.00

Sources: *) Fedler, A.J. and D.M. Nickum. 1994b. The 1991 Economic Impact of Sport Fishing in Oklahoma. Sport Fishing Institute, Washington, D.C. (in diskette).

**) Regional Multipliers: A User Handbook for Regional Input-Output Modeling System (RIMS II), USDC, BEA, 1992.

***) Stynes and Propst. 1992. Micro-Implan Recreation Economic Impact Estimation System, Michigan State University.

APPENDIX TABLE B.8 (Continued)

SPORT FISHING EXPENDITURE AND MI-REC BRIDGE TABLE

SPORTFISHING INSTITUTE*			MI-REC***						ADJUSTMENT	
Expenditure item	RIMS** sector #	Expenditure ($1,000)	Expenditure item	RIMS** sector #	Expenditure (%)	Per trip $	Per trip %	Expend adj ($1,000)	RIMS** sector #	Expenditure ($1,000)
OTHER EXPENDITURES										
Processing, taxidermy	35	$1,781.00	No comparable item						35	$1,781.00
Magazines	12	$1,124.84							12	$1,124.84
	28	$254.27							28	$254.27
	29	$619.89							29	$619.89
		$1,999.00								$1,999.00
Contributions to org.	38	$1,780.00	No comparable item						38	$1,780.00
Other purchases	24	$1,009.23							24	$1,009.23
	28	$291.23							28	$291.23
	29	$584.54							29	$584.54
		$1,885.00								$1,885.00
Bass boat	22	$24,708.58	Motor boats	14	0.20%				14	$139.96
	28	$7,129.32		18	0.50%				18	$349.91
	29	$6,595.10		19	4.84%				19	$3,387.08
		$38,433.00		20	0.08%				20	$55.98
Other motor boat	22	$13,819.14		22	66.22%				22	$46,341.42
	28	$3,987.32		24	0.30%				24	$209.94
	29	$3,688.54		25	0.88%				25	$615.83
		$21,495.00		26	0.04%				26	$27.99
Non-motor boat	22	$408.24		28	3.49%				28	$2,442.34
	28	$117.79		29	23.45%				29	$16,410.54
	29	$108.97			100.00%					$69,981.00
		$635.00								
Motors, boat accessories	22	$6,054.83								
	28	$1,747.04								
	29	$1,616.13								
		$9,418.00								
		$69,981.00								
Pickup, camper, trailer	21	$25,117.73	Trailers	22	52.83%				21	$18,737.22
	28	$4,263.13		25	8.90%				25	$3,156.56
	29	$6,086.14		28	3.45%				28	$1,223.61
		$35,467.00		29	34.82%				29	$12,349.61
					100.00%					$35,467.00
Other (ice chest)	24	$270.56	Rods & reels	18	52.27%				24	$224.76
	28	$54.52		25	1.06%				25	$4.56
	29	$104.92		28	8.96%				28	$38.53
		$430.00		29	37.71%				29	$162.15
					100.00%					$430.00
Land leasing	32	$1,579.00	No comparable item						32	$1,579.00
Fishing licenses	38	$7,513.00	No comparable item						38	$7,513.00
TOTAL OTHER EXPENDITURES										**$131,594.00**
GRAND TOTAL SPORTFISHING EXPENDITURES										***$387,326.00***

Sources: *) Fedler, A.J. and D.M. Nickum. 1994b. The 1991 Economic Impact of Sport Fishing in Oklahoma. Sport Fishing Institute, Washington, D.C. (in diskette).

**) Regional Multipliers: A User Handbook for Regional Input-Output Modeling System (RIMS II), USDC, BEA, 1992.

***) Stynes and Propst. 1992. Micro-Implan Recreation Economic Impact Estimation System, Michigan State University.

APPENDIX TABLE B.9

RESIDENT AND NONRESIDENT SPORT FISHING EXPENDITURES IN OKLAHOMA BY INDUSTRY, 1991

Industry	Total Sportfishing Expenditures ($1,000)		
	Resident	Nonresident	Total
Agriculture, forestry, and fisheries:			
1 Agricultural products and agricultural, forestry, and fisheries services	2404.185	401.413	2805.597
2 Forestry and fishery products	72.748	15.282	88.029
Mining:			
3 Coal mining			
4 Crude petroleum and natural gas			
5 Miscellaneous mining			
Construction:			
6 New construction			
7 Maintenance and repair construction			
Manufacturing:			
8 Food and kindred products and tobacco	27166.682	5457.619	32624.300
9 Textile mill products			
10 Apparel	3401.246	632.955	4034.201
11 Paper and allied products	811.163	150.837	962.000
12 Printing and publishing	1135.660	211.178	1346.837
13 Chemicals and petroleum refining	32347.740	8823.706	41171.446
14 Rubber and leather products	2078.940	547.732	2626.672
15 Lumber and wood products and furniture			
16 Stone, clay, and glass products	755.244	141.300	896.545
17 Primary metal industries			
18 Fabricated metal products	1087.323	203.992	1291.315
19 Machinery, except electrical	2871.261	535.944	3407.205
20 Electric and electronic equipment	249.491	73.286	322.776
21 Motor vehicles and equipment	15932.289	2980.315	18912.604
22 Transportation equipment, except motor vehi	45533.435	8274.983	53808.418
23 Instruments and related products	2242.330	416.965	2659.296
24 Miscellaneous manufacturing industries	22087.975	4107.296	26195.271
Transportation and public utilities: *			
25 Transportation	15353.184	3111.888	18465.073
26 Communication	23.603	4.389	27.992
27 Electric, gas, water, and sanitary services			
Wholesale and retail trade:			
28 Wholesale trade	23879.623	4958.688	28838.311
29 Retail trade	75604.597	13960.602	89565.198
Finance, insurance, and real estate:			
30 Finance			
31 Insurance			
32 Real estate	1331.420	247.580	1579.000
Services:			
33 Hotels and lodging places and amusements	13443.826	3082.850	16526.676
34 Personal services			
35 Business services	1503.306	279.542	1782.848
36 Eating and drinking places	18599.564	3907.127	22506.691
37 Health services			
38 Miscellaneous services	12073.383	2808.315	14881.697
TOTAL	321990.218	65335.782	387326.000

APPENDIX C

GAMS PROGRAM LISTING FOR OKLAHOMA BASE YEAR MODEL

GAMS PROGRAM TO SOLVE THE 1991 BASE GENERAL EQUILIBRIUM MODEL FOR OKLAHOMA

```
$TITLE OK CGE MODEL FOR 1991 (Base Year Model)
$OFFSYMLIST OFFSYMXREF OFFUPPER
***************************************************
*  The Impact of Sportfishing in Oklahoma Economy  *
*          Using IMPLAN 1991 database              *
*        Written by Rini Budiyanti, 1995           *
***************************************************
* -- SET DECLARATION
SETS
i        Sectors            /1Agr     ag prod ag serv forest fishery
                             2Min     coal misc mining stone clay
                             3Ptr     crude petr nat gas refining petr
                             4Cnst    new maint repair construction
                             5Food    food and kindred prod and tobacco
                             6Text    textile mill product and apparel
                             7Pprt    paper allied products printing
                             8Oman    other manufac
                             9Tran    transportation comm and utility
                             10Trd    wholesale trade and retail trade
                             11Fin    finance insurance real estate
                             12Htl    hotels lodging and amusements
                             13Eat    eating and drinking places
                             14Ser    other services
                             15Rest   resident trip
                             16Nres   nonres trip/

mk(i)    Market goods       /1Agr,2Min,3Ptr,4Cnst,5Food,6Text,7Pprt,
                             8Oman,9Tran,10Trd,11Fin,12Htl,13Eat,14Ser/

mk1(i)   Non-ag             /2Min,3Ptr,4Cnst,5Food,6Text,7Pprt,
                             8Oman,9Tran,10Trd,11Fin,12Htl,13Eat,14Ser/

ag(mk)   Agriculture sector /1Agr/

nag(mk)  Non ag market good /2Min,3Ptr,4Cnst,5Food,6Text,7Pprt,
                             8Oman,9Tran,10Trd,11Fin,12Htl,13Eat,14Ser/

nm(i)    Nonmkt goods       /15Rest,16Nres/

ci(i)    Reg cons goods     /1Agr,2Min,3Ptr,4Cnst,5Food,6Text,7Pprt,8Oman,
                             9Tran,10Trd,11Fin,12Htl,13Eat,14Ser,15Rest/

nmr(i)   Reg trips          /15Rest/
nme(i)   Exported trips     /16Nres/

f        Factors            /L1     managerial and profes
                             L2     tech, sales, adm
                             L3     service
                             L4     farmer
                             L5     laborers
                             K      capital
                             T      land/
s(f)     Skills             /L1, L2, L3, L4, L5/
s2(s)                       /L2, L3, L4, L5/
ff                          /L, K, T/
g        Governments        /SL, Fed/
h        Households         /Low, Med, High/

po(mk)   polluters          /1Agr,5Food/

np(mk)   non-polluters      /2Min,3Ptr,4Cnst,6Text,7Pprt,
                             8Oman,9Tran,10Trd,11Fin,12Htl,13Eat,14Ser/;
ALIAS(i,j)  ; ALIAS(mk,ml) ;
ALIAS(i,i1) ; ALIAS(mk,mj) ;
ALIAS(j,j1) ; ALIAS(s,s1)  ;
ALIAS(ci,cj); ALIAS(po,po1);

* -- PARAMETER DECLARATION
PARAMETERS
```

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* -- PARAMETERS FOR BASE YEAR (initialization of variables)
* -- Production block
  L0(i)            Labor demand all skills by industry
  LDemS0(s)        Labor demand by skill
  LSupH0(h)        Labor supply by hh
  TLSup0           Total labor supply
  LHHH0(s)         Labor employed by high income hh group
  LSL0(s)          Labor employed by St&Loc gov
  LFed0(s)         Labor employed by Fed
  LExo0(s)         Exogenous employment (LHHH+LFed+Sl)
  K0(i)            Capital demand
  T0(i)            Land demand
  KS0              Supply of pri capital
  TKS0             Total pri capital supply
  TS0              Supply of land
  VA0(i)           Value added
  V0(j,i)          Composite intermediate good demand
  TV0(i)           Composite intermediate good total demand
  VR0(j,i)         Reg int good demand
  VM0(j,i)         Imported int good demand
  TVR0(i)          Reg int good total demand
  TVM0(i)          Imported int good total demand
  X0(i)            Sector output
  E0(i)            Export of reg product
  M0(i)            Import
  R0(i)            Reg supply of reg product
* -- Income block
  YL0              Labor income
  YK0              capital income
  YAGK0            Agric capital income
  YT0              Land income
  YENT0            Enterprise income
  YH0(h)           Household income
  TYH0             Total household income
  DYH0(h)          Disposable hh income
  HSAV0(h)         Household saving
  SAV0             Total saving
  ROWSAV0          Saving from rest-of-world
  TRSL0(h)         St&loc gov transfer to hh
  TRFed0(h)        Fed gov transfer to hh
  REMIT0(h)        Remittance from outside the reg to hh
  FYL0             Labor income distrib to hhs
  FYK0             cap income distrib to hhs
  FYT0             Land income distrib to hhs
  YSL0             St&loc gov revenue
  YFed0            Fed gov revenue
  ENTY0            Enterprise income distrib to hhs
  SLBOR0           Transfer and borrowing of st&loc gov
  FedBOR0          Transfer and borrowing of fed gov
  GSP0             Gross state product
* -- Expenditure block
  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)          Demand for reg consump good
  TQM0(i)          Demand for imp consump good
  TQ0(i)           Demand for comp consump good
  SLEXP0           St&loc gov expend
  QSLR0(i)         St&loc gov demand for reg good
  QSLM0(i)         St&loc gov demand for imported good
  QSL0(i)          St&loc gov demand for comp good
  FedEXP0          Fed gov expend
  QFedR0(i)        Fed gov demand for reg good
  QFedM0(i)        Fed gov demand for imported good
  QFed0(i)         Fed gov demand for comp good
  QInvR0(i)        Invest gov demand for reg good
  QInvM0(i)        Invest gov demand for imported good
  QInv0(i)         Invest gov demand for comp good
  INV0             Total invest

