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# Modeling Monopsony Markets With Regional CGE: The Oklahoma Forest Products Industry Case*

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**Abstract.** Raw material markets frequently possess less than perfect competitive market structures. High industry concentration in processing and high costs of raw material transport allow the presence of price setting where processor's exertion of market power yields smaller quantities demanded and lower prices paid for raw materials. Taking the timber market as a case study, Oklahoma's Regional Computable General Equilibrium Model is modified to show buyer market power exertion in the raw material market. The monopsonistic CGE model is then used to simulate a pro-competitive shock. Simulation results suggest existence of welfare gains after the pro-competitive shock. Increases in gross state product are estimated at $36.9 and $88.6 million in the short and long run, respectively.

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http://www.agecon.okstate.edu/rcge/pdf/monops/.

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# 1. Introduction

Increasingly, elements of imperfect competition are found in regional agricultural primary and processed product markets. Both seller and buyer markets may show less than complete competitive behavior. For regional economies, the first-handler (processing) market for agricultural commodities (raw materials) are likely to exhibit buyers' market power (Rogers and Sexton 1994). Markets where buyers can affect the price paid for raw materials are generally clustered under monopsonistic, duopsonistic, and oligopsonistic market structure, depending on the degree of concentration of the market[1].

Rogers and Sexton's study on assessing the importance of oligopsony power in agricultural markets argues that issues pertaining to buyers' market power have not received sufficient attention. We find little in the literature since their study to contradict this claim. Even though concerns about low farm prices and incomes associated with buyer market power exertion are expressed for rural regions, especially when transportation costs limit movement of raw materials, few studies are available to address these concerns and to direct regional policy.

Economists have studied what happens at the regional level when economic conditions allow a market structure to be characterized by buyer market power. Their findings depend greatly on the method of analysis. Comparative statics analysis by Chen and Lent (1992) show that under oligopsony competition, an upward or downward shift in the supply of an agricultural commodity may result in either an increase or a decrease in its farm price depending on the nature of the supply disturbance. Chen and Lent's paper presents evidence that a perfectly competitive market versus an oligopsonistic market may yield different qualitative implications for the same policy shock. Especially relevant to us is the assertion that under oligopsony, an increase in supply may lead to an increase in raw material price. Durham and Sexton's study (1992) uses residual supply in estimating oligopsony potential in California's processing tomato market where they find the pro-competitive effect of the grower bargaining association. Other studies use the farm-retail price spreads framework to estimate possible effects of less/more concentrated industries. Kinnucan and Sullivan (1986)estimated between 12 to 35 percent potential reduction in prices received by catfish producers when a pure monopsony condition is assumed for west Alabama. Azzam and Schroeter's study (1995) finds that overall consolidation of beef packing in the U.S. has been welfare enhancing on balance and this as a direct consequence of cost economies despite the

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[1]As indicated by Goodwin, "high degree of concentration in an industry does not confirm the existence of discriminatory market power practices". Industrial organization theoreticians have not reached an agreement on the relationship between industry concentration and the exercise of market power.

anticompetitive effects of market power. Finally, none of the studies dealing with economic aspects of buyer market power uses the general equilibrium framework as the basis of their analysis for the purpose of determining regional economic impacts.

We argue that a general equilibrium specification may greatly increase the knowledge of price determination, factor payment distribution and other economic issues affected by buyer-market power exertion. Computable general equilibrium (CGE) analysis is generally conducted using models that postulate perfect competitive market structure. Furthermore, reviewing market structure used in computable general equilibrium models, we have found mostly seller power specifications (i.e. monopoly, olygopoly). In addition, these specifications have been implemented at the national or multi-country level, principally dealing with trade liberalization issues. Partridge and Rickman's survey in regional CGE modeling (1998) evidences the limited use of other market structure specifications compared to the standard perfect competitive market structure. They identify six studies that did not follow the assumptions of perfect competitive market structure and constant returns to scale, however, those studies deal only with the seller side of market power.

In this paper, we build a computable general equilibrium model for the Oklahoma region. It considers the non-competitive characteristics of the raw material market between timber (raw material producers) and the first-handler processing industry (wood processors). The following section introduces the Oklahoma Forest Products Industry. Then, a brief description of the Oklahoma CGE model is presented with modifications to accommodate the monopsonistic market structure of the wood processing industry. We then present simulation results of a pro-competitive market shock, where we qualitatively and quantitatively describe what potentially happens if monopsonistic power cannot be exerted[2].

## 2. Oklahoma Forest Product Industry

The wood-products manufacturing sector in Oklahoma has several highly concentrated industries. For example, in the sawmills and planning mills industry (SIC 242) 70% of the total employees work for one multinational company. In addition to the high concentration of the industry, Oklahoma timber producers have limited options on where to sell their timber mainly because of costly transportation and long

[2] This pro-competitive environment is justified in terms of possible value-added processing incursion by cooperatives, the arrival of other firms, or a technological shift making transportation of raw material less restrictive.

distances between processing centers[3]. This suggests an imperfect market structure for the timber (raw material) market in which wood processing industries are capable of affecting the price paid for timber. We refer to the Oklahoma Forest Product Industry (FPI) as possessing buyer market power.

Using Oklahoma's FPI, we empirically contrast the strengths of CGE model specification in comparing alternative market structures. We estimate the effects on such variables as household welfare, gross state product, employment, raw material prices, wage rate, and returns to capital, when the monopsony market is modified by a pro-competitive shock.

## 3. Oklahoma Regional Computable General Equilibrium Model[4]

The Oklahoma economy is small and open in that prices of tradable commodities are determined exogenously in the national market place although regional prices are endogenous. The model consists of six sectors. Non-manufacturing activities include agriculture (A), mining (M), and services (S). The forest complex consists of two sectors: forest products (P) and forestry (RM). The last sector is manufacturing (MA) which includes all manufacturing industries except forest products. There are three primary factors of production: capital (K), labor (L), and land (T). Land and capital are assumed to be in fixed supply for the short-run but only land is fixed in the long-run. Labor and capital supplies are affected by migration flows. The regional CGE model includes one household group, one government level, an enterprise account and an investment (capital formation) account.

The model allows substitution between imported and regionally produced commodities through a constant elasticity of substitution (CES) function and substitution between exports and regional markets through a constant elasticity of transformation (CET) function. The basic data for the CGE is a social accounting matrix (SAM) for the state of Oklahoma developed for 1993 and based on data obtained from the Minnesota IMPLAN Group (MIG 1996), Inc. (see Table 1). In this model,

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[3] The U.S. Forest Service (Howell and Johnson 1998, p12) reports 35,653 thousand cubic feet of roundwood exports and 33,006 thousand cubic feet of imports in 1996 for Oklahoma. This suggests a close correspondence of local processing of local supplies. Trading across state boundaries of fairly similar quantities would be because of location of processing facilities.

