IDENTIFYING RESOURCE BARRIERS TO LOCAL ECONOMY GROWTH

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INTRODUCTION

Congress and the majority of coastal states have recognized the complexity of public decisions concerning growth in coastal areas. The preponderance of common pool resources and regional goods in coastal areas has prompted lawmarkers to pass coastal zone management legislation prior to a national land use bill. New state level institutions have been fostered by the Office of Coastal Zone Management. However, it is at the local level where resulting institutional rules represent self-imposed natural resource barriers to growth [1]. Communities face the task of improving income streams from expansion of existing business activity or opting for new industries. Local governments have scurried to consultants and universities for solutions of community development and natural resource problems. The study described here represents one type of response. Although an Oregon county was the researcher's focus, it involved the pith of local economy growth—income generation and natural or self-imposed resource barriers.

In 1968, Clatsop County, Oregon, was faced with the opportunity to have a large aluminum manufacturing plant become part of its economic activity. By 1970, a university input-output study was completed with an aluminum sector included [2]. This permitted analysis of the monetary effects on the economy of an *operating* aluminum plant. As a result of certain local and state environmental concern, prompted by the sudden emergence of environmania, further analysis was requested on natural resource impacts. Another study began to develop information defining the role of natural resource endowment in this choice: Was the resource endowment neutral in the growth choice? Nearly neutral? Severely restrictive: What trade-offs were there between income generation and environmental goods?

Linking the Economy and Environment

Providing decision-oriented information on effects of locating a major aluminum plant required linking the locality's economy and environment [3]. The former was represented by an input-output (1-0) model with an endogenous aluminum sector. Linkage to the environment was provided through a matrix consisting of rows representing the environment and the economic sectors of the 1-0 matrix as columns [4, 5]. This linkage matrix identified natural resources *inputs* used by the economic sectors as imports from the environment and treated residuals flowing from economic activity as exports to the environment.[1] A positive sign was assigned to the former coefficients of the matrix and a negative sign to the latter [6, 7]. The linkage matrix was simply post-multiplied by the 1-0 inverse to secure the first, second, third, etc. round environmental requirements per dollar of final demand in each sector. The process yielded a simple absolute ranking of economic sector relationships to the natural resource endowment from the input and residuals viewpoint.

Linear Programming of Business and Environment

The linkage analysis permitted consideration of general equilibrium forces in the economy. However, trade-offs were formulated for single

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[1] The input-output model consists of thirty endogenous sectors. The linkage matrix is made up of fourteen links between the economy and natural resource base. Resource input linkages are Domestic Water, Cooling Water, Process Water, Total Water Intake, and Water Discharge. Residuals include Particulates, Carbon Monoxide, Fluoride, Hydrocarbons, 5-Day BOD, Suspended Solids, Organic Nitrogen, Solid Waste (lbs.), and Solid Waste (cu. yds.).

environmental goods rather than for simultaneous consideration of groups such as "air residuals" or "water inputs." It seems plausible that simultaneous consideration of several environmental goods may suggest business income effects of environmental regulation distinct from the one good case. For example, turbidity in estuaries is often a major public concern. Overt restriction of suspended solids disposition, through altering the magnitude or direction of certain economic activities, may be unnecessary if consideration is given to maximizing business sales subject to given levels of suspended solids *and* BOD. The latter may reach maximum permissible levels prior to the former thus emphasizing BOD, not suspended solids, as the relevant constraint to providing a desired mix of market and non-market goods.

A linear programming model of business and environmental aspects of the economy can proceed along either of two routes: 1) minimize (maximize) selected environmental good levels subject to given constraints on sales levels by economic sectors, 2) maximize economic sector sales given constraints on environmental goods. Information produced from the linkage analysis assures the feasibility of both approaches. The former involves an objective function with direct and indirect environmental links as coefficients and deliveries to final demand as unknowns. Unknowns are constrained singly and/or in combination to specific levels. Method two involves business income multipliers as coefficients in the objective function and deliveries to final demand as unknowns. Unknowns, when multiplied by direct and indirect environmental links, are constrained to specific levels of total environmental goods. The order of events common to most area growth problems and the previously-stated desire to include analyses of groups of environmental goods favor method two.

