NATIONAL COOPERATIVE
HIGHWAY RESEARCH PROGRAM REPORT

266

FORECASTING INPUTS TO TRANSPORTATION PLANNING

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM REPORT **266**

FORECASTING INPUTS TO TRANSPORTATION PLANNING

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RESEARCH SPONSORED BY THE AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS IN COOPERATION WITH THE FEDERAL HIGHWAY ADMINISTRATION

AREAS OF INTEREST:

PLANNING
FORECASTING
(HIGHWAY TRANSPORTATION)
(PUBLIC TRANSIT)

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
WASHINGTON, D.C. DECEMBER 1983

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

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NCHRP REPORT 266

Project 8-24 FY'80
ISSN 0077-5614
ISBN 0-309-03707-7
L. C. Catalog Card No. 84-50026

Price: $9.60

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Published reports of the

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

are available from:

Transportation Research Board
National Research Council
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

Printed in the United States of America

FOREWORD

By Staff
Transportation
Research Board

This report is an essential addition to a transportation planner's library. It is concerned with methods for projecting data input used to determine future travel demand for highways and transit. Highway and transit planners will gain from this report a better understanding of the sensitivity of travel projection methods to input variables, such as population, households, automobile ownership, income, and employment. Furthermore, the evaluation of the projection methods for these socioeconomic variables will enable such professionals to render better judgments on the usefulness of their agency projections.

Recent changes in transportation planning give increasing importance to the accuracy, simplicity of approach, reliability, and acceptability of travel projections. Transportation planners project travel demand and resulting transportation impacts on the basis of changes of socioeconomic variables such as population, employment, vehicle availability, income, and household size. Errors in the projections of these variables can be carried forward to cause substantial errors in information provided to decision-makers in the evaluation of transportation alternatives. Furthermore, with the increase of local involvement in the transportation planning process, local officials often are reluctant to accept projections or forecasts of socioeconomic variables, especially if declines in population, income, or employment are projected.

The research results identify socioeconomic variables having the greatest effect on travel demand projections and provide an evaluation of methods to project these variables. Particular emphasis is given to methods to project population, which was found to be the single, most important input variable. Resources required for and relative accuracy of each method to project socioeconomic variables are identified to assist transportation planners in their selection of projected values or in their selection of methods should they be involved in such projection. Guidance is provided on methods to disaggregate projections prepared for the national or state level to smaller geographic units, such as multi-county regions, SMSAs, or transportation study areas. However, disaggregation of projections to the level of traffic zones (or other subareas) was not included in this reseach project.

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ACKNOWLEDGMENTS

The research reported herein was performed under NCHRP Project 8-24 by John Hamburg and Associates, Inc. Dr. George T. Lathrop was the principal investigator. The other authors of this report were Dr. Edward J. Kaiser, Professor, Department of City and Regional Planning, University of North Carolina at Chapel Hill, and John R. Hamburg, President, John R. Hamburg and Associates, Inc.

FORECASTING INPUTS TO TRANSPORTATION PLANNING

SUMMARY

The research conducted under NCHRP Project 8-24 has produced a concise reference for transportation planners concerned with using projected socioeconomic and demographic characteristics in transportation planning. Guidance is provided on the accuracy and usefulness of various projection techniques for various levels of aggregation and periods of time.

Two general areas of research were pursued:

1. The sensitivity of the transportation planning process, particularly trip generation, to variation in input socioeconomic and demographic variables.
2. Review and evaluation of methodology for producing study area level projections either on the basis of other projections or independently.

The analysis indicated that *trip generation* is extremely sensitive to population projections, but much less sensitive to projections of numbers of households (or household size) if population is controlled. Given population and household size, household auto ownership and income substantially enhance the explanation of variation in household trip generation. Auto ownership is more powerful than income, and the level of interaction between the two and the marginal improvement offered by the use of both, suggest strongly that only one—auto ownership—should be used in trip generation.

Socioeconomic and demographic data also play a strong role in *mode-choice* models. Again, auto ownership (or availability) appears to be the stronger and more useful of the two variables.

Because of significant tradeoffs between complexity and required resources on the one hand, and theoretical content on the other, clearly preferred or recommended methodologies for projecting population, household size, auto ownership, income, and employment were not identified.

For planners with adequate resources, the widely used and available cohort-component population projection models are superior. They do require some time and effort, as well as computational resources.

Economic models for projection of income and employment are generally unsatisfactory unless considerable resources are available, in which case econometric models appear preferable.

For the planner with limited resources (of time, staff, or money) the best procedure is to "step-down" from national, state, or multicounty projections prepared using complex, sophisticated techniques. Several examples of such projections are cited, as well as the techniques used for their preparation.

Other major conclusions and recommendations include the following:

- Research is needed in disaggregating study area level projections to subareas—districts or zones—and in examining sensitivity at the subarea level.
- A competent review and presentation of techniques for disaggregation, interpolation, and projection of income are needed. The complexities of inflation and the use of means, medians, and income categories have caused considerable confusion for transportation planners.

- When family size and auto ownership or income are controlled, other variables, such as the sex of the household head, explain very little of the variation in trip-making. However, the influence of labor force participation, unemployment and work attendance on work trip-making is not well understood or known. It, too, deserves further research.

CHAPTER ONE

INTRODUCTION

STATEMENT OF PROBLEM

Few urban areas are unchanging for very long. If the population is not growing, it is declining. Even if it is indeed numerically static, the structural dynamics of household size, family income, car ownership, and household composition ensure an ever changing demand for transportation services.

The task of transportation planning is to evaluate these changes in the composition of an urban area and to recommend transportation plans and policies that will serve the changing transportation needs in a cost-effective way.

The transportation planner does not work in serene isolation. Economists and revenue specialists allocate tax revenues in part, if not solely, on the basis of resident population. Education planners must base their plans on anticipated change in the number of school-age children. Entrepreneurial interests also must judge and react to these changes.

Finally, population changes and shifts are not immutable; to some extent a self-fulfilling prophecy principle may operate in response to the collective decisions made by many and diverse groups. Major investments in a region may reverse a decline in employment. Neglect of transport facilities and the provision of access may blight a region's prospects. Moreover, it is unlikely that a study of recent trends in fertility rates would identify the impacts of such decisions.

The problem addressed in this project, therefore, is not a simple one-dimensional question of projecting the correct future population for a region. Instead, the problem is best described as a series of questions for which the best available answers must be sought:

1. How sensitive are the needs for transportation and, therefore, the transportation planning process itself, to changes in the population and specific aspects of its composition?
   - Changes in average household size.
   - Changes in employees per household.
   - Changes in the number of women in the labor force.
   - Changes in auto ownership.
   - Changes in type of employment.
2. What methods of projecting population are used and presumably acceptable to other disciplines which also make use of projections of future population for their decision-making process?
3. Are existing techniques sufficiently reliable and acceptable to be used in transportation planning?
4. How can they be used?

OBJECTIVES AND SCOPE OF PROJECT

The objectives of NCHRP Project 8-24 are to provide answers to the foregoing questions within the overall project objective, which was stated in the original RFP as follows:

> . . . to summarize and evaluate techniques of using previously forecasted, independent socioeconomic variables at appropriate levels of geography necessary for urban, rural, and statewide transportation planning.

The quest for accurate, comprehensible forecasting techniques, which provide acceptable answers to a broad array of local interest groups, antedates today's computer technology, although this computational power considerably enhances one's forecasting capability. At the outset, it was expected that the project would focus on existing techniques and forecasts and not attempt to "invent" new methods. Although integration and synthesis of existing techniques certainly were contemplated, the project has concentrated on maximizing the usability of available methods and techniques.

While the scope of the project was broad in terms of the range of methods of forecasting socioeconomic variables, as well as in the diversity of disciplines and purposes for which the forecasts were made, there was an important geographic restraint imposed on the research. Urban transportation planning basically is concerned with intraurban travel. The great bulk of all urban travel begins and ends within the urban area. The fundamental simulation technique used in urban transportation planning is the assignment of travel, which occurs among the many subregions (zones) of an urban area, to the network of transportation facilities (links) that interconnect the parts of the region. The accuracy of the estimation of population, employment, and other socioeconomic data by zone is absolutely critical

to this process. The estimates of population of the entire metropolitan area may agree with the actual population exactly, but if the estimated arrangement of these people and their attributes, by subarea, is substantially different from the actual distribution, urban transportation planning will be severely handicapped, if not useless. This aspect of potential research clearly was outside the scope of the project simply because of the resources that would have been required to investigate it. Subarea estimation remains a critical area of research.

CURRENT PRACTICE

It appears that there are, perhaps, only three generalities that may be made about current practice in forecasting the basic inputs to transportation planning.

First, given the institutionalization of the urban transportation planning process that has taken place over the last 15 to 20 years, the inputs have been narrowed to a fairly well-defined small set for almost all agencies. Of course, there are exceptions, but the following are typical of most:

- Number of persons, by age and sex.
- Number of households, by size (number of persons), income, auto ownership and number of employed members.
- Employed persons, by major employment sector (i.e., retail, service, manufacturing).

Occasionally, but infrequently, the type of dwelling unit is associated with the household, or the number of square feet of floor area is associated with nonhome sectors, rather than employment.

Second, many transportation agencies rely on other local agencies to prepare part or all of the projections of inputs. In many instances the transportation agency's problem is translating another agency's projection into terms specifically needed for the transportation planning process.

Third, the methodology used for preparing the inputs is almost as diverse as the locations and titles of the agencies. Certainly there are commonalities—the use of the cohort-component population projection technique is an obvious one—but every agency does something a little differently in response to local circumstances, resources, time, data availability and, ultimately, agency preference.

The research that follows, particularly the material describing and evaluating the methodology, reflects the diversity of technique, on the one hand, and circumstance on the other. It does not recommend a single best method for forecasting the basic inputs to transportation planning. Instead, it presents and describes a number of techniques, noting their positive and negative characteristics. Recommendations are made in some instances, but the ultimate choice of technique or methodology is left to the user.

RESEARCH APPROACH

In addressing the four questions raised earlier, the research was divided into two broad areas. The first deals with the sensitivity of the process to changes or variation in the inputs; the second addresses methods of projection, the data they require and their utility and use.

The ultimate purpose of transportation planning is providing transportation facilities and services that will meet the future demand for those facilities and services in a cost-effective or efficient way. Estimation of future demand is, perhaps, the key element in the process, and that demand, in turn, is a direct function of the inputs to the process. People produce travel demand, and it is known that some people produce more or less demand than others, depending on the characteristics or circumstances of their daily lives.

The first part of the research, then, is addressed to relating the sensitivity of demand to the characteristics of the people who produce the demand.

In practical terms, the results of a thoroughly validated and documented home interview survey of travel in an urban area were used to analyze how much change in several measures of demand (number of trips, miles of travel) occurred, given changes in the characteristics of the persons (or households) producing the travel.

Parallel to this largely analytical task, current practice in the fields of demographic and economic forecasting and projection was reviewed, as well as current practice for transportation planning. Because the choice of methodology frequently is dependent on the type of base data available, common data sources also were reviewed.

The result is a review of and commentary on various techniques. No best solution to the multifaceted problem is suggested. Instead, following a review and description of methodology, accompanied by references for further information and guidance, and a similar review and description of potentially useful data (again, with references and sources), guidance in the selection of methodology and data is provided, within a context that attempts to be responsive to the circumstances of the individual agency or transportation planner.

This project in part was initiated in response to a proposal from the federal government that uniform population and economic projections be required for use in programs involving federal funds. In effect, that requirement would have made the transportation planner's job more like that described in the second of the generalities listed earlier regarding current practice: he or she would be adapting others' projections to his or her own specific needs. That requirement, which was only a proposal when this research began, was never implemented.

However, as suggested by that requirement, transportation planning agencies, and transportation planners, can and should find help in making projections among the people who are responsible for making projections for other, important purposes in other local agencies or at the state and national level. Usually they have training, experience, time, and resources which the transportation agency or planner cannot duplicate. It is important, however, that their assumptions, methodology, and projections be subjected to careful review and analysis.

When all is said and done, the future is anybody's guess—but it can be an educated guess. The remainder of this report presents in Chapter Two the findings from the research concerning three major topics:

1. The sensitivity of the urban transportation planning process, and the simulation models that are a part of that process, to changes in the input socioeconomic and demographic variables.
2. The broad range of methodology and techniques that are

available to the transportation planner for preparing projections of the inputs to the process.

3. Data resources—public and private, local, state, and federal—that are available to serve as the base and basis for projections.

Chapters Three and Four provide an appraisal, evaluation, and application of the findings. Conclusions and recommendations regarding the research are noted in Chapter Five. A comprehensive bibliography categorized according to Population Projections and Estimates, Economic Projections, Projection in Transportation Planning, Data Resources, UTP Process Sensitivity Analysis, OMP Requirements, and Material Received from Agencies is contained in Appendix A. Details of the sensitivity analysis are given in Appendix B. The final Appendix C contains data resources.

CHAPTER TWO

FINDINGS

VARIABLES AND SENSITIVITY

The question of the sensitivity of the urban transportation planning process (UTPP) to changes or errors in the input variables, in the most abstract context, would treat the process as a "black box." That is, given a unit change in an input variable such as population, what is the change in output from the entire process?

There are a number of practical problems, however, with an approach that treats the entire process as a single "black box." Foremost is the inability to understand why or how or even at what stage the change in input has affected the output. While this may be irrelevant in a purely theoretical sense, it is vitally important in a complex chain of models such as that used in the UTPP. There are dozens, even hundreds of parameters involved in the steps in the UTPP, and an understanding of the relationship of intermediate results and parameters to the change in both input and output is vital to intelligent use of the models in the UTPP chain.

A second practical problem in treating the entire process as a "black box" is specifying the output variable to be used as the indicator of change. There are numerous candidates. Some of them are indicators of "goodness," such as percent RMS error in volume-count relationships. Others, however, are not truly "outputs" of the complete model chain. For example, total trips—or trips by purpose—is virtually a descriptor of the context in which the UTPP is being carried out. Simultaneously, it is an early or intermediate product of the process itself.

There is, then, a strong case to be made for examining the components of the UTPP rather than for treating the process as an indivisible whole.

Because the UTPP basically is concerned with estimating the demand for travel, the analysis that follows moves directly to the estimation of travel and examines its sensitivity to the future conditions on which the projection of travel demand is based.

Although there are a number of variables or characteristics of the study area that are used in estimating travel demand, the most typical are:

- Population.
- Family size (persons per household).
- Auto ownership (per household).
- Income (per household).

The measures of demand that capture its total magnitude are

- Trips.
- Person-miles of travel.
- Person-hours of travel.
- Vehicle-miles of travel.
- Vehicle-hours of travel.

Together these measures express both the basic amount of travel (trips) and the characteristics of that travel including trip length and speed. Obviously, they may be disaggregated. Typically, person-trips are subdivided into home-based work trips, home-based nonwork trips, and nonhome-based trips.

MEASURING SENSITIVITY

The usual measure of sensitivity is the change in the dependent variable associated with a unit change in the independent variable.

For example, if total trips is the dependent variable, assume that it is desired to know its sensitivity to an estimate of population. If a linear relationship is presumed to exist between total trips and population, a 1.0 percent change in population will produce a 1.0 percent change in total trips, and the sensitivity is 1.0. If the relationship between the dependent and independent variables is nonlinear, further information must be supplied. The sensitivity is x percent at a certain (stated) value of the independent variable. As will be seen in subsequent discussions, there are many forms which may be used to describe the relationships between dependent and independent variables.

For the moment, these forms are not as important as an examination of empirical data to determine sensitivity in a real context.

The data to be used in the analysis are from a major urban area home interview survey, conducted during the 1960's. The data have been thoroughly edited and checked, and a number of "secondary" variables (for example, total travel time from reported trip start and end times) have been added to trip, person, and household records.

Total Trips

Total Trips, Population, and Persons per Household

One of the most frequently used relationships in trip projection is between trip-making and characteristics of the household. Because of their interaction, projections of population, number of households, and household size are of particular interest.

Table 1 gives the distribution of households, population, and trips (in this table "Trips" and all others include all trips made in a vehicle: automobile, transit, taxi, etc., but do not include walking trips) reported by the households, by household size. (For the sake of simplicity, households of 5 persons and over are treated as having exactly 5 persons, which yields an average family size of 3.241.)

How sensitive is the estimate of total trips to a change in the distribution of family size? Table 1 shows a variation from 1.89 to 10.37 trips per household as persons per household increases. The correlation between the means of persons per household and trips per household in Table 1 is 0.99 with a slope of 2.1 and an intercept of 0.336; in other words, each increase in a person per household causes an increase of 2.1 trips per household. In this case, however, it is assumed that the forecast of population is a given. Therefore, as different assumptions in family size are made, it is not the population that varies, but the number of households. If it is assumed that the average family size is 2.89, 10 percent less than that shown in Table 1, then using the regression equation, trips per household would be 6.4, which is 90.5 percent of the average shown in Table 1. This suggests a high sensitivity: $9.5/10.0 = 0.95$. However, if the population remains the same (36,045), the number of dwelling units must increase (from 11,229 to 12,472). Multiplying 12,472 by 6.4 trips per household yields 79,883 trips. Compared to 80,492 trips in Table 1, this is a change of only -0.8 percent in trips with a change of -10.0 percent in average family size, or a very low sensitivity of -0.08. A 1 percent change in family size results in a change in trips of only 0.08 percent, if population is held constant.

Of course, this estimate is based on the linear regression of means in Table 1. Actually, there are a variety of distributions of family size that would give an average of 2.89. If Table 1 is assumed to represent 100 households with 321 people and 717 person-trips, the hypothetical reduction in family size to 2.89, holding population at 321, yields 111 households. Eleven households must be added to the 100 in Table 1 in such a way as to obtain 321 population in 111 households. The change in the number of households must sum to 11 and the change in population to zero. Table 2 illustrates the situation.

There are many values of $X_1, X_2, \ldots X_5$ which would satisfy the constraints in Table 2. Two possibilities are shown in Table 3. Using the trips per household in Table 1, for case 1 the trips would be 712.3 compared to the original 710.98 or a negligible change. For case 2 the trips would be 710.96, again a negligible change. From this it seems safe to conclude that, given population, the impact of moderate errors in the distribution of family size are negligible.

How sensitive is the estimate of total trips to the distribution of households with respect to family size, if number of households is known?

Table 4 shows the base distribution of 100 households by family size and the two distributions implied by cases 1 and 2 in Table 3, but constrained to a total of 100 households each.

Average household size for the base distribution is 3.21, while for cases 1 and 2, it is 2.89, a change of -10 percent. Total trips are almost the same for each case. For the 10 percent reduction in average household size, both redistributions yield:

$$\frac{711 - 640}{711} = \frac{71}{711} = 0.0999$$

or a 10 percent reduction in total trips. The sensitivity of total trips to average household size is:

$$\frac{0.0999}{(3.21 - 2.89)/3.21} = \frac{0.0999}{0.0997} = 1$$

On the basis of this analysis of the data, the travel—in total

Table 1. Households and total trips by family size, Buffalo (1962).

Persons Per Household	Households Number	Percent	Trips	Trips/ Household
1	1,198	10.6%	2,259	1.89
2	2,867	25.5%	13,697	4.78
3	2,144	19.1%	15,692	7.32
4	2,110	18.8%	18,616	8.82
5 and over	2,914	26.0%	30,227	10.37
Total	11,229	100.0%	80,492	7.17

Table 2. Hypothetical distributions of population by household size.

Household Size	Households	Population	Change In Households	Population
1	11	11	X_1	X_1
2	26	52	X_2	$2X_2$
3	19	57	X_3	$3X_3$
4	19	76	X_4	$4X_4$
5	25	125	X_5	$5X_5$
Total	100	321	11	0

Table 3. Trial changes in households by household size.

	Trial 1			Trial 2		
Household Size	Changes in Households	Changes in Population	Changes in Household Squared	Changes in Households	Changes in Population	Changes in Household Squared
1	10	10	100	11	11	121
2	5	10	25	4	8	16
3	0	0	0	0	0	0
4	0	0	0	-1	-4	1
5	-4	-20	16	-3	-15	9
Total	11	0	141	11	0	147

Table 4. Hypothetical distribution of 100 households by family size and resulting estimates of total travel.

Trips per Household	Family Size	Base Distribution			Case 1 Distribution			Case 2 Distribution		
		Households	Persons	Trips	Households	Persons	Trips	Households	Persons	Trips
1.89	1	11	11	20.79	18.9	18.9	35.72	19.8	19.8	37.42
4.78	2	26	52	124.28	27.9	55.8	133.36	27.0	54.0	129.06
7.32	3	19	57	139.08	17.1	51.3	125.17	17.1	51.3	125.17
8.82	4	19	76	167.58	17.1	68.4	150.82	16.2	64.8	142.88
10.37	5	25	125	369.25	18.9	94.5	195.99	19.8	99.0	205.33
Total		100	321	710.98	99.9	288.9	641.06	99.9	288.9	639.86

Table 5. Households, person-trips, and person-trips per household by cars per household.

Cars Per Household	Households	Person Trips	Person Trips Per Household
0	2,869	6,296	2.19
1	8,098	58,742	7.25
2	2,305	26,868	11.66
Total	13,272	91,906	6.92

trips—estimated from common trip generation procedures is very sensitive to changes (errors) in population estimation, but relatively insensitive to household size distribution estimates, *given an estimate of population.* However, if the input data to trip generation are in terms of households, a household size estimate also must be used, and the resulting travel estimate is extremely sensitive to this latter estimate.

Furthermore, the analysis suggests that efforts to be expended in projection of input data be concentrated on population rather than on households and household size.

Total Trips and Autos per Household

Household auto ownership is known to be highly associated with the number of trips per household. In fact, it has consistently had the highest correlation of any single variable with trips per household, including family size and income per dwelling. The rates of trips per household by autos per household from the data are given in Table 5.

A household with one auto makes 5.06 trips more than a household with zero autos and 4.41 trips fewer than a household

Table 6. Hypothetical distribution of households by auto ownership with resulting estimates of total travel.

Trips per House-hold	Autos per House-hold	Base Distribution House-holds (%)	Autos	Trips	Alternative Distribution House-holds (%)	Autos	Trips
2.19	0	21.6	0	47.3	26.4	0	57.8
7.25	1	61.0	61.0	442.3	61.0	61.0	442.3
11.66	2	17.4	34.8	202.9	12.6	25.2	146.9
Total	-	100	95.8	692.5	100	86.2	646.9

with two or more autos. If it is assumed that two (or more) auto households have two autos (actually, the rate is 2.1), the linear equation for trips is

$$Y = 2.30 + 4.74X$$

where Y = trips per household, and X = autos per household (if households with three or more autos are treated as a separate class, the equation is $Y = 2.42 + 4.4X$ and the sensitivity at one auto per household is 0.65).

If mean autos per household is 1.0, the equation yields an estimate of 7.03 trips per household. A 10 percent change (underestimate) of autos per household (0.9) would yield 6.56 trips per household, or a 6.7 percent reduction. The sensitivity is 0.67 (0.067/0.1 = 0.67).