[4] Variable and parameter descriptions, model equations, endogenous and exogenous variables are available from the authors or may be found on the web at http://www.okstate.edu/ag/asnr/agec/rcge/index.htm. A further detailed competitive CGE model and discussion is available at http://rri.wvu.edu/WebBook/Schreiner/contents.htm

households possess endowments of labor, land and capital. The assumption of competitive markets with full information and agents characterized by profit and/or utility maximizing behavior is maintained in five sectors (A, M, MA, RM, S). A sector is an aggregation of many producers, but the sector is treated as a single representative firm in the model. The sixth sector is forest products (P) and it is this sector that has elements of buyer market power.

Exogenous parameters used in the model include elasticities of substitution, elasticities of transformation, and elasticities of labor and capital migration. Relative prices are assumed to be the only force that determines the flow of commodities and factors. Therefore, all prices are expressed in terms of relative value with respect to a base price of one. The regional market price of the composite good is a weighted average of the imported and domestic good prices, except for the timber sector, which only has one regional (domestic) price. Import prices are exogenous to the region whereas regional prices are endogenous.

Production functions are characterized at two (nested) levels. At the first level, each of six production sectors produces only one homogeneous commodity using intermediate and primary inputs. Technology assumes no substitution between composite intermediate inputs and composite primary factors nor between intermediate inputs produced by different sectors. This is the Leontief input-output production function technology. At the second level, substitution among primary factors of labor, capital and land is represented by a decreasing returns to scale Cobb-Douglas (C-D) production function for the agriculture (A) and forestry (RM) sectors (land is fixed in each sector). Cobb-Douglas constant returns to scale production functions with labor and capital are used for the other sectors (P, MA, M, and S).

Demand for the composite and individual intermediate inputs is derived from the Leontief input-output production relationship whereas primary factor demand is determined from the C-D production relationship by profit maximizing for each sector. The model assumes that full employment is always attained by adjustment of the wage rate and the rates of return to land and capital for a given time period. Land is used only in agriculture and forestry and is assumed fixed in supply for each sector ($\bar{T}_{A}$, $\bar{T}_{RM}$). Labor migration is a function of the ratio of regional and out-of-region wage rate, the elasticity of labor migration, and base year labor supply. Similarly, capital migration is a function of the domestic/out-of-region capital price ratio, the elasticity of capital migration, and base year capital supply.

Intermediate inputs are treated as a mix of regional and imported products. Quantity of the intermediate input demanded is described by a constant elasticity of substitution (CES) function between regional and imported components. The elasticities of substitution are exogenously specified. However, timber raw material is not transported from

Oklahoma to other regions or from other regions to Oklahoma. Therefore, the quantity of raw material intermediate input ($V_{RM} - X_{RM}$) is determined in the region by a derived demand of the forest product industry (P). In general, the regional intermediate input demands are obtained from first order conditions of cost minimization subject to a given level of composite intermediate input defined by the CES function. Relative prices of regionally produced and imported inputs and the elasticity of substitution parameters determine regional intermediate input demands.

Similarly, each sector produces for export and regional markets, except for the raw material sector (RM) which produces only for the regional market. A constant elasticity of transformation (CET) function describes this market transformation process. The regional supply function for goods is derived from the first order conditions for maximizing revenue subject to a given output level with the CET function. Relative prices of regional goods to exported goods and the constant elasticity of transformation parameter determines regional and export supplies for market goods except for the forest product sector (P) where we assume that the regional supply is filled first and then the rest of production is exported[5].

Household annual income is determined by the level of ownership of the primary factors (labor, land, and capital), factor prices, and government transfers. Government transfers are assumed fixed in this analysis. Households are treated as a single representative household.

Consumer demand functions are derived from maximization of utility. The Stone-Geary utility function is used which results in a linear expenditure system (LES) that satisfies the assumption of diminishing marginal rate of substitution. The demand system derived from this utility function satisfies the general properties required; homogeneity of degree zero in all prices and income, symmetry of cross-substitution effects, adding up condition, and negativity of direct substitution effects. Household consumption is modeled at two levels. The first level determines consumption of the composite market goods derived from utility maximization subject to prices and full income. The average budget shares by sector are calculated from the SAM data (Table 1).

The second level determines the optimal combination of imported and regional consumer goods. The optimal combination is the result of first order conditions for cost minimization subject to the level of composite commodity obtained from the first level and is expressed as a CES function of imported and regionally produced components. The optimal combination is determined by relative prices and the elasticity of

[5] This raises two further issues: if the sector presents increasing returns, the representative firm (as modeled here) may necessarily export unlimited amounts; if the raw material supply is not sufficiently elastic, how could the firm exploit their economies of scales? We model these issues by assuming that the industry is at or near the minimum efficient scale.

substitution. Government revenues include indirect business taxes, factor taxes, and household and corporate income taxes. Their expenditures include commodity consumption, transfers to household, and payment to labor. Quantity of commodity consumption is held constant, but as regional prices change total government expenditure changes. The proportion of regional relative to imported commodities specified by a CES function changes as discussed above for the household.

Total saving is composed of household savings, retained earnings for enterprises, and net transfers (saving) from rest-of-world. Capital expenditures are for investment demand and include regionally produced and imported components as specified through a CES function. Capital expenditures are the result of a fixed quantity (exogenous) and a regionally determined composite. Gross regional product is estimated by before tax factor income generated from the production activities of the region plus indirect business taxes. A monopsony structure is imposed for the raw material (timber) market. Firms are assumed to minimize cost subject to a given output level. The different market structures studied require modeling of industries in terms of marginal pricing rules. That is, firms are instructed to sell their outputs at prices that satisfy the necessary conditions for optimality (Villar 1996). Non-linear programming algorithms (GAMS) are used to solve for prices and welfare effects (Brooke, Kendrick and Meeraus 1992).

# 4. Modifications to the Model

This section presents modifications of the perfectly competitive model to accommodate monopsony market structure between raw material sellers and raw material buyers.

Oklahoma's forest products industry (*P*) is modeled as a single representative firm that uses an intermediate input composite of raw material ($V_{RM,P}$) and all other intermediate inputs($V_{I,p} \forall I \neq RM$). The industry also uses a primary factor composite ($VA_p = f(L_p, K_p)$) of labor and capital. Labor ($L_p$) and capital ($K_p$) are combined in a CES functional form to give the value-added composite.

The firm uses value-added and intermediate good composites to produce a homogenous output ($X_p$). Therefore, the production decision is in two steps.

First, the firm chooses intermediate and value-added levels according to the Leontief production relationship given by:

$$X_P = Min\left[\frac{VA_P}{a_{o,P}}, \frac{V_{1,P}}{a_{1,P}}, \cdots, \frac{V_{6,P}}{a_{6,P}}\right] \quad (1)$$

where 1,...,6 represents the $i^{th}$ sector (A, M, P, RM, MA, and S); $\alpha_{0,p}$ is the composite value added requirement per unit of output of the processing industry; and $\alpha_{1,p}, \ldots \alpha_{6,p}$ are the requirements of intermediate goods per unit of output of the processing industry.

