AN ECONOMIC SIMULATION MODEL FOR ANALYZING NATURAL RESOURCE POLICY*

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The current energy crisis, water supply and distribution problems, land use conflicts, and environmental issues are bringing with them a series of federal and state policy actions (legislation, new institutions, and court decisions) in response to the complex problem of resource allocation. In their simplest form, the policy questions deal with the public sector influence on the allocation of available scarce resources among alternative uses, and the allocation of scarce public investment funds among alternative programs to augment available supplies of these resources.

The economic analyst's function in this setting is to analyze effects of alternative resource policies. Such analyses require a comprehensive framework which relates resource use to production and consumption activities and allows the identification of policy "control variables" at various points in the framework.[1]

This paper describes a simulation model which was designed for the analysis of public resource policy alternatives at the regional level for several resources and makes use of currently available input-output models. The simulation model can be easily adapted to other regions and other resources utilizing information from existing input-output models and other resource data. The model simulates consumption, savings, investment, population growth, income, employment, natural resource use, and industry output for 48 industrial classifications.

THE SIMULATION MODEL

The simulation model utilizes an input-output model framework to describe the interrelationships

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[1] A simulation model which allows one to investigate various policy questions may be expressed in a generalized form in three equations presented below:

(1) $S(t+1) = S\,[S(t), p(t), I(t)]$,
(2) $M(t) = M\,[S(t), SA(t)]$, and
(3) $I(t) = I\,[i(t)]$

where:

- S = variables defining the state of the system at any point in time,
- SA = variables describing the state of the real world system at any point in time,
- p = parameters representing the structure of the system,
- e = exogenous variables,
- i = policy instruments,
- M = variables that measure the correspondence of the state variables, S, to reality, SA, and
- I = variables of interest to the policy maker.

The state of the system at a given time period, S(t+1), is a function of the state of the system in previous time periods, S(t), the parameters describing the structure of the system, p(t), exogenous variables of the system outside the control of the policy-maker, e(t), and policy instruments of the system (taxes, public investment, property rights, transfer payments). Equation (1) is a difference equation which traces the time path of the state of the system with successive iterations. The set of variables M(t) is used to measure the ability of the model to describe reality as represented by the variables SA(t) [1].

between various industries within a region. The input-output model provides the link between production and consumption demand. Consumption demand consists of household, government, investment, and export demands. Income elasticity coefficients and past income provide the link to the level and distribution of household consumption in the current time period. Resource use coefficients provide the link between primary resources (labor, water, land, crude petroleum, and natural gas) and the producing industry which uses them. Investment demand is linked to projected final demand through expansion capital coefficients.

Given aggregate demand in any time period, the solution for output levels, resource use, and income payments is calculated by solving a set of simultaneous equations with linear constraints. This equation set represents the group of structural relationships which relate consumption to production and production to resource use in the same time period. In addition, the simulation model is composed of a series of consumption, investment, employment, and production equations which relate a variable in the current time period to one or more variables in past time periods. The flow diagram in Figure 1 illustrates the steps in the simulation model. The various matrixes and related definitions are shown in Figure 2, and the equations of the system are listed in Table 1.

UNDERLYING ASSUMPTIONS OF THE SIMULATION MODEL

The basic underlying assumption of the model is that final demand drives the system over time. In the model any increase in demand from one time period to the next is immediately met with the required change in supply, at constant relative market prices, so long as primary resources are available.

The "change in inventory" portion of final demand is held at zero in the model, but could be used to make the model more accurately depict cycles observed in reality. Consumption demand by households is assumed to be a function of lagged income in diminishing importance.