Sensitivity to auto ownership may be examined in terms of a distribution that deviates least from a known (base) distribution, but has a different mean auto ownership (as was done with family size). Table 6 gives the base percentage distribution of households by auto ownership per household and a changed distribution that has a mean auto ownership 10 percent less than the base.

Six-hundred forty-seven trips are estimated when autos per household is reduced by 10 percent. The underestimate of 10 percent in autos per household yields an underestimate of 6.5 percent (692 − 647)/692 in estimated trips, or a sensitivity of 0.65, which is essentially the same as the prior analysis.

Total Trips and Household Income

Table 7 presents households, person-trips, and person-trips per household by income.

The average income of the $8,000-and-over group is impossible to determine because the class is open-ended. However, if the midpoint is used for the lower three classes and $10,000 is used for the fourth, a regression of person-trips per household on income per household yields:

$$\text{Trips/household} = 1.94 + 0.0008759\ (\text{Household income})$$

Using the more detailed income codes (see Tables B-2–B-4 in App. B), two additional regressions of trips per household on income class yield:

$$\text{Trips/household} = 2.16 + 0008288\ (\text{Household income}) \quad (1)$$

Table 7. Households, person-trips, and person-trips per household by income.

Income Per Household	Households	Person Trips	Person Trips Per Household
0 - 3999	2,760	9,061	3.28
4000 - 5999	3,187	21,187	6.65
6000 - 7999	2,421	20,993	8.67
8000 - over	2,861	29,251	10.22
Unreported or Unknown	2,043	11,414	5.59
Total	13,272	91,906	6.92

Equation 1 ignores the open-ended class of $12,000-and-over for which there were 793 households. The correlation coefficient is 0.067.

$$\text{Trips/household} = 2.67 + 0.0007265\ (\text{Household income}) \quad (2)$$

Equation 2 includes the $12,000-and-over class, and sets its mean arbitrarily at $13,000. The correction coefficient is 0.960. Both of these equations tend to understate the middle income ($5 to $7,000) household trip rate, and overstate the low income and high income households, because trips per household increases with income per household, but at a declining rate. The median income is $5,826. The sensitivity from Eq. 1 is 0.69 at the median income of 0.61 for Eq. 2.

Alternatively, if an income of $6,000 is assumed, an estimate of trips per household of 7.2 is obtained. At an income of $6,000 per household, the estimated trips per household would be 7.73 trips. Thus, at a point close to the average income, a 10 percent increase in income would give an increase of 7.3 percent in trips per household or a sensitivity of 0.73.

Table 8. Total airline person-miles of travel per household by family size, autos owned, and income.

Income	No. Cars Owned	Family Size 1	2	3	4	5+	Total
Less than $4000	0	4.42	5.54	7.92	15.95	8.44	6.19
	1	9.55	14.94	17.70	23.78	30.35	17.23
	2+	0	17.52	41.90	43.41	40.06	34.28
	Subtotal	5.58	10.88	15.34	22.47	21.04	11.92
$4000 - $6000	0	7.98	9.73	11.87	11.73	14.22	11.02
	1	14.87	21.18	21.69	24.72	27.33	23.53
	2+	13.15	29.43	30.81	38.53	45.69	36.86
	Subtotal	11.74	19.30	21.35	25.10	27.46	22.71
$6000 - $6000	0	11.11	11.23	11.31	11.54	15.86	12.66
	1	19.04	23.08	25.73	32.31	35.62	30.07
	2+	81.80	33.89	38.72	48.77	52.01	45.54
	Subtotal	17.52	22.71	28.08	34.85	37.18	31.51
$8000 & over	0	8.37	11.74	32.19	33.50	21.56	16.37
	1	17.13	29.40	33.65	38.54	38.45	34.52
	2+	19.10	41.20	42.16	48.87	63.14	51.13
	Subtotal	14.49	31.27	37.60	43.01	49.02	40.39
Mean		7.924	19.505	26.298	32.758	36.431	26.457

Summary—Sensitivity of Total Trips

It has been shown that trips per household is relatively insensitive to household size if population is held constant. However, if both number of households and household size are being forecast, the sensitivity of trips per household to household size is 1.0. That is, a 10 percent error in the estimate of household size will result in a 10 percent error in trips per household. This strongly suggests that the forecasting process give first attention to population.

Trips per household displays a sensitivity to autos per household of about 0.65, and to income of about 0.70. Given these sensitivities, several additional questions should be addressed:

- Which variable provides the most explanation of the variation between households and trip-making?
- Which variable is easier to predict?
- Can several variables be used and, if so, which ones?

The power of the three variables in reducing the unexplained variation in trips per household singly and in combination is as follows.

Auto ownership shows the strongest single relationship. Family size follows, and, as has been seen, total trip estimation is relatively insensitive to household size estimation when population is fixed. Auto ownership and family size combined have a higher level of explanation than any other combination of two of these variables and only slightly less than all three combined. However, the level of accuracy that could be obtained in making forecasts of the joint distribution of households by auto ownership class and persons per household is unknown. But, because the sensitivity of total trips to family size is low, given population, a case can be made for these two variables.

Use of all three variables (i.e., family size, auto ownership, and income) seems unwarranted. The additional variation explained is quite small, and the difficulties of projection are much greater: 3-auto ownership and 5-household size classes require 15 cells. Addition of income expands this to 60 cells.

Travel Distance and Travel Time Per Household by Family Size, Auto Ownership, and Income

The foregoing discussion was concerned with total trips per household since this variable traditionally is a major input to travel forecasting. Ultimately, however, the process produces total travel mileage on the system and speeds and, therefore, travel time. This section briefly examines travel distance and travel time to see whether regionwide estimates of these values might be useful as checks on the entire process. The sensitivity of these estimates to input errors also is examined.

Travel Distance

In the following discussion the calculation of travel distance is based on the airline distance traveled by the trip-makers of a household. The detailed tables are shown in Appendix B. (The term VMT is used throughout the appendix tables where in fact the term person airline-miles of travel (PALMT) is more precise.) A summary of airline-miles of travel per household by family size, autos owned, and income is given in Table 8.

Overall, the PALMT per household was about 26 mi. The lowest average is 4.4 mi for one-person households with zero cars in the lowest income class, while the highest is 63 mi per household for 5-plus-person families with two or more cars in the highest income class. This is the expected result given an assumption of a reasonably constant distance per trip. However, the variation of PALMT/household within these classes is much greater than was the case for total trips.

The overall standard deviation of PALMT per household is 35.61 which, divided by the mean of 26.4, yields a coefficient of variation of 1.346. For comparison, the coefficient of variation of total trips per household was 0.89 $(\sigma/\bar{X}) = (6.19/6.92)$. The coefficient of variation for PALMT per household is 50 percent greater than for total trips. This simply says that the variation of trip distance within classes of households defined by income, autos owned, and family size is significantly greater than is the variation in total trips. Another example is given in Table 9, which compares the coefficients of variation of total person-trips per household and of PALMT per household by income and auto ownership. In every cell, the coefficient of variation of PALMT is substantially larger than the coefficient of variation in total person-trips.

This suggests that the reduction in overall variation (explanation of variation) afforded by income and car ownership would be substantially less for travel distance than for total trips. This indeed is the case. For PALMT, the coefficient of determination (explained variation divided by total variation) is 0.13, which is equivalent to a correlation coefficient of 0.36. The comparable coefficients for total trips are 0.27 and 0.52. Thus, knowledge of autos owned and income class gives twice the explanation of variation in total travel (trips) than it gives for person airline-miles of travel.

Coefficients of determination for autos, income, and family size alone are 0.110, 0.087, and 0.065, respectively.

The sensitivity of person airline-miles of travel was examined using a linear fit of the means. The resulting equations and the sensitivities are summarized in Table 10. The sensitivities are similar, ranging from a low of 0.71 to a high of 0.86. However, the proportion of the unexplained variation remaining in person airline-miles of travel per household suggests that it may not be sufficiently regular at a regional scale to be useful.

Table 9. Comparison of coefficients of variation of total person-trips per household and total person-miles of air line travel by household by income, and by autos owned.

Income Class		Cars Owned 0	1	2+
Less than $4000	Trips	1.40	.88	.73
	Distance	3.77	1.47	1.20
$4000 - $6000	Trips	.95	.75	.65
	Distance	1.53	1.31	1.08
$6000 - $8000	Trips	.83	.68	.62
	Distance	1.27	1.27	.83
Over $8000	Trips	1.07	.65	.61
	Distance	1.65	1.03	.88

Travel Time

Travel time per household is based on the sums of the differences of time leaving an origin and arriving at a destination for all trips reported in the home interview survey. It includes access and egress time as well as waiting and transfer times of persons using transit. Detailed tables of travel time per household by income, autos owned, and family size are presented in Appendix B. A summary of travel time per household by income, autos owned, and family size is presented in Table 11.

The average amount of time spent in travel per household is 3 hours. The lowest average travel time per household is 0.465 hours (28 min) for one-person households with no auto owned and an income of less than $4,000, and the highest is 6.836 hours by households with five or more persons, two or more autos and over $8,000 (the highest income category).

These average travel times follow the pattern of total trips and airline-miles of travel—increasing with autos owned, income, and family size.

The variation of travel time per household within the cells formed by these variables exceeds that of both total trips and PALMT. Overall, with a standard deviation for travel time per household of 6.771, and an average of 3.022 hours, the coefficient of variation is 2.24. The variation within the cells formed by income and autos owned is given in Table 12, which also presents the coefficients of variation for total person-trips per household.

As was the case for person airline-miles of travel, it appears that estimates of regional total travel time per household, using the conventional variables of trip generation, would be subject to a high degree of error because of the variability inherent in travel time which includes variation in (1) number of trips, (2) length of trips, and (3) speed of trips.

The amount of the variation in travel time per household that can be explained by knowing the distribution of households by income and car ownership is low; only 4.2 percent, which is

Table 10. Linear equations for person-miles of air line travel per household for income, cars owned, and family size and corresponding sensitivities.

Variable	Equation	Sensitivity
Income	Air Line Travel/Household = 4.98 + .00361 (Income/Household)	.81
Cars Owned	Air Line Travel/Household = 7.97 + 19.33 (Cars/Household)	.71
Family Size	Air Line Travel/Household = 3.50 + 7.027 (Family Size)	.86

Table 11. Person-trip travel time by household, family size, autos owned, and income (hours).

Income	No. Cars Owned	Family Size 1	2	3	4	5+	Total
Less than $4000	0	.465	.729	1.137	1.627	1.626	.793
	1	.986	1.887	2.083	2.608	3.376	2.023
	2+	.0	1.865	7.490	8.730	4.140	5.324
	Subtotal	.582	1.377	2.087	2.772	2.631	1.482
$4000 - $6000	0	1.051	1.264	1.503	1.985	2.181	1.555
	1	1.346	2.347	3.025	2.660	3.237	2.767
	2+	1.200	2.639	2.888	3.745	4.738	3.607
	Subtotal	1.210	2.136	2.602	2.720	3.251	2.645
$6000 - $8000	0	.930	1.397	2.063	1.868	2.086	1.669
	1	1.600	2.358	3.236	3.608	4.397	3.522
	2+	4.000	2.550	5.173	7.254	6.624	5.929
	Subtotal	1.425	2.256	3.618	4.266	4.632	3.804
$8000 & over	0	.746	1.363	2.864	7.025	2.892	2.010
	1	1.218	3.047	3.235	3.769	4.667	3.680
	2+	1.533	3.443	3.374	6.249	6.836	5.322
	Subtotal	1.083	3.031	3.291	4.900	5.592	4.264
Mean		.773	2.084	2.998	3.790	4.325	3.022

Table 12. Comparison of coefficients of variation of total person-trips per household and person travel time per household by income and cars owned.

Income Class		Cars Owned 0	1	2+
Less than $4000	Trips	1.40	.88	.73
	Time	2.06	2.32	2.66
$4000 - $6000	Trips	.95	.75	.65
	Time	1.12	2.53	.92
$6000 - $8000	Trips	.83	.68	.62
	Time	1.00	1.87	2.22
Over $8000	Trips	1.07	.65	.61
	Time	2.09	1.67	1.84

equivalent to a correlation coefficient of 0.20. For autos and income singly, the amount of explanation is 1.75 percent and 2.50, respectively. At a regional scale, there does not appear to be much promise in estimating travel time per household from auto ownership or income.

A linear fit to the class means yields the equations and sensitivities at the mean as presented in Table 13. Every $1,000 of income added to household income adds about 20 min of travel. Each additional auto adds 2 hours of travel per household. Each additional family member adds 53 min of travel time. Travel time per household is quite sensitive to income, autos owned, and family size. However, the magnitude of the variation left unexplained by these variables suggests that, at a regional scale, the utility of estimates of travel time per household will be extremely limited.

Household Type As An Independent Variable

The use of the household unit as the basis for estimating travel is typical. In addition to household income, autos owned, and number of persons, household travel patterns may vary according to characteristics of its members, such as their age, sex, and marital and employment status. One such characteristic, which may be changing through time, is whether the household is traditional, headed by a man with wife, as opposed to a head without a spouse. In order to examine how such a major shift in type of household might affect trip generation, households were subdivided into three strata:

1. Male head with spouse.
2. Male head no spouse.
3. Female head.

Total trips per household rates were calculated by auto ownership status and family size for each of the three types of households. The resulting rates are given in Table 14.

The row and column rates are substantially higher for the male head with spouse households than for either of the other two. The overall rate displays an even greater differential: 7.95

Table 13. Linear equations for person travel time per household for income, cars owned, and family size and corresponding sensitivities.

Variable	Equation	Sensitivity
Income	Travel Time/Household = .88 + .00036 (Income/Household)	.71
Cars Owned	Travel Time/Household = 1.06 + 2.05 (Cars/Household)	.66
Family Size	Travel Time/Household = .151 + 881 (Family Size)	.95

Table 14. Comparison of total trips per household by type of household by cars owned and household size.

Cars Owned	Household Head Type	Household Size 1	2	3	4	5+	Total
0	Male Head + Spouse	--	1.74	3.07	3.38	4.32	2.81
	Male Head No Spouse	1.06	1.93	3.10	1.91	2.57	1.43
	Female Head	1.18	2.27	2.79	3.70	3.40	1.85
1	Male Head + Spouse	--	5.30	7.11	8.26	9.70	7.68
	Male Head No Spouse	3.30	4.83	7.36	7.37	9.26	5.14
	Female Head	3.05	5.20	6.78	7.98	8.63	5.08
2+	Male Head + Spouse	--	7.54	9.72	12.48	14.80	11.83
	Male Head No Spouse	4.00	7.56	7.91	9.53	14.50	9.06
	Female Head	5.00	8.24	9.33	13.25	14.26	10.66
TOTAL	Male Head + Spouse	--	4.84	7.34	8.96	10.34	7.95
	Male Head No Spouse	2.31	4.41	6.85	7.02	9.40	4.23
	Female Head	1.70	3.96	5.35	7.10	6.81	3.51

for male head with spouse households compared to 4.23 and 3.52 for male head/no spouse and female head households, respectively. However, these differences are largely the result of differences in the household size and autos owned distribution. (Obviously, male head with spouse households have zero one-person households.)

The distribution by autos owned and family size is given in Table 15. Almost 60 percent of households with female heads have no cars compared to 12 percent for the male head with spouse households. The tendency of male head with no spouse and female head households to be either one- or two-person households is also apparent; 72 percent of both compared to 27 percent for the male head with spouse households.

When the rates are standardized for autos owned and family size, differences in trips per household are much smaller. Excluding one-person households, and assuming an equal weight for each of the twelve remaining cells, the average trips per household for each of the three household types would be:

Male Head with Spouse	7.285
Male Head, no Spouse	6.486
Female Head	7.194

It would appear that attempting to keep track of female head households, even on the regional level, would not have much impact on estimating total trips, because the means are only

Table 15. Comparison of percentage distribution of households by type of head, cars owned, and family size.

Cars Owned	Household Head Type	Family Size 1	2	3	4	5+	Total
0	Male Head + Spouse	0	5.4	2.1	1.4	3.0	11.9
	Male Head No Spouse	24.7	7.3	2.0	1.1	1.4	36.5
	Female Head	33.4	12.8	6.5	2.7	3.8	59.2
1	Male Head + Spouse	0	17.9	13.8	15.3	20.7	67.8
	Male Head No Spouse	22.0	13.9	7.7	3.8	4.7	52.2
	Female Head	12.5	12.0	5.8	2.4	2.0	34.7
2+	Male Head + Spouse	0	3.1	5.0	5.2	6.9	20.3
	Male Head No Spouse	.4	3.9	3.3	1.7	2.0	11.3
	Female Head	.2	1.6	2.1	1.1	1.2	6.2
TOTAL	Male Head + Spouse	0	26.5	20.9	21.9	30.6	100.0
	Male Head No Spouse	47.0	25.2	13.0	6.6	8.1	100.0
	Female Head	46.1	26.3	14.4	6.2	7.0	100.0

about 1 percent different. The male head with no spouse household has a total production rate about 11 percent lower, but only about 8 percent of all households were of this type.

Travel by Purpose

Similar analyses (to those performed for total trips) were performed for trips by purpose to determine their sensitivity to the same independent variables.

These sensitivities are summarized in Table 16. (Supporting tabulations and calculations, similar to those performed for total trips, are included in App. B.) For comparison, sensitivities discussed above for total trips, travel distance, and travel time also are included in Table 16.

Table 16. Comparison of travel measure sensitivity by trip purpose.

Demographic Characteristics	SENSITIVITY OF TRAVEL MEASURES: Total Trips	Home Based Work Trips	Home Based Other Trips	Non-Home Based Trips	Travel Distance	Travel Time
Number of H.H.s, Pop Constant	.016	+1%: -.14 -1%: +.21	negligible	negligible	-	-
Population, # of H.H.s Constant	.990	.81-.84	1.11	.82	.86	.95
Auto Ownership Per H.H.	.65	.56	.66	.84	.71	.66
Income Per H.H.	.73	.73	.66	.92	.81	.71

Several of the distributions are nonlinear with respect to the independent variable (as total trips was with respect to income, earlier). Values of the independent variable at or near its mean have been used in each case to calculate sensitivity. In the case of home-based work trips, however, nonlinearity near the mean resulted in different sensitivities for a decrease or an increase in the independent variable. (Note two values in the table.)

The work trip is the most important trip type to the transportation planning process. The fact that the bulk of all the workers in an area begin their work day in the morning and conclude it in late afternoon is the basic reason for morning and evening peak traffic flows, and it is the traffic in these flows that is the source of traffic problems and that creates a need for planning.

Traditionally, the transportation planning process has used separate models for estimating work trips. The typical unit is the home-based work trip, usually expressed in terms of a rate of home-based work trips per household.

Typically, these rates are established for a base year and simply assumed to be appropriate for a future time period. Changes in the labor force, including unemployment, obviously need to be considered in this process.

A direct comparison of work trips, determined in a home interview survey, to employment can be clouded by differences between attendance and employment (absenteeism, sickness, vacation, 4-day work weeks, etc.).

It should be recognized that the sensitivity of home-based work—and other—trips is being measured in a cross-sectional context using independent variables from what is essentially a "snap-shot" in a temporal sense. There is no information in these data which reflects changes that were occurring at the time they were collected. Although it is possible, after the fact, to examine trends that were affecting the data, it is not clear that it is necessary, or even appropriate.

What is important is to examine inventories and projections of labor force participation at a regional level, in comparison to current and projected work trips, to see if the two make sense. For example, given that the definition of home-based work trips is such that a person going to work and coming home, with no intervening destination, would "generate" two home-based work trips, then there should be two for each employee each day. However, given the differences between attendance and employment, as well as trip interruptions for other purposes, there invariably are fewer than two per employed person.

No source was found which analyzes this difference. But, if changes in labor force participation, work schedules, and other secular events are to be acknowleged in projections for planning, then, at least, current ratios of travel to employment should be examined at the regional level and major anticipated changes should be considered in reviewing projections of travel.

In general, trip-making by purpose reflects the same sensitivity to population, family size, auto ownership and income as was seen for total trip-making.

When population is held constant, the sensitivity of home-based other and nonhome-based trips to a change in number of households is negligible. Table 17 illustrates the strong relationship to persons for home-based other trips.

Home-based work trips are somewhat less sensitive to a change in population and more sensitive to a change in number of households than were total trips. This probably illustrates a general, and logical connection between employment and household formation. Measurement of the sensitivity of work trip-making to auto ownership and income implies that the latter two characteristics have some causal relationship to the former. It may well be the case, though, that income and auto ownership changes, as well as work trip-making, instead are causally related to employment. Clearly a work trip is related to employment; that belabors the obvious. But the other variables likely are also, although not as directly.

Table 17. Households and home-based other trips by family size, Buffalo (1962).

Persons Per Household	Households Number	Households Percent	Trips	Trips/ Household	Trips/ Capita
1	1,499	11.3	1,324	.883	.883
2	3,519	26.5	8,170	2,322	1.161
3	2,543	19.2	9,256	3.640	1.213
4	2,402	18.1	11,887	4.949	1.237
5 and over	3,307	24.9	20,589	6.226	1.245
Total	13,272	100.0	51,229	3.860	1.211

Sensitivity of Other Steps in the UTPP Model Chain

To this point, analysis and discussion have dealt exclusively with the sensitivity of three output variables of the urban transportation planning process—trips, miles of travel, and hours of travel—to input socioeconomic and demographic variables. The analysis has focused on the trip generation step of the UTPP.

The three output variables are summary or total measures of travel, and the sensitivity has been expressed as the error (or change) in one of these single, summary measures of travel as a result of a change in one or more of the input variables used to make that single estimate.

In fact, thousands of estimates of travel are made in a typical application of the UTPP—for individual traffic zones, for interchanges between zones, for traffic on specific network links or transit lines, and so forth. In short, the fine-grained geographic (and facility service) subdivision typically prepared and used in a study area has not been examined. While it is critical to understanding the sensitivity of the process, such analysis is well beyond the scope and fiscal resources of this project. However, some general observations may be made.