  ZVM(i,j)
  ZVR(i,j)
  NZV(i,j)
```

```
  ZQM(ci,h)
  ZQR(ci,h)
  NZQ(ci,h)

  ZSLM(i)
  ZSLR(i)
  NZSL(i)

  ZFedM(i)
  ZFedR(i)
  NZFed(i)

  ZInvM(i)
  ZInvR(i)
  NZInv(i)
* -- Price block
  PL0             Wage rate
  PLS0(s)         Wage rate by skills
  PLH0(h)         Aggregate wage rate by households
  PLROC0(s)       Wage rate of rest-of-country
  PKROC0          Cap rate of rest-of-country
  PK0(i)          Cap rate
  PT0(i)          Land rent
  PE0(i)          Export price
  PM0(i)          Import price
  PR0(i)          Reg price
  P0(i)           Composite price
  PN0             Net price
  PRX0(i)
  PX0(i)

  H0(h,s)         Proportion of skilled labor s in household h
  LSHS0(h,s)      Labor supply by skills by household
  LSupS0(s)       Labor supply by skill.
  EtaL(s)
* -- PARAMETERS TO BE CALIBRATED
* -- Production block
  a0(i)           comp value added req per unit of output i
  a(j,i)          req of interm good j per unit of good i
  alpha(i,ff)     value added share param
  Ava(i)          value added shift param
  RHOv(i)         interm input subs param
  deltav1(j,i)
  deltav(j,i)     interm input share param
  Av(j,i)         interm input shift param
  RHOx(i)         output transformation param
  deltax1(i)
  deltax(i)       output share param
  Ax(i)           output shift param
  DeltaSk(mk,s)
  RhoSk(mk)
  Ask(mk)
* -- Income block
  slIBT           sl gov prop out of tot gov tax rev fr ibt
  slSST           sl gov prop out of tot gov tax rev fr sst
  slKTT           sl gov prop out of tot gov tax rev fr ktax
  slTTT           sl gov prop out of tot gov tax rev fr ttax
  slHHT           sl gov prop out of tot gov tax rev fr hht
  fedIBT          fed gov prop out of tot gov tax rev fr ibt
  fedSST          fed gov prop out of tot gov tax rev fr sst
  fedKTT          fed gov prop out of tot gov tax rev fr ktax
  fedTTT          fed gov prop out of tot gov tax rev fr ttax
  fedHHT          fed gov prop out of tot gov tax rev fr hht
  ktax            capital tax rate
  sstax           factor income tax rates for labor
  ttax            factor income tax rates for land
  depr            rate of depr fr ag cap inc
  retr            rate of retained earnings fr ent inc
  l(h)            income distrib coefs to hh for labor
  k(h)            income distrib coefs to hh for cap
  t(h)            income distrib coefs to hh for cap & land
  e(h)            enterprise profit distrib coef to hh
  hhtax(h)        income tax rate for hh
  mps(h)          saving rate
  ibtax(i)        indirect business tax
```

```
  bet(i,h)
  tbet(h)
  bdisc(i,h)
  beta0(h)        leisure param calc fr elast of lab wrt inc
  beta(i,h)       param calc fr elast of comm demand wrt inc
  gamma(i,h)      minimum subsistence requirement
  MAXHOURS0(h)
* -- Expenditure block
  RHOq            consumer demand subs param
  deltaq1(i,h)
  deltaq(i,h)     consumer demand share param
  Aq(i,h)         consumer demand constant eff param
  RHOsl           st&loc gov demand subs param
  deltasl1
  deltasl         st&loc gov demand share param
  Asl             st&loc gov demand constant eff param
  RHOfed          fed gov demand subs param
  deltafed1
  deltafed        fed gov demand share param
  Afed            fed gov demand constant eff param
  RHOinv          inv gov demand subs param
  deltainv1
  deltainv        inv gov demand share param
  Ainv            inv gov demand constant eff param
  ;
* DATA ASSIGNMENT
TABLE IOR(i,j)    INPUT-OUTPUT REGIONAL MATRIX
        1Agr      2Min        3Ptr      4Cnst     5Food     6Text     7Pprt      8Oman
1Agr  745.90611  0.44042     0.21023  31.58649 402.22979  2.45395    0.43695    3.10950
2Min    1.62650 70.85163    11.69718  49.95477  30.25158  0.07032    2.17438   38.90084
3Ptr  221.84513 47.65774   160.89262 529.34358  56.50287  3.96692   62.28478  211.87430
4Cnst  48.01089  5.34107  2927.87986   8.04191   7.79000  0.45452    3.12879   60.25746
5Food  47.13926  0.02993     0.76563   0.11879 151.81400  0.01130    0.08961    0.55970
6Text   0.95372  0.10080     0.03608   4.39131   0.18726 33.27002    0.32197   20.23790
7Pprt   2.63555 12.64993     7.21152   3.77770  95.85590  3.78175   40.78885  103.76859
8Oman  33.59113 11.72897     9.04211 477.86190  31.55487  2.07250   22.35681  860.38510
9Tran 203.86003 96.53599    36.41571 394.49329 212.70304 12.44862 105.04769  530.25457
10Trd 131.88093 18.21996    11.76082 495.75198 140.10298  8.44061   44.55143  536.23829
11Fin 393.43035 17.20505    20.93090 138.48580  31.63006  5.73241   22.44369  133.29750
12Htl   8.14872  0.80667     0.30293   6.71054   3.18849  0.20923    2.90838   16.96799
13Eat   2.27681  2.87257     1.46193  27.30136   8.97332  1.91259   10.54104   47.44407
14Ser 196.00544 29.34813    26.42121 782.53486 102.45616  9.94778   74.60141  394.33411
+       9Tran     10Trd      11Fin     12Htl     13Eat      14Ser    15Rest   16Nres
1Agr    5.15296   2.01144   46.07129  5.39050   10.30197    34.77460  1.61602 0.27181
2Min   15.34632   0.24991    0.27396  0.32247    4.79545    19.38570  0.00346 0.00111
3Ptr  561.77775  35.79147    7.89490  2.03010    6.33399   250.12444 16.10117 4.39488
4Cnst 107.70986  14.98648  277.20103  2.89357    6.10933   447.94803  0.00000 0.00000
5Food   2.48231   0.02903    0.00157  1.92656  105.32310    33.75703  5.99098 1.20222
6Text   0.88695   0.31478    0.15562  0.57316    0.11989     9.54334  0.00144 0.00046
7Pprt  28.17874  60.06235   22.73780 10.33350   18.13522    93.13096  0.00000 0.00000
8Oman  68.72765   9.90804    7.06311  2.18781    3.91722   195.53032  0.65778 0.12363
9Tran 641.41640 194.72099  121.89716 27.16205   80.49630   745.83913  6.63093 1.37987
10Trd  72.72279  14.75699    6.30947  1.70951   57.11210   182.49862 37.68041 7.32098
11Fin 184.28722 155.37506  487.10363 19.89304   77.78977   653.83132  0.00000 0.00000
12Htl  47.97000   6.98449    5.01227 21.17279    2.94317    30.11116  6.93046 1.58302
13Eat  83.53885  57.05296   46.58941  3.78213    9.64032   101.67711 16.28608 3.42114
14Ser 314.69517 312.00531  343.92273 44.56178  159.20555  1415.78984  3.29084 1.05518
;
TABLE IOM(i,j)    INPUT-OUTPUT IMPORT MATRIX
        1Agr       2Min       3Ptr        4Cnst      5Food      6Text      7Pprt
1Agr  499.26188   0.09481     0.69913   20.73809  281.04443    4.75695    0.71117
2Min   10.34357 360.91257    91.50872  642.09660   17.61365    0.17613   11.80087
3Ptr  180.09367  58.64663  6639.62328  571.42496   71.35299   24.41611   47.53898
4Cnst   7.21640   0.79633   793.11075    0.83432    1.19340    0.06743    0.46848
5Food 147.08042   0.01152     1.49137    0.05977  344.67477    0.00495    1.41617
6Text   9.27378   0.38464     0.32289   25.31794    2.90894  191.44580   29.81884
7Pprt  12.81580  13.56370     7.93168   27.46977  128.83251    1.87594  584.99503
8Oman 105.59127  37.50892    21.56907 1456.1293   169.00408   13.89079   61.69237
9Tran  61.23146  25.71560     9.59307  168.17559   56.62502    3.23546   36.52904
10Trd  37.11728   5.15567     3.29335  121.73899   40.84506    2.37806   12.64473
11Fin 298.16139  12.06236    16.46783   94.77026   21.02927    3.69233   15.85914
12Htl   3.04031   0.69968     0.18731    7.15633    2.08048    0.13020    2.82907
13Eat   0.33050   0.40916     0.20768    4.07313    1.32459    0.27296    1.51043
14Ser  55.17841  16.24853    11.54813  254.45667   92.69960    6.46666   40.04060
```

```
+          8Oman       9Tran       10Trd      11Fin      12Htl      13Eat      14Ser      15Rest
1Agr     7.92243     1.43745     1.46994   32.81849    3.94921    6.78013   25.52233    0.86092
2Min   205.64811   162.79540     1.01935    0.11718    0.12418    0.41029   40.49206    0.00302
3Ptr   616.01664  1206.39446     1.44350    1.34892    1.41083    2.92961  161.18632   15.92210
4Cnst    9.11381    17.23123     2.32294   48.36367    0.44265    0.92487   70.86642    0.00000
5Food    0.52952    14.89596     3.99394    0.01123    2.61470  282.56092  104.37763   21.17570
6Text  128.72174     1.85072     0.66288    1.61467    1.74187    0.22180   18.67144    0.00223
7Pprt   60.09500    30.54641    65.51518   51.35193    2.49941   19.84856  264.65620    0.00000
8Oman 3701.82576   175.96668    23.99133   21.42434    7.04380   32.85337  761.61414    7.37659
9Tran  170.73010   382.02605    58.68123   58.54854    7.00744   22.01116  269.28908    4.97803
10Trd  153.52325    22.26761     4.09804    1.79851    0.48742   16.45064   46.00384    5.57216
11Fin   87.07455   150.16560   123.43449  451.12708   15.65969   56.51541  540.97442    0.00000
12Htl   16.48806    84.67181     4.96824    4.32350   28.33856    6.43124   31.51280    6.51337
13Eat    6.72967    13.87776     8.54700    7.09344    0.55831    1.40823   15.11138    2.31348
14Ser  237.09955   159.40388   164.02163  203.46204   26.71736   71.48140  626.13265    0.94665
;
TABLE VAD(I,F)   VALUE ADDED MATRIX
           L1          L2          L3          L4          L5          K           T
1Agr  51.5994315 20.674369 4.99483856 173.226994 23.7401557 388.787078 482.490033
2Min  84.6605574 40.944872 3.06622323 0.08078528 245.899527 1007.53764
3Ptr  360.143369 273.50577 21.2127799 0.38266055 850.010878 5909.14244
4Cnst 303.370224 155.4255  8.28736984 1.18219018 1437.15802 823.321891
5Food 70.5163922 61.683084 8.48974945 0.16495788 235.293189 317.951128
6Text 13.1953473 13.947754 1.02166364 0.00846243 90.0009149 43.1369573
7Pprt 113.416616 105.25505 3.71355864 0.1444571  186.051424 408.847695
8Oman 924.179257 589.70955 39.6558059 4.2994314  1993.63309 1966.71617
9Tran 533.807886 771.43857 43.9642966 0.90683071 1378.28092 2463.68139
10Trd 906.130686 2095.7886 53.1456227 1.97386036 1128.51849 1077.92092
11Fin 593.961092 911.00565 30.1247941 2.24206294 29.1538952 4836.30601
12Htl 183.816725 47.075934 43.0747782 6.26674499 32.3314157 136.879702
13Eat 325.717642 67.921079 322.121744 0.12503722 23.1965598 197.918039
14Ser 3222.13451 1227.8714 745.609553 8.38152496 985.492806 2439.64139
;
TABLE HHCONR(i,h)    HOUSEHOLD CONSUMPTION DEMAND FOR REGIONAL GOODS
            LOW         MED         HIGH
1Agr      73.72382    85.82421    43.68086
2Min       4.64942    16.67766    12.04307
3Ptr     294.39706   564.44091   257.43265
4Cnst      0.00000     0.00000     0.00000
5Food    222.82711   361.74770   147.06291
6Text     89.53354   155.07389    93.18383
7Pprt     32.30170    48.88260    22.19210
8Oman    140.98889   290.54386   150.75987
9Tran    817.28661   985.59345   528.44731
10Trd   1382.23797  2401.27531  1209.21161
11Fin   1641.97480  2574.42840  1214.21840
12Htl    137.01492   247.59576   144.65096
13Eat    529.96867   649.56568   325.32696
14Ser   2829.95087  3612.94980  2029.58289
15Rest    39.26039    58.30074    63.29267
;
TABLE HHCONM(i,h)    HOUSEHOLD CONSUMPTION DEMAND FOR IMPORTED GOODS
            LOW         MED         HIGH
1Agr      42.85906    51.79185    28.84471
2Min       7.17864    15.56221     8.43404
3Ptr     322.95703   405.14693   204.04318
4Cnst      0.00000     0.00000     0.00000
5Food    865.06677  1200.49473   515.82905
6Text    222.77740   343.12579   194.33651
7Pprt    219.79990   301.08510   145.07670
8Oman    804.21301  1390.57194   756.05886
9Tran    443.79005   523.26609   294.36669
10Trd    170.53790   267.83694   135.52808
11Fin   1040.68370  1586.89650   779.80560
12Htl    140.29271   226.38473   125.29713
13Eat     73.77716    90.03570    43.78519
14Ser    743.21514   959.18653   577.67711
15Rest    11.72475    17.41098    18.90177
;
TABLE GOVCONR(i,g)    GOVERNMENT CONSUMPTION DEMAND FOR REGIONAL GOODS
            SL          Fed
1Agr      15.79890     0.60770
2Min       4.22060     0.04900
3Ptr      89.94190   199.31530
4Cnst   1160.81340   348.35960
```