At this step, the firm minimizes any input with a positive price, hence value-added and intermediate input composites are obtained from the following:

$$X_P = \frac{VA_P}{a_{O,P}} = \frac{V_{i,P}}{a_{i,P}}, \quad \forall i = A, M, RM, MA, P, and\ S. \tag{2}$$

The second step chooses the labor and capital levels. Factor demands are derived from cost minimization subject to a given level of output. We use a CES function to represent the production relationship between labor and capital. The CES function for wood processing is given by:

$$VA_P = \phi_P^{VA}\left[\delta_P^{VA} L_P^{\rho_P^{VA}} + \left(1-\delta_P^{VA}\right) K_P^{\rho_P^{VA}}\right]^{\frac{\lambda}{\rho_P^{VA}}}, \quad \sigma_P^{VA} = \frac{1}{1-\rho_P^{VA}} \tag{3}$$

where $\phi_P^{VA}$, $\delta_P^{VA}$, $\sigma_P^{VA}$, and $\lambda$ are shift, factor share, elasticity of substitution, and returns to scale parameters, respectively. We assume constant returns to scale.

Allen partial elasticities of substitution between capital and labor given by Vincent, Lange and Seok (1992).were averaged to 1.033. Thus, we obtain a $\rho_P^{VA}$ value of 0.032. The CES function for the P sector is:

$$VA_P = \phi_P^{VA} \cdot \left[\delta_P^{VA} \cdot (L_P)^{0.032} + (1-\delta_P^{VA}) \cdot (K_P)^{0.032}\right]^{\frac{1}{0.032}} \tag{4}$$

Profit maximization in the Forest Products Industry is assumed. It chooses the level of output so as to maximize its profit function given by:

$$\pi_P = P_P X_P - PVC_P - IC_P - IBT_P \tag{5}$$

where $\pi$ , $P$ , *PVC*, *IC*, and *IBT* are profits, output price, primary variable costs, intermediate costs, and indirect business taxes of the processing industry (P). Equation (5) assumes separability of intermediate and primary inputs. On this basis, we further assume constant primary variable costs. We use the fixed coefficient technology (Leontief relationship) to express (5) as:

$$\pi_P = \overline{P}_P X_P - PVC_P(PL, PK, X_P) - P_{RM}(V_{RM,P}) \cdot V_{RM,P} - \sum_{i \neq RM} P_i \cdot V_{i,P} - IBT_P \quad (6)$$

where $PL$ and $PK$, are prices of labor and capital, respectively. Three elements are noted in the construction of equation (6). First, the horizontal bar over the price of output indicates that the representative firm takes the output price as given: no monopoly power is available to the firm. Second, the primary variable cost component ( $PVC_p$) is a dual to the CES value-added function, hence, its arguments are prices of labor and capital and level of output. Constant marginal cost is assumed for the firm. Finally, intermediate costs are separated into raw material intermediate input and all other intermediate inputs. This specification allows buyer market power exertion in raw material market.

Solving equation (2) for the intermediate and value-added variables, equation (6) becomes:

$$\begin{aligned}\pi_P = \overline{P}_P X_P - (a_{0,P} \cdot X_P)^{1/\lambda} \phi_P^{-1/\lambda} \left[ (\delta_P^{VA})^{\frac{1}{1-\rho}} \cdot PL^{-\rho/_{1-\rho}} + (1-\delta_P^{VA})^{\frac{1}{1-\rho}} \cdot PK^{-\rho/_{1-\rho}} \right]^{\frac{1-\rho}{-\rho}} \\ - P_{RM}(a_{RM,P} X_P) \cdot a_{RM,P} X_P - \sum_{i \neq RM} P_i \cdot a_{i,P} X_P - IBT_P, \quad \sigma = \frac{1}{1-\rho}, \text{and } \lambda \succ 1 \end{aligned} \quad (7)$$

where $\phi$, $\sigma$, $\delta$, *and* $\lambda$ are the CES value-added shift parameter, labor-capital elasticity of substitution, value-added share parameter, and returns to scale parameter, respectively.

Calibration of the Forest Products Industry offers new challenges when benchmarking production for a sector that assumes imperfect competition. In this case, the forest products industry is assumed to exert monopsony profits from the raw material market as well as possessing constant returns to scale technology.

## 5. General Procedure for Calibration

The presence of a monopsonist prescribes the possibility of profit from raw material pricing. Thus to calibrate the monopsony model we first determine profits from the base SAM. The profit function for the forest products industry was given in (6). Because we allow market power exertion in raw material, input cost of equation (6) is expressed by:

$$P_{Rm}(V_{RM,P}) \cdot V_{RM,P} \quad (8)$$

where the price of raw material $P_{RM}$ is a function of the industry's demand for raw material. Next, using equalities described in (2) and the first order condition for profit maximization, it can be proven that the monopsonist maximizes profits when:

$$\overline{P}_P - \frac{\partial PVC_P}{\partial X_P} - \sum_i P_{i,P} a_{i,P} - a_{IBT,P} = a_{RM,P} P_{RM}\left(1 + \frac{1}{\varepsilon^S_{RM,P_{RM}}}\right), \forall i = A, M, P, MA, and\ S \quad (9)$$

where the left-hand side is the difference between the marginal revenue ($\overline{P}_P$) and the marginal cost of processing less the marginal cost of raw material intermediate input. The term $\varepsilon^S_{RM,P_{RM}}$, is defined as:

$$\varepsilon^s_{rm,p_{rm}} = \frac{\partial V_{RM,P}}{\partial P_{RM}} \frac{P_{RM}}{V_{RM,P}} \equiv \frac{\partial X_{RM}}{\partial P_{RM}} \frac{P_{RM}}{X_{Rm}} \quad \text{where } V_{RM,P} = X_{RM} \quad (10)$$

and is the own-price supply elasticity for the forestry sector. The right-hand side of equation (9) indicates that for profit maximization under the monopsony market structure a price distortion occurs. Following Azzam and Schroeter, we define the proportional gap between the value of the marginal product of the raw material (net of marginal processing costs and marginal indirect business taxes) and the price of the raw material input as:

$$v = \frac{1}{\varepsilon^S_{RM,P_{RM}}} \quad (11)$$

which for the case of monopsony market defines the price supply flexibility of raw material. The parameter $v$ connects the production technology of the forestry sector with the profit maximization behavior of the forest products sector.