In addition to trip generation, there are three further computational steps which typically are undertaken to obtain estimates of use for a transportation link or line:

1. Trip distribution.
2. Modal split.
3. Assignment of trips to networks.

These steps in the UTPP are even more dependent on geographic and network subdivision than is trip generation; macro-techniques of trip distribution, modal split, and assignment not only are unsatisfying except in very general sketch planning, they break down badly in situations where assumptions (con-

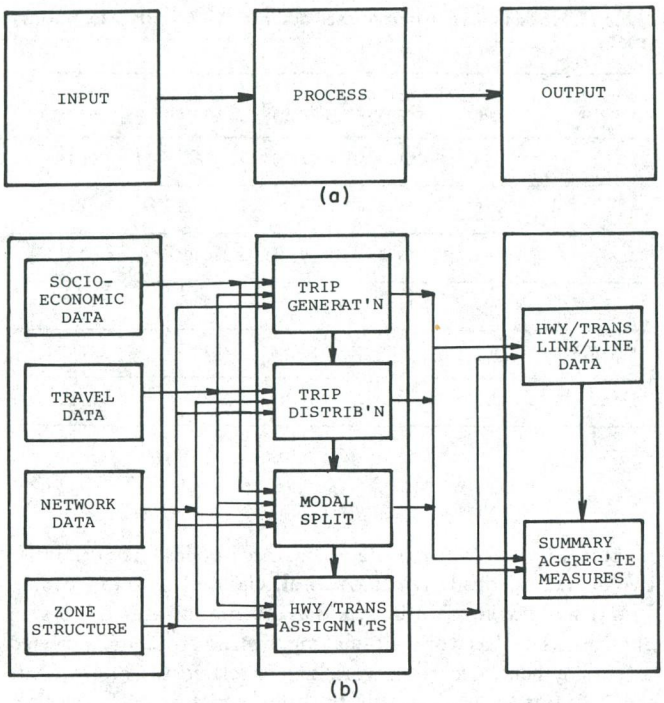


Figure 1. The urban transportation planning process.

tinuous plane, uniform development, or "regular" development) are violated. Although a meaningful analysis of sensitivity and error propagation in these steps is dependent on a full-scale analysis, using a system of small zones and a detailed network, there are other points that illustrate sensitivity at a general level.

Figure 1(a) illustrates the UTPP in terms of a simple "black box" system: input, process, output. As mentioned at the beginning of this chapter, the concern is change of the output relative to change in the input. In Figure 1(b), the simple input-process-output system is shown in greater detail, with several listed inputs and outputs and their relationships or linkages to steps in the process (the model chain).

The input data are in terms of the finely structured geographic partitioning—traffic zones—or network/service segments (links and lines):

- The socioeconomic data must be allocated to zones.
- The travel data must be in zone-to-zone detail to calibrate trip distribution, mode split and assignment models.
- The network/service data must be in terms of links/lines.

Although the zone structure is the description of the location of trip-makers in the study area and forms the framework for simulation, it is feasible to examine the sensitivity of aggregate output measures of the amount of travel—trips, miles of travel, and hours of travel—to changes in input socioeconomic data.

But, referring again to Figure 1(b), it may be seen that the UTP process also—and primarily—provides detailed output by highway link and/or transit link/line. Although it is possible to aggregate these detailed data (and that is, in effect, what has been done earlier) and to examine their sensitivity to socioeconomic input data changes, it is not possible to examine the sensitivity of the detailed outputs without looking at the details of the process.

Notice, however, that socioeconomic data also are direct inputs to the modal split model, which estimates the mode of travel that will be used by any given person-trip, previously simulated by the trip generation and distribution models. The mode split model most often is applied at the level of the zone-to-zone interchange (the "post-distribution" model) so that the output is critically sensitive to the network (service on a zone-to-zone basis) and the zone structure.

Two socioeconomic variables that commonly are used in modal split models are household income and household auto ownership. Auto ownership has an enormous impact on modal choice because it conditions the tripmaker's perception of the costs and travel times for the highway and transit networks. For a zero-auto household, travel time and travel cost by auto, measures typically drawn from the network using highway speeds, costs on a distance (per mile) basis, and parking costs, must be different from that for a household with one or two autos. For the zero-auto household, auto options are taxi, rental car, borrowing an auto from a friend or relative, or arranging for a ride. Each of these adds time, cost, and inconvenience even though the values—travel time and cost—taken from the network remain the same.

While the most logical or sensitive place to use auto ownership in simulation is at the disaggregate level—zone or household—it also is possible to relate the split between auto and transit to the regional or area level of auto ownership. There are extensive descriptive data on this relationship dating back to the first home interview surveys in the 1950's.

Recent survey results in Pittsburgh in 1978 and 1979 show the relationship dramatically. Table 18 presents the modal choice behavior of 1,260 trip-makers in the Pittsburgh region stratified by trip purpose and household auto ownership.

Two out of three persons from zero-auto households making trips to work used transit. However, the rate of transit use was only 1 in 9 from households with one or two autos. For nonwork travel, 6 of 10 trip-makers used transit when no auto was available, but when an auto was available, only about 4 in 100 used transit. Clearly, while the overall split between auto and transit will reflect service levels, fares, parking charges, and other measures of service, auto availability has a fundamental effect on mode choice. Although location of households with varying auto ownership is critical (the allocation or disaggregation to zones), misestimation of regional or study area levels of auto ownership would have a significant effect on mode split estimates.

An alternative way to examine the effect of auto ownership is to examine the elasticities of the variables in a mode split model to see how they are affected by auto ownership. Table 19 shows the elasticities of service variables, for auto ownership groups, from a multinomial logit model calibrated to the 1978-1979 Pittsburgh data.

Without exception, the elasticities of the service variables (times, costs—by highway and transit) are sharply different for the auto ownership groups. For example, a 1 percent increase in transit access time will decrease transit use for work trips by only 0.179 percent in zero-auto households. In one- and two-auto households, that same 1 percent change will decrease work-trip transit use by over 4 percent: a ratio of 23:1 between the elasticities for the two groups. These data show a general inelasticity of transit use, relative to service levels, for zero-auto households, particularly for work trips. The comparatively high elasticity of the auto owning households persists for nonwork travel, even though elasticities increase for zero-auto households.

SUMMARY—SENSITIVITY OF OUTPUT VARIABLES TO INPUT DATA

The analysis indicates that trip-making levels are quite sensitive to the traditional major demographic characteristics used in trip generation. It also clearly shows that the emphasis on *household* trip generation may lead to serious errors unless total population is controlled, because trip-making is so sensitive to the *product* of number of households and persons per household.

This first conclusion suggests that primary emphasis in projection efforts be directed to population projection. Secular change in household size and the projection of household formation are important for a number of reasons—as a logical next step in projecting the effects of other variables such as auto ownership, and as an "input" to projections of land consumption and the location of emerging households. But people, not households, make trips. Therefore, the first order of business is making as accurate an estimate of population as is possible.

Next, because other attributes of the population such as income, cars owned, and sex of head of household require (usually) a specification in terms of households, estimation of the distribution of population *by household size* is needed. While this specification, given a control on total population, in itself will not improve precision very much, it is needed for the further specification of other characteristics to which travel estimates are sensitive—automobile ownership and/or income.

Finally, after estimates of population, households, and cars owned (or income) have been tightened up, it does not appear that an additional variable, requiring further cross classification of households, adds significantly to the explanation of variation, especially considering the difficulty of adding another variable and the potential error inherent in further detailing forecasts of the future.

Second, both distance traveled (VMT) and travel time are outputs of the transportation planning process. It was thought that estimates of these aggregates, based on the input population and related characteristics, might be useful as reasonableness checks for the final output, simulated trips over the network. While these aggregate measures *are* very sensitive to autos owned, household income, and household size, their variability appears to be so large as to preclude their use as checks. However, given a finer geographic framework on which to base these estimates, they might have real utility. This is an area for future research at a more detailed geography.

Third, concern has been expressed that there have been changes in life style, household formation rates, and household composition which are not included in the standard travel forecasting models. it is feared that this omission might seriously flaw travel estimates and that the resulting errors would undermine plans based on these estimates. The work undertaken in this area was limited but insightful. Travel by households headed by women was contrasted to travel by households headed by a man with spouse. In terms of raw travel behavior, there was a tremendous difference. However, when the comparison was standardized by cars owned and persons per household, little if any difference was apparent. This is reassuring, but it underscores the need for careful forecasts of population, households, and autos or income.

Finally, because the UTP process is directed to specifying detailed data regarding travel at the highway link or transit line level, it is clear that the major improvements in the process (including specification of input variables) must come from analysis at a finer level of geography. Even if the population, family size, autos owned, household income, and other variables are forecast with no error, travel estimation, and plans based on that estimation, will be very sensitive to *allocation* of population and related data *to the traffic analysis zone level.* Examination of the effect of allocation is the logical next step beyond this research project.

Table 18. Trip behavior in the Pittsburgh Region, 1978-1979.

	HB Work		HB Other	
Mode of Travel	Zero Cars	1+ Cars	Zero Cars	1+ Cars
Transit	19	101	60	54
Auto	10	813	40	1260
Total Observations	29	914	100	1314

Table 19. Elasticities at mean values of variables (transit users).

	HBWork		HBOther	
SERVICE VARIABLE	0-Auto	1&2-Auto	0-Auto	1&2-Auto
TIME TRANSIT USE (D)	-.0308	-1.53	-.168	-2.19
TIME TRANSIT ACCS (D)	-.179	-4.12	-.780	-6.34
COST TRANSIT USE (D)	-.106	-.407	-.295	-1.63
TIME AUTO USE (C)	.0178	.909	.102	1.33
TIME AUTO ACCS (C)	.213	1.68	1.03	2.37
COST AUTO USE (C)	.208	.589	.284	1.60

(D), (C) indicate Direct or Cross Elasticities

DESCRIPTIVE REVIEW OF PROJECTION TECHNIQUES

This section provides a description of the methods available for projecting socioeconomic inputs for transportation planning. Although the emphasis is on description rather than assessment for transportation planning, some strengths and limitations of the techniques are noted as part of the description. More systematic assessment follows in Chapter Three. The techniques first are classified to provide a perspective on the range of styles of projection. Descriptions of the individual techniques then follow. Space precludes full descriptions adequate to completely guide the transportation planner who wishes to apply any of the techniques, but references to more complete descriptions and guides to application are provided.

Transportation planning—and, indeed, planning in general—has placed demands on the art (or science) of forecasting or projection which is relatively new. In part, these demands are

nothing more than arithmetic—precision, small areas, etc.—and may be attributed to data needs and, to some extent, expanded computation capabilities (the computer).

However, planning of all kinds—and the computer's capabilities—has both generated a demand for and made possible integration of what were previously largely separate "fields" of projection work. Economists projected income or employment or industry activity assuming population, and demographers projected fertility and mortality rates assuming migration. While they might borrow from each other sometimes, integrated models rarely, if ever, were used.

The categories of techniques used below are rooted in that history and practice. Not only are the techniques categorized by general approach, they also are attributed to the material for which they were first developed: population, employment, income and so forth.

Like any taxonomy, however, this one suffers from imprecision and duplication in definition. More importantly, in use and application, almost no projection or forecast is made without the use of some part of each of the techniques which are here so arbitrarily categorized.

Classification of Projection Techniques

Projection techniques may be organized into several categories for purposes of exposition. The most general level distinguishes between those techniques that are based on forecasts for larger "parent" areas and those that assume that the study area is an independent economic, social, and demographic entity.

Superficially, it would seem that the assumption that any entity is completely independent of what goes on around it is wrong. Even projection for the nation must account for international trade and migration effects. But, as will be seen in descriptions of those techniques, blind assumptions that ratios between the area of interest and a "parent" area will remain the same are equally unrealistic.

In practice, the use of a single technique is rare: most projections (or forecasts) use a combination.

Techniques that relate the area of interest to a "parent" usually are called "ratio," "share," or "step-down" methods. Data for the transportation study area are expressed as ratios to analogous data for the parent population or economy, for which an adequate forecast already exists. Either ratios are assumed to remain the same, or an historical trend is determined and projected into the future, usually on the basis of mathematical or graphic extrapolation, and sometimes mediated by other mathematical models or by judgment. Then the projected ratio(s) is (are) multiplied by the independently obtained projection for the parent area to obtain a projection for the study area. Hence, the term "step-down"—from the larger to the smaller area.

The rationale for using the technique is based on several arguments. First, as has been noted, larger populations and economies are inherently easier to project than are smaller ones. Second, data for larger areas (say, the nation, economic regions, and states) are more readily available and more statistically reliable and, therefore, should provide a better basis for projection. Third, changes in fundamental socioeconomic factors (birthrate, labor-force participation, etc.) usually are recognized and analyzed more readily in larger areas (due both to statistical reliability and data collection). Fourth, transportation study areas, such as cities and even metropolitan areas, are presumed to share in the effects of economic and demographic change in the parent area, as they have in the past. Fifth, local departures from the change processes characterizing the parent area are presumed to have less impact on the accuracy of the projection for the study area than they would have on projections based on the assumption that the study area is a relatively independent entity. That is, the ratio techniques shift to the parent area projection, the burden of accounting for shifts in socioeconomic trends.

These arguments add up to a contention that projecting the share of a phenomenon (say, population) in a larger area is, under many circumstances, more reasonable than projecting the population itself. In addition, ratio techniques are much less complex than many other methods of projecting the study area population for the intermediate and longer range time period. Of course, ratio techniques are especially suitable where the study area is judged to be very dependent on its parent region and where nothing is seen on the horizon to change that relationship. Ratio methods also are especially reasonable when an analysis of historical data reveals a relatively stable ratio or one that has changed in a consistent manner which can be extrapolated into the relatively long-range future.

Techniques in the second category, those which assume that the study area is a relatively independent geographic, demographic and economic entity, exhibit greater variety. They can be put into four subcategories: (1) direct extrapolation of past trends by use of graphs, judgment, and, most commonly, simple mathematical equations; (2) component analysis methods that base projection on analysis of the basic components of change (e.g., births, deaths and migration for population projection); (3) joint economic-population projection techniques, usually with economic analysis driving the projection; and (4) carrying capacity methods, sometimes called density models or land use techniques, which focus on the population and employment holding capacity of the study area, given the amount of available land, predominant densities, and, sometimes, land use policies and availability of other resources.

The first of these four subcategories, the direct extrapolation methods, is not well suited for transportation planning, because it is oriented to shorter range projections (10 years or less) (Shryock and Siegel (*32*), p. 443; Greenberg (*11*), p. 7). It is suitable for projections of 5 to 10 years in slower growth areas (where it is also the most cost effective), and for areas where historic Census counts are the only reliable data available. Direct extrapolation also may serve as a baseline projection, and is used to project parameter values for other techniques (discussed more fully below).

In general, the techniques in the second broad group of strategies are most useful where the study area is "different" from its parent area. For example, a university-based community in a rural region or an urban area with an economic structure very different from that of its parent region might better use a nonratio technique.

The extent to which the third group, the "joint" economic-population projection techniques, are truly "joint" varies. In some instances, estimates of employment demand from "economic" models are used to condition "migration" coefficients in a separate demographic model. In others (for example, some of the econometric models, below) they are integrated.

Carrying capacity methods are used most frequently as checks on the reasonableness of results from other models. They are

not reviewed here, but are described thoroughly in Chapin and Kaiser (*7*).

Earlier, the traditional or "historic" division among techniques was pointed out: (1) population or demographic, and (2) economic.

Techniques in both fields may be characterized as "parent" or "independent" (and only fairly recently have the two fields begun to cross over).

In addition to analogous extrapolation techniques, economic projections include the basic/nonbasic ratio that has been extended to the idea of multipliers, which differ primarily in the activities used (i.e., dollars rather than employment) and in further disaggregation of activity in some cases.

The input-output technique carries both formalization and disaggregation further, using a matrix of multipliers or coefficients relating each industry to every other industry and to total final demand.

Data and computation requirements increase sharply in moving from the simplest, the economic base study, to the most complex, input-output analysis.

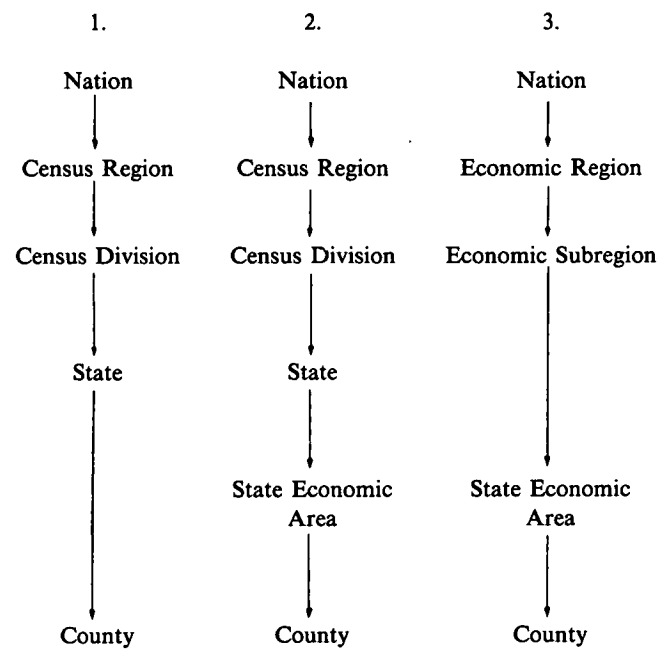
A final major economic technique is the construction of an econometric model of activity for the area. These models are multiequation, multivariate statements of relationships among various activities. They have several advantages from a theoretical point of view, but are demanding in data, computation, and expertise.

The organization of the material that follows then is (1) ratio techniques in population projection, (2) ratio techniques in economic projection, (3) independent techniques for population, and (4) independent techniques for economic projection.

Ratio Techniques—Demographic Projections

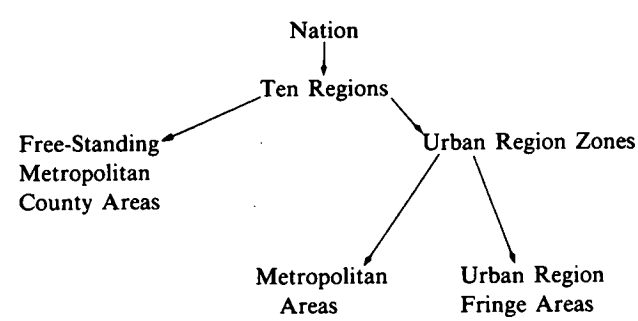
Ratio techniques may be applied in a single step-down from parent to study area or in a multiple step-down. In the former, the ratio is established directly between a single appropriate parent area, e.g., the state in which the study area is located. The forecast for the study area then is projected directly by multiplying the parent area forecast by the appropriate ratio.

In the multiple step-down approach, a forecast for the largest parent area (e.g., the nation) is multiplied by ratios for one or more intermediate areas (e.g., Census region and state). The study area forecast then is obtained by applying an appropriate ratio to the last of the intermediate areas, which itself was obtained by the ratio technique. Pittenger (*21*), for example, suggests three possible chains to the county level:



Chain one uses all political jurisdictions. Chains two and three introduce economic functioning units that are made up of counties.

Pickard (*24*) uses a different hierarchy of areas in his "ratio trend projection methodology" to reach projections for metropolitan area populations. His chain is:



Obviously, the transportation planner has a number of choices within the ratio technique. It may be appropriate to go beyond the state level forecasts and to use economic units and other functioning areas as parent areas. It is not necessary or even

always desirable to rely solely on a one-step, state-to-study area ratio.

In addition to the single versus multiple step variation, step-down methods either may apply the ratio to the intermediate area and/or study area, with reference to the way other subareas of the system may be sharing in the parent area total, or the ratio technique may be applied to all subareas of the parent area of every step-down, balancing the sum of the estimates for all subareas with the parent area total, before proceeding to the next step-down (or on the last step before settling on the study area projection).

The ratio technique also may be applied to changes in levels of population or employment. More specifically, the subarea's share of the change in population or employment experienced by the larger area is projected. The projection is based on historical shares of the larger area's growth which were attributed to the subarea (Pittenger (*25*), p. 98–101, Pickard (*24*)).

Ratio techniques are not limited to total population. They can be applied to levels of population components or cohorts as well. For example, if parent area projections are available by age-sex-race cohorts, the ratio technique can be applied to obtain a similar breakdown for the study area without resorting to the more complex component projection techniques. (Similarly, parent-area ratios of age- sex- or race-specific participation rates may be used to forecast population characteristics.)

Finally, the ratio technique may be applied to attributes of a study area's population, for example, auto ownership or average size of household. That is, a trend of ratios of auto ownership rate per capita for the parent area to auto ownership rate for a subarea may be computed for a historical period, projected into the future, and then a projection of such figures for the parent area can be used to project future auto ownership rates for the subarea. (See material below on "Conversion of Population and Employment Projections.")

The projection of ratios to a future point is the critical task in this technique. Extrapolation techniques usable for projecting population or employment levels directly, but not recommended for longer range transportation planning, also may be applied to the projection of ratios. These include graphic (always a good idea, to reveal sharp bends and breaks in trends), linear, and other mathematical extrapolation models and other special techniques (e.g., Pickard's ratio trend method (*24*), also cited in Pittenger (*25*), pp. 94–98). Care must be taken, however, to avoid projecting ratios declining to unreasonable values. There are several ways to handle this problem. One is to assume that the ratios will reach stability at a determined future date and then systematically to decrease the rate of change in the ratio to converge on those assumed stable ratios by that future date. Adjusting the complete set of subarea ratios so that they are forced to total 1.0 also helps to avoid unreasonable future ratios.

A second way is to project the ratios using a logistic curve (or some other form) which limits the value the ratio may take.

Ratio Techniques—Economic Projections

Ratio or step-down techniques frequently are used in employment projection (or in industrial activity projection from which employment is derived as a dependent variable).

Specific applications vary from situation to situation. The precise chain may be different, as was the case in forecasting population, or categories of industry or employment may be stepped down independently (analogous to age-sex cohorts for population).

Recently, the introduction of sophisticated models of economic activity, particularly at the national level (*91*), has made use of a step-down for regional and substate activity more attractive. Primarily because of the availability of data at the national level, these models incorporate a larger number of variables than is possible at the state or substate level.

Carefully calculated step-down ratios, with attention to the maintenance of totals at each level, permit projection of local study area data in considerable detail with the reassurance that totals are not diverging wildly from reasonable values.

Analysis of activity (economic, employment) by ratio or step-down techniques is analysis of the share of that activity in the subarea, relative to the parent area. If the analyst assumes that share does not change, his work is simple (assuming his data are available), but the trivial case is not the case of interest. Instead, change is expected.

Shift-share analysis is a way of examining change in shares in a systematic way.

Perloff (*80*) explains the concept of "shifts" using relative and absolute values of population change:

> The net shifts by which we measure state and regional growth or decline are the relative gains and losses among the states with regard to a given variable (such as population growth, as here) in comparison to the national figures. These relative changes are determined in the following way. In measuring the population changes between 1939 and 1954, for example, the percentage increase in national population for these years is applied to each state's population to give what might be called the expected change by 1954 if population had increased uniformly throughout the states. This expected population change for each state is then compared with the actual population change in each state as estimated by the United States Census Bureau for 1954. The fact that population did not increase uniformly throughout the states means that some states achieved more and others less than the expected increase; i.e., some states increased their numbers proportionally more than the ratio over the 15-year period; others increased their number proportionally less than the ratio. For example, California's actual increase over the period 1939–1954 was 5,152,000 more than it would have been if population had increased in the same proportion as the ratio (its expected change), whereas New York's increase in population was 827,000 less than it should have been to conform with the national increase. Thus, it can be said that California had a "net upward shift" of 5,125,000 people and New York a "net downward shift" of 827,000 over this period. California's share of the total net upward shift (that is, the sum of all state upward shifts) over the period was 43.9%, while New York sustained 8.74% of the total net downward shift [see Table 20].
>
> Both the downward and upward shifts can further be classified as absolute or relative. An absolute downward shift is one in which all or some part of the downward shift was contributed by an actual decline in population. A relative downward shift is one in which there has been an increase in population, but one insufficient relative to the total increase to maintain that state's share of the total. An absolute upward shift is one in which all or some part of the shift was contributed by an actual increase in population. A relative upward shift is one in which there has been an actual decrease in the population but one that has been insufficient relative to the total decline to reduce that state's share of the total. (Perloff (*80*), p. 33)

The *shift* then is disaggregated into two components for analysis of economic activity (in this case, employment):

> [S]hifts in total employment (or in other important economic growth components) observed among the states and regions in

relation to the national average are generated by two distinct types of phenomena. We call the resultant employment shifts "proportionality employment shifts" and "differential employment shifts."

