Natural Resource Supply Constraints and Regional Economic Analysis: A Computable General Equilibrium Approach

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ABSTRACT

Traditional, fixed-price (input-output) economic models provide a useful framework for conceptualizing linkages in a regional economy. However, inherent limitations with input-output (IO) methods can severely restrict the analyst's ability to deduce valid prescriptions for public policy and economic development when examining the impact changes in the availability of natural resource supplies have on regional economic activity. A superior approach using regional computable general equilibrium (CGE) models is presented. In a severe CGE scenario, elimination of 80 percent of federal log supplies to a timber dependent region resulted in the loss of 2,532 jobs (4.2 percent of regional employment), and $60 million (3.3 percent) of household income. Results of the same shock with an input-output model of the region indicated a loss of 3,453 jobs and $83 million in household income. The IO estimate of job loss was 36 percent higher than the CGE estimate, while the IO household income loss was 38 percent higher than the CGE estimate. For less severe scenarios (a 50 percent reduction in federal log supply) the IO estimates of income and employment loss were larger than the CGE estimates by between 60 and 70 percent. Study results indicate an upward bias in estimated loss of regional income and jobs using IO methods.

Keywords: Regional economics, computable general equilibrium models, input-output models.

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Introduction

Recent concern over the viability of several native anadromous fish runs has jeopardized traditional public land uses in the Pacific Northwest. Ecological disturbances caused by livestock grazing and logging has been shown to adversely affect salmon spawning beds. In July 1999, the Ninth Circuit U.S. Court of Appeals issued an injunction which could effectively stop grazing activities (and eventually, perhaps, logging and road building) in the Umatilla and Wallowa-Whitman National Forests for the purpose of preserving viable spawning habitat for threatened or endangered salmon. As a result, the degree of future access to the public forest land for timber harvest and cattle grazing is uncertain. While it is currently unclear what changes in logging policy will be introduced, the relative importance of timber-related industries in a five-county region of Northeast Oregon suggests that any reduction in the access to federal timber supplies could have a significant impact on regional employment and income. Lumber and wood products comprise 4101 jobs (6.9% of total employment) in this timber dependent five-county region and 30% of all logs harvested in the region come off federal lands.

Background

Historically, natural resource industries have provided a significant portion of Oregon's employment and income. In 1997, livestock and timber-related industries together directly provided an estimated 105,000 jobs (not including several thousand resource management jobs in federal, state, and local governments). This represents about 6.5 percent of total jobs and 7.7 percent of employee compensation paid in the state (Table 1). Given the historic importance of natural resource industries to the Oregon economy a significant reduction in the rate of natural resource use is likely to have a significant impact on the aggregate level of economic activity

within the state. The magnitude of this impact will be greatest in the most natural resource dependent regions of the state. In the five northeast Oregon counties which provide the focus for this study (i.e., Baker, Grant, Umatilla, Union, and Wallowa Counties), natural resource related industries provide about 15 percent of regional employment and employee compensation (Table 1). In 1997, of the nearly 60,000 jobs in this five county region, logging, lumber, and wood products provided 4,100 jobs, and livestock, primarily grazed on public lands, another 5,300 jobs.

Study Purpose and Scope

The purpose of this study was to estimate the regional economic impact of alternative Forest Service policies regarding access to public resources in Northeast Oregon. In the regional economic impact analysis, estimates of total change in regional employment and income are provided under varying assumptions about the nature and magnitude of the policy shift and length of time over which adjustment to the policy occurs. Analysis is limited to examining the impact of hypothetical resource supply constraints on timber harvest from federal lands. Instead of a traditional analysis using a conventional demand-driven fixed-price model,[3] this study presents results obtained using a flexible-price, computable general equilibrium (CGE) model of the regional economy. CGE models provide several advantages over more conventional regional models in that they are more consistent with neoclassical economic theory and are flexible enough to incorporate factor and commodity substitution into the structure of production and demand.

[3]For example, input-output (IO), economic base (EB), and social accounting matrix (SAM) models. These types of models produce constant, marginal multipliers (i.e., invariant of the size of the economic shock) by assuming that factor (labor and capital) supply constraints are nonbinding; and that factor demand ratios, commodity supply proportions, and all prices are fixed. Multipliers derived from fixed-price models can generally be described as providing an upper bound on the amount of economic impact resulting from an exogenous demand shock.

Fixed-price models, such as IO or SAM-based models, do provide internally consistent representations of regional economic structure but under very restrictive assumptions (e.g., fixed-proportion production functions, unconstrained factor and commodity supplies, and fixed or price-inelastic demand for goods and services). Moreover, in contrast to the CGE models, fixed-price models regard all factor supplies, both interregionally and intersectorally, as perfectly elastic by holding all commodity and factor prices fixed. Constant multipliers result from the assumption of fixed proportion, column-normalized expenditure coefficients. The magnitude of these multipliers reflect the strength of backward linkages in the regional economy. The fixed-price specification embodies traditional demand driven assumptions and procedures regarding regional economic systems. Consequently, fixed price models, model resource supply shocks as "equivalent" reductions in exogenous demand for the output of the directly impacted industrial sectors. While fixed price models are ideally suited to estimating the impact of changes in final demand, but are severely limited in their applicability to supply-side issues.

Despite the inherit limitations of fixed price models, some researchers have creatively used fixed-price models to analyze the impacts of natural resource constraints, the reader is referred to Petkovich and Ching (1978) (mining), and Waters, Holland, and Weber (1994) (timber). Examples of CGE applications to resource policy issues can be found in Despotakis and Fisher (1988) (petroleum) and Berck, Robinson, and Goldman (1991) (water).

Regional CGE Models

A regional CGE model consists of a system of equations representing the equilibrium behavior of factor and commodity markets and other relevant economic institutions. The system can simulate economic response to changes in a wide array of policy, management, and behavioral variables. A key feature is the inclusion of relative prices which reflect the economic scarcity of

all commodities and productive factors in the model. Endogenous prices adjust until factor and commodity market equilibrium conditions are satisfied. Compared with fixed-price models, CGE methodology is more consistent with modern economic theory, allows greater flexibility in the specification of economic behavioral relationships, and generally produces more moderate estimates of economic impact.

Implementation of a regional CGE model does not require the a priori designation of an economic base and basic activity is not necessarily limited to a few traditional manufacturing sectors. In a CGE model, economic change is governed by "supply-side" (e.g. available quantities of productive goods and services) and trade-related constraints, rather than by backward linkages transmitted via changes in final demand. Also, since the opportunity to substitute among resource inputs is subject to diminishing returns in a CGE model, measures such as employment multipliers are variable depending on the resource input level.

Figure 1 traces the basic steps of a regional CGE modeling effort. First, data are collected, organized, and reconciled into a benchmark equilibrium data set (the social accounting matrix).[4] Next, behavioral and accounting relationships are specified, and the model parameters are calibrated given the benchmark data. Finally, the policy change scenarios are introduced, and counterfactual equilibria representing the situation under the new policy regimes is calculated. Impacts are estimated by comparing the counterfactual equilibria against the benchmark scenario.