```
5Food    34.78090   1.86920
6Text     5.42930   0.32800
7Pprt    21.16180   0.13390
8Oman    79.88390  50.91210
9Tran   221.53720 106.16730
10Trd    68.78090  12.99060
11Fin   108.41260   0.59290
12Htl    15.85510   0.21790
13Eat    21.70050  13.54180
14Ser   316.34900 265.74740
;
TABLE GOVCONM(i,g)    GOVERNMENT CONSUMPTION DEMAND FOR IMPORTED GOODS
          SL          Fed
1Agr     10.72530   0.57430
2Min      6.43510   1.08270
3Ptr     96.31210   8.55600
4Cnst    64.98050  22.15850
5Food    53.66540   5.53690
6Text    10.39760   0.72460
7Pprt   114.43840   0.34650
8Oman   216.42020 260.61040
9Tran   108.91140  61.55720
10Trd    18.37010   3.62120
11Fin    78.82770   0.19800
12Htl    16.88290   0.24190
13Eat     3.08260   1.92370
14Ser   130.97040  97.58160
;
TABLE FYDist(h,f)   FACTOR INCOME DISTRIBUTION TO HHS
           L1          L2          L3          L4          L5          K         T
LOW   855.837840  669.040492  236.459690  18.580483  764.316889  5.984878  12.946951
MED  2650.122375 2071.699912  732.203095  57.534909 2366.725559 84.278861 182.318534
HIGH 5340.153496 4174.597985 1475.432589 115.936249 4769.092131 97.131632 210.122641
;
TABLE ParamA(*,i)   BASE YEAR VALUES FOR INDUSTRY
             1Agr        2Min        3Ptr        4Cnst       5Food
PT0          1           1           1           1           1
PK0          1           1           1           1           1
PR0          1           1           1           1           1
P0           1           1           1           1           1
PM0          1           1           1           1           1
PE0          1           1           1           1           1
X0         4681.29910 2242.85790 22426.39250 9084.65690 3206.29290
R0         1515.15751  287.30172  3596.27527 9018.76000 1121.37744
E0         3166.14159 1955.55618 18830.11723   65.89690 2084.91546
M0         1027.40229 1589.76660 11207.46284 1163.21791 3570.57472
QINVR0        3.55800    3.75640    11.93080 3591.83420    1.84860
QINVM0        4.53970    6.01220   570.69860  123.12620    5.08330
IBT0         71.73950   14.66930  4199.41160   11.11570    5.72530
IBTSL0       52.82095   10.80083  3091.97732    8.18436    4.21547
IBTFed0      18.91855    3.86847  1107.43428    2.93134    1.50983
SIGMAv        1.42       0.5         0.5         3.55        3.55
SIGMAx        3.9        2.9         2.9         2.9         2.9
SIGMAq        1.42       0.5         0.5         3.55        3.55
SIGMAsl       1.42       0.5         0.5         3.55        3.55
SIGMAfed      1.42       0.5         0.5         3.55        3.55
SIGMAinv      1.42       0.5         0.5         3.55        3.55
SigmaSk       1.5        1.5         1.5         1.5         1.5
+            6Text       7Pprt       8Oman       9Tran       10Trd
PT0          1           1           1           1           1
PK0          1           1           1           1           1
PR0          1           1           1           1           1
P0           1           1           1           1           1
PM0          1           1           1           1           1
PE0          1           1           1           1           1
X0          500.20700 2064.06770 13986.17310 10121.31980 8070.57320
R0          415.47166  628.41196  3702.08467  6134.84574 7070.41336
E0           84.73534 1435.65574 10284.08843  3986.47406 1000.15984
M0         1196.48859 2053.63372 11189.08812  2798.62910 1118.98822
QINVR0        0.82840    0.69150  1252.28710    64.51210  228.85910
QINVM0       12.16650    0.89000  1163.73190    32.36080   49.71940
IBT0          1.31360    7.10820   108.83170   370.81590 1478.67600
IBTSL0        0.96719    5.23368    80.13150   273.02738 1088.73173
IBTFed0       0.34641    1.87452    28.70020    97.78852  389.94427
SIGMAv        3.55       3.55        3.55        2           2
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SIGMAx       2.9         2.9          2.9          0.7          0.7
SIGMAq       3.55        3.55         3.55         2            2
SIGMAsl      3.55        3.55         3.55         2            2
SIGMAfed     3.55        3.55         3.55         2            2
SIGMAinv     3.55        3.55         3.55         2            2
SigmaSk      1.5         1.5          1.5          1.5          1.5
+          11Fin       12Htl       13Eat        14Ser       15Rest       16Nres
PT0          1           1           1            1           1            1
PK0          1           1           1            1           1            1
PR0          1           1           1            1           1            1
P0           1           1           1            1           1            1
PM0          1           1           1            1           1            1
PE0          1           1           1            1           1            1
X0        10152.67110 788.06270 2128.07980 15908.43010 160.85380 20.75430
R0         7916.36510 707.35755 1964.87531 13286.90236 160.85380
E0         2236.30600  80.70515  163.20449  2621.52774             20.75430
M0         5402.52282 708.47032  276.37207  4478.58874  48.0375
QINVR0       35.30220   0.07260    0.00000    22.14690
QINVM0       29.11750   0.00000    0.00000     4.05420
IBT0       1494.24010  96.08300  128.02870    88.94660
IBTSL0     1100.19139  70.74478   94.26602    65.49033
IBTFed0     394.04871  25.33822   33.76268    23.45627
SIGMAv       2          2          2          2           2
SIGMAx       0.7        0.7        0.7        0.7
SIGMAq       2          2          2          2           2
SIGMAsl      2          2          2          2
SIGMAfed     2          2          2          2
SIGMAinv     2          2          2          2
SigmaSk      1.5        1.5        1.5        1.5
;
TABLE ELASTY(i,h)    INCOME ELASTICITY OF FINAL CONSUMPTION
             LOW      MED      HIGH
1Agr        0.30     0.30     0.30
2Min        0.89     0.89     0.89
3Ptr        0.89     0.89     0.89
4Cnst       1.06     1.06     1.06
5Food       1.06     1.06     1.06
6Text       1.06     1.06     1.06
7Pprt       1.06     1.06     1.06
8Oman       1.06     1.06     1.06
9Tran       0.985    0.985    0.985
10Trd       0.985    0.985    0.985
11Fin       0.985    0.985    0.985
12Htl       0.985    0.985    0.985
13Eat       0.985    0.985    0.985
14Ser       0.985    0.985    0.985
15Rest      0.82     0.82     0.82
;
TABLE ParamB(f,*)    BASE YEAR VALUES FOR FACTORS
   WAGE0 WAGEROC0 CAP0  CAPROC0  FTAXSL0     FTAXFED0     FTAX0
L1     1      1                  220.64210  1148.15610  1368.79820
L2     1      1                  172.48419   897.55662  1070.04081
L3     1      1                   60.96127   317.22439   378.18566
L4     1      1                    4.79020    24.92679    29.71700
L5     1      1                  197.04724  1025.37543  1222.42267
K                    1       1   993.002258 1935.363604 2928.365862
T                                 26.102711   50.999197   77.101907
+    LHHH0         LSL0         LFed0     DEPRAG0     RETENT0        EtaL
L1              1740.853780 787.408385                                .92
L2              1103.848482 499.283490                                .92
L3 95.044000     963.122681 435.631575                                .92
L4                15.411733   6.970906                                .92
L5               333.121325 150.674644                                .92
K                                      149.683025 12578.871333
T
;
TABLE ParamC(h,*)    BASE YEAR VALUES FOR HH GROUPS
         HTAXSL0     HTAXFed0     HTAX0         HSAV0          TRSL0
LOW    65.704089  298.307542  364.011631  -3871.652095  1001.867893
MED   399.999617 1816.065108 2216.064725   2180.921088   751.275254
HIGH  503.982961 2288.166864 2792.149825   2908.660127   297.813984
+         TRFed0      ELASTLY   FRISCH   ENTYDis0       REMIT0
LOW     4257.062354    -0.12     -1.8    815.383497   1199.867570
MED     2187.724546    -0.18     -1.6   1399.459390  11345.339377
HIGH     937.796969    -0.24     -1.4   3958.629957  -5511.782983
```