The net differential shift in employment arises out of the fact that some regions are expanding in certain employment sectors (say, in the steel industry or personal services) more rapidly than other regions. The regions that show net upward differential shifts, as we shall see, are those in which over-all access to basic inputs or to markets has been improved relative to other regions engaged in the same activity; they have gained because of their greater locational advantages for the operations of given activities or industries.

Proportionality shifts are distinct from differential shifts. They arise out of the fact that, nationwide, some of the employment sectors or industries expand more rapidly than others. (That is, here the "growth industry" effect is recorded.) As a consequence, those regions that tend to specialize in the slow-growth sectors (e.g., agriculture and mining) show net downward proportionality shifts in total employment, while those that tend to specialize in the rapid-growth sectors show net upward proportionality shifts.

There are two ways by which the net proportionality shift in total employment can be computed. One way would be to use a complex weighted average based upon the degree of specialization in each sector by each state and the rate of employment growth for each sector. Obviously this is a very time-consuming method. The second way is based on the premise that the net differential shift in total employment and the net proportionality shift in total employment add up to the net total employment shift.

Thus we can simply subtract the net differential shift in total employment from the net total employment shift to obtain the net proportionality shift in total employment. (Perloff (*80*), p. 70)

More formally, Perloff defines the two shifts in a footnote (*80*, p. 71) as follows:

E_{ij} = employment in the i-th industry and j-state in the initial time period

E^*_{ij} = the same in the terminal period

$E_{i\cdot}$ = national employment in the i-th indusltry = $\Sigma_j E_{ij}$

$E_{\cdot j}$ = total state employment = $\Sigma_i E_{ij}$

$E_{\cdot\cdot}$ = total national employment in all industries = $\Sigma_{i,j} E_{ij}$

Then, the total shift for a state is:

(1) $S_t = E^*_{\cdot j} - (E^*_{\cdot\cdot}/E_{\cdot\cdot})\, E_{\cdot j}$

The differential shift for the state is:

(2) $S_d = \Sigma_i\, [E^*_{ij} - (E^*_{i\cdot}/E_{i\cdot})E_{ij}]$

And,

$$S_t - S_d = [E^*_{\cdot j} - (E^*_{\cdot\cdot}/E_{\cdot\cdot})E_{\cdot j}] - \Sigma_i[E^*_{ij} - (E^*_{i\cdot}/E_{i\cdot})E_{ij}]$$

$$= \Sigma_i\, (E^*_i/E_{i\cdot})E_{ij} - (E^*_{\cdot\cdot}/E_{\cdot\cdot})\Sigma_i E_{ij}$$

(3) $= \Sigma_i\, [(E^*_{i\cdot}) - (E^*_{\cdot\cdot}/E_{\cdot\cdot})]E_{ij}$

But, (3) is simply the proportionality shift, S_p, a weighted average of the excess of national industry growth rates over that for all industry nationally, where the weights for a given state are its total industry employment in the initial period.

Shift-share analysis offers two significant advantages. First, it is intuitive and straightforward; the relative and absolute changes, which it identifies, are immediately understandable. Second, it is relatively easy to calculate. Its major limitation is that it only identifies and quantifies relative and absolute change in share; it does nothing to explain the cause (beyond inferential attribution to national change rate). Put differently, it supplies the initial data for an exploration of causality.

Table 20. Illustration of population shift.*

	U.S.	California	New York
1939	130,880,000	6,785,000	13,523,000
1954	161,191,000	12,508,000	15,828,000
Actual change	+30,311,000	+5,723,000	+2,305,000
% Change	+23.16		
Expected change		+1,571,000	+3,132,000
Net Shift		+4,152,000	-827,000

*Table adapted from Perloff (80), p. 33.

Independent Techniques—Demographic Projections

In cases where the study area population dynamics are relatively independent of those characterizing the parent geographic area, ratio techniques will not be appropriate. Trend extrapolation techniques and component analysis techniques are two types of projection techniques that assume relative independence of any area other than the study area. They are based primarily on what has happened in the past, what is happening, and what is projected to happen to the study area itself, without respect to the parent area. This is not to say that component analysis techniques do not look to the parent area and other places for clues about trends in causal factors and components of population change.

Trend Extrapolation of Total Population Size

The quickest and simplest means of extrapolating past trends in population size is by graph. Past population size data are plotted on the vertical scale and time is plotted on the horizontal scale at the base of the graph. A line is fitted by judgment to the points representing the past association between time and population size and the analyst extends that line into the future to obtain a projection of populaiton sizes at future times.

The implicit assumption is that time represents the causal variable in the relationship. That is, population size, on the vertical scale, is presumed dependent on time, represented on the horizontal scale. This is the basic assumption of trend extrapolation techniques, including those that use mathematical methods (to be discussed below). Population size, of course, is not believed to be literally caused by change in time. Rather, time is considered to be a proxy for the combination of true causes of population change—births, deaths, and migration.

Often the analyst will want to use (or at least try) semilogarithmic graph paper instead of arithmetic graph paper. On semilogarithmic paper, time is still plotted on the horizontal scale, which is an ordinary arithmetic scale. Population size is again plotted on the vertical scale, but that scale is logarithmic.

A straight line on an ordinary arithmetic graph associates equal increments in absolute population change with equal in-

crements of change in time. It indicates a *constant amount of arithmetic change* with respect to change in time. For example, a population change of 10,000 people every 10 years would be represented by a straight line on the graph. A straight line on the semilogarthmic graph indicates a *constant rate of change* with respect to change in time. That is, the change over two equal increments of time would be equal proportions of the population sizes at the beginning of those two periods of time. For example, the growth from 1950 to 1960 might be one-half of the population size in 1960. Because proportions are the same, the rates of growth over the two periods are equal. The absolute amount of change from 1960 to 1970, however, would not be the same as the change in population from 1950 to 1960 because the population base on which the proportion is measured in 1960 is larger than that in 1950. The line connecting points on the arithmetic graph would not be straight in such a case, but would be straight on the semilogarithmic graph.

It is a good idea to plot population data, even when one does not intend to rely on the graph for making a projection. The graph produces an independent picture (literally) of what has happened over an historical period. It may suggest insights about the form of the relationship between population size and time. Is the relationship linear on an arithmetic graph? On a semilogarithmic graph? Is population changing monotonically, i.e., in one direction, even if not on a straight line? Is the shape of the nonlinear change convex or concave? Can shifts in rate or direction be associated with other historical occurrences that might in turn be related to migration, fertility, or mortality? In addition to providing insights about the past, such a graph, when extended into the future, provides a literal extension of past trends against which other more sophisticated projections may be compared. In that way the graph provides a "baseline" projection and an easy referent decimal by which to apply a "reasonability" criterion to projections from other models.

Of course, curves (lines) may be fit mathematically as well as manually to data, at least if the association of the data with time is fairly smooth and regular. There are six common mathematical formulas (curves) that have been used to describe historical population growth and to extrapolate past growth trends into the future:

1. Linear Arithmetic Change Model.
2. Geometric—or Exponential—Change Model.
3. Gompertz Model of Population Growth.
4. Logistic Model of Population Growth.
5. The Modified Exponential Model.
6. Polynomial Model.

Like the manually fitted curves, these mathematical forms project population as a direction function of time itself.

The Linear Arithmetic Change Model. While appropriate for shorter range population projections, the linear or constant arithmetic change model is not appropriate for the longer range projections that generally are required for transportation planning. As one methodologist has stated, "We could not find populations that had experienced constant numerical growth for several decades. Such population growth behavior is very rare, so the reader need not worry about having to use this model of growth extensively as a projection tool." (Pittenger (*25*), p. 47)

Mathematically, the linear model of population change uses the familiar general form:

$$y = a + bx \tag{3}$$

In this form, the model may be appropriate for projecting population statistics other than total level of population. For example, birth or death rates or population characteristics of other variables that are shown to exhibit linear relationships with time for the study area in question may be projected quite validly using the linear model. The dependent variable, y, represents the population-related variable of interest. The constant, a, represents the value of that variable at the current or past time used as the base year for the projection. The constant, b, represents the change in the dependent variable per unit of time change. Finally, x is the measure of time, say in years or decades.

When using the linear model to project population size directly, the form is:

$$P_{t+n} = P_t + bn \tag{4}$$

where:

P = population size;

P_t = population size of the base year, t;

P_{t+n} = projected population size at a future year, n units of time beyond the base year, t; and

b = average increment of change in population size per unit of time

Simple linear regression may be used to calibrate the model.

The Geometric—or Exponential—Change Model. This model assumes that growth will be proportionally the same in the next period of time as it was in the last period. Such an assumption and the resulting model are generally preferable to the assumption of constant arithmetic change in the linear model. The reason is that populations, in the absence of shifts in rates in the basic demographic components of births, deaths, and migration, tend to approach a fixed, or intrinsic rate of growth. (Pittenger (*25*) p. 467.) That is, the *rate* of change, rather than the *absolute amount* of change, is assumed to remain constant over time. Population growth compounds like interest on money left in a savings account. The result is growth at a geometric rate; although the percentage of growth remains the same each time, the absolute addition to the population gets bigger and bigger with each passing unit of time. In other words, this model says that the amount of population growth over a unit of time is proportional to the size of the population at the beginning of the period, not to the amount of growth over the previous unit of time. The assumption is one of constancy in proportionality of change. Thus, the geometric model may be called a constant rate of change model.

The form of the geometric model is:

$$P_{t+n} = P_t(1 + r)^n \tag{5}$$

where P_{t+n}, P_t, and n are as before, and r is the rate of growth per unit time.

The constant rate of change model has two forms. In the geometric form, stated above, the rate of change is measured with respect to discrete intervals of time, say decades or years. In a second form, the exponential form, the rate is calculated as the instantaneous rate of change in population size with respect to time. That form of the model can be represented as:

$$P_{t+n} = P_t e^{(r)n} \tag{6}$$

where P_{t+n}, P_t, and n are as before; e is the irrational number representing the limiting, instantaneous rate of compound growth; approximately 2.7182183, the base of natural logarithms; and r is the instantaneous rate of growth, different in value from the r calculated on a discrete time period for the geometric model.

Generally, the geometric form is more convenient to use for population projection. Data on which the model is calibrated are often available for fairly regular time intervals for small areas such as transportation study areas.

The geometric form in Eq. 5 may be changed to its equivalent logarithmic form:

$$\begin{aligned} \log P_{t+n} &= \log [P_t(1 + r)^n] \\ &= \log P_t + [\log (1 + r)]n \end{aligned} \tag{7}$$

This form can be recognized as linear, identical to the linear model in Eqs. 3 and 4, and the least squares method of parameter estimation can be used to estimate $\log (1 + r)$. (It should be recognized that it is the square of the value of the *differences of the logs* which is being minimized, not the square of the value of the *differences*. This dampens the effect of large differences for large values.) Equation 7 also represents a curve plotted as a straight line on semilogarithmic paper. Population, P, is plotted on the vertical, logarithmic axis, while n is plotted along the horizontal, arithmetic axis.

As may be seen from the graphic representation of the exponential growth curve in Figure 2, demographic conditions could seldom, if ever, be maintained to sustain such a curve indefinitely. Evenually, the curve would become impossibly steep, and the population would exceed any holding capacity of the finite geographic area. Carried to its logical extreme, population size would become infinite, clearly an unrealistic projection. For this reason, where implications of the exponential model become unreasonable for the study area, other model forms, such as the following, become more appropriate.

The Gompertz Model of Population Growth. Underlying the Gompertz curve is the assumption that geometric growth will reach, or has already reached, a level beyond which growth will slow down. Population size is assumed eventually to approach, but not pierce, a ceiling. Graphically, these assumptions translate into an S-shaped curve that begins slowly, gathers momentum until it hits an inflection point, then decelerates more and more until it ultimately approaches an upper limit of population size (see Fig. 3).

The formula for the Gompertz curve may be written:

$$P_{t+n} = K\, a^{b^n} \tag{8}$$

where

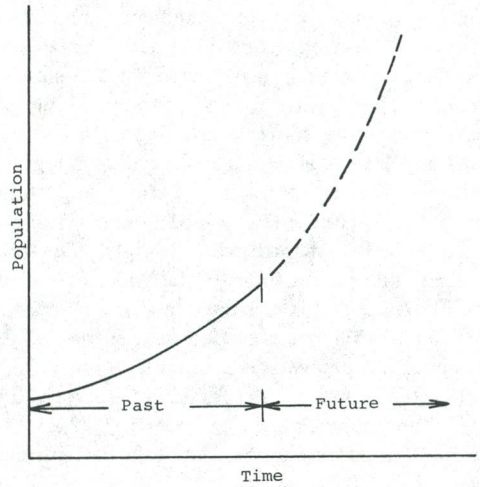


Figure 2. The geometric growth curve.

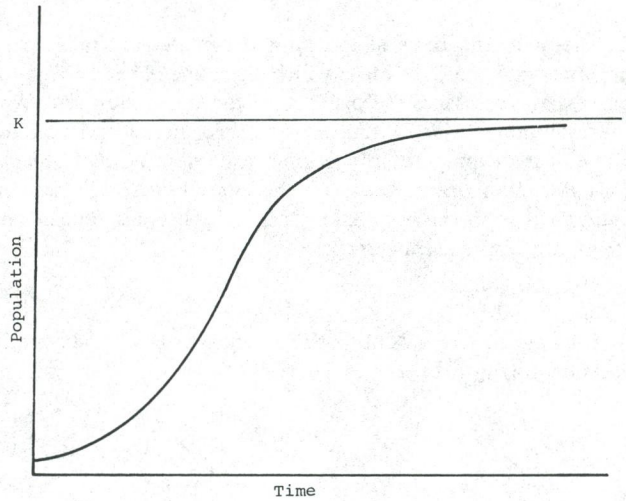


Figure 3. A Gompertz curve.

P_{t+n} is as before; and K is the upper limit of population size for the study area, a value that the curve approaches but never quite attains—an asymptote; n equals number of units of time beyond the base year; i.e., the year measured as year zero in the curve fitting procedure; and a, b equal parameters to be estimated by fitting the model to historical data for the study area.

If a study area is growing according to the assumptions incorporated in a Gompertz curve, the population increases in size by larger and larger arithmetic values during the first part of the growth path. Proportional growth is decreasing, however. That is, growth is less than geometric. This effect is hidden by rapid arithmetic gains for awhile. At some point, the point of inflection in the S-shaped curve, the decreasing proportional gains become decreasing arithmetic gains as well. Eventually, the gains become very small. In a Gompertz growth curve then, the increments of population gain start small, increase to a peak (corresponding to the point of inflection in the curve), and then decrease to very small gains as the population ceiling, K, is approached.

The transportation analyst can apply two empirical tests to see whether the "Gompertz curve" growth is occurring and is already beyond the point of inflection (Pittenger (*25*), p. 58).

In one test, arithmetic growth increments are plotted on an arithmetic graph. Evidence of a Gompertz curve exists if the plot of increments describes a regular pattern of slowly increasing increments over time at first, then more rapidly increasing increments, then more slowly increasing (but still increasing) increments until a peak is reached, after which a regular pattern of ever-smaller increments of arithmetic change takes place. Such a plot, on an arithmetic graph of increments of population change, would be bell-shaped, with the right side stretched out over a longer time period than the left side. In the other test, the first differences (i.e., the increments of change) in the logarithms of population size are examined. If the differences decline by a constant percentage, a Gompertz curve is indicated. Curve fitting procedures are described in Croxton and Crowden (*8*), Murphy and Nagnur (*22*), and Keyfitz (*42*).

The Gompertz curve may be written in logarithmic form:

$$\log P_{t+n} = \log K + (\log a)\, b^n \qquad (9)$$

The term to the right of log K in the expression takes on a negative value because log a will be negative. That part of the expression represents the distance of the population size from the asymptote value, K. As n, time, becomes very large, the value of the expression, b^n, becomes exceedingly small because b is less than one. Thus, as n becomes larger, the amount subtracted from the population "ceiling" becomes smaller and eventually approaches zero.

The Logistic Curve Model of Population Growth. The mathematical form of the logistic curve is:

$$P_{t+n} = \frac{K}{I = e^{a+bn}} \qquad (10)$$

where P_{t+n}, K are as before; e equals the irrational number representing the limiting instantaneous rate of compound growth, approximately 2.7182183; a, b equal parameters to be estimated by fitting the model to historical data for the study area; and n equals the number of units of time beyond the base year, i.e., that year measured as year zero in the curve fitting procedure; and all elements are as in the Gompertz (or exponential) curves. The logistic curve also describes an S-shape on an arithmetically scaled graph. In the logistic curve, however, the first differences, or increments of growth, are more symmetric about the peak of the bell-shaped curve; it is not drawn out to the right as it is in the Gompertz curve. Thus the inflection point is assumed to be encountered at a population size one-half of the ceiling. In the case of the Gompertz curve, this point of inflection is assumed to be reached at about 37 percent of the population ceiling.

The Modified Exponential Curve. If the analyst sees a pattern of declining increments of absolute growth, as in Figure 4, the appropriate mathematical form may be the modified exponential model. It also assumes an upper limit on population size for the study area. It may be written as:

$$P_{t+n} = K - [(K - P_t)\, b^n] \qquad (11)$$

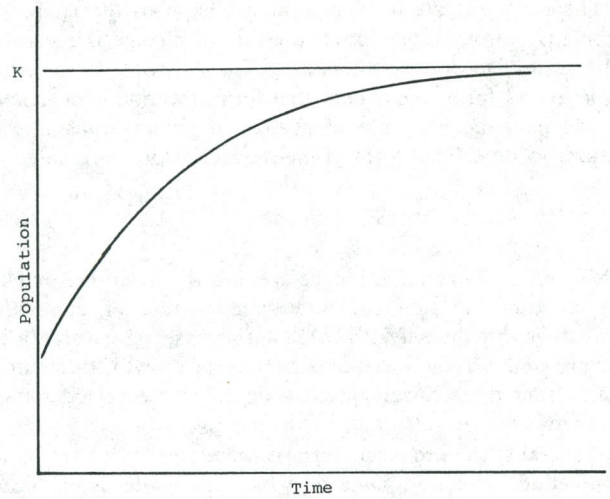


Figure 4. The modified exponential curve.

where P_{t+n}, P_t and K are as before; b equals the constant ratio (less than one) of change by which $(K - P)$ is reduced each successive time unit from its value in the immediately preceding time unit; and n equals the number of time units beyond the base year t. Thus, P_{t+n} approaches K as n increases; that is, the equation projects P_{t+n} in terms of a constantly decreasing distance from the population ceiling, K.

The Polynomial Model of Population Change. A sixth type of model is the most general purpose. It permits fitting to more complicated curves than any of those models suggested earlier. At the same time, however, it has the least rationale behind it, because it results from mechanical curve fitting. The polynomial model is of the form:

$$P_{t+n} = P_t + bn + cn^2\, dn^3 + \ldots + mn^P \qquad (12)$$

The highest exponent indicates the degree of the polynomial. The linear model is a first-degree polynomial. A second-degree polynomial would describe a curve with one bend; it could be either convex or concave. A second-degree polynomial could approximate the exponential or geometric curve, for example. A third-degree polynomial would describe a curve that has two bends and could be used to approximate the Gompertz and logistic curves. A fourth-degree polynomial curve has three bends, and so on.

The polynomial curve is less rigid in its form than any of the previously described models. Therefore, it can describe more accurately less regular growth patterns, and even patterns that include both decline and growth. That is, the polynomial need not assume monotonically increasing or decreasing population as do the other five model forms.

Summary of Trend Extrapolation. This section has been devoted to simple techniques for projecting population sizes into the future using only data on past total population size. Population size is always a function of time in these techniques. Time is the proxy variable that encompasses the many factors that influence change in population size. All the techniques fit a model to data describing the historical association between

time and population size. They vary, of course, in the presumed shape of this association.

For the graphed models as well as the mathematical models, it is assumed that the better the fit of the mathematical function of the curve on a graph to historical data (i.e., the better the fit to the empirical evidence), the better the model has captured the effects of the underlying forces. In the linear, the geometric and the modified exponential models, the assumption is that the balance of basic demographic forces that held sway in the past will continue in the same balance into the future. The Gompertz and logistic curve models, on the other hand, assume that past growth trends probably cannot hold indefinitely and that the shape of the future association will reflect the influence of an upper limit on population growth. The graphic models' extensions into future time are based on judgment and therefore may or may not reflect changes from the past association between time and population size.

The basic problem with all trend extrapolation models is that in no way are underlying causal forces identified or measured. That historical data can be fitted by an extrapolation model implies only that the model has been able to summarize the net effect of many forces acting on population for the period of time for which the model is calibrated. Examination of the model reveals nothing about what forces molded the population change. What is described is an empirical regularity. The exclusive use of extrapolation models is justified only when there is lack of data and time to formulate better population projections models.

Other justification for using extrapolation models might occur under certain circumstances. If the analyst is interested primarily in the bottom line—total population—and he or she lacks time, data, or access to computer programs, such a "quick" technique might be justified. If the transportation study area shows very steady and slow rates of change in total population and only total population projection figures are needed for the transportation methodology contemplated, extrapolation techniques will do and the use of more elaborate methods is not justified. Another valid use of extrapolation of total population size is to provide a baseline projection under the assumption of continuation of past trends. Such a projection is useful for comparison with the results of more complex techniques. Even here, however, caution is advised. The assumptions allowed about the underlying forces of demographic change in extrapolation techniques, and the examination of the sensitivity of population size to those assumptions, are inferior to the assumptions allowed in the more complex techniques. In fact, the implicit assumptions may be at variance with the reality that the extrapolation model is attempting to reflect.

Component Analysis Method

Almost 30 years ago, Jacob S. Siegel, coauthor of today's most complete standard reference on demographic analysis methods (Shryock, et al. (*31, 32*), stated in an article on forecasting the population of small areas that "future research on methodology may most effectively be directed toward attacking the problem from a component point of view. . . . " (Siegel (*34*), p. 81.) At that time, he found that about 40 percent of the small area projections were prepared using a component analytic method. Today, component methods are the most widely used techniques for preparing regional population projections (Shryock, et al. (*32*), p. 456).

In population analysis, these techniques are called cohort-component methods. They are component methods because they analyze birth, death, and migration components of population change separately, and separately assign them parameters for projection. The total population projection is the sum of the several separate analyses and projected components. Moreover, populations and population change are disaggregated by age and sex, and sometimes race, in these methods, hence the cohort aspect.

