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ESTIMATING VALUES AND USE OF THE IRRIGATED LAND RESOURCE - A REGIONAL ANALYSIS*

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This study is designed to evaluate the irrigated land resource in the context of a regional economy under assumptions of both static and growth conditions. For several reasons, including data availability and the recency of development, the authors elected to choose the Columbia Basin Project in central Washington state as the region of study.

Model

The analytical technique used is basically a linear programming model that combines a "Leontief-type" from-to matrix and resource constraints into a linear programming format.

The transaction matrix is used to estimate trading interrelationships between industries and to define the activities in the linear programming model. The linear model is completed when a regional objective function, resource constraints, and alternative processes are added to the basic transaction matrix. A highly aggregated model used to study the economy of the Columbia Basin Irrigation Project is shown in Table 1.

The capacity constraints (Equations 8-10, Table 1) represent the total productive capacity of these industries. These are physical limitations expressed in dollars with an industry limited to producing a certain amount of goods when all of its facilities are being used at full capacity.

The coefficient in the maximum export row (Equation 11, Table 1) represents market limitations for products produced in the regional economy. Other resource constraints -- land, labor, and water -- represent the amount of resources available for use in the economy. Population as a resource acts as a restriction on the consumption of goods and services by the residents of the local economy and as a source of labor supply.

Economic interdependence which exists in the economy is expressed by having the resource supply generated from within the model itself. The resources in Table 1 refer to agriculture, manufacturing, agricultural processing, and services. The negative coefficients in Equations 1-5 generate resource supply when an activity in the model comes into solution. Since all activities are viewed simultaneously, the most profitable activity brings other activities into solution so as to generate the needed resource supply.

With some of the resource supplies being generated from within the model, it is necessary to limit the amount of resource being generated. Again, there is a need for capacity constraints to prevent all resources from being used by one or two industries. Conventional wisdom tells us that primary resources are not the usual constraints on market size of an industry.

Imports, as shown in Table 1, are defined in dollars with one dollar of imported goods and services being a perfect substitute for any other dollar of imported goods. The same is true for labor, although labor is defined as number of workers. One worker is a perfect substitute for any other worker. Because of this perfect substitution of resources and physical limitations on production capabilities, it is necessary to limit the amount of production that can take place in any given industry.

The regional objective for economic organization, the objective function, is to maximize gross economic product of the regional economy. Gross regional product is defined as being the summation of the value added by each producing industry and the non-producing sectors, governments, and households. Value added represents the amount of an industry's revenue available for factor payments, capital consumption, and indirect business taxes.

Since the study is designed to study the effects of changes in agriculture and the rest of the economy upon resource values, additional agricultural sectors such as Agriculture B are added to the model. The different agricultural sectors represent different production patterns, levels of resource use, and also sources and amounts of sales and purchases from other sectors of the economy.

Model Validation

Since the value of the objective function in 1963 is known, it is possible to validate the linear programming model with reference to the base year. The objective function is maximized, and the value obtained should equal the total value added as estimated from the transaction table.

Not only does the validation procedure provide an opportunity to check the model for validity, it also provides values that can serve as points of references from which comparisons can be made. It approximating the conditions which existed in the base year, all alternative processes are "blocked-out" of consideration by associating a high cost instead of a return with each alternative process (i.e., Agriculture B in Table 2).

Irrigated Land Values

The three economic models of the Columbia Basin are intended to depict an economy that is experiencing growth in the producing sectors. As the economy expands, Model A through Model C, the value of irrigated land changes and becomes a measure of the relative importance of the land upon which agricultural production is based.

In the base year, 1963, the marginal value product (MVP) of irrigated land was estimated as being $43.7 million. In Model B, the MVP of irrigated land increased to $46.8 million, and in Model C it decreased to $46.5 million. The change in the MVP was due in part to changes that took place in agriculture. As production patterns change from those used in Agriculture A to Agriculture B, the value added to the region's gross regional product by agriculture increased (Table 2). This increase in value is reflected in a higher MVP of land.

Since the MVP represents the total imputed value per year of the irrigated land resource in terms of value added, the average and marginal value productivities are the same in terms of value added. Using the land values in Table 2 and dividing by 380,322 total irrigated acres, the average value per acre is $155, $123, and $122 for Models A, B, and C, respectively. The present value of irrigated land to the economy of the Basin can be estimated by calculating the average opportunity cost or average MVP per acre and dividing this value by an assumed interest rate. If an interest rate of 6 percent is assumed, the present value of irrigated land to the regional economy is $2,583 per acre in Model A, (155/.06 = 2,583) $2,050 per acre in Model B, and $2,033 per acre in Model C.

The decline in the MVP of the irrigated land resource (Table 2) can be attributed to the fact that as other industries expand, from Model A through Model C, they compete for relatively scarce, non-land resources. Thus, the source of value is spread among more constraints resulting in different MVPs [4, p. 91].

The fact that the imputed MVP of land declines as the economy expands is of interest. This decline in the imputed MVP of land from Model B to Model C indicates that the relative importance of agriculture is declining. This is not to say that land and thus agriculture are not important to the economy, only that its relative overall influence decreases as the economy expands.

The magnitude of the MVP indicates that irrigated land represents an area where an additional dollar spent may result in greater returns. However, caution must be exercised interpreting these MVPs because an additional dollar spent in the development of more irrigated land means additional costs, which are not considered in this study.

It is not possible to compare the MVP of land as computed in this study with the private MVP of land for an individual firm, where the MVP of land is measured in terms of change in income for the farm firm. In contrast, the measures of income used in this study encompass all direct trade flows in the economy of the area, some of which occur among nonagricultural sectors. Thus, the measures of income used in this study more closely approximate marginal social values of land than do those obtained from farm analyses.