[4]The data set for the Northeast Oregon CGE was assembled mainly from IMPLAN-generated regional product accounts (Alward, 1999), state of Oregon tax and expenditure data, and REIS county income and employment estimates (U.S. Dept. of Commerce, 1999). Timber harvest estimates (Oregon Department of Forestry) and livestock grazing statistics (Bedell; Bedell and Stringham, 1994; Hewlett, Cross, and Hart, 1987) were also used to estimate benchmark resources flow levels.

The Northeast Oregon CGE Model

Allocation of all resources and commodities in the Northeast Oregon CGE model is a function of economic scarcity as reflected by the relative prices of all goods, services, and productive factors. Thus, price variables assume a preeminent role in the model. Key determinants of relative prices include: 1) factor supply and production constraints; 2) ability of regional consumers to substitute between alternative sources of commodity supply (i.e., regional industrial supply, regional non-industrial supply and imported supply); 3) ability of regional producers to supply alternative markets (i.e., regional versus outside the region, or "export"); and 4) demand conditions affecting regional and export markets.

Figures 2 traces the linkages between components of the regional CGE model.[5] At the bottom of the figure, value is added to inputs of labor, proprietors' services, and capital via linearly homogeneous Cobb-Douglas production functions, and combined with intermediate inputs to produce output for each sector (X). Behavioral assumptions ensure that producers maximize economic returns by equating the marginal factor cost with the value of each factor's contribution to marginal product.

Each unit of X is either sold to local buyers (XXD) or exported outside the region (E). A constant elasticity transformation function (CET) governs the ease with which regional producers can switch between regional and export market destinations. Revenue maximization behavior by producers determines the proportion of output supplied to satisfy regional demand versus export markets. Export demand is assumed to be perfectly elastic (i.e., world commodity prices are fixed), while regional demand is influenced by endogenous price and income effects.

[5]A list of variables, parameters, and equations, and detailed descriptions of the regional CGE model is available on request.

Commodities produced for regional use (XXD) are combined with available non-industrial supplies (GS, "government sales") to form total aggregate supply from regional sources (XD). The aggregation occurs via a constant elasticity substitution (CES) function. The treatment of government supplies as imperfect substitutes for private supplies in generating total regional commodity supply illustrates the flexibility of the regional CGE framework. In constructing this paper's analysis, we imposed quantity restrictions on federal government supplies of logs. Regional supply (XD) is, in turn, combined with competitive imports (M) via a CES aggregation to form a composite absorption good (or service) for each class of commodity (Q). The role of the nested CES functions is to allow partial substitution of private (and imported) sources of logs for federal log supplies.[6] Expenditure minimization at both stages of aggregation determines substitution between XXD and GS, and between XD and M, respectively. The use of CET and CES functions in the model accommodates the observed phenomenon of "crosshauling" in which simultaneous imports and exports appear in highly aggregated commodity classifications.

To give these variables more content, consider the following figures for the private logging sector in the baseline (1997) economy in which all estimates are in millions of dollars. Regional output of the logging sector was $158.15 (X). Of this, $139.05 (E) was exported outside the region and $19.10 (XXD) was used in the region. Logs produced and used regionally $19.10 (XXD) were combined with logs from government sales of $93.51 (GS) to form total log supply from regional sources of $112.61 (XD). Government sales were made up $20.67 (SS) from state sources and $72.84 (FS) from federal sources. Regional log supply of $112.61 (XD)

[6]This treatment contrasts with a fixed-price analytical approach where the relative proportions of inputs from public, private, and imported sources is assumed to be fixed.

was combined with log imports $16.62 (M) to form the composite log supply to the region (Q) of $129.23.

In response to a reduction of logs from federal government land (FS), the partial substitution structure of the CGE model will increase the log supply from private regional sources (XXD) and from non-regional sources (M) to partially offset the reduction in federal supply. This response will be driven by an increase in the price of logs produced and consumed in the region (XXD) that is a function of the regional excess demand for logs stemming largely from the Wood Products sector. As the regional price of logs increases, cost minimization implies that imported logs (M) will be substituted for regionally produced and consumed logs (XD).

Total supply of Q supports intermediate demand (ND) and final demand for consumer goods (C), investment needs (IT), and government purchases (G). In this model, all spending by local agencies of federal, state, and local government is fixed at baseline levels. Any reduction in revenues from taxation or government sales are assumed to be offset by transfers form other sources (i.e., state and federal government).[7] Consumption by each of three household income classes is driven by changes in endogenous factor incomes and relative commodity prices. Finally, business investment spending is fixed at baseline levels.

Modeling Scenarios

The length of run used in this analysis varies from relatively short-run to intermediate run. Labor is assumed to adjust across sectors according to changes in factor demand, and in the intermediate-run is assumed to be perfectly mobile in and out of the region. Corporate capital and

[7]While it can be argued that this assumption may tend to underestimate the extent of regional economic adjustment, it is not unreasonable given the currently changing relationship between state and local fiscal responsibilities.

proprietors' capital are assumed to be fixed by sector and are fixed in total for the region. Investment does not feed into the capital stock, and no technical change is assumed.

General equilibrium adjustments to federal log shocks are estimated using the above assumptions about the labor adjustment process. In the short-run, unemployed labor is assumed to remain in the region and draw unemployment compensation. In the intermediate-run, unemployment compensation is assumed to be exhausted and unemployed labor is assumed to leave the region. In a variant of the intermediate-run results, the national price of logs and wood products is assumed to change in response changes in Forest Service timber policy across the West.

Table 2 summarizes the main differences in assumptions between the three modeling scenarios. In the **short-run** scenario, labor's wage, the level of investment and the quantity of capital are fixed. Total regional employment, returns to capital, and the level of net financial inflows adjust to maintain equilibrium (Table 2). Unemployed labor remains in the region and draws unemployment compensation in the form of a government income transfer from outside the region. In the **intermediate-run** scenario, the outside transfer of unemployment compensation is lost and the unemployed labor is assumed to leave the region (Table 2) in search of other employment. In the **national price effect** scenario, both log and wood product prices are assumed to increase at the national level as the result of reductions in Federal log supply across the West. Unemployment compensation transfers are assumed to be zero.

All three CGE model specifications feature endogenously determined output, consumption, imports, exports, and regional commodity prices. In all three CGE formulations, sectoral capital (i.e., "corporate and proprietors") is assumed to remain fixed at baseline levels.

The supply of capital by sector is a vertical straight line. The demand for capital varies as does the return to capital by sector.

The log supply resource shocks are implemented as proportional reductions in the baseline availability of "federal government sales" of logs. Thus, the direct impacts of resource supply shocks are treated as supply-side phenomena. This treatment has logical appeal and is also consistent with neoclassical economic theory.