Prices are constant in the model from one time period to the next, and input substitutions are not allowed by the producing sectors in any given time period. By incorporating the change in resource

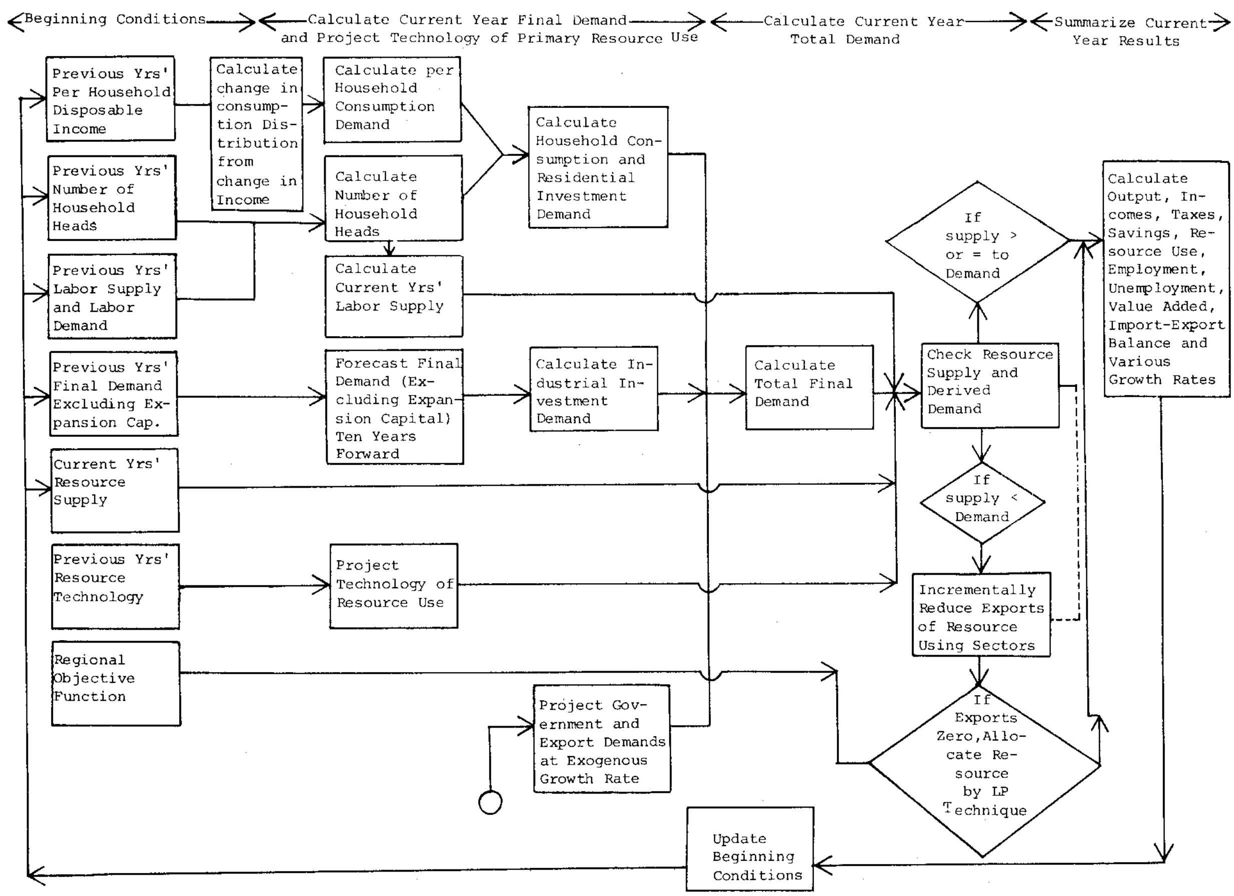

Figure 1. FLOW DIAGRAM

TRANSACTION MATRIX

	Indogenous Sector	Exogenous Sector	Row Sum
1	x^g_{11} x^g_{12} .... x^g_{1n}	Y_{1h} Y_{1s} Y_{1f} Y_{1e} DK_1	X_1
2	x^g_{21} x^g_{22}	Y_{2h} Y_{2s} Y_{2f} Y_{2e} DK_2	X_2
	X_{ij}	DK_i	X_i
n	x^g_{1n} x^g_{2n} x^g_{nn}	Y_{nh} Y_{ns} .... DK_n	X_n
Final	Z_{h1} Z_{h2} .... Z_{hn}	Z_{hh} Z_{hs} Z_{hf}	Z_h
	Z_{11} Z_{12} .... Z_{1n}	Z_{1h} Z_{1s} Z_{1f}	Z_1
Pay-ments	Z_{s1} Z_{s2} .... Z_{sn}	Z_{sh} Z_{ss} Z_{sf}	Z_s
	Z_{f1} Z_{f2} .... Z_{fn}	Z_{fh} Z_{fs} Z_{ff}	Z_f
	Z_{v1} Z_{v2} .... Z_{vn}	Z_{vh} Z_{vs} Z_{vf}	Z_v
	Z_{m1} Z_{m2} .... Z_{mn}	Z_{mh} Z_{ms} Z_{mf}	Z_m
Col. Sum	X_1 X_2 .... X_n	$\overline{H}$ $\overline{S}$ $\overline{F}$ $\overline{E}$ $\overline{DK}$	

Primary Resource Requirements

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1,nd} \\ r_{21} & r_{22} & & \vdots \\ \vdots & & r_{ij} & \vdots \\ r_{51} & \cdots & \cdots & r_{5,nd} \end{bmatrix}$$

Capital Requirements Matrix

$$K = \begin{bmatrix} k_{11} & k_{12} & \cdots & k_{1n} \\ k_{21} & k_{22} & & \\ \vdots & & k_{ij} & \\ k_{r1} & \cdots & \cdots & k_{rn} \end{bmatrix}$$

Household Tax Rates

$$TX = \begin{bmatrix} t_{f1} & t_{f2} & \cdots & t_{fm} \\ t_{s1} & t_{s2} & \cdots & t_{sm} \\ t_{11} & t_{12} & \cdots & t_{1m} \end{bmatrix}$$

Income Elasticity Coefficients

$$E = \begin{bmatrix} e_{11} & e_{12} & \cdots & e_{1m} \\ e_{21} & e_{22} & & \\ \vdots & & e_{ij} & \\ e_{n1} & \cdots & \cdots & e_{nm} \end{bmatrix}$$