A model formulated on the method one format proved unsatisfactory [2]. Minimization of an environmental good was to be achieved by maintenance of existing sales for each economic sector and allowance for a potential increase in economic activity. Hite and others employed the procedure in a South Carolina study [8]. Due to insufficient data, the minimization problem reduced to that which could be revealed by a simple ranking of environmental impact by economic sector. The linear programming technique simply reproduced the obvious. All growth is directed to the sector with the smallest direct and indirect coefficients for the environmental good in question. Due to the trivial nature of solutions flowing from method one, and the previously-cited desired to examine *grouped* environmental goods in a linear programming model, method two was adopted for the analysis.

Subset and Total Linear Programming Models

Business income multipliers, sales to final demand, absolute environmental goods levels, and direct and indirect environmental linkages were utilized to develop linear programming optimum for selected subsets of economic sectors and environmental goods. A problem representing total economic sector activity and several environmental goods using the same general format can be stated as:

$$\text{Maximize} \quad \theta = \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n$$

$$\text{subject to:} \quad K_1 \leqslant X_1 \leqslant a_1$$
$$K_2 \leqslant X_2 \leqslant a_2$$
$$\vdots$$
$$K_n \leqslant X_n \leqslant a_n$$
$$\sum_{i=1}^{n} e_{fi} X_i \leqslant Z_f \quad f = 1, \ldots, g$$

where:

θ = total business sector sales

β_i = business multiplier for economic sector i, i = 1, . . . , n

X_i = sales to final demand for economic sector i, i = 1, . . . , n

K_i = 1968 level of sales to final demand for economic sector i, i = 1, . . . , n

a_i = maximum sales to final demand for economic sector i, i = 1, . . . , n

e_{fi} = direct and indirect environmental linkages of environmental good f, f = 1, . . . , g per dollar of sales to final demand for economic sector i = 1, . . . , n

Z_f = maximum permissible level of environmental good f, f = 1, . . . , g

The objective function was maximized subject to the constraint that: 1) no economic sector's sales be diminished below k_i and none permitted to balloon above level a_i, 2) the total level of each environmental good not exceed a specified amount, Z_f. Applied to Clatsop County data, the first constraint was formulated to permit k_i to slip no lower than levels experienced in 1968. In addition, a_i could be no larger than twice the projection of sales for 1980 made by the U.S. Department of Commerce's Bureau of Economic Analysis. The latter was required to prevent ballooning of figures above those that could be realistically expected. If community leaders chose to pursue economic growth of a specific sector(s), it was assumed that realistic attainment would be exclusive of sales being more than double the 1980 projection, even though a deliberate public effort was applied with gusto. Constraints included maximum and minimum values for unknowns and maximum allowable use of selected environmental goods.

Three linear programming problems were designed to reveal trade-offs involving: 1) air quality considerations and economic growth, 2) water-borne residuals generation and economic growth, 3) combined air quality, water input, water-borne residuals, and solid waste considerations and economic growth. The analysis required four runs for each problem. Runs one and two involved environmental good constraints computed as if the aluminum sector had been a functioning part of the economy in 1980. Run two differed only in that the maximum upper bound placed on the aluminum unknowns was increased from 60 to 85 million dollars.

The third and fourth runs included environmental goods constraint magnitudes simulating the non-existence of an aluminum plant in 1980 to contribute to residual levels. Run four differed from the third as two had differed from one.

Runs one and two were designed to provide information concerning possible reallocation of the predicted 1980 level of environmental goods and residuals in the economy, among economic sectors, as a means of increasing income. Thus, these

Table 1. COMPARISON OF AIR RESIDUALS LINEAR PROGRAMMING RUNS FOR CLATSOP COUNTY, OREGON (PROBLEM 1)[1]

	RUN			
	1 (000)	2 (000)	3 (000)	4 (000)
Sales to final demand ($)				
Lumber	76,269	74,318	69,743	67,792
Fish Processing	111,549[3]	111,549	111,549	111,549
Communications & Transportation	5,022[3]	5,022	5,022	5,022
Construction	44,559[3]	44,559	44,559	44,559
Products	38,730[3]	38,730	38,730	38,730
Port Authority	3,933[3]	3,933	3,933	3,933
Aluminum	60,000[3]	85,560[3]	60,000	85,560
Total business income ($)	600,885	638,237	588,842	626,194
Constraint level				
BOD (lbs.)	42,913	41,843	39,313	38,244
Suspended Solids (lbs.)	66,872	66,872	62,613	62,613

[1] The seven sectors selected for inclusion in the air residuals equation system accounted for 77 percent of all 1968 sales to final demand. The percentage of air residuals accounted for by the seven sectors. was: Particulates 99 percent; Carbon Monoxide 74 percent; Hydrocarbons 73 percent.