A key feature of the implemented CGE modeling framework is the ability to substitute among public, private, and imported sources of logs via CES aggregation functions as described in the previous section. The ease of substitution is determined by exogenously specified elasticities and endogenous variation in the relative cost of inputs obtainable from the three alternative sources of supply. An implication of the constant elasticity specification used here is that, due to the law of diminishing returns, relatively small shifts in the availability of alternative supplies are much more easily accommodated than are major shifts. In practice, we have assumed that the substitution of private or imported logs to replace reduced public supplies is fairly difficult due to high transportation costs, and the length of time necessary to alter timber growth and harvest rotations.[8]

Empirical Results

Results for each scenario under alternative reductions in federal log supply are presented below. Each scenario was simulated for eleven alternative harvest levels on Forest Service lands. The eleven harvest levels were derived by reducing the allowed cut in increments of 10 percent from the baseline level. Estimates of relative adjustments in output, income, government

[8]This assumption of difficult substitution results in larger estimates of economic impact in response to a reduction in federal log supplies than would a less restrictive assumption.

revenues, and other variables are presented. Effects on income distribution are highlighted under the different modeling assumptions.

Short-Run Scenario

Table 3, presents the short-run microeconomic results for the logging and wood product sectors of the regional economy as percentage changes from their respective baseline values for each hypothetical Forest Service harvest level.[9] The short-run economy-wide changes in employment and factor income, by industrial sector, are presented as percentages from baseline levels in Table 4. As shown, the short-run impact of a reduction in logging of federal timber is mixed depending on the severity of the reduction. For reductions in federal supply up to 50 percent of the baseline, output of private logs increases slightly but is allocated away from export markets to supply regional mills (Table 3). Log imports increase 34.7 percent, but total log supply in the region falls. For a 50 percent reduction in federal log supply, wood processing sheds almost one fourth of baseline employment (928 jobs) largely due to the increased cost of purchasing higher priced logs. Incomes of low, medium, and high income households decline by 0.2 percent, 0.91 percent and 1.02 percent, respectively. For reductions larger than 50 percent of the baseline supply, private log output is reduced. At the zero supply of federal logs, the private output of logs is reduced by 20 percent with logging employment falling by 31 percent. This stems largely from the run-up in price of regionally supplied logs which chokes off demand from the wood product sector. For the 100 percent reduction in federal log supply, total log supply to the region (Q) is down 38 percent in spite of an increase in log imports of 97 percent (Table 3).

[9]For a description of the model sectoring scheme, see Appendix A. EMPLOY is the number of jobs in a given sector. LAB is the wage bill or labor payments, PROPR is proprietor payments, and CAP is payments to corporate capital all reserved in millions of dollars. All other variables, except prices, are measured in millions of dollars.

A 100 percent reduction in federal log supply is very damaging to the wood products sector. Output is reduced 56 percent relative to the baseline with a 72 percent reduction in wood products employment (Table 3). Under the assumption that households receive unemployment transfers. Incomes of low, medium, and high income households in the five county region decline by 0.6, 2.5, and 2.8 percent respectively (Table 3).

Looking at the ripple effect of the log shock on the regional economy, the agricultural sectors are basically unaffected. The higher regional prices for logs and wood products cause these production costs to go up, but these costs are offset by decreased regional price on other inputs that on balance result in slightly greater employment and income in the agricultural sectors (Table 4). The construction sector is damaged by higher cost wood products and smaller household income and sheds about two percent of baseline jobs for the 100 percent reduction in federal log supply (Table 4). Hitech manufacturing is minimally affected by the run-up in wood product cost since most of the demand source for these products is outside the local economy, and very little of the cost structure is in wood products. Overall production and employment in this sector is basically unchanged. Other manufacturing (Omanu) is a different story. Here the increased cost of logs and wood products has a measurable impact on production cost and the sector loses both jobs and factor income in the amount of roughly 8 percent of baseline figures for this sector. Next to logging and wood products, other manufacturing is the most heavily damaged sector in the economy (Table 4).

The economic impact on the service sectors' ranges between 1 and 3 percent of baseline employment and income depending on the sector. Wholesale and retail trade sectors are the most impacted with nearly a 3 percent reduction in income and employment, while the financial sectors

(Fire) and business service sectors (Edl) are the least impacted with less than 1 percent loss in employment and factor income.

The Loss of Unemployment Benefits

This section summarizes the impact of federal log supply restrictions on regional economic activity under the assumption labor unemployed by the log shock eventually exhausts the benefits period and/or must leave the region to seek employment.[10] The loss of unemployment compensation further reduces regional household income and additionally dampens regional household consumption demand. The reduction in regional household demand feeds back mainly in terms of induced effects in the service part of the economy. This, in turn, lowers output, employment, and income derived from that part of the economy. The loss of unemployment benefits approximately doubles the percent loss in household income. For example, in the case of a 100 percent reduction in federal log supply, the percent loss in household income for low, medium, and high income households is 0.57 percent, 2.47 percent, and 2.79 percent. For the same shock with no unemployment compensation the income loss is 1.28 percent, 5.59 percent, and 5.68 percent. Clearly, unemployment compensation makes a difference in the measured impact of reductions in federal log supply and should be accounted for in any short-run analysis of log supply impacts on regional household income.

As expected, the goods producing part of the economy is virtually unchanged by the elimination of unemployment transfers. The story is different, however, for the service sectors. Both the trade and other service sectors feel most of the impact. In the case of total elimination of federal logs, the loss of unemployment benefits reduces service sector jobs by approximately

[10]Due to page limitations the empirical results for this scenario and all subsequent scenarios are primarily summarized within the text without supporting tables.

200 jobs compared to the same shock with unemployment compensation. The additional loss in service sector jobs is about 1 percent of service sector jobs base.

Comparison with Fixed Price Model Results

A standard input-output model was subjected to same log shocks as the CGE model under the assumption of no unemployment transfers in each model.[11] As expected, the estimated employment and income losses are greater for the IO model than the CGE model. For a 50 percent reduction in federal log supply, the IO total employment impacts are roughly 64 percent greater than the CGE impacts (Table 5). As the supply reduction becomes more severe the CGE results begin to approach the IO results. For example, for an 80 percent federal log supply reduction, the IO employment impacts are roughly 36 percent greater than the CGE employment impacts.

Turning to household income impacts, considerable differences between the between IO and CGE impact estimates were also observed. For a 50 percent reduction in federal log supply, the loss in regional household income is 68 percent greater in the IO model results than the CGE model (Table 6). For the 80 percent log shock the IO model results are roughly 40 percent greater than CGE results (Table 6).