```
;
TABLE ParamD(g,*)   BASE YEAR VALUES FOR GOVTS
              BOR0          GOVDR0       GOVDM0
SL          710.901256   2164.666000   930.419700
Fed       -1203.964842   1000.832700   464.713500
;
SCALAR YENT0      Enterprise income               /  18752.364177/;
SCALAR ROWSAV0    Saving from ROW                 /  -6727.355278/;
SCALAR QINVMSUM0  Inv demand for imported goods   /   2001.500300/;
SCALAR etaK       Capital elasticity              /       .92    /;
SCALAR omega      Fishing demand elasticity       /      -.5775  /;
SCALAR Small      Small number for lower bounds   /      0.000001/;
* Simulation parameters
SCALAR qTax       Quality tax                     /       0      /;
SCALAR KMobil                                     /       0      /;
PARAMETER ExoPtax(po) Exo pollution tax          /1Agr   0
                                                  5Food  0       /;
PARAMETER EndoPtax(po) Endo pollution tax prop   /1Agr   0.5
                                                  5Food  0.5     /;
* -- ASSIGN PARAMETERS
* -- Production block
  L0(i)          =SUM(s,VAD(i,s));
  K0(i)          =VAD(i,"K");
  T0(i)          =VAD(i,"T");
  VA0(i)         =L0(i)+K0(i)+T0(i);
  VM0(j,i)       =IOM(j,i);
  VR0(j,i)       =IOR(j,i);
  V0(j,i)        =IOR(j,i)+IOM(j,i);
  TVM0(i)        =sum(j,VM0(i,j));
  TVR0(i)        =sum(j,VR0(i,j));
  TV0(i)         =TVM0(i)+TVR0(i);
  LHHH0(s)       =ParamB(s,"LHHH0");
  LSL0(s)        =ParamB(s,"LSL0");
  LFed0(s)       =ParamB(s,"LFed0");
  LExo0(s)       =LHHH0(s)+LSL0(s)+LFed0(s);
  LDemS0(s)      =Sum(i,VAD(i,s));
  FYL0           =sum((h,s),FYDIST(h,s));
  TLSup0         =Sum(s,LDemS0(s)+LExo0(s));
  H0(h,s)        =FYDist(h,s)/Sum(s1,FYDist(h,s1));
  LSupH0(h)      =TLSup0*Sum(s,FYDist(h,s))/FYL0;
  LSHS0(h,s)     =H0(h,s)*LSupH0(h);
  LSupS0(s)      =Sum(h,LSHS0(h,s));
  X0(i)          =ParamA("X0",i);
  E0(i)          =ParamA("E0",i);
  R0(i)          =ParamA("R0",i);
  KS0(i)         =K0(i);
  TKS0           =sum(i,KS0(i));
  TS0(i)         =T0(i);
* -- Income block
  TRSL0(h)       =ParamC(h,"TRSL0");
  TRFed0(h)      =ParamC(h,"TRFed0");
  FYK0           =sum(h,FYDIST(h,"K"));
  FYT0           =sum(h,FYDIST(h,"T"));
  YL0            =TLSup0;
  YK0            =Sum(i,K0(i));
  YAGK0          =(VAD("1Agr","K"));
  YT0            =Sum(i,T0(i));
  YENT0          =YENT0;
  REMIT0(h)      =ParamC(h,"REMIT0");
  YH0(h)         =sum(f,FYDIST(h,f))+ParamC(h,"ENTYDis0")+TRSL0(h)
                  +TRFed0(h)+REMIT0(h);
  TYH0           =sum(h,YH0(h));
  DYH0(h)        =YH0(h)-ParamC(h,"HTAX0");
  HSAV0(h)       =ParamC(h,"HSAV0");
  HEXP0("Low")   =DYH0("Low")-HSAV0("Low");
  HEXP0("Med")   =DYH0("Med")-HSAV0("Med");
  HEXP0("High")=DYH0("High")-HSAV0("High")-Sum(s,LHHH0(s));
  SAV0           =ParamB("K","DEPRAG0")+ParamB("K","RETENT0")+
                  sum(h,ParamC(h,"HSAV0"))+ROWSAV0;
  ROWSAV0        =ROWSAV0;
  SLBOR0         =ParamD("SL","BOR0");
  FedBOR0        =ParamD("Fed","BOR0");
  YSL0           =sum(i,ParamA("IBTSL0",i))+sum(f,ParamB(f,"FTAXSL0"))
                  +sum(h,ParamC(h,"HTAXSL0"))+SLBOR0;
  YFed0          =sum(i,ParamA("IBTFed0",i))+sum(f,ParamB(f,"FTAXFed0"))
```

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                 +sum(h,ParamC(h,"HTAXFed0"))+FedBor0;
  ENTY0         =sum(h,ParamC(h,"ENTYDis0"));
  GSP0          =YL0+YK0+YT0+sum(i,ParamA("IBT0",i));
* -- Expenditure block
  QR0(i,h)      =HHCONR(i,h);
  QM0(i,h)      =HHCONM(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));
  SLEXP0        =ParamD("SL","GOVDR0")+ParamD("SL","GOVDM0")
                 +sum(h,ParamC(h,"TRSL0"))+Sum(s,LSL0(s));
  QSLR0(i)      =GOVCONR(i,"SL");
  QSLM0(i)      =GOVCONM(i,"SL");
  QSL0(i)       =QSLM0(i)+QSLR0(i);
  FedEXP0       =ParamD("Fed","GOVDR0")+ParamD("Fed","GOVDM0")
                 +sum(h,ParamC(h,"TRFed0"))+Sum(s,LFed0(s));
  QFedR0(i)     =GOVCONR(i,"Fed");
  QFedM0(i)     =GOVCONM(i,"Fed");
  QFed0(i)      =QFedM0(i)+QFedR0(i);
  QINVR0(i)     =ParamA("QINVR0",i);
  QINVM0(i)     =ParamA("QINVM0",i);
  QINV0(i)      =QINVM0(i)+QINVR0(i);
  INV0          =sum(i,QINV0(i));
  M0(i)         =ParamA("M0",i);
* -- Price block
  PLS0(s)       = ParamB(s, "WAGE0");
  PLH0(h)       = Sum(s,LSHS0(h,s)*PLS0(s))/Sum(s,LSHS0(h,s));
  PL0           = Sum(s,PLS0(s)*LSupS0(s))/TLSup0;
* PK0           =ParamB("K","CAP0");
  PLROC0(s)     =ParamB(s,"WAGEROC0");
  EtaL(s)       =ParamB(s,"EtaL");
  PKROC0        =ParamB("K","CAPROC0");
  PK0(i)        =ParamA("PK0",i);
  PT0(i)        =ParamA("PT0",i);
  PE0(i)        =ParamA("PE0",i);
  PM0(i)        =ParamA("PM0",i);
  PR0(mk)       =ParamA("PR0",mk);
  PR0(nm)       =ParamA("PR0",nm);
  P0(i)         =ParamA("P0",i);
  PRX0(mk)      =PR0(mk);
  PRX0(nm)      =PR0(nm)+qTax;
  PX0(ci)       =(PRX0(ci)*R0(ci)+PM0(ci)*M0(ci))/(R0(ci)+M0(ci));
*-----------------------------------------------------
* 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
*-----------------------------------------------------
  ZVM(i,j)      =(VM0(i,j) eq 0);
  ZVR(i,j)      =(VR0(i,j) eq 0) and (VM0(i,j) ne 0);
  NZV(i,j)      =(VR0(i,j) ne 0) and (VM0(i,j) ne 0);

  ZQM(ci,h)     =(QM0(ci,h) eq 0);
  ZQR(ci,h)     =(QR0(ci,h) eq 0) and (QM0(ci,h) ne 0);
  NZQ(ci,h)     =(QR0(ci,h) ne 0) and (QM0(ci,h) ne 0);

  ZSLM(i)       =(QSLM0(i) eq 0);
  ZSLR(i)       =(QSLR0(i) eq 0) and (QSLM0(i) ne 0);
  NZSL(i)       =(QSLR0(i) ne 0) and (QSLM0(i) ne 0);

  ZFedM(i)      =(QFedM0(i) eq 0);
  ZFedR(i)      =(QFedR0(i) eq 0) and (QFedM0(i) ne 0);
  NZFed(i)      =(QFedR0(i) ne 0) and (QFedM0(i) 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);
option decimals=6;
DISPLAY
  PL0,PLROC0,PLS0,PLH0, PK0,PT0,PE0,PM0,PR0,PRX0,PX0,P0,L0,K0,T0,
  VA0,V0,TV0,VM0,VR0,TVM0,TVR0,LSupH0,TLSup0,H0,LSHS0,LSupS0,X0,E0,R0,
  KS0,TS0,LHHH0,LSL0,LFed0,YL0,YK0,YAGK0,YT0,YENT0,REMIT0,YH0,DYH0,YSL0,
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  YFed0,GSP0,QM0,QR0,Q0,TQM0,TQR0,TQ0,HSAV0,HEXP0,HEXP0,HEXP0,SLEXP0,
  QSLM0,QSLR0,QSL0,FedEXP0,QFedM0, QFedR0,QFed0,SAV0,ROWSAV0,QINVM0,QINVR0,
  QINV0,INV0,TRSL0,TRFed0,FYL0,FYK0,FYT0,ENTY0,SLBOR0,FedBOR0,M0,GSP0;
* -- CALIBRATION
* -- Production block
  a0(i)          =VA0(i)/X0(i);
  a(j,i)         =V0(j,i)/X0(i);
  alpha(mk,"K")=VAD(mk,"K")/VA0(mk);
  alpha(mk,"T")=VAD(mk,"T")/VA0(mk);
  alpha(mk,"L")=1-alpha(mk,"K")-alpha(mk,"T");
  Ava(mk)        =VA0(mk)/(SUM(s,VAD(mk,s))**alpha(mk,"L")
                  *VAD(mk,"K")**alpha(mk,"K")*VAD(mk,"T")**alpha(mk,"T"));
  RHOv(ci)       =1-1/ParamA("SIGMAv",ci);
  deltav1(j,i)$(NZV(j,i)) =(VR0(j,i)/VM0(j,i))**(1-RHOv(i))*(PR0(i)/PM0(i));
  deltav(j,i)$(NZV(j,i))  =1/(1+deltav1(j,i));
  Av(j,i)$(NZV(j,i))      =V0(j,i)/(deltav(j,i)*VM0(j,i)**RHOv(i)
                           +(1-deltav(j,i))
                           *VR0(j,i)**RHOv(i))**(1/RHOv(i));
  RHOx(mk)       =1+1/ParamA("SIGMAx",mk);
  deltax1(mk)    =(R0(mk)/E0(mk))**(1-RHOx(mk))*(PR0(mk)/PE0(mk));
  deltax(mk)     =1/(1+deltax1(mk));
  Ax(mk)         =X0(mk)/(deltax(mk)*E0(mk)**RHOx(mk)+(1-deltax(mk))
                  *R0(mk)**RHOx(mk))**(1/RHOx(mk));
* -- Income block
  sstax          =Sum(s,ParamB(s,"FTAX0"))/YL0;
  ktax           =ParamB("K","FTAX0")/YK0;
  ttax           =ParamB("T","FTAX0")/YT0;
  depr           =ParamB("K","DEPRAG0")/(VAD("1Agr","K"));
  retr           =ParamB("K","RETENT0")/(sum(i,VAD(i,"K"))-VAD("1Agr","K"));
  ibtax(mk)      =ParamA("IBT0",mk)/(PR0(mk)*X0(mk));
  l("Low")       =Sum(s,FYDIST("Low",s))/FYL0;
  l("Med")       =Sum(s,FYDIST("Med",s))/FYL0;
  l("High")      =1-l("Low")-l("Med");
  k("Low")       =FYDIST("Low","K")/FYK0;
  k("Med")       =FYDIST("Med","K")/FYK0;
  k("High")      =1-k("Low")-k("Med");
  t("Low")       =(FYDIST("Low","T"))/FYT0;
  t("Med")       =(FYDIST("Med","T"))/FYT0;
  t("High")      =1-t("Low")-t("Med");
  e("Low")       =ParamC("Low","ENTYDis0")/ENTY0;
  e("Med")       =ParamC("Med","ENTYDis0")/ENTY0;
  e("High")      =1-e("Low")-e("Med");
  hhtax(h)       =ParamC(h,"HTAX0")/YH0(h);
  mps(h)         =ParamC(h,"HSAV0")/YH0(h);
  slIBT          =(ParamA("IBTSL0","1Agr"))/(ParamA("IBT0","1Agr"));
  slSST          =Sum(s,ParamB(s,"FTAXSL0"))/Sum(s,ParamB(s,"FTAX0"));
  slKTT          =ParamB("K","FTAXSL0")/ParamB("K","FTAX0");
  slTTT          =ParamB("T","FTAXSL0")/ParamB("T","FTAX0");
  slHHT          =ParamC("Low","HTAXSL0")/ParamC("Low","HTAX0");
