A SIMULATION MODEL FOR PREDICTING AND ANALYZING MANPOWER REQUIREMENTS*

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In Oklahoma, manufacturing employment continues to grow, playing a crucial role in the state's economy. The proportion of state employment in manufacturing rose from 12 percent in 1960 to 15 percent in 1970. Since then, the growth rate of manufacturing jobs has been even greater [3]. In addition, many of the jobs created were in rural communities—from 1963 through 1971, 54 percent were located in communities smaller than 15,000 [2]. State and community leaders planning for future growth could benefit from a manpower analysis. State leaders need to insure a sufficient supply of manpower in appropriate occupations. Community leaders could benefit from a manpower analysis estimating occupational needs resulting from changes in local economic base.

OBJECTIVE

The major objective of this paper is to present a model which can (1) project future manpower requirements for the state and (2) analyze manpower impact caused by change in economic base. The model is different from others in that a detailed human resource account, allowing for a detailed manpower analysis, is included. Previous models concentrate on measuring total impact of change on employment. Only a few have specified occupation of the employed. Those that did used different methodologies and aggregated occupational categories.[1] For example, many previous models yield aggregate employment growth estimates and/or impact estimates but do not specify whether the jobs are for engineers, scientists, technicians, computer and other machine specialists, etc.

DATA AND INFORMATION SYSTEM

Because secondary data were more complete for 1967, it was chosen as base year. The economy was divided into 17 endogenous sectors and five exogenous sectors. Agriculture was divided into two sectors; mining, one; manufacturing, nine; and services, five. The five exogenous sectors consisted of federal government, state and local government, private capital formation, households and exports.

Data were organized into a social accounting system. The Oklahoma social accounting system includes four major accounts which are outlined by a flow chart in Figure 1. The system includes: a capital account, a human resource account, a government account and an inter-industry account. The latter is the system's base. Capital, human resource and government accounts are directly related to the inter-industry account.

The Inter-industry Account

As outlined in Figure 1, the inter-industry account of the Oklahoma social accounting system consists of three major parts: a transaction or inter-industry flow table, a direct coefficient table, and a direct and indirect coefficient table. The transaction table forms the base of the inter-industry account. Other tables are derived directly from it. Data from secondary sources such as 1967 Census of Agriculture, Oklahoma State Department of

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[1] For instance, Drummond and White [7] specified nine occupations and used different methodology.