The Impacts of National Price Effects

Assuming that the reduction in access to federal timber supplies is played out not just in Northeast Oregon but throughout the entire West; then it becomes appropriate to consider log and wood product price effects at the national level. Logs from federal lands account for less than 20 percent of national soft wood log supply (Adams, 1999). Even in the case of a moderate

[11]In the fixed-price model used for this study, household incomes and household consumption expenditures are also assumed endogenous. Such a model is referred to as a Type II input-output model.

reduction in log supply from federal lands in the West, total log supply will decline and product price will increase in national markets, ceteris paribus, for both logs and wood products. We investigated the impact such price changes would have on our timber dependent regional economy assuming a 50 percent reduction in federal log supply that is accompanied by modest price increases in the price of both logs and wood products at the national level. In the regional CGE model, national prices are treated as exogenous and industries in the region are treated as price takers. Changes in national prices are simulated in the model as changes in the export price and the import price of logs and wood products.

The price elasticity of demand for both logs and for wood products is quite inelastic in the short-run (Adams 1999; Haynes, Adams, and Mills, 1995). The hypothesized 50 percent reduction of federal log supply (relative to the 1997 baseline) translates roughly into a 5 to 10 percent reduction in total national softwood log supply. As national log prices increase, private log harvest will increase to take advantage of the price increase and so instead of a 10 percent reduction of national log supply, perhaps the public plus private reduction may be more on the order of 2 or 3 percent of supply. With a national price elasticity of demand for logs of between -.15 and -.25, the expected national log price increase would be expected to conservatively range between 5 and 15 percent. Accordingly, national log price shocks in the range of 5 to 15 percent were simulated with the CGE model.

The expected price effect in the wood product market is more difficult to predict. The lumber and wood products price elasticity of demand is estimated as -.15 (Adams, 1999; Haynes, Adams, and Mills, 1995). On the assumption that substitutes for wood products are readily available, the range of possible increases in wood products price stemming from a 50 percent reduction in forest service log supply was limited to a maximum of 6 percent.

The simulated national price change scenarios show is that relatively modest increases in the national log price and wood product price more than mitigate the impact of the 50 percent reduction in federal log supply. Log price increases (exports and imports) by themselves are very beneficial to the logging sector, but harmful to downstream sectors that use logs as an intermediate input. A 5 percent increase in national log price (with the 50 percent reduction in federal log supply) results in a 19 percent increase in private log output. The wood products sector, however, is damaged by the national log price increase. Output declines by 37 percent relative to the baseline and employment declines by 40 percent. In terms of changes in regional household income, the change in income is almost unchanged from the change from the federal log shock with no national price effect. The increased income and employment in logging is almost offset by decreased employment and income in wood products. However, when the national price increase extends to the wood product sector as well, the story is very different.

Assuming a 5 percent increase in log price and a 3 percent increase in wood product price, instead of the above noted 37 percent output decline, model results indicate only a 14 percent decline in wood products output. Logging output increases by 18 percent, but the increase in imported logs increases by a remarkable 80 percent. The increase in wood product price allows increased log imports even in the face of an increased price for imported logs.

In a scenario where log prices are increased by 5 percent and wood products prices are increased by 6 percent, the negative regional household income effects of the federal log shock are totally mitigated. Regional household income is actually increased by 1 percent over the baseline level and regional employment is increased by 1.3 percent. Employment in the logging sector is increased by 32 percent over baseline levels and employment in the wood products sector is increased by 15 percent over baseline levels. The regional sector that is most damaged

by the higher log and wood product prices is other manufacturing which sheds 9 percent of jobs and income. No other regional sector is damaged by as much as 1 percent in either income or employment.

Summary and Conclusions

The results presented here emphasize the complexity of the answer to the question of how dependent is the Northeast Oregon on logging and wood product industries. Data show that in 1997, 7 percent of regional employment was logging and wood product based. Consequently, by most accounts, a sustained severe reduction in the availability of public timber resources will have dramatic impacts on the existing regional economic structure. Our findings paint a somewhat different picture.

Log Response on Private Lands

For moderate reductions in the supply of federal logs, production of logs on private land responds to the supply deficit and the output of private logs increases. For reductions in federal log supply greater than 50 percent of the base, the private output of logs begins to decline as a function of the decrease in regional log demand that stems from the run up in regional log price. The increase in regional log price harms the competitiveness of the regional wood products sector. It is reductions in output, employment, and income in wood products that define most of the damage that stems from reduction in federal log supply.

Unemployment Compensation

The treatment of unemployment transfers made some difference in the regional assessment of the log shocks. Unemployment compensation supports household income which, in turn, supports household consumption. Household consumption affects the regional economy mainly through the production of trade and services. The difference between counting unemployment

transfers and not counting them was typically a difference of several hundred jobs in the trade and service sectors on a service and trade employment base for the region of approximately 25 thousand jobs. The percent error of not including unemployment transfers would be to overstate the employment loss in trade and services by about 1 percent.

Comparison to Results with An IO Model

For moderate (50 percent reduction) reduction in federal log supply, the IO results are much more pessimistic than the CGE results. The magnitude of induced and indirect effects in the IO model was often on the order of 2 to 3 times as great as equivalent induced and indirect effects in the CGE model. For the more severe scenarios (reductions of 80 percent or greater) the logging and wood products impacts began to approach the IO results but the indirect and induced effects of the IO model were still on the order of twice those of the GGE model. Most of the difference can be attributed fixed response nature of the IO model relative to flexible price response nature of the CGE model. It is important to keep in mind the very different assumptions that each model makes in the treatment of capital. In the IO framework both capital and labor are assumed perfectly mobile. In the CGE model for this study, capital was assumed fixed by sector and only labor was allowed to adjust across sectors or out of the region. If capital had been assumed to be more mobile out of the region the CGE results would have been more like the IO results or even more pessimistic. The framework for this study was the intermediate run. The results of this study indicate that economic impacts estimated from an IO model should be interpreted with great caution involving reductions in timber from the federal forest.

National Price Effects

When log shocks were assumed to be West-wide and therefore to translate into national price effects for logs and wood products, much of the damage to regional economy in the

moderate (50 percent) log shock scenario was largely mitigated by higher log and wood product prices. Especially important were price effects in the wood products sector. Since most regional models are fixed price in nature it is likely that the relationship between federal log supply reductions and national price effects has not been given the attention it deserves in regional economic impact analysis. When the national price effect is combined with flexible price response of the CGE framework the story of regional impact of supply shocks becomes much less pessimistic than the IO story. On balance the CGE story is more consistent with economic theory and should be a more accurate story. Having said this, it should be noted that this analysis may be too optimistic regarding private log output response to price increases. Output levels for all sectors are determined by the condition of marginal factor price equal to value of marginal product. In the case of logging these conditions may generate more log output than could be sustained from private forest land. On the other hand the wood products sector is not under such a severe constraint and it is the price effect for this sector that mitigates much of economic damage stemming from the log shock.