Estimating the price distortion, we derive production and supply functions for the forestry sector that replicates base SAM data from Table 1. We start with the production function. The forestry sector (RM) gathers under the single-representative-firm many identical (small) producers of raw material (logs, roundwood, etc.) who are precluded from affecting raw material price. Due to high costs in transportation, raw material producers are regional price-takers. We assume the representative firm for the forestry sector produces raw material ($X_{RM}$) to be sold exclusively to processors in the forest products sector ($P$). At the first level of production, the Leontief production function is described by:

$$X_{RM} = Min\left[\frac{VA_{RM}}{a_{o,RM}}, \frac{V_{1,RM}}{a_{1,RM}}, \ldots, \frac{V_{6,RM}}{a_{6,RM}}\right] \quad (12)$$

At the second level of production, value-added composite faces increasing marginal costs because of the fixed amount of available land. The Cobb-Douglas production function is used to express the value-added relationships among the primary factors of production - land, labor, and capital:

$$VA_{RM} = \phi_{RM} L_{RM}^{\alpha_{RM}^{L}} K_{RM}^{\alpha_{RM}^{K}} T_{RM}^{\alpha_{RM}^{T}} \quad (13)$$

where $T$, $K$, and $L$ are land, capital and labor, respectively; $\phi_{RM}$ is a technical shifter; and $\alpha_{RM}^{i}\ \forall\ i = L, K, T$, are share parameters obtained from the expenditures of the forestry sector in Table 1. Calibration of the value added production function yields:

$$VA_{RM} \cong 2.926 \cdot L_{RM}^{0.34} K_{RM}^{0.24} T_{RM}^{0.42} \ . \quad (14)$$

In the short run, we assume land to be fixed, therefore the industry optimizes over labor and capital levels. The restricted value added function becomes:

$$VA_{RM}(L, K / \bar{T}) \cong 124.74 \cdot L_{RM}^{0.34} K_{RM}^{0.24} . \quad (15)$$

Using equation (2) for the forestry sector (*RM*), we calibrate the coefficient parameters of equation (12) as:

$$a_{O,RM} = 0.453,\ a_{A,RM} = 0.245,\ a_{M,RM} = 0.037,\ a_{P,RM} = 0.099,\ a_{MA,RM} = 0.078,\ a_{S,RM} = 0.065$$

To obtain the total regional supply function for raw material intermediate input ($V_{RM}$) we use the relationship

$$X_{RM} = \frac{VA_{RM}}{a_{O,RM}},$$

and the fact that no out-of-region supply is allowed. We use results of Beattie and Taylor (page 172) to obtain the supply function given by:

$$X_{RM}^{S} = 44.2 \cdot (P_{RM})^{1.38} \left[124.74 \left(\frac{0.34}{PL}\right)^{0.34} \left(\frac{0.24}{PK}\right)^{0.24}\right]^{2.38} \quad (16)$$

where *PL* and *PK* are prices of labor and capital, respectively. From (16) we obtain $v = 0.72$ which yields profits in the base year of $29.2 million ($v \times P_{RM} \times V_{RM,p}$))where the price of raw material input is normalized to one and the level of raw material supply is 40.4 million units (see SAM data in Table 1).

Next, we adjust the base SAM capital compensation in Table 1 by the amount of profits. Therefore, the level of capital used in calibration of the value added function of the FPI sector is $496.6 million instead of the $525.8 million originally assumed. The $29.2 million monopsonist's profit is then allocated to enterprise and distributed to factor owners.

To calibrate share parameters of the CES value-added function, we use equation (17):

$$\delta_P^{VA} = \left[1 + \left(\frac{L_P}{K_P}\right)^{\rho_P^{VA}-1}\left(\frac{PK}{PL}\right)\right]^{-1} \quad . \tag{17}$$

Prices of labor and capital are normalized to unity and with the new capital level, we calibrate the share parameters for labor (0.28) and capital (0.72).

The primary variable cost function ($PVC_P$) is a dual to (4), the CES value-added function. By solving the following cost minimization problem

$$\underset{L,K}{MIN}\ PL \cdot L_P + PK \cdot K_P$$

$$\text{s.t.} \quad \left(\frac{VA_P}{\phi_P^{VA}}\right)^{\rho_P^{VA}} = \delta_P^{VA} L_P^{\rho_P^{VA}} + \left(1 - \delta_P^{VA}\right) K_P^{\rho_P^{VA}} \tag{18}$$

and assuming constant returns to scale ($\lambda = 1$), we can derive the indirect cost function in terms of factor prices and composite value-added (Beattie and Taylor, page 248):

$$\tilde{C}(PL, PK, VA_P) = (VA_p)\cdot(\phi^{-1})\cdot\left[(\delta_P^{VA})^{\frac{1}{1-\rho}} \cdot PL^{-\rho/_{1-\rho}} + (1-\delta_P^{VA})^{\frac{1}{1-\rho}} \cdot PK^{-\rho/_{1-\rho}}\right]^{\frac{1-\rho}{-\rho}} \quad . \tag{19}$$

When the share parameter and the labor-capital elasticity of substitution are substituted into (19), primary variable cost function takes the form:

$$\tilde{C}(PL, PK, VA_P) = (VA_p)\cdot(\phi^{-1})\cdot\left[(0.28)^{1.03} \cdot PL^{-1.03/_{1-0.03}} + (0.72)^{1.03} \cdot PK^{-0.03/_{1-0.03}}\right]^{\frac{1-0.03}{-0.03}} \quad . \tag{20}$$

We use the SAM data to solve equation (20) for the shift parameter. This is the result of normalizing the prices of factors to unity and, therefore, the total expenditure on primary factors is given by the expression. $PL \cdot L_p + PK \cdot K_p$. This expression is obtained from our SAM data. We calibrate the shift parameter $\phi_P^{VA}$ by using the expression:

$$\phi_P = \left[ \frac{X_P \cdot a_{0,P} \cdot \left[ (\delta_P^{VA})^{\frac{1}{1-\rho}} \cdot PL^{-\rho/1-\rho} + (1-\delta_P^{VA})^{\frac{1}{1-\rho}} \cdot PK^{-\rho/1-\rho} \right]^{1-\rho/-\rho}}{0.38} \right]^{\nu} \tag{21}$$

This yields a shift parameter of 1.8.

With CRS technologies and perfect competitive markets, the average cost (AC) and marginal cost (MC) of an industry are interchangeable (de Melo and Tarr). However, the assumption of monopsony market implies that average revenue is greater than marginal cost in our base data. How much do they differ? They differ by the amount of the average profits. To see this, recall that the firm maximizes profits by choosing the output level that maximizes equation (7). Note that this equation is a function of the output variable ( $X_p$ ). The marginal profit function is given by:

$$\frac{\partial \pi_P}{\partial X_P} = P_P - \frac{\partial PVC_P}{\partial X_P} - \sum_{i \neq RM} P_i a_{i,P} - \frac{\partial P_{RM} V_{RM,P}}{\partial X_P} - a_{IBT,P} = 0 \tag{22}$$

and in derivative form:

$$\frac{\partial \pi_P}{\partial X_P} = \overline{P}_P - X_P a_{0,P} \phi_P^{-1} \left[ (\delta_P^{VA})^{\frac{1}{1-\rho}} \cdot PL^{-\rho/1-\rho} + (1-\delta_P^{VA})^{\frac{1}{1-\rho}} \cdot PK^{-\rho/1-\rho} \right]^{\frac{1-\rho}{-\rho}}$$
$$- a_{RM,P} P_{RM} (1 + \tfrac{1}{\varepsilon}) - \sum_{i \neq RM} P_i \cdot a_{i,P} - a_{IBT,P} = 0 \cdot \tag{23}$$

This marginal profit function equals zero if the industry maximizes profits. It is also important to note that the partial of the primary variable cost function is expressed with gross output as an argument and not the value added composite. Thus, it is close to the partial of equation (20).