The advantages of this method include the simplicity and directness with which assumptions may be varied and linked to demographic consequences. It can reflect the reality that each component not only is determined by different factors and may move in independent directions, but also has qualitatively different consequences for population change. Furthermore, because of the cohort aspect, the effects of the fact that rates of change of the fundamental demographic components vary by age (and even sex and race) also can be accounted for. Subtle, but significant, interactions between component change rates and the age structure of a population can be captured in this method, where they cannot in noncomponent methods.

The cohort-component method usually is considered to be the most complicated and sophisticated approach to projecting population. Indeed, there are many subtleties in the estimation of parameters and in the arithmetic calculations, but the method is relatively simple in concept, and the availability of computer programs makes its application less complicated. The component concept is shown in the expression:

$$P_1 = P_0 + B - D + NM$$

where:

P_0 = population of the study area at the beginning of some time period;
P_1 = population at the end of the period;
B = number of births during the period;
D = number of deaths during the period; and
NM = net migration: that is, the number of people who move into the study area (in-migrants) minus the number of people who move out of the area (out-migrants) during the time period.

In more elaborate, recent versions of the method, in-migrants and out-migrants are treated separately to reflect the fact that in reality they are separate streams, affected by separate factors. The Bureau of the Census has been working on such a "directional flow model" since 1966 and others have adapted versions of it (U.S. Bureau of the Census, *140*). (See also Morrison (*43*) for a discussion of the effect of use of net migration.)

In the simplest versions of the model, the single component of net natural increase may be substituted for the two separate components of births and deaths.

Whether the method uses two, three, or four components, there are different techniques for projecting each component into the future and, of course, assumptions must be specified separately for each component. In fact, the techniques of extrapolation and ratios often are applied, based on historical data and often modified by judgment. After specification of the assumptions and projection of the rates of change in the components, the cohort-component method is simply a logical

simulation of the aging, dying, fertility, and residential mobility processes. If there are no errors in the assumptions and in the basic historical data on which the component rates are calibrated, the population should be exactly as projected. The technique itself is true-to-life and logically correct and produces correct projections, *providing the assumptions hold true.*

Projecting the three component rates of change is the essential task in applying the cohort-component method. In order of increased difficulty of projection are mortality, fertility, and migration.

Mortality is the most stable component, assuming no war or famine or other local catastrophe. It varies less from study area to study area as a ratio of the national or state mortality rate, and therefore is the most easily projected. In fact, some cohort-survival projection programs build the mortality rates into the logical structure, so that the analyst is not even expected to provide these rates as input. For a detailed discussion of mortality analysis, see Irwin (*17*), pp. 17–19; Pittenger (*25*), Ch. 6; Shryock, et al. (*32*), pp. 444–445.

Fertility fluctuates more widely and irregularly over time and between geographic areas. It is, therefore, less easy to project. Nevertheless, there are projections of fertility at the national level, and sometimes at the state level, which can be used. Care must be taken, in making projections of fertility for a study area, to account for the changing nature of the population over the projection period. For example, a suburban or other fringe area may be changing from a generally rural population (with usually higher fertility rates) to a more urban-suburban population (with usually lower fertility rates, depending on the age structure of that study area, which may in turn depend on whether it is a suburb characterized by higher income and older population or a suburb of lower income and younger families). Of course, this same danger is true for projection of mortality rates but to a lesser degree. Discussions of the task of estimating fertility rates can be found in Irwin (*17*), pp. 16–17; Pittenger (*25*), Ch. 7; Shryock (*32*), pp. 445–452.

Migration is the component posing the most difficult projection task, by far, in small area population projection. The smaller the area, the greater the problem. Nationally, over 15 percent of the population will change county of residence in a 5-year period, the time period on which most cohort-component projection methods are based. In swiftly growing areas, an even greater proportion of the population may be involved. Not only is migration likely to involve a substantial proportion of the population, it also is more volatile than the other two components, and therefore more difficult to project. Furthermore, it is likely to differ greatly among various age groups, and frequently is negative for some age groups while positive for others. In spite of its critical role in projection for areas the size of transportation study areas, migration receives little attention from demographers. Methods for estimating migration, especially net migration, can be found in Irwin (*17*), pp. 19–23 and App. H; Pittenger (*25*), Ch. 8; and Shryock et al. (*32*), pp. 456–459.

Making the task of projecting components even more difficult is the fact that the cohort-component method requires (generally) that the fertility, mortality, and migration rates be age-specific and (usually) sex-specific. That is, each rate must be projected for each 5-year age group of each sex (0–4 years of age, 5–9, 10–14, and so on). Usually there are seventeen such cohorts, the last 85 and older. For example, the cohort aged 10–14 in 1980 is projected to 1985 by applying 10–14 age-specific survival and migration rates, at which time that cohort is 15–19 years of age. The cohort is projected another 5 years forward to 1990 by applying 15–19 age-specific rates of survival and migration, again aging the cohort so that it is 20–24 years of age in 1990. Longer term projections are made in these 5-year steps (sometimes 10-year steps) until the horizon projection date is reached. Births are projected for each 5-year projection period by applying age-specific 5-year birth rates to the population of women in their child-bearing years, usually assumed to be the cohorts between 15 and 44 years of age. These births are added together and then divided into males and females. With adjustments for mortality and migration for these births, the computation produces a cohort aged 0–4 at the end of the 5-year projection step.

Variations on the general cohort-component model are found. Hamilton and Perry (*13*) offer a simplified technique. The Bureau of the Census (*140*) outlines a methodology using in-and-out migration which permits more detailed analysis of causation.

The cohort-component method is preferred by most demographers as the best approach to projection, other factors being equal. That is, if the necessary data are available and the analyst has confidence in them and enough time (and a computer program), the cohort-component method is preferred. For one thing, it provides age-sex specific projections. These may be used in conjunction with age-specific participation rates to generate more sensitive projections of such variables as car ownership. Even if the age-sex specific cohorts simply are added to obtain total population, the analyst knows that the subtle effects of the age-sex distribution through the projection period have been accounted for in a way impossible to achieve by other methods.

Independent Techniques—Economic Projections

As was the case with population projections, instances may occur in which the analyst does not wish to use ratio techniques for projection of economic variables. The study area may be different from the parent area or ratio techniques may be inappropriate.

There are both differences and parallels between demographic and economic techniques (in addition to the obvious difference in the variables to which they are applied).

Trend extrapolation may be applied to economic data just as it is to population data. The previous section on trend extrapolation for population projection describes linear and a variety of nonlinear curves that may be fit using historical data. (Of course the alternative, manual graphic fitting, also is parallel.)

That section points out that extrapolation techniques may be applied to total population or to cohorts or special subgroups of the total. Similarly, economic variables such as employment, income, or labor force participation may be extrapolated in total (or average, etc.) or for subgroups.

Although a parallel to the cohort-components technique outlined for population might be drawn for, say, employment (i.e., rates analogous to birth and mortality for persons entering or leaving the labor force, rates analogous to migration for other changes in the labor pool, additional rates for participation, etc.), no standard technique is available, even though the logic is followed in principle.

Tri-State Regional Planning Commission (*162*) is an example

of a trend analysis and projection of employment. Southwestern Pennsylvania Regional Planning Commission (*181*) illustrates projection (of both absolute values and local shares of state) using regression techniques and a variety of models.

Therefore, keeping in mind that extrapolation techniques are equally applicable to economic projection as to demographic, this section begins with a review of economic base analysis and continues with a discussion of multiplier and input-output techniques. The section concludes with discussion of econometric models that are quite complex and data-demanding. If the taxonomy were followed strictly, econometric models would fall in the subsequent section describing joint models. However, the fact that their emphasis is on economic variables and that their treatment of population varies widely leads to their inclusion here. (They also are not necessarily "independent": parent area-local area ratios or miltipliers are used extensively.)

As a final general note, it should be recognized that many of the techniques described next do not project employment *per se*. Instead they project economic activity in terms of production, roles, value added, or some other monetary measure of activity. This leaves to the transportation anlayst the problem of translating that activity into employment (or income). Perhaps the simplest way is to determine a ratio between current values of the projected measure and current employment. That ratio then may be used "as is" or if there is reason to do so, it may be changed to reflect projected or anticipated trends. (See following section on "Conversion of Population and Employment Projections Into Transportation-Related Socioeconomic Characteristics.")

Economic Base Analysis

The projection (or forecasting) of local economic activity through analysis of the "economic base" of an area—an "economic base study"—was perhaps the first true analytical projection methodology.

As pointed out earlier, it shares, with other projection methodologies, the concept of two types of economic activity: one serving a larger area, outside the boundaries of the study area; the other serving the needs of the study area itself. The former are "basic" or "primary," and the latter are "nonbasic," "service," "local," or "secondary." Growth of local population, employment, and other characteristics is presumed to be related to "basic" growth in either a constant basic/nonbasic ratio or in a predictably changing ratio, over time.

Isard (*18*), p. 190 ff) describes the technique and illustrates it briefly.

> The economic base type of analysis distinguishes between basic (primary) industry and service (non-basic or residential) industry. This distinction is in keeping with a promise that has been increasingly taken as a point of departure for regional study. This premise states that the reason for the existence and growth of a region—whether it is a community or a small resource area at one extreme or a huge metropolitan or resource region at the other extreme—lies in the goods and services it produces locally but sells beyond its borders. These "basic" activities not only provide the means of payment for raw materials, food, and manufactured products which the region cannot produce itself but also support the "service" activities, which are principally local in productive scope and market areas.
>
> It was not until the late 1930's that attempts were made to measure quantitatively the basic and service components of individual urban or regional economies. Homer Hoyt developed the idea of a "basic-service ratio". This ratio purports to describe either (1) the proportion between *total* employment in a city's basic or export activities and *total* employment in its service or local activities; or (2) the proportion between the *increase* in employment in a city's basic or export activities and the *increase* in its service or local activities. From the data required to compute this basic-service ratio, a regional multiplier is easily calculated. This multiplier is equal to total (or increase in) employment in both basic and service activities divided by total (or increase in) basic employment.
>
> For example, we present in Table [21] a relevant classification of the data required for the calculation of basic-service ratios and regional multipliers for the city of Wichita, Kansas. The unit of measurement is employment. Total employment for years 1940 and 1950 is listed in the first two columns, by industry. For each industry the total figure is broken into two parts. That part which produces for and caters to the local market is classified as *service* activity and is noted in the middle two columns of Table [21]. That part which produces for (is oriented to) the regional, national, and world markets is classified as *basic* and is noted in the last two columns.
>
> From the materials of Table [21] we may calculate both basic-service ratios and regional employment multipliers. In Table [21] the basic-service ratios are calculated on the basis of total employment in 1940, total employment in 1950, and change in employment in 1940–1950. The corresponding regional employment mutlipliers are simply the ratio of the total employment to basic employment (or change in total employment to change in basic employment), that is, unity plus the basic-service ratio. It is to be noted that different ratios and multipliers obtain, depending on both the selected key year and the method of computation. That method based on *change* in employment is generally considered to yield the more relevant results, although it is generally recognized that the type of computation employed should depend on the nature and purpose of a particular study.
>
> Some analysts have made extensive use of the employment multiplier concept for projection purposes. By evaluating future prospects of expansion in the *basic* activities of the cities and regions they study, and then applying the employment multipliers derived from the basic-service ratios relating to existing industrial composition, they have forecast future expansions in *total* employment. By the use of employment-to-population ratios, these forecasts are often extended to include the future population that could be supported by the total future employment opportunities.
>
> Other analysts have been more cautious about employing the multiplier concept. Many urban and regional economic base studies have had the more limited objective of an improved understanding of the economic composition of the city or region and of its relation with other cities and regions.
>
> Whether the basic-service ratio (already designated in the literature by several different terms) and the associated "simple" regional multiplier are employed for description alone, or are adapted for projection and prediction purposes, numerous limitations are involved in their use. These limitations are both technical and conceptual. (Isard (*18*) pp. 190–193)

Pfouts (*81*) collects a number of papers that describe the economic base study and its history and address is limitations.

Andrews (in Pfouts, *81*), in a series of eight papers originally published in *Land Economics*, addresses what might be termed practical problems of application of economic base analysis. These range from terminology, at one extreme, through measurement and classificaton of basic and nonbasic activities to area delimitation and the relationship of economic analysis to planning.

Other papers address empirical and theoretical limitations. Pfouts (*81*, p. 325 ff) concludes that the theoretical content of the methodology is insufficient to support its use in projection.

The material below, evaluating various techniques, addresses these limitations more specifically.

Table 21(a).*

Regional Cycle and Multiplier Analysis
Wichita Employment, 1940 and 1950, Classified by the Type of Market Served

	Employment		Market Served: Local (Service)		Market Served: Regional, National, and World (Basic)	
	1940	1950	1940	1950	1940	1950
Total	52,091	88,575	37,148	59,325	14,943	29,250
Agriculture	4,074	3,276	1,109	1,442	2,965	1,834
Total non-agricultural	48,017	85,299	36,039	57,883	11,978	27,416
Mining	925	971	50	71	875	900
Construction	2,837	7,297	2,837	7,297	-	-
Manufacturing	8,692	23,931	2,705	4,605	5,987	19,326
Food and kindred products	2,624	3,243	1,232	1,193	1,392	2,050
Textile mill products	16	53	16	53	-	-
Apparel	146	205	-	-	146	205
Furniture	135	459	135	459	-	-
Printing	1,208	1,714	686	1,200	522	514
Chemicals	172	242	-	-	172	242
Petroleum	572	548	-	-	572	548
Metals	985	1,973	-	-	985	1,973
Machinery	637	1,857	-	-	637	1,857
Transportation equipment	1,561	11,937	-	-	1,561	11,937
Other manufacturing	636	1,700	636	1,700	-	-
Transportation, communications, public utilities	4,473	6,833	3,752	5,576	721	1,257
Wholesale trade	3,003	4,616	1,498	2,774	1,505	1,842
Retail trade	10,216	16,542	8,617	14,509	1,599	2,033
Finance, insurance, and real estate	3,115	4,118	2,729	3,447	386	671
Service	12,105	16,711	11,200	15,324	905	1,387
Public administration	1,765	3,437	1,765	3,437	-	-
Industry not reported	886	843	886	843	-	-

Table 21(b).*

Basic-Service Ratios and Multipliers, Wichita

	Basic-Service Ratio	Regional Employment Multiplier
1. Based on total employment: 1940	$\frac{14,943}{37,148}$ = 1:2.5	3.25
2. Based on total employment: 1950	$\frac{29,250}{59,325}$ = 1:2.0	3.0
3. Based on change in employment: 1940-1950	$\frac{14,307}{22,177}$ = 1:1.6	2.6

* Tables from Isard (15), pp. 191-192.

Multipliers

In the middle 1950's the economic base study approach was analyzed carefully in a series of articles by Andrews, which were mentioned above. Shortly following publication of Andrews's series, theoretically critical articles by Blumenfeld, Tiebout, Ferguson, and Pfouts (all reprinted in Pfouts, *81*) appeared. In addition to criticism of the economic base study (which is summarized below in the evaluation of various techniques), Pfouts and Tiebout, particularly, pointed the way to the application of more traditional economic theory to the analysis of urban economic activity.

The ultimate concept is the income multiplier.

If we let E designate exports and I designate imports then the balance of trade is indicated by

(1) $B = E - 1$

We assume that the quantity of imports into the community depends on income within the community; that is

$I = F(Y)$,

where Y stands for income. To consider a specific case we assume

(2) $I = e + fY$,

here lower case letters indicate constants. Hence in this case the "marginal propensity to import" or the change in imports following a change in income is a constant, i.e.,

(3) $\frac{dI}{dY} = f.$

We also assume that consumption expenditure depends on income. Thus we assume a consumption function for the community,

(4) $C = a + bY.$

Then the marginal propensity to consume within the community is

$$(5)\ \frac{dC}{dY} = b.$$

It is clear that both f and b are positive fractions, i.e.,

$$0 < f, b < 1.$$

We shall now turn our attention to a consideration of what happens to the income stream of the community when "new money" enters the community because exports are larger than imports. As such money represented by B in (1) comes into the community it represents income to the members of the community who receive it. But these members of the community will spend part of the money within the community, part they will spend for imports and part they will save. The proportion of this income that remains within the community is given by $1 - f$. Hence we must multiply B by $1 - f$ in this round of spending to take into account the effects of importing. (If f is the marginal propensity to import, $1 - f$ is the marginal propensity to spend money within the community.) Similarly, to take the effects of savings into account we must multiply by b. Thus after this round of spending the money left in the community income stream is $B(1 - f)b(1 - f)b$ or $B[(1 - f)b]$.[2] For each subsequent round of spending we must multiply by $(1 - f)b$. Thus the change in income within the community is shown by

$$(6)\ dY = B + B(1 - f) + B[(1 - f)b]^2 + B[(1 - f)b]^3 + \ldots + B[(1 - f)b]^n$$

This last equation exhibits a geometric progression and the sum is given by

$$(7)\ dY = B\frac{1}{1 - (1 - f)b} = \frac{B}{1 - b + bf} = kB$$

In equation (7) the expression $\frac{1}{1 - b + bf}$ is a community income multiplier similar to the multiplier $\frac{1}{1 - b}$ for a closed system. The multiplier will be larger than one if both b and f are positive fractions. The multiplier is larger for a larger value of b, the marginal propensity to consume, than for a smaller value b. The numerical value f, the marginal propensity to import, works in the opposite direction. That is, a large marginal propensity to import causes a lower net addition to the community income stream.

For purposes of illustration suppose $b = .8$ and $f = .3$. Then $k = 2.3$. Hence the circulation of money within the community increases the original injection of money by a factor of 2.3 or by 130%. As a consequence, it seems incorrect to emphasize exporting industries to the exclusion of industry that causes the circulation of money within the community. If b increases to .9 while f remains fixed at .3, k becomes 2.7, and the injection of income is expanded by a larger amount than formerly due to a decrease in savings. If b is .8 and f increases to .4 then k falls to 1.92 and due to the increase in imports an injection of income is not expanded by as large an amount as in the first example. Thus it may be seen that income generation within the community, imports and consumption (or savings) are important "city builders" as well as exports.

In the model outlined above, exports, the important manifestation of basic industry, are one of three variables taken into account. Imports and savings, the chief ways for income to leak from the community, are also given a place in the community income picture. Hence it can be contended that even this simple model gives a better picture of urban income generation than does the economic base theory.

If B is negative, that is if imports exceed exports, the multiplier works in reverse. In this case, dY will be a contraction in income, and will be larger in absolute amount than B. This observation cannot be taken as evidence that the economic base theory is sound, because a negative value of B depends on the relative size of imports and exports, and the multiplier effect depends on savings and imports. (Pfouts (*81*), pp. 302–305)

Pfouts' point is that simple models of a local economy, based solely on the relationship between exports and imports, or on the proportion of exports in total local production, overlook the important function of circulation of money within the local economy and of savings. He concludes not by offering specific alternatives but by suggesting further empirical research to verify and extend the framework described above. More recent developments in modeling of local economies are described in the following sections.

Combined Trend Projection-Economic Base

The Bureau of Labor Statistics (BLS) has developed and maintains a set of employment-occupation projection models that rely primarily on trend projection or shift-share techniques. The models and data are contained in a software system (Data Analysis System for Industry Employment: DASIE) which is made available to State Employment Security Agencies (SESA's) for use in projecting occupational employment needs to support federally sponsored training programs. The first step in the BLS process, regardless of the specific technique used, is projection of employment.

A recent research project, sponsored by the Department of Labor, has resulted in an improved version of the techniques included in the DASIE system (Goldstein, *195*). This improved version uses a combination of segregation of industry into four major groups and the fitting of linear models to historic data for employment by SIC category. The independent variables in the original model, time and national employment by industry, are supplemented and/or replaced by "local" variables. "Local" in this instance refers to variables for the geographic area for which the projection is being made (a labor market area, for example) or for a level between the area of interest and the national level (for example, the state level when a labor market area is being projected).

Preliminary results of the use of the technique have been encouraging. Equations have been fit with data from time $t-2$ to $t-1$, then used to project for the period $t-1$ to t with high correlation coefficients and good statistical reliability.

From the point of view of the transportation planner, the technique offers a simple, understandable and straightforward methodology. The use of the methodology is particularly simple if one's State Employment Security Agency is willing to offer assistance. The simplicity of the technique and the availability of data (below) make the technique a good candidate for use regardless. (See "Data Sources for Projection," below.)

It should be noted that the occupation-employment technique is oriented to short-term projections and forecasts; nominally, approximately 2 years and, at most, 5 years. This is not inherent in the implementation of the technique. The calculations may be made for any period of time. Rather, it is a recognition of the error implicit in trend projection, with confidence declining for longer periods, and the short period of time normally used in fitting the equations used in the model.

Input-Output Techniques

Isard pioneered in the adaptation of the input-output technique, originated by Leontief, to regional and interregional anal-

ysis. Although other earlier publications describe initial development, the section of *Methods of Regional Analysis,* "Inter-regional and Regional Input-Output Techniques" (Isard,*18*) is a succinct, thorough reference. (See also Stevens (*82*) for a transportation-related discussion.)

Tiebout (Pfouts (*81*), p. 395 ff) also describes the basic model:

> The conceptual framework of an open, static input-output model is given by Leontief. The accounting balance equation is given as:
>
> $$(1.1) \qquad X_i - \sum_{k=1}^{m} x_{ik} = Y_i$$
>
> Here X represents the total output of industry i. x_{ik} gives the amount of i products absorbed by industry k. Given the number of industries 1,2 . . . , m; equation (1.1) yields the amount of i products going to final demand, that is to Y_i.
>
> The structural equations are given by the production coefficients for each industry,
>
> $$(1.2) \qquad x_{ik} = a_{ik}X_k \quad i = 1,2, \ldots, m. \quad i = 1,2, \ldots, m.$$
>
> where a_{ik} is the production coefficient indicating the amount of i needed to produce a unit of k. Substituting (1.2) in (1.1) yields:
>
> $$(1.3) \qquad X_i - \sum_{k=1}^{m} a_{ik}X_k = Y_i$$
>
> This system of linear equations may be solved for X_i if a bill of final demands, $Y_1, Y_2 \ldots, Y_m$ is known.
>
> Regional models have the effect of adding another dimension to national models, namely the regions are identified. X_i becomes ${}_rX_i$, which represents the total output X, of industry i, in region r. Here ${}_{rs}X_{ij}$ represents the flow from industry i in region r to industry j in region s. If the number of regions r, s = 1,2, . . . n is known, the interregional model takes the form,
>
> $$(2.1) \qquad {}_rX_i - \sum_{s=1}^{n} \sum_{j=1}^{m} {}_{rs}x_{ij} = {}_ry_i \quad j = 1,2, \ldots, m.$$
>
> In this equation ${}_ry_i$ represents the final demand for the products of industry i in region r. Production coefficients are given as
>
> $$(2.2) \qquad \frac{{}_{rs}X_{ij}}{{}_rX_i} = {}_{rs}a_{ij}$$
>
> (2.2) states that the inputs from industry i in region r to industry j in region s are some proportion of the total production, X, of good j in region s. (Note that the production coefficient now has a spatial as well as a technical component.)
>
> Total output for the whole system of regions and industries may be determined by substituting (2.2) and (2.1) and solving for ${}_rX_i$. This is the same process as used in equations (1.1), (1.2) and (1.3). Four further considerations apply to regional models.
>
> (1) Not all of the sub-boxes come into inter-regional trade, i.e., possibly, ${}_{rs}x_{ik} = 0$. Such industries as barber shops do not enter interregional trade.
>
> (2) Regional models, like their national counterpart, may be open or closed. Here, however, a greater variety of alternatives exist. Models may be open regionally; for example, households within the region may be part of final demand. Models may also be closed regionally, eg., households are endogenous. Either of these two possibilities may be combined within a national model which, in turn, may be either open or closed.
>
> (3) Another characteristic of regional models is that they may or may not assume technological equivalence. That is to say, the production coefficients, equation (2.2), may be assumed the same throughout the nation or they may vary from region to region.
>
> (4) The final point concerning regional models is that the balance of regional payments equilibrium may be considered. Not all models are concerned with this condition.
>
> Yet the major item to note is that equations (2.1) and (2.2) merely add a spatial component to national models. This is important. National models have limitations of their own. Any limitations placed on national models also apply with equal force to regional models. Above and beyond these limitations, regional models have limitations of their own.

