APPLICATION OF SIMULATION TO REGIONAL AND COMMUNITY PLANNING

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Economic planning can assist policy makers in using available resources to improve the quality of life for rural and urban people. The objective of this paper is to illustrate how simulation can aid in regional and community planning. The paper will be presented in three main sections. First, economic planning and simulation will be defined. Second, empirical results of a regional simulation study will be presented. Third, empirical results of multi-county and community simulation studies will be discussed.

ECONOMIC PLANNING AND SIMULATION

Economic planning is defined as an organized, intelligent attempt to select the best available alternatives to achieve specific objectives. Regional, state, multi-county and local government leaders have their own interpretation of the elements involved in economic planning. One element common to all governmental planning units is the process of determining the objectives to be achieved, evaluating the means for achieving them, and taking the necessary action to reach the desired objectives. In short, economic planning is involved with increasing the efficiency of resources in meeting socially desirable objectives.

Simulation is defined as the use of a model to represent, overtime, essential characteristics of a system or process under study [8, p. 2]. In setting up the simulation framework, the system is given the initial conditions, parameters, and variables. The simulation model then generates values of certain preselected variables. These values, in turn, are used for the next time span and the model is rerun. Simulation allows the introduction of many relationships which conventional optimizing models may not. In this sense, simulation is a flexible technique for testing and evaluating a proposed system in a laboratory environment. Due to the complexity and interdependencies of the many relationships in a system, it takes an analytical tool as simulation to identify and quantify the many interrelationships of variables in a system.

EMPIRICAL RESULTS-REGIONAL

To illustrate how simulation can be used in regional planning, empirical results from the Oklahoma model will be used. This model has been used to project economic variables and to estimate impact parameters. The model was formulated around the basic Leontief input-output system.[1] The complete multiple sector recursive model consists of 51 major equations. The 12 endogenous sectors included in the Oklahoma study were two agricultural sectors (livestock and livestock products, crops), four manufacturing sectors (petroleum processing, agricultural processing, machinery and other manufacturing), one mining sector, and five service-type sectors (transportation, communication, and public utilities; real estate, finance and insurance; services; wholesale and retail trade; and construction.)

Projections of Economic Variables

Economic planning, to be effective, requires economic projections. Sidney Sonenblum and Louis Stein [10] emphasize the need as follows:

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[1] For a presentation of the simulation model see [4]. The model incorporates growth and development into the analysis through capital investment (capital-output ratios and changes in capital-output ratios), through human resource productivity (labor-output rations, changes in labor-output ratios, and changes in wage rates), and through current activity (changes in population, government expenditures, and exports). The input-output coefficients are assumed constant. Productivity changes were incorporated as explained above because an estimate of how input-output coefficients change over time is not available.

> One of the critical problems in planning at any level including state or regional planning, is to obtain internally consistent projections of relevant variables.

Data from the Oklahoma social accounts were used to simulate levels of state economic variables from 1963 to 1980. The simulated results obtained from the model are compared with published data from 1963 to 1970. Wage and salary employment by sector, proprietor employment, wage and salary payments by sector, proprietor income, disposable income, per capita income, gross state product, federal government revenue, and state and local government revenue are some of the economic variables which were projected. Figure 1 contains illustrations of the projections obtained from the model.[2]

Figure 1 contains estimates of total employment, proprietor employment and wage and salary employment. The solid line indicates values derived from the simulation model. The broken line shows the actual estimates as published by the Oklahoma Employment Security Commission. Total employment is projected to increase from 874,700 in 1963 to 1,347,645 in 1980. The simulated data from 1964 to 1970 are slightly higher than the published estimates. Wage and salary employment is projected to increase from 638,400 in 1963 to 1,094,841 by 1980. The projections are above the published estimates for 1964 and 65 and slightly below for 1968 through 1970. Proprietor employment according to the simulation model is projected to increase only slightly from 236,300 in 1963 to 252,804 in 1980. The simulation results are higher than the published estimates. The reason proprietor employment changes very little is that the decreasing number of farmers is offset by a slight increase in proprietor employment for the service sectors.

Impact Parameters

What will be the effect on the regional economy of the location of a new plant? What industry will create the greatest amount of economic activity per dollar invested in a given sector? What is the impact on the regional economy of increased government spending? Impact parameters or multipliers derived from a simulation analysis can be used to determine the total regional effects resulting from induced changes occuring in the region.

Income and Employment Multipliers. To trace short and long run income and employment benefits from private investment, the procedure was to assume a one million dollar investment by sector in 1970. Simulation runs were made for each endogenous sector.[3] The impact was measured in terms of new income and employment created in 1970 and through 1980. Listed in Table 1 are the income and employment multipliers.