Next, we solve (23) for the marginal primary variable costs component and substitute prices and values derived from the SAM. These are obtained from equation (2):

$a_{O,P} = 0.384,\ a_{A,P} = 0.002,\ a_{M,P} = 0.046,\ a_{P,P} = 0.014,$

$a_{MA,P} = 0.258,\ a_{S,P} = 0.209,\ a_{IBT,P} = 0.048$

Thus, the profit maximization condition is now expressed by the unit profit function obtained when equation (5) is divided by total output ($X_P$):

$$\frac{\pi}{X_P} = P_P - \frac{PVC_P}{X_P} - \sum_i \frac{P_i V_{i,P}}{X_P} - \frac{IBT}{X_P} . \quad (24)$$

Substituting our calibration results in (24) is a test of the accuracy of the procedure. Because prices are normalized to unity, this equation holds for our data.

# 6. Simulating a Pro-competitive Market Structure

A computable general equilibrium model for the Oklahoma region is constructed that considers the non-competitive characteristics of the raw material market between timber (raw material producers) and the first-handler processing industry (wood processors). Specifically we model a monopsonistic market structure of the wood processing industry. Then if the raw material market structure changes from the monopsony market to a perfect competitive market, we are able to examine effects of the pro-competitive shock. This pro-competitive environment may be the result of value-added processing incursions by cooperatives, the arrival of other firms, or a new technological strategy that makes transportation of raw material less restrictive.

The way we have modeled monopsony market structure allows us to simulate a pro-competitive movement in the raw material market. To see this, observe equation (11) where the supply elasticity is given. Notice that if the raw material supply is infinitely elastic, the industry will not be able to reap monopsonistic profits no matter how high the degree of concentration and/or collusion. By redefining the value of the supply elasticity to infinitely elastic and solving the model for new equilibrium prices we see the effects a pro-competitiveness scenario bears in the regional economy.

# 7. Analysis of Results

Short-run pro-competitive simulation results for major endogenous variables are presented in Table 2. An index greater (lesser) than unity implies positive (negative) change in percentage terms with respect to base SAM values. The most significant changes accrue to the forest complex: forestry and forest products industries. Raw material price (RM) increases 2.6% and output increases by 1.3%. This implies a price response elasticity of about 0.52 for the raw materials sector. Although, output increases from 40.4 million to 40.9 million, the total revenue from raw material increases from $40.4 million to $42.0 million, representing additional income of $1.6 million for raw material producers.

In addition to the revenue change, factor compensation changes for forestry. The pro-competitive simulation increases returns to capital and land by 3.9 % (Table 2). The regional wage rate increases marginally by 0.015%. The small wage increase is expected because the forestry complex is but 1.7% of total regional output and labor demand in the forestry complex increases by about 4%. Total value added in the forest complex increases by 1.3%. Whether regional raw material producers receive additional factor income depends on factor ownership. If we assume regional land ownership, then regional raw material producers are compensated 3.9% more for their land endowment which implies a land compensation increase of $303,600 dollars.

In the forest product industry (FPI), output increases at the same rate as raw materials (1.3%) but the sector receives a 0.2% lower price for its product (see Table 2). This translates into additional revenue of $19.5 million for the FPI. With the pro-competitive shock, monopsony profits of $29.2 million (some refer to this as extraordinary profits) have been eliminated but the normal rate of return to capital has increased by 4.9%. This increase in rate of return to capital is expected because in the short-run capital is fixed but output has expanded by 1.3%. With limited capital-labor substitution, the rate of the fixed resource will increase.[6] Labor demand in the sector increases by 4.9% and value added by 1.3%. The FPI sells its increased output to the export market (2% increase) and the regional market (0.7% increase). The composite price for FPI is reduced by 0.2% mainly because of the reduced regional price of 0.4%. The reduced composite price increases composite final demand by 0.2% and final demand from regional production by 1.2%. The reduced regional price decreases imported final demand by 0.3%.

Outside the forest complex, changes in endogenous sector variables are small, generally less that 0.01%. This is not surprising considering that the forestry complex is less than 1.7% of the total output for the state. However, the regional general equilibrium results for the other sectors (AGR, MIN, MAN and SER) show that output levels decrease, mainly because of increased output prices and decreased exports. Regional prices increase thus increasing composite prices and reducing slightly regional outputs consumed in region. With regional price increases, imports increase marginally.

Long-run simulation results for a pro-competitive change in the raw material market are presented in Table 3. The long-run assumes capital and labor variable and land fixed. Again the forest complex has the

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[6] Notice in the following discussion on results of the long-run simulation, the rate of return to all regional capital increases by 0.142%. The one rate of return is because of one capital market for all sectors.

more significant changes. Output price in forestry increases 6.6% and output increases 9.6%. Total revenue increases $6.8 million. Factor prices differ from those obtained in the short-run. Regional labor and capital markets increase in price by 0.045% and 0.142%, respectively. Forest land rent increases by 17.1% or $1.3 million. Labor and capital demands in forestry increase by 17.1% and 17.0%, respectively. Land rent increases 13 percentage points more in the long-run compared to the short-run. This is because land is the only fixed factor in the long-run.

FPI output increases 9.6% but receives 1.5% less per unit of output. Total exports of the sector increase by 14.6% and regional demand increases by 5.1%. Demand for labor and capital increases by 9.6% and 9.5%, respectively. Capital mobility allows more response in forest products manufacturing in the long-run compared to the assumption of fixed capital in the short-run. The overall lower capital return in the long-run compared to the short-run allows the FPI to use more capital relative to labor and, thus, allows more flexibility to adjust to the new economic environment.

With the pro-competitive shock, regional price of forest raw material (RM) increases more in the long-run than the short-run (6.6% compared to 2.5%). However, the FPI sector which processes the raw material has decreases in regional price of -0.4% in the short-run and -2.9% in the long-run. The effect of eliminating monopsony pricing of raw materials is much greater in the long-run compared to the short-run. The decrease in FPI regional price decreases output price (-1.5%) and leads to the increase in exports (14.6%) and regional demand (5.1%). Furthermore, the decrease in regional price decreases the composite price (-1.4%) which leads to an increase in final demand (excluding exports) of 1.4%. The increase in final demand is distributed between an increase in regional demand of 8.9% and a decrease in import demand of -2.0%.

The general equilibrium results with the other four sectors show marginally increased output prices, decreased outputs, decreased exports, and decreased regional demands. The increased output prices are because of increases in regional wage and capital price. Imports increased for MAN and SER but decreased for AGR and MIN. The demand for labor and capital in these four sectors decreased except for labor in SER.

Regional indexes for selected quantity and price variables resulting from the pro-competitive short-run and long-run simulations are presented in Table 4. In general, changes for Oklahoma economic indexes are low due to the low base for the forest complex. However, because of the significant increases in outputs of the forest complex sectors (1.3% and 9.6% in short-run and long-run, respectively), all regional indexes are positive except short-run aggregate imports.