  fedIBT         =1-slIBT;
  fedSST         =1-slSST;
  fedKTT         =1-slKTT;
  fedTTT         =1-slTTT;
  fedHHT         =1-slHHT;
* -- Expenditure block
  RHOq(ci)                =1-1/ParamA("SIGMAq",ci);
  deltaq1(ci,h)$NZQ(ci,h)=(QR0(ci,h)/QM0(ci,h))**(1-RHOq(ci))*(PR0(ci)/PM0(ci));
  deltaq(ci,h)$NZQ(ci,h) =1/(1+deltaq1(ci,h));
  Aq(ci,h)$NzQ(ci,h)      =Q0(ci,h)/(deltaq(ci,h)*QM0(ci,h)**RHOq(ci)+
                           (1-deltaq(ci,h))*QR0(ci,h)**RHOq(ci))**(1/RHOq(ci));
  RHOsl(mk)               =1-1/ParamA("SIGMAsl",mk);
  deltasl1(mk)$NZSL(mk)   =(QSLR0(mk)/QSLM0(mk))**(1-RHOsl(mk))*(PR0(mk)/PM0(mk));
  deltasl(mk)$NZSL(mk)    =1/(1+deltasl1(mk));
  Asl(mk)$NZSL(mk)        =QSL0(mk)/(deltasl(mk)*QSLM0(mk)**RHOsl(mk)+
                           (1-deltasl(mk))*QSLR0(mk)**RHOsl(mk))**(1/RHOsl(mk));
  RHOfed(mk)              =1-1/ParamA("SIGMAfed",mk);
  deltafed1(mk)$NZFed(mk)=(QFedR0(mk)/QFedM0(mk))**(1-RHOfed(mk))*(PR0(mk)/PM0(mk));
  deltafed(mk)$NZFed(mk) =1/(1+deltafed1(mk));
  Afed(mk)$NZFed(mk)      =QFed0(mk)/(deltafed(mk)*QFedM0(mk)**RHOfed(mk)+
                           (1-deltafed(mk))*QFedR0(mk)**RHOfed(mk))**(1/RHOfed(mk));
  RHOinv(mk)              =1-1/ParamA("SIGMAinv",mk);
  deltainv1(mk)$NZInv(mk)=(QINVR0(mk)/QINVM0(mk))**(1-RHOinv(mk))*(PR0(mk)/PM0(mk));
  deltainv(mk)$NZInv(mk) =1/(1+deltainv1(mk));
  Ainv(mk)$NZInv(mk)      =QINV0(mk)/(deltainv(mk)*QINVM0(mk)**RHOinv(mk)+(1-
                           deltainv(mk))*QINVR0(mk)**RHOinv(mk))**(1/RHOinv(mk));
```

```
  beta0(h)=PL0*LSupH0(h)*ParamC(h,"ELASTLY")/(PL0*LSupH0(h)*ParamC(h,"ELASTLY")-HEXP0(h));
* -- forcing betas sum to 1 by allocating the discrepancy proportionally
* -- sectors (helpers: bet(ci,h) tbet(h) and bdisc(ci,h)
  bet(ci,h)    =ELASTY(ci,h)*(1-beta0(h))*P0(ci)*Q0(ci,h)/Sum(cj,Q0(cj,h));
  tbet(h)      =sum(ci,bet(ci,h));
  bdisc(ci,h) =1-beta0(h)-bet("1Agr",h)-bet("2Min",h)-bet("3Ptr",h)
               -bet("4Cnst",h)-bet("5Food",h)-bet("6Text",h)-bet("7Pprt",h)
               -bet("8Oman",h)-bet("9Tran",h)-bet("10Trd",h)-bet("11Fin",h)
               -bet("12Htl",h)-bet("13Eat",h)-bet("14Ser",h)-bet("15Rest",h);
  beta(ci,h)  =(1+bdisc(ci,h)/tbet(h))*bet(ci,h);
  gamma(ci,h) =Q0(ci,h)+(beta(ci,h)/(1-
  beta0(h))*P0(ci))*(Sum(cj,Q0(cj,h))/ParamC(h,"FRISCH"));
  MAXHOURS0(h)=LSupH0(h)+(beta0(h)/PL0)*(Sum(ci,Q0(ci,h))-sum(ci,P0(ci)*
                gamma(ci,h)))/(1-beta0(h));
  RhoSk(mk)         = 1-1/ParamA("SigmaSk",mk);
  DeltaSk(mk,s)     = 1/Sum(s1,  (VAD(mk,s1)/VAD(mk,s))**(1-RhoSk(mk)));
  Ask(mk)           = L0(mk)/(Sum(s,DeltaSk(mk,s)*VAD(mk,s)**RhoSk(mk))**(1/RhoSk(mk)));
option decimals=6;
DISPLAY a0,a,alpha,Ava,RHOv,deltavl,deltav,Av,RHOx,deltaxl,deltax,Ax,ktax,
  sstax,ttax,depr,retr,l,k,t,e,mps,hhtax,RHOq,deltaql,deltaq,Aq,slIBT,
  slSST,slKTT,slTTT,slHHT,ibtax,fedIBT,fedSST,fedKTT,fedTTT,fedHHT,RHOsl,
  deltasl1,deltasl,Asl,RHOfed,deltafedl,deltafed,Afed,RHOinv,deltainvl,
  deltainv,Ainv,bdisc,beta0,beta,gamma,MAXHOURS0,RhoSk,DeltaSk,Ask;
* -- VARIABLE DECLARATION
* -- ENDOGENOUS VARIABLES
Variables
   adjK                 Capital adjustment
   adjL(h)              Labor adjustment
   ADQ(i,h)             Adj demand for comp consump good
   AHEXP(h)             Adjusted household expenditure
   ALS(h)               Adj labor supply
   AQM(i,h)             Adj demand for reg consump good
   AQR(i,h)             Adj demand for imp consump good
   AYL                  Adjusted labor income
   CAP(i)               capital demand
   DYH(h)               Disposable hh income
   EXP(i)               Export
   FedBOR               Fed gov borrowing
   FedEXP               Fed gov expend
   GSP                  Gross state product
   HEXP(h)              Household expenditure
   HSAV(h)              Household saving
   INV                  Investment
   KMIG                 Capital migration
   LAB(i)               Labor demand
   LAND(i)              Land demand
   LD(mk,s)
   LDemS(s)             Labor demand by skills
   LMIG(s)              Labor migration
   LMigH(h)
   LSupH(h)             Labor supply by household
   LSupS(s)             Labor supply by skill
   M(i)                 Import
   Mratio               Migr compared to initial lab supply
   P(i)                 Composite price
   PK(i)                cap rate
   PL                   Wage rate
   PLM(mk)
   PLH(h)               Aggregate wage rate by households
   PLS(s)               Wage rate by skills
   PN(mk)               Net price
   PR(i)                Regional price
   PRX(i)               Reg price faced by consumers
   PT(i)                Land rent
   pTax(mk)             Pollution tax
   PX(i)                Comp price faced by consumers
   Q(i,h)               Demand for comp consump good
   QFed(i)              Fed gov demand for reg good
   QFedM(i)             Fed gov demand for imported good
   QFedR(i)             Fed gov demand for comp good
   QINV(i)              Invest gov demand for reg good
   QINVM(i)             Invest gov demand for imported good
   QINVR(i)             Invest gov demand for comp good
   QM(i,h)              Demand for imp consump good
   QR(i,h)              Demand for reg consump good
```

```
   QSL(i)                St&loc gov demand for reg good
   QSLM(i)               St&loc gov demand for imported good
   QSLR(i)               St&loc gov demand for comp good
   R(i)                  Regional supply
   ROWSAV                Saving from rest-of-world
   SAV                   Total saving
   SLACK(i)
   SLACK2(i)
   SLBOR                 St&loc gov borrowing
   SLEXP                 St&loc gov expend
   TCAP                  Total demand for cap
   TLAB                  Total demand for land
   TLMig
   TLSrat                lab supply ratio
   TLSup                 Total labor supply
   PTaxCost
   TQ(i)                 Total demand for comp consump good
   TQM(i)                Total demand for imp consump good
   TQR(i)                Total demand for reg consump good
   TV(i)                 Composite intermediate good total demand
   TVM(i)                Imported int good total demand
   TVR(i)                Reg int good total demand
   TYH                   Total hh income
   V(j,i)                Composite intermediate good demand
   VA(i)                 Value added
   VM(j,i)               Imported int good demand
   VR(j,i)               Reg int good demand
   X(i)                  Output
   YAGK                  Agr capital income
   YENT                  Enterprise income
   YFed                  Fed gov revenue
   YH(h)                 Household income
   YK                    capital income
   YL                    Labor income
   YSL                   St&loc gov revenue
   YT                    Land income
   Z                     Objective Function Value
POSITIVE VARIABLE   SLACK, SLACK2;
* -- MODEL EQUATIONS
EQUATIONS
  EQZ                  objective function
  Ldemand              labor demand
  Kdemand              capital demand
  Tdemand              land demand
  TLdem                total labor demand
  TKdem                total capital demand
  LSupply              labor supply
  LSupplys             Labor supply
  TLSupp               labor supply
  ALSupply             adjusted labor supply
  LMIGrat              labor migration
  KMIGrat              capital migration
  KMIGrat1
  TLSratio             labor supply ratio
  MIGratio             migration compared to initial labor supply
  VAdemand             value added demand
  Vdemand              intermediate demand
  VAprod               value added prod fc
  Vces                 ces fc for int demand
  TVdemand             intermediate total demand
  TVRdemand            int reg total demand
  TVMdemand            int imp total demand
  VRdem0               demand for reg int good
  VRdem1               demand for reg int good for goods with zero import
  VRdem2
  VMDem1               demand for imp int good for goods with zero import
  VMDem2
  Xcet                 cet fc for reg product
  Rsupply              reg supply of reg product
  RsupSFR              reg supply of reg product
  RsupSFE              reg supply of reg product
  YLincome             labor income
  AYLincome            adjusted labor income
  YKincome             capital income
  YAGKincome           ag capital income
```

```