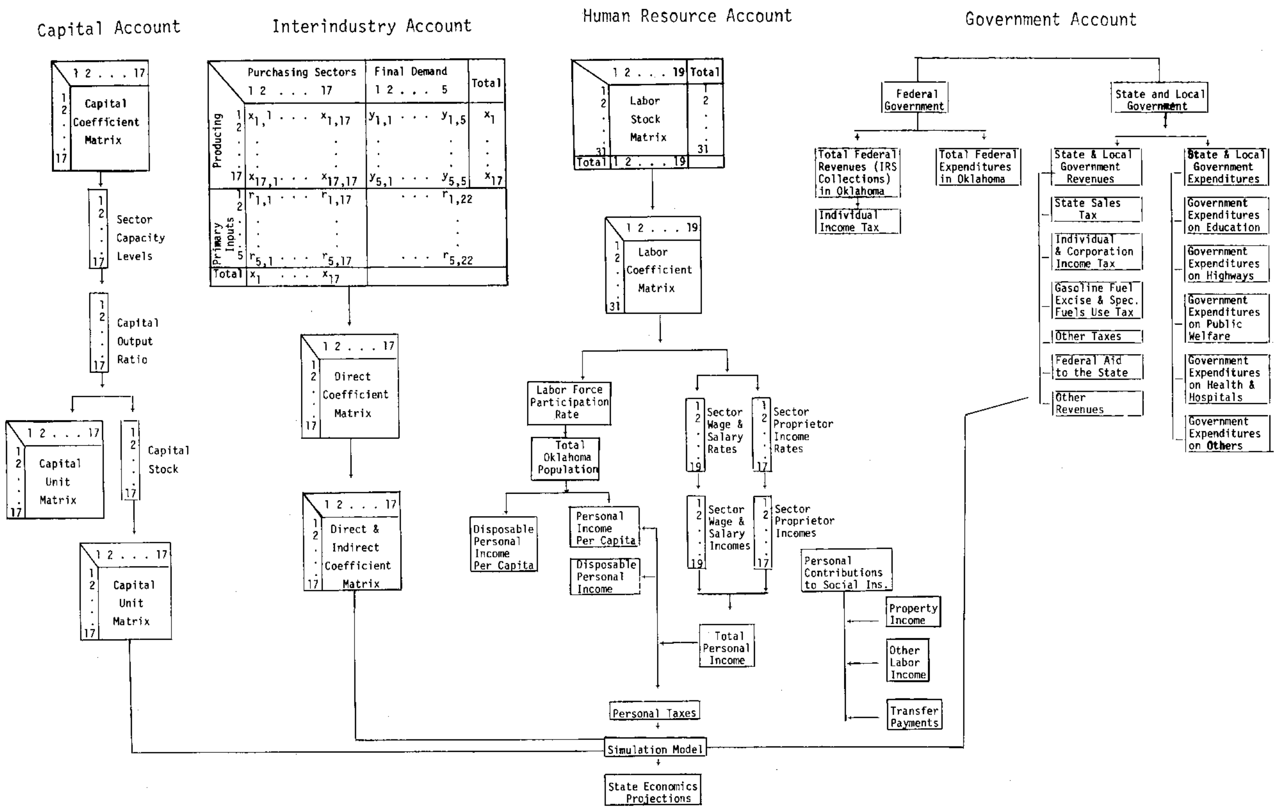

FIGURE 1. THE SOCIAL ACCOUNTING SYSTEM

Agriculture publications, Census of Mining, Mineral Yearbook, Census of Manufacturing, etc., were used to construct the transaction table.

Where secondary data were not available, either Polenske's model [15] or the national input-output model [17] were utilized. Exports and imports were derived as net. Thus, the transaction table reflected input and output flows of the Oklahoma economy.

The Capital Account

The capital account includes a capital coefficient matrix, sector capacity levels, capital-output ratios, capital unit matrix, capital stock matrix and depreciation rates. The capital coefficient matrix is the base of the capital account and is used in deriving many other matrices. Data for the capital account were based on a capital study completed for Oklahoma [5]. The data were adjusted to reflect 1967 prices as well as sector output.

The Government Account

In this study, government activities are analyzed in two sub-sections: federal government and state and local government (Figure 1). Both are further detailed into revenue and expenditure categories. Numerous federal and state publications were utilized as data sources.[2]

The Human Resource Account

Special emphasis was given the human resource account. The Oklahoma human resource account is formed around the labor stock matrix, which classifies labor force into 29 occupations for 19 sectors (Figure 1). Data for the labor stock matrix were obtained from unpublished data provided by the Oklahoma Employment Security Commission [13]. This source provided employment data on an eight-digit statistical industry code with 440 occupational categories. By combining similar type jobs, these were aggregated into 29 groups. In addition, industries were aggregated to reflect the 17 endogenous sectors of the model, a state government sector and a federal government sector.

The labor stock matrix indicates occupational mix for the 19 sectors. This matrix also provides total employment in each sector and the total employment

[2]For a complete presentation of data sources and data see [16].

in the 29 occupations. Rows were added to reflect total wage and salary employment and total proprietor employment, making a total of 31 in the labor stock matrix.

The labor coefficient matrix is derived from the labor stock matrix. Each coefficient here indicates amount of change in labor requirements in each occupation group as a result of a one-unit change in the total employment of that sector. They are calculated by dividing each entry in labor stock matrix by the column total. This matrix is used, along with output estimates and output-employment ratios, to project future employment by sector. Then, wage data etc. are used to estimate income, population and taxes.

MODEL

The simulation model is constructed around the input-output system of analysis.[3] It has strong ties to a lineage of regional simulation models by Maki, Suttor and Barnard [11]; Mullendore [12]; MacMillian [10]; Doeksen [4]; Byerlee and Halter [1]; Holloway [9]; and Ekholm [8]. These measure employment in the aggregate sense and do not specify occupations.

The simulation model is a series of difference equations, arranged in a recursive sequence, to describe dynamic behavior of a regional economy. In a recursive system, influences of exogenous and endogenous variables have an undirectional influence on resultant endogenous variables. The framework allows an explicit causal interpretation of any variable's effects on the system.

The Oklahoma simulation model involves 62 major equations. Many of these are disaggregated into sub-equations, one for each endogenous sector in the economy and for each occupation group. The entire system contains over 1,500 equations. The model's basic structure can be outlined in four steps.