Aggregate regional output increases even though the aggregate regional output price increases. This is because of the forest product industry's (FPI) decreased output prices (see Tables 2 and 3), increased exports, and decreased imports. Aggregate export quantity increases even though the aggregate export price index remains at 1.0 (all commodities). Reviewing sector detail in Tables 2 and 3 shows that all quantity export indexes are less than 1.0 except for FPI (1.02 and 1.15 for short and long-run, respectively) which indicates that the FPI gain exceeds the other sector losses.

All aggregate factor price indexes are positive. For land, the increase in forest land rent is sufficient to offset the decrease in agricultural land rent (Tables 2 and 3). In the long-run, we would expect marginal agricultural land to shift to forest raw material production. However, the two types of land classification are fixed in supply in both the short-run and long-run simulations. Aggregate labor demand increases in the short- and long-run thus increasing the single labor market wage rate. In percentage points, the long-run wage rate increases three times the short-run rate. Aggregate capital price increases in both short- and long-run although the long-run price is only marginally higher than the short-run price. Capital is mobile across sectors and regions in the long-run allowing more substitutions with labor and land thus keeping capital demand and capital price lower than the corresponding changes with respect to labor and land. The pro-competitive effect on capital rent is substantially greater compared to labor wage and land rent. The major reason for the results on capital rent is the high capital share for FPI relative to labor share (see SAM, Table 1).

The level and change in regional factor compensations due to the pro-competitive shock in the forest complex are shown in Table 5. Labor compensation increases by $10.7 million in the short-run and $32.5 million in the long-run. The increase in labor compensation is the result of a higher wage rate and labor inmigration. Capital compensation increases by $26.1 million in the short-run and $55.5 million in the long-run. For the short-run this increase is due to higher capital rent (price) on a fixed stock of capital whereas the long-run increase is due to increased capital stock (capital inmigration) and higher capital rent (price). Overall land compensation increases by $289 thousand in the short-run and $595 thousand in the long-run. In the long-run both labor and capital are added in the forest complex sectors but land is fixed. Therefore, land becomes the scarce resource with its subsequent increase in land rent (4.0% in the short-run and 17.1% in the long-run).

The increase in all factor payments (value added) is an estimate of growth in gross regional (state) product (GRP) excluding indirect business tax payments. The growth in GRP from the pro-competitive simulations is $36.9 million in the short-run and $88.6 million in the long-run. This measurement is the most comprehensive regional impact from eliminating the potential monopsony price effect in the timber raw material commodity market in Oklahoma. This is the regional general equilibrium effect of eliminating monopsony profit, increasing raw material (timber) price, and expanding timber and processed product outputs. The regional general equilibrium results, however, assume that all external commodity and factor prices are not affected by the pro-competitive internal result for Oklahoma.

Effects on welfare of regional households are shown in Table 6 as measurements in changes in nominal and real household income. Sources of household income are shown by the SAM in Table 1 and include resource compensations, transfer payments and extra-regional earnings and gifts. Income from transfers and extra-regional sources are held constant. Resource compensations change as wage rate and capital and land rents change. Compensation for resource ownership by the original regional households increased by $18.0 million in the short-run simulation and $28.3 million in the long-run simulation. However, because composite prices increased for the region due to the pro-competitive impact, household real income increased by $16.3 million in the short-run simulation and $10.0 million in the long-run simulation. The increased composite price effect was much stronger in the long-run relative to the short-run thus decreasing the long-run household real income effect. This is an important result from regional general equilibrium in showing the welfare effects on households versus the regional growth effects on gross regional (state) product. GRP increased by 0.154% in the long-run simulation versus a 0.019% increase in household real income.

Two observations are made with respect to the magnitude of values reported in Tables 4-6. Although the changes in magnitude are small, when considering that the forest complex is located in the sub-region of eastern Oklahoma, the significance of these changes in that sub-region are important. For example, long-run results show a $1.3 million increase in forest land rents and a $0.8 million increase in capital compensation from increased demand for capital and increased capital returns. This combines for about a $2.1 million annual increase in land and capital compensation to forest land owners. In addition, the forest products industry increases output by 9.6% which results in an increase in the demand for capital and an increase in capital compensation of about $51.0 million. This is a total effect of about $53.1 million increase to the forest industry complex, which would accrue to land and capital owners in the forest region of eastern Oklahoma. Gross state product increased by $88.6 million with most of this increase occurring in the forest region.

Finally, by comparing columns IPR and IX in Tables 2 and 3, we observe that sectors with an increase in price were not able to increase output except for the forest raw material (RM) sector. Forest products industry (FPI), however, has a decrease in output price but an increase in output quantity. Chen and Lent (1992), and Kinnucan and Sullivan

(1986), using different methods of analysis, have reported simultaneous price and output increases when imperfect competition is assumed. Our results extend their findings to the CGE framework.

# 8. Summary and Conclusions

Monopsony power-exertion in agricultural commodity markets is likely to be present in many rural economies. Using the monopsony structure of a raw material market in Oklahoma, modifications to the competitive general equilibrium model were introduced. A calibrated and validated monopsony model for Oklahoma was implemented in a computable general equilibrium framework. A pro-competitive shock in the market structure of the raw material market was simulated using the monopsony regional CGE model. Changes in gross state product, household income, commodity trade, commodity prices, wage rate, and rates of return to land and capital were estimated.

The pro-competitive shock shows a significant redistribution of revenues between the forest products industry and the forest raw material industry. Monopsony profits of the forest products industry, calibrated at $29.2 million, are eliminated and a new competitive price equilibrium in the raw material market is determined. Results are higher raw material prices, increased raw material output, higher factor demands, and increased returns to forest land. Because of the assumption of no raw material exports due to high transport costs, increased raw material output must be processed within the region. A fixed ratio between forest product processing and raw material inputs results in expansion of the forest products industry at the same level as the expanded raw material output. Forest product processing is assumed at constant returns to scale. Thus the pro-competitive shock increases the forest product complex (raw material plus processing) output by 1.3% in the short-run (labor mobile and capital and land fixed) and 9.6% in the long-run (labor and capital mobile and land fixed).

The regional general equilibrium results show increased demands for labor and capital (long-run) and thus increased internal wage rate and capital price. This increases product prices in all other sectors, making them less competitive relative to other regions and thus decreasing output and export levels. Import levels of these other sectors increase. However, the net regional effects are increased employment, gross regional product, and household income. Real household income increases less than nominal household income, particularly for the long-run where the internal price level has adjusted to the higher composite prices. Changes in incomes favor resource owners in the forest complex relative to resource owners in other sectors.

