A SIMULATION MODEL FOR RURAL COMMUNITIES IN OKLAHOMA

By

MICHAEL DENTON WOODS

Bachelor of Science
Arkansas Tech University
Russellville, Arkansas
1975

Master of Science
University of Arkansas
Fayetteville, Arkansas
1978

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Thesis Approved:

Thesis Adviser

Dean of the Graduate College

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CHAPTER I

INTRODUCTION

Need for the Study

Decisionmaking for community development takes place at various spatial and political levels in the United States. Nationwide decision-making is usually concerned with aggregate national economic variables such as national employment, income, and inflation. Regional decision-making usually occurs at the state or sub-state level with the state government or county government providing leadership. There are many community decisions, however, which are important at the municipal or community level. With population and industrial growth in rural areas, local governments are seeing changes in local job situations, government budgets, and community service requirements. The planning of community services often involves large capital investments (water systems, hospitals, schools, etc.) and thus, it is important to obtain the best estimated of employment, income and population that are possible. Eddleman (1974) emphasizes the need for information when making community service decisions. Alternative policies and different courses of action need to be considered when planning for the provision, financing, and operation of public services.

To summarize the importance of community decisionmaking, particularly relating to services, three points can be noted: (1) limited resources are available to provide municipal services, (2) municipal services directly influence the quality of life, and (3) municipal services have present and long run implications (Shaffer, 1978).

One useful tool for decisionmakers in the area of community development is simulation analysis. What will be the results of, say, a change in the community's existing economic base? A simulation model would allow decisionmakers to receive some estimate of the results of various decisions and policies. Of course, to aid economic and demographic planning, the model should also provide baseline predictions or estimates based on past experience with no new impacts. For the model to be useful, it should: (1) be readily available and usable, (2) provide the most reliable estimates possible, and (3) provide information over time (Doeksen, 1979a). An important link can be developed between a community simulation model and community service budgets (i.e., fire service budgets, water system budgets, etc.). If a simulation model can be programmed to generate a reasonable estimate of the need for a particular community service, then such a model can greatly aid in planning for local growth (Nelson, 1979).

Rural Communities in Oklahoma

Large city governments such as Tulsa or Oklahoma City usually have their own planning staff and other resources necessary for planning community growth. Smaller cities and towns often do not have the personnel to gather the information and conduct analysis. For decision-makers in the smaller communities, this study will be most useful.

In Oklahoma, municipalities are classified in the following manner. Incorporated places with less than 1000 inhabitants are called towns whereas those with 1000 inhabitants or greater are called cities.

Three forms of government are possible: mayor-council, council-manager, and strong-mayor. Cities with a population greater than 2000 may adopt a charter and choose any form or combination of forms of government. Unincorporated communities are called villages and are not classified, for census statistics, as units of government. Other sub-county local governments in Oklahoma include special districts for conservation purposes, water systems, fire protection, hospitals, etc., and school districts.

Oklahoma has 77 counties in the state. The Census of Government for 1977 lists 567 municipalities, 406 special districts, and 625 public school districts in the state. Oklahoma ranks seventeenth among states in the number of local governments with 1675. This study is concerned primarily with local municipalities and the services they provide to the local population. The terms community, city and municipality are often used interchangeably.

Unemployment for the state of Oklahoma was 3.4 percent in 1980 and is the same level that was recorded for 1970. The Oklahoma Employment Security Commission (1981a) notes the 1980 figure is well below the national average of 7.1 percent. Unemployment increased nationally from 4.9 percent in 1970 to the 1980 figure of 7.1 percent. As reported by the Oklahoma Employment Security Commission (1981b), the U.S. Bureau of Census lists the state population as of April 1, 1980 to be 3,025,266. This represents a net gain since 1970 of 18.2 percent. This figure is also above the national average of 11.4 percent. Preliminary reports of 1980 counts are presently available for counties and cities. Between 1970 and 1980, 68 counties in Oklahoma increased in population. This is compared to only 38 counties increasing in population for the period 1960-70 with 39 counties experiencing a population decrease for that period. The largest gains in population came in the four Oklahoma Standard Metropolitan Statistical Areas. However, many smaller cities experienced population growth. Economic expansion in the mineral industry, as well as other industries, occurred throughout the state. Preliminary census figures, analyzed by the Oklahoma Employment Security Commission, indicate that nine counties in Oklahoma experienced population declines. These counties lie along the northwest border of the state and the southwest corner.

It is obvious that different economic and demographic situations exist in various geographic sections of Oklahoma. For a model to be useful, it should be adaptable to the various local settings, yet be as specific as possible for each community. The community of interest as well as the surrounding service area should be analyzed as economic boundaries often do not follow given governmental boundaries. Baseline projections measuring natural growth are needed as well as projections which measure the impact from a change in the economic base. A community simulation model should be able to provide for both needs.

The Objectives of This Study

A community specific simulation model for rural communities in Oklahoma does not exist. Local decisionmakers need reliable information concerning the costs and benefits associated with growth in their community. A simulation model for a community could provide useful baseline projections as well as impact information concerning various policy alternatives in the private and public sectors.

In general, the objective of this study is to develop and test a community simulation model. The model would utilize specific community data when available yet need not be completely reestimated for each community. Default data would be utilized when specific community data are not available.

Specifically, the objectives of the study are to:

1. Develop a methodology for constructing social accounts which are applicable to specific rural communities. The social accounts include:
   A. An Economic Account
   B. A Capital Account
   C. A Demographic Account
   D. A Local Community Service Account
   E. A Local Community Revenue Account
2. Develop a simulation model which will:
   A. Project output, employment, income, population, and other relevant variables in the community for future years
   B. Relate the economic and demographic projections to the public sector. This includes community service requirements and estimates of local government revenue.
   C. Provide estimates of structural parameters such as income and employment multipliers by industry sector
   D. Provide impact analysis of the effects on the community system of various public and private policy alternatives

The accounts will provide the data and form the respective modules for a simulation model. The model can then provide the desired baseline and impact projections.

CHAPTER II

BRIEF REVIEW OF SOCIAL ACCOUNTING SYSTEMS, COMMUNITY MODELS, AND COMMUNITY SERVICE BUDGETS

Simulation involves the development of a model that represents a real world situation over time. Social accounts organize the data necessary for a socio-economic simulation model. The simulation model consists of a set of equations describing the relationships among variables contained in the model. Baseline projections and impact projections for economic and demographic variables are provided by the community model. Community service budgets provide information on the costs of alternative delivery systems for individual community services.

Social Accounting Systems

A social accounting system can be used in economic and demographic analysis to describe and analyze a given economic system. For a given community, Clayton (1977) defines community growth as changes in employment and resident population. Growth can be measured in physical terms as net dollar effects on the public and private sectors. Community or regional growth is closely linked to the basic sectors that export goods and services outside the community. However, other factors such as retirement and tourism may contribute to growth in a region. Clayton describes community growth as follows:

> Total growth in a community thus consists of the employment and resident population effects of primary industry growth, service industry expansion, primary or indirect commercial development and primary or indirect residential development (1977, p. 63).

Social accounts provide a data base for analyses of community growth. Leven (1961) describes a social account as a tool that can be used in the analysis of a particular question. Social accounts break observable phenomenon into a discrete number of parts. In constructing the various components or accounts in the system, the interdependence exists within the separate accounts and among accounts. A system of social accounts forms a basic set of empirical data. The data are then utilized in a simulation model. Examples of useful accounts are economic, demographic, and fiscal accounts representing a complete system.

Social accounts are constructed for many spatial and political levels. National accounts are constructed using nationwide data and are concerned with problems at the national level. Income and product accounts are one form of national accounts which measure income, final product, consumption, and capital accumulation. National accounts are discussed fully in the literature (Kendrick, 1972).

Of more interest for regional economists are studies at the subnational level. Richardson (1969) notes that while national accounts usually analyze questions of short-run cyclical stability, regional accounts are frequently used to analyze long-run secular trends or to answer questions concerning what happens to growth in an individual region over time. Richardson states that the regional concept is not necessarily a clear one. Size of regions may vary in terms of population or geographic characteristics. Political boundaries and economic boundaries are not necessarily coincident at the regional level. When developing a regional account, the openness of the region must be considered. Imports by economic sector are important. Also, in most cases the federal government will be an exogenous force. When constructing regional accounts, the availability of adequate data is also a most practical concern. Regional accounts can be considered to be a link between empirical data and economic theory.

Richardson (1969) lists two uses for regional accounts. One, the accounts provide a base of information for decisionmaking by public and private agencies. Two, the accounts provide a framework for impact evaluation. Any regional system is an "open" system with external forces operating on the economy. The impact evaluation capability is important for decisionmakers trying to plan and implement policy.

Much previous work has been done in describing the methodology for constructing regional accounts (Level, 1961; Bernard, 1969; Hirsch and Sonenblum, 1970). The early work in this area need not be repeated except to emphasize that the accounts contain data to be used for decisionmaking, not data that are indiscriminately collected (Hirsch and Sonenblum, 1970). The accounts are integrated into a system or simulation model that notes the interdependence among the variables. This type of interdependence or linkage was presented in early work by Perloff and Level (1964). Simulation models have the ability to trace the effects throughout the accounts of a change in a selected account.

Brief Review of Community Models

Impact models describe economic and demographic changes which affect both the public and private sectors. Determining the results of rapid growth or decline provides better information for decisionmakers. Most impact models are ex ante in nature, providing projections before the impact occurs. The alternative is ex post impact analysis which describes the impact after it has occurred. Obviously, ex ante projections are most useful for planning, while ex post models add empirical and theoretical foundations to the body of knowledge on impact modeling. With shifting population, economic change and energy development, reliable ex ante impact models are very useful.

Many types of models and methodologies have been developed. These range from economic base analysis to complicated community simulation models. Shaffer and Tweeten (1972) present an early version of an impact model developed to measure the impact of new industry on rural communities in Oklahoma. The model uses partial budgeting to determine the net gain (loss) to the community resulting from an outside impact. Primary or direct effects of a new industrial plant such as jobs and wages are considered. Also, secondary impacts as measured by multipliers are considered. Shaffer and Tweeten (1972, p. 61) note, "The reduction of the scope of economic activity carried on in an area reduces the size of the multiplier."

The study also notes the difficulty of estimating the indirect and induced effects at the community level because there are no published rural community input-output tables. The Shaffer-Tweeten model contains three sectors: private, municipal government, and school district. Benefits and costs are accounted for in each sector. The model is general in application and easy to use. Two conclusions reached by the authors are that industrial impacts vary over different economic sectors, and the impacts will differ among communities. The model is a single period tool with no dynamic time considerations.

Ford (1976) presents a computer model that is designed to describe the impacts of locating large power plants near small, isolated communities. Small towns in the Western states that experience this type of impact generally go through an initial "boom" period with rapid expansion. Following the initial construction phase, the economic and demographic changes will often level off. Public service capital and economic activity are often expanded to support the rapid population growth putting a strain on the public sector. Following completion of the energy project, a "bust" period often follows. Tax revenues decrease and the local government is often left with excess capacity in the public sector. The BOOM1 model provides economic, demographic, public service, and fiscal projections of the proposed impact (Ford, 1976). A series of feedback loops are utilized to provide more dynamic projections from year to year.

Clayton and Whittington (1977) present a community model developed for use in the state of Florida. The model is an ex ante evaluation of the impacts of community growth. Output includes employment and population change resulting from an outside impact such as a new industry. Private sector impacts include such variables as direct, indirect and induced sales from the impact being analyzed. Public sector impacts include projection of local revenues and expenditures. A net fiscal surplus (deficit) is calculated along with a break-even assessment ratio. City, county, and school district levels of government are included. The Florida model emphasizes user access with default data provided when local data are unavailable. This type of data avilability increases the usefulness of the model and allows more timely analysis.

An early version of the Colorado Population and Employment Model (CPEIO) is presented by Monarchi and Taylor (1977). The model includes population and employment projections as well as some public service projections. Yearly projections for the baseline, construction, and operation phase are included. The economic portion of the model is built around the input-output model while the population portion of the model utilizes an age-specific cohort survival technique. The CPEIO model is notable because it demonstrates an adaptation of a model developed by Hamilton et al. (1969). The model emphasizes the interaction between population and employment. Feedback loops are used in both models to cause various sub-systems or accounts to affect one another.

As has been previously noted, many methodologies are available for impact analysis. However, there are some standard procedures that appear in many models. A useful summary of various assessment practices is provided by Chalmers and Anderson (1977). The study was primarily prepared to recommend procedures to project the economic, demographic and community facilities impacts of Bureau of Reclamation water resource development projects. However, the manual is useful for models constructed for various purposes. The manual provides a survey of current practices and common procedures that appear in many impact models. Baseline projections of economic and demographic variables are discussed. Procedures for projecting employment such as input-output techniques and economic base studies are reviewed. Techniques for projecting population such as the cohort-survival technique are reviewed. Impact analysis is included and notes direct, construction, and operation phases of a project. Community facilities, services and community revenue are also discussed. The manual provides a good summary of the current methodologies used in impact analysis.

Runyan (1977) provides another very good review of tools and models used for impact assessment. The article by Runyan, in the Journal of the American Institute of Planners, presents 12 techniques that are used in community impact assessment, ranging from a simple checklist to very complex models. The methods are discussed in terms of usefulness and data requirements. Runyan lists three criteria in judging the usefulness of various techniques.

1. The technique should be simple to facilitate ease of preparation and time commitment;
2. The technique should not rely on a complex data base; and
3. Use of the technique should provide new insight and information for local analysis, not a repackaging of already available information.

The combining of various techniques to increase model flexibility is emphasized by Runyan. An impact model should provide decisionmakers with a wide range of information and a conceptual framework for addressing a given problem. The techniques noted in the article include a simple checklist to identify significant impact areas and focus the problem. A second technique involves IMPASSE, an impact assessment game that structures group discussions. Group members cover various impact results through discussion and interaction. Dialectical scanning is another group technique where an experienced moderator leads the issue discussions. A fourth technique is the Delberg technique which is another version of group discussion where participants are required to list their ideas on expected impacts. The Delphi technique emphasizes the opinion of "experts" concerning various issues. The Delphi technique provides a wide range of information on complex issues from individuals with possibly differing opinions.

The first five techniques listed by Runyan, as can be seen, are discussion orientated. The remaining techniques are more empirically orientated and include surveys, trend extrapolation, cost-benefit analysis, cost effectiveness analysis, cross impact analysis, simulation modeling, and input-output analysis. The important consideration when choosing among alternative techniques is to provide useful information to aid in solving the problem at hand. It is expected that group discussion and interaction can best be facilitated if the decisionmakers have empirical results to refer to. Technical experts, such as Cooperative Extension personnel, can explain much of the implications of growth and development if they have a good model to refer to.

A model has recently been developed in North Dakota which meets many of Runyan's criteria. It is designed specifically to measure the impact of energy developments (Hertsgaard et al. 1978; Leistritz et at., 1979). The model provides annual projections for key variables, both impact and baseline projections. Impacts of energy resource development was measured for employment, population, settlement patterns, school enrollments, housing requirements, and public sector costs and revenues. Like the Clayton (1977) model for Florida, the North Dakota model is built around input-output techniques and results. Output is provided at state, county, and city levels, as well as for school districts. The model is notable for emphasizing user capabilities. Also, the complex process of interfacing economic projections with population growth is well documented.

When discussing impact models, a technique frequently mentioned is input-output analysis. As noted, both the Florida model (Clayton and Whittington, 1977) and the North Dakota model (Hertsgaard et al., 1978) are built around the input-output technique. Input-output models describe the flow of goods and services in an economy. Most input-output work is based on the early work of Leontief (1960) with the national economy. Richardson (1972) presents a detailed discussion of the application of input-output analysis to regional economics. Assumptions of input-output analysis include fixed technical coefficients and no errors of aggregation. The fixed coefficient assumption, implying no change in technology, is generally acceptable for predictions over a reasonable length of time. Errors of aggregation are reduced by using the most disaggregate data available. The sectoral detail and interrelationships provided by an input-output model generally outweigh any constraints produced by model assumptions. In a study of industry in Oklahoma, Blalock (1980) found the input-output model provided detailed and precise projections that were useful when conducting interindustry analysis.

Many adaptions of previous models are now being used. Monts and Bareiss (1979) present a community-level impact projection system, CLIPS. The model developed for the state of Texas, draws from many previous studies and methodologies including the North Dakota model (Hertsgaard et al., 1978). CLIPS was developed to provide baseline and impact projections for large-scale economic activity such as the construction of a power plant. CLIPS uses trend-extrapolation or past growth rates to project the baseline changes in a region. The model uses a "step-down" methodology in that regional projections are compared to single community projections. Population growth for communities within a region must sum to the regional population total. The model is written in FORTRAN computer language which is generally transferable among computer systems. Interactive programming is provided through a time-sharing system that makes the model more user oriented.

Another model adaptation for the state of Texas is provided by Andrews (1980) and Murdock et al. (1980a). This model is an adaptation of the North Dakota regional impact model. The Texas model provides essentially the same output as does the North Dakota model. The authors note special considerations of model adaptation (Murdock and Leistritz, 1980a). Data sources and alternative estimating techniques should be carefully considered. The adaptation effort should not be taken lightly as the authors note time frame differences may not be too different between initial development and the adaptation effort. If possible, a member of the team building the original model should be included in the adaptation effort. The main point made is that adaptation is a major effort, and the staff undertaking such as effort should be prepared to commit appropriate time and effort.

As a final reference to model adaptation, the Virginia model for impact analysis is noted (McNamara and Brokaw, 1979/1980). The model provides results of economic impacts on rural communities and utilizes the previous work of both Shaffer and Tweeten (1972) and Clayton (1977). Net fiscal impacts on the local economy are the primary results.

Bender and Parcels (1980) provide a fresh look at modeling efforts and structural changes in rural areas. The authors note that structural changes such as increased demand for service activities, changes in transportation systems, the relative cost of transportation, and the changing function of cities and towns have not been included in working models. The regional or local level economy should be treated as a subset of the national economy with all the linkages and interdependencies. Increases in relative incomes, labor force participation, and service activities should be included in impact models when possible.

Murdock and Leistritz (1980b) present a review of selected impact models. The paper's intent is to provide users with a base of information and criteria for selecting a specific model for use. Geographical units, time dimensions, project phases, data requirements, and ease of use are all considered for several widely used models. The authors note that methodologies used are often similar but user characteristics differ. Some models are highly user oriented and flexible while others are not. Three criteria for evaluation of various models are given.

1. Information requirements of what data does the user need to supply? Data requirements can make some models inoperable. Also, the output will be determined by the input data. Geographic levels and time periods are important determinants of the usefulness of the model.
2. Methodological considerations are determinants of the reliability of a model. For example, using age cohorts for population prediction are generally more reliable than those with less detail. The model should be able to project changes over time, should incorporate key structural dimensions of the question at hand, and should use feedback loops to update baseline figures. The interrelations of various components of the model should be included.
3. Use characteristics relate to the availability of model output and the associated costs. The tradeoff between more accurate locally collected data and the cost of collecting this data

should be considered when developing the model. Finally, key parameters such as the size of the impact project, birth rates, and per capita service usage should be easily altered to increase model flexibility.

The authors conclude that a major effort of model developers in the 1980's should be validity checks of their models by using data provided by the 1980 census.

Much additional work can be done to improve modeling efforts. Temple (1980) notes that most impact models are equilibrium models. But boomtown growth is a disequilibrium process where the construction phase does not allow instant adjustment. Increased participation rates and migration rates often alter the local economy and the adjustment may be quite slow. The length of the disequilibrium phase is important as the adjustment process may eventually return the impacted region to a more stable level. Temple presents several disequilibrium models and dynamic models that might be incorporated in present modeling techniques.

Fox (1980) discusses the development of impact models from a user's viewpoint. Governments at all levels are faced with decisions that would be greatly aided by the development of these model forecasts. Fox emphasizes the fact that user confidence will be enhanced by more accurate and useful models, thus increasing clientele support for model builders. For users to utilize models to the best advantage, they need to understand the basic model assumptions and structure. If information is clearly communicated to the users, then less misinterpretation will occur. Users should be encouraged to ask as many questions as necessary to understand the model.

Review of Community Service Budgeting

For many local governments, a primary responsibility is the provision of public services. Some local services are capital intensive (water and sewer systems) while others are more labor intensive (police protection, education). In any case, projections of service requirements over time provide useful information for local decision-makers. A useful impact model will relate economic and demographic change to the public sector.

Hirsch et al. (1974) note that providing information to local governments to increase efficiency is important:

> Since a strong case can be made that a major objective of local governments should be to allocate their resources efficiently in the service of their constituents, steps taken to increase the productivity of their activities can be quite appropriate (p. 146).

Hirsch is referring to large local governments in his discussion. He notes they have many citizens and complex decisions to make. It can be argued, however, that smaller local governments face complex problems as well. In addition, the smaller governments have less information and fewer resources to work with.

Schreiner (1974) notes two objectives in planning for rural public sectors:

1. What is the expected number and spatial distribution of jobs and people in rural regions in future time periods?
2. What is the expected form and quality of community services that will be desired over a planning period?

A useful model would largely satisfy these two objectives if it provided employment, income and population projections over time for a given community as well as community service needs.

When considering the provision of community services, the nature of public goods should be noted. Local government services often have some or all of the following interrelated characteristics (Hirsch, 1970). Services are produced collectively and jointly consumed. Pricing in this case becomes difficult. The "free rider" problem arises. Local government services also can exhibit externalities in consumption. In this case, impacts occur that are not exerted through the market. Distributional or welfare considerations also come into play. Often zero or nominal pricing occurs to aid specific groups such as the poor or the aged.

In competitive markets, prices send signals to producers and production costs are considered. Consumers consider the price of goods and thus transmit their demand preference. Demand and supply considerations become complex with public goods when price signals are weak or absent. In the absence of information on price response for community services, some estimate is necessary of community service requirements over time. Often population and income are important variables related to the level of service requirements.

A supply function for local services would relate service costs to output. Marginal cost and the concept of profit maximization does not readily apply to local government's provision of services. Hirsch (1970) notes that local government supply functions cannot readily be derived from a marginal cost function. Instead of a function relating quantity supplied to dollars, often supply is measured in terms of quality. Increasing the quality or type of service provided is considered a shift in supply. Community service supply and demand considerations can include many of the topics listed when considering public goods.

Useful information related to the provision of community services can be obtained from budget studies. This technique is discussed by King and Wall (1977) and involves developing a financial report for specific services. The budgets include cost and revenue information, often for alternative delivery systems used to provide a given service. The budgets include a section on initial capital outlay and a section on operation expenses. Budgets, for example, might provide capital and operating expenses for providing various types of fire protection. Alternatives include different types of equipment and vehicles, various labor and employment options, and alternatives for financing the service.

The budgeting technique borrows heavily from farm management work. Budgets provide a basic data base to answer practical questions for decisionmakers. In the case of public services, however, we refer to public goods provided by local governments instead of a private farm firm. The budgets need to be continually modified and updated to provide the best use.

Mackey (1976) has developed budgets for water, fire protection, police and health services and other services using an engineering approach. Similar budgets have been developed for Oklahoma using survey methods.

In Oklahoma, the demand for health care and ambulance services have been shown to relate to specific age and sex characteristcs of a served population (Dunn and Doeksen, 1979, 1980; Doeksen et al., 1975). Demand for water service is related to the number of commercial and residential users (Goodwin et al., 1979). Demand for fire protection has been shown to be related to population, land area, number of vehicles, and businesses in the service area (Childs et al., 1977).

Demand estimate techniques and cost estimates for alternative service systems are available in Oklahoma. For a summary of the community services that are analyzed, see Doeksen and Nelson (1981).

The important link is to relate the economic and demographic projections of the simulation model to specific community services. Estimates of need over time allow planners to anticipate situations where capacity is strained. If problems with a specific service are indicated, then budgets are available for detailed analysis. For example, Doeksen et al. (1979b) present a breakdown of capital and operating costs for community clinics in Oklahoma. Existing methods for estimating costs of community service systems can be used to calculate the expected costs of system expansions.

Overview of the Oklahoma Model

The simulation model for rural Oklahoma communities draws from previous work. A system of social accounts was developed to empirically describe the economic-demographic system of a community. The social accounts provide input data for a simulation model which describes interrelations among the various accounts and variables within the accounts. The accounts included in the simulation model for Oklahoma communities are:

1. An economic account which describes interindustry transactions and employment and income growth;
2. A capital account which provides information on capital structure and capital expansion for the economic sectors;
3. A demographic account which utilizes an age-sex cohort survival technique to project population;

4. An account for projecting requirement levels of various community services; and

5. A community government revenue account.

The simulation model is built around the economic account. The driving force incorporated in the economic account is the input-output model. It measures the processing and movement of commodities by industry sector. The input-output model is made community specific through the use of a location quotient technique. The social accounting system and the localized input-output model are described in detail in the following chapter.

The simulation model is composed of a set of equations describing the relations between variables in the model. The model is recursive in nature, each year's projections depend on the projections of the previous year. Economic variables projected annually include employment and income by industrial sector. Population is also projected by age and sex cohorts.

The Oklahoma simulation model relates the growth of economic and demographic variables to community service requirements. What will be the level of use for medical services, fire protection, schools, water systems, sewer systems and solid waste service if growth occurs as the model projects? The projections in the model are community specific, making the results very useful.

CHAPTER III

THE OKLAHOMA COMMUNITY SOCIAL ACCOUNTING SYSTEM

The community simulation model provides baseline and impact projections of economic and demongraphic variables. The accounts provide the data base for the simulation model. The social accounts included in the model are: an economic account; a capital account; a demographic account; and local government accounts for community services and revenue. An overview of the community social accounting system is presented in Figure 1.

This chapter describes the accounts that are used in the simulation model. However, before discussing each individual account, area delineation or spatial considerations are discussed.

Area Delineation

When describing economic activity within a community, the concept of an "open" region must be noted. In general, the smaller an area is the more that area depends on the outside world. Often, people will live in one location and work at another. Even with the relatively high transportation costs of the past several years, many people still rely heavily on the automobile. It is obvious that the political boundaries of a community, the city limits, do not necessarily define the economic boundaries for that community. In the United States, larger cities have experienced the commuter phenomenon for years.