1. *Estimation of final demand.* Final demand is divided into private capital formation, households, exports, federal government, and state and local government. Private capital formation is estimated by using the accelerator principle. Household demand is estimated using income elasticities. Exports are a function of national growth, whereas government expenditures are projected from income estimates and previous year's expenditure.
2. *Sector output.* Given final demand estimates, sector output is derived by multiplying them times direct and indirect coefficients. However, sector output estimates are constrained by available sector labor and capital.
3. *Model projection.* After estimating output, variables such as employment, population, income, government revenue, etc. for the state can be derived. For example, sector employment is derived by multiplying sector output times labor-output coefficients times one, plus annual rate of change in the labor-output coefficient. Rate of change variables, such as the labor-output coefficients, allow for technology to be introduced into the model.
4. *Manpower requirements.* Sector occupational needs are obtained by multiplying total sector employment needs times the labor coefficients for that sector.[4]

Although the model is quite large, it can be run on computer at a reasonable cost, thus allowing the researcher to measure impacts of various changes.[5]

EMPIRICAL RESULTS

The usefulness of the model to analyze manpower needs will be illustrated in two ways: (1) to project the state's future manpower needs and (2) to measure these needs resulting from change in economic base of a community or state.

Projecting State Manpower Needs

The Oklahoma Simulation Model projects manpower needs for Oklahoma from 1967 through 1985. Manpower needs of Oklahoma by occupation for selected years are presented in Table 1. This table is obtained by adding the number of employees in each occupation group for each sector for each year from 1967 through 1985. For instance, the projected numbers of wage and salary employees in Oklahoma in 1985 is: 13,513 engineers (occupation group 1); 3,483 scientists (group 2); 27,170 technicians (group 3); etc. Total number of employees is 1,140,230. Proprietors number 307,687. Total employment in Oklahoma in 1985 is 1,447,917. Only the total Oklahoma employment by occupation table is presented in Table 1. Similar tables—one for each endogenous sector, federal government sector, and state and local government sector are presented in [16].

[3] For a complete specification of the model and explanation of the information system see [16].

[4] Manpower demanded assuming stable prices.

[5] Costs per computer run are approximately $15. However, development costs of the simulation model and data collection are extremely large.

TABLE 1. PROJECTED MANPOWER NEEDS BY OCCUPATION FOR 1975, 1980 and 1985 FOR OKLAHOMA

	Occupation	1975	1980	1985	Est. Employment Change 1975-1980	Est. Employment Change 1975-1985
1.	Engineers (02)	11,747	12,377	13,513	630	1,766
2.	Scientists (04 + 06)	3,214	3,286	3,483	72	269
3.	Technicians (including health) (08 + 10 + 12)	20,419	23,146	27,170	2,727	6,751
4.	Computer & Other Machine Specialists (14 + 16)	6,992	7,461	8,149	469	1,157
5.	Economists, Planners & Teachers (18 + 20)	6,971	8,145	9,833	1,174	2,862
6.	Misc. Artists (22)	5,801	6,558	7,764	757	1,873
7.	Other Professional & Technical Workers (24 + 99)	32,346	36,095	41,414	3,749	9,068
8.	Financial Managers (02)	15,395	17,483	20,623	2,088	5,228
9.	Other Managers and Administrators (04 + 99)	67,634	76,201	88,148	8,567	20,514
10.	Sales Workers (00)	66,148	75,455	88,962	9,307	22,814
11.	Secretaries (02)	46,344	52,101	60,372	5,757	14,028
12.	Other Machine Operators (04)	8,023	8,869	10,132	846	2,109
13.	Other Clerical Workers (06-09)	121,885	134,994	154,332	13,109	32,447
14.	Construction Traders (02)	30,103	37,723	48,890	7,620	18,787
15.	Foremen (04)	16,514	18,013	20,453	1,499	3,939
16.	Metal Workers (06)	9,803	10,667	11,976	864	2,173
17.	Mechanics & Repairment (08)	36,899	40,278	45,433	3,379	8,534
18.	Printing & Trades (10)	3,218	3,625	4,224	407	1,006
19.	Electrical Workers (12)	6,619	7,004	7,685	385	1,066
20.	Other Misc. Craftsmen (14-00)	17,531	19,573	22,825	2,042	5,294
21.	Metal & Machine Shop Workers (02)	15,236	16,814	19,133	1,578	3,897
22.	Textile Machine Workers (02)	631	623	636	-8	5
23.	Final Processors (06)	9,900	10,804	12,242	904	2,342
24.	Misc. Operatives (08-00)	112,599	124,107	142,369	11,508	29,770
25.	Janitorial Workers (02)	19,723	22,604	26,697	2,881	6,974
26.	Food Workers (04)	40,559	46,878	55,884	6,319	15,325
27.	Personnel Service Workers (06 + 08 + 12 + 20)	37,320	44,643	55,200	7,323	17,880
28.	Public Service Workers (10)	53,236	60,309	68,747	7,073	15,511
29.	Laborers (00)	52,154	56,688	64,031	4,534	11,877
	Total Wage & Salary	874,964	982,524	1,140,230	107,560	265,266
	Total Proprietorship	245,998	269,345	307,687	23,347	61,689
	Total Employment	1,120,962	1,251,869	1,447,917	130,907	326,955