Two contributions of this research are emphasized; the first concerns regional economic policy and the second concerns general equilibrium modeling of imperfect markets. First, using the example of the forest products industry, there is evidence of significant regional and welfare gains when comparing competitive over monopsony market structure. In the Oklahoma case, gross regional product increases $36.9 million and $88.6 million annually in the short and long-run, respectively, when comparing competitive over monopsony market structure in pricing forest raw material. Regional household incomes increase by $17.9 million and $28.3 million in nominal prices and $16.3 million and $10.0 million in real prices, short- and long-run, respectively. A policy improving competition in the raw material market by, for example, promoting value-added processing cooperatives in the forest region of eastern Oklahoma would result in a redistribution of the monopsony profit to forest land resource owners and increase regional economic growth. Raw material producers would increase their total revenue from $1.6 million to $6.8 million and increase the rate of return to forest land by 4.0% to 17.1%, depending on whether the analysis is short- or long-run. Areas with an economy linked to a specific industry will be strongly affected by a monopsonistic market structure.

Second, the procedure used to calibrate the monopsony CGE model offers additional possibilities for regional modeling of imperfect market structure. No model has been identified in the literature that incorporates monopsony markets in a regional general equilibrium framework. A further step to incorporating imperfect market structure in regional CGE is the oligopsony case. This requires further modifications to the model, especially the number of firms in the oligopsony market and an explicit specification of raw material supply elasticities.

The results of this research are affected by the assumptions of constant returns to scale and the comparative static nature of the modeling technique used. An examination of how these assumptions affect the validation of our analysis would be highly desirable. Furthermore, the allocation of monopsony profits to regional institutions versus extra-regional institutions is also an area for additional analysis.

**Table 1: Oklahoma Social Accounting Matrix, 1993 in thousands of dollars.**

| | EXPENDITURES | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | INDUSTRY | | | | | | | FACTORS | | | | INSTITUTIONS | | | | | | ROW |
| | Agri-culture | Mining | Forestry | FPI | Manufacturing | Services | Total | Labor | Capital | Land | Total | Enterprise | Households | Governments | Capital | Total | Exports | TOTAL |
| **INDUSTRY** | | | | | | | | | | | | | | | | | | |
| Agriculture | 870862 | 8116 | 4936 | 2668 | 820923 | 34800 | 1542305 | | | | | | 147210 | 12863 | 9780 | 169053 | 2591601 | 4303759 |
| Mining | 122579 | 2180942 | 891 | 85705 | 1192412 | 881343 | 4443872 | | | | | | 1587998 | 231250 | 19097 | 1838345 | 5807568 | 12089785 |
| Forest Complex | | | | | | | | | | | | | | | | | | |
| Forestry | | | | 40400 | | | 40400 | | | | | | | | | | | 40400 |
| FPI | 9839 | 72630 | 1264 | 6026 | 179590 | 206456 | 475805 | | | | | | 138648 | 96782 | 248026 | 483456 | 826339 | 1785600 |
| Manufacturing | 147584 | 1318071 | 984 | 109769 | 3299584 | 3746744 | 8622736 | | | | | | 2517437 | 1757284 | 4503431 | 8778152 | 15003939 | 32404827 |
| Services | 379945 | 1317332 | 1597 | 275941 | 4996845 | 9752027 | 16723087 | | | | | | 30727365 | 1477994 | 557652 | 32763011 | 9629092 | 59115191 |
| Sub-total industry | 1330809 | 4897091 | 9672 | 499909 | 10489354 | 14621370 | 31848205 | | .......... | | .......... | | 35118658 | 3576175 | 5337986 | 44032817 | 33858539 | 109739561 |
| **FACTORS** | | | | | | | | | | | | | | | | | | |
| Labor | 426998 | 1622808 | 6244 | 188400 | 7389027 | 20767388 | 30400863 | | | | | | 107070 | 6981839 | | 7088909 | | 37489772 |
| Capital | 566973 | 2713109 | 4387 | 525780 | 3499379 | 12042709 | 19352337 | | | | | | | | | | | 19352337 |
| Land | 701385 | | 7681 | | | | 709066 | | | | | | | | | | | 709066 |
| Sub-total | 1695356 | 4335915 | 18312 | 714180 | 10888406 | 32810097 | 50462266 | | .......... | | .......... | | 107070 | 6981839 | | 7088909 | | 57551175 |
| **INSTITUTIONS** | | | | | | | | | | | | | | | | | | |
| Enterprises | | | | | | | | | 12510953 | | 12510953 | | | | | | | 12510953 |
| Households | | | | | | | | 31363057 | 7848069 | 683300 | 39894426 | 1734234 | | 11490516 | | 13224750 | 7600825 | 53880001 |
| Governments | 95405 | 866971 | 896 | 85720 | 101159 | 4318042 | 5268193 | 6126715 | -1006686 | 25766 | 5145795 | 1699623 | 11490516 | 8477813 | | 17154007 | 4375095 | 31943090 |
| Capital | | | | | | | | | | | | 9077096 | 3869320 | | | 5207776 | 2789519 | 7997295 |
| Sub-total institutions | 95405 | 866971 | 896 | 85720 | 101159 | 4318042 | 5268193 | 37489772 | 19352336 | 709066 | 57551174 | 12510953 | 3107251 | 19968329 | | 35586533 | 7925439 | 106331339 |
| **IMPORTS** | | | | | | | | | | | | | | | | | | |
| Agriculture | 574915 | 5160 | 4955 | 1230 | 377192 | 41300 | 1004752 | | | | | | 181550 | 20097 | 10447 | 212094 | | 1216846 |
| Mining | 11222 | 1274869 | 628 | 16247 | 294847 | 385272 | 1983085 | | | | | | 141562 | 29912 | 15759 | 187333 | | 2170418 |
| Forest Complex | | | | | | | | | | | | | | | | | | |
| Forestry | | | | | | | | | | | | | | | | | | |
| FPI | 27620 | 23552 | 2742 | 19243 | 436987 | 143637 | 653781 | | | | | | 299232 | 43146 | 128560 | 470938 | | 1124719 |
| Manufacturing | 414296 | 427425 | 2171 | 350537 | 8028706 | 2606708 | 11829843 | | | | | | 5414473 | 780700 | 2326243 | 8521416 | | 20351259 |
| Services | 154136 | 458802 | 1024 | 998534 | 1788176 | 4188764 | 6689436 | | | | | | 9510103 | 542893 | 178299 | 10231295 | | 16920731 |
| Sub-total imports | 1182189 | 2189808 | 11520 | 485791 | 10985908 | 7365681 | 22160897 | | .......... | | .......... | | 15547020 | 1416748 | 2659308 | 19623076 | | 41783973 |
| COLUMN TOTAL | 4303759 | 12089785 | 40400 | 1785600 | 32404827 | 59115190 | 109739561 | 37489772 | 19352336 | 709066 | 57551174 | 12510953 | 53879999 | 3193089 | 7997294 | 106331335 | 41783978 | 315406048 |