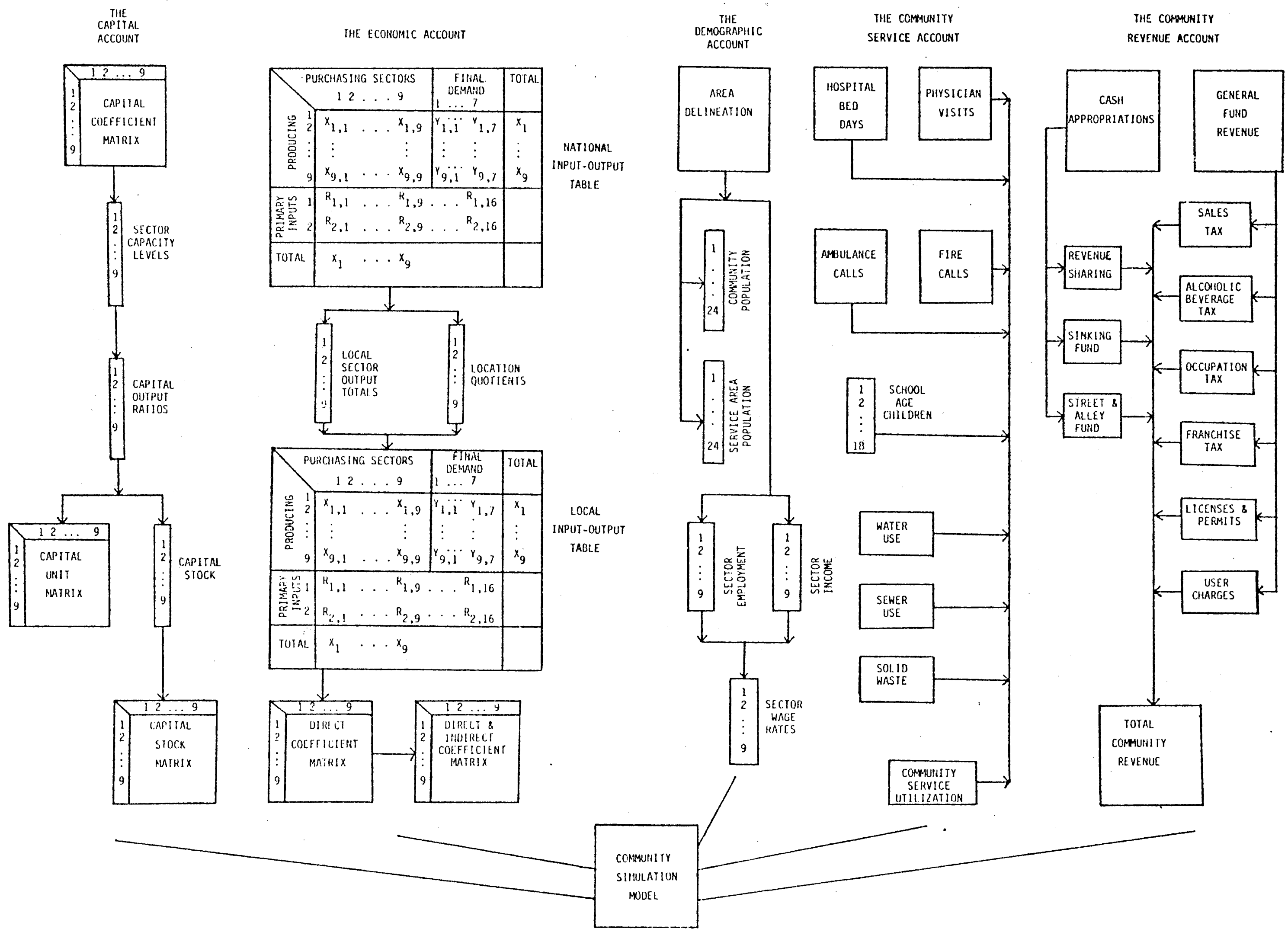


Figure 1. Overview of the Community Social Accounting System

People drive to work in the city, utilize city services, then often take a large part of their paycheck home to suburban areas. This affects the fiscal support for the community and the level of service provision. In rural communities, a similar but smaller scale pattern exists. To clearly understand the economic and demographic characteristics of a community some measure of the outlying service area is necessary.

The economics of the community and the surrounding periphery are related. There are several factors that affect the influence or pull that a community has including: distribution of population; distance to competing communities; and the transportation network. Lonsdale (1966) conducted a commuting study in North Carolina and found that commuting distance defines a laborshed area which provides labor to some central point. Lonsdale used a series of probability models based on gravity concepts to determine the importance of population and distance on commuting. The study found that commuting varied directly with population and inversely with distance from a given point.

The data requirements for the simulation model for rural Oklahoma communities includes some measure of employment by place of work. This means a measure of the number of employees in a community work force, no matter where they live. Also a measure of the total population both in and surrounding the community is desirable as people have service demands no matter where they work.

Collection of primary data for each community is infeasible due to time and cost constraints. A gravity model was chosen to aid in estimating a community's service or trade area, thus estimating population and employment. When utilizing gravity models, the region or area is thought of as a mass. Certain principles govern the mass and determine the activity of particles within the mass. Early work in this area relating to the movement of people can be found with Zipf (1946). Reilly (1929) also related the concept to the study of retail business patterns.[1]

In more recent work, Grimes (1970) utilized a form of gravity model to test the hypothesis that the number of workers drawn by the Oklahoma City air material area (OCAM) near Tinker Air Force Base is a function of commuting distance between the county of residence and OCAM and the population of the county. The model employed was:

$$C_i = \frac{kP_i}{D_i^b} \tag{3.1}$$

where C_i = number of labor force employees from county i,

P_i = the population of county i,

D_i = the commuting distance between the center of i and OCAM,

k = a constant, and

b = the exponent of D determining the level of influence of distance.

The model results indicated that the population variable was positively related to the number of employees while the distance variable had a negative relation. Other factors such as wage rates, intervening opportunities, and geographic or transportation characteristics were also noted to be important.

Carroll (1955) describes a form of gravity model that can be used to measure the influence of a city. Carroll begins by stating:

> . . . any city exerts an influence on persons and organizations outside of its boundaries. The magnitude of this influence will depend on two things: first, the size of the city exerting the influence, and second, the distance

---

[1]A complete discussion of gravity models and spatial interaction is found in Isard (1960).

> from such city of the affected persons or organizations. This involves a simple formulation in which the power or influence of the central city is proportional to the city size and varies inversely as the distance over which this influence acts (p. D2).

The attractive power of a city can be described with the following equation:

$$UI_a = (K) \frac{P_a}{(f)D} \qquad (3.2)$$

where UI_a = the attractive power of city A,

P_a = the population mass of city A,

D = a variable measure of distance,

(f) = the unknown rate at which increments of distance modify the urban influence, and

(K) = some constant to balance the equation.

Carroll notes that for the concept of a city's influence to be measured, the term influence must be defined. The idea of different cities performing a pyramid of functions is used. There is a heirarchy of city sizes, with a given city size providing a certain set of services. There exists a level of interdependence between the city and the surrounding hinterland. The outer limit of a city's influence is then the point where the magnitude of the city's influence on the hinterland population is equal to the magnitude of a competing city's influence. This concept is concerned with the measure of influence for functions that are carried on in both cities which are serving the hinterland. Thus, Carroll is describing a system where a trade area or service area exists for any city, noting that most cities perform a standard set of functions. Diversity of functions is related to city size and population.

To determine the point of equal influence for any pair of cities the following formulation is used:

$$\frac{P_i}{D_i^x} = \frac{P_j}{D_j^x} \tag{3.3}$$

or

$$D_j = \sqrt[x]{P_j/P_i}\ D_i \tag{3.4}$$

where P_i, P_j = population masses of cities I and J respectively,

D_i, D_j = distances from the respective cities to the point of equal influence, and

x = exponent showing the effect of distance.

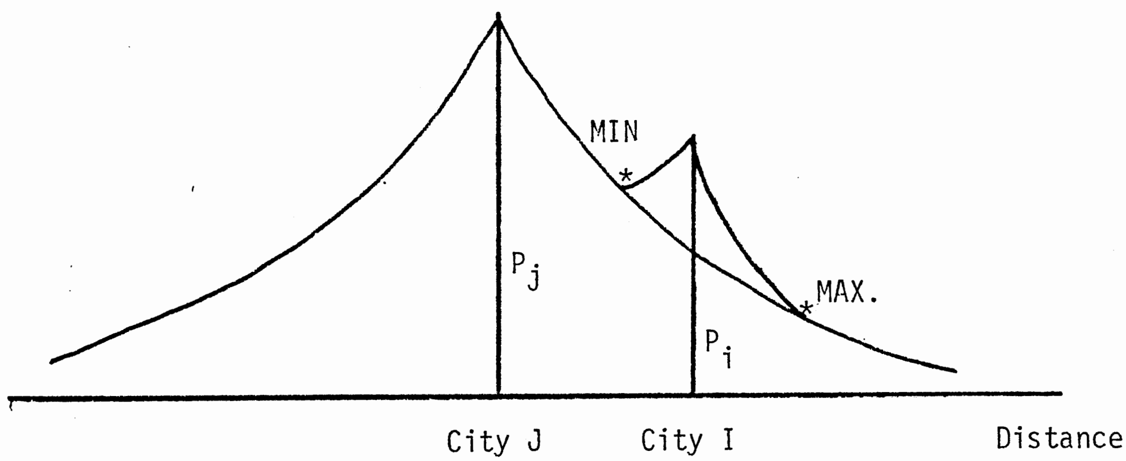
The relation of two competing cities is shown graphically in Figure 2. The areas of influence for cities I and J are shown as tent-like figures. The height or influence of the cities is directly related to the population of the cities, and influence declines with distance at some empirically determined rate. The example shown in the figure is for a larger city and a smaller city. The points describing the smaller city I's area of influence will fall inside the area of influence for city J. The two cities are compared only for functions or services that both cities provide. The equal points of influence will form a circle around the smaller city. Two points on the circle can be determined using the following:

$$D_i + D_j = K_{ij} \quad \text{to determine the minimum point,} \tag{3.5}$$

and

$$D_j - D_i = K_{ij} \quad \text{to determine the maximum point,} \tag{3.6}$$

where K_{ij} = the distance from city I to city J, and



Source: Carroll (1955).

Figure 2. Proportional Influence for Two Cities

D_i, D_j = the respective distances from city I and city J to the minimum and maximum points of equal influence.

To find the minimum point of indifference between two cities then equations (3.4) and (3.5) can be combined:

$$D_i = K_{ij} - D_j \tag{3.7}$$

and

$$D_i = K_{ij} - \sqrt[x]{P_j/P_i}\ D_i \tag{3.8}$$

or

$$D_i = \frac{K_{ij}}{1 + \sqrt[x]{P_j/P_i}} \tag{3.9}$$

Using the above described relationship and information on population and distance to competing cities, the area of dominant influence for a given city can be plotted. Carroll (1955) conducted this type of analysis for Flint, Michigan. The value for the exponent on distance is one source of controversy. Zipf (1946) proposed a value of one which minimizes the effect of distance and emphasizes population. Reilly (1929) used an exponent of two. Carroll (1955) found that an exponent of three provided more realistic results. However, the same basic relation between distance and population holds.

To determine the service area for rural communities, a modified version of Carroll's model was used. Points of indifference or equal influence are calculated for a given community and surrounding competitive communities. If, for example, four points of equal influence can be determined for a community, then a boundary of influence or service area can be estimated. Figure 3 describes this type of relationship. City I is located near the center of the box shaped figure representing a county boundary. Cities A, B, C, and D are

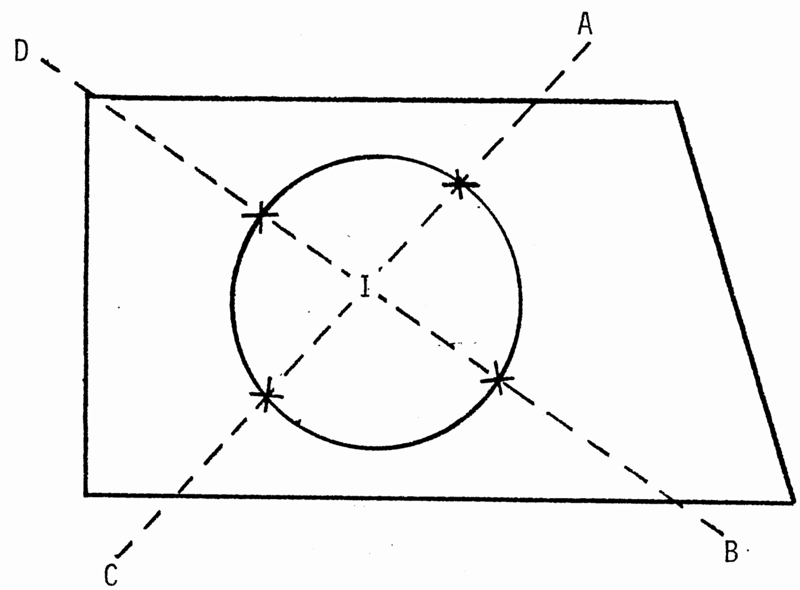


Figure 3. City Service Area When Compared to Competing Cities

located at various distances from city I. If equation (3.9) is used to estimate equal points of influence between city I and the four competing communities then a boundary is established.

The boundary for a community service area was empirically estimated for the simulation model by using a coordinate mapping system. The competing communities are given a set of locational (x,y) coordinates describing their respective locations. The community of interest has the coordinates (0,0). The coordinates are scaled in miles and thus, provide a distance measure. By applying distance and population information to equation (3.8) the boundary for the community service area is estimated. The four points forming the boundary can be used to estimate the area inside the boundary. Using three points at a time, two triangles can be formed which approximate the service area. The following formula from Hodgman (1959), is then applied to the coordinates for the boundary points of the two triangles to compute the number of square miles (A) inside the service area:

$$A = \tfrac{1}{2}\left|X_1Y_2 - X_2Y_1 + X_2Y_3 - X_3Y_2 + X_3Y_1 - X_1Y_3\right| \tag{3.10}$$

where the vertices of the triangle are X_1,Y_1; X_2,Y_2; and X_3,Y_3.

The example presented in this study is Holdenville, Oklahoma. In order to develop a simulation model for Holdenville, an initial step is to estimate the Holdenville service area. This provides useful information about the economic activity of the area and aids in estimating employment, income, and population levels to be used for Holdenville and the service area. The geographic location of Holdenville and four competing communities is shown in Figure 4. Using a standard highway map, coordinates were plotted with Holdenville having the center location of 0,0. The relevant information is shown in Table I.

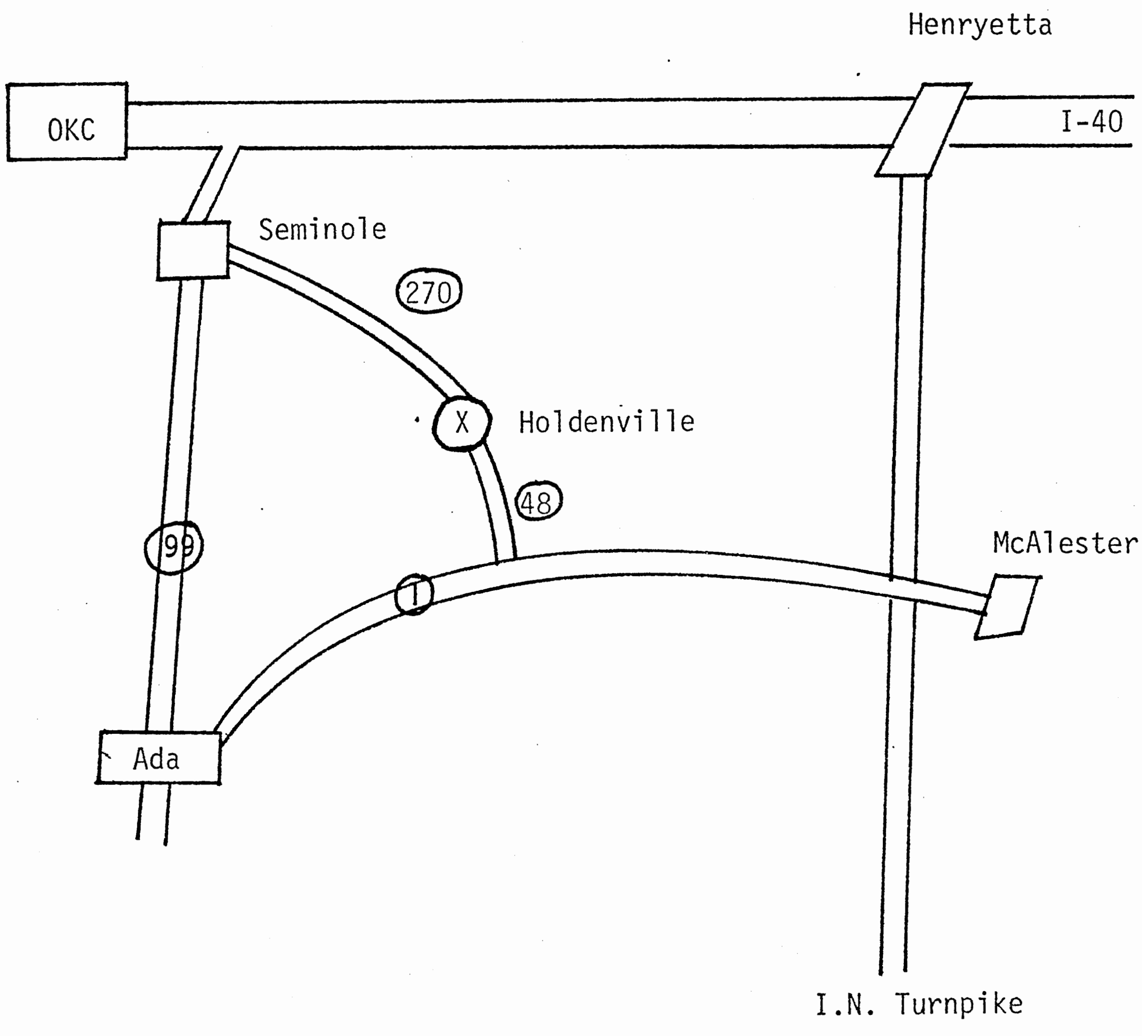


Figure 4. Geographic Location for Holdenville, Oklahoma

TABLE I

POPULATION AND DISTANCE INFORMATION FOR HOLDENVILLE, OKLAHOMA

Community	Population	Total Distance from Holdenville (Miles)	Coordinate Position	Distance from Holdenville to Point of Equal Influence (Miles)
Holdenville	5099	--	0, 0	--
Henryetta	6290	28.7	14, 15	15.1
McAlester	18802	30.2	21, -5	19.8
Ada	14859	18.8	-5, -9	11.9
Seminole	7878	15.1	-9, 6	8.4

The source for the information is the 1970 Census of Population and an Oklahoma Department of Transportation highway map. The area within the service area is estimated to be 346 square miles using a distance exponent of 2. It should be noted that Holdenville has almost an ideal spatial setting. The four competing communities form a rectangular boundary around Holdenville and the community is located near the center of Hughes County.

The process of calculating the service area for a community is a complex procedure. However, to use the simulation model all that is required is the basic distance and population information. The model then makes all calculations to provide the estimates for a given community. The gravity model is utilized in the demographic account to estimate employment and income for a community. The employment data by sector are then utilized in the economic account to estimate local sector output.

Community Social Accounts

Economic Account

The economic account describes the process of economic activity in a given community. This account consists of an input-output model estimated for a community. For community studies the large expense of collecting first-hand data is often not feasible. In these cases, some estimating technique can be used to off-set the expense.

There are many methods available to estimate a local interindustry table from a large national or state table. Schaffer and Chu (1969) present and evaluate three families of techniques: (1) the location quotient procedure, with three variations; the conventional location quotient, the purchases-only location quotient, and the cross-industry location quotient; (2) the commodity-balance or supply-demand pool procedures; and (3) an iterative simulation procedure. In comparing the success of the various techniques it is significant to note that the simple location quotient approach was the most successful in estimating survey-based coefficients for the state of Washington for the year 1963. In a more recent study, Morrison and Smith (1974) also found the location quotient technique most successful in constructing an input-output model for the city of Peterborough, England. Morrison and Smith used several techniques to estimate a city input-output table from a national table, and the location quotient provided results most similar to empirical data. Thus, while recognizing that all nonsurvey techniques have data limitations, this study utilizes the location quotient approach in constructing community specific input-output tables.

For this paper the data source utilized is the 1972 National Input-Output Table (U.S. Dept. of Commerce, 1979a; 1979b). A location quotient technique is then used to estimate a local community input-output model. The technique is a part of the program for the simulation model. In order to apply the location quotient technique, local sector output must be known. Local employment data estimated from the gravity model are used along with known national employment and output by sector. The national input-output table must be aggregated to correspond with the local data before the location quotient technique can be applied. The standard industrial classification (SIC) code was used to match the national input-output table with available local data. Table II presents the aggregation scheme used to derive the nine endogenous sectors used in this model. The complete national transactions or flow table is shown in Table III. The simulation model is constructed to utilize whatever input-output table is provided in order to estimate a local table. If state or regional tables are available, then these could be used as an alternative. The national table was chosen because 1972 is the most recent year for which data are available.

Fisher (1958) notes that aggregation problems can result when using input-output tables. However, this is the most detailed data available. Also, as the region under study gets smaller, it is reasonable to expect the interindustry transactions to decrease. The local economy is more "open" and dependent on exports and imports. The level of aggregation used in this study will be sufficient to describe interindustry transactions and is preferable to a less detailed model without sectoral information.

TABLE II

LOCAL SECTOR CLASSIFICATION AND SIC CODES

Sector	SIC
1. Agriculture, Mining	01, 02, 07-09, 10-14
2. Construction	15, 16, 17
3. Manufacturing-nondurable	20-23, 26-31
4. Manufacturing-durable	19, 24, 25, 32-39
5. Transportation	40-47
6. Communication, utilities, and sanitary services	48, 49
7. Wholesale and retail trade	50-59
8. Finance, insurance, business and repair services	60-67, 70, 72-76, 78, 79, 88
9. Professional and related services educational, public ad. and other	80-89, 91-94

Characteristics of National Input-Output Table. Several factors should be noted concerning the national data shown in Table III. First, the row and column totals for the interindustry sectors are not equal. The reason this occurs is because the national table used before aggregation exhibits the same characteristics.

For 1972, a use and make table were published. The use table is interpreted as follows: the row entries represent the dollar value of use by each industry and sales to final demand of the output of the commodity named at the beginning of the row; the column entries are the dollar value of inputs of commodities, value added generated in production in the industry named at the column head. The make table is interpreted as follows: the row entries are the dollar value of each

TABLE III

NATIONAL FLOW TABLE, 1972, MILLIONS OF DOLLARS

	Ag Mining	Constr.	Manuf. Nond.	Manuf. Dur.	Trans.	Comm., Ut., San. Serv.	Wh. & Ret. Tr.	Fin., Ins. Bus. & Rep.	Ed., Proff.	Dummy Industry
Agriculture, Mining	28119	1670	54729	7715	49	6171	121	2392	738	0
Construction	1441	47	1704	1545	2262	2751	863	12295	4092	0
Manufacturing-Nondurable	11694	8810	100518	21071	3924	1841	4340	24379	6382	0
Manufacturing-Durable	3130	50420	13803	144731	2674	1094	676	13075	1940	0
Transportation	1582	4256	11287	10729	8810	613	2757	3430	2144	0
Communication, Utilities, and Sanitary Services	1618	697	5938	6453	1457	12410	6339	7949	4330	0
Wholesale and Retail Trade	3516	12797	11944	14908	1826	503	3011	7056	1352	0
Finance, Insurance, Business and Repair Services	11897	11727	23404	22168	7875	6398	30366	73406	13715	0
Education Services, Professional Services	336	148	1367	1214	317	412	1642	4012	2147	0
Dummy Industries	101	26	521	2488	6	0	7	62	0	0
Imports	14	59	1892	639	1010	400	164	469	458	0
Value Added	51044	76107	122870	170510	44875	53638	166103	288797	72185	136624

TABLE III (Continued)

	Hh. Cons.	Pr. Cap. Form.	Inv. Ch.	Fed. Govt. Exp.	St. Govt. Exp.	Loc. Govt. Exp.	Exports	Imports	Net Exp.
Agriculture, Mining	7140	252	2716	-1485	102	236	5798	-6115	-317
Construction	0	99087	0	6471	13405	20024	16	0	16
Manfacturing-Nondurable	148908	208	4898	3503	2558	4737	11529	-18773	-7244
Manfacturing-Durable	64611	71903	8692	26717	1375	3224	26337	-32338	-6001
Transportation	20638	1213	529	2762	568	1244	5214	-1153	4061
Communication, Utilities, and Sanitary Services	34456	2167	0	1492	1331	2284	548	-414	134
Wholesale and Retail Trade	140321	10204	1000	1130	98	1485	4098	2993	7091
Finance, Insurance, Business and Repair Services	235390	4624	-164	5837	2987	3849	3572	-188	3384
Education Services Professional Services	75199	0	0	2730	2337	5250	193	-30	163
Dummy Industries	3988	-5332	-7387	49488	25767	57886	15086	-4651	10435
Imports	6550	5	4	3495	2	3	681	-15843	-15162
Value Added	0	0	0	0	0	0	0	0	0

commodity produced by the industry named at the beginning of the row, this is industry output; the column entries are the dollar value of total output of the commodity named at the head of the column and the amount of that commodity produced in each industry, this is commodity output. The row total of the use table equals the column total of the make table. The column total of the use table equals the row total of the make table.

This study employs the use table as the data source, and the industry output figures (column totals of the use table) are used to derive direct coefficients.