The short run employment multipliers are listed in column (1). Each multiplier indicates the change in direct and indirect employment throughout the Oklahoma economy by a one-unit change in production employment in the specified sector. The petroleum sector has the largest employment multiplier at 7.25. The magnitude results from the sector's large interaction with other sectors, particularly mining and manufacturing. Agricultural processing has the second largest employment

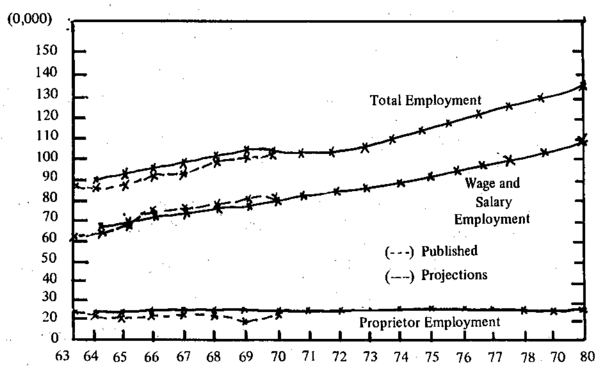

Figure 1. Total Employment, Proprietor Employment, and Wage and Salary Employment, Oklahoma

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[2] For a complete presentation of the income and employment projections see [4].

[3] For a presentation of the methodology involved in the procedure see [2].

Table 1
SHORT AND LONG RUN EMPLOYMENT AND INCOME MULTIPLIERS FOR OKLAHOMA

	Short Run Employment Multiplier	Long Run Employment Multiplier	Short Run Income Multiplier	Long Run Income Multiplier
Livestock and Livestock Products	2.37	2.05	2.89	3.28
Crops	1.24	.72	1.49	1.10
Agricultural Processing	6.29	6.25	4.10	5.55
Petroleum	7.25	6.25	5.27	5.78
Machinery	2.02	2.58	1.86	2.94
Other Manufacturing	1.87	3.13	1.79	3.78
Mining	2.12	2.10	1.87	2.02
Transportation, Communications and Public Utilities	1.54	1.65	1.42	1.41
Real Estate, Finance and Insurance	1.52	1.59	1.42	1.69
Services	1.30	1.62	1.32	1.99
Wholesale and Retail	1.29	1.56	1.34	1.98
Construction	2.36	2.57	2.24	3.19

multiplier at 6.29. This multiplier is interpreted to mean that for each man-year directly employed in processing agricultural products for delivery to final demand, a total of 5.29 additional man-years are generated throughout the economy.[4] Long run employment multipliers are listed in column (2). Each multiplier indicates the total employment generated in 1980 resulting from the one man-year production employment in 1970. Petroleum, agricultural processing, and other manufacturing have the largest long run employment multipliers at 6.25, 6.25, and 3.13, respectively. The long run employment multiplier for crops is 0.72. The less than unity multiplier reflects the rapid increase in technology used in the crop sector and the small amount of interaction with other sectors.

Short and long run sector income multipliers are presented in columns (3) and (4) respectively. Petroleum, agricultural processing, and livestock have the largest short run income multipliers. The petroleum multiplier at $5.27 indicates that for each dollar of production income directly generated, a total of $5.27 is generated throughout the economy. Sectors with the smallest income multipliers are services and wholesale and retail trade. Petroleum, agricultural processing, and other manufacturing have the largest long run income multipliers at 5.78, 5.55, and 3.78, respectively.

Investment Cost Per Job Created. To determine the number of jobs created per unit of capital, investment cost per 100 jobs created were derived for each sector. These costs are presented in Table 2. The cost to directly employ 100 men is presented in column (1). For example, to directly employ 100 men in the agricultural processing sector, $1,282,000 (1963 prices) must be invested in that sector. The wholesale and retail trade sector has the lowest short run investment requirements per 100 jobs. Following in second order is the service sector.

[4] Marginal changes in output and employment due to the additional investment are assumed equal to average changes for 1970. New output is assumed forthcoming from all indirect sources.

The direct investment costs per 100 jobs created directly and indirectly in the short run by industry are presented in column (2) of Table 2. These costs indicate the direct investment needed in a particular sector to create 100 jobs. Jobs are directly created in the sector receiving the investment; however, employment created by the interaction of sectors is also included. Thus, all sectors may witness an increase in employment. For example, if $204,000 were invested in agricultural processing, 100 jobs would be created throughout the economy in the short run. The agricultural processing sector has the lowest short run direct investment requirement per 100 men employed. Next in order are the construction, wholesale and retail trade and service sectors.