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Table 1. The Northeast Oregon Regional Economy--1997
(Baker, Grant, Umatilla, Union, and Wallowa Counties)

FULL AND PART-TIME EMPLOYMENT	*State*		*Region*	
	Jobs	*Percent*	*Jobs*	*Percent*
Livestock Related	24,461	1.5	5,353	8.9
Other Agriculture	42,454	2.6	3,744	6.3
Food Processing	25,053	1.6	2,792	4.7
Logging and Wood Processing	81,074	5.0	4,101	6.8
Other Ag. & Nat. Res.	26,110	1.6	1,484	2.5
Other Employment	1,420,848	87.7	42,294	70.8
Total	1,620,000	100	59,768	100

(Source: IMPLAN and Bureau of Economic Analysis, Regional Economic Information System, U.S. Dept. of Commerce, Washington, D.C. [REIS CD-ROM])

Table 2. Main Features of Alternative Modeling Specifications

Model Type	*Labor Supply*	*Other Factor Supplies*	*Savings-Investment Behavior*	*Comments*
Short-run CGE	Perfectly Elastic Regional Labor Supply; Fixed Wage Rate	Fixed Sector Supplies of "Capital" and "Proprietors;" Endogenous Factor Returns	Fixed Investment Level (maintained by variation in flow of outside funds)	"Labor" is intersectorally mobile.
Intermediate-run CGE	Perfectly Elastic Regional Labor Supply; Fixed Wage Rate	Same as Above	Fixed Investment Level (maintained by variation in flow of outside funds)	Same as above except "Labor" is also interregionally mobile.
National Price Effect CGE	Same as Above	Same as Above	Same as Above	Log prices and Wood Product price assumed to increase nationally.

Table 3. Logging and Wood Products Sectors--Percent Change for Selected Variables for Alternative Forest Service (FS) Harvest Levels Relative to Baseline Harvest Level

Micro Affects: Short Run Scenario

Industry	Variable	Base	0.9*FS	0.8*FS	0.7*FS	0.6*FS	0.5*FS	0.4*FS	0.3*FS	0.2*FS	0.1*FS	0.0*FS
LOGGING												
	X	0.00%	1.66%	2.24%	2.07%	1.26%	-0.17%	-2.27%	-5.12%	-8.85%	-13.73%	-20.20%
	XD	0.00%	-2.23%	-5.72%	-10.04%	-15.06%	-20.67%	-26.87%	-33.66%	-41.10%	-49.27%	-58.33%
	XXD	0.00%	26.49%	47.49%	64.61%	78.43%	89.06%	96.44%	100.37%	100.21%	95.13%	83.61%
	Q	0.00%	-1.32%	-3.59%	-6.46%	-9.81%	-13.55%	-17.65%	-22.13%	-27.01%	-32.37%	-38.41%
	PX	0.00%	1.00%	1.00%	2.00%	2.00%	3.00%	3.00%	4.00%	4.00%	4.00%	5.00%
	PD	0.00%	1.00%	3.00%	6.00%	8.00%	11.00%	15.00%	19.00%	23.00%	29.00%	36.00%
	PDD	0.00%	5.00%	9.00%	12.00%	15.00%	17.00%	19.00%	21.00%	22.00%	23.00%	24.00%
	E	0.00%	-1.85%	-4.26%	-7.06%	-10.15%	-13.52%	-17.18%	-21.17%	-25.56%	-30.49%	-36.23%
	M	0.00%	4.81%	10.83%	17.81%	25.75%	34.72%	44.83%	56.02%	68.47%	82.13%	96.57%
	EMPLOY	0.00%	2.78%	3.78%	3.50%	2.13%	-0.29%	-3.77%	-8.41%	-14.37%	-21.89%	-31.44%
	LAB	0.00%	2.77%	3.77%	3.50%	2.11%	-0.28%	-3.77%	-8.41%	-14.36%	-21.88%	-31.43%
	PROPR	0.00%	2.83%	3.64%	3.64%	2.02%	-0.40%	-3.64%	-8.50%	-14.17%	-21.86%	-31.58%
	CAP	0.00%	2.77%	3.77%	3.47%	2.12%	-0.29%	-3.77%	-8.42%	-14.37%	-21.91%	-31.45%
WOOD Products												
	X	0.00%	-3.82%	-8.72%	-14.29%	-20.36%	-26.84%	-33.68%	-40.86%	-48.38%	-56.31%	-64.78%
	XD	0.00%	-1.96%	-4.51%	-7.43%	-10.70%	-14.25%	-18.13%	-22.32%	-26.96%	-32.13%	-38.16%
	XXD	0.00%	-1.96%	-4.51%	-7.43%	-10.71%	-14.25%	-18.13%	-22.33%	-26.96%	-32.14%	-38.17%
	Q	0.00%	-1.38%	-3.17%	-5.19%	-7.43%	-9.82%	-12.35%	-15.02%	-17.86%	-20.86%	-24.07%
	PX	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.00%	1.00%
	PD	0.00%	0.00%	0.00%	0.00%	1.00%	1.00%	1.00%	2.00%	2.00%	3.00%	4.00%
	PDD	0.00%	0.00%	0.00%	0.00%	1.00%	1.00%	1.00%	2.00%	2.00%	3.00%	4.00%
	E	0.00%	-4.16%	-9.47%	-15.51%	-22.09%	-29.09%	-36.47%	-44.18%	-52.23%	-60.67%	-69.60%
	M	0.00%	-0.61%	-1.39%	-2.22%	-3.08%	-3.91%	-4.66%	-5.30%	-5.75%	-5.86%	-5.33%
	EMPLOY	0.00%	-4.62%	-10.48%	-17.07%	-24.14%	-31.56%	-39.25%	-47.13%	-55.17%	-63.38%	-71.81%
	LAB	0.00%	-4.63%	-10.48%	-17.07%	-24.14%	-31.57%	-39.25%	-47.12%	-55.17%	-63.38%	-71.81%
	PROPR	0.00%	-4.69%	-10.55%	-17.09%	-24.12%	-31.49%	-39.20%	-47.07%	-55.11%	-63.32%	-71.86%
	CAP	0.00%	-4.64%	-10.51%	-17.08%	-24.17%	-31.52%	-39.23%	-47.11%	-55.17%	-63.40%	-71.80%
Regional Household Income Affects												
	Low	0.00%	-0.02%	-0.06%	-0.10%	-0.15%	-0.21%	-0.27%	-0.33%	-0.40%	-0.48%	-0.57%
	Medium	0.00%	-0.10%	-0.26%	-0.45%	-0.67%	-0.91%	-1.18%	-1.46%	-1.77%	-2.10%	-2.47%
	High	0.00%	-0.11%	-0.29%	-0.50%	-0.75%	-1.02%	-1.32%	-1.64%	-1.99%	-2.37%	-2.79%

Note: Allowed harvest levels are calculated as a percent of baseline level (FS), thus 0.9*FS indicates the allowed cut is 90 percent of the base level.