A S S U M P T I O N S

(1) a_{ij} are constant over time.

(2) k_{ij} are constant over time.

(3) e_{ik} are constant over time.

(4) r_{ij} are constant over time with the exception of labor and land (r_{1j} and r_{3j}, respectively) which change with time to reflect changes in technology.

(5) Relative input and output prices are constant.

D E F I N I T I O N S

X_i = Gross Domestic Output of Sector i.

XN = X_i Vector plus $\overline{H}$, $\overline{S}$, and $\overline{F}$.

Y_{ih} = Purchases by Households from Sector i.

Z_{mh}, Z_{sh}, Z_{fh} = Purchases by Households from Imports and Taxes to Government.

Y_{is} = Purchases by State and Local Governments from Sector i.

Z_{ms}, Z_{ss}, Z_{fs}, Z_{hs} = Purchases by State and Local Governments from Imports, Governments, and Households.

Y_{if} = Purchases by Federal Government from Sector i.

Z_{mf}, Z_{sf}, Z_{ff}, Z_{hf} = Purchases by Federal Government from Imports, Governments, and Households.

Y_{ie} = Net Exports of Sector i Product, Including Exported Capital.

Y_i = $Y_{ih} + Y_{is} + Y_{if} + Y_{ie} + DK_i$ = Total Final Demand for Product of Sector i.

DK_i = Sector i Product Flowing to Capital Formation (Expansion Capital Plus Net Additions to Inventory).

Z_{mj} = Imports Used as Inputs by Sector j.

Z_{mh}, Z_{ms}, Z_{mf} = Imports by Households, Governments.

Z_{sj} = State and Local Government Tax Receipts from Sector i.

Z_{sh}, Z_{ss}, Z_{sf} = State and Local Goverment Tax Receipts from Households and Governments.

Z_{fj} = Federal Government Tax Receipts from Sector j.

Z_{fh}, Z_{fs}, Z_{ff} = Federal Government Tax Receipts from Households and Governments

Z_{hj} = Household Income from Sector j.