A second factor to be noted is that there are several negative entries in the final demand columns. The negative entry for federal government demand is associated with the agricultural sector. This is related to the accounting procedures for agricultural commodity programs. Inventory change also has a negative final demand entry but this presents no problem when predicting final demand. The negative entry for capital formation is removed when the special dummy industries in the table are treated separately.

Imports are also treated in a special way in the national use and make tables. Imported commodities that are comparable to domestically produced commodities are included with the distribution of the output of the comparable domestically produced commodity. Their domestic port value is shown as a negative entry in the import column of final demand. In this way, the row total for each commodity equals the domestic production of that commodity. Imports that are not comparable to domestically produced commodities are shown in the row for non-comparable imports at foreign port value. The total of this row is shown where the row for imports intersects the column for imports. The import row shown in Table III is noncomparable imports. The dummy industries shown in Table III are used only to keep industry output totals consistent. These entries are related to the accounting procedures used to construct the table. After applying the location quotient technique these dummy industries can be eliminated. This is a similar procedure to that used in other studies (DiPietre et al., 1980). For a complete discussion of the methodology and conventions used to construct the 1972 National Input-Output Model, see Ritz (1980).

For the 1972 National Input-Output Table, as with previous tables, state and local expenditures are presented as a single final demand column. For the purposes of this study, local government expenditures were broken out as a separate final demand column. To separate state and local government expenditures the following procedure was used. First, state and local expenditures were aggregated by economic sector and by function. Functions included such measures as education, health, transportation, etc. This information was available from a U.S. Department of Commerce (1977) publication on government purchases. Then each function was broken into local and state expenditures. This is a total figure by function (U.S. Dept. of Commerce, 1978). The proportion of expenditures by state and local government were then allocated to economic sectors based on total expenditures and the proportion going to state and local government. This is an estimating procedure based on proportions and total expenditures which provides an estimate of the proportion of government expenditures for local government.

Location Quotient Technique. A location quotient computer program is used to estimate the local input-output tables for the simulation model. The location quotient program was developed by Mustafa and Jones (1971).

The notable feature of the location quotient program is that all that is needed is a national, state or regional flow table and total output for each local sector. The user can then construct a local flow table in much less time. The simulation model for rural Oklahoma communities contains the location-quotient procedure as a sub-routine. The location quotient procedure compares the percentage share of individual sector output of a region to the percentage share of that sector output in the nation. In order to estimate an input-output flow table for the example of Holdenville, Oklahoma, the following data are necessary:

1. The 1972 National Flow Table aggregated to the appropriate sector classification;
2. The total output figures by sector for the 1972 National Input-Output Table; and
3. The total output figures by sector for 1972 for Holdenville.

As can be seen, the only additional data necessary to apply the location quotient technique for a series of local communities is total sector output information. Output figures are difficult to obtain at the local level. However, local employment data are available. Local sector employment figures are utilized along with national sector output and employment figures. A constant relation is assumed between the national and local employment-output ratio, thus providing an estimate of local output. The location quotient technique is then applied to the national flow table to estimate a community specific input-output table. The sector totals for employment, output and the resulting location quotients are presented in Tables IV, V, and VI respectively. As can be seen in Table VI, the primary exporting sector for Holdenville is in agriculture and mining with a location quotient of 3.93.

TABLE IV

SECTOR TOTALS, EMPLOYMENT, 1972

Sector	National (1) (1000)	Holdenville (2)
Agriculture, Mining	1994	164
Construction	3704	34
Manufacturing-Nondurable	8081	178
Manufacturing-Durable	10958	1
Transportation	2652	25
Communication, Utilities, and Sanitary Services	1864	60
Wholesale and Retail Trade	15829	252
Finance, Insurance, Business and Repair Services	8738	256
Professional and Related Services, Educational, Public Ad. and Other	25369	629

(1) Source: U.S. Department of Commerce (1973).

(2) Source: U.S. Department of Agriculture (1980).

TABLE V

SECTOR TOTALS, OUTPUT, 1972, MILLIONS OF DOLLARS

Sector	National (1)	Holdenville (2)
Agriculture, Mining	114492	9.44
Construction	166764	1.51
Manufacturing-Nondurable	349977	7.71
Manufacturing-Durable	404171	0.02
Transportation	75085	0.70
Communication, Utilities, and Sanitary Services	86231	2.78
Wholesale and Retail Trade	216389	3.44
Finance, Insurance, Business and Repair Services	437322	12.82
Professional and Related Services, Educational, Public Ad. and Other	109483	2.71

(1) Source: U.S. Department of Commerce (1979b).

(2) Source: Estimated.

TABLE VI

LOCATION QUOTIENTS, HOLDENVILLE, OKLAHOMA, 1972

Sector	
Agriculture, Mining	3.93
Construction	0.43
Manufacturing-Nondurable	1.05
Manufacturing-Durable	0.00
Transportation	0.44
Communication, Utilities and Sanitary Services	1.54
Wholesale and Retail Trade	0.76
Finance, Insurance, Business and Repair Services	1.40
Professional and Related Services, Educational, Public Administration and Other	1.18

The location quotient procedure compares the percentage share of a particular sector output of a region with the percentage share of that sector output of the nation. If the local region's share is equal to the nation's share, then the location quotient is one. If the industry of the local region produces more than its proprotionate share, the location quotient is greater than one. In this case, the industry of the local region is assumed to export the surplus. If an industry in the local region produces less than its proportionate share, the location quotient is less than one, and the region is assumed to import the deficit production.

The input-output table derived using the location quotient technique is presented in Table VII for Holdenville. Direct coefficients, which indicate the input requirements per dollar of output for a given sector, are then derived from the flow table and are reported in Table VIII. Table IX presents the interdependence coefficients derived for Holdenville. These coefficients show the total change in input requirements as a result of a one dollar change in final demand.

TABLE VII

INPUT-OUTPUT FLOW TABLE, HOLDENVILLE, OKLAHOMA, 1972, MILLIONS OF DOLLARS

Sector	Ag., Mining	Constr.	Manuf. Nond.	Manuf. Dur.	Trans.	Comm., Ut., San. Serv.	Wh. & Ret. Tr.	Fin., Ins., Bus. & Rep Serv.	Ed. Serv., Proff. Serv.
Agriculture, Mining	2.318	0.015	1.205	0.000	0.000	0.199	0.002	0.070	0.018
Construction	0.046	0.000	0.015	0.000	0.008	0.035	0.005	0.140	0.039
Manfacturing-Nondurable	0.960	0.080	2.205	0.001	0.036	0.059	0.069	0.712	0.158
Manfacturing-Durable	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.000
Transportation	0.053	0.016	0.100	0.000	0.033	0.008	0.018	0.041	0.021
Communication, Utilities and Sanitary Services	0.133	0.006	0.131	0.000	0.014	0.401	0.101	0.233	0.107
Wholesale and Retail Trade	0.213	0.085	0.193	0.001	0.012	0.012	0.035	0.152	0.025
Finance, Insurance, Business and Repair Services	0.981	0.107	0.515	0.001	0.073	0.207	0.483	2.153	0.340
Education Services, Professional Services	0.028	0.001	0.030	0.000	0.003	0.013	0.026	0.118	0.053
Imports	0.488	0.511	0.552	0.009	0.091	0.106	0.058	0.720	0.151
Value Added	4.217	0.692	2.759	0.010	0.425	1.744	2.644	8.484	1.801
Total	9.437	1.515	7.706	0.024	0.696	2.784	3.441	12.824	2.714

TABLE VII (Continued)

	Hh. Cons.	Pr. Cap. Form.	Inv. Ch.	Fed. Govt. Exp.	St. Govt. Exp.	Loc. Govt. Exp.	Exports	Total
Agriculture , Mining	0.150	0.005	0.057	-0.073	0.002	0.005	5.462	9.437
Construction	0.000	0.874	0.000	0.057	0.118	0.177	0.000	1.515
Manfacturing-Nondurable	3.095	0.004	0.102	0.073	0.053	0.098	0.000	7.706
Manfacturing-Durable	0.007	0.008	0.001	0.003	0.000	0.000	0.000	0.024
Transportation	0.312	0.018	0.008	0.042	0.009	0.019	0.000	0.696
Communication, Utilities and Sanitary Services	0.723	0.045	0.000	0.031	0.028	0.048	0.782	2.784
Wholesale and Retail Trade	2.467	0.179	0.018	0.020	0.002	0.026	0.000	3.441
Finance, Insurance, Business and Repair Services	4.941	0.097	-0.004	0.123	0.063	0.081	2.665	12.824
Education Services, Professional Services	1.578	0.000	0.000	0.057	0.049	0.110	0.647	2.714
Imports	0.137	0.000	0.000	0.073	0.000	0.000	-2.898	
Value Added	0.000	0.000	0.000	0.000	0.000	0.000		

TABLE VIII

DIRECT COEFFICIENTS, HOLDENVILLE, OKLAHOMA, 1972

Sector	Ag., Mining	Constr.	Manuf. Nond.	Manuf. Dur.	Trans.	Comm., Ut., San. Serv.	Wh. & Ret. Tr.	Fin., Ins. Bus. & Rep. Serv.	Ed. Serv., Proff. Serv.
Agriculture, Mining	0.024560	0.01001	0.15638	0.01909	0.00065	0.07156	0.00056	0.00547	0.00674
Construction	0.00489	0.00011	0.00189	0.00149	0.01171	0.01241	0.00155	0.01093	0.01453
Manfacturing-Nondurable	0.10177	0.05264	0.28619	0.05195	0.05207	0.02127	0.01999	0.05555	0.05808
Manfacturing-Durable	0.00007	0.00072	0.00009	0.00085	0.00008	0.00003	0.00001	0.00007	0.00004
Transportation	0.00557	0.01028	0.01300	0.01070	0.04728	0.00286	0.00513	0.00316	0.00789
Communication, Utilities and Sanitary Services	0.01413	0.00418	0.01697	0.01597	0.01940	0.14392	0.02929	0.01818	0.03955
Wholesale and Retail Trade	0.02259	0.05644	0.02510	0.02713	0.01789	0.00429	0.01023	0.01187	0.00908
Finance, Insurance, Business and Repair Services	0.10391	0.07032	0.06687	0.05485	0.10488	0.07420	0.14033	0.16785	0.12527
Education Services, Professional Services	0.00293	0.00089	0.00391	0.00300	0.00422	0.00478	0.00759	0.00917	0.01961

TABLE IX

INTERDEPENDENCE COEFFICIENTS, HOLDENVILLE, OKLAHOMA, 1972

Sector	Ag., Mining	Constr.	Manuf. Nond.	Manuf. Dur.	Trans.	Comm., Ut., San. Serv.	Wh. & Ret. Tr.	Fin., Ins. Bus. & Rep. Serv.	Ed. Serv., Proff. Serv.
Agriculture, Mining	1.37524	0.03415	0.30876	0.04706	0.02499	0.12642	0.01599	0.03361	0.03800
Construction	0.01008	1.00209	0.00714	0.00345	0.01481	0.01696	0.00448	0.01440	0.01803
Manfacturing-Nondurable	0.21619	0.09066	1.46386	0.08978	0.09545	0.06593	0.04783	0.10400	0.10672
Manfacturing-Durable	0.00013	0.00074	0.00018	1.00088	0.00012	0.00007	0.00003	0.00011	0.00008
Transportation	0.01215	0.01302	0.02287	0.01336	1.05202	0.00592	0.00708	0.00613	0.01119
Communication, Utilities and Sanitary Services	0.03333	0.01215	0.04037	0.02477	0.03063	1.17529	0.04048	0.03004	0.05467
Wholesale and Retail Trade	0.04030	0.06187	0.04732	0.03245	0.02487	0.01237	1.01477	0.01926	0.01656
Finance, Insurance, Business and Repair Services	0.20238	0.10989	0.17263	0.08944	0.15259	0.13131	0.18366	1.22404	0.17788
Education Services, Professional Services	0.00741	0.00300	0.00904	0.00483	0.00677	0.00773	0.01004	0.01230	1.02267

Capital Account

Kendrick (1976) notes that the capital account is an important segment of the U.S. economy. According to Kendrick, the wealth account, or its synonym capital, "is generally defined as income and/or output-producing capacity" (p. 10). Wealth, as described by the capital account represents the accumulation of past investment. This measure of productive capacity could include such tangible investments as capital structures, equipment and net stock or intangibles such as investment in human capital (education).

Isard (1960) notes that capital information is useful when considering a growing region that is facing the many problems related to economic development. When combined with a regional input-output model, relevant capital data can provide useful input for more dynamic projections over time. Isard (1960) presents a good discussion of the relation between regional input-output studies and various capital and capacity studies. Doeksen and Schreiner (1971c) present a capital account developed for the state of Oklahoma. The capital account for Oklahoma provides data for regional economists interested in developing models of Oklahoma growth. Also, capital data are provided by economic sector for sector analysis. In another publication, Doeksen and Schreiner (1971b) utilize the capital account to develop a simulation model for the Oklahoma economy.

It should be noted that several problems exist when attempting to develop a regional capital account. The definition of the region or boundary must be considered as well as the openness of the region in its relation to the national economy (Kendrick, 1972). Local data are often difficult to obtain and estimates based on national data are often used. However, it is useful and perhaps necessary to develop a regional capital account as this is a very important component of the overall economy. Particularly, if a system of economic accounts are to be used to predict economic growth over time in a region, the capital structure of that region and its capacity should be considered.

Concepts and Definitions Used in the Capital Account. The base of the capital account for rural Oklahoma communities is the capital coefficients matrix. The capital coefficients matrix is derived from the capital flow table that accompanies the national input-output table. National capital data are used in this study as default data as local capital data are not available. Adjustments are made for the state situation where possible. Additional adjustments for a given rural community can be made if the user has more reliable or accurate information.

The capital coefficient matrix is computed from capital flows as follows:

$$W_{ij} = \frac{b_{ij}}{b_j} \tag{3.11}$$

where W_{ij} = the amount of capital goods required from the ith sector per dollar's worth of capital expenditures by the jth sector,

b_{ij} = capital purchases of the jth sector from the ith sector, and,

b_j = the total capital purchases of the jth sector.

A capital stock matrix can be computed by using the capital coefficient matrix and capital-output ratios by sector. Capital-output ratios $(K/X)_j$ are defined as the ratio of total cost of plant and equipment to output at capacity. Capacity is defined as output at peak production. Capacity output $(XDC)_j$ is estimated and used to determine the capital stock matrix:

$$(K)_j = (XDC)_j \, (K/X)_j \tag{3.12}$$

where $(K)_j$ = sector capital stock estimates,
then

$$(K_{ij}) = (K)_j \, W_{ij} \tag{3.13}$$

where K_{ij} = the capital stock matrix.
Each K_{ij} represents the total amount of capital goods from sector i that is invested in sector j.

A capital unit matrix shows the amount of capital invested and the composition of that capital per unit of output capacity for the producing sector. It is computed as:

$$O_{ij} = (K/X)_j \, W_{ij} \tag{3.14}$$

Each coefficient for O_{ij} shows the amount of capital needed from the ith sector to provide one unit of output capacity for the jth sector.

Depreciation coefficients are also a useful part of a capital account. The coefficient d_j indicates the annual depreciation rate per dollar of depreciable assets:

$$d_j = \frac{D_j}{K_j} \tag{3.15}$$

where D_j = the total annual depreciation of capital stock in sector j.

The sectors included in the capital account are the nine endogenous sectors as defined earlier in this chapter. The basis of the account is the capital coefficients matrix.

Capital Coefficients Matrix. Capital coefficients can be constructed by using direct survey techniques or through the use of a flow matrix. The use of survey techniques is prohibited in this study since the model will be applied to several different communities. Therefore, a capital flow matrix will be utilized to estimate the coefficients. The most recent data available are the 1967 national capital flow matrix for expenditures on new plants and equipment published by the U.S. Department of Commerce (1975). The flow table is an expansion of the 1967 national input-output table information on fixed capital purchases. The matrix shows estimates of transactions in new structures and equipment between producing and using industries. A more desirable table would be one that accompanies the 1972 national input-output table but this information is not yet available.

The initial step in estimating a capital coefficients matrix is to aggregate the capital flow table to match the nine endogenous sectors included in the model. Capital coefficients are then derived and shown in Table X. Reading down a column, purchases of capital goods from producing sectors per dollar of capital investment for that sector are shown. For sector one (agriculture and mining) .39417 dollars worth of capital goods are purchased from sector 2 (construction), .00018 dollars worth of capital goods are purchased from sector 3 (manufacturing-nondurable), and so forth.

Capital-Output Ratios. Several alternatives are available as techniques to be used in estimating a capital account for this model. One would be to estimate a capital account for the state of Oklahoma and then apply this to any rural community analyzed with the model. Another alternative is to utilize national capital data and adjust the

TABLE X

CAPITAL COEFFICIENTS, 1967

Sector	Ag., Mining	Constr.	Manuf. Nond.	Manuf. Dur.	Trans.	Comm., Ut., San. Serv.	Wh. & Ret. Tr.	Fin., Ins. Bus & Rep. Serv.	Ed. Serv., Proff. Serv.
Agriculture, Mining	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.39417	0.05950	0.29193	0.28307	0.13999	0.52162	0.34242	0.75562	0.58336
Manfacturing-Nondurable	0.00018	0.00159	0.00108	0.00148	0.00058	0.00030	0.00286	0.00086	0.00267
Manfacturing-Durable	0.47832	0.80325	0.64574	0.65498	0.80218	0.37574	0.54313	0.19465	0.33196
Transportation	0.01091	0.01696	0.00920	0.00773	0.00998	0.00502	0.01729	0.00375	0.00644
Communication, Utilities and Sanitary Services	0.0	0.0	0.0	0.0	0.0	0.07934	0.0	0.0	0.0
Wholesale and Retail Trade	0.11620	0.11863	0.05199	0.05274	0.04716	0.01798	0.09430	0.03672	0.07551
Finance, Insurance, Business and Repair Services	0.00022	0.00007	0.00006	0.0	0.00011	0.0	0.0	0.00840	0.00006
Education Services, Professional Services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

data for each individual community as much as possible. A combination of the methods has been chosen for this project. As noted, capital-output ratios are defined as the ratio of total cost of plant and equipment to output at capacity. Capacity estimates developed for Oklahoma are applied to individual community output estimates. Capital-output ratios are then estimated for that community and utilized in the model. The capital-output ratios developed for Holdenville are presented in Table XI.

TABLE XI

CAPITAL-OUTPUT RATIOS, HOLDENVILLE, OKLAHOMA, 1972

Sector	
Agriculture, Mining	.31273
Construction	.10873
Manufacturing-Nondurable	.33844
Manufacturing-Durable	.61516
Transportation	2.19788
Communication, Utilities, and Sanitary Services	1.61910
Wholesale and Retail Trade	.51800
Finance, Insurance, Business and Repair Service	.27178
Education Services, Professional Services	.79977

In order to develop simulated estimates over time, a rate of change is necessary for the capital-output ratios. Here national data are used since a good time series is available.

Capital-Output Growth Rates. National data for output and capital comes from Bureau of Labor Statistics publications which present time series data by industry sector. Output data are provided by the U.S. Department of Labor, BLS, for the years 1958-1976 (U.S. Department of Labor, 1979, Bulletin 2018). Output (OPCD) is a current measure (millions of dollars) and includes: (a) producer's value of total production of an industry, including the primary and secondary products and miscellaneous receipts and (b) producer's value of secondary products of other industries which are primary to the given industry.

The data for capital stocks by major sector are provided by another Bureau of Labor Statistics publication for the years 1947-1974 (U.S. Department of Labor, 1979, Bulletin 2034). The gross investment (GINV) series includes equipment and structures and is the basic time series used in a perpetual inventory model to develop two capital stock series. Gross capital stocks (GSTK) represent the accumulation of all past investments adjusted for the discard of worn out assets. Net capital stocks (RNSTK) are the accumulation of all past investments adjusted for the discard of worn out assets and the loss of efficiency (depreciation) of the assets over their service life. Net stocks are calculated in the same manner as gross stocks with the exception that the assets lose efficiency during the course of their service to the industry (U.S. Department of Labor, 1979, Bulletin 2034). The loss of efficiency is assumed to occur over the entire lifetime of the assets and at an increasing rate. Thus, the major portion of depreciation occurs toward the end of the service life. Also it is assumed in the BLS publication that structures depreciate more slowly than equipment.

For both BLS publications data are presented in both historical-dollar and constant-dollar value. For this study, the historical-dollar values are used. Thus, any rate of growth over time assumes that the same rate of inflation occurring in the past will occur in the future.

The capital data are broken into 72 sectors and includes the years 1947-1974. The sectors are a very close match to the input-output sectors of the Office of Business Economics, U.S. Department of Commerce.

Output by sector is listed in 161 sectors for the years 1958-1976. The output data were aggregated to match the available 72 sector aggregations of the capital data. Thus, capital-output data are provided for 72 sectors for the years 1958-1974. When the data are compared to the 1972 input-output table by sector (using SIC codes) the two data sources are very similar in aggregation.

The national capital-output data were aggregated to match the nine endogenous sectors in the model. Growth rates using the various capital measures were then calculated and are shown in Table XII.

The growth rates were calculated for the period 1958-1974 using the functional form:

$$y = a_0 e^{gt} \tag{3.16}$$

where y = the capital-output ratio, and

g = the calculated growth rate per year.

Growth rates for these ratios describe how capital investment or capital stock changes over time in relation to output. It should be noted that many of the ratios for gross stock to output (GSTK/OPCD) show a positive growth rate. This indicates that capital stocks are growing relatively faster than output. Many of these positive growth rates are in the service sectors, however, where employment is very important. On the other hand, a negative growth rate is evident in the manufacturing sector. This implies increased productivity of capital in these sectors.

TABLE XII

ANNUAL GROWTH RATES FOR CAPITAL/OUTPUT, 1958-1974

Sector*	GINC/OPCD	R^2	GSTK/OPCD	R^2	RNSTK/OPCD	R^2
1	.0025	.03	-.0061	.08	-.0073	.12
2	-.0100	.26	.0058	.12	.0039	.07
3	.0172	.35	.0020	.03	.0015	.01
4	.0140	.30	-.0033	.08	-.0050	.13
5	.0028	.01	-.0152	.65	-.0164	.68
6	.0216	.53	.0019	.26	.0015	.17
7	.0909	.73	.0866	.75	.0874	.76
8	.0269	.56	.0261	.83	.0277	.84
9	-.0247	.58	-.0063	.20	-.0064	.19

*See Table XI for Sector descriptions.

Also, note that the growth rates for gross stocks to output and net stocks to output (RNSTK/OPCD) are very similar. This is to be expected as the two stock measures differ only by an estimated depreciation function.

For the rural community simulation model the annual growth rate (GSTK/OPCD) is utilized to provide an estimate of technological change.

This measure of capital stock to output is similar to the measure used to estimate capital-output ratios in the capital account.

These growth rates and the accompanying ratios are based on national data. Use of these measures in a state or local model implies assumptions concerning the similarity with national situations. Any adjustments that could be made to reflect more accurately the local or regional situation would improve the model results. However, this data provides detailed information often not available at the sub-national level.

Capital Unit Matrix. The capital unit matrix is constructed by using the capital coefficients and the capital-output ratios. Each coefficient (O_{ij}) in this matrix shows the capital required from sector i to produce one unit of output capacity for sector j. The capital unit coefficients are computed by multiplying the capital coefficients of sector j by the capital-output ratio for sector j.

Table XIII presents the capital unit matrix for Holdenville. For an example interpretation consider the nondurable manufacturing sector. For each dollar of output at capacity the sector needs .09880 dollars worth of capital goods from the construction sector, .00037 dollars worth of capital goods from manufacturing-nondurable, etc. Composition of required new capital is determined from the capital unit matrix.

Capacity Estimates. Capacity levels were estimated for the nine endogenous sectors included in the model. Production levels are difficult to obtain at the state level, much less the community level. Sector employment levels for the state were used as proxies for the production levels. Quarterly employment data by sector were used to chart peak employment (Oklahoma Employment Security Commission, 1979).

TABLE XIII

CAPITAL UNIT MATRIX, HOLDENVILLE, OKLAHOMA, 1972

Sector	Ag., Mining	Constr.	Manuf. Nond.	Manuf. Dur.	Trans.	Comm., Ut., San. Serv.	Wh. & Ret. Tr.	Fin., Ins. Bus & Rep. Serv.	Ed. Serv., Proff. Serv.
Agriculture, Mining	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.12327	0.00647	0.09880	0.17413	0.30768	0.84455	0.17737	0.20536	0.46651
Manfacturing-Nondurable	0.00006	0.00017	0.00037	0.00091	0.00127	0.00049	0.00148	0.00023	0.00214
Manfacturing-Durable	0.14959	0.08734	0.21854	0.40292	1.76310	0.60836	0.28134	0.05290	0.26547
Transportation	0.00341	0.00184	0.00311	0.00476	0.02193	0.00813	0.00896	0.00102	0.00515
Communication, Utilities and Sanitary Services	0.0	0.0	0.0	0.0	0.0	0.12846	0.0	0.0	0.0
Wholesale and Retail Trade	0.03634	0.01290	0.01760	0.03244	0.10365	0.02911	0.04885	0.00998	0.06039
Finance, Insurance, Business and Repair Services	0.00006	0.00001	0.00002	0.0	0.00025	0.0	0.0	0.00229	0.00011
Education Services, Professional Services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital-Output Ratios	0.31273	0.10873	0.33844	0.61516	2.19788	1.61910	0.51800	0.27178	0.79977

Peak employment levels were determined by inspection and 100 percent capacity level of operation was assumed at each peak. Present capacity is estimated by extrapolating a line connecting peak employment.

Capacity levels by industry are presented in Table XIV. These indicate the estimated level of operation in each sector. For example, the agriculture-mining sector is estimated to be operating at 88.92 percent of capacity.