   YTincome           land income
   YENTincome         enterprise income
   TYHinc             total hh income
   YHincome(h)        household income
   DHYincome(h)       disposable income
   HSAVings(h)        household savings
   SAVings            total savings
   INVest             total investment
   YSLincome          state and local gov income
   YFedincome         fegeral gov income
   GSProduct          gross state product
 * -- Expenditure block
   HEXPendLOW         household expenditure
   HEXPendMED         household expenditure
   HEXPendHi          household expenditure
   AHEXPend           adj household expenditure
   Qces               ces fc for consumption
   Qdemand            cons demand for composite good
   QRdem0             cons demand for reg goods
   QRdem1
   QRdem2
   QMdem1
   QMdem2
   AQdemand           adj Qdemand
   AQMdemand          adj QMdemand
   AQRdemand          adj QRdemand
   TQdemand           total Qdemand
   TQRdemand          total QRdemand
   TQMdemand          total QMdemand
   SLEXPend           state and loc gov expenditure
   QSLces             ces for st and loc gov demand
   QSLdemand          st and loc gov cons
   QSLRdem0           st and loc gov reg cons
   QSLRDem1
   QSLRDem2
   QSLMDem1
   QSLMDem2
   FedEXPend          fed gov expenditure
   QFedces            ces for fed gov demand
   QFeddemand         fed gov cons
   QFedRdem0          fed gov reg cons
   QFedRdem1
   QFedRdem2
   QFedMdem1
   QFedMdem2
   QINVces            ces for invest gov demand
   QINVemand          invest gov cons
   QINVRdem0          invest gov reg cons
   QInvRdem1
   QInvRdem2
   QInvMdem1
   QInvMdem2
   EXPortSFR          export
   EXPortSFE          export
   Mimports           import
   MimpSF
   NETprice           net price
   Price              composite price
   PriceSFE           composite price
   Price1
   PrDem
   PrDem1
   COMMequil          comm market equilibrium
   SFRequil           nonmarket equilibrium
   SFEequil           nonmarket equilibrium
   Lequil             labor market equilibrium
   Kequil             cap market equilibrium
   Kequil1
   Tequil             land market equilibrium
   adjustL            labor migration adjustment
   adjustK            capital migration adjustment
   ePLH
   eTLMig
   eLMigH
   eLDem
```

```
   ePL
   ePLM
   eLDemS
   ePR
   ePtax1
   ePtax2
   ePTaxCost
   KPrice
;
* -- MODEL EQUATIONS
   EQZ..            Z          =e= sum(i,Slack(i)*SLACK(i)+SLACK2(i)*Slack2(i));
   VAdemand(mk)..   VA(mk)     =e= a0(mk)*X(mk)+slack(mk)-slack2(mk);
   Vdemand(ci,i).. V(ci,i)     =e= a(ci,i)*X(i);
   VAprod(mk)..     VA(mk)     =e= Ava(mk)*LAB(mk)**alpha(mk,"L")*CAP(mk)**
                                   alpha(mk,"K")*LAND(mk)**alpha(mk,"T");
   Ldemand(mk)..    LAB(mk)    =e= alpha(mk,"L") *PN(mk)*X(mk)/PLM(mk);
*                          -- Industry labor demand depends on industry
*                          -- specific labor prices.  Labor price is industry
*                          -- specific since different industries requires
*                          -- different combinations and levels of skilled labor

   Kdemand(mk)..    CAP(mk)    =e= alpha(mk,"K") *PN(mk)*X(mk)/PK(mk);
   Tdemand(ag)..    LAND(ag)   =e= alpha(ag,"T") *PN(ag)*X(ag)/PT(ag);
   TLdem..          TLAB       =e= sum(mk,LAB(mk));
   TKdem..          TCAP       =e= sum(mk,CAP(mk));
   ePLM(mk)..       PLM(mk)    =e= Sum(s,PLS(s)*LD(mk,s))/Sum(s,LD(mk,s));
*                          -- Industry specific agregate labor price is a
*                          -- weighted average of prices of different skilled
*                          -- labor.  Weights used is the proportion of
*                          -- different skilled labor used in that industry.

   elDem(mk,s)..    LD(mk,s)   =e= Lab(mk)/Ask(mk)*Sum(s1,DeltaSk(mk,s1)*
                                    (PLS(s)/PLS(s1)*DeltaSk(mk,s1)/DeltaSk(mk,s))
                                    **(RhoSk(mk)/(1-RhoSk(mk))))**(-1/RhoSk(mk));
*                          -- Demand of labor by industry by skill,
*                          -- Based on cost minimisation to supply industry
*                          -- specific labor.  Equation reference: Dixon
*                          -- et el problems in applied microeconomic theory. page 297

   eLDemS(s)..      LDemS(s)   =e= sum(mk, LD(mk,s));
*                                   -- Total demand of labor by skills.

   ePL..            PL         =e= Sum(s,PLS(s)*LDemS(s))/Sum(s,LDemS(s));
*                          -- Overall aggregated price of labor.

   ePLH(h)..        PLH(h)     =e= Sum(s,PLS(s)*LSupS(s)*LSHS0(h,s)/LSupS0(s))
                                   / Sum(s,LSupS(s)*LSHS0(h,s)/LSupS0(s));
*                          -- Price of labor by household. Note that LSupHS(h,s)/LSupH(h)
*                          -- is the share of skilled labor type s in the h-th households.
*                          -- These shares are used as weights to compute a weigthed
*                          -- avg price of skilled labor prices. In general, difference
*                          -- hh faces different labor price because of different
*                          -- endowment of skilled labor.

   LSupply(h)..     LSupH(h)   =e= MAXHOURS0(h)-(beta0(h)/PLH(h))*((AHEXP(h)-
                                    sum(ci,PX(ci)*gamma(ci,h)))/(1-beta0(h)));
   LSupplyS(s)..    LSupS(s)   =e= Sum(h,LSHS0(h,s)/LSupH0(h)*LSupH(h));
*                          -- Supply of skilled labor.  Assume households
*                          -- supply skill labor in same proportion as in base line

   LMIGrat(s)..     LMIG(s)    =e= etaL(s)*LSupS0(s)*LOG(PLS(s)/PLROC0(s));
*                          -- In-migration of labor by skills

   eLMigH(h)..      LMigH(h)   =e= Sum(s,LMig(s)*LSHS0(h,s)/LSupS0(s));
*                          -- In-migration of labor by households, assume distribution
*                          -- of migrated skill labor is same as distribution of skill
*                          -- labor among households in base solution.  Migration
*                          -- elasticity can be skill specific.

   KMIGrat$(KMobil)..          KMIG=e= etaK*(SUM(mk,K0(mk))*LOG(PK("1Agr")/PKROC0));
   KMIGrat1$(not KMobil).. KMIG=e= 0;
*                          -- Note that with capital mobility, price of capital
*                          -- in all sectors are equal to each other thus PK("1Agr")
*                          -- is the overall capital price
```

```
eTLMig..          TLMig       =e= sum(h,LMigH(h));
TLSupp..          TLSup       =e= sum(h,LSupH(h));
TLSratio..        TLSrat      =e= TLSup/TLSup0;
MIGratio..        Mratio      =e= TLMig/TLSup0;

Vces(j,i)$NZV(j,i)..   V(j,i)   =e= Av(j,i)*(deltav(j,i)*VM(j,i)
                                    **RHOv(i)+(1-deltav(j,i))
                                    *VR(j,i)**RHOv(i))**(1/RHOv(i));
VRdem0(j,i)$NZV(j,i).. VR(j,i) =e= VM(j,i)*((1-deltav(j,i))/deltav(j,i)*
                                    PM0(i)/PR(i))**(1/(1-RHOv(i)));
VRdem1(j,i)$ZVM(j,i).. VR(j,i) =e= V(j,i);
VMdem1(j,i)$ZVM(j,i).. VM(j,i) =e= 0;
VRdem2(j,i)$ZVR(j,i).. VR(j,i) =e= 0;
VMdem2(j,i)$ZVR(j,i).. VM(j,i) =e= V(j,i);

TVRdemand(mk)..   TVR(mk)     =e= sum(j,VR(mk,j));
TVMdemand(mk)..   TVM(mk)     =e= sum(j,VM(mk,j));
TVdemand(mk)..    TV(mk)      =e= TVR(mk)+TVM(mk);
Xcet(mk)..        X(mk)       =e= Ax(mk)*(deltax(mk)*EXP(mk)**RHOx(mk)+(1-
                                  deltax(mk))*R(mk)**RHOx(mk))**(1/RHOx(mk));
Rsupply(mk)..     R(mk)       =e= EXP(mk)*((1-DELTAx(mk))/DELTAx(mk)
                                  *PE0(mk)/PR(mk))**(1/(1-RHOx(mk)));
RsupSFR(nmr)..    R(nmr)      =e= X(nmr);
RsupSFE(nme)..    R(nme)      =e= 0;
EXPortSFR(nmr)..  EXP(nmr)    =e= 0;
EXPortSFE(nme)..  EXP(nme)    =e= E0(nme)*(P(nme)+qTax)**omega;

GSProduct..       GSP         =e= YL+YK+YT+sum(i,ibtax(i)*X(i));
adjustL(h)..      adjL(h)     =e= (LSupH0(h)+LMigH(h))/LSupH0(h);
*                      -- Household specific adjustment factor

adjustK..         adjK        =e= (TKS0+KMIG)/TKS0;
ALSupply(h)..     ALS(h)      =e= LSupH(h)/adjL(h);

YLincome..        YL          =e= Sum(h,PLH(h)*LSupH(h));
AYLincome..       AYL         =e= Sum(h,PLH(h)*LSupH(h)/adjL(h));
*                      -- Total labor is sum of product of household labor supplied