[2] Lower constraint achieved.

[3] Upper constraint achieved.

runs began with environmental goods and residuals levels predicted for a 1980 economy as the environmental constraints. The levels included a functioning aluminum plant. Constrained and bounded linear programming runs then sought to redistribute environmental goods and residuals among sectors to determine if growth was still possible within the natural resources barrier specified. Runs three and four were designed to provide similar information. However, the natural resource barrier was represented via the environmental goods and residuals constraints for the 1968 non-aluminum economy. Thus, the linear programming runs sought to determine if environmental goods and residuals of the 1968 non-aluminum economy could be redistributed among economic sectors (including aluminum) to increase business income. This was necessitated by the controversy over the aluminum plant's bringing its environmental goods and residuals effects into the 1968 economy.

Aluminum production appeared in the solution to runs one and two of the air quality problem at the maximum constraint level (Table 1). Proxies for air quality included particulates, hydrocarbons, and carbon monoxide. The latter two reached maximum constraint levels in runs one and two. However, the particulate level consistent with maximization of business income was far below the constraint. All three air quality proxies reached full constraint levels in runs three and four. Total business income, though, was but 77 percent of that for runs one and two. Aluminum production of $38,300,000 was included in estimates of the objective function unknowns. Sales were far below those proposed by the aluminum company, thus possibly representing an infeasible level of production.

BOD and suspended solids sectors served as

Table 2. COMPARISON OF BOD AND SUSPENDED SOLIDS LINEAR PROGRAMMING RUNS FOR CLATSOP COUNTY, OREGON (PROBLEM 2)[1]

	RUN			
	1 (000)	2 (000)	3 (000)	4 (000)
Sales to final demand ($)				
Lumber	55,605[2]	55,605	55,605	55,605
Fish Processing	111,549[3]	101,596	71,661	71,661
Service Stations	200[2]	200	200	200
Construction	20,460	13,121[2]	13,121	13,121
Products	38,730[3]	38,730	38,730	38,730
Port Authority	932[2]	932	932	932
Aluminum	60,000[3]	85,560[3]	38,300	38,300
Total Business income ($)	500,392	509,815	381,750	381,750
Constraint level				
Particulates (lbs.)	3,957	4,815	3,201	3,201
Carbon Monoxide (lbs.)	8,483	8,483	6,670	6,670
Hydrocarbons (lbs.)	1,573	1,573	1,236	1,236

[1] The seven sectors selected for inclusion in the water effluent equation system accounted for 78 percent of all 1968 sales to final demand. The percentage of water effluent accounted for by the seven sectors was: BOD 99 percent; Suspended Solids 73 percent.

[2] Lower constraint achieved.

[3] Upper constraint achieved.

water-borne residuals constraints. The objective function's value was largest for run two, followed by runs four, one, and three (Table 2). Only the suspended solids level specified actually proved to be a constraint. BOD did not reach maximum permissible levels. In all cases, aluminum reached the maximum allowable sales level. As aluminum sales increased between runs one and two and three and four, lumber sector sales declined. Thus, even though BOD did not prove to be a constraint when associated with suspended solids, increased aluminum sector sales were traded for lower lumber sector sales.

Simultaneous consideration of numerous environmental goods in the third problem resulted in particulates, process water, and solid waste reaching constraint levels (Table 3). The value of the aluminum sector sales unknown corresponded with those of runs one and two of the previous problems—maximum permissible. Runs three and four reveal a fate for aluminum production identical to that of the first problem. Thus, if the aluminum sector were facing an agency with broad responsibility for environmental goods man-

Table 3. COMPARISON OF PARTICULATES, COOLING WATER, PROCESS WATER, BOD, AND SOLID WASTE LINEAR PROGRAMMING RUNS FOR CLATSOP COUNTY, OREGON (PROBLEM 3)[1]