TABLE XIV

CAPACITY LEVELS FOR OKLAHOMA, 1972

Sector	Capacity Levels
Agriculture, Mining	88.92
Construction	92.84
Manufacturing-Nondurable	98.83
Manufacturing-Durable	92.02
Transportation	93.20
Communication, Utilities and Sanitary Services	97.56
Wholesale and Retail Trade	96.42
Finance, Insurance, Business and Repair Services	96.79
Education Services, Professional Services	96.89

<u>Capital Stock Matrix</u>. Using capacity estimates, capital-output ratios, and the capital coefficient matrix, a capital stock matrix can

be estimated. By multiplying the capital-output ratio times the estimated output at capacity, sector capital is derived. The amount of capital in a sector times that sector's capital coefficients column gives the composition of each sectors' capital. The capital stock matrix for Holdenville is presented in Table XV. Each coefficient (K_{ij}) shows the total value of capital goods produced by sector i and invested in sector j. For example, consider the transportation sector. Total investment in the sector for 1972 is $1,648,410 of which $230,760 is from the construction sector, $960 from the manufacturing-nondurable sector, etc.

Depreciation Coefficients. Depreciation coefficients are estimated to complete the capital account construction. Depreciation coefficients are defined as depreciation per year to total depreciable assets. The depreciation rates shown in Table XVI are estimates using the national capital data published by the U.S. Department of Labor (1979b). The difference between the gross stock series and the net stock series provides an estimate of depreciation value by sector. Annual depreciation rates shown in Table XVI range from 5 percent to 9 percent of total depreciable assets.

Demographic Account

The demographic or human resource account is closely aligned with the economic account. The demographic account in this model is also concerned with population data by age and sex cohorts. Population and the accompanying labor force are linked to the economic account through income and employment and also interface through the migration process.

TABLE XV

CAPITAL STOCK MATRIX, HOLDENVILLE, OKLAHOMA, 1972, MILLIONS OF DOLLARS

Sector	Ag., Mining	Constr.	Manuf. Nond.	Manuf. Dur.	Trans.	Comm., Ut.,San. Serv.	Wh. & Ret. Tr.	Fin., Ins. Bus. & Rep. Serv.	Ed. Serv., Proff. Serv.
Agriculture, Mining	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Construction	1.29309	0.01048	0.77065	0.00348	0.23076	2.40698	0.63145	2.71695	1.30169
Manfacturing-Nondurable	0.00059	0.00028	0.00285	0.00002	0.00096	0.00138	0.00527	0.00309	0.00596
Manfacturing-Durable	1.56915	0.14148	1.70464	0.00806	1.32232	1.73383	1.00158	0.69989	0.74072
Transportation	0.03579	0.00299	0.02429	0.00010	0.01645	.02316	0.03188	0.01348	0.01437
Communication, Utilities and Sanitary Services	0.00000	0.00000	0.00000	0.00000	0.00000	0.36611	0.00000	0.00000	0.00000
Wholesale and Retail Trade	0.38120	0.02090	0.13724	0.00064	0.07774	0.08298	0.17390	0.13204	0.16849
Finance, Insurance, Business and Repair Services	0.00072	0.00001	0.00000	0.00000	0.00018	0.00000	0.00000	0.03020	0.00013
Education Services, Professional Services	0.00000	0.00000	0.00016	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	3.28054	0.17614	2.63983	0.01230	1.64841	4.61444	1.84408	3.59565	2.23136

TABLE XVI

DEPRECIATION RATES BY ECONOMIC SECTOR

Sector	
Agriculture, Mining	.0544
Construction	.0764
Manufacturing-Nondurable	.0683
Manufacturing-Durable	.0729
Transportation	.0568
Communication, Utilities and Sanitary Services	.0848
Wholesale and Retail Trade	.0711
Finance, Insurance, Business and Repair Services	.0846
Education Services, Professional Services	.0943

Employment and Income. For this study, employment and income data are needed to describe the economic environment of the local community. The data needs to refer to the employment and income generated within the community so this information will be consistent with the input-output model that is developed.

Three data sources were available in order to estimate employment for the model: census data published by the U.S. Department of Commerce (1970); data provided by the Oklahoma Employment Security Commission (1972); and unpublished Bureau of Economic Analysis (BEA) data tapes provided by the U.S. Department of Agriculture (1980).

The census source provides employment data by community and by individual industrial sector. Chalmers and Anderson (1977) note that employment figures from either the state or BEA cannot be directly compared with those contained in the census. The sources differ in the following respects:

1. The state employment agency shows the number of jobs by industry in a county, while the census shows the number of people working.
2. The census shows the person as being employed in the county where he is living while state, industry-specific data shows him in the employment figures for the county. However, the state employment agency data and BEA data can be adjusted for commuting and multiple jobs. After these adjustments the aggregate employment estimate by the state agency is conceptually similar to that used in the census.
3. The census classifies as government workers those directly involved in public administration. Construction and maintenance workers for the government, for example, would be distributed throughout the data.

The primary problem to be addressed is one of "place of work" versus "place of residence". The BEA data provided by the U.S. Department of Agriculture were chosen because the data are reported on a place of work basis. The data are industry specific and available for the sectors in the model. Data are reported by county. The BEA data tapes also provide county income data that corresponds to the employment data. The income data are also available in less sector detail in U.S. Department of Commerce publications for the relevant years (1978, 1980).

The necessary step is to go from the county level to the community level. For the example used in this study, Holdenville, data for

Hughes county are available. The county data are for all employees working in Hughes county. Thus, Holdenville figures are included. If an estimate can be derived of the community share of county employment and income, then an economic measure is derived which does not have the inter-county distortions made by commuting. The first step in estimating community specific data is to aggregate the sector data into the endogenous sectors shown in Table II. The sector classification utilizies the Standard Industrial Classification (SIC) code and the sector aggregation scheme is used throughout this paper.

Income and employment for the county are allocated on the basis of population and area. The population relation is described as:

$$\text{PPROP} = \frac{\text{Community Population}}{\text{County Population}} \tag{3.17}$$

The area relation is:

$$\text{SPROP} = \frac{\text{Community Service Area (Square Miles)}}{\text{County Area (Square Miles)}} \tag{3.18}$$

Community employment (EMPLC) and income (RINC) are then estimated from county employment (CEMP) and income (CRINC) as follows:

$$\text{EMPLC} = [\text{CEMP}]\text{PPROP} + \text{SPROP}[\text{CEMP} - (\text{CEMP} \times \text{PPROP})] \tag{3.19}$$

and

$$\text{RINC} = [\text{CRINC}]\text{PPROP} + \text{SPROP}[\text{CRINC} - (\text{CRINC} \times \text{PPROP})] \tag{3.20}$$

Thus, employment and income are first allocated to the community based on population relative to county population, with the remainder of the county data are allocated on the basis of the estimated service area from the gravity model.

For the Holdenville example presented in this study, the population relation was calculated as using equation (3.17):

$$PPROP = \frac{5099}{13288} = .39$$

The area relation was based on the gravity model estimate of the service area and calculated using equation (3.18):

$$SPROP = \frac{346}{810} = .43$$

The resulting estimates of employment and income for the Holdenville area are presented in Tables XVII and XVIII respectively.

TABLE XVII

EMPLOYMENT BY SECTOR, HOLDENVILLE, OKLAHOMA, 1972

Sector	Employment: Wage and Salary	Employment: Proprietor
Agriculture, Mining	164	543
Construction	34	34
Manufacturing-Nondurable	178	6
Manufacturing-Durable	1	0
Transportation	25	10
Communication, Utilities, and Sanitary Services	60	3
Wholesale and Retail Trade	252	133
Finance, Insurance, Business and Repair Services	256	232
Professional and Related Services, Educational, Public Administration and Others	629	151
Total	1599	1112

TABLE XVIII

INCOME BY SECTOR, HOLDENVILLE, OKLAHOMA, 1972, MILLIONS OF DOLLARS

Sector	Income	
	Wage and Salary	Proprietor
Agriculture, Mining	.31372	1.32245
Construction	.22440	.23182
Manufacturing-Nondurable	.91596	.01944
Mnaufacturing-Durable	.00365	.00008
Transportation	.23857	.03330
Communication, Utilities, and Sanitary Services	.60475	.01098
Wholesale and Retail Trade	1.22099	.40524
Finance, Insurance, Business and Repair Services	.68984	.44355
Professional and Related Services, Educational, Public Administration and Others	3.08047	.45814
Total	7.29235	2.92500

When utilizing the county employment and income data provided by the BEA, additional adjustments are necessary to provide comparable measures for wage and salary versus proprietor employment and income. Sectoral income is provided as wage and salary, proprietor, and other income with total figures provided for each type of income. Employment is provided on a sectoral basis for wage and salary workers with a total figures provided for proprietor employment. To provide sectoral estimates for proprietor employment, the total figure for proprietor employment is allocated among sectors based on the state sectoral proportions of proprietor employment to wage and salary employment.

Proprietor income by sector is broken out of the county data using a similar state proportion for income.

Once income and employment data are available by sector for proprietors and wage and salary workers, wage rates and income rates can be calculated. Growth rates are utilized in the simulation model to predict changes in wage rates over time. When estimating annual growth rates the most desirable data are the time series values over a recent time interval. A continuous time series was not available. Because of time and expense considerations the data obtained from the BEA tapes were for two years. The years 1972 and 1978 were chosen as the base year and the most recent year available, respectively. A formula calculating a compound interest factor (Weston and Brigham, 1978) was utilized. An annual growth rate by sector was calculated for wage rates and income rates using the following:

$$V_t = P_0(1 + i)^t = P_0(CVIF) \tag{3.21}$$

where V_t = value at the end of t periods,

P_0 = beginning amount at time 0,

i = rate of growth, and

CVIF = compound value interest factor.

And

$$CVIF = V_t/P_0 \tag{3.22}$$

Using a compound interest table, then an annual rate of growth can be calculated.

It should be noted that the aggregation of the endogenous sectors used in the model allows for some flexibility. The sectors are aggregated in a manner that is consistent with data on employment provided by the Census Bureau. With minor modifications to the program, census employment data by community could be used as an alternative. A reason for keeping this sector aggregation scheme is the possibility of utilizing 1980 census data in some form when it becomes available. Of course, the census procedure for reporting by place of residence would have to be considered when modifying the model in this way.

The employment estimates described in this section are utilized throughout the simulation model. One purpose for developing estimates of this sort is to provide information helpful in deriving a community specific input-output model. The gravity model estimate of service area provides a link between the economic account and the demographic account by providing estimates of employment and income.

Population Projection. In order to more accurately project population, age and sex cohorts are utilized to provide more detail. The cohorts used in the model are: less than 15 years of age, 15 to 19 years, 20 to 29 years, 30 to 39 years, 40 to 44 years, 45 to 49 years, 50 to 54 years, 55 to 59 years, 60 to 64 years, 65 to 69 years, 70 to 79 years, and over 80 years. The age cohorts are for each sex, thus, there are 24 cohorts in all.

Population in the demographic account is projected through the use of a traditional cohort-survival model. The following formulation describes the cohort-survival model and is taken from Dunn and Doeksen (1979):

$$(POP)_t = \sum_{j=1}^{2} \sum_{i=1}^{12} G_{ijt} \tag{3.23}$$

where $(POP)_t$ = the population in time period t, and

G_{ijt} = the population in time period t for cohort i and sex j.

Then

$$G_{i,j,t} = G_{i,j,t-1} + AG_{i-1,j,t-1} + M_{i,j,t-1} - AG_{i,j,t-1} - D_{i,j,t-1} \quad (3.24)$$

where $G_{i,j,0}$ = the initial population in cohort i of sex j,

$AG_{i,j,t}$ = the advancement from group i to group i+t between year t and year t+1,

$M_{i,j,t}$ = the net migration into group i between year t and year t+1, and

$D_{i,j,t}$ = the deaths by members of cohort i from sex j in year t to t+1.

$$AG_{0,j,t} = \sum_{i=1}^{12} B_i \, G_{i,2,t} \quad (3.25)$$

where $AG_{0,j,t}$ = the births of sex j for year t, and

B_i = the birth rate for women in cohort i;

$$D_{i,j,t} = D_{i,j,0} \, T_{i,j} \, G_{i,j,t} \quad (3.26)$$

where $D_{i,j,0}$ = the initial death rate for group i, and

$T_{i,j}$ = the trend in the death rate for group i,j.

Initial population values are found in the 1970 Census of Population for Oklahoma. Birth rates, death rates, and trends are found in the Statistical Abstract of the U.S. (U.S. Department of Commerce, 1976).

Population is projected in the simulation model for both the community and the service area. For the Holdenville example, the community data is available in the 1970 census of population by age and sex categories. For the service area, population was estimated using rural Hughes county population data by age and sex and the gravity model estimate of service area. The two population groups are kept separate throughout much of the model as several local services are affected only by the population within city limits. Initial census data are for the year 1970 and the cohort-survival model is used to project population to the base year of 1972. For 1971 and 1972 a migration rate that is community specific is utilized to project population. For following years, the migration rate in the cohort-survival model is assumed zero. Migration is determined through interaction of the economic and demographic accounts. Table XIX presents the 1972 population values for Holdenville and the service area by are and sex cohorts.

TABLE XIX

POPULATION BY AGE AND SEX, HOLDENVILLE, OKLAHOMA AND SERVICE AREA, 1972

Age Cohort	Community		Service Area	
	Male	Female	Male	Female
<15	520	490	432	402
15-19	174	186	157	146
20-29	239	294	187	195
30-39	176	215	147	175
40-44	99	129	83	95
45-49	114	153	101	111
50-54	110	154	102	119
55-59	146	200	107	123
60-64	171	243	115	124
65-69	173	246	104	114
70-79	249	397	129	139
80+	126	217	58	70

Beginning with the base year of 1972, an interface procedure is used to compare population projections with economic projections. The cohort-survival model projects population for year t+1 based on birth rates, death rates, and age-sex categories. The population projections include 24 cohort projections for both the community and service area. Participation rates are available for Oklahoma from the 1970 Census of Population. The participation rates are by age-sex cohorts and are state-wide in application. In some instances, county specific data may be available to utilize as well. The participation rates are applied to the population projections to produce an estimate of the available labor force. At the same time, the economic account provides projections from the input-output model. Output projections and employment-output ratios are utilized to obtain projections of employment requirements by economic sector. The labor force estimates are then compared to the employment requirements and net migration levels are determined. If excess labor levels exist, then a net out-migration would result. If there were excess employment opportunities then a net in-migration will occur. This relationship emphasizes the relationship between demographic and economic activity within a community.

Murdock et al. (1979) notes that the key to a truly integrated model system lies in the interface procedure for various components. There must be some methodology for matching employment demands with local employment availability, and for using the results to determine levels of migration and population change. Murdock et al. (1979) list several characteristics that are important when developing the procedure for comparing population and employment projections:

1. The interface procedure should be consistently utilized for both baseline and impact projections;
2. Data specific to the local area should be used;
3. Differentiate between the various forms of employment demands;

4. Accurately assess local labor force availability and employability for each of the types of employment demands, and
5. Use estimates of population characteristics that are specific to various worker types.

The methodology for interfacing the economic and demographic accounts in the simulation model follows the above description. Each year, employment requirements are compared to labor availability to determine population change and migration levels. The resulting population is then input for the cohort-survival model to determine labor availability for the next year.

Community Service Account

Once reliable estimates are available for population, the projections can be used to estimate the level of community service usage for a community. For a given service, a community can usually handle only a given level of demand. Capacity for a hospital would be determined by the number of beds available as well as the number of physicians. A water system has some capacity level of volume that can be supplied. As population changes and economic growth occurs, the level of community service demand will vary. Useful information would include some estimate of when capacity constraints will be reached for specific community services. This information would be helpful under both baseline and impact projections.

Several services are applicable to the service area population as well as the community. For this reason, the two populations were kept separate and included detail for age and sex cohorts. The particular services are: hospital usage measured in bed days per year; clinics measured as the number of physician visits per year; ambulance service;

fire protection; and school or educational services. Annual requirements are projected for the community and the service area separately. Model projections are made based on age categories and then summed to provide an aggregate figure.

As has been noted, the economic and demographic accounts are interfaced to provide annual estimates of population based on employment demand and supply. The resulting population data are in the 24 age-sex cohort detail described in the demographic account. Use coefficients are available for many community services based on age categories. For example, Dunn and Doeksen (1979) present the average annual hospital usage for various disease categories by the age cohorts less than 15, 15 to 44, 45 to 64, and 65 and above for both males and females. The population data from the simulation model interface are aggregated to match these age groups and applied to the data in Table XX to estimate annual bed-day usage for various disease categories. The data are then summed over disease categories to obtain a total annual figure.

A measure of the demand placed on clinics is the number of physician visits per year. Table XXI provides use coefficients to estimates annual physician visits based on the population projections.

Another important factor in providing for rural health care is ambulance service. In order to anticipate future needs, an estimate of ambulance calls for each year is helpful. Highway accident calls and transfer calls from one hospital to another are both dependent upon local conditions, thus estimates should come from local records. Doeksen, Frye, and Green (1975) provide sources for this information. Other ambulance calls include those not associated with highway accidents or transfer calls. Heart attacks, strokes, and home accidents are examples of other ambulance calls that might be made.

TABLE XX

AVERAGE ANNUAL HOSPITAL USAGE FOR VARIOUS DISEASE CATEGORIES BY AGE AND SEX COHORT (PER 1000)

DISEASE CATEGORIES	MALE				FEMALE			
	>15	15-44	45-64	65+	>15	15-44	45-64	65+
Infective and Parasitic	11.100	16.720	18.740	27.200	9.360	31.950	25.500	116.050
Neoplasms	3.080	13.500	122.400	680.800	2.050	81.780	250.560	726.880
Endocrine, Nutritional, and Metabolic	2.050	8.840	28.980	88.560	5.110	22.440	59.200	193.200
Blood and Blood Forming Organs	2.340	1.880	5.120	11.400	0.930	2.800	5.060	16.550
Mental Disorders	6.240	42.000	50.050	163.080	2.540	79.920	84.360	154.000
Nervous System and Sense Organs	13.500	17.980	42.640	73.670	8.400	23.460	47.040	144.000
Circulatory System	2.000	35.990	353.220	1362.240	1.410	58.460	245.650	1244.700
Tonsillectomy	13.760	4.940	0.500	0.0	15.040	13.250	0.680	3.000
Respiratory System	37.440	54.530	159.000	647.250	27.750	84.480	183.580	718.110
Digestive System	14.620	56.200	169.320	447.320	9.200	108.630	220.580	723.350
Genitourinary System	6.500	30.450	98.820	365.180	10.640	218.880	220.590	477.120
Maternity Care	0.0	0.0	0.0	0.0	0.0	140.980	0.250	0.0
Skin and Subcutaneous Tissue	2.790	12.740	11.640	31.980	2.320	10.140	20.460	69.307
Musculoskeletal System and Connective Tissue	3.440	47.120	93.010	172.200	4.720	60.300	157.600	425.020
Congential Anomolies	10.290	3.920	11.440	4.900	6.840	4.600	8.700	9.500
Certain Causes of Perinatal Morbidity and Mortality	17.290	0.0	0.0	0.0	147.400	0.0	0.0	0.0
Symptoms and Ill-Defined Conditions	9.230	22.140	62.640	155.400	8.640	56.160	87.000	312.420
Accidents, Poisoning and Violence	24.180	65.720	83.200	213.720	17.200	79.380	117.780	426.300

Source, Dunn and Doeksen (1979).

Other ambulance calls can be projected by making them a function of the age districution of the population and utilizing Table XXII.

TABLE XXI

ANNUAL VISITS TO A PHYSICIAN PER PERSON

Age Cohort	Male	Female
>15	3.18	2.12
15-44	3.02	3.97
45-64	3.78	3.52
65+	4.31	4.20

Source: Dunn and Doeksen (1979).

TABLE XXII

OTHER AMBULANCE CALLS PER 1000 POPULATION

Age Cohort	
>20	3.23
20-29	10.66
30-39	11.29
40-49	8.81
50-59	21.15
60-69	37.81
70-79	137.87
80+	216.95

Source: Dunn and Doeksen (1979).

As population and rural investments grow, the need for fire protection increases. To anticipate needs an estimate of annual fires is useful. Childs et al. (1977) provide information for estimating the number of fires in a given area. A fire frequency coefficient for population is used to estimate annual fires occurring in the community and the service area.

As has been noted, population is projected separately for the community and the service area. Population is allocated to age-sex cohorts for each year. It would be useful for detailed information to be available for school-age children. As normal population growth or decline occurs, if a new plant or development occurs, it would be helpful to know the impact on demand for educational services. The number of children in each grade category will determine the number of teachers needed as well as indicate if capital expansion is necessary. The model projects population based on age-sex cohorts with the cohorts less than 15 years and 15 to 19 years as the most detailed data available for school age children.

In order to project the number of school-age children by single age cohorts, Bureau of Census data for Oklahoma was used (B38, 1970). A state breakdown of population by single year age groups is available for places of 2,500 to 10,000 and also for rural places. That proportionate breakdown is used to estimate the number of school-age children for the city population and the service area population. Obviously, using state proportions for the single age groups does not provide as accurate results as community specific data. If the local school district or some other source can provide the appropriate information on enrollment then that data should be used.

Up to this point, all model estimates of service requirements are available for the city, service area, and total population. The service requirements for water use, sewer, and solid waste requirements are estimated for the city population only.

In order to estimate water use for the city, the number of user hookups needs to be estimated. Hookups are estimated using the assumption of 2.62 persons per tap (Goodwin et al., 1981). Also, the number of commercial and business establishments is needed. A simple method of estimating business establishments is employed in the model as a default procedure. The procedure relies on central place theory and the concept that different sizes of cities perform different functions and provide various levels of service. Flood and Schreiner (1972) developed a study for rural towns in South Central Oklahoma that included this concept. The study indicates a system of cities with various sized cities providing a given range of services. In a more recent study, Negero (1979) found that population and distance to the nearest larger town were major determinants of service variability in Idaho towns. Negero found functionally different levels of town hierarchies in Idaho. Smaller towns were found to be more similar in functional complexity than larger towns. Population was found to affect the total number of establishments more than the number of different functions.

This simulation model links the concept of central places to the economic and demographic activity in an area. The concept of threshold populations is utilized to link population change to central place theory. The number of commercial establishments in the city is based on research conducted in the Ozarks region of Oklahoma and Missouri (Simon et al., 1981). Threshold popoulation is defined to be the minimum level population necessary to support a business establishment. This information is provided by Simon et al. for various businesses at the one, two and three firm level. The threshold population is compared to the city population plus service area population calculated each year to estimate the number of firms in the city. Of course, this is considered default data in the model, and the user may supply specific data if desired. Table XXIII reports the threshold populations for various businesses that are used in the model.

Total industrial establishments within a community are set at a given number specified by the user. The Oklahoma Directory of Manufacturers published by the Oklahoma Industrial Development Department (1978) provides reliable default estimates. The total volume of water consumed annually (VOLW) is then estimated as a function of user hookups (HOUS) and business and industrial establishments (CIUS) from Goodwin et al. (1979):

$$(VOLW)_t = 82628.62(HOUS)_t + 203556.56(CIUS)_t \qquad (3.27)$$

Sewer or waste water generation is also closely related to population. Nelson and Fessehaye (1981) note that 100 gallons per person is often used to estimate daily sewage flow rates. Additional major usage from industrial establishments should also be considered. The model allows the user to try alternative per capita figures if desired.

Cities have many alternatives available to handle solid waste collection, transfer, and disposal (Fessehaye and Kuehn, 1981a, 1981b, 1981c; Kuehn, 1980). However, no matter what method of service delivery is chosen, some estimate of solid waste service need is useful. The estimate used to determine collection and disposal needs for solid

TABLE XXIII

FIRM ENTRY THRESHOLD POPULATION FOR CITY AND MARKET AREA, MEDIAN POPULATION, 1975

Firm Title	1 Firm Entry Threshold	2 Firm Entry Threshold	3 Firm Entry Threshold
Lumber and Building Materials Dealers	2595	8748	12854
Paint, Glass, and Wallpaper Stores	11528	23220	54047
Hardware Stores	3709	9925	15818
Lawn and Garden Supply Stores	5845	20082	NR*
Mobile Home Dealers	11625	19553	NR
Department Stores	11626	51221	NR
General Merchandise Stores	1536	2147	7662
Grocery Stores	1250	1883	3575
Motor Vehicle Dealers, New and Used	4761	8266	11197
Motor Vehicle Dealers, Used Only	9642	14290	NR
Auto and Home Supply Stores	4000	7307	12719
Boat Dealers	12887	NR	NR
Recreation and Utility Trailer Dealers	19574	NR	NR
Motorcycle Dealers	31485	49948	NR
Men's and Boy's Clothing Stores	9798	20452	45647
Women's Ready-to-Wear Stores	5449	8680	12643
Children's and Infants' Wear Stores	18633	NR	NR
Shoe Stores	10352	15781	20426
Furniture Stores	4013	9297	12530
Floor Covering Stores	8806	31034	NR
Drapery and Upholstery Stores	20178	NR	NR
Household Appliance Stores	7802	15214	18673
Radio and Television Stores	5952	20056	34707
Music Stores	23442	42382	NR
Drug Stores	2939	8702	11923
Sporting Goods or Bicycle Stores	6932	16326	44973
Book Stores	41478	NR	NR
Stationery Stores	40424	NR	NR
Jewelry Stores	9151	19574	42382
Hobby, Toy and Game Shops	17085	NR	NR
Gift, Novelty, and Souvenir Shops	9131	17084	20725
Sewing, Needlework, & Piecegoods Stores	8261	19173	23220
Florists	7079	12796	18286

*NR = Not reported.

Source: Simon et al. (1981).

waste generation comes from Goodwin and Nelson (1980). Total volume in cubic yards of solid waste collected per week (VOLC) is estimated as a function of the users of the system (USSRS).

$$(VOLC)_t = .1948(USSRS)_t \qquad (3.28)$$

The primary purpose of the community service account is to project usage levels or demand. Various usage coefficients, often developed for the state of Oklahoma, are utilized to project service demand over time as a function of the model results. When compared to capacity constraints, these projections provide useful information for planning purposes. Community service provision is related to the expenditures of a local community. The costs of providing the various services are described in detail in budgets mentioned earlier. The accompanying topic of interest is one of revenue. Projections of revenue over time from various sources also will be of interest to local leaders.