Z_{hh}, Z_{hs}, Z_{hf} = Household Income from Households and Governments.

i and j denote row and column in Transaction Matrix; i, j=1,....,n endogenous sectors.

np = n processing sectors plus final payment sectors.

nd = n processing sectors plus exogenous final demand sectors.

Figure 2. MATRIXES AND VARIABLE DEFINITION

Table 1. STEPS IN SIMULATING A REGIONAL ECONOMY

STEP 1. Compute Household Consumption Demand for Time, t

a) Compute population of heads of household

$$P(t) = P(t-1)\left[r(t) + \frac{L_R(t-1)}{L_A(t-1)} * UP\right] \qquad \text{(C-1)}$$

where:

P = population of heads of households, from Step 1 in (t-1)
r = natural population growth rate, exogenously determined
L_R = labor required, from Step 5 in (t-1)
L_A = labor available, from Step 5 in (t-1)
UP = unemployment factor

b) Compute per household total consumption demand

$$PC(t) = C\left[\frac{PDI(t-1)}{e^0} + \ldots + \frac{PDI(t-10)}{e^9}\right] \qquad \text{(C-2)}$$

where:

PC = total per household consumption demand
C = empirically determined constant
PDI = per household disposable income, from Step 5 in nine previous time periods.

c) Compute household consumption demand by sector (includes imports and services from households)

$$Y_{ih}(t) = \left[e_i\, w\left(\frac{PC(t-1)}{PC(t-2)} - 1\right) + 1\right] \frac{P(t)\, Y_{ih}(t-1)}{P(t-1)} \qquad \text{(C-3)}$$

where:

Y_{ih} = household consumption demand for processing sectors, household services, and imports
e_i = income elasticity coefficient
w = weight required to make $\sum_i Y_{ih} = PC$
i = 1,....n+2
n = number of processing firms.

STEP 2. Compute Industrial Investment Demand

a) Compute expected final demand ten years forward exclusive of private expansion capital

$$\widehat{YK}(t) = YK(t-1) + \left(\frac{\Delta YK_1 + \Delta YK_2 + \Delta YK_3}{3}\right) * RK \qquad \text{(I-1)}$$

where:

$\widehat{YK}$ = expected final demand ten years forward exclusive of private expansion capital
YK = Final demand exclusive of private expansion capital
$\Delta YK_1 = YK(t-1) - YK(t-2)$
$\Delta YK_2 = YK(t-2) - YK(t-3)$
$\Delta YK_3 = YK(t-3) - YK(t-4)$
RK = 10

b) Compute private investment demand, $\Delta K(t)$, (matrix notation)

$$\begin{bmatrix} X(t) \\ \hline \Delta K(t)' \end{bmatrix} = \begin{bmatrix} C & -E \\ \hline K & -I \end{bmatrix}^{-1} \begin{bmatrix} \widehat{YK}(t) \\ \hline \overline{K}_o(t) \end{bmatrix} \qquad \text{(I-2)}$$

where:

$\Delta K(t)'$ = private investment demand to meet expansion requirements for ten year projected final demand

$\Delta K(t) = \frac{1}{RK} * \Delta K(t)' \quad C = (I-A)$

K = capital expansion matrix
E = operator which subtracts $1/10\Delta K$ from output level X(t)
I = Identity matrix
$\overline{K}_o = K\,X(t-1)$
A = technical coefficients

c) Project Y_{F1}, Y_{F2}, Y_s, Y_L (Government Demands), and Y_e (exports) exogenously, at fixed annual rate of increase.

STEP 3. Compute Total Final Demand, Y(t), (matrix notation)

$$Y(t) = Y_h(t) + Y_{F1}(t) + Y_{F2}(t) + Y_s(t) + Y_L(t) + \Delta K(t) + Y_e(t) \qquad \text{(D-1)}$$

where:

Y_h is determined from Step 1
Y_{F1}, Y_{F2}, Y_e, and portions of Y_s and Y_L are exogenously determined
ΔK is determined from Step 2