*                      -- and price of labor paid to different households (prices are
*                      -- different because skills endowment of hh may be different).

YKincome..        YK          =e= sum(mk,PK(mk)*CAP(mk));
YAGKincome..      YAGK        =e= PK("1Agr")*CAP("1Agr");
YTincome..        YT          =e= PT("1Agr")*LAND("1Agr");
YENTincome..      YENT        =e= (YK-YAGK)*(1-ktax);
YHincome(h)..     YH(h)       =e= PLH(h)*LSupH(h)/adjL(h)*(1-sstax)+k(h)*(YAGK*(1-ktax-
                                  depr))+t(h)*YT*(1-ttax)+e(h)*(YENT-retr*(YK-YAGK))
                                  +TRSL0(h)+TRFed0(h)+REMIT0(h);
*                      -- Household income, note household specific adjustment factor

TYHinc..          TYH         =e= sum(h,YH(h));
DHYincome(h)..    DYH(h)      =e= YH(h)*(1-hhtax(h));
HSAVings(h)..     HSAV(h)     =e= mps(h)*YH(h);
SAVings..         SAV         =e= (sum(h,AdjL(h)*hSAV(h)))+depr*YAGK+retr*(YK-YAGK)+ROWSAV;
INVest..          INV         =e= sum(mk,P(mk)*QINV(mk));
YSLincome..       YSL         =e= slIBT*(sum(mk,ibtax(mk)*PR(mk)*X(mk)))+slSST*
                                  (sstax*YL)+slKTT*(ktax*YK)+slTTT*(ttax*YT)
                                  +slHHT*(sum(h,hhtax(h)*YH(h)))+SLBOR+pTaxCost;
YFedincome..      YFed        =e= fedIBT*(sum(mk,ibtax(mk)*PR(mk)*X(mk)))+
                                  fedSST*(sstax*YL)+fedKTT*(ktax*YK)+fedTTT*(ttax*YT)
                                  +fedHHT*(sum(h,hhtax(h)*YH(h)))+FedBOR;
* -- Expenditure block
HEXPendLow..    HEXP("Low") =e= DYH("Low")-HSAV("Low");
HEXPendMed..    HEXP("Med") =e= DYH("Med")-HSAV("Med");
HEXPendHI..     HEXP("High")=e= DYH("High")-HSAV("High")-Sum(s,PLS(s)*LHHH0(s));
AHEXPend(h)..   AHEXP(h)    =e= adjL(h)*HEXP(h);

Qdemand(ci,h)..  Q(ci,h)    =e= gamma(ci,h)+(beta(ci,h)/((1-beta0(h))*
                                PX(ci)))*(AHEXP(h)-sum(cj,P(cj)*gamma(cj,h)));
AQdemand(ci,h).. ADQ(ci,h) =e= Q(ci,h)/adjL(h);

Qces(ci,h)$NZQ(ci,h)..   Q(ci,h)   =e= Aq(ci,h)*(deltaq(ci,h)*QM(ci,h)**RHOq(ci) +(1-
                                       deltaq(ci,h))*QR(ci,h)**RHOq(ci))**(1/RHOq(ci));
QRdem0(ci,h)$NZQ(ci,h).. QR(ci,h) =e= QM(ci,h)*((1-deltaq(ci,h))/deltaq(ci,h)*
                                       PM0(ci)/PRX(ci))**(1/(1-RHOq(ci)));
QRdem1(ci,h)$ZQM(ci,h).. QM(ci,h) =e= 0;
```

```
QMdem1(ci,h)$ZQM(ci,h).. QR(ci,h) =e= Q(ci,h);
QRdem2(ci,h)$ZQR(ci,h).. QR(ci,h) =e= 0;
QMdem2(ci,h)$ZQR(ci,h).. QM(ci,h) =e= Q(ci,h);

AQMdemand(ci,h).. AQM(ci,h)=e= QM(ci,h)/adjL(h);
AQRdemand(ci,h).. AQR(ci,h)=e= QR(ci,h)/adjL(h);
TQRdemand(ci)..   TQR(ci)  =e= sum(h,QR(ci,h));
TQMdemand(ci)..   TQM(ci)  =e= sum(h,QM(ci,h));
TQdemand(ci)..    TQ(ci)   =e= TQR(ci)+TQM(ci);

SLEXPend..                  SLEXP    =e= sum(mk,P(mk)*QSL(mk))+
                                         (sum(h,AdjL(h)*TRSL0(h)))+Sum(s,PLS(s)*LSL0(s));
QSLdemand(mk)..             QSL(mk)  =e= QSL0(mk);
QSLces(mk)$NZSL(mk)..       QSL(mk)  =e= Asl(mk)*(deltasl(mk)*QSLM(mk)**RHOsl(mk)+ (1-
                                         deltasl(mk))*QSLR(mk)**RHOsl(mk))**(1/RHOsl(mk));
QSLRdem0(mk)$NZSL(mk)..     QSLR(mk) =e= QSLM(mk)*((1-deltasl(mk))/deltasl(mk)*
                                         PM0(mk)/PR(mk))**(1/(1-RHOsl(mk)));
QSLRdem1(mk)$ZSLM(mk)..     QSLM(mk) =e= 0;
QSLMdem1(mk)$ZSLM(mk)..     QSLR(mk) =e= QSL(mk);
QSLRdem2(mk)$ZSLR(mk)..     QSLR(mk) =e= 0;
QSLMdem2(mk)$ZSLR(mk)..     QSLM(mk) =e= QSL(mk);

FedEXPend..                 FedEXP   =e= sum(mk,P(mk)*QFed(mk))+(sum(h,
                                         AdjL(h)*TRFed0(h)))+Sum(s,PLS(s)*LFed0(s));
QFeddemand(mk)..            QFed(mk) =e= QFed0(mk);
QFedces(mk)$NZFed(mk)..     QFed(mk) =e= Afed(mk)*(deltafed(mk)*QFedM(mk)**RHOfed(mk)+(1-
                                     deltafed(mk))*QFedR(mk)**RHOfed(mk))**(1/RHOfed(mk));
QFedRdem0(mk)$NZFed(mk).. QFedR(mk)=e= QFedM(mk)*((1-deltafed(mk))/deltafed(mk)
                                       *PM0(mk)/PR(mk))**(1/(1-RHOfed(mk)));
QFedRDem1(mk)$ZFedM(mk).. QFedM(mk)=e= 0;
QFedMDem1(mk)$ZFedM(mk).. QFedR(mk)=e= QFed(mk);
QFedRDem2(mk)$ZFedR(mk).. QFedR(mk)=e= 0;
QFedMDem2(mk)$ZFedR(mk).. QFedM(mk)=e= QFed(mk);

QINVemand(mk)..             QINV(mk) =e= QINV0(mk);
QINVces(mk)$NZInv(mk)..     QINV(mk) =e= Ainv(mk)*(deltainv(mk)*QINVM(mk)**RHOinv(mk)+(1-
                                     deltainv(mk))*QINVR(mk)**RHOinv(mk))**(1/RHOinv(mk));
QINVRdem0(mk)$NZInv(mk).. QINVR(mk)=e= QINVM(mk)*((1-deltainv(mk))/deltainv(mk)
                                       *PM0(mk)/PR(mk))**(1/(1-RHOinv(mk)));
QInvRDem1(mk)$ZInvM(mk).. QInvM(mk)=e= 0;
QInvMDem1(mk)$ZInvM(mk).. QInvR(mk)=e= QInv(mk);
QInvRDem2(mk)$ZInvR(mk).. QInvR(mk)=e= 0;
QInvMDem2(mk)$ZInvR(mk).. QInvM(mk)=e= QInv(mk);

Mimports(mk)..  M(mk)      =e= TVM(mk)+TQM(mk)+QSLM(mk)+QFedM(mk)+QINVM(mk);
MimpSF(nmr)..   M(nmr)     =e= TQM(nmr);

NetPrice(mk)..  PN(mk)     =e= PR(mk)-sum(ml,A(ml,mk)*P(ml))-ibtax(mk)*PR(mk)-pTax(mk);
ePR(nmr)..      PR(nmr)    =e= sum(mk,A(mk,nmr)*P(mk));
Price(ci)..     P(ci)      =e= (PR(ci)*R(ci)+PM0(ci)*M(ci))/(R(ci)+M(ci));
PriceSFE(nme).. P(nme)     =e= sum(ci,P(ci)*A(ci,nme));
PrDem(mk)..     PRX(mk)    =e= PR(mk);
PrDem1(nmr)..   PRX(nmr)   =e= PR(nmr)+qTax;
*                      -- Prices faced by the consumer: equilibrium price plus tax

Price1(ci)..    PX(ci)     =e= (PRX(ci)*R(ci)+PM0(ci)*M(ci))/(R(ci)+M(ci));

ePtax1(po)$(EndoPTax(po)).. pTax(po)*X(po)=e= EndoPTax(po)*qTax*(X("15Rest")+X("16Nres"));
 ePtax2(po)$(ExoPTax(po)).. pTax(po)     =e= ExoPtax(po);
 ePTaxCost..    pTaxCost   =e= Sum(mk,pTax(mk)*X(mk));
* -- Equilibrium
 COMMequil(mk).. X(mk)+M(mk)      =e= TV(mk)+TQ(mk)+QSL(mk)+QFed(mk)+QINV(mk)+EXP(mk);
 SFRequil(nmr).. X(nmr)+M(nmr)    =e= TQ(nmr);
 SFEequil(nme).. X(nme)           =e= EXP(nme);
 Lequil(s)..     LMIG(s)+LSupS(s) =e= LDemS(s)+LExo0(s);
*                      -- Labor equilibrium: supply equals demand by all skills.

 Kequil1$(KMobil)..            KMig      =e= Sum(mk,CAP(mk)-KS0(mk));
 Kequil(mk)$(not KMobil).. CAP(mk)   =e= KS0(mk);
 Kprice(mk1)$(KMobil)..        Pk(mk1)   =e= pk("1Agr");
 Tequil(mk)..                  LAND(mk)  =e= TS0(mk);
* -- Initialization
 AdjL.L(h)  = 1          ;  GSP.L      = GSP0      ;  ADQ.L(i,h) = Q0(i,h)   ;
 HEXP.L(h)  = HEXP0(h)   ;  AHEXP.L(h) = HEXP0(h)  ;  HSAV.L(h)  = HSAV0(h)  ;
 ALS.L(h)   = LSupH0(h);    INV.L      = INV0      ;  AQM.L(i,h) = QM0(i,h)  ;
```

```
KMIG.L      = 0          ;   AQR.L(i,h) = QR0(i,h) ;  LAB.L(i)    = L0(i)    ;
AYL.L       = YL0        ;   LAND.L(i)  = T0(i)    ;  CAP.L(i)    = K0(i)    ;
LDem.L(mk,s)= VAD(mk,s);     DYH.L(h)   = DYH0(h)  ;  LDemS.L(s)  = LDemS0(s);
EXP.L(i)    = E0(i)      ;   LMIG.L(s)  = 0        ;  FedBOR.L    = FedBOR0  ;
LMigH.L(h)  = 0          ;   FedEXP.L   = FedEXP0  ;

LSupH.L(h)  = MAXHOURS0(h)-(beta0(h)/PLH0(h))*((HEXP0(h)
              -sum(ci,PX0(ci)*gamma(ci,h)))/(1-beta0(h)));

LSupS.L(s)  = LSupS0(s);     PL.L       = PL0      ;  M.L(i)      = M0(i)    ;
PLH.L(h)    = PLH0(h)  ;     Mratio.L   = 0        ;  PLM.L(mk)   = 1        ;
P.L(i)      = P0(i)    ;     PLS.L(s)   = PLS0(s)  ;  PK.L(i)     = PK0(i)   ;

PN.L(mk)    = PR0(mk)-sum(ml,A(ml,mk)*P0(ml))-ibtax(mk)*PR0(mk);

PR.L(i)     = PR0(i)   ;     PTax.L(mk) = 0        ;  PRX.L(i)    = PRX0(i)  ;
PX.L(i)     = PX0(i)   ;     PT.L(i)    = PT0(i)   ;

Q.L(ci,h)   = gamma(ci,h)+(beta(ci,h)/((1-beta0(h))*
              PX0(ci)))*(HEXP0(h)-sum(cj,P0(cj)*gamma(cj,h)));

Q.L(nme,h)  = 0          ;   TLSrat.L    = 1         ;  QFed.L(i)   = QFed0(i) ;
TLSup.L     = TLSup0     ;   QFedM.L(i)  = QFedM0(i);   TQ.L(ci)    = TQ0(ci)  ;
QFedR.L(i)  = QFedR0(i);     TQM.L(ci)   = TQM0(ci) ;   QINV.L(i)   = QINV0(i) ;
TQR.L(ci)   = TQR0(ci) ;     QINVM.L(i)  = QINVM0(i);   TV.L(i)     = TV0(i)   ;
QINVR.L(i)  = QINVR0(i);     TVM.L(i)    = TVM0(i)  ;   QM.L(ci,h)  = QM0(ci,h);
TVR.L(i)    = TVR0(i)  ;     QR.L(ci,h)  = QR0(ci,h);   TYH.L       = TYH0     ;
QSL.L(mk)   = QSL0(mk) ;     V.L(j,i)    = V0(j,i)  ;   QSLM.L(mk)  = QSLM0(mk);
VA.L(mk)    = VA0(mk)  ;     QSLR.L(mk)  = QSLR0(mk);   VM.L(j,i)   = VM0(j,i) ;
R.L(ci)     = R0(ci)   ;     VR.L(j,i)   = VR0(j,i) ;   ROWSAV.L    = ROWSAV0  ;
X.L(i)      = X0(i)    ;     SAV.L       = SAV0     ;   YAGK.L      = YAGK0    ;
SLack.L(i)  = 0        ;     YENT.L      = YENT0    ;   SLack2.L(i)= 0         ;
YFed.L      = YFed0    ;     SLBOR.L     = SLBOR0   ;   YH.L(h)     = YH0(h)   ;