Community Revenue Account

For communities in Oklahoma, general fund revenue sources comprise most of the revenue for day-to-day operation. In the general fund, there are five basic sources of revenue: (1) Tax revenue including a sales tax, alcoholic beverage tax, occupation tax, and franchise tax. The sales tax level is decided on by the city and can be o, 1, 2, or 3 percent. The city sales tax is collected with the state sales tax and then returned to the city. The alcoholic beverage tax is transferred from the state government and allocated based on population. Cities can also levy an occupation tax and a franchise tax. (2) Revenue from licenses and permits is another source of income. Dog tags and plumbing and electrical permits are examples of this source of revenue.

As population grows, more construction in housing occurs, thus more revenue from this source. (3) User charges are a third source of revenue for the general fund. User charges such as water, garbage and other services are directly related to the level of use in many cases. The model allows projection of user charges based on population using the most recent years per capita figure. (4) Revenue from court fines is another source of funds and is projected using a per capita figure in the model. (5) A final category in the general fund is miscellaneous revenues and includes any funds not counted in previous categories. Interest revenue or rental fees for a civic center are examples of miscellaneous revenues.

Other sources of revenue include three main categories: (1) Revenue sharing, which is a direct allocation from the federal government. Revenue sharing is very difficult to predict and depends on many things including the prevailing political climate. Revenue sharing funds should be used for capital expenditures projects rather than operating expenses as the revenue is not guaranteed from year to year. (2) Another cash appropriation is a street and alley fund. Taxes on commercial vehicles, bus mileage, and gas excise taxes are ear-marked for street and alley funds and transferred from the state government. (3) A sinking fund is often found in rural communities. This fund is established to retire bond indebtedness. This is usually the only ad valorem tax revenue a city or community will receive. Projections of revenue from these sources of funds varies greatly and depends on factors not included in the model. However, a per capita estimate can be made if the user desires.

Annual projections of general fund revenue are provided in the model, based on the most recent data available. Table XXIV presents actual revenue data for Holdenville by source for the fiscal year 1979-1980. The data were obtained from the Oklahoma State Board of Equalization (1981). All cities are required to file an annual report dealing with revenue and income estimates for the coming fiscal year. Included in this report are actual data for previous fiscal years. This source provides the most accurate and community specific data that are available for rural communities in Oklahoma.

TABLE XXIV

REVENUE BY SOURCE, HOLDENVILLE, OKLAHOMA, 1979-80 FISCAL YEAR, THOUSANDS OF DOLLARS

Revenue Source	
Sales Tax	448.078
Alcoholic Beverage Tax	32.104
Occupation Tax	1.193
Franchise Tax	47.419
Licenses and Permits	.512
User Charge - Police	7.769
- Garbage	68.392
- Cemetery	7.480
- Landfill	4.747
Fines	37.106
Miscellaneous and Other	32.204
Total General Fund	687.004
Revenue Sharing	223.440
Street and Alley Fund	57.013
Sinking Fund	1.669

CHAPTER IV

SIMULATION MODEL FOR RURAL COMMUNITY DEVELOPMENT

A model is an abstract representation of a real world situation. Economic and social relationships are often very complex. In order to investigate real world problems, a model should represent the actual situation as closely as possible. The more complex and detailed a model becomes, the more unmanageable and unwieldy it will often be. The obvious trade-off then becomes one of accuracy and exact representation versus manageability and ease of interpretation or usefulness.

Simulation is a technique useful in problem solving or conducting experiments. Manetsch and Park (1974) define simulation as the process of generating a time path of modeled variables when a specific set of systems inputs and parameters are used interactively. Manetsch and Park emphasize that simulation can be thought of as a sequential numerical technique to solve systems of equations for the endogenous variables. Simulation is not the same as a mathematical technique where a single solution can be found. Simulation, then, is very useful for complex dynamic systems where no single solution exists. Hutton (1971) notes that the attribute differentiating simulation from other methods of analysis is the depth that simulation makes feasible. He states, "With simulation one is limited in depth only by his knowledge and capacity to handle the data mangement problems that arise when he attempts to model reality closely" (p. 8).

As computer technology and software capabilities increase, data management and more complex simulation models are possible. It is important to insure that economic theory and empirical observation are closely checked as we construct the more complex models. Complexity and detailed abstraction are useless unless the simulation model subscribes to theory and represents some real world situation. The model will not solve the problem, only aid in decisionmaking concerning the problem.

The simulation model for rural community development in Oklahoma is not a simple abstraction. As much detail as possible is included, with economic and demographic realities modeled as closely as possible. The model is flexible so as to represent various situations that might exist in different communities. Flexibility also exists within the model as the researcher can experiment by changing variables and measuring their impact. The simulation model equations are written in Fortran and can be run at very little cost on the computer.

The simulation model is built around the input-output model. Demand is estimated through a set of final demand predictive equations. Output requirements necessary to meet estimated final demand are estimated using the input-output model. The output projections are used to estimate various community variables such as employment, income, and population. The economic and demographic variables are then used to determine requirements for various community services such as water needs, medical needs, etc. Also, local government revenue is estimated. An overview of the simulation model is shown in Figure 5.

The detailed relationships for the model are included in this chapter. Variables are represented by letters, matrices by the capital letter A, and scalars by the capital letter S. A complete

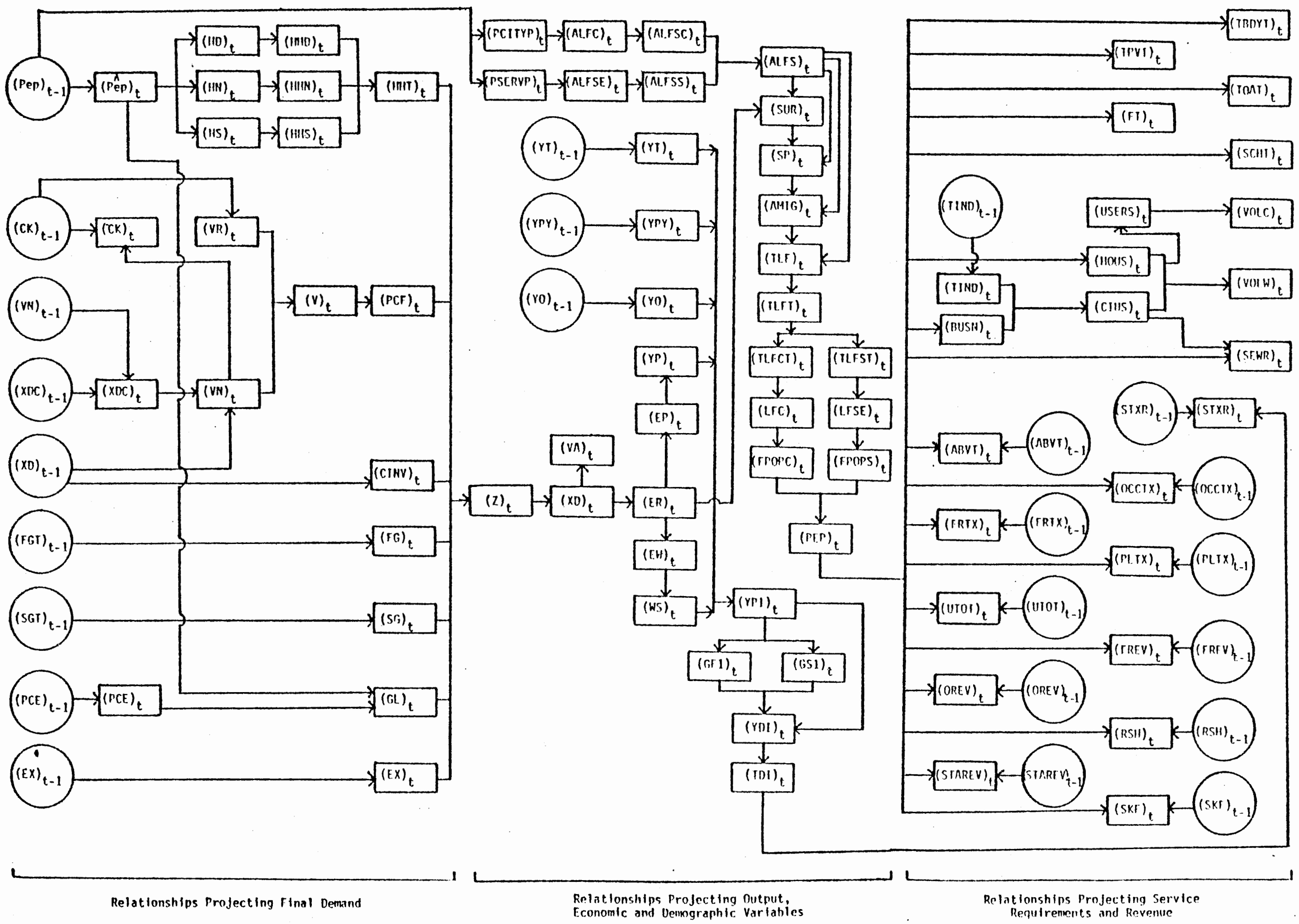


Figure 5. Flow Chart of the Simulation Model for Rural Communities in Oklahoma

listing of the variables, matrices, and scalars are included in Tables XXV, XXVI, and XXVII.

The Oklahoma Community Development Simulation Model

Relationships Projecting Final Demand

Household Demand. Personal consumption expenditures are classified into three categories which are durables, nondurables, and services. Durable good purchases, such as automobiles and household appliances, are easily postponed and durable purchases as a percentage of total personal consumption have changed little since 1975. Nondurable purchases include such items as food, clothing, some house furnishings, and drugs. These expenditures have decreased slightly since 1975 as a percent of total consumption. Services include expenditures such as utilities, professional services, transportation and domestic help. Nationwide, the percent of personal expenditures allocated to services continues to rise.

Household expenditures will obviously vary as the number of households or population changes. A separate equation was used to estimate expenditures for each consumer good category. Durable good purchases $(HHD)_t$ were estimated as follows:

$$(PEP)_t = (PEP)_{t-1}\ S7 \tag{4.1}$$

$$(S1)_t = (S1)_{t-1}\ S2 \tag{4.2}$$

$$(HD)_t = (S1)_t\ (PEP)_t \tag{4.3}$$

and

$$(HHD)_t = A1\ (HD)_t \tag{4.4}$$

TABLE XXV

VARIABLES IN SIMULATION MODEL

Variable	Description
$(HD)_t$	Total demand for durable goods in year t
$(HHD)_t$	Column vector of sector purchases of durable goods in year t
$(PEP)_t$	Total projected population in year t
$(HN)_t$	Total demand for nondurable goods in year t
$(HHN)_t$	Column vector of sector purchases of nondurable goods in year t
$(HS)_t$	Total demand for services in year t
$(HHS)_t$	Column vector of sector purchases of services in year t
$(HHT)_t$	Column vector of total household expenditures in year t
$(XDC)_t$	Column vector of sector output at capacity level in year t
$(VN)_t$	Column vector of new plant and equipment investment in year t
$(XD)_t$	Column vector of sector output necessary to meet estimated final demand in year t
$(VR)_t$	Column vector of replacement investment by sector in year t
$(CK)_t$	Column vector of capital stock by sector at the beginning of year t
$(V)_t$	Column vector of total investment in year t
$(PCF)_t$	Column vector of composition of new investment in year t
$(CINV)_t$	Column vector of net inventory change in year t for sector j
$(FG)_t$	Column vector of federal government purchases in year t
$(FGT)_t$	Total federal government purchases in year t
$(SG)_t$	Column vector of state government purchases in year t
$(SGT)_t$	Total state government purchases in year t
$(PCE)_t$	Per capita local government expenditures by sector
$(GL)_t$	Column vector of local government purchases in year t
$(EX)_t$	Total net export demand by sector for year t
$(Z)_t$	Column vector of total final demand in year t
$(ER)_t$	Local employment requirements by sector in year t
$(EW)_t$	Wage and salary employment by sector in year t
$(EP)_t$	Proprietor employment by sector in year t

TABLE XXV (Continued)

Variable	Description
$(WS)_t$	Sector wage and salary payments in year t
$(YP)_t$	Sector proprietor income in year t
$(YT)_t$	Transfer payments in year t
$(YPT)_t$	Property income in year t
$(YO)_t$	Other labor payments in year t
$(YPI)_t$	Total personal income less contributions to social insurance
$(VA)_t$	Value added by sector in year t
$(GF1)_t$	Federal personal income tax
$(GS1)_t$	State personal income tax
$(YDI)_t$	Disposable personal income by sector in year t
$(TDI)_t$	Total disposable personal income in year t
$(ALFC)_t$	Available labor force in city in year t by age-sex cohorts
$(ALFSE)_t$	Available labor force in service area in year t by age-sex cohorts
$(PCITYP)_t$	Baseline population in city for year t
$(PSERVP)_t$	Baseline population in service area for year t
$(ALFCT)_t$	Total available labor force in city in year t
$(ALFST)_t$	Total available labor force in service area in year t
$(ALFT)_t$	Total available labor force for city and service area combined
$(ALFSC)_t$	Available labor force by economic sector in city for year t
$(ALFSS)_t$	Available labor force by economic sector in service area for year t
$(ALFS)_t$	Available labor force by economic sector for city and service area combined in year t
$(SUR)_t$	Surplus (deficit) of available labor force when compared to employment requirements by economic sector
$(SP)_t$	Surplus of available labor force as a percentage of total available labor force
$(AMIG)_t$	Net migration in year t
$(TLF)_t$	Total labor force by economic sector after net migration in year t
$(TLFT)_t$	Total labor force after net migration in year t
$(TLFCT)_t$	Total labor force after net migration allocated to the city

TABLE XXV (Continued)

Variable	Description
$(TLFST)_t$	Total labor force after net migration allocated to the service area
$(LFC)_t$	Total labor force by age-sex cohorts in year t to city
$(LFSE)_t$	Total labor force by age-sex cohorts in year t for service area
$(FPOPC)_t$	Population in city after net migration for year t
$(FPOPS)_t$	Population in service area after net migration for year t
$(BDYC)_t$	Annual bed days for year t by disease category for city population
$(PBD)_t$	Population in thousands for city in year t by cohort: <15, 15-44, 45-64, and 65+ for males and females
$(TBDYC)_t$	Total bed days per year for city population
$(BDYS)_t$	Annual bed days for year t by disease category for service area population
$(PBD2)_t$	Population in thousands for service area in year t by cohort: <15, 15-44, 45-64, and 65+ for males and females
$(TBDYT)_t$	Annual bed days for city and service area population combined in year t
$(PVC)_t$	Physician visits by age group for city population
$(PPV)_t$	Population for city in year t by cohort: <15, 15-44, 45-64, 65+
$(TPVC)_t$	Total annual physician visits for city in year t
$(PVS)_t$	Physician visits by age group for service area population
$(PPV2)_t$	Population for city in year t by cohort: <15, 15-45, 45-64, 65+
$(TPVS)_t$	Total annual physician visits for service area in year t
$(TPVT)_t$	Total annual physician visits for city and service area combined in year t
$(OAC)_t$	Other ambulance calls per year by age group for city
$(POA)_t$	Population in thousands for city by cohort: <20, 20-29, 30-39, 40-49, 50-59, 60-69, 70-79, 80+
$(TOAC)_t$	Total other ambulance calls for city in year t
$(OAS)_t$	Other ambulance calls per year by age group for service area
$(POA2)_t$	Population in thousands for service area by cohort: <20, 20-29, 30-39, 40-49, 50-59, 60-69, 70-79, 80+
$(TOAS)_t$	Total other ambulance calls for service area in year t

TABLE XXV (Continued)

Variable	Description
$(TOAT)_t$	Total other ambulance calls for city and service area in year t
$(FC)_t$	Fires occurring in city in year t
$(FS)_t$	Fires occurring in service area in year t
$(CTOT)_t$	Total city population in year t
$(SATOT)_t$	Total service area population in year t
$(SCHC1)_t$	Number of male school age children by age cohort: <1, 2, . . ., 13, 14, in year t for city population
$(SCHC3)_t$	Number of male school age children by age cohort: 15, 16, 17, 18, 19, in year t for city population
$(SCHC2)_t$	Number of female school age children by age cohort: <1, 2, . . ., 13, 14, in year t for city population
$(SCHC4)_t$	Number of female school age children by age cohort: 15, 16, 17, 18, 19, in year t for city population
$(HOUS)_t$	Number of water user hookups in year t
$(BUSNT)_t$	Number of commercial business establishments in year t by establishment type
$(BUSN)_t$	Total number of commercial business establishments in year t
$(TIND)_t$	Total industrial establishments in year t
$(CIUS)_t$	Total commercial and industrial user hookups in year t
$(VOLW)_t$	Total annual volume of water consumed
$(VOLC)_t$	Total annual volume of solid waste collected per week for year t
$(STXR)_t$	Sales tax revenue for time period t
$(ABVT)_t$	Alcoholic beverage tax revenue for time period t
$(OCCTX)_t$	Occupation tax revenue for time period t
$(FRTX)_t$	Franchise tax revenue for time period t
$(PLTX)_t$	Revenue from permits and licenses for time period t
$(UPO)_t$	Revenue from police service charges for time period t
$(UGB)_t$	Revenue from user charges for garbage service in time period t
$(UCE)_t$	Revenue from charges for cemetery in time period t
$(ULF)_t$	Revenue from user charges for landfill in time period t
$(OREV)_t$	Revenue from other revenue sources in time period t

TABLE XXVI

MATRICES IN SIMULATION MODEL

Matrix	Description
A1	Column vector where elements are proportion of durables purchased from sector j
A2	Column vector where elements are proportion of nondurables purchased from sector j
A3	Column vector where elements are proportion of services purchased from sector j
A4	Column vector containing average capital-output ratios
A5	Column vector containing one plus the annual growth rate of the capital-output ratios
A6	Column vector where elements are annual depreciation rates
A7	Capital coefficients matrix
A8	Column vector whose elements are proportionals of sector inventory changes to sector output lagged
A9	Column vector where elements are proportion of federal government purchases to total federal government purchases
A10	Column vector where elements are proportion of state government purchases to total state government purchases
A11	Column vector where elements are sector output growth rates
A12	Inverse matrix $(I-A)^{-1}$ where A is the direct coefficient matrix
A13	Column vector of output-labor ratios
A14	Column vector where elements are one plus the growth rate of output ratios
A15	Column vector where elements are the ratio of wage and salary employment to total employment
A16	Column vector where elements are one plus the growth rate of A15
A17	Column vector containing wage rates by sector
A18	Column vector where elements are one plus the annual growth rate of wage rates
A19	Column vector containing proprietor income rates by sector
A20	Column vector where elements are one plus the annual growth rate of proprietor income rates
A21	Column vector where elements are the ratio of value added to output
A22	City labor force participation rates by age-sex cohorts

TABLE XXVI (Continued)

Matrix	Description
A23	Service area labor force participation rates by age-sex cohorts
A24	Column vector where elements are proportionals of the available labor force by age-sex cohorts in city to total available labor force
A25	Column vector where elements are proportionals of the available labor force by age-sex cohorts in service area to total available labor force
A26	Column vector where elements are proportionals of employment requirements by economic sector to total employment requirements
A27	Matrix where elements are average annual hospital stay for disease categories by age and sex cohorts
A28	Column vector where elements are annual visits to a physician per person by age-sex cohorts
A29	Column vector where elements are utilization rates per 1000 population for other medical calls
A30	Column vector where elements are threshold population for one firm entry by establishment type
A31	Column vector where elements are threshold population for two firm entry by establishment type
A32	Column vector where elements are threshold population for three firm entry by establishment type
A33	Column vector where elements are proportion of total population going to each cohort, males: <1, 2, ..., 13, 14, for city population
A34	Column vector where elements are proportion of total population going to each cohort, females: <1, 2, ..., 13, 14, for city population
A35	Column vector where elements are proportion of total population going to each cohort, males: 15, 16, 17, 18, 19, for city population
A36	Column vector where elements are proportion of total population going to each cohort, females: 15, 16, 17, 18, 19, for city population

TABLE XXVII

SCALARS IN SIMULATION MODEL

Scalars	Description
S1	Ratio of total durable expenditures to population
S2	One plus the annual growth rate of S1
S3	Ratio of total nondurable expenditures to population
S4	One plus the annual growth rate of S3
S5	Ratio of total service expenditures to population
S6	One plus the annual growth rate of S5
S7	One plus the annual growth rate of local population
S8	90% of upper limit of capacity
S9	One plus the annual growth rate of federal government purchases
S10	One plus the annual growth rate of state government purchases
S11	One plus the annual growth rate of local government per capita expenditures
S12	One plus the annual increase in transfer payments
S13	One plus the annual rate of growth in property income
S14	One plus the annual rate of growth in other labor income
S15	Ratio of social security payments to wage and salary income
S16	One plus the annual growth rate of S15
S17	Federal income tax rate
S18	State income tax rate
S19	One plus the annual change in labor-force participation rates
S20	Proportion of total labor force allocated to city before net migration
S21	Proportion of total labor force allocated to service area before net migration
S22	Fire frequency coefficient for population
S23	Ratio of sales tax revenue to disposable income
S24	Ratio of alcoholic beverage tax revenue to total city population
S25	Ratio of occupation tax revenue to total city population
S26	Ratio of franchise tax revenue to total city population
S27	Ratio of permit and license revenue to total city population

TABLE XXVII (Continued)

Scalars	Description
S28	Ratio of revenue for police services to total city population
S29	Ratio of garbage service revenue to total city population
S30	Ratio of revenue from cemetery to total city population
S31	Ratio of landfill service revenue to total city population
S32	Ratio of other revenue to total city population

where $(HD)_t$ = total demand for durable goods in year t,

$(HHD)_t$ = column vector of sector purchases of durable goods in year t,

$(S1)_t$ = ratio of total durable expenditures to population in year t,

S2 = one plus the annual growth rate of S1,

A1 = column vector where the elements are proportion of durables purchases from sector j,

$(PEP)_t$ = total population predicted for year t, and

S7 = one plus the annual growth rate of population.

Nondurable expenditures were calculated using the following equations:

$$(S3)_t = (S3)_{t-1}\ S4 \tag{4.5}$$

$$(HN)_t = (S3)_t\ (PEP)_t \tag{4.6}$$

and

$$(HHN)_t = A2\ (HN)_t \tag{4.7}$$

where $(HN)_t$ = total demand for nondurable goods in year t,

$(HHN)_t$ = column vector of sector purchases of nondurable goods in year t,

$(S3)_t$ = ratio of total nondurable expenditures to population in year t,

S4 = one plus the annual growth rate of S3, and

A2 = column vector where the elements are the proportion of nondurables purchased from sector j.

Demand for services is estimated as follows:

$$(S5)_t = (S5)_{t-1}\ S6 \tag{4.8}$$

$$(HS)_t = (S5)_t\ (PEP)_t \tag{4.9}$$

and

$$(HHS)_t = A3\ (HS)_t \tag{4.10}$$

where $(HS)_t$ = total demand for services in year t,

$(HHS)_t$ = column vector of sector purchases of services in year t,

$(S5)_t$ = ratio of total service expenditures to population,

S6 = one plus the annual growth rate of S5, and

A3 = column vector where elements are proportion of services purchased from sector j.

Total household expenditures are then the sum of the three consumer goods categories.

$$(HHT)_t = (HHD)_t + (HHN)_t + (HHS)_t \qquad (4.11)$$

where $(HHT)_t$ = column vector of total household expenditures in year t.

Capital Formation. Capital expenditures can consist of new plant and equipment investment as well as replacement investment used to replace old or depreciated capital. The equations used in this model are based on the concept of induced investment or the accelerator principle. Peterson (1974) notes the principle is based on the idea that net investment is a function of the rate of change in final output. Thus one source of investment, induced or new investment, is related to output increases. Another source of investment, replacement investment is related to capital stock and the associated depreciation rates. Peterson lists the definition of capacity as one drawback to the accelerator principle. If surplus capacity exists in the economy, the principle breaks down because additional output can be provided using the excess capacity in capital stock. An assumption must be made that at some point, the entrepreneur decides he must expand facilities to provide for increased demand. Capacity output for the model was estimated as follows:

$$(XDC)_t = (XDC)_{t-1} + \left[\frac{1}{(A4)_{t-1}} (VN)_{t-1}\right] \quad (4.12)$$

where $(XDC)_t$ = column vector of sector output at capacity level in year t,

$(VN)_{t-1}$ = column vector of new plant and equipment investment in year t-1, and

$(A4)_{t-1}$ = column vector containing average capital-output ratios.

New plant and equipment investment, based on the accelerator principle is then estimated as follows:

$$(A4)_t = (A4)_{t-1}\ A5 \quad (4.13)$$

IF $(XD)_{t-1} \leq (XDC)_t\ S8$ (4.14)

THEN $(VN)_t = 0$

IF $(XD)_{t-1} > (XDC)_t\ S8$ (4.15)

and

THEN $(VN)_t = (A4)_t\ [(XD)_{t-1} - (XDC)_t\ S8]$

where A5 = column vector containing one plus the annual growth rate of the capital-output ratios,

$(XD)_{t-1}$ = column vector of sector output necessary to meet estimated final demand in year t-1, and

S8 = 90 percent of the upper limit of capacity.

Replacement investment is related to the stock of capital and depreciation rates.

$$(VR)_t = A6\ (CK)_{t-1} \quad (4.16)$$

where $(VR)_t$ = column vector of replacement investment by sector in year t,

$(CK)_{t-1}$ = column vector of capital stock at the beginning of year t-1, and

A6 = column vector where elements are annual depreciation rates.

Total investment and the composition of new investment by sector is then computed as follows:

$$(CK)_t = (CK)_{t-1} + (VN)_t \tag{4.17}$$

$$(V)_t = (VN)_t + (VR)_t \tag{4.18}$$

$$(PCF)_t = A7\ (V)_t \tag{4.19}$$

where $(V)_t$ = column vector of total investment in year t,

$(PCF)_t$ = column vector of composition of total investment in year t, and

A7 = capital coefficients matrix.