STEP 4. Compute Sector Output Given Resource Constraints (matrix notation)

a) Compute output levels

$$X(t) = (I-A)^{-1}\, Y(t) \qquad \text{(P-1)}$$

subject to: $R(t)\; XN(t) \le L(t)$
$Y'(t) \le Y(t)$

where:

X = output of processing sectors i=1,....,n
I = identity matrix
A = technical coefficients
Y = final demand from Step 3
Y' = final demand supplied from LP solution
R = resource requirements matrix
XN = vector of sector output, X, household consumption, PC, and government expenditures, $\overline{Y}_{F1}, \overline{Y}_{F2}, \overline{Y}_s, \overline{Y}_L$
L = resource availability

If $R(t)\; XN(t) > L(t)$, reduce $Y_e(t)$, then if constraint is still operative, maximize $\sum_{j=1}^{n} VA_j$, subject to $R(t)\; XN \le L(t)$ where differences between $Y'(t)$ and $Y(t)$ is imported. Household consumption patterns are maintained as estimated in Step 1.

STEP 5. Compute Labor Available, Labor Required, Per Household Disposable Income, Savings, Taxes, Primary Resource Use, and Projected Primary Resource Availability (Matrix notation)

a) Compute labor and natural resource use

$$R(t)\; XN(t) = r \qquad \text{(R-1)}$$

b) Compute labor available, $L_A(t)$

$$L_A(t) = lp\; P(t) \qquad \text{(R-2)}$$

where:

lp(t) = labor force participation rate

c) Surface water supplies are exogenously determined from a hydrology simulation model.

d) Per household disposable income

$$PDI(t) = \left[\sum_j z_{hj}\, X_j(t) + Y_{hh}(t) + Y_{hF1}(t) + Y_{hF2} + Y_{hs}(t) + Y_{hL}(t) + Y_{he}(t)\right] - \left[Y_{Fh}(t) + Y_{sh}(t) + Y_{Lh}(t)\right] \div P(t) \qquad \text{(R-3)}$$

where:

$\sum z_{hj} X_j + Y_{hh} + Y_{hF1} + Y_{hF2} + Y_{hs} + Y_{hL} + Y_{he}$ = Total Personal Income

$Y_{Fh} + Y_{sh} + Y_{Lh}$ = Tax (t)

$$Y_{Fh}(t) = \left[e_F\left(\frac{PI(t-1)}{PI(t)} - 1\right) + 1\right] \frac{P(t)}{P(t-1)} \qquad \text{(R-4)}$$

$[Y_{Fh}(t-1)]$ = Federal Tax

$$Y_{sh}(t) = \left[e_s\left(\frac{PI(t-1)}{PI(t)} - 1\right) + 1\right] \frac{P(t)}{P(t-1)} \qquad \text{(R-5)}$$

$[Y_{sh}(t-1)]$ = State Tax

$$Y_{Lh}(t) = \left[e_L\left(\frac{PI(t-1)}{PI(t)} - 1\right) + 1\right] \frac{P(t)}{P(t-1)} \qquad \text{R-6)}$$

$[Y_{Lh}(t-1)]$ = Local Tax

e) Compute Household Savings

$$Y_{vh}(t) = PI(t) - Tax(t)$$

STEP 6. Summarize Regional Accounts from Steps 1 through 5

$PI(t-1) \div P(t)$ = Average Household Income from Step 5
$PDI(t-1) \div P(t)$ = Average Household Disposable Income from Step 5
$Y_{Fh}(t) + Y_{sh}(t) + Y_{Lh}(t) \div P(t)$ = Average Household Taxes from Step 5
$Y_{vh}(t) \div P(t)$ = Average Household Savings from Step 5
r = Resource Use, Including Employment from Step 5
ΔK = Private Expansion Capital from Step 2
X = Sector Output from Step 4

productivity within the resource requirements matrix, intermediate inputs are substituted for primary resources from one time period to the next as resource productivity changes. The change in productivity is just offset by the increase (decrease) in returns to ownership of the resource such that the technical coefficients (measured in base year dollar values) stay constant over time, but the physical quantities of resources relative to intermediate inputs diminishes (increases) as primary resource productivity increases (decreases).[2]

Population in the region is assumed to be a function of natural population growth rates and migration which responds to the ratio of labor demand to labor supply. If labor demand exceeds labor supply (by a fixed percentage), population is imported in the next time period. If, on the other hand, labor supply exceeds labor demand, population is exported in the next time period.