The investment cost per 100 jobs created in the long run are presented in column (3) of Table 2. In the long run, employment is increased directly, indirectly, and induced. Employment created by additional consumer spending is measured as the induced effect. Each figure in column (3) indicates the amount of direct investment required in 1970 to increase employment throughout the economy by 100 jobs in 1980. The agricultural processing sector requires $205,000 of direct investment in 1970 to create 100 jobs in 1980. Following this sector in order of increased investment costs are construction, services, and wholesale and retail trade.

Table 2

SHORT AND LONG RUN INVESTMENT
COST PER HUNDRED JOBS CREATED
OKLAHOMA, 1970

Sector	Cost Per 100 Jobs Directly Created in the Short Run (1)	Cost Per 100 Jobs Directly and Indirectly Created in the Short Run (2)	Cost Per 100 Jobs Created Directly, Indirectly and Induced in the Long Run (3)
	(Thousands of Dollars in 1963 Prices)		
Livestock and Livestock Products	1,695	714	826
Crops	901	724	1,250
Agricultural Processing	1,282	204	205
Petroleum and Coal Products	8,333	1,149	1,333
Machinery, Except Electrical	1,316	649	510
Other Manufacturing	1,219	654	389
Mining	3,125	1,471	1,492
Transportation, Communication And Public Utilities	4,167	2,703	2,500
Real Estate, Finance, and Insurance	1,250	830	787
Services	452	347	279
Wholesale and Retail	443	344	283
Construction	658	279	256

Table 3

INCOME AND EMPLOYMENT MULTIPLIERS RESULTING FROM CHANGES IN FEDERAL GOVERNMENT EXPENDITURES IN OKLAHOMA, 1971

	Income		Employment	
	Increase	Decrease	Increase	Decrease
Short Run	1.33	1.33	1.61	1.61
Intermediate Run	1.95	1.83	2.45	2.43
Long Run	1.62	1.62	1.97	1.97

Impact of a Change in Government Spending. The impact of government spending has greatly influenced the economic activity of regions in the U.S. The Oklahoma simulation model can be used to measure impacts of government spending. For example, let's assume a change in Federal government spending in 1971. The impacts measured would be the expected changes occurring in income and employment during 1971 and through 1980. For general discussion purposes, these impacts are discussed as multipliers and are presented in Table 3.

The multipliers are presented for an increase and a decrease in federal spending. The short run federal expenditures multipliers are 1.33 for income and 1.61 for employment. This means that if 100 men are directly employed from an increase in federal expenditures, an additional 61 men are indirectly employed. For each dollar's worth of income resulting from a change in federal expenditures in Oklahoma, an additional .33 dollar's worth of income will be generated in all other sectors.

The intermediate run period multipliers resulting from an increase in federal spending are 1.95 for income and 2.45 for employment. For a decrease in federal spending they are 1.83 and 2.43 for income and employment, respectively. In the intermediate run, the multipliers include direct, indirect, induced, and capital effects.[5] An expanding economy has a larger intermediate run multiplier as capacity has to be constructed to meet the new direct, indirect, and induced demands, whereas a declining economy (case where federal expenditures decrease) has a smaller multiplier as facilities are then operated at lower capacity levels. In the long run the multipliers include direct, indirect, and induced effects. The long run income multipliers is 1.62, whereas the long run employment multiplier is 1.97.

[5] For a discussion of the capital effect see [3].

Other Uses of Simulation in Regional Planning

The simulation model as constructed was used to establish a basic trend for the various economic variables. The above empirical results were derived by injecting changes in the economy at the present time and then measuring the effects through 1980. Additional uses of the simulation technique include: measuring the impact on revenue and expenditure of different taxes, evaluating various government programs, measuring the impact on labor needs of industrial expansion, and estimating future needs for public services.

The regional simulation model developed for Oklahoma is only a beginning illustration. Its major limitations are that it includes a small number of sectors, assumes constant production coefficients, and includes a limited number of equations. Additional research is needed to study, evaluate, and improve the model, thus making it more realistic and sensitive. In brief, there is still much to learn about the construction and use of regional simulation models.

EMPIRICAL RESULTS--MULTI-COUNTY AND COMMUNITY

To illustrate how simulation can be used in multi-county and community planning, empirical results from three studies will be discussed. Simulation studies by Clark Edwards and Rudolph DePass [5] and by Dean F. Schreiner and George Muncrief [9] will be used to discuss multi-county planning, whereas a study by Carl Swanson and Raymond Waldmann [11] will be used to illustrate community planning.

Multi-county Planning

Multi-county simulation studies have primarily been completed for two reasons. First, they have been completed to evaluate the effect of national or state policies on rural America. Second, they have been conducted to assist in providing adequate public services at least cost.