Inventory Change. Change in business inventories includes the value of raw materials, partly finished goods, and finished goods held by business. The technique used to project inventory change relates inventory levels to output by sector. This methodology is similar to that used by the Bureau of Labor Statistics, U.S. Department of Labor, when they estimate national final demand, employment, and output (U.S. Department of Labor, 1980).

$$(CINV)_t = (XD)_{t-1}\ (A8)_t \tag{4.20}$$

where $(CINV)_t$ = column vector of net inventory change in year t for sector j, and

$(A8)_t$ = column vector whose elements are proportionals of sector inventory changes to sector output lagged.

Government Purchases. Federal government expenditures are difficult to predict as each year's level of expenditure depends on the prevailing political climate. Forecasting federal expenditures locally is more difficult to predict because of wide variations and the lack of data. The method used in this study is to employ the past growth rate for expenditures in the state as a proxy for local federal government purchases.

$$(FG)_t = A9\ [(FGT)_{t-1}\ S9] \tag{4.21}$$

where $(FG)_t$ = column vector of federal government purchases in year t,

$(FGT)_{t-1}$ = total federal government purchases in year t-1,

S9 = one plus the annual growth rate of federal government purchases in Oklahoma, and

A9 = column vector whose elements are the proportion of federal government purchases to total federal government purchases.

This model is concerned with economic activity at the local level. The local government is the unit of interest at this level. In order to facilitate possible further analysis concerning the local government sector, the expenditures for state government and for local government were estimated separately. State government expenditures were estimated as follows:

$$(SG)_t = A10\ [(SGT)_{t-1}\ S10] \tag{4.22}$$

where $(SG)_t$ = column vector of state government purchases in year t,

$(SGT)_{t-1}$ = total state government purchases in year t-1,

S10 = one plus the annual growth rate of state government purchases, and

A10 = column vector where elements are the proportion of state government purchases to total state government purchases.

Local government expenditures are projected as follows:

$$(PCE)_t = (PCE)_{t-1}\ S11 \tag{4.23}$$

and

$$(GL)_t = (PCE)_t \ (PEP)_t \tag{4.24}$$

where $(PCE)_t$ = per capita local government expenditures by sector in year t,

S11 = one plus the annual growth rate of local government per capita expenditures, and

$(GL)_t$ = column vector of local government purchases in year t.

Export Demand. National exports are influenced by worldwide demand. State exports are related to national demand and some estimate of national demand is often used in state models (Doeksen, 1971; Sarigedik, 1975). Output growth rates were used as default values with county specific rates of growth included, at least for key sectors like agriculture, mining, and manufacturing. Net exports were estimates as follows:

$$(EX)_t = (EX)_{t-1} \ A11 \tag{4.25}$$

where $(EX)_t$ = total net export demand by sector for year t, and

A11 = column vector where elements are sector output growth rates, with county specific data added when available.

Total Final Demand. Total final demand is the sum of the individual demand components:

$$(Z)_t = (HHT)_t + (PCF)_t + (CINV)_t + (FG)_t + (SG)_t + (GL)_t + (EX)_t \tag{4.26}$$

where $(Z)_t$ = column vector of total final demand in year t.

Determining Sector Outputs

Sector output $(XD)_t$ required to produce estimated final demand is estimated as follows:

$$(XD)_t = A12\ (Z)_t \tag{4.27}$$

where A12 = inverse matrix $(I-A)^{-1}$ where A is the direct coefficient matrix.

Relationships Projecting Community Economic and Demographic Variables

Employment Requirements. Employment by economic sector $(ER)_t$ is projected using predicted output and employment-output ratios. Changes in the ratio over time are also incorporated into the equations.

$$(A13)_t = (A13)_{t-1}\ A14 \tag{4.28}$$

and

$$(ER)_t = (XD)_t\ /\ (A13)_t \tag{4.29}$$

where $(A13)_t$ = column vector of output-labor ratios in year t,

A14 = column vector where elements are one plus the annual growth rate of output-labor ratios, and

$(ER)_t$ = local employment requirements by sector in year t.

Total employment is separated into wage and salary employment and proprietor employment using the proportional county relationship of wage and salary employment to total employment.

$$(A15)_t = (A15)_{t-1}\ A16 \tag{4.30}$$

$$(EW)_t = (A15)_t\ (ER)_t \tag{4.31}$$

and

$$(EP)_t = (ER)_t - (EW)_t \tag{4.32}$$

where $(A15)_t$ = column vector where elements are the ratio of wage and salary employment to total employment,

A16 = column vector where elements are one plus the growth rate of A15,

$(EW)_t$ = wage and salary employment by sector in year t, and

$(EP)_t$ = proprietor employment by sector in year t.

<u>Income</u>. Income is calculated using the estimated employment requirements from the model. Each year the wage rates are multiplied by the employment estimates to obtain sector income. Wage and salary income is calculated using the following equations:

$$(A17)_t = (A17)_{t-1}\ A18 \tag{4.33}$$

and

$$(WS)_t = (A17)_t\ (EW)_t \tag{4.34}$$

where $(A17)_t$ = column vector containing wage rates by sector,

A18 = column vector where elements are one plus the annual growth rate of wage rates, and

$(WS)_t$ = sector wage and salary payments in year t.

Similarly, sector proprietor income is calculated as follows:

$$(A19)_t = (A19)_{t-1}\ A20 \tag{4.35}$$

and

$$(YP)_t = (A19)_t\ (EP)_t \tag{4.36}$$

where $(A19)_t$ = column vector containing proprietor income rates by sector,

A20 = column vector where elements are one plus the annual growth rate of proprietor income rates, and

$(YP)_t$ = sector proprietor income in year t.

Other sources of income include transfer payments $(YT)_t$, property income $(YPT)_t$, and other labor income $(YO)_t$. Annual growth rates for these sources of income are available at the county level.

$$(YT)_t = (YT)_{t-1} \; S12 \tag{4.37}$$

$$(YPT)_t = (YPT)_{t-1} \; S13 \tag{4.38}$$

and

$$(YO)_t = (YO)_{t-1} \; S14 \tag{4.39}$$

where S12 = one plus the annual increase in transfer payments,

S13 = one plus the annual rate of growth in property income, and

S14 = one plus the annual rate of growth in other labor income.

Total personal income less contributions to social security $(YPI)_t$ is calculated using the following:

$$(S15)_t = (S15)_{t-1} \; S16 \tag{4.40}$$

$$(YPI)_t = (WS)_t + (YP)_t + (YT)_t + (YPY)_t + (YO)_t - [(S15)_t \; (WS)_t] \tag{4.41}$$

where $(S15)_t$ = ratio of social security payments to wage and salary income, and

S16 = one plus the annual growth rate of S15.

Value Added. Value added is assumed to have a constant relation to output and is calculated as follows:

$$(VA)_t = A21 \; (XD)_t \tag{4.42}$$

where $(VA)_t$ = value added by sector in year t, and

A21 = column vector where elements are the ratio of value added to output.

Income Tax. In order to estimate disposable income after income taxes, the following equations are used:

$$(GF1)_t = (YP1)_t \; S17 \tag{4.43}$$

and

$$(GS1)_t = (YP1)_t \; S18 \tag{4.44}$$

where $(GF1)_t$ = federal personal income tax,

$(GS1)_t$ = state personal income tax,

S17 = federal income tax rate, and

S18 = state income tax rate.

Disposable income is then calculated as follows:

$$(YDI)_t = (YPI)_t - (GS1)_t - (GF1)_t \tag{4.45}$$

and

$$(TDI)_t = \sum_j (YDI)_t \tag{4.46}$$

where $(YDI)_t$ = disposable personal income by sector in year t, and

$(TDI)_t$ = total disposable personal income.

Economic-Demographic Interface. For this model to be useful in planning and projection, economic, demographic, and social factors must be interrelated in the model or interfaced. In other words, employment demands and local labor availability must be matched. Migration levels and population change are linked in this matching process.

This model interfaces the economic and demographic components in three main steps. First, employment requirements are estimated using the final demand predictions, output estimates, and output-employment ratios. Second, the demographic component estimates the available local labor force using population projections and labor force participation rates. Finally, employment requirements are compared to the available labor force to determine if any net migration is necessary to balance the labor market. Murdock and Leistritz (1980) note the obvious superiority of using age-sex cohorts when projecting local population. In view of these comments, the available local labor force is estimated each year as follows:

$$(A22)_t = (A22)_{t-1}\ S19 \tag{4.47}$$

$$(A23)_t = (A23)_{t-1}\ S19 \tag{4.48}$$

$$(ALFC)_t = (PCITYP)_t\ (A22)_t \tag{4.49}$$

and

$$(ALFSE)_t = (PSERVP)_t\ (A23)_t \tag{4.50}$$

where $(A22)_t$ = the community population labor force participation rates by age-sex cohorts in year t,

$(A23)_t$ = service area labor force participation rates by age-sex cohorts in year t,

$(PCITYP)_t$ = baseline population in community for year t,

$(PSERVP)_t$ = baseline population in service area for year t,

$(ALFC)_t$ = available labor force by age-sex cohort in community in year t, and

$(ALFSE)_t$ = available labor force in service area by age-sex cohort in year t.

As can be seen, the in-community population and the service area population are predicted separately. Separate participation rates are used and are county specific when available. The available labor force by age-sex cohort is then compared to the employment requirements generated by the input-output model. To compare the two sets of estimates, the available labor force is totaled over all cohorts for both the community and the service area. Available labor force is then assumed to be distributed by economic sector in the same proportion as employment requirements are distributed. The following equations are used:

$$(ALFSC)_t = (ALFCT)_t \, (A26)_t \tag{4.51}$$

and

$$(ALFSS)_t = (ALFST)_t \, (A26)_t \tag{4.52}$$

where $(ALFSC)_t$ = available labor force (baseline) by economic sector for community in year t,

$(ALFSS)_t$ = available labor force (baseline) by economic sector in service area for year t,

$(A26)_t$ = column vector where elements are proportionals of sector employment requirements to total employment requirements,

$(ALFCT)_t$ = total available labor force in community in year t, and

$(ALFST)_t$ = total available labor force in service area in year t.

The available labor force by economic sector is then compared to employment requirements by sector to determine if a net labor surplus (deficit) exists. This calculation is done with community and service area combined to simplify the equations.

$$(ALFS)_t = (ALFSC)_t + (ALFSS)_t \tag{4.53}$$

$$(SUR)_t = (ALFS)_t - (ER)_t \tag{4.54}$$

and

$$(SP)_t = (SUR)_t \,/\, (ALFS)_t \tag{4.55}$$

where $(ALFS)_t$ = available labor force by economic sector for community and service area combined in year t,

$(SUR)_t$ = surplus (deficit) of available labor force when compared to employment requirements by economic sector, and

$(SP)_t$ = surplus of available labor force as a percentage of total available labor force.

If the local labor force exhibits a surplus, the net out-migration is assumed to occur. If employment requirements are greater than the baseline labor force, then a deficit exists in the labor pool and net in-migration occurs. But this migration process does not occur instantly. The methodology employed by Lietritz et al. (1979) is adopted. In-migration is assumed to occur if the surplus of labor dips below 6 percent. There will never be zero surplus as frictional and institutional unemployment are present. Likewise, if the surplus rises above 16 percent, then out-migration occurs. The levels of 6 and 16 percent are similar to that used in other studies and can be adjusted as local conditions dictate. The level of the labor force surplus between the range of 6 and 16 percent is termed the unallocated labor pool and includes unemployment. The equations are as follows:

$$\text{IF } (SP)_t \geq .06 \quad \text{AND } (SP)_t \leq .16 \quad \text{THEN } (AMIG)_t = 0 \tag{4.56}$$

$$\text{IF } (SP)_t < .06 \quad \text{THEN } (AMIG)_t = [(.06 - (SP)_t)(ALFS)_t] \tag{4.57}$$

$$\text{IF } (SP)_t > .16 \quad \text{THEN } (AMIG)_t = [((SP)_t - .16)(ALFS)_t] \tag{4.58}$$

where $(AMIG)_t$ = net migration for community and service area combined in year t.

Total labor force is then the sum of baseline labor force plus net migration.

$$(TLF)_t = (ALFS)_t + (AMIG)_t \tag{4.59}$$

$$(TLFT)_t = \sum_j (TLF)_t \tag{4.60}$$

where $(TLF)_t$ = total labor force by economic sector after net migration to balance employment requirements, and

$(TLFT)_t$ = total labor force after net migration.

Total labor force is not computed for the community and service area combined by economic sector. This must be converted back to age-sex cohorts in order to determine population.

$$(TLFCT)_t = (TLFT)_t \, (S20)_t \tag{4.61}$$

and

$$(TLFST)_t = (TLFT)_t \, (S21)_t \tag{4.62}$$

where $(TLFCT)_t$ = total labor force after net migration allocated to the community,

$(TLFST)_t$ = total labor force after net migration allocated to the service area,

$(S20)_t$ = proportion of total labor force allocated to community before net migration, and

$(S21)_t$ = proportion of total labor force allocated to service area before net migration.

Total labor force by age-sex cohorts is then calculated for the community and service area assuming the same proportion over cohorts as before migration. This implies that the migrants have the same demograhpic distribution as the baseline population. This assumption can be adjusted for the age-sex cohorts or the economic sectors in the case of an outside impact.

$$(LFC)_t = (A24)_t \ (TLFCT)_t \qquad (4.63)$$

and

$$(LFSE)_t = (A25)_t \ (TLFST)_t \qquad (4.64)$$

where $(LFC)_t$ = total labor force by age-sex cohort for community in year t,

$(LFSE)_t$ = total labor force by age-sex cohort for service area in year t,

$(A24)_t$ = column vector where elements are proportionals of the available labor force by age-sex cohorts to total available labor force in the community, and

$(A25)_t$ = column vector where elements are proportionals of the available labor force by age-sex cohorts to total available labor force in the service area.

The final population values for year t are then calculated using the relation of labor force to participation rates in the following manner:

$$(FPOPC)_t = (LFC)_t \ / \ (A22)_t \qquad (4.65)$$

$$(FPOPS)_c = (LFSE)_t \ / \ (A23)_t \qquad (4.66)$$

where $(FPOPC)_t$ = population in the community after net migration for year t, and

$(FPOPS)_t$ = population in the service area after net migration for year t.

Community Service Requirements. For this model to be useful at the local level, it should provide information that is helpful in decision-making and planning. Projections of employment, income, and population are useful. An additional step is to relate the economic and demographic change to the public sector.

Hospital usage or bed days per year is estimated with the use of population projections for each year. Bed days are calculated for the community population and service area population separately, as well as for the total population. If the service area for hospital bed days is different than that specified by the model, then the appropriate service area population needs to be incorporated into the model.

$$(BDYC)_t = A27\ (PBD)_t \tag{4.67}$$

where $(BDYC)_t$ = annual bed days for year t by disease category,

$(PBD)_t$ = population in thousands for the community in year t, by appropriate age-sex cohorts, and

A27 = matrix where elements are average annual hospital usage for various disease categories by age and sex cohort per 1000 population.

Total bed days per year for the community $(TBDYC)_t$ is then the sum of bed days across all disease categories:

$$(TBDYC)_t = \sum_j (BDYC)_t \tag{4.68}$$

Hospital requirements are also calculated for the service area population. This information is calculated in the same manner as above, with service area population utilized:

$$(BDYS)_t = A27\ (PBD2)_t \tag{4.69}$$

and

$$(TBDYS)_t = \sum_j (BDYS)_t \tag{4.70}$$

where $(BDYS)_t$ = annual bed days for year t by disease category for service area population,

$(PBD2)_t$ = population in thousands for the service area population, and

$(TBDYS)_t$ = total annual bed days for service area population.

The number of total hospital days is then the sum of the community requirements plus service area requirements:

$$(TBDYT)_t = (TBDYC)_t + (TBDYS)_t \tag{4.71}$$

where $(TBDYT)_t$ = total annual bed days for community and service area population combined.

A measure of the demand placed on clinics is the number of physician visits per day or per year. One doctor can see only a given number of patients per year. Physician visits per year for the community population $(PVC)_t$ are estimated as follows:

$$(PVC)_t = (PPV)_t \, A28 \tag{4.72}$$

where $(PPV)_t$ = population projections for the community by appropriate age-sex cohorts in year t, and

A28 = column vector where elements are annual visits to a physician per person by age-sex cohorts.

Total physician visits per year $(TPVC)_t$ is then the sum of visits across all age groups:

$$(TPVC)_t = \sum_j (PVC)_t \tag{4.73}$$

The same procedure is applied to the service area population:

$$(PVS)_t = (PPV2)_t \, A28 \tag{4.74}$$

and

$$(TPVS)_t = \sum_j (PVS)_t \tag{4.75}$$

where $(PVS)_t$ = physician visits per year for the service area population by age-sex cohorts, and

$(TPVS)_t$ = total physician visits per year for the service area population.

The grand total of physician visits per year for city and service area $(TPVT)_t$ is then the sum of the two separate estimates:

$$(TPVT)_t = (TPVC)_t + (TPVS)_t \tag{4.76}$$

Another important factor in providing for rural health care is ambulance service. In order to anticipate future needs, as estimates of ambulance calls for a given time period is useful. Highway accidents and transfer calls are both dependent upon local conditions, thus estimates should come from local records. Other medical calls can be projected by making them a function of the age distribution of the population.

For the city population, other ambulance calls are predicted as follows:

$$(OAC)_t = (POA)_t \ A29 \tag{4.77}$$

and

$$(TOAC)_t = \sum_j (OAC)_t \tag{4.78}$$

where $(OAC)_t$ = other ambulance calls by population in year t for community,

$(POA)_t$ = population in thousands for community by appropriate age-sex cohorts,

A29 = column vector where elements are utilization rates per 1000 population for other medical calls, and

$(TOAC)_t$ = total other ambulance calls across all age-sex cohorts for the community in year t.

Other medical calls for the service area are also calculated based on service area population by age groups.

$$(OAS)_t = (POA2)_t \ A29 \tag{4.79}$$

where $(OAS)_t$ = other ambulance calls by age-sex cohort in year t for service area, and

$(POA2)_t$ = population in thousands for the service area by appropriate age-sex cohorts.

Total other calls across all age-sex cohorts $(TOAS)_t$ is then calculated for the service area by summing $(OAS)_t$:

$$(TOAS)_t = \sum_j (OAS)_t \tag{4.80}$$

Other medical calls for the community and service area population combined $(TOAT)_t$ is the sum of the two separate estimates.

$$(TOAT)_t = (TOAC)_t + (TOAS)_t \tag{4.81}$$

As population and rural investments grow, the need for fire protection increases. To anticipate needs an estimate of annual fires is useful. Fires occurring in the community $(FC)_t$ and fires occurring in the service area $(FS)_t$ are estimated separately.

$$(FC)_t = (CTOT)_t \ / \ S22 \tag{4.82}$$

$$(FS)_t = (SATOT)_t \ / \ S22 \tag{4.83}$$

and

$$(FT)_t = (FC)_t + (FS)_t \tag{4.84}$$

where $(CTOT)_t$ = total community population in year t,

$(SATOT)_t$ = total service area population in year t,

S22 = fire frequency coefficient for population, and

$(FT)_t$ = total number of annual fires in city and service area combined.

In order to project the number of school-age children by single age cohorts, state census data were used (U.S. Department of Commerce, 1970a). A state breakdown of population by single year age groups is available for places of 2500 to 10,000 population and also for rural places.

That proportionate breakdown is used to estimate the number of school-age children for the community population and the service area population.

$$(SCHC1)_t = A33\ (MPOPC1)_t \tag{4.85}$$

$$(SCHC3)_t = A35\ (MPOPC2)_t \tag{4.86}$$

where $(SCHC1)_t$ = number of male school age children by age cohort >1, 2, ..., 13, 14,

A33 = column vector where elements are proportion of total cohort population going to each single age group,

$(MPOPC1)_t$ = predicted community population in year t for (>15) cohort,

$(SCHC3)_t$ = number of male school age children by single age cohort 15, 16, 17, 18, 19,

A35 = column vector where elements are proportion of total cohort population going to each single age group in cohort (15-19) for males, and

$(MPOPC2)_t$ = predicted city population in year t for (15-19) male cohort.

Similarly, female single age cohorts are estimated for the community as follows:

$$(SCHC2)_t = A34\ (FPOPC1)_t \tag{4.87}$$

and

$$(SCHC4)_t = A36\ (FPOPC2)_t \tag{4.88}$$

where $(SCHC2)_t$ = number of female school age children in the community by age cohort >1, 2, ..., 13, 14, where $(SCHC4)_t$ = number of female school age children in the community by age cohort 15, 16, 17, 18, 19,

$(FPOPC1)_t$ = predicted community population in year t for female cohort (>15),

$(FPOPC2)_t$ = predicted community population in year t for female cohort (15-19),

A34 = column vector where elements are proportion of total cohort population going to each single age group for female cohort (>15), and

A36 = column vector where elements are proportion of total cohort population going to each single age group for female cohort (15-19).

Service area population is also broken down in the model to determine school-age children by single age categories. The proportional breakdown for the male and female cohorts used in the model come from Bureau of Census data for rural places in Oklahoma. Model output is available to the user for the community population alone, the service area population alone, or for total population.

Up to this point, all model estimates of service requirements are available for the city, service area, and total population. The service requirements for water use, sewer, and solid waste requirements are estimated for the community population only.

In order to estimate water use for the city, the number of farm and household user hookups needs to be estimated. Also, the number of commercial and industrial business establishments is needed. The number of household hookups $(HOUS)_t$ are estimated using the assumption of 2.62 persons per tap (Goodwin et al., 1981). This assumption can be changed or experimented with by the model user.

$$(HOUS)_t = (CTOT)_t / 2.62 \tag{4.89}$$

where $(HOUS)_t$ = number of user hookups, and

$(CTOT)_t$ = total community population in year t.

The threshold population is compared to the city population plus service area population calculated each year to estimate the number of firms in the city. Of course, this is considered default data in the model, and the user may supply specific estimates if desired.

$$\text{IF } (TFPOP)_t < A30 \tag{4.90}$$

$$\text{THEN } (BUSNT)_t = 0$$

$$\text{IF } A30 \leq (TFPOP)_t < A31 \tag{4.91}$$

$$\text{THEN } (BUSNT)_t = 1$$

$$\text{IF } A31 \leq (TFPOP)_t < A32 \tag{4.92}$$

$$\text{THEN } (BUSNT)_t = 2$$

$$\text{IF } (TFPOP)_t \geq A32 \tag{4.93}$$

$$\text{THEN } (BUSNT)_t = 3$$

where $(BUSNT)_t$ = number of commercial business establishments in year t by establishment type,

$(TFPOP)_t$ = column vector where every element is the total city and service area population for year t,

A30 = column vector where elements are the threshold population for one firm entry in the town plus market area for various firm types,

A31 = column vector where elements are the threshold population for two firm entry in the town plus market area, and

A32 = column vector where elements are the threshold population for three firm entry in the town plus market area.

Total commercial establishments $(BUSN)_t$ is then the sum of the estimated number of firms by type.

$$(BUSN)_t = \sum_j (BUSNT)_t \tag{4.94}$$

Total industrial establishments $(TIND)_t$ are set at a given value in the model. The Oklahoma Directory of Manufacturers published by the Oklahoma Industrial Development Department (1978) provides reliable default estimates.

Total commercial and industrial user hookups $(CIUS)_t$ is then estimated as follows.

$$(CIUS)_t = (BUSN)_t + (TIND)_t \tag{4.95}$$

The total volume of water consumed annually is based on the estimates of user hookups:

$$(VOLW)_t = 82628.62\ (HOUS)_t + 203556.56\ (CIUS)_t \tag{4.96}$$

where $(VOLW)_t$ = total annual volume of water consumed in gallons.

The ordinary least squares regression estimating this equation is:

$$\underset{(.0466)}{VOLW = 82628.62\ HOUS} + \underset{(.0466)}{203556.56\ CIUS} \tag{4.97}$$

$$R^2 = .9125$$

where the value in parentheses is the observed significance level of the variable determined by the t-statistic (Goodwin et al., 1979).

Sewer or waste water generation is also closely related to population. Nelson and Fessehaye (1981) note that 100 gallons per person is often used to estimate daily sewage flow rates. Any additional major usage from industrial establishments should also be considered. The estimate used to determine collection and disposal needs for solid waste generation comes from Goodwin and Nelson (1980). Total volume (cubic yards) of solid waste collected per week $(VOLC)_t$ is estimated as follows:

$$(VOLC)_t = .1948\ (USSRS)_t \qquad (4.98)$$

where $(USSRS)_t$ = total number of users served.

Community Revenue. Among tax revenues, the largest source of income is the sales tax. City sales tax is decided upon in each city and can be 0, 1, 2, or 3 percent. Sales tax revenue $(STXR)_t$ is projected with the following:

$$(STXR)_t = S23 * (TDI)_t \qquad (4.99)$$

where S23 = the ratio of sales tax revenue to disposable income.

Another source of tax revenue is the alcoholic beverage tax. This revenue is transferred from the state and allocated on the basis of population. Alcoholic beverage tax revenue $(ABVT)_t$ is projected annually by the following:

$$(ABVT)_t = S24 * (CTOT)_t \qquad (4.100)$$

where S24 = the ratio of alcoholic beverage tax revenue to total community population.

Many cities have an occupation tax collected for certain types of business establishments, for example, recreational businesses. The prjections for occupation tax revenue $(OCCTX)_t$ for year t are provided with the following:

$$(OCCTX)_t = S25 * (CTOT)_t \qquad (4.101)$$

where S25 = ratio of occupation tax revenue to total community population.

A franchise tax is similar to a permit. Telephone or cable companies are often required to pay a franchise tax. Franchise tax revenue $(FRTX)_t$ for year t is projected as:

$$(FRTX)_t = S26 * (CTOT)_t \quad (4.102)$$

where S26 = ratio of franchise tax revenue to total community population.