Resource constraints are incorporated by combining a linear programming framework with the input-output model. The assumption is that resource use will be shifted among users (beginning at the shortage point) in a manner appropriately described by maximization of the objective function. Maximum value added in production is taken as the objective, given constraints on consumption patterns by households and resource use by producers.

Resource shortages are treated under a variety of assumptions depending on the nature of the resource. Labor is assumed to be completely mobile and to migrate in and out of the region (or between industries) freely as output expands or constraints in response to changes in final demand and/or resource supplies.[3] The availability of water, petroleum, and natural gas may be treated under two assumptions. If a shortage of reserves occurs in the region, imports by the intermediate sectors may be assumed to increase. An alternative assumption (that imports cannot exceed base year or some other fixed level) can be investigated by way of the linear programming framework. Land use for urban purposes is assumed to grow proportionately with population, thus diminishing the total land available for agricultural purposes. As agricultural land requirements reach the land constraint point, agricultural exports are reduced until the constraint is satisfied.

MODEL CONSTRUCTION AND TESTING

Figure 3 shows the results of simulated versus actual for selected economic variables during the period 1950-1970 for a region in the north central portion of Texas [3]. These values were obtained by "fitting" the model to the data by estimating various growth parameters. The simulated variables include resource use (land, water, oil, and natural gas), employment, unemployment, population, and heads of households. In addition, the dollar value of output for selected aggregates of economic sectors is included in 1967 dollar terms. Personal income, taxes, and savings for households also were included. These simulations were obtained by beginning in the base year, 1967, and simulating backward to 1950 and forward to 1990. The numerical results are presented in the following Table 2 in the form of values of Theil's μ coefficient.[4]

USE OF THE SIMULATION MODEL IN ANALYZING WATER RESOURCE DEVELOPMENT QUESTIONS

To illustrate use of the model in analyzing water resource development questions, the technique was applied to the economy of the north central region of Texas in the analysis of three reservoir sites. The analysis required several steps. First, a hydrology simulation model was used to project (exogenous to the economic simulation model) a set of equally likely hydrologic sequences which allowed the estimation of various magnitude floods and water availability over time [4]. The economy was then analyzed with and without three water development projects. Without the policy under consideration, the data required to begin the simulation was the availability of primary resources without the policy, several years' lagged per capita income, prior year's final demand (excluding capital expansion), and parameter estimates from the fit of the model to historical data. The simulation was divided into flood

[2] Adjustments in the resource requirements coefficients do not, of course, completely handle the technology change problem since technology induced substitutions in the processing sectors will change the technical coefficients. One method of adjusting the technical coefficients is reported in a recent West Virginia study by Miernyk [2]. In his approach, future coefficients are based on current "best practice" firms in each industry. This procedure is currently being incorporated into the simulation model.

[3] This assumption would not be a very realistic one if the focus of the study was on specific industry and/or occupation impact analysis for the short term. In the long-term analysis presented here with the focus at the regional level, the assumption is better than an attempt to model interregional and intersectorial labor movements.

[4] Thiel's μ coefficient is a measure of "goodness of fit" of simulated values about actual variable values, relative to the variation in actual variable values over time – the smaller the μ coefficient, the better the fit.