Table 4. Economy-Wide Employment and Factor Payments Changes by Industrial Sector Measured in Percent Change for Alternative Forest Service Harvest Levels

Macro Affects: Short Run Scenario

Scenario	Variable	LVSTOC	FEEDLO	CRO	FEED	LOGGIN	OANR	CONS	FOOD	WOOD	HITECH	OMANU	TCU	TRADE	EDL	FIRE	OSERVS	GOVT	TOTAL
Base	EMPLOY	0.00%	0.00%	0.00	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	LAB	0.00%	0.00%	0.00	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	PROPR	0.00%	0.00%	0.00	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	NA	0.00%
	CAP	0.00%	0.00%	0.00	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
0.9*FS	EMPLOY	0.00%	0.00%	0.01	-0.00%	2.78%	-0.00%	-0.08%	0.01%	-4.62%	-0.04%	-0.33%	-0.07%	-0.12%	-0.01%	-0.03%	-0.08%	-0.07%	-0.23%
	LAB	0.00%	0.00%	0.00	0.00%	2.77%	0.00%	-0.08%	0.02%	-4.63%	0.00%	-0.33%	-0.07%	-0.12%	0.00%	-0.03%	-0.08%	-0.07%	-0.37%
	PROPR	0.00%	0.00%	0.00	0.00%	2.83%	0.00%	-0.08%	0.00%	-4.69%	0.00%	-0.61%	-0.09%	-0.09%	0.00%	0.00%	-0.08%	NA	-0.13%
	CAP	0.00%	0.00%	0.00	0.00%	2.77%	0.00%	0.00%	0.02%	-4.64%	0.00%	-0.33%	-0.07%	-0.14%	0.00%	-0.03%	-0.07%	-0.10%	-0.06%
0.8*FS	EMPLOY	0.01%	0.01%	0.03	-0.01%	3.78%	-0.01%	-0.20%	0.03%	-10.48%	-0.08%	-0.78%	-0.15%	-0.29%	-0.02%	-0.08%	-0.22%	-0.16%	-0.58%
	LAB	0.00%	0.00%	0.00	0.00%	3.77%	0.00%	-0.19%	0.03%	-10.48%	0.00%	-0.78%	-0.15%	-0.29%	-0.03%	-0.07%	-0.22%	-0.16%	-0.92%
	PROPR	0.00%	0.00%	0.03	0.00%	3.64%	0.00%	-0.16%	0.00%	-10.55%	0.00%	-0.61%	-0.19%	-0.26%	0.00%	0.00%	-0.21%	NA	-0.31%
	CAP	0.00%	0.00%	0.00	0.00%	3.77%	0.00%	-0.28%	0.02%	-10.51%	0.00%	-0.74%	-0.14%	-0.27%	0.00%	-0.08%	-0.20%	-0.20%	-0.25%
0.7*FS	EMPLOY	0.01%	0.01%	0.05	-0.01%	3.50%	-0.01%	-0.33%	0.05%	-17.07%	-0.14%	-1.31%	-0.25%	-0.49%	-0.04%	-0.14%	-0.39%	-0.27%	-1.00%
	LAB	0.00%	0.00%	0.00	0.00%	3.50%	0.00%	-0.33%	0.05%	-17.07%	-0.26%	-1.32%	-0.24%	-0.49%	-0.03%	-0.13%	-0.39%	-0.27%	-1.60%
	PROPR	0.01%	0.00%	0.06	0.00%	3.64%	0.00%	-0.32%	0.00%	-17.09%	0.00%	-1.23%	-0.28%	-0.53%	0.00%	0.00%	-0.40%	NA	-0.54%
	CAP	0.00%	0.00%	0.07	0.00%	3.47%	0.00%	-0.28%	0.04%	-17.08%	0.00%	-1.32%	-0.25%	-0.50%	0.00%	-0.14%	-0.39%	-0.31%	-0.55%
0.6*FS	EMPLOY	0.01%	0.01%	0.07	-0.02%	2.13%	-0.02%	-0.49%	0.08%	-24.14%	-0.20%	-1.91%	-0.35%	-0.72%	-0.05%	-0.21%	-0.59%	-0.39%	-1.49%
	LAB	0.00%	0.00%	0.10	0.00%	2.11%	0.00%	-0.48%	0.08%	-24.14%	-0.26%	-1.91%	-0.36%	-0.72%	-0.06%	-0.20%	-0.60%	-0.39%	-2.36%
	PROPR	0.01%	0.00%	0.06	0.00%	2.02%	0.00%	-0.48%	0.00%	-24.12%	0.00%	-1.84%	-0.38%	-0.70%	0.00%	-0.39%	-0.59%	NA	-0.81%
	CAP	0.00%	0.00%	0.07	0.00%	2.12%	-0.04%	-0.56%	0.09%	-24.17%	0.00%	-1.90%	-0.34%	-0.73%	0.00%	-0.21%	-0.59%	-0.41%	-0.91%
0.5*FS	EMPLOY	0.02%	0.02%	0.10	-0.03%	-0.29%	-0.04%	-0.66%	0.11%	-31.56%	-0.27%	-2.60%	-0.47%	-0.96%	-0.07%	-0.28%	-0.82%	-0.52%	-2.02%
	LAB	0.00%	0.00%	0.10	0.00%	-0.28%	0.00%	-0.66%	0.10%	-31.57%	-0.26%	-2.59%	-0.46%	-0.96%	-0.06%	-0.27%	-0.82%	-0.52%	-3.19%