Revenue from licenses and permits includes such diverse sources as dog licenses and plumbing or electrical permits. However, with population increases and housing starts the number of building permits would be expected to rise. Revenue from permits and licenses $(PLTX)_t$ is projected as:

$$(PLTX)_t = S27 * (CTOT)_t \quad (4.103)$$

where S27 = the ratio of permit and license revenue to total community population.

User charges for various city services often are a source of revenue. There are many types of services for which charges could be levied. The following are the most common services found.

Revenue for police services $(UPO)_t$ for year t is estimated as:

$$(UPO)_t = S28 * (CTOT)_t \quad (4.104)$$

where S28 = the ratio of revenue for police services to total community population.

Revenue obtained from garbage service charges $(UGB)_t$ is calculated as:

$$(UGB)_t = S29 * (CTOT)_t \quad (4.105)$$

where S29 = the ratio of garbage service revenue to total community population.

A smaller source of revenue that is present in most communities is charges for a cemetery. Revenue from charges for a local cemetery $(UCE)_t$ is projected annually as:

$$(UCE)_t = S30 * (CTOT)_t \tag{4.106}$$

where S30 = ratio of revenue from cemetery to total community population.

A final community revenue service that provides service charge revenue is the local landfill. Revenue from landfill charges $(ULF)_t$ is projected as:

$$(ULF)_t = S31 * (CTOT)_t \tag{4.107}$$

where S31 = ratio of landfill service revenue to total community population.

A final source of revenue for the local general fund is miscellaneous revenue. This includes any revenue source not included in the above. Oil and gas tax royalties and interest revenue are examples of this source. Other revenue $(OREV)_t$ is calculated as:

$$(OREV)_t = S32 * (CTOT)_t \tag{4.108}$$

where S32 = the ratio of other revenue to total community population.

This chapter presents a detailed description of the simulation model for rural communities in Oklahoma. The model is written in Fortran and is relatively inexpensive to run. This means repeated simulations can be made, providing relative comparisons of alternative assumptions. Economic variables, such as employment and income by sector, are projected annually. Population is projected by age and sex categories. Usage levels are projected annually for various community services. Revenue by source is also projected annually. A strength of simulation modeling is that much information is provided. More important, the interrelations among the variables projected are demonstrated through use of simulation techniques. The following two chapters provide an example of the output provided by the simulation model.

CHAPTER V

APPLICATION OF COMMUNITY SIMULATION MODEL--BASELINE PROJECTIONS

For illustration purposes, the community of Holdenville, Oklahoma was selected. Holdenville is located 74 miles from Oklahoma City and had a population of 5,373 in 1980. It is the county seat of Hughes County, which is primarily an agricultural county. The simulation model projects values of economic and demographic variables from the base year of 1972 to 1991. This chapter presents and discusses both economic and demographic projections. The following chapter discusses the potential for impact analysis using the model, as well as presenting the results of industrial development occurring in Holdenville.

Employment Projections

Employment projections for Holdenville and the surrounding service area are presented in Tables XXVIII and XXIX. Wage and salary employment by economic sector are shown in Table XXVIII. Data obtained from the U.S. Department of Agriculture (1980) for 1972 and 1978 are also reported. The agriculture and mining sector shows a steady increase over the simulation period. Manufacturing-nondurable and the communication sector both show a decline in employment over the study period with the decline leveling off after 1980. This corresponds to the reported data for these sectors and declining rates of growth were utilized for the case of Holdenville. Durable manufacturing also

TABLE XXVIII

WAGE AND SALARY EMPLOYMENT BY SECTOR, PROJECTED VALUES FOR HOLDENVILLE, OKLAHOMA, 1973 TO 1991

Sector	1972[a]	1973	1974	1975	1976	1977	1978	1978[a]	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Agricultural, Mining	164	168	178	184	190	196	203	209	211	220	229	240	250	261	273	286	299	313	327	343	359
Construction	34	43	55	62	59	54	53	49	57	63	68	76	84	91	98	107	117	128	141	156	174
Manufacturing-Nondurable	178	164	162	153	142	132	124	123	120	117	115	113	112	110	109	108	108	108	108	109	110
Manufacturing-Durable	1	1	131	143	129	113	111	107	114	121	127	131	135	138	142	145	150	155	161	168	176
Transportation	25	25	29	30	30	29	29	22	29	30	30	31	32	33	34	35	36	38	39	41	43
Communication, Utilities, Sanitary Services	60	52	48	43	38	35	32	29	31	30	30	30	30	30	30	30	30	30	31	31	32
Wholesale and Retail Trade	252	259	290	312	322	326	335	371	348	365	385	409	435	463	493	525	561	600	644	693	747
Finance, Insurance, Business and Repair Services	256	264	282	298	311	319	329	267	342	355	373	392	413	436	461	487	515	545	579	616	656
Education Services, Professional Services	629	650	671	703	731	747	764	775	783	803	832	865	904	945	989	1035	1085	1139	1198	1262	1332
Total	1599	1626	1846	1928	1952	1951	1980	1952	2035	2104	2189	2287	2395	2507	2629	2758	2901	3056	3228	3419	3629

[a]Unpublished Data, USDA, ESCS, 1980

TABLE XXIX

PROPRIETOR EMPLOYMENT BY SECTOR, PROJECTED VALUES FOR HOLDENVILLE, OKLAHOMA, 1973 TO 1991

Sector	1972[a]	1973	1974	1975	1976	1977	1978	1978[a]	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Agriculture, Mining	543	536	544	543	538	534	531	551	532	533	534	535	536	537	537	538	538	538	539	539	538
Construction	34	42	52	57	52	45	43	39	44	47	49	52	55	57	59	61	63	66	69	72	76
Manufacturing-Nondurable	6	5	5	5	5	4	4	3	4	4	4	4	4	4	3	3	3	3	3	3	4
Manufacturing-Durable	0	0	5	5	5	4	4	3	4	4	5	5	5	5	5	5	5	6	6	6	6
Transportation	10	10	11	11	11	10	10	7	9	9	9	9	8	8	8	8	8	8	8	7	7
Communication, Utilities, Sanitary Services	3	2	2	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Wholesale and Retail Trade	133	132	143	148	147	143	142	157	142	142	144	146	148	150	152	154	156	158	160	162	163
Finance, Insurance, Business and Repair Services	232	230	237	242	242	239	237	192	236	236	237	239	240	242	244	245	246	248	249	250	251
Educational Services, Professional Services	151	150	148	148	147	143	139	148	135	131	128	126	123	120	117	113	109	105	100	94	88
Total	1112	1107	1147	1161	1148	1123	1111	1101	1107	1106	1110	1116	1119	1123	1125	1127	1128	1132	1134	1133	1133

[a]Total Proprietor Employment from USDA, ESCS, 1980.

exhibits special characteristics. Reported data indicated that a new plant was established in this sector in 1974. Employment increased from almost nothing to over 100. The community simulation model allows the researcher the flexibility to include a sudden change in the economic base of a region.

The service sectors, including wholesale and retail trade, finance, business and professional services, as well as government, show steady growth in employment. These sectors are very dependent on the more basic (exporting) sectors and they also exhibit independent growth following the national norm. Total wage and salary employment is projected to increase from a published figure of 1599 in 1972 to 3629 for the year 1991. The 1978 projected value for total wage and salary employment is slightly higher than the published figure.

Proprietor employment by sector is presented in Table XXIX. Unpublished data obtained from the U.S. Department of Agriculture (1980) are also reported for 1972 and 1978. Sector proprietor employment was not actually available. Reported total proprietor employment for 1972 and 1978 was allocated by sector based on the state relation of proprietor employment to wage and salary employment by sector. In general, proprietor employment changes in the same direction as the previously reported wage and salary employment. Two exceptions are the finance, business service sector and the final sector including professional services. These two sectors show declining proprietor employment indicating an increasing proportion of employment in these sectors going for wage and salary workers. Total proprietor employment for Holdenville and the surrounding service area is projected to grow to 1133 by 1991, a slight increase from the 1972 reported figure of 1112.

The projected figure and the reported figure for total employment in 1978 are very close.

In the case of employment growth over time, the model shows the result of the new plant added to the manufacturing sector in 1974 with employment increasing steadily after 1980.

Income Projections

Tables XXX and XXXI present income for Holdenville by sector in millions of current dollars. Actual income for 1972 and 1978 are reported and available from the BEA data tapes held by the USDA (1980). Also, similar information is published by the U.S. Department of Commerce (1978; 1980). Income from these sources is reported by sector but includes an aggregate of wage and salary, proprietor, and other labor income. Tables XXX and XXXI present wage and salary income and proprietor income separately. They are broken out by using state data relating wage and salary income by sector to total income. Total wage and salary income in 1978 was projected to be 13.74 million dollars which compares to a published figure for 1978 of 13.89 million dollars. Proprietor income was projected to be 4.78 million dollars comparing to a published figure of 5.09 million dollars.

The largest wage and salary payments projected for 1991 are in the education and professional services sector. Agriculture and mining income, on the other hand, increases rapidly in the 1970's and levels off in the last years of the simulation.

Population Projections

Population projection is one of the useful outputs of a simulation model at the community level. Provision of local public services is a

TABLE XXX

WAGE AND SALARY INCOME BY SECTOR, MILLIONS OF CURRENT DOLLARS, PROJECTED VALUES FOR HOLDENVILLE, OKLAHOMA, 1973 TO 1991

Sector	1972[a]	1973	1974	1975	1976	1977	1978	1978[a]	1979	1980	1981
Agriculture, Mining	.31372	.40820	.55089	.73037	.96367	1.27177	1.35654	1.76614	1.45477	1.56243	1.67916
Construction	.22440	.29844	.40244	.47821	.47280	.45444	.47123	.42528	.52598	.61008	.69521
Manufacturing-Nondurable	.91596	.89026	.93231	.93239	.91918	.90494	.90361	.89099	.92823	.95999	.99631
Manufacturing-Durable	.00365	.00376	.89351	1.07395	1.06214	1.03080	1.11021	1.08612	1.25391	1.45951	1.68823
Transportation	.23857	.25927	.33672	.38875	.42199	.45148	.49271	.37698	.54622	.61107	.68745
Communication, Utilities, Sanitary Services	.60475	.56194	.56296	.54964	.53406	.52143	.51973	.46880	.55159	.58924	.63266
Wholesale and Retail Trade	1.22099	1.29433	1.50016	1.67523	1.79160	1.87674	1.99863	2.21308	2.15309	2.33553	2.55515
Finance, Insurance, Business and Repair Services	.68984	.78044	.92206	1.07578	1.23651	1.40206	1.59794	1.32495	1.83009	2.10115	2.43130
Educational Services, Professional Services	3.08047	3.36024	3.67667	4.08591	4.50370	4.87933	5.28973	5.33749	5.74297	6.24236	6.85679
Total[b]	7.29235	7.85688	9.77772	10.99023	11.90565	12.79299	13.74032	13.88983	14.98684	16.48134	18.22226

TABLE XXX (Continued)

Sector	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Agriculture, Mining	1.80601	1.94293	2.09072	2.25037	2.42312	2.61030	2.81328	3.03349	3.27252	3.53214
Construction	.81955	.93970	1.07115	1.21747	1.38723	1.58812	1.82779	2.11413	2.45652	2.86705
Manufacturing-Nondurable	1.03885	1.08549	1.13671	1.19320	1.25608	1.32649	1.40551	1.49423	1.59386	1.70588
Manufacturing-Durable	1.92617	2.18422	2.46525	2.78053	3.14379	3.56823	4.05605	4.65022	5.33675	6.14696
Transportation	.77720	.88034	.99756	1.13129	1.28502	1.46303	1.67023	1.91227	2.19585	2.52922
Communication, Utilities, Sanitary Services	.68239	.73829	.80068	.87052	.94922	1.03844	1.13999	1.25592	1.38858	1.54081
Wholesale and Retail Trade	2.80958	3.09673	3.41369	3.76427	4.15542	4.59592	5.09530	5.66389	6.31336	7.05769
Finance, Insurance, Business and Repair Services	2.82455	3.28875	3.83192	4.46698	5.21114	6.08631	7.11913	8.34153	9.79190	11.51699
Educational Services, Professional Services	7.56522	8.37505	9.28157	10.29258	11.42184	12.68933	14.11902	15.73810	17.57734	19.67251
Total	20.24950	22.53149	25.08923	27.96718	31.23283	34.96613	39.25629	44.20375	49.92665	56.56920

(a) Derived from Published Data, U.S. Department of Commerce, BEA.

(b) Column Total May Not Be Exact Due To Rounding Error.

TABLE XXXI

PROPRIETOR INCOME BY SECTOR, MILLIONS OF CURRENT DOLLARS, PROJECTED VALUES FOR HOLDENVILLE, OKLAHOMA, 1973 TO 1991

Sector	1972[a]	1973	1974	1975	1976	1977	1978	1978[a]	1979	1980	1981	1982
Agriculture, Mining	1.32245	1.49002	1.73216	1.97749	2.24588	2.55026	2.61549	3.01984	2.69571	2.78124	2.87002	2.96243
Construction	.23182	.28512	.35625	.39197	.35858	.31865	.30524	.27962	.31447	.33634	.35308	.38302
Manufacturing-Nondurable	.01944	.01829	.01906	.01899	.01862	.01824	.01813	.01469	.01854	.01908	.01971	.02045
Manufacturing-Durable	.00008	.00008	.01841	.02211	.02185	.02118	.02279	.01791	.02572	.03012	.03457	.03940
Transportation	.03330	03622	.04332	.04779	.04952	.05052	.05252	.03986	.05539	.05887	.06284	.06731
Communication, Utilities, Sanitary Services	.01098	.00944	.00839	.00716	.00596	.00487	.00391	.00662	.00316	.00233	.00140	.00033
Wholesale and Retail Trade	.40524	.41035	.45183	.47891	.48570	.48199	.48576	.53449	.49467	.50661	.52260	.54107
Finance, Insurance, Business and Repair Services	.44355	.47419	.52539	.58101	.62889	.67097	.71891	.58285	.77331	.83305	.90347	.98263
Education Services, Professional Services	.45814	.47155	.48943	.51512	.53681	.54882	.56030	.60012	.57157	.58229	.59782	.61460
Total[b]	2.92500	3.19525	3.64723	4.04053	4.35180	4.66550	4.78306	5.09600	4.495253	5.14993	5.36551	5.61125

TABLE XXXI (Continued)

Sector	1983	1984	1985	1986	1987	1988	1989	1990	1991
Agriculture, Mining	3.05698	3.15350	3.25104	3.35282	3.45597	3.56147	3.66920	3.77900	3.89070
Construction	.40368	.42244	.44022	.45924	.48060	.50480	.53189	.56188	.59491
Manufacturing-Nondurable	.02127	.02217	.02316	.02427	.02551	.02690	.02846	.03022	.03219
Manufacturing-Durable	.04464	.05034	.05672	.06408	.07266	.08272	.09452	.10838	.12472
Transportation	.07211	.07715	.08244	.08806	.09405	.10047	.10732	.11462	.12234
Communication, Utilities, Sanitary Services	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
Whole and Retail Trade	.56068	.58012	.59935	.61869	.63850	.65897	.68013	.70187	.72407
Finance, Insurance, Business and Repair Services	1.06979	1.16396	1.26521	1.37415	1.49168	1.61873	1.75608	1.90440	2.06428
Education Services, Professional Services	.63180	.64766	.66138	.67245	.68044	.68481	.68477	.67925	.66690
Total	5.86096	6.11733	6.38053	6.65375	6.93942	7.23886	7.55237	7.87961	8.22009

[a] Derived from Published Data, U.S. Department of Commerce, BEA

[b] Column total may not be exact due to rounding error

main function of local government. Population is directly related to the level of requirement for many services.

Table XXXII presents population projections for Holdenville and the service area from a base year of 1972 to 1991. Total population figures are presented to preserve space. Population by age-sex cohorts are also available to model users. Various groupings of the age-sex cohorts are used to estimate service requirements for community service.

The population figures for 1970 are published census data. The figure for Holdenville is a published number while the service area population is an estimate based on rural county population. A preliminary figure from the 1980 census is also reported. As can be seen, the projected population for 1980 is slightly less than the preliminary census figures. Population projections from the Oklahoma Employment Security Commission are also reported for the years 1985 and 1990. The projection population for 1985 from the simulation model is less than the figure projected by the Oklahoma Employment Security Commission. For 1990, the simulation model projects a larger population for the community and service area.

Overall, population demonstrates a large increase in 1974-1975 which is when a new large firm began operating. Population growth levels off after 1975 and declines until 1980. From 1980 to 1991 population increases steadily, reflecting employment growth in the model within the migration constraints.

Community Service Requirements

Providing medical service is often of prime importance to rural community leaders. Information on population growth by age-sex cohort provides a useful point from which to project service requirement

TABLE XXXII

POPULATION PROJECTIONS, HOLDENVILLE, OKLAHOMA AND SERVICE AREA, 1973 TO 1991

	1970[a]	1972	1973	1974	1975	1976	1977	1978	1979	1980	1980[b]	1981
Holdenville Population	5181	5222	5165	5297	5386	5337	5284	5233	5185	5215	5373	5276
Service Area Population	3460	3534	3521	3636	3723	3715	3702	3691	3680	3724	3828	3790
Total Population	8641	8756	8686	8933	9109	9052	8986	8924	8865	8939	9201	9066

TABLE XXXII (Continued)

	1982	1983	1984	1985	1985(c)	1986	1987	1988	1989	1990	1990(c)	1991
Holdenville Population	5362	5457	5557	5662	6300	5777	5905	6050	6213	6397	6600	6605
Service Area Population	3873	3963	4056	4152	3913	4256	4368	4493	4631	4785	4085	4956
Total Population	9235	9420	9613	9814	10213	10033	10273	10543	10844	11182	10685	11561

(a) Published Census Data
(b) Preliminary Census Data
(c) Oklahoma Employment Security Commission, Population Projections.

levels for medical services. Population information is utilized for both the community and the service area. If the service area for a particular service is different from the model estimate, then the actual service area should be used. Many medical needs are related to specific age or sex cohorts. Respiratory problems might be expected to occur more frequently with older people. The incidence of tonsillectomies is higher for children. Visits to a physician and emergency ambulance calls have also been shown to be related to population (Dunn and Doeksen, 1979). Table XXXIII lists bed-days estimates of service requirements for hospitals, clinics and ambulance calls from 1973 to 1991.

Hospital bed days represent the average annual number of bed days required in a hospital for a given population. Table XXXIII lists bed-days for the city population and the service area population separately as well as combined. The model also provides bed-days estimated by population group and disease category if the user desires. For Holdenville and the service area, bed days are estimated to grow from 16,364 in 1973 to 19,853 in 1991. The obvious importance of this projection rests on the estimate of hospital capacity for Holdenville. If available hospital space will not provide 20,000 bed days per year then planning to increase capacity or solving the problem in some other way should begin well before the year 1990.

Physician visits per year are also presented for the city, service area, and combined population. The model also provides physician visits for various age groups. For the total population, annual physician visits grow from 30,774 in 1973 to 40,531 in 1991.

Ambulance calls is the final service category listed in Table XXXIII. Other calls include all ambulance trips except those for highway accidents and transfers. Transfers are defined as moving a

TABLE XXXIII

ANNUAL HOSPITAL BED DAYS, VISITS TO A PHYSICIAN, AND OTHER AMBULANCE CALLS, 1973 TO 1991

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Hospital Bed Days																			
City Population	10706	10954	11112	10961	10787	10609	10429	10399	10426	10497	10579	10665	10759	10869	11001	11162	11356	11588	11861
Service Area Population	5658	5881	6051	6061	6057	6048	6036	6109	6216	6349	6488	6630	6777	6932	7102	7289	7489	7731	7992
Total Population	16364	16835	17163	17022	16844	16657	16465	16508	16642	16846	17067	17295	17536	17801	18103	18451	18854	19319	19853
Physician Visits																			
City Population	18499	18965	19271	19085	18878	18678	18486	18572	18759	19054	19368	19699	20050	20434	20865	21355	21910	22540	23252
Service Area Population	12245	12659	12969	12949	12911	12874	12838	12993	13223	13515	13826	14149	14485	14843	15235	15668	16149	16684	17279
Total Population	30744	31624	32240	32034	31789	31552	31324	31565	31982	32569	33194	33848	34535	35277	36100	37023	38059	39224	40531
Other Ambulance Calls																			
City Population	227	235	240	239	237	235	232	233	234	237	239	241	244	246	249	253	257	261	267
Service Area Population	108	113	118	119	129	121	122	124	127	130	134	137	140	144	148	152	157	162	167
Total Population	335	348	358	358	357	356	354	357	361	367	373	378	384	390	397	405	414	423	434

patient from one hospital to another. Highway accident calls and transfers are closely related to local conditions and model users should supply the most recent year's information. Other ambulance calls are related to population and reported in Table XXXIII for the community, service area, and total population.

Table XXXIV lists estimates of annual fires occurring in the community, in the service area, and for community and service area combined. In 1973, fires occurring in the community are estimated to be 83 while 56 fires are estimated to occur in the service area for a total of 139 fires. By 1991, the total number of fires is estimated to grow to 185.

Projected levels of water usage, sewage, and solid waste generation are presented in Table XXXV. These estimates are presented for the community only as service is usually provided within community political boundaries. Water usage is projected to grow from 168 million gallons per year in 1973 to 216 million in 1991. This is almost a 30 percent increase in water used and capacity constraints should be considered before actual problems arise.

Table XXXV also presents the gallons of waste water or sewage generated per day. Sewer requirements grow from 519,000 gallons per day in 1973 to 664,000 gallons per day in 1991.

Solid waste generated, measured in cubic yards per week, is also presented in Table XXXV. This figure is projected to be 389 in 1973, growing to 498 in 1991.

In projecting the requirements for provision of educational services, the important variable is the number of school age children. Table XXXVI presents single-age cohorts for the ages 5 to 18 from the year 1972 to 1991. The number of school age children reflects the use

TABLE XXXIV

ANNUAL ESTIMATED FIRES, 1973 TO 1991

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Fires In City	83	85	86	86	85	84	83	84	85	86	88	89	91	93	95	97	100	103	106
Fires in Service Area	56	58	60	59	59	59	59	60	61	62	63	65	66	68	70	72	74	77	79
Total Fires	139	143	146	145	144	143	142	144	146	148	151	154	157	161	165	169	174	180	185

TABLE XXXV

PROJECTED REQUIREMENTS FOR WATER, SEWER, SOLID WASTE,
HOLDENVILLE, OKLAHOMA, 1973 TO 1991

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Water, Million Gallons Per Year	168.6	173.8	176.1	174.6	172.9	171.3	169.8	170.7	172.6	175.8	179.0	182.1	185.8	189.7	193.7	198.5	203.6	209.4	216.4
Sewer, Million Gallons Per Day	.519	.532	.541	.536	.531	.526	.521	.524	.530	.539	.549	.559	.569	.581	.594	.608	.625	.643	.664
Solid Water, Cubic Yards Per Week	389	399	406	402	398	395	391	393	398	405	412	419	427	436	446	457	469	483	498

TABLE XXXVI

SINGLE YEAR COHORT, SCHOOL AGE CHILDREN
HOLDENVILLE, OKLAHOMA, 1973 TO 1991

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
5	64	66	67	66	65	65	64	65	66	67	68	70	71	73	75	76	79	81	84
6	67	68	69	59	68	67	67	67	68	70	71	72	74	76	77	79	82	84	87
7	70	72	73	72	72	71	70	71	72	73	75	76	78	80	81	84	86	88	91
8	72	73	75	74	73	73	72	73	74	75	76	78	80	81	83	85	88	90	93
9	70	72	73	72	72	71	70	71	72	73	75	76	78	80	81	84	86	88	91
10	73	75	76	75	75	74	73	74	75	76	78	80	81	83	85	87	89	92	95
11	70	72	73	72	72	71	70	71	72	73	75	76	78	80	81	84	86	88	91
12	73	74	75	75	74	73	73	73	75	76	77	79	81	82	84	86	89	92	95
13	72	73	74	74	73	72	72	73	74	75	76	78	80	81	83	85	88	90	93
14	73	74	75	75	74	73	73	73	74	76	77	79	81	82	84	86	89	92	95
15	70	72	73	72	71	70	69	70	70	71	73	74	75	77	78	80	82	85	87
16	71	72	73	72	72	71	70	70	71	72	73	74	76	77	79	81	83	85	88
17	69	71	72	71	70	69	68	69	69	70	72	73	74	76	77	79	81	83	86
18	74	76	77	76	75	74	73	73	74	75	77	78	79	81	83	85	87	89	92

of a cohort survival technique and economic growth within the model, both considered each year for projection purposes.

Community Revenue

General fund revenue by source is presented for Holdenville in Table XXXVII. For communities in Oklahoma, general fund revenue sources comprise most of the revenue for day-to-day operation. Table XXXVII presents projections of general fund revenue for Holdenville from 1973 to 1991 in thousands of dollars. Total general fund revenue is projected to grow to $2,206,411 by 1991.