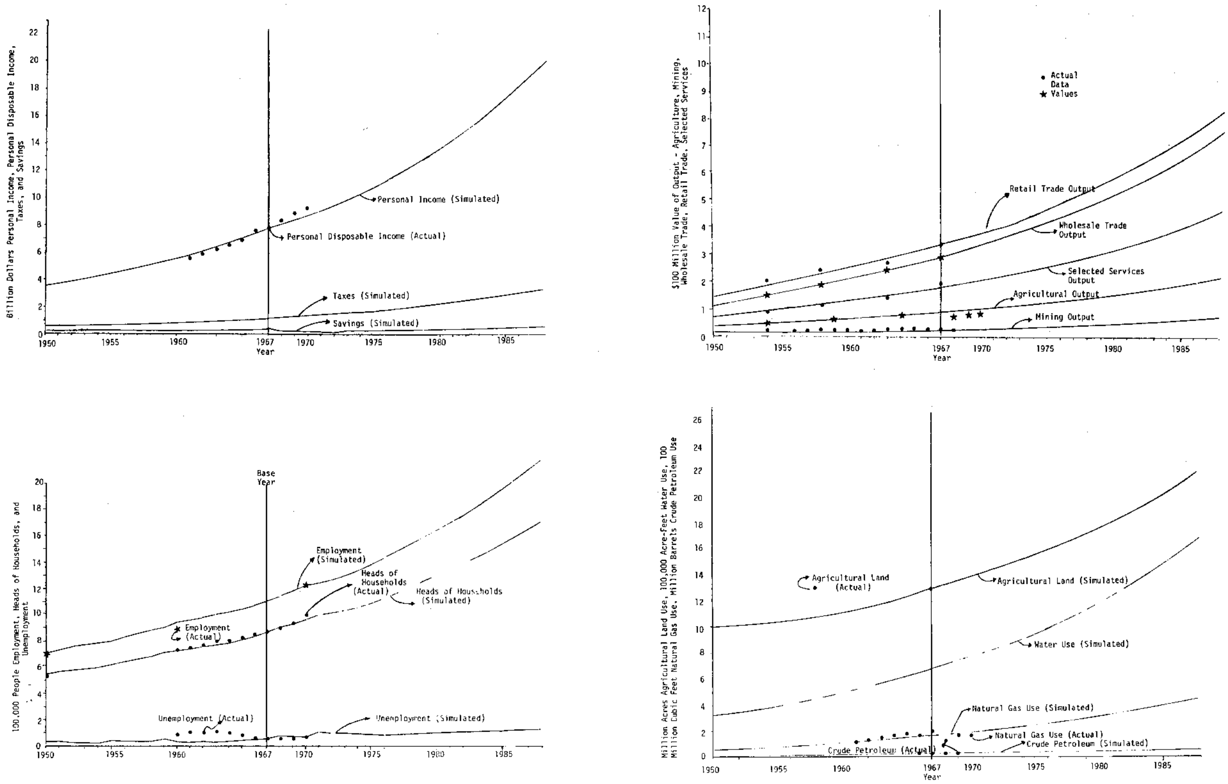

Figure 3. SIMULATED AND ACTUAL TRENDS IN ECONOMIC VARIABLES, NORTH CENTRAL REGION OF TEXAS, 1950-1985

Table 2. THEIL'S μ VALUES FOR SELECTED VARIABLES[a]

Variable	Theil's μ	Variable	Theil's μ
Population	.3039	Retail Trade Output	2.1607
Heads of Households	.3823	Selected Services Output	1.4044
Employment	2.2470	Wholesale Trade	.2983
Unemployment	11.1764	Petroleum Use	2.2300
Personal Income	.4400	Nat. Gas Use	3.4500
Agricultural Output	5.0430		

[a]Theil's μ coefficient is defined as: $\mu = \frac{\Sigma(A_t - S_t)^2}{\Sigma(A_t - A_{t-1})^2}$ where A and S are actual and simulated values, respectively.

and non-flood years.

In a non-flood year the simulation model components were assembled, and the steps outlined in Figure 1 were followed. For a flood year the capital stock was adjusted to reflect flood damages in each sector based on aggregate flood damage estimates by flood size as experienced in recent years [5]. The components of the simulation model were then assembled and the procedure followed as before. This procedure automatically incorporated the interrelated impacts of the flood damage, both intersectoral and intertemporal. Direct losses of output of the flood year were estimated and included. Water supply augmentation was estimated for each policy alternative, and water shortages were treated as specified above.