	PROPR	0.01%	0.00%	0.09	0.00%	-0.40%	0.00%	-0.64%	0.00%	-31.49%	0.00%	-2.45%	-0.47%	-0.96%	0.00%	-0.39%	-0.82%	NA	-1.11%
	CAP	0.00%	0.00%	0.07	0.00%	-0.29%	-0.04%	-0.56%	0.11%	-31.52%	-0.43%	-2.56%	-0.47%	-0.95%	-0.13%	-0.28%	-0.85%	-0.51%	-1.34%
0.4*FS	EMPLOY	0.02%	0.02%	0.13	-0.03%	-3.77%	-0.05%	-0.84%	0.14%	-39.25%	-0.35%	-3.36%	-0.58%	-1.23%	-0.09%	-0.36%	-1.07%	-0.66%	-2.60%
	LAB	0.04%	0.00%	0.10	0.00%	-3.77%	0.00%	-0.85%	0.14%	-39.25%	-0.26%	-3.37%	-0.59%	-1.23%	-0.09%	-0.37%	-1.07%	-0.66%	-4.09%
	PROPR	0.03%	0.00%	0.13	0.00%	-3.64%	0.00%	-0.80%	0.00%	-39.20%	0.00%	-3.07%	-0.57%	-1.23%	0.00%	-0.39%	-1.07%	NA	-1.42%
	CAP	0.00%	0.00%	0.14	0.00%	-3.77%	-0.04%	-0.84%	0.13%	-39.23%	-0.43%	-3.39%	-0.58%	-1.23%	-0.13%	-0.36%	-1.05%	-0.61%	-1.84%
0.3*FS	EMPLOY	0.03%	0.03%	0.16	-0.05%	-8.41%	-0.07%	-1.05%	0.17%	-47.13%	-0.44%	-4.22%	-0.71%	-1.52%	-0.12%	-0.45%	-1.35%	-0.81%	-3.23%
	LAB	0.04%	0.00%	0.21	0.00%	-8.41%	0.00%	-1.04%	0.17%	-47.12%	-0.52%	-4.22%	-0.71%	-1.52%	-0.12%	-0.44%	-1.35%	-0.81%	-5.05%
	PROPR	0.03%	0.00%	0.16	0.00%	-8.50%	0.00%	-1.05%	0.00%	-47.07%	0.00%	-4.29%	-0.66%	-1.49%	0.00%	-0.39%	-1.36%	NA	-1.77%
	CAP	0.00%	0.00%	0.14	0.00%	-8.42%	-0.04%	-1.12%	0.17%	-47.11%	-0.43%	-4.22%	-0.71%	-1.50%	-0.13%	-0.45%	-1.38%	-0.81%	-2.40%
0.2*FS	EMPLOY	0.03%	0.04%	0.19	-0.05%	-14.37%	-0.09%	-1.27%	0.21%	-55.17%	-0.54%	-5.20%	-0.84%	-1.83%	-0.14%	-0.54%	-1.65%	-0.97%	-3.90%
	LAB	0.04%	0.00%	0.21	0.00%	-14.36%	0.00%	-1.27%	0.20%	-55.17%	-0.52%	-5.20%	-0.84%	-1.83%	-0.15%	-0.54%	-1.66%	-0.97%	-6.09%
	PROPR	0.03%	0.05%	0.19	0.00%	-14.17%	0.00%	-1.29%	0.00%	-55.11%	0.00%	-4.91%	-0.85%	-1.84%	0.00%	-0.39%	-1.65%	NA	-2.14%
	CAP	0.00%	0.00%	0.21	0.00%	-14.37%	-0.09%	-1.40%	0.20%	-55.17%	-0.43%	-5.21%	-0.83%	-1.82%	-0.13%	-0.54%	-1.64%	-1.02%	-3.04%
0.1*FS	EMPLOY	0.03%	0.04%	0.23	-0.07%	-21.89%	-0.11%	-1.52%	0.24%	-63.38%	-0.66%	-6.33%	-0.98%	-2.16%	-0.17%	-0.64%	-1.99%	-1.15%	-4.63%
	LAB	0.04%	0.00%	0.21	0.00%	-21.88%	-0.20%	-1.53%	0.24%	-63.38%	-0.78%	-6.34%	-0.98%	-2.16%	-0.18%	-0.64%	-1.99%	-1.15%	-7.20%
	PROPR	0.04%	0.05%	0.22	0.00%	-21.86%	0.00%	-1.53%	0.00%	-63.32%	0.00%	-6.13%	-0.95%	-2.19%	0.00%	-0.78%	-1.99%	NA	-2.55%
	CAP	0.00%	0.00%	0.21	0.00%	-21.91%	-0.13%	-1.40%	0.24%	-63.40%	-0.87%	-6.37%	-0.98%	-2.18%	-0.13%	-0.64%	-1.97%	-1.12%	-3.78%
0.0*FS	EMPLOY	0.04%	0.05%	0.26	-0.08%	-31.44%	-0.15%	-1.81%	0.29%	-71.81%	-0.81%	-7.67%	-1.13%	-2.53%	-0.20%	-0.75%	-2.38%	-1.34%	-5.43%
	LAB	0.04%	0.00%	0.31	0.00%	-31.43%	-0.20%	-1.81%	0.29%	-71.81%	-0.78%	-7.68%	-1.13%	-2.53%	-0.21%	-0.74%	-2.38%	-1.34%	-8.42%
	PROPR	0.04%	0.05%	0.25	0.00%	-31.58%	0.00%	-1.85%	0.00%	-71.86%	0.00%	-7.98%	-1.14%	-2.54%	0.00%	-0.78%	-2.38%	NA	-3.01%
	CAP	0.00%	0.00%	0.28	0.00%	-31.45%	-0.13%	-1.69%	0.28%	-71.80%	-0.87%	-7.69%	-1.12%	-2.55%	-0.26%	-0.75%	-2.36%	-1.32%	-4.62%