Estimated changes in total Oklahoma employment by occupation from 1975 through 1980 and from 1975 through 1985 are also presented in Table 1. Each entry indicates the change in employment of each occupation group in the corresponding year, compared to 1975. For instance, the demand for engineers and scientists is expected to be 1,766 more than the number in 1975. The largest demand for employment is expected to occur in other clerical workers, where 32,447 new jobs are expected by 1985. It is followed by miscellaneous operatives of 29,770; sales workers of 22,814; and other managers and administrators by 20,514.

The demand for wage and salary employees is expected to be 265,266 more than in 1975. Initially, this increase appears large. In percentage terms, it represents a 30 percent increase in wage and salary employment from 1975 through 1985. Historically, this is not unreasonable—from 1965 through 1975, wage and salary workers increased by 247,800—or 38 percent [14]. The increase during 1967 through 1975 can be explained by increased labor participation of women and by population growth. Also, 61,689 more proprietors are expected to be demanded by 1985, compared to 1975. Total employment is expected to increase by 326,955 in 1985 over that in 1975.

Occupational needs indicate additional jobs without regard to (1) labor turnover and (2) employee retirement. If number and age of workers in an occupation is high, this method does not predict the total number of employees needed.[6] Rather, it predicts the number above 1975 levels. Given an analysis of employee age level by occupation, others (planners, economists and educators) will be equipped to better plan manpower and education programs.

Measuring Occupational Needs of a Proposed Change

The simulation model can be used to measure changes affecting the economy. These range from measuring the impact of a proposed government program aimed at hiring the unemployed, to measuring that of a new plant locating in the state. For illustration purposes, consider the following. The army is considering constructing an ammunition factory at McAlester, Oklahoma. The proposed plant will take five years to construct and will cost 450 million dollars. When construction is completed, the plant will employ 1,200 workers. It was assumed construction would begin in 1976 and be completed in 1980, normal operations commencing in 1981.

Anticipated change in employment for each year is presented in Table 2. Since production is not assumed to begin until 1981, years 1976 through 1980 indicate the change in total employment resulting from construction activity. During construction years (1976-1980), four employment impacts are felt in the economy. These include: (1) direct construction effect, (2) indirect construction effect, (3) induced consumption effect and (4) induced capital formation effect.[7] The *direct construction effect* measures employment generated directly in the construction sector from constructing the plant. *Indirect construction effects* arise as the construction sector demands additional goods and services from other sectors, and employment increases in those sectors. The *induced consumption effect* occurs as construction workers have additional money to spend in other sectors and additional workers are hired to meet increased demand. The *induced capital formation effect* is the increased employment, arising as other sectors increase capital investment to expand capacity to meet new production demands. Employment generated from all effects are: 3,218 jobs in 1976; 5,327 in 1977; 5,644 in 1978; 5,159 in 1979; and 4,945 in 1980.

Years 1981 through 1985 indicate expected changes in employment mainly from the plant's operation. Impacts occurring during the period are effects of: (1) direct production, (2) indirect production, (3) induced consumption and (4) induced capital formation. The *direct production effect* measures employment generated directly in the sector due to increased production. The *indirect production effect* arises as the sector which increases production demands additional goods and services from the others, and hires additional workers. The *induced consumption effect* arises as increased production yields a greater amount of personal income and employment, due to additional household spending. *Induced capital effect* again arises as other sectors are induced to invest to expand production capacity, and thus create additional jobs. Total anticipated employment changes from these effects are: 4,041 jobs in 1981; 4,107 in 1982; 4,187 in 1983; 4,275 in 1984; and 4,358 in 1985.

TABLE 2. EMPLOYMENT GENERATED EACH YEAR FROM CONSTRUCTION AND OPERATION OF AN ARMY PLANT IN McALESTER, OKLAHOMA, 1976-1985

Year	Total Change in Employment
1976	3,128
1977	5,327
1978	5,644
1979	5,159
1980	4,945
1981	4,041
1982	4,107
1983	4,187
1984	4,275
1985	4,358

The impact of the ammunition plant on employment in Oklahoma is further analyzed in terms of manpower needs. Table 3 contains data which summarizes the results of this analysis. The occupational categories the jobs created directly, indirectly and induced are shown. Not only is total employment given by wage and salary employment and proprietor employment, but the occupation of the wage and salary job is given. For instance, in 1985, the expected increase in the number of: engineers (occupation group 1) is 51; scientists (occupation group 2) is 8; technicians (occupation group 3) is 75; etc.