To analyze structural policy questions, alternative project designs in combination with

Table 3. **SELECTED ECONOMIC IMPACTS AND RELATED FEDERAL EXPENDITURES FOR BELTON, WHITNEY, AND LEWISVILLE RESERVOIRS, NORTH CENTRAL REGION OF TEXAS, 1950-1990, FOR SELECTED YEARS**

Year	Total Additional Personal Income a/ ($1,000 Dollars)	Additional Aggregate Value Added ($1,000 Dollars)	Additional Employment (1,000 Employees)	Federal Operation and Maintenance Expenditures b/ ($1,000 Dollars)	Federal Construction Expenditures b/ ($1,000 Dollars)
1950	5,801	5,983	1.318		12,073
1951	4,123	4,239	.933		9,475
1952	4,405	4,522	.992	38	8,144
1953	14,749	15,107	3.292	77	7,465
1954	32,304	33,024	7.147	223	4,173
1955	42,212	43,069	9.260	297	1,685
1956	55,009	55,966	12.063	319	768
1957	60,980	62,017	13.344	340	292
1958	57,242	58,215	12.471	396	152
1959	48,340	49,162	10.486	432	223
1960	43,420	44,158	9.379	515	355
1961	37,140	37,771	7.919	523	357
1962	36,202	36,817	7.574	587	454
1963	39,443	40,114	8.066	589	561
1964	45,759	46,537	9.170	621	463
1965	47,980	48,796	9.383	712	141
1966	51,850	52,731	9.914	820	151
1967	53,000	53,901	9.851	1,029	181
1968	50,020	50,870	9.095	960	286
1969	50,450	51,308	8.882	809	364
1970	54,112	55,032	9.196	834	254
1975	55,750	56,698	8.877	1,109c/	
1980	59,220	60,227	8.849	1,109c/	
1985	71,114	72,323	9.877	1,109c/	
1990	79,420	80,770	10.293	1,109c/	

[a]Estimated in 1967 dollars.

[b]Unpublished data on expenditures by reservoir, U.S. Army Corps of Engineers, Fort Worth District, adjusted by the wholesale price index for construction to 1967 dollars.

[c]Estimated to be the mean value for actual expenditures for 1970-1972.

optional operating rules were considered. The impact in the simulation model comes through the augmentation of primary resource availability and changes in the federal, state, and local government expenditures for the construction and operation of the structure(s).[5]

Recreation was included by valuing projected demand in terms of user days by the prices suggested by the Water Resources Council by type of recreation experience. Indirect effects were included in the simulation model by changing the consumption demand among sectors for each socio-economic group, thus automatically incorporating the change in consumption patterns in future time periods for recreation participants.

SIMULATION RESULTS

Several simulations were made to incorporate the effects from each function for each reservoir including recreation, flood control, construction, operations and maintenance expenditures, and water supply as shown in Table 3.

Construction activities did not affect the income stream for the region during the construction period as might ordinarily be expected, since construction sectors import a large portion of their inputs. The largest contribution to regional income was from exported recreational services. Water supplies in the region were adequate in both the with and without project cases, and consequently no impact was estimated for that function. Significant impacts on regional output distribution and total regional employment were estimated. The change in income distribution due to the relative change in industry output, also was measured but was insignificant.

Other information including 48 regional industry

[5]Only one structural alternative was analyzed in this example.

output and expenditure impacts were estimated, but space does not allow their presentation. Many alternative project formulations could be easily evaluated by estimating the time-distributed impacts for the region as an aggregate and for individual sectors for comparison under a range of assumptions.

CONCLUSIONS

This paper presents a model which is highly aggregated in some respects, but maintains the industry sector detail embodied in the input-output model to which it relates. Since it makes use of static technical and capital expansion coefficients, it has the usual difficulties of input-output analysis. Also, the assumptions involving labor movements will be unrealistic for some purposes. The model does, however, allow one to investigate a large number of alternative resource development questions for comparison, under assumptions of fixed relative prices, historical trends in technology of primary resource use, highly mobile labor, and changes in consumption distribution by households in response to income changes. Further development should include price mechanisms in industries of interest in order to simulate changing relative price influences and technical expansion capital coefficients which reflect technology changes.

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