Table 5. Results: Comparative Aggregate Employment Impacts (Number of Jobs)

	Model Configuration	
LOG SHOCKS:	Intermediate-Run (CGE)	Fixed-Price (IO)
50% Reduction		
Logging & Wood Products	-928	-1,246
Other	-387	-914
Total	-1,315	-2,160
Employment Multiplier	1.42	1.73
80% Reduction		
Logging & Wood Products	-1,786	-1,993
Other	-746	-1,460
Total	-2,582	-3,453
Employment Multiplier	1.42	1.73

Table 6. Results: Comparative Aggregate Income Impacts (millions of $'s)

	Model Configuration	
LOG SHOCKS:	Intermediate-Run (CGE)	Fixed-Price (IO)
Moderate (-50%)		
Household Income		
Low Income hhs.	-2.15	-3.92
Med. Income hhs.	-18.45	-30.39
High Income hhs.	-10.42	-17.92
Total	-31.02	-52.23
Severe (-80%)		
Household Income		
Low Income hhs.	-4.17	-6.260
Med. Income hhs.	-35.44	-48.590
High Income hhs.	-20.08	-28.65
Total	-59.69	-83.500

Figure 1. Flow Chart of General CGE Modeling Procedures.

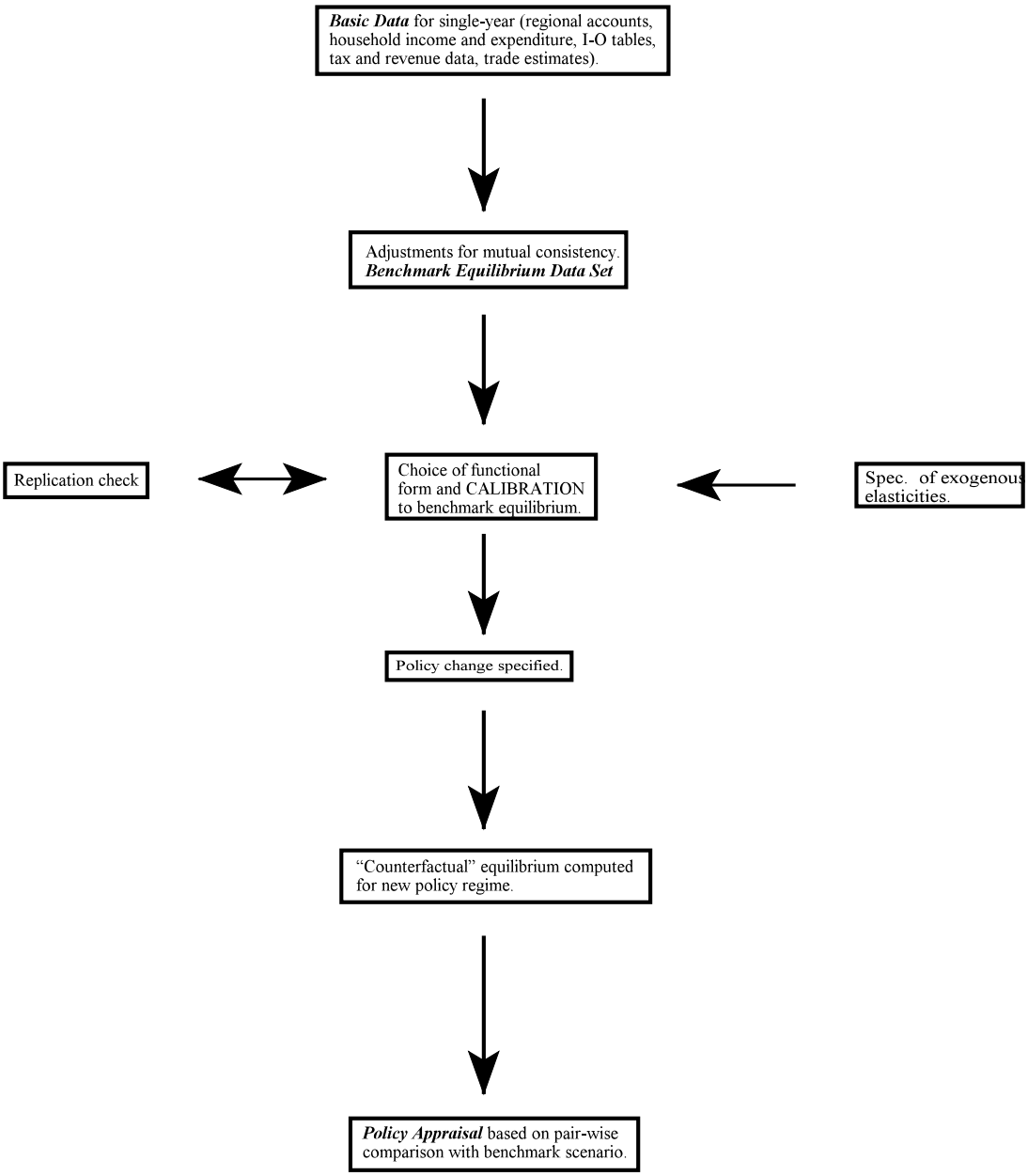
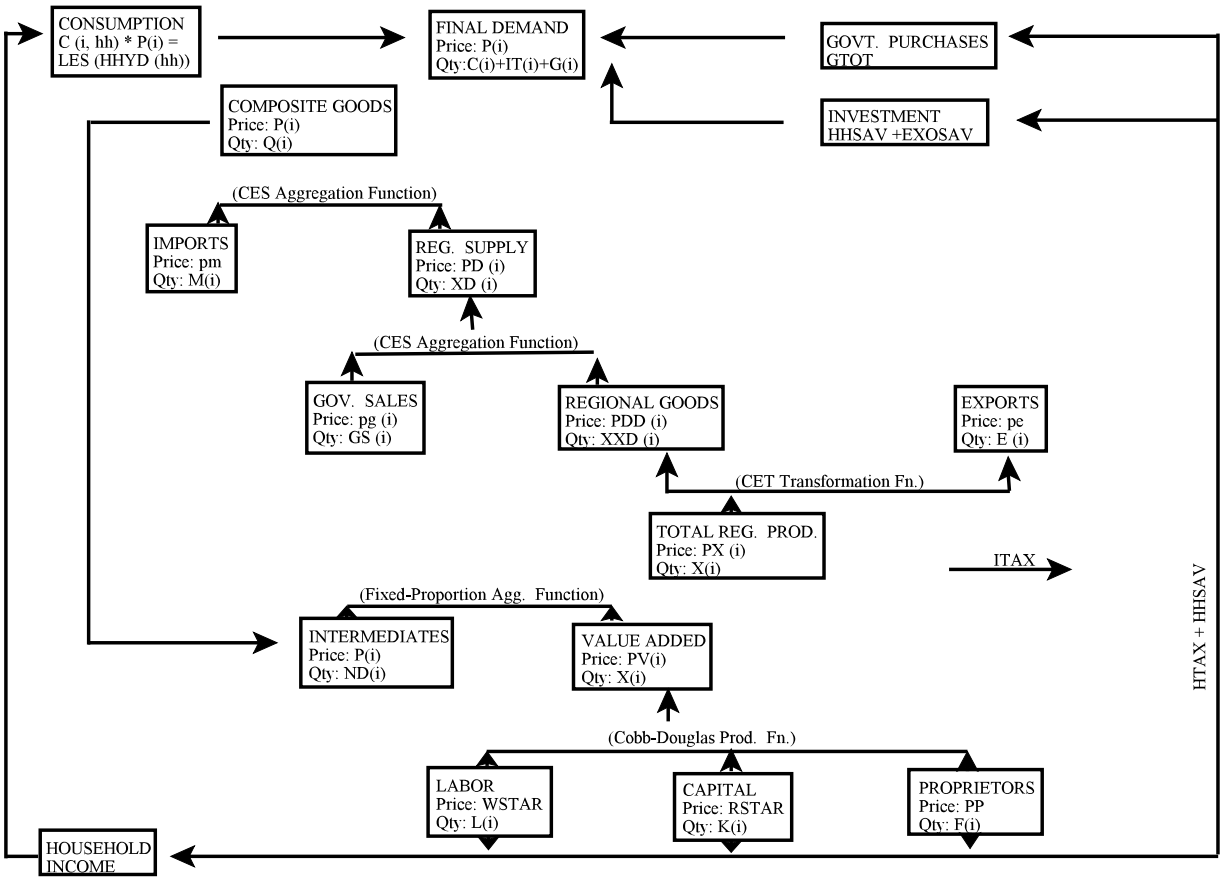


Figure 2. Schematic of the Northeast Oregon CGE Model.



Appendix A. Northeast Oregon Model Sector's Scheme

Sector Name	Sector Description
Lvstock	Range and Ranch Fed Livestock
Feedlot	Cattle Feedlots
Crops	All Crops except Hay and Pasture
Feed	Hay and Pasture
Logging	Forestry Products and Logging
Oanr	Other Ag. and Natural Resources including Mining
Constr	All Construction
Food	All Food Processing
Wood	All Wood Processing
Hitech	Electronic and Instrument Manufacturing
Oman	All Other Manufacturing
Tcu	Transportation, Communication, and Public Utilities
Trade	Wholesale and Retail Trade
Edl	Engineers, Doctors, and Lawyers
Fire	Finance, Insurance, and Real Estate
Oservs	All Other Services
Govt	Government Industry and Government Enterprises