[6] If demographic data were available for ages of wage and salary workers and proprietors, the model could be used to predict the number of replaced workers needed in each occupation. Likewise, if labor turnover data were available by occupation by sector, this could be incorporated into the model. Data availability limits incorporation of more detail into the model.

[7] For a more detailed discussion of induced capital formation effect, see [6].

TABLE 3. YEARLY EMPLOYMENT NEEDS BY OCCUPATION FROM CONSTRUCTION AND OPERATION OF AN ARMY AMMUNITION PLANT, OKLAHOMA 1976-1985

	Occupation	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1.	Engineers (02)	46	77	78	67	63	47	48	49	50	51
2.	Scientists (04 + 06)	5	9	9	8	7	8	8	8	9	8
3.	Technicians (including health) (08 + 10 + 12)	63	103	109	100	97	69	72	72	73	75
4.	Computer and Other Machine Specialists (14 + 16)	9	16	17	15	14	11	10	11	11	11
5.	Economists, Planners & Teachers (18 + 20)	15	26	29	28	28	19	21	20	21	22
6.	Misc. Artists (22)	13	22	25	23	22	21	21	21	21	22
7.	Other Professional & Technical Workers (24 + 99)	59	99	106	99	95	84	86	87	88	90
8.	Financial Managers (02)	34	61	68	64	61	51	51	52	53	54
9.	Other Managers & Administrators (04-99)	139	242	258	236	226	175	176	182	185	188
10.	Sales Workers (00)	104	213	241	226	214	205	198	206	213	215
11.	Secretaries (02)	92	156	168	157	151	124	126	127	129	132
12.	Other Machine Operators (04)	15	26	29	27	25	22	21	21	22	23
13.	Other Clerical Workers (06-99)	224	396	428	398	380	329	330	335	341	350
14.	Construction Traders (02)	310	496	508	458	446	185	201	207	214	220
15.	Foremen (04)	83	137	139	123	115	107	109	113	114	115
16.	Metal Workers (06)	91	147	144	123	115	70	72	73	75	75
17.	Mechanics & Repairmen (08)	81	145	155	140	132	113	112	116	118	120
18.	Printing Trades (10)	6	12	14	13	13	10	10	10	10	11
19.	Electrical Workers (12)	25	42	44	39	37	80	81	82	82	84
20.	Other Misc. Craftsmen (14-00)	71	118	123	111	107	75	77	79	81	82
21.	Metal & Machine Shop Workers (02)	161	258	254	217	202	91	95	97	99	99
22.	Textile Machine Workers (02)	3	4	4	4	4	31	32	32	32	32
23.	Final Processors (06)	45	75	76	66	62	116	118	120	121	123
24.	Misc. Operatives (08-00)	419	708	728	643	605	795	803	820	835	847
25.	Janitorial Workers (02)	42	71	77	73	71	62	64	64	65	66
26.	Food Workers (04)	62	124	142	135	129	100	96	100	103	106
27.	Personnel Service Workers (06 + 08 + 12 + 20)	91	151	171	169	167	121	126	125	128	133
28.	Public Service Workers (10)	22	38	42	39	38	41	42	42	43	44
29.	Laborers (00)	173	289	303	274	264	195	199	204	208	212
	Total Wage & Salary	2,503	4,261	4,489	4,075	3,890	3,357	3,405	3,475	3,544	3,610
	Total Proprietorship	625	1,066	1,155	1,084	1,055	684	702	712	731	748
	Total Employment	3,128	5,327	5,644	5,159	4,945	4,041	4,107	4,187	4,275	4,358

Miscellaneous operatives (occupation group 24) have the highest number of expected employment increase at 847 in 1985. Total wage and salary employment is expected to increase by 3,610; total proprietorship employment by 748; and total employment by 4,358 in Oklahoma in 1985.

With a manpower analysis, community leaders can not only determine an adequate number of workers, but whether or not skills of available labor force are adequate.

SUMMARY

The study summarizes a social accounting system and simulation model which permits a detailed manpower analysis. The social accounting system includes interindustry, capital, human resource, and government accounts. The human resource account contains information on 29 occupational groups for 19 sectors. The simulation model, built around the input-output system, enables the research to project future manpower needs and to measure the impact of changes in the economic base of a community or state. Both uses are illustrated in the paper.

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