The relationship to the economic base and multiplier techniques described earlier should be clear. Here the initial table relates each industry sector to each other sector in a ratio of input to output and includes too the relationship to final demand, either inside the region or outside (i.e., the export required). Presumably, the effect of an internal change, say an increase in some particular activity, may be estimated through a rebalancing of the matrix. Alternatively, the effect of an increase in final demand (either for internal consumption or for export) may be reflected as it reverberates through the local economy.

The analogy to the assumptions of economic base and multiplier techniques remains. The increased detail and sophistication in computation simply permit a (presumably) more accurate and realistic accounting.

Econometric Models

Econometric or "full specification" models of the economy have developed over the last 15 to 20 years, certainly in part because of the availability of large-scale computers which permitted economists to express the complex relationships involved and to cope with the large quantities of data.

It is impossible to review these models adequately here. Instead, recent publications, which emerged from conferences on regional economic modeling, are suggested as references. Adams and Glickman (*68*); Stevens (*83*); Bolton (*70*); Ballard and Wendling (*69*); Harris (*75*); Milne, Glickman and Adams (*78*); and Treyz (*85*)).

Bolton (*70*) provides a review of multiregional models and the current "state of the art." His "model-of-a-model" illustration, reproduced here as Figure 5, provides a convenient referent for a discussion of the components of most current models.

As a further note before turning to Bolton's description of econometric models, it should be recognized that there is considerable variation within the general group. For example, one type of multiregional econometric model is called "bottom-up," another "top-down," and many are a mixture. Top-down models begin with national projections (sometimes produced by the model, sometimes from other sources). The model itself then allocates or estimates variables to regions while maintaining national totals or averages.

The bottom-up approach does just the opposite: the model is operated for regions, and national totals or averages emerge at the end.

Of course, rarely is a given model purely one or the other. Turning to Bolton's "model-of-a-model" and using his circled numbers to identify particular links, the first element is the National Model. (Note that Bolton refers to the other four papers cited above: "Harris," "Treyz," and "BW" (Ballard and Wendling) and "MGA" (Milne, Glickman and Adams.)

Figure [5] will help focus discussion on both common features and differences. It shows the main elements of the structure of all multiregional models, and, for that matter, single-region models. The figure applies to each region in a multi-regional model. In most models there is extensive interdependence among regions; that is true of all four reported here. However, that is not shown in the figure.

Each rectangle represents a "block" or group of equations, and the arrows connecting them show causation (sometimes simultaneous, sometimes recursive). In the figure we assume a top-down approach, so there are no flows from the region back up to the exogenous national model; for a bottom-up model, there would be arrows going up from regional blocks and the national model would be an endogenous part of the whole.

In the rest of this section I shall discuss some of the most important blocks, but I do not attempt to cover all of them or all the connecting lines in detail. My goal is to give illustrative examples of common features and differences.

National Models

A variety of national models can be used to "drive" the regional models in the top-down approach; a builder's choice is sometimes affected by institutional affiliation. To be useful, a national model must produce fairly detailed values of industry outputs or employment. In some cases, aggregate demand components are also useful (consumption, investment, defense demand, etc.) because a region's share of some industry's output may depend on the composition of demand (e.g., a state's aircraft industry may be more oriented to civilian aircraft production than to military). BW have their own national model in a bottom-up approach; their paper gives relatively few details on it, but noteworthy is its apparent smaller size compared to the others. MGA use the Wharton model and Harris the INFORUM model. Treyz's design is consistent with a variety of national models.

Figure [5] shows three kinds of industries in the region. Export industries sell exclusively outside the regional or enough so that the region's own market can be ignored; local industries sell exclusively or almost so to the region's own market; mixed industries sell to both markets. In recent models, a very large number of industries are mixed, thus departing significantly from a now outdated rigid separation into "export" and "local" industries. In principle, all industries in the Treyz, Harris, and BW models are mixed, although naturally the relative importance of extraregional demand varies greatly from industry to industry and region to region. Only MGA divide all industries into export or local (their terminology is "exposed" and "sheltered").

In the rest of the discussion, I refer to the linkages between blocks by the numbers on the lines in the Figure [5].

Link 1

The usual explanatory variables in this link are national industry output, relative (to the nation) factor costs, and transportation costs or other measure of "access." Another possibility is capacity utilization in the national industry; some older regions' industries are known to be "marginal" capacity from the viewpoint of their national counterparts. Utilization of this capacity varies more over the business cycle than the national rate. National utilization rate is not used in the models here, but it is a prominent feature of a leading commercial model, that of Chase Econometrics.

Each model has at least one unique feature in this link, which is not found in the others and, in many cases, not in the typical single-region model either. In addition, there are substantial differences among the models in the treatment of transportation costs and in the reliance on a priori knowledge of structure.

Harris is unique in his treatment of transportation costs; he uses a linear programming model of an optimal transportation system to determine shadow transportation prices. This routine is the simultaneous part of the model; in other respects the model is recursive. Harris includes the transportation costs along with relative labor and land prices in determining "location rent" for an industry in a region; he then assumes that a region in which an industry earns high location rents will gradually increase its share of that industry's output.

BW, on the other hand, rely on the very traditional gravity approach in which an industry's output in a region depends on its potential: this is the sum of incomes or outputs in all other

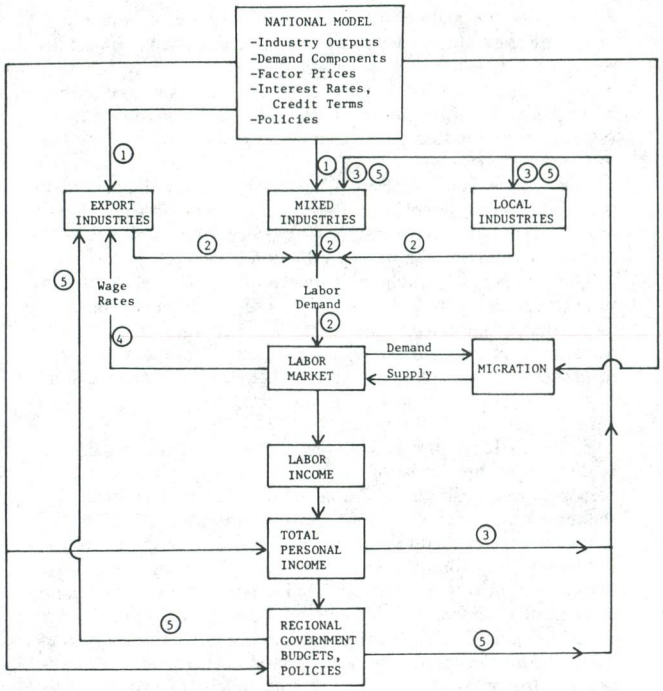


Figure 5. Model of a model. (Source: Bolton (70) p. 134)

regions, weighted by distance with an elasticity of -1. In many cases, outputs in all regions affect output in any one, so all regions must be determined simultaneously. MGA have the simplest formulation, in which a region's share in an industry depends on the relative costs of labor and energy. The novel twist is a logit relationship. Treyz's link is actually combined with his link 2, so I postpone discussion of it.

Harris and Treyz are notable in having *investment* as a separate variable. Harris's explicit handling of investment makes his approach very unusual among the current models. Investment in an industry is a function of output and changes in output. In turn, investment has several effects on other variables. First, investment demand for a product is one component of demand and thus enters into the linear programming submodel. Second, lagged equipment purchases have a positive effect on a region's share of an industry's output; high recent investment is a proxy for newer capital stock. Third, lagged equipment purchases affect the *response of employment to output* (positively in some industries, negatively in others). Finally, lagged equipment purchases affect wage rates in an industry (again, with varying sign).

In Treyz's model, investment is determined by an optimal capital stock adjustment process just as labor demand is determined from an optimal adjustment process, with an explicit production function, demands for output, and relative factor prices (see below). Treyz's present design requires data on capital stock in each industry in each state, which will undoubtedly prove an obstacle to early implementation of the design.

Link 2

This is the labor demand linkage. In all the models, there is at least implicitly a production function and optimal labor usage. MGA use a CES function, so labor demand depends on output and wage rate relative to product price; the lagged dependent variable reflects a gradual adjustment process. BW use output and a national productivity variable to reflect labor-saving technology, but not the wage rate. Harris does not use wages either, but rather change in output, lagged output, and lagged investment.

As mentioned earlier, Treyz combines links 1 and 2. The specification is extremely complicated, but is basically as follows. A region's share of an industry is determined by its transportation

and relative production costs. The production cost is assumed to be the cost achieved by firms minimizing costs subject to regional factor prices and the parameters of a production function which is identical in all regions. Once a region's share of output is determined, its employment depends on the *national labor intensity* in that industry, and the region's labor intensity *relative* to the nation.

The national labor intensity is known from the national model; the relative labor intensity in the region is assumed to be determined by the same cost-minimizing process and uniform production function as the total production cost.

Thus, Treyz's formulation is marked by heavy reliance on a priori specification of technology. The only roles for econometric estimation of parameters are in the lag structure of firms' adjustment to changes in minimum-cost input combinations and in the sensitivity of each region's market shares in other regions to transportation and relative production costs.

Link 3

Except in Treyz, this is relatively routine, in that local income is directly or indirectly of major importance. MGA use *only* personal income, another example of how their model is definitely the most traditional of the four. Harris again uses relative factor costs, but transportation costs are not relevant for some services industries. Treyz departs most from tradition, for he makes little distinction between local and other industries; he uses the same complicated relative cost and relative labor intensity framework for all industries. It is true that he does not enter transportation costs into the equations for some services. However, a region's relative production cost does affect how much of its own market it supplies from its own production, as opposed to imports. Thus no region has a completely sheltered market.

Labor Market

A labor market submodel is crucial in a good econometric model. It "balances" supply and demand and thus distinguishes an econometric model from both a simpler economic base model and an elaborate input-output model. Wage rates or other variables affect regional competitiveness in product markets (link 4). Employment and wage rates from the submodel also determine the wage bill, the major part of personal income, which is an important variable in itself and also affects final demands for local and mixed industries (link 3).

I have already discussed labor demand. A good model will also make labor supply endogenous, through net migration and/or labor force participation. Unfortunately, BW are not as informative on this as we would like, and the other two operational models are relatively simple. Treyz, however, introduces many important new elements from basic theory.

In MGA the unemployment rate is a function of change in employment, and itself lagged (absolutely and also relative to the national rate). It is then relevant for wage rates, which are endogenous. However, labor *supply* does not affect the unemployment rate, because while migration is *affected by* wage rates and unemployment rates, it does not *affect them.* The same is true in Harris; wage rates affect supply, but not vice versa.

In Treyz, on the other hand, the wage rate and unemployment rate help balance the labor market by affecting both demand and supply. The formulation is extremely complex and relies on a number of concepts, such as labor force surplus or deficit and the number of available trained workers, not yet found in other models. Treyz makes the migration flow between each state and *every other* state endogenous, a truly substantial departure from previous practice. He plans to rely on the Continuous Work History Sample of the Social Security Administration. One can predict that in time other models will use this important data source.

All four models have a feedback from the labor market to regional competitiveness, although in BW and MGA it is not relevant in every industry and state.

Link 5

This link from regional government policy to competitiveness is important in view of debates on how tax and spending policies affect industrial location and migration. Only Treyz has a direct link. In his model, regional government spending is a function of income and demographic variables, employment conditions, and Federal aid. Tax *rates* are then assumed to be high enough to raise the required revenue. The tax *structure* (degree of reliance on different kinds of taxes) is an exogenous policy handle. The resulting tax rates affect production costs and cost of living in a state.

Public investment in "infrastructure," which is often an explicit policy, appears to affect regional costs only if it lowers transportation costs, and that only in Harris and Treyz.

Clearly, the group of econometric models, of which this description is an example, are simultaneously the most sophisticated technically and theoretically and also the most demanding in terms of resources. As will be seen in Chapter Four, many agencies rely on projections made by others using models similar to these, but only rarely attempt to mount their own full econometric projection technique.

Conversion of Population and Employment Projections into Transportation-Related Socioeconomic Characteristics (References used for this section include: Siegel (*34*); Irwin (*17*), p. 15; Shryock (*32*), p. 464; Munson (*56*), pp. 46 ff; Bogue (*6*))

The majority of the techniques and models discussed in the earlier sections provide:

- Projections of population, generally by age and sex cohorts and, in some instances, by race.
- Projections of employment, generally according to some level of SIC code (which in most instances is at a level of detail greater than that needed for transportation planning).

Although the earlier discussion of the sensitivity of trip generation and other models in the simulation process emphasized population and employment, it is clear that (1) other, more detailed characteristics enter one or more of the models (i.e., household size, household auto ownership) and (2) interrelationships between or among the variables are important (i.e., a joint distribution of households by size and number of autos owned).

The first requirement, projection of "secondary" variables given the basic projections of population and employment, is discussed, followed by a review of methods for establishing joint distributions.

Projection of Additional Variables

Most conversion techniques consist of the application of participation rates, ratios and/or proportions in a systematic manner to projected population and/or employment levels. (Some demographers seem to make subtle distinctions between rates, ratios and proportions, which may or may not be appropriate for purposes of transportation planning: (1) The term, *rate,* measures *incidence* of events among a population, e.g., rates of household headship among age-sex specific groups. (2) A *ratio* measures prevalence of some status among the population or prevalence of a characteristic related to the population level; e.g., a car-to-household ratio. (3) *Proportion* measures the *composition* of the population, e.g., distribution of the number of households into household types.) That is, the projections of population or employment levels for a particular future year are multiplied by (or divided by) a parameter (rate, ratio, pro-

portion) that represents a linear relationship between the population or employment size and the socioeconomic characteristics in which the transportation planner is interested. The methodology is simple, although the arithmetic computations may become involved, tedious, and voluminous.

Sometimes a socioeconomic characteristic is obtained in one step by multiplying the population or employment level by the appropriate rate, ratio, or proportion. For others, it is more appropriate to make the conversion in several steps. For example, in the first step, a rate may be used to convert a population level to a number of households, which may then be proportioned to households of several types, which in turn would be converted to number of autos owned by multiplying the number of each type of household by the household type-specific car ownership rates.

The rate-ratio-proportion methodology may be applied either to total population levels or to age-sex-race-specific population groups as well as to a special population, such as military personnel or college students. It is desirable to use age-, sex-, race- or other group-specific populations if the socioeconomic characteristic (e.g., households) to be projected varies greatly by the available subgroup projections.

The method may be represented in equation form as follows:

$$S^t_a = P^t_a * {}_1r^t_a * {}_2r^t_a$$

where:

S^t_a = projected value of a socioeconomic characteristic at future time, t, for age-sex-race-other-specific group, a;

P^t_a = age-sex-race-other-specific population projection for year, t;

${}_ir^t_a$ = age-sex-race-other-specific rate, ratio or proportion, $i = 1$ to n such rates-ratios-proportions.

The value of the socioeconomic variable for the population as a whole is the sum of the values for all age-sex-race-other groups; i.e.,

$$S^t = \sum_a S^t_a$$

From this explanation of the conversion methodology, it becomes evident that the quality of the socioeconomic projections will depend on two sets of factors:

1. The quality of the projection of population or employment levels.
2. The quality of the projected rate-ratio-proportion parameters.

Errors in projection of population and employment levels are magnified by any errors in the rate-ratio-proportion parameters. They are further magnified if rates-ratios-proportions are used in series. That is, the conversion methodology represents a pyramiding of assumptions about the future. The greater the number of assumptions used in this multiplicative relationship, the greater the likely error (see Alonso, *1*).

Given a population or employment projection of reasonable quality, the obviously critical task in the conversion methodology is projecting the future values of the rate-ratio-proportion parameters. The techniques for projecting parameters are familiar ones: (1) extrapolation of past trends for the study area (adjusted for assumptions about important factors affecting the trend line in the future), (2) study area-to-parent area ratio projection based on available projections of the parameters for the parent area, (3) an historical analysis of the changes in ratio-rate-proportion in question relative to other socioeconomic characteristics (e.g., marital status) for which projections are available, or (4) borrowing rate-ratio-proportion values from an area representing the kind of population and economy toward which the study area is trending. The procedure may involve, under any of these four approaches, setting a terminal value for the rate-ratio-proportion parameter and perhaps several intermediate values at intermediate dates, and then interpolating values for the parameters for all other intervening years.

Just as it is important to obtain consultation of demographers and economists in making assumptions for projecting population and employment levels, so also is it important to obtain the advice of analysts who specialize in the data of the type being projected. Fortunately, as the conversions are for transportation planning, the operations get closer and closer to the transportation planner's own area of expertise.

There are several specific conversions that apply to transportation studies: conversions to households, to car ownership, and so forth.

Conversion from Population Levels to Households. Several approaches are commonly used. From least to most complex, they are:

Step 1. Develop a rate, ratio, or proportion that expresses in the base year the incidence, prevalence, or composition of the function or status in the total population or in some subclassification of the population.

Step 2. Multiply this rate, ratio, or proportion by a projection of the population or by an already converted projection that represents the subclassification to which the rates/ratios/proportions apply.

Step 3. Summarize the data by adding the various subgroups to arrive at the exact functional classifications desired.

Step 4. Repeat the above three steps for each interval of the projection period, with the following modifications:

Step 1. Develop a set of rates, ratios, or proportions that express, for some specified future year, the incidence, prevalence, or composition of the function or status in the total population or some subclassification of it.

Step 2. Identify the years for which a projection is desired. Interpolate the values of the rates/ratios/proportions to that year to get measures of incidence/prevalence/composition that refer to the specified year.

Figure 6 illustrates a worksheet for projecting households by age at some future date, t.

Establishment of Joint Distributions. Many of the techniques or methods for preparing projections (both those described in

Age	Female			Male		
	Projected population year t (perhaps in marital status i)	Age-specific household ratio (perhaps in marital status i)	Projected number households	Projected population year t (perhaps in marital status i)	Age-specific household ratio (perhaps in marital status i)	Projected number of households
Total.....						
10-14 years..						
15-19 years..						
20-24 years..						
25-29 years..						
30-34 years..						
35-39 years..						
40-44 years..						
45-49 years..						
50-54 years..						
55-59 years..						
60-64 years..						
65-69 years..						
70-74 years..						
75-79 years..						
80-84 years..						
85 and over..						

*Table adapted from Bogue (7): Table 1-10, p. 32

Figure 6. Worksheet for projecting households by age and sex at some future specified date.

earlier sections and variations and combinations encountered in practice) produce variables of interest such as mean household income or number of persons or auto ownership, or they produce numbers of households by classes or categories (zero-car, one-car, two-car households, etc.).

In either case, even given the best in projection methodology and computation, the transportation analyst is confronted with the need for joint distributions or cross-tabulations of the households using the variables of interest.

Two techniques have been encountered in reviewing agency practice: one which assumes the availability of mean values for the variables and one which assumes the availability of individual distributions and an earlier distribution.

Mean values known. Northeastern Ohio Areawide Coordinating Agency (*177*) (NOACA) provides an example in which typical distributions are established for auto ownership and persons per household, given mean values of each for an area.

The distributions were prepared by:

- Classifying household (home interview) records according to the known mean values for the area in which they were located.
- Preparing distributions of household characteristics for households associated with mean values (or ranges of mean values).
- Dividing the cell values in each resultant distribution by the number of households in the distribution, in effect producing a probability for each cell.
- Applying these to the total households in an area for which mean household size and auto ownership are known.

It should be noted that this technique in this application was used to establish values at the zone level. Its applicability at the level of a study area would depend on the availability of typical distributions for the mean values for the variables at the study area level. In turn, this would require independent data sources.

Similar methodology is described in North Carolina State Highway Commission (*115*); however, minor differences are notable.

Areas (zones) were categorized according to their attributes: mean household size, auto ownership, etc. Cross-tabulations (joint distributions) of all households within zones with similar attributes were prepared from interview data. In application, distributions were prepared first for household size. Each group by household size and zonal average income then was distributed by income category (yielding a joint distribution by income and household size: a 3 $\times$ 5 matrix). These 15 groups then were disaggregated into auto ownership groups.

The distributions were "smoothed" at each step, graphically.

The model is applied in the same sequence: given projections of population, households, and household income, appropriate tables are entered first to yield a size distribution, then an income distribution, and finally an autos-owned distribution. As with the NOACA technique, this technique is oriented to zone-level estimation. Rather than distributions of zones, distributions of larger areas would be required to apply the technique at the study area level.

Note too that both techniques assume that distributions observed in existing circumstances (i.e., the interview) will continue in the future.

Individual distributions known. The alternative circumstance in which individual distributions are known (marginals for the cross-tabulation) permits the use of iterative techniques for filling the cells. In effect, this is analogous to the problem of m equations in n unknowns, where n is greater than m.

For example, suppose a 2×2 matrix of auto ownership and family size is known for time t.

		Family Size		
		1-2	3+	
Autos Owned	0	2	3	5
	1+	7	10	17
		9	13	

For time $t + 1$, the marginal distributions are projected.

		Family Size		
		1-2	3+	
Autos Owned	0			12
	1+			48
		27	33	60

The problem is to fill the cells.

The technique is identical to the familiar (to transportation planners) Fratar method of trip distribution. (See any of several manuals describing the technique.)

The 2×2 case is trivial, but the effort involved in computation is considerable for larger cases. Available computer programs may be used, however (for example, FRATAR in the FHWA PLANPAC battery (*194*)).

Joint Demographic-Economic Projection Techniques

Almost all of the planning agencies contacted in the course of this project use some sort of technique for relating demographic and economic projections. These range from comparisons for consistency, to more formal incorporation of employment projection as a "driver" for migration models which relate to two directly. (See previous section on "Econometric Models.")