SLEXP.L     = SLEXP0   ;     YK.L        = YK0      ;   TCAP.L= Sum(mk,K0(mk));
YL.L        = YL0      ;     TLab.L   = Sum(i,L0(i));
TLMig.L     = 0        ;     YT.L        = YT0      ;   YSL.L       = YSL0     ;

* -- VARIABLE BOUNDS
 PLS.LO(s)    = .0; PN.LO(mk) = .0   ;  PT.LO(i)   = .0; PRX.LO(i)    = .0   ;
 PLH.LO(h)    = .0; P.LO(i)   = .0   ;  PK.LO(i)   = .0; PTAX.LO(mk)  = .0   ;
 PLM.LO(mk)   = .0; R.LO(ci)  = .0   ;  PR.LO(i)   = .0; PTAX.UP(np)  = .0   ;
 PL.LO        = .0; PX.LO(i)  = .0   ;

 VR.LO(i,j)$(VR0(i,j) ne 0)  = Small;  R.LO(i)$(R0(i) ne 0)         = Small;
 VM.LO(i,j)$(VM0(i,j) ne 0)  = Small;  X.LO(i)$(X0(i) ne 0)         = Small;
 V.LO(i,j)$(V0(i,j) ne 0)    = Small;  EXP.LO(i)$(E0(i) ne 0)       = Small;

 VR.LO(i,j)$(VR0(i,j) eq 0)  = 0    ;  R.LO(i)$(R0(i) eq 0)         = 0    ;
 VM.LO(i,j)$(VM0(i,j) eq 0)  = 0    ;  X.LO(i)$(X0(i) eq 0)         = 0    ;
 V.LO(i,j)$(V0(i,j) eq 0)    = 0    ;  EXP.LO(i)$(E0(i) eq 0)       = 0    ;

 VR.UP(i,j)$(VR0(i,j) eq 0)  = 0    ;  R.UP(i)$(R0(i) eq 0)         = 0    ;
 VM.UP(i,j)$(VM0(i,j) eq 0)  = 0    ;  X.UP(i)$(X0(i) eq 0)         = 0    ;
 V.UP(i,j)$(V0(i,j) eq 0)    = 0    ;  EXP.UP(i)$(E0(i) eq 0)       = 0    ;

 QM.LO(i,h) = 0;  AQR.LO(i,h)= 0    ;  VA.LO(i)$(VA0(i) ne 0)       = Small;
 QR.LO(i,h) = 0;  Q.LO(i,h)  = 0    ;  VA.LO(i)$(VA0(i) eq 0)       = 0    ;
 AQM.LO(i,h)= 0;  ADQ.LO(i,h)= 0    ;  VA.UP(i)$(VA0(i) eq 0)       = 0    ;

 LAB.LO(i)$(L0(i) ne 0)      = 0    ;  QM.LO(i,h)$(QM0(i,h) ne 0)  = Small;
 LAB.LO(i)$(L0(i) eq 0)      = 0    ;  QR.LO(i,h)$(QR0(i,h) ne 0)  = Small;
 LAB.UP(i)$(L0(i) eq 0)      = 0    ;  Q.LO(i,h)$(Q0(i,h) ne 0)    = Small;

 CAP.LO(i)$(K0(i) ne 0)      = Small;  QM.LO(i,h)$(QM0(i,h) eq 0)  = 0    ;
 CAP.LO(i)$(K0(i) eq 0)      = 0    ;  QR.LO(i,h)$(QR0(i,h) eq 0)  = 0    ;
 CAP.UP(i)$(K0(i) eq 0)      = 0    ;  Q.LO(i,h)$(Q0(i,h) eq 0)    = 0    ;

 LAND.LO(i)$(T0(i) ne 0)     = Small;  QM.UP(i,h)$(QM0(i,h) eq 0)  = 0    ;
 LAND.LO(i)$(T0(i) eq 0)     = 0    ;  QR.UP(i,h)$(QR0(i,h) eq 0)  = 0    ;
 LAND.UP(i)$(T0(i) eq 0)     = 0    ;  Q.UP(i,h)$(Q0(i,h) eq 0)    = 0    ;

 AQM.LO(i,h)$(QM0(i,h) ne 0) = Small;  QFedR.LO(i)$(QFedR0(i) ne 0)= Small;
 AQR.LO(i,h)$(QR0(i,h) ne 0) = Small;  QFedR.LO(i)$(QFedR0(i) eq 0)= 0    ;
 ADQ.LO(i,h)$(Q0(i,h)  ne 0) = Small;  QFedR.UP(i)$(QFedR0(i) eq 0)= 0    ;
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  AQM.LO(i,h)$(QM0(i,h) eq 0) = 0     ;  QFedM.LO(i)$(QFedM0(i) ne 0)= Small;
  AQR.LO(i,h)$(QR0(i,h) eq 0) = 0     ;  QFedM.LO(i)$(QFedM0(i) eq 0)= 0    ;
  ADQ.LO(i,h)$(Q0(i,h)  eq 0) = 0     ;  QFedM.UP(i)$(QFedM0(i) eq 0)= 0    ;

  AQM.UP(i,h)$(QM0(i,h) eq 0) = 0     ;  QFed.LO(i)$(QFed0(i) ne 0)  = Small;
  AQR.UP(i,h)$(QR0(i,h) eq 0) = 0     ;  QFed.LO(i)$(QFed0(i) eq 0)  = 0    ;
  ADQ.UP(i,h)$(Q0(i,h)  eq 0) = 0     ;  QFed.UP(i)$(QFed0(i) eq 0)  = 0    ;

  QINVR.LO(i)$(QINVR0(i) ne 0)= Small;  QSLR.LO(i)$(QSLR0(i) ne 0)  = Small;
  QINVR.LO(i)$(QINVR0(i) eq 0)= 0    ;  QSLR.LO(i)$(QSLR0(i) eq 0)  = 0    ;
  QINVR.UP(i)$(QINVR0(i) eq 0)= 0    ;  QSLR.UP(i)$(QSLR0(i) eq 0)  = 0    ;

  QINVM.LO(i)$(QINVM0(i) ne 0)= Small;  QSLM.LO(i)$(QSLM0(i) ne 0)  = Small;
  QINVM.LO(i)$(QINVM0(i) eq 0)= 0    ;  QSLM.LO(i)$(QSLM0(i) eq 0)  = 0    ;
  QINVM.UP(i)$(QINVM0(i) eq 0)= 0    ;  QSLM.UP(i)$(QSLM0(i) eq 0)  = 0    ;

  QINV.LO(i)$(QINV0(i) ne 0)  = Small;  QSL.LO(i)$(QSL0(i) ne 0)    = Small;
  QINV.LO(i)$(QINV0(i) eq 0)  = 0    ;  QSL.LO(i)$(QSL0(i) eq 0)    = 0    ;
  QINV.UP(i)$(QINV0(i) eq 0)  = 0    ;  QSL.UP(i)$(QSL0(i) eq 0)    = 0    ;

  LDem.LO(mk,s) = 0;  M.LO(i) = 0     ;


Options ITERLIM=5000, LIMROW=0, LIMCOL=0;
Model OK91CGE /All/;
Solve OK91CGE Minimizing Z Using NLP;
option decimals=6;
DISPLAY Z.L,PL.L,PLS.L,PLH.L,PK.L,PT.L,PR.L,PRX.L,PN.L,P.L,PX.L,LAB.L,LAND.L,
   CAP.L,TLAB.L,LDemS.L,TCAP.L,LSupS.L,LSupH.L,TLSup.L,TLSrat.L,VA.L,VR.L,
   VM.L,TVR.L,TVM.L,TV.L,V.L,X.L,EXP.L,R.L,M.L,LMIG.L,Mratio.L,YL.L,YK.L,
   YAGK.L,YT.L,YENT.L,YH.L,TYH.L,DYH.L,HSAV.L,SAV.L,ROWSAV.L,INV.L,YSL.L,
   SLBOR.L,YFed.L,FedBOR.L,GSP.L,HEXP.L,Q.L,QM.L,QR.L,TQM.L,TQR.L,TQ.L,SLEXP.L,
   FedEXP.L,QSL.L,QSLR.L,QSLM.L,QFed.L,QFedR.L,QFedM.L,QINV.L,QINVR.L,QINVM.L,
   adjL.L,AYL.L,AHEXP.L,ALS.L,ADQ.L,AQM.L,AQR.L,GSP.L, pTax.L, pTaxCost.L;
* -- PARAMETERS AS INDEX WITH 1991=1.000
PARAMETERS
* -- Production block
  IL(i)               Labor demand index
  ILS(h)              Labor supply index
  IK(i)               capital demand index
  IT(i)               Land demand index
  IVA(i)              Value added index
  IX(i)               Output index
  IVM(j,i)            Imported interm demand index
  IVR(j,i)            Regional interm demand index
  IR(i)               Regional supply index
  IE(i)               Export index
  IM(i)               Import index
* -- Income block
  ITYH                Total household income index
  IYH(h)              Household income index
  IDYH(h)             Disposable income index
  IHSAV(h)            Household saving index
  IGSP                Gross state product index
* -- Expenditure block
  IHEXP(h)            Household expenditure index
  IQ(i,h)             Commodity demand index
  IQM(i,h)            Imported commodity demand index
  IQR(i,h)            Regional commodity demand index
* -- Price block
  IPL                 Wage rate index
  IPK(i)              Rent to  capital index
  IPT(i)              Land rent index
  IPR(i)              Regional price index
  IP(i)               Composite price index
  ILDemS(s)
  ILSupS(s)
  ILSupH(h)
;
* -- EQUATIONS FOR CALCULATION OF INDEX WITH 1991=1.000
* -- Production block
  IL(mk)          = LAB.L(mk)/L0(mk);
  ILS(h)          = ALS.L(h)/LSupH0(h);
  IK(mk)          = CAP.L(mk)/K0(mk);
  IT(ag)          = LAND.L(ag)/T0(ag);
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  IVA(mk)        = VA.L(mk)/Va0(mk);
  IX(i)          = X.L(i)/X0(i);
  IVM(ml,ci)     = (VM.L(ml,ci)/VM0(ml,ci))$(VM0(ml,ci) ne 0)+1$(VM0(ml,ci) eq 0);
  IVR(ml,ci)     = (VR.L(ml,ci)/VR0(ml,ci))$(VR0(ml,ci) ne 0)+1$(VR0(ml,ci) eq 0);
  IR(ci)         = R.L(ci)/R0(ci);
  IE(mk)         = EXP.L(mk)/E0(mk);
  IE(nme)        = EXP.L(nme)/E0(nme);
* -- Income block
  IYH(h)         = YH.L(h)/YH0(h);
  ITYH           = TYH.L/TYH0;
  IDYH(h)        = DYH.L(h)/DYH0(h);
  IHSAV(h)       = HSAV.L(h)/HSAV0(h);
  IGSP           = GSP.L/GSP0;
* -- Expenditure block
  IHEXP(h)       = HEXP.L(h)/HEXP0(h);
  IQ(ci,h)       = (ADQ.L(ci,h)/Q0(ci,h))$(Q0(ci,h) ne 0) +1$(Q0(ci,h) eq 0);
  IQM(ci,h)      = (AQM.L(ci,h)/QM0(ci,h))$(QM0(ci,h) ne 0)+1$(QM0(ci,h) eq 0);
  IQR(ci,h)      = (AQR.L(ci,h)/QR0(ci,h))$(QR0(ci,h) ne 0)+1$(QR0(ci,h) eq 0);
  IM(ci)         = M.L(ci)/M0(ci);
* -- Price block
  IPL            = PL.L/PL0;
  IPK(i)         = PK.L(i)/PK0(i);
  IPT(ag)        = PT.L(ag)/PT0(ag);
  IPR(i)         = PR.L(i)/PR0(i);
  IP(i)          = P.L(i)/P0(i);
  ILDemS(s)      = LDemS.L(s)/LDemS0(s);
  ILSupS(s)      = LSupS.L(s)/LSupS0(s);
  ILSupH(h)      = LSupH.L(h)/LSupH0(h);
Option Decimals=6;
DISPLAY IPL,IPK,IPT,IPR,IP,IL,IK,
   IT,ILS,IVA,IE,IR,IX,IM,ITYH,
   IYH,IDYH,IHSAV,IGSP,IHEXP;
* -- Welfare
PARAMETERS
  CV(h)  Compensating variation
  EV(h)  Equivalent variation
  TCV    Total compensating variation
  TEV    Total equivalent variation
;

 CV(h)    = (1/(1-beta0(h)))*((AHEXP.L(h)-sum(cj,PX.L(cj)*
            gamma(cj,h)))-(adjL.L(h)*(HEXP0(h))-sum(cj,P0
            (cj)*gamma(cj,h)))*PROD(ci,(PX.L(ci)/P0(ci))
            **beta(ci,h))*(PL.L/PL0)**beta0(h));
 EV(h)    = (1/(1-beta0(h)))*((AHEXP.L(h)-sum(cj,PX.L(cj)*
            gamma(cj,h)))*PROD(ci,(P0(ci)/PX.L(ci))
            **beta(ci,h))*(PL0/PL.L)**beta0(h)-(adjL.L(h)*
            (HEXP0(h))-sum(cj,P0(cj)*gamma(cj,h))));
 TCV      = sum(h,CV(h));
 TEV      = sum(h,EV(h));

DISPLAY CV, EV, TCV, TEV;

DISPLAY PLS.l, PLH.l;
DISPLAY ILDemS, ILSupS, ILSupH;
DISPLAY LMIG.L;
DISPLAY ETAL;
DISPLAY PLROC0;
DISPLAY Slack.L;
DISPLAY Slack2.L;

*-- THE END OF PROGRAM
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VITA

RINI BUDIYANTI

Candidate for the Degree of

Doctor of Philosophy

Thesis: APPLICATION OF GENERAL EQUILIBRIUM MODELING FOR MEASURING REGIONAL ECONOMIC AND WELFARE IMPACTS OF QUALITY CHANGES IN SPORT FISHING IN OKLAHOMA

Major of Field: Agricultural Economics

Biographical:

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