TABLE XXXVII

PROJECTIONS FOR GENERAL FUND REVENUE SOURCES, HOLDENVILLE, OKLAHOMA, 1973 TO 1991, THOUSANDS OF DOLLARS

Revenue Source	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Sales Tax Revenue	233.814	273.873	309.003	343.134	380.104	419.136	465.556	519.187	580.554	650.889	730.460
Alcoholic Beverage Tax Revenue	30.992	31.783	32.313	32.024	31.704	31.398	31.108	31.287	31.654	32.174	32.742
Occupation Tax Revenue	1.033	1.059	1.077	1.067	1.057	1.047	1.037	1.043	1.055	1.072	1.091
Franchise Tax Revenue	45.454	46.616	47.393	46.968	46.499	46.051	45.625	45.888	46.427	47.188	48.021
Revenue from Licenses & Permits	.517	.530	.539	.534	.528	.523	.518	.521	.528	.536	.546
User Charges - Police	7.231	7.416	7.540	7.472	7.398	7.326	7.259	7.300	7.386	7.507	7.640
- Garbage	65.599	67.275	68.397	67.784	67.106	66.460	65.845	66.225	67.002	68.101	69.303
- Cemetery	7.231	7.416	7.540	7.472	7.398	7.326	7.259	7.300	7.386	7.507	7.640
- Landfill	4.649	4.768	4.847	4.804	4.756	4.710	4.666	4.693	4.748	4.826	4.911
Revenue from Court Fines	35.640	36.551	37.160	36.827	36.459	36.108	35.774	35.980	36.403	36.999	37.653
Other Revenue in General Fund	30.992	31.783	32.313	32.024	31.704	31.398	31.108	31.287	31.654	32.174	32.742
Total General Fund Revenue[a]	463.152	509.069	548.122	580.109	614.711	651.482	695.754	750.711	814.796	888.972	972.749

TABLE XXXVII (Continued)

Revenue Source	1984	1985	1986	1987	1988	1989	1990	1991
Sales Tax Revenue	820.448	922.371	1038.147	1169.985	1320.368	1492.108	1688.444	1913.159
Alcoholic Beverage Tax Revenue	33.339	33.972	34.661	35.430	36.298	37.277	38.383	39.629
Occupation Tax Revenue	1.111	1.132	1.155	1.181	1.210	1.243	1.279	1.321
Franchise Tax Revenue	48.898	49.825	50.836	51.964	53.236	54.673	56.295	58.122
Revenue from Licenses & Permits	.556	.566	.578	.591	.605	.621	.640	.660
User Charges - Police	7.779	7.927	8.088	8.267	8.469	8.698	8.956	9.247
- Garbage	70.568	71.907	73.366	74.994	76.830	78.904	81.243	83.881
- Cemetery	7.779	7.927	8.088	8.267	8.470	8.698	8.956	9.247
- Landfill	5.001	5.096	5.199	5.315	5.445	5.592	5.757	5.944
Revenue from Court Fines	38.340	39.068	39.860	40.745	41.742	42.869	44.140	45.573
Other Revenue in General Fund	33.339	33.972	34.661	35.430	36.298	37.277	38.383	39.629
Total General Fund Revenue	1067.158	1173.761	1294.639	1432.168	1588.968	1767.960	1972.475	2206.411

(a) Column Total May Not Be Exact Due To Rounding Error.

CHAPTER VI

APPLICATION OF COMMUNITY SIMULATION MODEL--
IMPACT ANALYSIS

One method for measuring the impact of rural industrialization is to simulate capital expansion in the appropriate economic sector. The methodology used in this study is similar to previous studies. Doeksen (1971a) determined the investment impact of a hypothetical one million dollar capital investment by industry sector. Sarigedik (1975) measured income and employment impacts of a proposed army ammunition plant on the Oklahoma economy. Ghebremedhin (1981) evaluated the impacts of increased energy production and increased efficiency in energy utilization on the Oklahoma economy. Both Doeksen and Sarigedik simulated capital investment through impacts described in the capital equations.

For this model, investment is reflected in the capital equations for final demand. It is assumed that a new plant will be established in the durable manufacturing sector. A total of 50 new jobs are created in the sector and output expansion is estimated using employment-output ratios for the initial investment year, 1982. Necessary capital expansion is estimated using capital-output ratios. The increased production is assumed exported if the sector is a net exporter and consumed in the community if the sector is a net importer. For most cases with small rural communities, it is expected that increased production from a new industrial plant would be exported.

Dynamic considerations are included in the model by utilizing rates of change for employment-output ratios and rates of change for capital-output ratios. Elements of economic growth are also included in the model via wage rate changes, population growth, and final demand growth.

Multiplier analysis provides a technique for summarizing the effect of economic change. Employment multipliers measure the total employment change generated per one unit change in direct employment in a given sector. The total employment change will vary, depending upon the time period considered. Doeksen and Schreiner (1972) break the impact of potential capital investment into three time periods: (1) Short run effects occur during the first year of the impact and include a direct effect, indirect effects, and a capital formation effect. The direct and indirect effects result from increased sector production. The capital formation effect includes employment generated by the initial capital investment. (2) Intermediate period effects include the direct and indirect production effects. An induced consumption effect is also included as income rises with the increased production. Also, induced capacity effects occur as output in other sectors increases. (3) The third time period considered is the long run. The initial capital formation effect is reduced to zero in the short-run. Induced capacity effects decline to zero over a number of years. All that is left are direct and indirect production effects and the induced consumption effects. By analyzing employment effects (or any other change) over time, dynamic considerations are included in the model. Long-run adjustments provide planners with useful information that static models do not consider.

Changes in Economic and Demographic Variables

For illustrative purposes, a new plant is assumed to be established in Holdenville in 1982. The plant creates 50 new jobs in the durable manufacturing sector along with the corresponding capital expansion. The net effect of the hypothetical expansion is presented in Tables XXXVIII through XLIII. Table XXXVIII presents wage and salary employment impacts by sector for the years 1982 to 1991. Total proprietor employment impacts are also presented. The direct employment effect in 1982 includes the 50 new jobs created in the durable manufacturing sector.

The impact on wage and salary income as well as proprietor income is shown in Table XXXIX. Wage and salary income is increased in 1982 by 1.4 million dollars while proprietor income is increased by 151 thousand dollars. The population impact in 1982 shows a total increase in population of 388 people (Table XL). This figure rises to a high of 614 people in 1984. It should be noted that this figure includes new employees and family members for the new plant as well as for all service sector jobs that would be created. The important factor to note is that while population increases at a fast rate in the early years of the impact, the net population impact declines over the long run.

The implications of the impact on hospital bed days, physician visits, ambulance calls, and fire calls are shown in Table XLI. Here again, the comparison of short-run and long-run impacts are noted. The number of hospital bed days, for example, reaches a high of 683 in 1984. This declines to a net impact of 276 by 1991. Thus, capital expansion effects and direct effects eventually reduce to zero and

TABLE XXXVIII

EMPLOYMENT IMPACT, HOLDENVILLE, OKLAHOMA

Sector	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Agriculture, Mining	2	4	4	3	2	2	2	2	2	2
Construction	11	14	13	8	3	0	0	1	3	3
Manufacturing-Nondurable	6	6	6	5	4	3	3	3	3	3
Manufacturing-Durable	67	65	56	44	37	32	30	29	28	26
Transportation	2	3	3	2	2	2	1	1	1	1
Communications, Utilities, and Sanitary Services	1	2	2	1	1	1	1	1	1	1
Wholesale and Retail Trade	15	31	37	34	29	23	20	19	19	20
Finance, Insurance, Business and Repair Services	7	18	22	22	19	16	15	13	12	13
Educational Services, Professional Services	4	30	44	47	43	36	30	26	25	26
Total Wage and Salary	115	173	187	166	140	115	102	95	94	95
Total Proprietor	25	44	49	42	33	25	19	16	18	17
Total	140	217	236	208	173	140	121	111	112	112

TABLE XXXIX

INCOME IMPACT, HOLDENVILLE, OKLAHOMA, MILLIONS OF DOLLARS

Income Source	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Total Wage and Salary	1.42650	2.06551	2.25977	2.13682	1.90617	1.72387	1.65671	1.69825	1.80135	1.92180
Total Proprietor	.15175	.24704	.26767	.22947	.18025	.14358	.12514	.12063	.12339	.12691
Total	1.57825	2.31255	2.52744	2.36629	2.08642	1.86745	1.78185	1.81888	1.92474	2.04871

TABLE XL

POPULATION IMPACT, HOLDENVILLE AND SERVICE AREA

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
City	225	331	355	317	258	208	176	161	156	153
Service Area	163	241	259	232	190	154	131	121	117	115
Total	338	572	614	549	448	362	307	282	273	268

TABLE XLI

MEDICAL AND FIRE SERVICE REQUIREMENT IMPACT, HOLDENVILLE, OKLAHOMA

Service	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Hospital Bed Days	440	642	683	603	486	388	326	296	283	276
Physician Visits	799	1177	1261	1122	913	735	623	570	550	540
Other Ambulance Calls	10	15	16	15	12	9	7	7	7	7
Fire Calls	4	5	6	5	4	4	3	3	3	3

service requirements decline. Local leaders should understand that initial short-run effects might not justify expanding hospital facilities or other services without first considering the long-run implications.

Table XLII presents the impact of the capital expansion on water usage, sewer and solid waste generation. In 1984 usage is more than twice the level than in 1991. This again demonstrates an important concept when comparing service demand with capacity levels. Table XLIII presents the revenue impact for sales tax and the total general fund. As a result of the hypothetical impact, total general fund revenue will be increased by 25,048 dollars in 1982. Sales tax revenue is the primary source of revenue for communities. The impact on sales tax revenue reaches a high of 24 thousand dollars in 1984, falling to 19 thousand dollars by 1991.

Multiplier Analysis

Net changes in economic and demographic variables resulting from industry expansion were presented in Tables XXXVIII through XLIII. The procedure was to assume capital expansion sufficient to create 50 new jobs in the durable manufacturing sector. Table XLIV presents the employment effects for the short-run, intermediate, and long-run. For comparison, simulation runs were also made for the other endogenous sectors to determine effects of similar investments. The impact is measured in terms of additional employment created from 1982 to 1991.

Column 1 of Table XLIV presents the direct and indirect employment effects. The manufacturing-durable sector has a direct and indirect effect of 80 jobs created and caused by the initial change in production. This includes the 50 new jobs directly created by the capital expansion.

TABLE XLII

IMPACT ON WATER, SEWER, SOLID WASTE USE, HOLDENVILLE, OKLAHOMA

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Water--Million Gallons Per Year	7.3	11.1	11.9	10.5	8.4	6.8	5.6	5.2	5.2	5.3
Sewer--Million Gallons Per Day	.023	.034	.036	.033	.026	.021	.018	.016	.016	.016
Solid Waste--Cubic Yards Per Week	17.0	26.0	28.0	25.0	20.0	16.0	13.0	12.0	12.0	13.0

TABLE XLIII

REVENUE IMPACT, HOLDENVILLE, OKLAHOMA, THOUSANDS OF DOLLARS

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Sales Tax Revenue	15.075	22.081	24.104	22.518	19.818	17.691	16.853	17.173	18.148	19.274
Total General Fund Revenue	25.048	36.798	39.895	36.576	31.272	26.917	24.689	24.347	25.077	26.078

TABLE XLIV

SHORT-, INTERMEDIATE-, AND LONG-RUN EMPLOYMENT IMPACTS AND MULTIPLIERS RESULTING FROM CAPITAL EXPANSION TO ADD 50 NEW JOBS BY INDUSTRY, HOLDENVILLE, 1982

	Direct and Indirect Employment Effect (1)	Direct, Indirect Induced, and Capital Effect (2)	Long Run Employment Effect (3)	Short Run Production Employment Multiplier (4)	Intermediate Employment Multiplier (5)	Long Run Employment Multiplier (6)
Agriculture, Mining	62	114	75	1.24	2.28	1.50
Construction	67	114	94	1.34	2.28	1.88
Manufacturing-Nondurable	115	247	142	2.30	4.94	2.84
Manufacturing-Durable	80	217	112	1.60	4.34	2.24
Transportation	70	269	101	1.40	5.38	2.02
Communications, Utilities, & Sanitary Services	91	388	142	1.82	7.76	2.84
Wholesale & Retail Trade	56	120	80	1.12	2.40	1.60
Finance, Insurance, Business and Repair Services	62	124	82	1.24	2.48	1.64
Educational Services,	53	87	68	1.06	1.74	1.36

The largest direct and indirect effect occurs in the nondurable manufacturing sector with 115 new jobs created.

Direct, indirect, induced consumption, and capital effects are shown in column 2 of Table XLIV. The capital effect is the result of the capital expansion in the sector imported. Induced effects include the effect of income expansion and also capital expansion in other sectors as output increases. The durable manufacturing sector shows a total effect in column 2 of 217 new jobs. Large effects are also shown for the nondurable manufacturing sector, transportation sector, and communication, utilities, and sanitary services sector. This is primarily the capital effect occurring in these sectors as investment is occurring to create 50 new jobs.

In the long run, only production effects and induced consumption effects remain. Column 3 presents the long run employment effects for the individual sectors. Manufacturing-durable shows a long-run effect of 112 jobs while the largest long-run effect is in the nondurable-manufacturing and communication, utilities, and sanitary services sectors with 142 jobs created.

Short-run, intermediate, and long-run employment multipliers are presented in the final three columns of Table XLIV. These multipliers are computed by dividing employment effects in columns 1, 2, and 3 by the direct employment effect of 50 new jobs. The durable manufacturing sector has a short-run production employment multiplier of 1.60. This means that for each new job directly created in this sector for delivery to final demand, a total of 1.60 new jobs or .6 additional jobs are created. The largest short-run multiplier occurs in the nondurable manufacturing sector with a value of 2.30. The smallest short-run multiplier occurs in one of the service sectors, educational and professional services, with a value of 1.06.

Intermediate multipliers are shown in column 5. Durable manufacturing has a multiplier of 4.34. This is the total change in employment resulting from a production increase of one job in 1982. In the long run, capital formation and induced capacity effects fall to zero. Only direct production and induced consumption effects are included. Column 6 presents the long-run multipliers by sector. Manufacturing-durable has a long-run multiplier of 2.24. This is the total employment generated in 1991 by an increase in production employment of one in 1982. The largest long-run employment multiplier is in the nondurable manufacturing sector with a value of 2.84. The educational and professional services sector has the smallest long-run multiplier with a value of 1.36.

The simulation model allows impact analysis through the use of the capital equations. Employment changes can be projected and compared to baseline results. Employment impacts are separated into direct and indirect production effects, direct capital effects, and induced capital and income effects. Other flexible features of the model include adjusting economic sectors for no growth, declining growth, or a leveling off of growth in given years. Many types of changes or impacts could be considered (any parameter in the model could be changed) thus, providing the user with a relative comparison of projections.

CHAPTER VII

SUMMARY AND EVALUATION

Summary

The objective of this thesis was to develop and present a community specific simulation model. The model provides projections of economic and demographic variables over time. The simulation model has been designed to be available and usable for decisionmakers of rural communities.

The simulation model is built around a data base comprised of various accounts. The accounts provide the input data for the simulation equations and consists of: an economic account, a capital account, a demographic account, community service and revenue accounts. The accounts employ various techniques and methodologies to provide yearly data for the simulation model.

A procedure to delineate a service area for local communities is utilized in the simulation model. A gravity model is employed to analyze population and distance data for the community of interest and competing communities. Employment and income values by sector are estimated through use of the gravity model.

The economic account contains a community specific input-output model estimated with the use of a location quotient technique. Final demand categories are projected over time and utilized along with the input-output model to project output yearly. This procedure is the driving force of the model.

The capital account provides information on capacity and capital expansion. The capital information allows more realistic projections over time, introducing a dynamic concept into the model. National capital relationships are utilized where necessary local data are not available. The capital equations contained in the simulation model also provide an appropriate entry point for projecting impact results. Capital expansion can be simulated over time, providing a relative comparison to baseline projections.

The demographic account uses an age-sex cohort survival technique to project population. Yearly projections are utilized to estimate the local labor force which in turn is compared to employment requirements provided by the economic account. Migration levels for the community and service area are estimated by comparing labor force data with labor demand in the community.

The community service account is comprised of age-specific usage coefficients for various community services. Levels of demand are estimated for services such as hospital bed days, ambulance, physician visits, fires, water, sewer, and solid waste based on the economic and demographic projections of the model. Community revenue by source is also estimated over time based on published community specific revenue data and model projections.

Holdenville, Oklahoma, is used as an illustrative community to describe and present model output. Employment and income projections by sector are provided for the years 1973 to 1991. Baseline projections are also provided for population change in the community and service area. Finally, community service demand and revenue projections are provided. In addition, an analysis is made of the net impact of a hypothetical industry expansion in Holdenville. Baseline projections are compared to projections following the impact for the years 1982 to 1991. The results emphasize the difference between initial short-run impacts and smaller long-run impacts.

Evaluation

Two important characteristics should be noted when evaluating the simulation model for rural Oklahoma communities. First, the model is community specific. This means that when the model is utilized, the community of interest is analyzed with the most applicable data. Many models of this nature take a regional approach and do not provide output for a specific community. Secondly, the model contains much information on community service demand not included in previous work. Again, for a specific community, the model provides projections of user needs for such services as fire protection, health services, water, sewer, and solid waste.

In evaluating the usefulness of a simulation model, reliability or accuracy is an obvious criterion. The problem associated with local models is a lack of published data. The Oklahoma simulation model for rural communities relies heavily on population data from the U.S. Department of Commerce and employment and income data obtained from the U.S. Department of Agriculture (BEA) data tapes. These input data were utilized as a check-point to insure that the model was simulating change accurately for the years for which data were available. Preliminary 1980 census data were used to check population projections for that year.

Employment and income projections for Holdenville in 1978 are very close to the data provided by BEA, both total figures and sectoral values, for the Holdenville example. Population projections for Holdenville and the service area for 1980 are slightly less than the 1980 preliminary census figures. Population projections from the model for the years 1985 and 1990 are also compared to projections of population from the Oklahoma Employment Security Commission (1981b).

Model evaluation is not necessarily a "one-step" process but an on-going or dynamic process. Immediate future work with the model should compare results with detailed 1980 census results when data are published. Data and methodology should be continually evaluated as the model is utilized. In this way, further refinements and improvements will be forthcoming.

In developing the simulation model interrelationships must be considered. Linking economic and demographic projections provides a methodology for determining the effect on population changes of economic activity. Feedback loops are utilized to continually update baseline projections.

Impact analysis provides a very useful output of the model. By comparing impact projections to baseline results, model users can better understand the results of various public and private policies. The impact projections are converted to useful information when related to community services and revenue. In the Holdenville example, the model demonstrates the result of capital expansion. Community service demand and community revenue both increase rapidly in the initial years. The impact is not as dramatic in the later years. Model users should better understand that long run planning has many implications. Capacity expansion in the initial impact years can lead to over-capacity in later years. The final decision of expanding (or not expanding) community service facilities is left to local leaders. The model primarily demonstrates the relationships involved in such a decision.

Ease of use and access to the model are also of primary importance. The simulation model is written in Fortran and is relatively inexpensive to run. Thus, repeated runs can be compared for various policies and assumptions. Default data are provided and the model can be run relatively easily.

Limitations

Assumptions related to the input-output model should be noted when using the model. The most restrictive assumption is that the direct coefficients are fixed. This implies that technology remains constant over time. Also, no new price or material substitutions occur. This assumption can limit the time horizon for which projections are appropriate. However, for reasonable time periods the assumption is not too restrictive. In addition, when later input-output tables become available, they can be introduced into the model. The assumption of no errors of aggregation is also related to the input-output model. Industries within a sector are assumed to be homogeneous and different from other sector industries.

A location-quotient technique is used to estimate a community specific input-output model. A nonsurvey technique such as this cannot provide data as accurate as survey based data. However, time and expense considerations lend support to the use of such a technique.

The accelerator principle is utilized to project new investment in the capital account. The assumption is that net investment is a function of the rate of change of final output. This assumption is somewhat mechanical and depends on the measurement of capacity by sector. No entrepreneur motivation or decisionmaking is included. However, the accelerator principle does provide a mechanism for projecting investment that would otherwise not be possible.

The capital account utilizes national capital flow relations. Rates of change for capital-output ratios are also obtained from national data. When using national data the assumption implied is that local conditions are similar to national conditions. This is not always the case. However, the methodology of capital expansion is considered necessary for a useful model. In this case, methodological considerations overrule data considerations and the technique is employed using national data as default values.

Additional Research

Future work related to a simulation model for rural development should concentrate on updating the data base. More recent input-output relations are desirable given the energy and economic changes that have occurred in recent years. Community specific input-output data and capital data are desirable to provide more accurate projections.

Further work is needed to estimate commuting flows and labor force information for communities. Detailed employment data for communities is useful, especially in time-series form.

The use coefficients for community services are age-specific and often apply specifically to Oklahoma. However, these coefficients change over time and should also be continually updated. Additional work is needed in the community revenue sector. Also, time series data can provide useful rates of change. Also, the relationships of community growth and revenue should be closely explored. A simulation model can be evaluated by its use. Continual refinement is possible as more recent data and new methodologies become known.

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APPENDIXES

TABLE XLV

VECTORS AND SCALARS NOT PRESENTED IN THE SOCIAL ACCOUNTS

Sector / Matrix	Ag., Mining	Constr.	Manuf.- Nond.	Manuf.- Dur.	Trans.	Comm., Ut., San. Serv.	Wh. & Ret. Tr.	Fin., Ins., Bus. & Rep. Serv.	Ed. Serv., Proff. Serv.
A1	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
A2	0.0462	0.0000	0.9538	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
A3	0.0000	0.0000	0.0000	0.0000	0.0311	0.0722	0.2462	0.4930	0.1575
A9	-0.2204	0.1717	0.2190	0.0092	0.1255	0.0942	0.0598	0.3686	0.1724
A10	0.0066	0.3653	0.1642	0.0005	0.0265	0.0863	0.0053	0.1937	0.1516
A11	1.0950	1.0740	1.1010	1.0990	1.1040	1.1060	1.0530	1.1130	1.1090
A13	0.0134	0.0223	0.0420	0.0356	0.0201	0.0440	0.0089	0.0263	0.0035
A14	1.0910	1.0640	1.0960	1.0880	1.0950	1.0930	1.0700	1.0780	1.0790
A15	0.2325	0.4960	0.9690	0.9647	0.7083	0.9500	0.6542	0.5253	0.8063
A16	1.0290	1.0180	1.0000	1.0000	1.0100	1.0050	1.0120	1.0170	1.0080
A17	0.0019	0.0066	0.0051	0.0056	0.0097	0.0100	0.0048	0.0027	0.0049
A18	1.2800	1.0490	1.0600	1.1010	1.1000	1.0860	1.0360	1.1040	1.0600
A19	0.0024	0.0067	0.0033	0.0032	0.0033	0.0036	0.0030	0.0019	0.0030
A20	1.1450	1.0080	1.0550	1.1000	1.0900	1.0820	1.0200	1.0800	1.0500
A21	0.4468	0.4568	0.3580	0.4301	0.6110	0.6265	0.7685	0.6616	0.6635
A26	0.2609	0.0250	0.0678	0.0002	0.0128	0.0234	0.1420	0.1800	0.2879

S1	0.0001	S12	1.1244	S23	10.3160
S2	1.0920	S13	1.1510	S24	0.0060
S3	0.0004	S14	1.1656	S25	0.0002
S4	1.0900	S15	0.0710	S26	0.0088
S5	0.0011	S16	1.0146	S27	0.0001
S6	1.1050	S17	0.1174	S28	0.0014
S7	1.0050	S18	0.0196	S29	0.0127
S8	0.9000	S19	1.0070	S30	0.0014
S9	1.1077	S20	0.5749	S31	0.0009
S10	1.0770	S21	0.4251	S32	0.0060
S11	1.0900	S22	62.0000		

TABLE XLVI

LABOR FORCE DATA NOT PRESENTED IN THE SOCIAL ACCOUNTS

	A22		A23		A24		A25	
Age Cohort	Male	Female	Male	Female	Male	Female	Male	Female
<15	0.0120	0.0100	0.0120	0.0100	0.0035	0.0028	0.0040	0.0031
15-19	0.4070	0.2670	0.4070	0.2670	0.0401	0.0282	0.0491	0.0300
20-29	0.8590	0.4830	0.8590	0.4830	0.1165	0.0806	0.1236	0.0723
30-39	0.9310	0.4730	0.9310	0.4730	0.0928	0.0577	0.1053	0.0634
40-44	0.9310	0.5060	0.9310	0.5060	0.0522	0.0372	0.0595	0.0368
45-49	0.7580	0.4020	0.7580	0.4020	0.0492	0.0349	0.0587	0.0341
50-54	0.7580	0.4020	0.7580	0.4020	0.0473	0.0354	0.0592	0.0367
55-59	0.7580	0.4020	0.7580	0.4020	0.0626	0.0456	0.0622	0.0379
60-64	0.7580	0.4020	0.7580	0.4020	0.0737	0.0555	0.0669	0.0382
65-69	0.3660	0.1430	0.3660	0.1430	0.0360	0.0199	0.0292	0.0125
70-79	0.1220	0.0480	0.1220	0.0480	0.0173	0.0108	0.0121	0.0051
80+	0.0010	0.0010	0.0010	0.0010	0.0001	0.0001	0.0000	0.0001

TABLE XLVII

POPULATION DATA NOT PRESENTED IN THE SOCIAL ACCOUNTS

Age	A33	A34	A35	A36
<1	.061	.062		
1	.060	.060		
2	.057	.057		
3	.055	.058		
4	.060	.057		
5	.065	.064		
6	.066	.068		
7	.072	.069		
8	.074	.070		
9	.071	.072		
10	.073	.074		
11	.069	.072		
12	.073	.073		
13	.073	.071		
14	.071	.075		
15			.205	.191
16			.206	.193
17			.194	.197
18			.204	.214
19			.191	.205

VITA

Michael Denton Woods

Candidate for the Degree of

Doctor of Philosophy

Thesis: A SIMULATION MODEL FOR RURAL COMMUNITIES IN OKLAHOMA

Major Field: Agricultural Economics

Biographical:

Personal Data: Born in Fort Smith, Arkansas, September 9, 1953, the son of Mr. and Mrs. G. M. Woods.

Education: Graduated from Alma High School, Alma, Arkansas, in May, 1971; received Bachelor of Science degree in Economics and Finance from Arkansas Tech University in 1975; received Master of Science in Agricultural Economics from University of Arkansas in 1978; completed requirements for the Doctor of Philosophy degree at Oklahoma State University in December, 1981.

Professional Experience: Research Assistant in the Department of Agricultural Economics, University of Arkansas, from September, 1975 to August, 1977; Research Assistant in the Department of Agricultural Economics, Oklahoma State University, from September, 1977 to September, 1981; Extension Specialists, Rural Development, Texas A&M University, September, 1981 to Present.