Policy Analysis. A simulation study by Clark Edwards and Rudolph DePass [5] was undertaken to evaluate the impact certain development policies would have on rural America. The study was conducted for all the multi-county planning and research areas, of which 109 areas were classified as urban and 373 as rural. A two-sector simulation model was constructed to estimate population, income, employment and net migration from 1970 to 2020. A basic trend was established during this period. Then, alternative runs were made to examine the sensitivity of the system to rural-urban policies affecting natural population increase, migration, job creation, and labor productivity.

Four development strategies were evaluated with the simulation model. These included gearing broad rural-urban policies towards: (1) migration, (2) the natural population increase, (3) aggregate demand for job creation, and (4) productivity per worker. The objective of the model was to evaluate the effects that policies related to these strategies would have in closing the gap between rural and urban development.

The results of the study indicate that the most promising policy action for the economic development of rural America is an expansion of nonfarm job opportunities. Some specific programs supported by this broad policy include providing information to firms seeking new locations, tax relief for firms locating in rural areas, wage supplements for creating new jobs, and providing loans to small business concerns.

The second best broad rural-urban policy according to the simulation analysis is increased labor productivity for rural workers. The recommended educational programs (also including job training, placement services, and extension activities) are aimed at raising the general educational level of the rural population and upgrading the skills of the labor force. Other program recommendations are aimed at upgrading the quality of the job through, for example, adopting new technologies.

Planning Public Services. Another example of multi-county simulation analysis is a study by Schreiner and Muncrief [9] on the planning of public services. Most policies influencing regional incomes are under federal and to some extent state control. Thus local decisions are usually programmatic in nature, involving efficient and equitable distribution of public services and financing burdens [6]. Hence, efficient planning of public services is probably the most important policy means available to sub-state and local decision-makers for obtaining local objectives.

A research project is presently being conducted at the Agricultural Economics Department at Oklahoma State University which analyzes a multi-county region in South Central Oklahoma.[6] The Objective of the project is to provide techniques which multi-county and local planners can use to assist in efficient physical planning. To illustrate this, completed research on the planning of solid waste disposal services for a multi-county region in Oklahoma is considered.[7]

Municipalities in the region have professional planners which have prepared plans for solid waste systems. One municipality suggested that two or more cities share a common facility. The Association of South Central Oklahoma Governments support a seven-county waste disposal system. These events suggest a need for comprehensive planning of waste disposal systems. A discussion of demand for solid waste disposal, data for development of solid waste multipliers and the application to comprehensive planning of area wide solid waste disposal services provides a good illustration of the uses of simulation on a regional level.

The Schreiner-Muncrief paper [9] centers around the estimation of demand for solid waste disposal services. Some factors affecting variation in demand for waste disposal are income, intergovernmental transfers, employment characteristics, population-age distribution, area size and density, and consumer preferences [7]. Variations in the needs for solid waste disposal services are conducive to estimation through coefficients of industry, household and institution generation of waste material. The study for the multi-county planning region in South Central Oklahoma used data from the U.S. Department of Health, Education, and Welfare [1, 13] and estimated a set of solid waste coefficients. These are given in column (1) of Table 4 and are averages for nine industry groupings.[8] Consider sector eight (food processing) for example. The sector generates annually 9.48 thousands of pounds of solid waste

[6] Dean Schreiner and George Muncrief, associate professor and research assistant, are responsible for the project.

[7] This section relies heavily on the paper written by Schreiner and Muncrief [9].

[8] A total of 33 sectors were included in the study, however, only nine are presented in Table IV.

Table 4
INCOME AND EMPLOYMENT MULTIPLIERS RESULTING FROM CHANGES IN FEDERAL GOVERNMENT EXPENDITURES IN OKLAHOMA, 1971

Oklahoma Industrial Classification	Solid Waste Coefficient (kpye)[b] (1)	Waste in Thousands of Pounds per year (2)	Direct and Indirect Solid Waste Disposal Coefficients (kpye) (3)
(1) Farms and Ranches	---[c]	---	1.771
(2) Agric. Services	7.620	9,357	12.848
(3) Mining	---[c]	---	2.604
(4) Cont. Construction	82.504	213,603	89.651
(5) Transportation and Storage	7.620	13,503	8.487
(6) Finance, Insurance and Real Estate	7.620	24,338	8.921
(7) Communication and Public Utilities	7.620	11,864	9.941
(8) Food Processing	9.479	8,825	14.672
(9) Textile and Apparel Mfg.	1.348	2,145	2.149

[a]Only 9 sectors are presented in the table, however 33 sectors were included in the Schreiner-Muncrief study.