**Table 2: Short-run Pro-competitive Simulation Results: Indexes for Selected Endogenous Variables**

| Sector | IP (1) | IPR (2) | IPX (3) | IPL (4) | IPK (5) | IPT (6) | IX (7) | IR (8) | IEXP (9) | IIMP (10) | IQ (11) | IQR (12) | IQM (13) | IVA (14) | IL (15) | IK (16) | IT (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AGR | 1.00001 | 1.00001 | 1.00000 | 1.00015 | 0.99998 | 0.99998 | 0.99996 | 0.99999 | 0.99994 | 1.00001 | 0.99974 | 0.99973 | 0.99975 | 0.99996 | 0.99984 | 1.00000 | 1.00000 |
| MIIN | 1.00005 | 1.00007 | 1.00003 | 1.00015 | 1.00002 | | 0.99995 | 1.00004 | 0.99985 | 1.00006 | 0.99970 | 0.99970 | 0.99973 | 0.99995 | 0.99987 | 1.00000 | |
| RM | | 1.02550 | 1.02550 | 1.00015 | 1.03953 | 1.03953 | 1.01326 | | | | | | | 1.01326 | 1.03938 | 1.00000 | |
| FPI | 0.99802 | 0.99573 | 0.99772 | 1.00015 | 1.04920 | | 1.01326 | 1.00742 | 1.02001 | 0.99465 | 1.00173 | 1.01217 | 0.99690 | 1.01326 | 1.04904 | 1.00000 | 1.00000 |
| MAN | 1.00002 | 1.00003 | 1.00002 | 1.00015 | 1.00003 | | 0.99992 | 0.99997 | 0.99987 | 1.00020 | 0.99973 | 0.99965 | 0.99977 | 0.99992 | 0.99989 | 1.00000 | |
| SER | 1.00005 | 1.00007 | 1.00006 | 1.00015 | 0.99999 | | 0.99990 | 0.99991 | 0.99986 | 1.00005 | 0.99970 | 0.99967 | 0.99980 | 0.99990 | 0.99984 | 1.00000 | |

where P, PR, PX, PL, PK, PT are composite price, regional price, output price, wage rate, capital price, and land price; X, R, EXP, IMP, Q, QR, and QM are regional output, regional production consumed in region, export, import, composite household demand, household demand from regional production, and household import demand; VA, L, K, T are composite value added, labor demand, capital demand, and demand for land. The I before each variable indicates index.

**Table 3: Long-run Pro-competitive Simulation Results: Indexes for Selected Endogenous Variables**

| Sector | IP (1) | IPR (2) | IPX (3) | IPL (4) | IPK (5) | IPT (6) | IX (7) | IR (8) | IEXP (9) | IIMP (10) | IQ (11) | IQR (12) | IQM (13) | IVA (14) | IL (15) | IK (16) | IT (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AGR | 1.00015 | 1.00025 | 1.00010 | 1.00045 | 1.00142 | 0.99897 | 0.99881 | 0.99940 | 0.99842 | 0.99986 | 0.99975 | 0.99956 | 0.99991 | 0.99881 | 0.99852 | 0.99756 | 1.00000 |
| MIIN | 1.00097 | 1.00131 | 1.00068 | 1.00045 | 1.00142 | | 0.99795 | 0.99976 | 0.99599 | 0.99979 | 0.99893 | 0.99888 | 0.99953 | 0.99795 | 0.99856 | 0.99759 | |
| RM | | 1.06612 | 1.06612 | 1.00045 | 1.00142 | 1.17142 | 1.09566 | | | | | | | 1.09566 | 1.17089 | 1.16976 | |
| FPI | 0.98584 | 0.97064 | 0.98486 | 1.00045 | 1.00142 | | 1.09566 | 1.05139 | 1.14630 | 0.96320 | 1.01426 | 1.08934 | 0.97998 | 1.09566 | 1.09643 | 1.09537 | 1.00000 |
| MAN | 1.00017 | 1.00038 | 1.00020 | 1.00045 | 1.00142 | | 0.99912 | 0.99963 | 0.99854 | 1.00180 | 0.99972 | 0.99881 | 1.00015 | 0.99912 | 0.99943 | 0.99847 | |
| SER | 1.00050 | 1.00067 | 1.00056 | 1.00045 | 1.00142 | | 0.99981 | 0.99989 | 0.99942 | 1.00125 | 0.99940 | 0.99908 | 1.00042 | 0.99981 | 1.00017 | 0.99920 | |

where P, PR, PX, PL, PK, PT are composite price, regional price, output price, wage rate, capital price, and land price; X, R, EXP, IMP, Q, QR, and QM are regional output, regional production consumed in region, export, import, composite household demand, household demand from regional production, and household import demand; VA, L, K, T are composite value added, labor demand, capital demand, and demand for land. The I before each variable indicates index.

**Table 4:** Regional Indexes for the Pro-Competitive Simulations, Selected Variables

| Variable | Short-run | Long-run | Weighting |
|---|---|---|---|
| Quantities | | | |
| Output | 1.00014 | 1.00096 | base prices |
| Export | 1.00036 | 1.00195 | base prices |
| Import | 0.99998 | 1.00038 | base prices |
| Labor demand | 1.00013 | 1.00041 | NA |
| Capital demand | 1.00000 | 1.00146 | NA |
| Land demand | 1.00000 | 1.00000 | NA |
| Prices | | | |
| Output | 1.00002 | 1.00022 | base quantities |
| Export | 1.00000 | 1.00000 | NA |
| Import | 1.00000 | 1.00000 | NA |
| Labor | 1.00015 | 1.00045 | NA |
| Capital | 1.00135 | 1.00142 | SR (base quantities) |
| Land | 1.00041 | 1.00084 | base quantities |

**Table 5:** Regional Impacts on Factor Payments from the Pro-Competitive Simulations

| Factor | Units | Short-run | Long-run |
|---|---|---|---|
| Labor compensation | $ thousand | 37,500,224 | 37,522,232 |
| Change | $ thousand | 10,652 | 32,460 |
| Index | base = 1.0 | 1.00028 | 1.00087 |
| Capital compensation | $ thousand | 19,378,463 | 19,407,836 |
| Change | $ thousand | 26,126 | 55,499 |
| Index | base = 1.0 | 1.00135 | 1.00287 |
| Land compensation | $ thousand | 709,355 | 709,662 |
| Change | $ thousand | 289 | 595 |
| Index | base = 1.0 | 1.00041 | 1.00084 |
| Value added | $ thousand | 57,588,042 | 57,639,730 |
| Change | $ thousand | 36,867 | 88,554 |
| Index | base = 1.0 | 1.00064 | 1.00154 |

**Table 6:** Regional Household Income Impact from the Pro-Competitive Shock

| Item | Units | Short-run | Long-run |
|---|---|---|---|
| Household nominal | | | |
| Income | $ thousand | 53,897,921 | 53,908,295 |
| Change | $ thousand | 17,920 | 28,295 |
| Index | base = 1.0 | 1.00033 | 1.00053 |
| Composite price | | | |
| Index | base = 1.0 | 1.00003 | 1.00034 |
| Household real | | | |
| Income | $ thousand | 53,896,304 | 53,889,972 |
| Change | $ thousand | 16,303 | 9,972 |
| Index | base = 1.0 | 1.00030 | 1.00019 |

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