Other than the econometric models, however, each of these operates on the assumption that population change occurs in response to employment demand change. If the economic model forecasts increased employment, migration is assumed to occur to fill that demand. (In some cases, labor force participation rate shifts also are included.) Conversely, if employment is forecast to decline, outmigration is assumed to increase, unemployment to rise, and labor force participation to decline.

In the strict sense of the term model (that is, "if this happens, then that will occur"), these techniques are "joint" or linked models with population and economic submodels. However, they are not linked automatically (again, except in the case of some econometric models) and may be considered as separate models for all practical purposes.

Harris (*14, 15*) developed a complex model that included consideration of population change, household formation, and household status and income on a base of age-sex-race cohorts.

Although the relationships in the model are quite complex, in general it performs the following steps:

1. Persons, by age, sex, race, and status are "survived" into the next 5-year time period using a cohort-component model and fertility and mortality rates.
2. Using tables of rates, men and women (including newly eligible singles who have survived into the late 'teens and been separated from households) are associated into households using status as a guide to association.
3. Income is imputed from the status of the individuals associated in the households.
4. Households are maintained from period to period, but are dissolved as mortality rates are applied.

The last of the reports on the work (Harris, *15*) cites a number of potential improvements in the model. In correspondence (June 1980), Harris described some of the conceptual and practical difficulties:

> The model operates as if in a matriarchal society. From period to period track is kept only of mothers and their children living at home. Fathers are provided and families constituted by what might be called a computer dating arrangement. Track is kept of people by age, sex, and socio-economic status or income. The basic problem with this model is probably that it is somewhat awkward to deal with changes in income, fertility, and mortality status.
>
> . . . . There was a design decision which was made very early in the generation of this model which seemed rational at the time, but which probably precluded some other alternatives, one of which I will discuss below. We considered making use of a transition probability matrix, but considering the very large number of different types of households by age of two parents, size, number of children and their ages, it is obvious that this matrix can be very large. It is also obvious that for any period longer than a quarter or a year, the number of combined possibilities such as birth and death and change of status would be very large and the problems of computing them to fill all the relevant cells of the matrix would be unmanageable. This is why we abandoned this method and used the somewhat unsatisfactory method which appeared in the final model.
>
> At the time, given the existing state of computer technology, we did not consider a micro-economic simulation of the type urged by Orcutt *et al.* This procedure could work on a large file of individual households over short periods of time (anywhere from a month to a year). Each type of possible event could have a conditional probability dependent on the state of the household and the occurrence or non-occurrence of the events could be calculated either independently or serially. This elementary form of solution does not actually require as much data as might be believed and could probably be put up in a few months' time. I must caution you that the principal practical difficulty in using it would be the necessity for getting adequate disaggregated data for a start. Methods exist by which large-scale cross-tabulations can be generated from marginal totals as in census tracts, but these methods are somewhat tedious and of slightly questionable validity.
>
> There is one more subtle difficulty which applies to all of the models described above and which is perhaps best described through an example. Fertility rates, divorce rates, and economic mobility rates could be derived, perhaps with some difficulty, for every disaggregated stratum of the population. Even so, variations within strata would be neglected, and in certain cases, this neglect could be serious. If, for example, it is discovered

> that a center city tract contains predominantly middle-income childless couples, it might be a mistake to apply universe rates to this group. Such a population by self-selection might indeed have lower fertility and greater economic mobility than the same group located in the suburbs. Questions of this kind might be significant for transportation planning, but the methods of these models are inadequate to explore them.

Apparently, no further development of or work on the model has been performed at USDOT (the agency for which Harris and The Institute for Environmental Studies did the reported development).

Projecting Auto Ownership

Three general techniques appear, in the literature of research and past practice, for projecting levels of household auto ownership:

1. Extrapolation of observed rates for households, either based on cross-sectional data and relationship to other characteristics, such as income, or, in occasional instances, based on longitudinal data.
2. Extrapolation of total motor vehicle registration data using some form of fitted curve.
3. Fitting of a multinomial logit model to disaggregate data, with the inclusion of auto ownership as a dependent variable and independent variables such as household size, income, number of employees, and measures of transit availability.

Extrapolation of Observed Rates

Trip generation analysis (USDOT, *107*) recommends the use of curves relating household auto ownership to income for projecting ownership. The presumption is an extrapolation of current (or past) empirical evidence that auto ownership is related to household income in a regular and continuing way. (See earlier sections on extrapolation and curve fitting.)

In an analysis involving additional variables, Lansing and Hendricks (*131*) found relationships between household auto ownership and income, family size, number of employed workers, and area type (central city, suburb, older or younger city). They summarize (p. 20):

> The relation between income (in constant dollars) and whether a spending unit owns at least one car has been approximately stable for the country as a whole for the last decade. It seems reasonably safe, therefore, to use this relationship for projections. The relation between income and multiple ownership has not been stable, but has been shifting at a steady rate. It seems fairly safe, therefore, to project the level of multiple ownership for several years on the assumption that the shift will continue at the same rate. Two factors account for the upward shift in the relation of multiple ownership to income: the increasing use of automobiles by women, and the increasing proportion of the population living in residential areas built since the auto came into common use.

Numerous transportation studies also have used this methodology for projection.

Extrapolation of Total Motor Vehicle Registration

A corollary to the task of predicting auto ownership on a household basis has been the projection of total motor vehicle (automobile) registration, frequently as a check on the numbers aggregated from projection of auto ownership at the household level and independent projections of households.

Pearman and Button (*134, 135*) do a thorough job of reviewing the main issues in this methodology.

Essentially, they revolve around the type of curve to be fit to longitudinal data on percent or per capita auto ownership and the asymptote to be introduced as a limiting value: the saturation level. The curves discussed in their paper are a logistic curve and a power growth curve which was introduced by the Transport and Road Research Laboratory. Both use similar constants, including the prespecification of a saturation level (see earlier section on fitting a logistic curve).

Disaggregate Models

Recently, work has appeared extending disaggregate behavioral travel models, based on a multinomial logit curve, to decisions regarding choice of auto ownership (Lerman *132*; Burns *124*) and location and housing choice (Lerman, *133*).

Lerman (*132*) defines nine market segments based on four stages in the household life cycle and two employment groups, plus a ninth with no fulltime workers. For these segments (actually a subset of the nine due to data limitations), multinomial logit models are fit using some or all of six independent variables:

1. Transportation level of service to work.
2. Car-ownership costs.
3. Locational attributes.
4. Housing attributes.
5. Spatial opportunity variables.
6. Socioeconomic variables.

(The socioeconomic variables included household income, size and number of licensed drivers (see Lerman (*132*), Table 1, p. 44).)

Lerman concluded that the models had promise: "[they] provide a behaviorally sound method of incorporating . . . linkages (between car ownership and travel patterns) and provide a set of reliable, policy-sensitive forecasting tools by which car ownership and choice of travel mode to work can be predicted" (*132*, p. 49).

Burns (*124*) reports fitting a multinomial logit model of auto ownership involving a utility function based on household income, leisure time, travel time, and number of trips made by auto or an alternative mode, set of destinations accessible by auto or the alternative mode, and the cost of owning and operating an automobile. Separate curves were fit for households with 1, 2, or 3 or more trip-makers. Results of empirical tests were termed "encouraging."

Other Models and Variables

Dunphy (*126*) and Kingham (*130*) report models involving independent variables representing transit accessibility (Dun-

phy) and transit service (Kingham). Both found a significant, if small, relationship (in simpler models: cross-tabulations in Kingham's case, linear regression in Dunphy's) between transit availability and auto ownership, given control for socioeconomic characteristics of households.

DATA SOURCES FOR PROJECTION

The only data absolutely required to prepare projections are those describing the base situation.

The most commonly required additional data are related to the projection technique to be used. For example, if trends are to be extrapolated, data for prior points in time are needed to establish the trends. If step-down techniques are the choice, projections for the parent area are required. In the ideal situation, the analyst selects the projection technique, then procures the data needed. Obviously though, and unfortunately and frequently, the data available (with reasonable effort) dictate the projection technique. This section is intended to provide a review of data and data sources that may be used with earlier material on projection techniques, in deciding what to do, and as a guide to how to do it.

The data of interest to the transportation planner are not always available in precisely the form needed for analysis, either at the base time point, for past times, or as projections for the future. This is a common problem, not limited to transportation planning. (A corollary to Murphy's Law says *no* data are available in the needed form.) However, the data are available.

In general, the transportation planner is interested in data describing the population and their characteristics, employment, income and, if not part of population characteristics, auto ownership.

The material that follows is organized according to the broad categories of type of data: population and population characteristics; employment and income; auto ownership. Within these broad groups the data are described further in terms of whether they are historical (and current) or projections, their sources, frequency of collection or updating, area covered and detail, method of collection (or projection), and other characteristics as relevant.

Population and Population Characteristics—Current and Historical Data

The Decennial Census

The primary source of data for forecasting the basic inputs to transportation planning is the decennial census conducted by the U.S. Bureau of the Census. Thought of generally as a population count, it has expanded its coverage and function in recent decades so that it is now of considerable use in transportation planning and is an indispensable foundation for projection work.

However, the Census is not a ready-made data source either for a "snapshot" of the existing situation or for analysis of trends. The following discussion, and the discussion in Chapter Three, reviews the characteristics of data available from the Census and some of its pitfalls.

Contents of the Decennial Census

Recent decennial censuses have obtained generally similar information, some of it from all households and persons, some of it on a sample basis. Table 22 shows items for population and housing obtained in 1980.

Table 22. Subject items included in the 1980 Census.*

100-Percent Items[1]

Population	Housing
Household relationship	Number of units at address
Sex	Access to unit
Race	Complete plumbing facilities
Age	Number of rooms
Marital status	Tenure (whether unit is owned or rented)
Spanish/Hispanic origin or descent	Condominium identification
	Value of home (owner-occupied units and condominiums)
	Contract rent (renter-occupied units)
	Vacant for rent, for sale, etc., and duration of vacancy

Sample Items[2]

Population	Housing
School enrollment	Type of unit and units in structure
Educational attainment	Stories in building and presence of elevator
State or foreign country of birth	Year built
Citizenship and year of immigration	Year moved into this house
Current language and English proficiency	Acreage and crop sales
Ancestry	Source of water
Place of residence 5 years ago	Sewage disposal
Activity 5 years ago	Heating equipment
Veteran status and period of service	Fuels used for house heating, water heating, and cooking
Presence of disability or handicap	Costs of utilities and fuels
Children ever born	Complete kitchen facilities
Marital history	Number of bedrooms
Employment status last week	Number of bathrooms
Hours worked last week	Telephone
Place of work	Air conditioning
Travel time to work	Number of automobiles
Means of transportation to work	Number of light trucks and vans
Number of persons in carpool	Homeowner shelter costs for mortgage, real estate taxes, and hazard insurance
Year last worked	
Industry	
Occupation	
Type of employment	
Number of weeks worked in 1979	
Usual hours worked per week in 1979	
Number of weeks looking for work in 1979	
Amount of income in 1979 by source	

[1] Censuses similar in subject content to that of the United States were also taken in Puerto Rico, Virgin Islands of the United States, American Samoa, Guam, Northern Mariana Islands, and the remaining parts of the Trust Territory of the Pacific Islands. Subjects were added or deleted as necessary to make the census content appropriate to the area. The questionnaire for Puerto Rico had complete-count items and sample items, but in the other areas all questions were complete-count items.

[2] For most areas of the country in 1980, one out of every six housing units or households received the sample form. Areas estimated to contain 2500 or less persons in 1980 had a three-out-of-every-six sampling rate, which is required to obtain reliable statistics needed for participation in certain Federal programs.

*Source: U.S. Department of Commerce, Bureau of the Census, 1982.

Perhaps the major concern for the transportation planner is the level of geographic detail for which the data are available. Generally, the published reports will include more widely used data at fairly fine geographic levels (i.e., population and dwelling

units at the tract level) or more detailed data at grosser levels. This is in part a function of the size and specialization of detailed data at fine geographic levels, of the requirement for confidentiality which may be violated by detailed reports for small areas, and of the nature of the data: the sample rate does not permit reliable estimation of sampled data for very small areas. However, for purposes of projection at the county or study area level, adequate detailed data are usually available in published form. But two further difficulties remain.

The first, handling the large volume of data, is largely resolved by the computer tape versions of data made available by the Census Bureau. These tapes (summary tape files or "STF's") are described in greater detail in Appendix C. They include detailed data at the block and enumeration district level (and larger areas) for 100 percent items and sample data for enumeration districts and larger areas. Several software packages were available for processing corresponding data from the 1970 Census and similar software is available for the 1980 Census (*145, 150, 151*). (A recent USDOT manual provides more detailed information (*193*), and a forthcoming TRB Record discusses the availability and relevance of census data for use in transportation planning (*200*).) As might be expected, there were a large number of STF's in 1970 and will be a large number for 1980. While it is possible to obtain and use the software and STF's of interest if the potential user has computer resources, public access is established in most states by state agencies and from various service organizations. (It should be noted that data which would violate confidentiality restrictions are omitted from the STF's as well as from printed reports.)

The second problem is dependent on the user's needs, and may or may not be resolved by the STF's: the need for cross-tabulations of data within geographic areas. For example, the transportation planner may wish to examine dwelling units by number of occupants by autos available. Aside from the question of the specific meaning of the Census' term "dwelling unit" (as opposed to "household"), the particular cross-tabulation may not be included among those on the STF. If it is not, the user must resort to some means of estimating or approximating the entries in the cross-tabulation (see the section on "Establishment of Joint Distributions," above). Of course, the probability of having the desired tabulation available diminishes as the detail of the tabulation desired increases: where D.U.'s by number of occupants and autos available might be included in the STF, a table adding a third variable, such as income or means of transportation to work, might not. Documentation of the content of the STF's and related datasets will be available as the STF's are released.

Files related to the STF's are the Master Area Reference File, which provides numeric codes and names for geographic areas, and the GBF/DIME files, initiated for the 1970 Census, which permit address and geographic coding. (See App. C for additional information.)

Census Public Use Samples

Another potentially useful set of related files are the Public Use Samples created from the original individual Census returns for persons and households. They permit the user to examine data at the individual or household level and to relate the approximately 50 household characteristics and 55 personal characteristics directly to each other (i.e., the cross-tabulation problem mentioned previously can be overcome).

Obviously, for confidentiality, all personal identifying information is removed. Geographic information is preserved at the state level and for various subdivisions of states (counties, county groups, or SMSA's), depending on the particular sample.

Three public-use samples have been created using the long-form return as a basis: a 5 percent sample identifying states, various subdivisions, and most counties; a 1 percent sample identifying metropolitan territory, most SMSA's and county groups; a 1 percent sample identifying regions, divisions, and states by type of area (urban/rural). Less bulky 1 in 1,000 samples corresponding to these three also are available.

The Current Population Survey

The CPS, carried out monthly by the Census Bureau, interviews a carefully selected sample of almost 70,000 households nationally on a wide variety of topics. The CPS has been conducted monthly for about 35 years. Its main purpose is to collect information on the current employment situation, and its data form the basis for the monthly Bureau of Labor Statistics publication, *Employment and Earnings* (see material below and in App. C). Because the sample rate is so low, the data from the CPS are usable only at the state level and above and for a few large SMSA's. However, they provide important information and indicators regarding trends in employment and other demographic data.

The monthly interviews' core questions are supplemented on an annual basis with additional questions that are repeated annually in the same month. The March supplement contains questions on family structure, marital status, education, income, work experience, and migration. Individual sample records (with sufficient geographic and other identifying information removed to preserve confidentiality) are available on computer tape for analysis. Appendix C contains additional information on the CPS extracted from "The Current Population Survey: Design and Methodology" (*146*).

Special Census Reports

The Census prepares and publishes a number of special reports that are of potential interest. They cover topics including migration and mobility of the population, estimated from Census questionnaire responses, components of change (i.e., births, deaths, migration) at various geographic levels and income.

A number of these publications from the 1970 Census are listed in Irwin (*17*). The Census Bureau (see App. C) should be consulted for titles forthcoming from the 1980 Census.

Population and Population Characteristics—Projections

Bureau of the Census

The Bureau of the Census periodically prepares projections of the population for the nation and for the states disaggregated by such characteristics as age, race, and sex. A recent (1979) set of projections (*67*) includes not only population numbers but also tables of components of change by age, sex, and race and tables describing special populations, birth and mortality rates, and migration.

This particular report includes two "series" of projections, each of which reflects different assumptions regarding migration patterns (as well as a projection assuming "zero" migration). Earlier series have reflected other assumptions regarding, for example, fertility rates.

Each series offers the analyst a beginning set of data and assumptions that may be used in a "step-down" projection for the local area or may suggest assumptions or provide data for his own projections.

State Agency

A frequently available alternative source (as it is for current and past data) is the agency in the analyst's own state which is responsible for projections at the state (and substate) level. North Carolina (as an example) regularly prepares estimates and projections of population at the county level. While the analyst at the local level may not agree completely with the methodology and assumptions used, he or she will find such state level projections of great value to provide a "starting point."

In 1980, partially as a result of the 1979 proposal by the Federal Office of Management and Budget to establish a mechanism for standardizing local area and state population forecasts (See Ch. One), the Federal-State Cooperative Program for Population Projections (FSCPPP) was formed. Originally consisting of representatives of 34 states, the Bureau of the Census, the Office of Federal Statistical Policy and Standards, and the Bureau of Economic Analysis, the FSCPPP subsequently has added representatives of other states. The organization is primarily devoted to communication among members and to technological and methodological issues. However, contact with the member agency in a planner's state will provide a resource of information about projections at the national as well as the state level. (Appendix C includes a list of state member agencies as of 1983.)

Other

Finally, many private companies and organizations regularly prepare population projections. Access to these is dependent on the policy of the individual organization, but local inquiry and contact frequently uncover surprising levels of activity. Public utilities frequently prepare population projections to estimate future demand (as do transportation planners).

Further sources of population data include combined employment/population projections which are discussed below.

Employment and Income Data—Current and Historical

The Decennial Census

The Decennial Census also is one of the most important sources of employment and income data. Among data collected by the Census (on a sample basis) from each household during the decennial census are:

- Employment status (previous week).
- Hours worked (previous week).
- Place of work.
- Travel time to work.
- Means of transportation to work.
- Industry.
- Occupation.
- Type of employment.
- Amount of income (previous year).

These data are (or will be) available at levels of detail previously described for other population characteristics.

The 1970 Census included a question to determine address of place of work. Published tabulations indicated place of employment for residents, usually by "in county of residence," "outside of county of residence," and similar large geographic areas. However, finer geographic detail is available from the tapes of Census data. In 1970 the "Fourth Count" tape showed detailed coding based on the address of place of work. In 1980, similar data will be available in published and computer tape-form (see App. C).

Use of Decennial Census data to determine employment is compromised by several problems. From a practical point of view, partial responses and errors in coding make the data somewhat incomplete. The data also are from the sample questionnaire rather than the 100 percent form. However, the most substantive problem stems from the fact that the data were collected and are controlled (and expanded) at the residence location. Given commuting patterns, a relatively large number of residential areas must be examined to be certain that all (or a large percentage of all) workers in an employment location are captured. Of course, the larger the geographic area the less the concern, and at the level of a "study area" this problem and the variability inherent in sample-based data may be less critical.

Economic Censuses

The Census Bureau also conducts Economic Censuses of

- Retail Trade
- Service Industries
- Wholesale Trades
- Construction Industries
- Manufacturers
- Mineral Industries
- Transportation

every 5 years. (The most recent were in 1977 and 1982.)

Although the specifics vary for each of the Economic Censuses, they represent surveys of all, or a sample of all, large firms and are supplemented with information from other federal administrative sources such as the Internal Revenue Service and the Social Security Administration. Generally, they include information on firms by industrial classification, location, type of ownership, dollar volume of business, number of employees, and amount of payroll. Depending on the particular Census, more specific information also may be included. (The Transportation Census is oriented to sampling of commodity flows rather than transportation firms.) Data are available at a detailed industry level for the nation and, depending again on the particular Census, with less detail down to the SMSA, county, and even incorporated place level. (Generally, SMSA or county level data needed for study area analysis and projection are available.)

The list of Censuses (above) seems complete superficially, but besides the omission of firms in the transportation, communication, and utilities SIC categories, Finance, Insurance, and Real Estate firms are not included; and Agriculture and Government activities are covered by their respective special Censuses (1974 and 1977 and 1982 in the case of Agriculture).

Other Federal Sources

Through various offices and programs, the U.S. Department of Commerce and the U.S. Department of Labor produce several reports on employment in cooperation with the Social Security Administration. These include:

- *Employment and Earnings,* monthly estimates from a sample of payroll and administrative records from establishments, Department of Labor, Bureau of Labor Statistics.
- *Employment and Wages,* quarterly, from state employment security agency reports, Department of Labor, Bureau of Labor Statistics.
- *Employment and Earnings,* monthly, from a sample of about 47,000 households nationally, by the Department of Commerce, Bureau of the Census.
- *County Business Patterns,* annually, employment and payroll information required by FICA, from administrative reports and supplementary surveys, Department of Commerce, Bureau of the Census and Social and Economic Statistics Administration.
- *Annual Survey of Manufacturers,* sample of about 70,000 manufacturers drawn from the Census of Manufactures (above) and Social Security records, Department of Commerce, Bureau of the Census.

The Continuous Work History Sample (CWHS) prepared by the Social Security Administration (SSA) is a unique resource of information. It is based on a 1 percent sample of workers' earnings records from employers' quarterly reports to the SSA and, more recently, a 10 percent sample. The CWHS system was designed originally in 1940 for SSA use and contains some information dating from 1937. Most of the information, however, is available for the period since 1957.

Basically, the system contains records showing, for each worker:

- Personal characteristics—sex, race, year of birth.
- Wage information—quarterly (or annual) taxable wages and estimated total.
- Employer information—state, county, and industry (by SIC).

Because it is drawn from reports of Social Security-covered employees, the system includes only about 90 percent of the labor force, omitting many government employees at the local, state, and, particularly, federal levels as well as other noncovered workers.

Careful confidentiality precautions are taken with the data, but because it is possible to trace workers from year-to-year (once selected in the sample, a worker remains), longitudinal information is available not only to trace structural changes but also to establish migration patterns (geographic and, also, from one type of employment or industry to another and into and out of the work force).

The 1 percent and 10 percent CWHS files are overwhelming in size, and their processing is beyond the resources of most potential users. However, as a by-product of its own use of the CWHS, the Bureau of Economic Analysis (U.S. Department of Commerce) provides tabulating and reporting services at reasonable cost. Other agencies that have acquired CWHS data and from which assistance is or may be available include Indiana University (Department of Economics), the RAND Corporation, the Tennessee Valley Authority , and the Oak Ridge National Laboratory.

The smallest geographic level to which data are coded is the county. Because the data are from a 1 percent sample, many tabulations of interest at the county level are not useful because of their variability. This situation will improve as the 10 percent sample grows.

Of particular interest to transportation planners is the recent addition of residence location coding to the data. This will permit analysis of commuting patterns, but only between counties, and of residence migration as well as work place migration.