[b]Pounds of solid waste material for disposal per year per employee.

[c]No waste coefficients were estimated for agriculture and mining since the type of disposal services required for these sectors is sufficiently different from the other sectors to warrant separate study.

Source: Schreiner and Muncrief [9, p. 23].

material per employee. Residential solid waste material has been estimated on a basis of average waste material per employee of resident work force.The total amount of solid waste estimated for each sector are presented in column 920. An estimated total of 787,063 thousand pounds of solid waste material was generated in Planning Region Nine for disposal in 1970.
material was generated in Planning Region Nine for disposal in 1970.

For planning future waste disposal requirements two approaches can be used. One approach is to use a simulation model and project employment by sector. From these projections, the planner could anticipate the amount of solid waste which would be needed for disposal each year. From this information he could develop or propose a system which would meet the expected waste disposal needs of 1975, 1980 or some future date.

Another approach would be to estimate the amount of waste material expected from a new industry locating in the region or community. This method was used for Oklahoma Planning Region Nine. In this case, direct and indirect employment interdependence coefficients were multiplied by the solid waste coefficients to arrive at the total disposal coefficients. These are presented in column (3) of Table 4. As an example of the interpretation of the total solid waste coefficients, sector eight shows that for each man-year of employment in that sector a total of 14.672 thousand pounds of solid waste is generated in producing sectors of the region. Residential waste generated may also be estimated by multiplying the employment multiplier for sector eight by the household solid waste coefficient. Hence, for each man-year employed in food processing, a total of approximately 10.5 tons of solid waste is generated. By relating solid waste coefficients to direct and indirect employment requirements, specific industy and location factors for solid waste generation are identified for the planning region. The figures in column (3) of Table 4 yield solid waste multipliers resulting in the short run from increases in production in a sector. The simulation model would also indicate intermediate and long run effects.

Community Planning

Simulation studies for communities have mainly been conducted for urban areas. A good illustration is a study completed by Carl Swanson and Raymond Waldmann [11]. The simulation model was for Grand Rapids, Michigan and was used to project economic variables and to analyze future labor needs. The model incorporated feedback between population and employment sectors to determine population, migration, job changes, labor force, participation rate change and industrial location and growth.

The simulation analysis concluded that skilled people would more than likely be exported from the community unless action was taken to create jobs for them. The model also described the future labor situation to firms thinking about locating in Grand Rapids. The community model could also be used to describe to what degree different industry mixes would be sensitive to the business cycle.

The Grand Rapids simulation model did not include government, education and land use. Including these sections in the model would permit an analysis of the impact on revenue and expenditure of different taxes and an evaluation of government programs. A land use and concentration section would be a valuable asset in planning land use needs and zoning. Again, as discussed with the solid waste study in Oklahoma, the future need for public services could be predicted. Then cost models could be used in conjunction with these projections to efficiently provide these public services.

SUMMARY AND CONCLUSIONS

The objective of the paper was to illustrate how simulation can aid in regional and community planning. Empirical results of regional and multi-county simulation studies were presented. Regional applications included projections of economic variables and an impact analysis. The impact discussion included presenting income and employment multipliers, deriving the investment cost per job created, and measuring the effect of a change in government spending. Multi-county and community applications of simulation were concerned with determining the impact national policies have on multi-county districts and with planning public services.

The paper was intended to exemplify how simulation can be a tool to assist in regional and community development. It is not *the* tool, but rather one which may be combined with other tools. For example, in the case of planning public services, cost models would have to be combined with simulation projections to arrive at an efficient plan. In this context, the author envisions simulation as a core model with many subsidiary models. The core model would provide major inputs for the subsidiary models.

The simulation studies presented in this paper assumed current conditions would continue and projected key economic variables. Then, alternative strategies were injected into the models and the changes each strategy had on the key economic variables were measured. The results of the strategies are then compared and the best strategy was selected. If each strategy consists of a government program aimed at reaching rural development objectives with the least amount of public funds, the simulation technique alone may not select the optimal program or combination of programs. Most simulation models do not include an optimizing technique. The author suggests that future researchers might want to incorporate an optimizing technique into some simulation models.

An optimizing model aimed at obtaining maximum efficiency with limited public funds is proposed by Tweeten [12]. His proposal is directed at finding the optimum combination of programs to maximize net income of a region with limited public funds by means of programming type model. By combining a programming model and a simulation model, the optimizing technique of the programming model would be incorporated into the analysis as well as the flexibility and dynamic aspects of the simulation model. Additional research is needed to determine the most efficient use of available resources in regional and community planning.

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