Structural Changes in Agriculture

In moving from Model A to Model B and C, changes occur within the agriculture sector (Table 2). These changes are primarily changes in the number of acres devoted to various crops and the number of livestock being produced. Agriculture 1963 devotes more acreage to

the production of cereal grains, seed crops, and miscellaneous crops than does Agriculture B. Agriculture B devotes more total acres to field crops, vegetables, forages, and livestock. However, within these major crop classifications there may be variations in the number of acres being devoted to the various crops in each group [1, p. 121].

These changes in the amount and type of agricultural products being produced affect the rest of the economy. Changes in production require a different mix of goods and services from the local economy as well as those being imported. This may be related to differential amounts of change in output levels in other sectors of the economy.

Conclusions

A gross flows table of a regional economy can be used effectively as the enterprise core of a linear programming model of that economy to obtain imputed resource value productivities and imputed resource values. If gross regional product is used as an objective function, the shadow prices on resources more nearly approximate regional societal values than would the shadow prices resulting from solution of the models of single firms or industries. It is possible also to consider optimizing the structure of an industry to regional goals in the context of opportunity cost interpretations.

The model shown here is highly aggregated and experimental. Refinements or disaggregation in industrial sector composition, public sector activities, output and input-mixes and markets, etc. should be possible and should yield much more refined information for interpretation.

FOOTNOTES

* Technical Article 9314 of the Texas Agricultural Experiment Station. This paper is based upon work conducted by the authors at Washington State University under Project H-1820.

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Table 1. Linear programming model of the Columbia Basin economy[a/]

Equation no.	Description	Activities[b/] Services	Manufacting	Agric. proc.	Agric. 1963	Agric. B	Households	Government	Exports	Resource supply[d/] RHS I	RHS II
1	Services	88055[c/]	-1818	-2587	-4894	-5003	-64068	-3878	-10810	0	0
2	Manufacturing	-2903	15534[c/]	-33	-194	-217	-2273	-8412	-1705	0	0
3	Agric. processing	0	0	22381[c/]	-1223	-1001	-957	0	-20197	0	0
4	Agriculture 1963	0	0	-12972	71021[c/]	0	-1737	-20	-56291	0	0
5	Agriculture B	0	0	-15385	0	77009[c/]	-1842	-15	-58901	0	0
	Imports										
6	Washington	2113	2016	975	10695	11757	26888	0	0	42687	47785
7	Other	6528	3791	666	14527	15525	42377	0	0	67889	77278
8	Service capacity	1	0	0	0	0	0	0	0	1	1.7
9	Mfg. capacity	0	1	0	0	0	0	0	0	1	1.7
10	Agric. proc. capac.	0	0	1	0	0	0	0	0	1	2.2
11	Maximum export	0	0	0	0	0	0	0	1	1	2
12	Govt. capacity	0	0	0	0	0	0	1	0	1	1
13	Labor	9943	1609	702	4449	4449	0	3792	0	20494	25905
14	Land	0	0	0	380322	380322	0	0	0	380322	380322
15	Water	0	0	0	300205	297958	0	0	0	371966	371966
16	Population	0	0	0	0	0	80297	0	0	80297	80297
	Objective function										
	Value added	-76491	-7909	-5148	-39488	99999	-22498	-20050			
	Value added	-76491	-7909	-5148	-39488	-29320	-22498	-20050			

a/ Accounting rows used to account for Washington imports by industry, total sales, and rent are not shown in this table.

b/ Equations 1-7 are in $000, equations 8-13 are in numbers, equation 14 is in acres, equation 15 is in acre-feet, and equation 16 is in numbers.

c/ Positive values, where row and column having the same name intersect, are obtained by subtracting intraindustry purchases from total sales by that industry.

d/ All constraints are equal-to-or-greater-than, except population which is equal-to.

Table 2. Results obtained in Model A, B, and C

Activity	Amount of economic activity in Model			Marginal value product associated with the constraint on the industry or resource in model			Gross regional product
	A	B	C	A	B	C	
	thousand dollars						
Printing	2,367	2,661	3,148	1,568			
Clay	2,468	2,926	3,697				
Machinery	601	911	1,442	390			
Metal products	322	547	966	151	160	159	
Lumber	678	972	1,356				
Transportation	13,842	21,912	34,605			11,502	
Communication	5,630	6,227	7,206	5,076			
Utilities	7,309	8,610	10,379	5,069			
Construction	9,888	10,234	10,778	5,433			
Trade	39,472	41,051	43,419				
Finance	6,294	7,018	8,119	5,616			
Services	24,852	27,238	31,065				
Chemical	241	241	386	89	93	92	
Apparel	60	60	96		29	29	
Sporting goods	73	73	117	42	46	46	
Grain mills	1,883	2,429	3,804				
Canning	4,446	8,714	13,249	2,479			
Meat products	1,505	2,355	4,064				
Dairy	1,166	2,282	4,268				
Other food	13,406	26,599	40,200			2,910	
Agriculture 1963	71,021						
Agriculture B		77,009	77,009				
Agriculture C							
Households	160,798	160,798	160,798				
Exports							
Wash.	51,060	102,120	204,240	6,542	8,277	3,428	
U.S.A.	29,021	58,042	87,042	3,629	6,932	3,291	
Foreign	8,922	17,844	35,688	1,300	1,390	154	
Government	32,360	32,360	32,360	22,259	28,330	27,227	
Land				43,691	46,833	46,545	
Population				67,683	81,884	78,209	
Model A							171,579
Model B							190,686
Model C							215,166