	RUN			
	1 (000)	2 (000)	3 (000)	4 (000)
Sales to final demand ($)				
Lumber	81,655	63,584	55,605[2]	55,605
Fish Processing	111,701	111,647	111,622	111,625
Agriculture & Fur	2,720[2]	2,720	2,720	2,720
Manufacturing	10,400[3]	10,400	10,400	10,400
Service Stations	1,400[3]	1,400	1,400	1,400
Communications & Transportation	5,022[3]	5,022	5,022	5,022
Construction	44,560[3]	44,560	44,560	44,560
Products	38,700[3]	38,700	38,700	38,700
Port Authority	3,417	2,679	2,328	2,328
Aluminum	60,000[3]	85,560[3]	12,140	12,140
Total business income ($)	639,425	645,047	510,648	510,655
Constraint level				
Particulates (lbs.)	6,117	6,117	3,216	3,216
Cooling Water (gals.)	11,377,706	9,016,875	7,562,360	7,562,360
Process Water (gals.)	5,721,600	5,721,600	3,079,500	3,079,500
BOD (lbs.)	45,895	35,932	31,179	31,179
Solid Waste (lbs.)	465,243	465,243	427,896	427,896

[1] The ten sectors selected for inclusion in the equation system accounted for 80 percent of all 1968 sales to final demand. The percentage of residuals and inputs accounted for by the ten sectors was: Particulates 99.8 percent; Cooling Water 99.8 percent; Process Water 61 percent; BOD 99.8 percent; Solid Waste 73 percent.

[2] Lower constraint achieved.

[3] Upper constraint achieved.

agement, or even well-coordinated action among several agencies, aluminum production would likely not be feasible.

Table 4 indicates objective function values for the three problems. Among the sectors with large economic impact, lumber and aluminum compete vigorously for the constrained environmental goods. As the aluminum sector increases lumber sector sales decline. The reverse of the relationship did not occur. When aluminum sector sales decreased in runs three and four to infeasible levels, lumber sector sales entered the solution at minimum allowable levels. Lumber and aluminum processings appear to exemplify supplementary and competitive relationships. Fish processing exhibits supplementary relationships to both lumber and aluminum processing with the exception of a minor indication of competition with the aluminum sector for "air" environmental goods.

Table 4. SUMMARY OF LINEAR PROGRAMMING PROBLEMS: ESTIMATED OBJECTIVE FUNCTION, LUMBER, FISH PROCESSING, AND ALUMINUM VALUES

	RUNS			
	1 (000 $)	2 (000 $)	3 (000 $)	4 (000 $)
Problem 1				
Total business income	500,392	509,815	381,750	381,750
Lumber	55,605	55,605	55,605	55,605
Fish Processing	111,549	101,596	71,661	71,661
Aluminum	60,000	85,560	38,300	38,300
Problem 2				
Total business income	600,885	638,237	588,842	626,194
Lumber	76,269	74,318	69,743	67,792
Fish Processing	111,549	111,549	111,549	111,549
Aluminum	60,000	85,560	60,000	85,560
Problem 3				
Total business income	639,425	645,047	510,648	510,655
Lumber	81,655	63,584	55,605	55,605
Fish Processing	111,701	111,647	111,622	111,625
Aluminum	60,000	85,560	12,140	12,140

Growth Implications

Coastal zone literature of technical and lay nature contains conspicuous common elements. An awareness of alternate levels of consuming coastal zone resources can be cited. Recent national, state, and local coastal zone planning efforts include emphasis on abandonment of final consumption attitudes directed toward the relevant resources. The task of organizing public management to facilitate inclusion of intermediate goods values remains a central issue in improved decision-making.

The implication of methods employed in the revisit of the aluminum decision evolves from the model's versatility. Previously revealed interdependencies are given a new dimension via the linkage process. The process enables an intermediate-good viewpoint of indentified coastal area resources. Inclusion of aluminum, as the proposed growth impetus, *and* existing economic pursuits in the study is desirable if historical sector growth and resource usage are not to be allowed preferential treatment. As an established economic pursuit, production of aluminum retained appeal to the economic goal specified for the county. However, viewing the aluminum sector as an outsider looking in with constraints to economic growth purposely constructed to reflect intermediate goods attitudes of county/residents yielded low sales levels. Sales may in fact be low enough to represent a discontinuity, making aluminum production infeasible.

Recalling the basis of runs three and four, an objective function excluding the aluminum plant would be a plausible alternative for the county economy. Optimization of the system revealed a potential increase of 30 percent in total business income. Thus, the aluminum plant does not represent a choice of growth versus stagnation for the economy. Incentives for economic activity to proceed in alternate directions remains a viable choice for public sector inputs to the growth process.

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