The Bureau of Economic Analysis published an excellent guide to the CWHS in 1976 (*148*). (The CHWS has been suspended since 1981 for a variety of reasons. The BEA should be consulted for details.)

State Sources

At the state level, agencies collectively referred to as State Employment Security Administrations (SESA's) (but with individual names on a state-by-state basis) are an excellent source of historical and current employment data. Their data generally are derived from unemployment insurance reports (and serve as the basis for several of the federal sources referenced earlier), but frequently they offer greater detail and the advantage of "local knowledge." A listing of reports available for the State of North Carolina is included as an example in Appendix C.

Commercial Sources

Another important source of household and employment data, which is finding increasing use in transportation planning, is data furnished from commercial organizations. Perhaps the most familiar of these is the R. L. Polk Company, which publishes city directories in many areas of the country; however, other city directory firms, Dun and Bradstreet and International Data and Development, also are significant sources of data.

In general, household, employment, income, and auto ownership data are directly available (and work-trip data may be developed). However, there are problems of coverage (i.e., whole areas may not be included, or only the urbanized or "built-up" area may be selected, omitting the "fringe") and of accuracy.

Stuart (*139*) provides a thorough review of commercial data sources and a comparison of their characteristics to the Census.

Employment and Income Data—Projections

Bureau of Economic Analysis

Perhaps the single best-known employment and income pro-

jections are prepared by the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce. Known as the "OBERS Projections" they were prepared and published in 1972 and 1974 (using different Census projection series) and, again, in 1981.

The methodology used in preparing these projections is described in Refs. (*89, 90,* and *91*).

The data which result include:

1. Population, personal income, labor, and proprietors' income and employment.
2. Population by age and sex.
3. Labor and proprietors' income by industry or industry group.
4. Employment by industry or industry group.

All data are for 1969–1978 and projected, at 5-year intervals, from 1985 to 2030. The population and associated data are presented by place of residence, while the industry associated data are presented by place of work. The geographic places include:

1. The nation, 50 states, and the District of Columbia.
2. One-hundred eighty-three BEA economic areas.
3. Two-hundred sixty-six SMSA's (as of 1977).
4. Five-hundred eighty-five substate areas:
   - BEA areas entirely within one state, having no SMSA.
   - SMSA and non-SMSA part of BEA's entirely within one state.
   - State parts of economic areas or SMSA's where they are divided by state boundaries.

Appendix C includes examples from the 1980 projections.

Other Sources

The National Planning Association also prepares population and economic projections at the national, multistate regional, regional, and (for selected areas) substate level (*77*). NPA projections include tables showing:

- Population by age, sex, and race.
- Components of population change.
- Employment by industry.
- Personal income by source.
- Earnings by industry.
- Labor force by age, sex, and race.
- Labor force participation by age, sex, and race.
- Personal consumption expenditures by type of product.
- Households, families, and unrelated individuals by type and age.
- Consumer units, families, and unrelated individuals by Census money income class.

The 1976 projections included data for the years 1960–1985 (or 1990) at each 5-year interval.

Earlier reference (in the discussion of projection techniques) was made to the active employment projection program of the Federal Bureau of Labor Statistics. In cooperation with state employment security offices, projections of employment by occupation (and, frequently, industry) are prepared for substate areas for "short-term" projection periods, usually 3 to 5 years. Although short-term projections such as these frequently do not meet the specific needs of transportation planners who are concerned with a 15- to 25-year time horizon, they may provide useful starting points or direct information for short-range planning. Examples of projections for an area in North Carolina are included in Appendix C.

Reference also was made to several other sets of national and state or regional level economic projections which include projections of employment. The availability of these projections for reference or as a source of data for "step-down" or ratio analysis by local area planners is not known. Some of the clients are private organizations which retain proprietary rights to the data. Others are oriented particularly to research or academic purposes. Regardless, they are rarely part of an on-going program, such as that of BEA, and their availability is much more restricted. However, specific inquiry in local areas through the academic or research community may yield additional projections.

Auto Ownership

Data on current and historic auto ownership generally are available from two sources: the Decennial Census and special Census surveys, and state departments responsible for vehicle registration.

The Census produces data in a form most nearly like that needed for transportation planning. But as with other Census data, it suffers from its decennial collection timing as well as sampling variability problems and confidentiality restrictions. (See the earlier discussions of the content of recent Census surveys and other questions under sections on current population and employment data.)

In theory, state agencies responsible for motor vehicle registration should be excellent sources of data, primarily because they cover *all* vehicles and their data are current. Given certain confidentiality restrictions, they usually are quite willing to make their data available. However, several problems intervene.

First, the location of the vehicle only is known to be the address of the owner. While this is not a problem in "normal" situations, the frequency of abnormal situations is sufficiently large to make the geographic location assumption suspect: company-owned vehicles operated regularly by employees and vehicles operated away from "home" (by students, for example) are two of several categories that cause problems.

Second, geographic coding usually is limited to county or to mailing address (i.e., zip code or street address). This would not be a problem if the study area and county were coincident; but it could be, in other cases.

However, the limited geographic coding points up a third and major problem: motor vehicle registration data really are useful only to establish area total auto-ownership. There is no tie to the characteristics of the households or persons who own the automobiles, and the totals are useful primarily as a check on the results of other projection (or estimation) techniques and to establish trends.

SUMMARY—DATA SOURCES FOR PROJECTION

The Decennial Census and the "OBERS" projections, prepared by BEA, probably represent the best sources of both

historic and projected data for input estimation for transportation planning. They are comprehensive, competently prepared, and uniformly available.

The Census becomes dated because of the decennial collection period. The OBERS projections of necessity overlook many local considerations because they concentrate on systematic projections at multiple levels of disaggregation. Variables of interest to, and needed by, transportation planners are missing from both. Geographic areas may not correspond with study area boundaries.

Data are available from other sources, but with only one or two exceptions, they are not ubiquitously available as are Census and OBERS. The examples included or suggested here, some of which are more specialized by subject and content and others by geographic coverage or location, should give the transportation planner starting points for local or state inquiries and, in turn, access to such specialized data. The transportation planner may also find much of his work already done, as is the case with several of the examples discussed in Chapter Four.

CHAPTER THREE

INTERPRETATION AND APPRAISAL

Chapter Two has described the findings of this project with respect to the sensitivity of the transportation planning process to socioeconomic input variables, various methodologies available for forecasting the socioeconomic "input" variables, and sources of data for those projections. In this chapter, a set of criteria is specified by which to judge the projection methodologies. Each criterion is discussed in terms of the projection methodologies. Each methodology is then evaluated, using the criteria.

CRITERIA FOR EVALUATING METHODOLOGIES

The criteria that are suggested for use in rating the projection methodologies are of three kinds:

1. Related to the transportation planning process.
2. Related to the projection methodology *per se*.
3. Related to the logistics of use of the methodology.

Criteria Related to the Transportation Planning Process

Prodution of the Desired "Input" Variables

Does the projection technique produce projections for variables that are required for or relevant to the transportation process? Chapter Two shows "input" variables: population, distribution of household size, car ownership and/or income, and, by inference, employment (for home-based work). All are significant in trip generation in terms of sensitivity and explanation of variation. The question then is, which (if any) of these variables does a methodology forecast directly? Are they in the required format? (Cross-classification, for example.)

Inclusion of Other Variables

While a particular methodology may not include a desired variable in its output, it may be possible to include an additional variable within the overall projection. For example, the cohort-component model keeps track of tables of population by age and sex as an integral part of its forecasting procedure. If a variable can be expressed as a ratio of a specified age/sex group, the projection can produce estimates of population, possessing the desired characteristic, by applying age-specific ratios.

Interface with Allocation Models

It has been noted at several points that the output of the transportation planning process is particularly sensitive to errors in zonal allocation of input variables, such as total population. Ultimately, regional aggregate projections of population, households, autos owned, employment, etc., must be allocated to the traffic analysis zone in order to use the forecast in the planning process. Can a projection produced using a cohort-component technique at the regional level be disaggregated to the traffic analysis zone? Disaggregation clearly is possible, but as the geographic area to which the projection must be allocated becomes smaller, the allocation of a share of the aggregate forecast to a specific zone becomes more difficult and prone to error.

Sensitivity to Transportation Policy

Is the technique sensitive to transportation policy? Does the technique or methodology produce projections which reflect some effect of national, state, or local transportation policy? More specifically, transportation policy is reflected in regulation, funding, program, and even location decisions at various levels

of government: does the projection technique include variables (particularly as inputs) which reflect differences in these elements of policy and is the model itself responsive to these differences?

Criteria Related to the Projection Methodology Per Se

Theoretical Basis or Framework for the Projection Methodology

The projection procedure should be examined to determine the extent to which it rests on a meaningful theoretical foundation. A theoretically based approach rates higher than an empirical method which extrapolates a past historical curve or a ratio. Both methods might assume, in error, a continuation or extension of a past trend. However, a procedure with a theoretical basis usually will be more explicit in terms of the assumptions involved in extension of a trend. Unreasonable assumptions, because they are specific, are more likely to be revealed in such a projection than they would be in empirical extrapolations. Moreover, a methodology with a strong theoretical basis often spins off by-products that are useful or permit comparison to other forecasts.

Usefulness for Other Planning Purposes

If the projection technique produces data useful for other planning purposes, two advantages accrue to the method. First, because it costs time, manpower, and other resources, the utility of the projection technique for other types of planning may permit, ultimately, some sharing of costs among parties requiring the output data. Second, the use of a single set of projections for different types of planning in a metropolitan area will have a unifying effect on the plans resulting from those projections.

Method's Track Record

Has the projection methodology been tested? Basically this comes down to a question of the method's track record in making projections of the independent variables. Have tests been conducted comparing the projections to actual change, and have the reasons for differences been analyzed? How does the methodology compare in accuracy to others? Obviously, no methodology is perfect. But while it cannot be expected to anticipate some sorts of changes (there is always a disclaimer for war or "acts of God"), analysis of the relationship of projections and actual occurrences may reveal successful techniques as well as understanding of the reasons for success or failure.

Comprehensibility of the Methodology

Can a typical planner, interested in using the methodology, not only follow the steps, given a reasonable user's guide or set of instructions, but can he or she also understand the assumptions, limitations, and characteristics of the technique, so that he or she can use it effectively and intelligently? (This criterion often is observed in reverse: if a method is *not* comprehensible, it gets short shrift.)

Inherent Biases or Limitations

Some methodologies are considered more useful for projections of large areas than for projections of small areas. Although the distinction usually turns on data availability rather than the model itself, the statistical robustness of a model may be diminished when sample data are disaggregated. Occasionally models calibrated on a set of data from one period may behave unexpectedly when presented with different data. (For example, see the description of the difficulties with migration in the Mid-America Council model in Chapter Four.)

Criteria Related to the Logistics of Using the Projection Methodology

Cost of Using the Methodology

Some techniques require detailed and voluminous data, while others proceed from readily available, published data (usually from the Census). Some techniques also involve either laborious calculation or fairly sophisticated computer resources. Of course, size of area has an effect as well, but for aggregate projection, size is not as critical as detail of data and computation. Clearly, cost is a substitute for resources in most instances, and resources needed to use a particular methodology might include everything from computer programs to outside assistance.

Input Data Availability

In Chapter Two, it was suggested that the availability of data often dictates the ultimate choice of methodology. There are at least two aspects to the problem. First, the geographic area for which the projection is being prepared may be one that does not follow common data collection boundaries (such as political jurisdictions). Second, the data simply may not be available: some econometric models require employment information that is not collected at all.

Means of Monitoring Projections

Can the projections be monitored? Is there a way to monitor the changes in the projected variables, either input or output? If one is available, projections can be modified to reflect new information. Actually, almost all variables can be monitored. The problem lies with the frequency (i.e., once every 10 years with Census), cost (a special survey), or accuracy (the monthly Current Population Survey is inadequate for small areas).

While there may be other criteria—and combinations or permutations of these—which may be applied in selecting a projection technique, these capture the major characteristics. They are used below as a general framework for discussion of major types of techniques, and they should provide the planner with a useful checklist when he or she is trying to select a technique (or combination of techniques).

EVALUATION OF METHODOLOGIES

Given the 12 criteria described above and the methodologies and techniques described in Chapter Two, an obvious and comprehensive way to relate each to the other for evaluation is a matrix—such as Figure 7. Simply filling in such a matrix, however, is both difficult and potentially confusing. In part this is true because many of the relationships to be described cannot be reduced to a single word or phrase to fit the available space and, in part, because there are subtleties and reservations which mandate elaboration. Most importantly though, evaluation of a given technique is highly dependent on the particular specific circumstances of the planner or analyst.

Instead, the matrix presents a schematic for the discussion that follows. As a generality, both the criteria and the techniques are discussed in the sequence shown on the matrix. Perhaps the reader may wish to keep score in the matrix as he or she reviews the material that follows, keeping in mind his or her needs, resources, data, and other circumstances. First the 12 criteria are discussed relative to the multiple techniques, then each technique is reviewed in terms of the criteria.

Production of the Desired "Input" Variables

Actually there are three questions involved in this single criterion:

- What are the desired variables?
- Does the technique produce these variables?
- Does it produce them in the desired format?

If the desired variables are not some group such as those examined in Chapter Two, which are typical of the urban transportation planning process, they are specific to a particular circumstance. In that case they must be specified by the analyst or planner who is responsible for the work. This is not a trivial point because a number of the techniques can be adapted readily to produce desired variables in desired formats (given certain qualifications). Others might be modified to produce different, desired variables, but there is no evidence that they have been, and the effort to do so is considerable.

As an example, assume that total population is desired by age and sex categories, distributed among households in a joint distribution (cross-classification) by household (or family) size, household auto-ownership, and number of employed members per household. (Household income might be substituted for auto ownership.) On the economic side, assume that employment in some 10 to 15 industry sectors is needed.

If the analyst has a time series of data in the same form, then a trend projection of absolute numbers of each element (i.e., cell in the cross-classification table or employment sector) provides a made-to-order set of projected data. By this criterion, trend projection scores 1.0 (or 100 percent).

Given this criterion alone, the other weaknesses of trend projection and the difficulty of the assumption of data availability are moot: trend projection is the most easily adaptable of all the techniques described because it is simple: the only independent variable is time. There are no implicit or explicit relationships to other variables, buried in the technique, which restrict the analyst in prescribing the form of the output.

Perhaps the next most flexible (and by this criterion, highest ranked) are the ratio techniques—absolute or change and single or multistage.

As was the case with trend projection, the availability of data in the proper form is critical, although in this case, it is data for the parent area or areas.

Both of these circumstances—availability of time series or parent-area data of the desired form—rarely occur, however, and the abstract advantage of trend and ratio techniques, derived from the assumption that they might occur, disappears.

Unfortunately, none of the techniques provides projections in the assumed "ideal" format outlined above.

Because time series and parent-area data are more readily available, individual variables (population by age and sex; employment, total and by sector; households, total and by size or income or auto ownership; and so forth) may be projected using trends or ratios. But other techniques then also rank equally high on this criterion and, as will be seen, higher on other criteria: cohort-component models for population, special cases of trend and share models for employment and income, and so forth. In most circumstances, the flexibility and adaptability of trend and ratio techniques in working with a specific set of desired outputs is irrelevant. They become useful, instead, in relating desired variables to other variables which may be projected by another technique.

Inclusion of Other Variables

Much of the discussion of the "desired variables" criterion (above) applies to this criterion. The primary point to "inclusion of other variables" is directed to recognizing whether a technique which produces some specific subset of the desired variables, also can be made to produce ("include") other variables. Obviously, from the discussion above, ratio and trend projection techniques can.

So too can several of the more sophisticated techniques, notably econometric models. However, the fact that this is true is more because there is (as yet) no such thing as a "standard" econometric model than it is because a given "model" can be made to include other variables: the design and fitting of a particular application frequently can be tailored to include other variables.

Several techniques that have been standardized to some extent do not permit easy modification to "include" other variables. Notable among these is cohort-component population projection techniques, but economic base and input-output techniques share the same characteristic, perhaps to a lesser extent. However, and importantly, it should be noted that other variables can be related to the specific variables projected using these techniques through rates, ratios, or proportions. This possibility is addressed in a separate section, below.

In summary, as was the case with the criteria concerning "desired" variables, the mechanics of inclusion of additional or other variables are trivial for several of the techniques, becoming more a matter of availability of data. For others, significant modifications are required, but the use of rates, ratios, or proportions to establish relationships between the projected and other variables provides a bridge.

	Produces Desired Variables	Includes Other Variables	Interfaces Allocation Models	Theoretical Basis	Useful for Other Planning	Tested	Comprehensible	Biases & Limitations	Cost of Using	Data Available	Can be Monitored
Ratio-Demographic: General											
Ratio-Economic: General											
Shift-Share											
Independent-Demographic: Extrapolation											
Component Methods											
Independent-Economic: Extrapolation											
Economic Base											
Multipliers and Input-Output											
Econometric											

Figure 7. Evaluation matrix—methodologies and criteria.

Interface With Allocation Models

The ranking of a technique on this criterion is partly a function of the variables which it projects and partly a function of the allocation model to be used for disaggregation.

In general, allocation models used in transportation planning are "techniques" that are adapted to specific circumstances, except in a few instances where they have been implemented or made "operational" in computer programs. In the former case, the analyst can control the "interface" either through manipulation of the projection technique or through specification of the allocation technique. In the latter case, where a technique is implemented in an available computer program, the allocation program input and output generally fit the needs of the transportation planning process fairly well, primarily because they have been designed for that purpose.

There is no way to rank the projection techniques reviewed here on this criterion. Although it is true that one or the other may be better in a specific set of circumstances, there are too many variations in the application of both the aggregate projection technique and the methodology chosen for allocation to permit general conclusions.

Sensitivity to Transportation Policy

As with several of the other criteria there are a number of questions inherent in this criterion.

First, and obviously, is the question, what transportation policy? At the level of an urban area, possible policy actions usually are related to the provision of facilities and services, as opposed to policy or program actions that might take place at the state or federal level, such as changes in fuel taxes or in regulation of common carriers.

Second, there must be some sort of distinction in the type of effect to be anticipated, and there is another obvious question: Does a relationship between the variables to be projected and the transportation policy even exist? Can it be perceived or measured?

None of these questions have easy or ready answers. But examples may provide some assistance with the basic problem: Are projection techniques sensitive to transportation policy?

Literally, only a very few of the economic models include independent variables that reflect transportation policies. Input-output models include transportation costs in some cases, although the typical application has treated economic activities as if they were located at a single point (see Isard (*18*), for elaboration). Harris (*74, 75*), in his econometric model of the national economy, included variables and relationships that reflected the effect of various levels of highway construction through changes in transport cost and the effects of employment and capital investment at different levels in different regions of the country. Both of these techniques are difficult to apply at the urban area or urban region level and, moreover, may not be relevant at what amounts to the "micro" scale as opposed to the national subregion or nation.

As a generality, the techniques examined in this project are *not* sensitive to transportation policy variables. Certainly this is disappointing, but it should be recognized that it is not at all clear whether this results from simple failure to include the variables or relationships in the models or is because the relationships are extremely weak or nonexistent.

It should be emphasized that these techniques relate to *aggregate* projections, *not* to allocation within an urban area. Many of the allocation models explicitly include variables that, in turn, are dependent on policies concerning differential provision of facilities and services within the area.

Theoretical Basis or Framework for the Projection Methodology

At one level every technique shares the same theoretical basis: that the future can be extrapolated from the past. But in this case, the more important level is the knowledge about, or understanding of, the phenomenon about which a future course or state is assumed. When total population is projected as a trend, in effect using time as the independent variable, the analyst is blind to factors about which much better information is available: the effect of birth and mortality rates and of migration. Similarly, if he projects employment as a trend, he ignores additional information about change in individual industries or occupations and local circumstances.

At this "second" level the cohort-component population technique and the economic base, input-output and econometric techniques all are clearly superior to simple trend projection. In the middle are fitted "trend" techniques involving relationships to variables other than time and, similarly, rate, ratio, or proportion techniques. Here the theoretical content is a function not of the technique, but of the relationship and the variables. Shift-share models fall in the same group.

Usefulness for Other Planning Purposes

Usually this is a function of the variables projected by the technique. In general, population and employment, as well as income and other transportation variables, are used or useful in other planning activities: potential demand for housing, water and sewer services, occupational training, social service needs, and so forth. For many functional areas of planning, the extent of public intervention and the reliance on projection (as opposed to planned or programmed change) is quite different. In part, too, the utility of a given technique is a function of the agency's program.

In general though, the more sophisticated techniques appear to have greater utility for other planning purposes, but the advantage is not significant given other criteria. In a specific context, however, given particular circumstances (such as choice of variables to be projected), one technique might emerge as clearly advantageous.

Method's Track Record

Has the methodology been tested? Very little research or *ex post* analysis of the accuracy of projection methods in transportation applications is reported. The main body of material relating to the quality of projections—and of the methodology—is related to population projections and methodology.

Siegel (*33*) analyzes the accuracy of the cohort-component model, used by the Bureau of the Census since the late 1930's, and points out that the "sub-projections" of the components of change pose a source of error, with fertility and migration assumptions contributing the largest proportion.

Isserman (*41*) compares a number of different curves for projection of a small-area population, and concludes that extrapolative methods "may yield sufficiently accurate projections for many planning purposes" and that exponential extrapolation is most accurate for rapidly changing (growing or declining) areas while linear extrapolation was most accurate for moderately growing areas.

Stevens and Moore (*84*) discuss the accuracy of the shift-share technique for projection of population, but their major emphasis is on theoretical problems, although they do discuss the results of using different curves for projection of changes in share.

Siegel (*33*, p. 54) notes that "the possibilities of measuring the accuracy of a set of projections are limited because current estimates or census counts for many years subsequent to the base data are needed. . . . This would permit evaluation of projections only after a long period of time has elapsed; by this date the methodology in current use may have changed."

There are several points in Siegel's comment. First, he implies that a number of censuses (hence, decades) are needed to track the accuracy of a projection technique. While this may seem to imply a long period, it really is related to the number of observed "points" in the projection period. That this is true, though, does not mean that the situation is much different, in terms of time, for transportation variable projections. Checks of their accuracy may rely on the census too, with the same time constraints, or on special surveys or on estimates. Special surveys are expensive, while estimates may have an error as great as the projection they are meant to check (if they are undertaken for that reason).

Second is Siegel's suggestion that the methodology may have changed (and, presumably, improved) making the evaluation irrelevant. Third, the variables of interest (or the area) may have changed so that comparison of projected and real values is not possible.

Goldstein (*73*) reports fitting of regression models, for projection of employment, to historic data, then projecting current values with good success. This underscores the fundamental difficulty of evaluating the accuracy of any projection technique: No matter how good the technique is, it must rely on assumptions about the future. Unfortunately, there is nothing about a good past performance in assuming the future which guarantees that new assumptions are correct.

Comprehensibility of the Methodology

Superficially, the more sophisticated techniques are likely to be less comprehensible or understandable to an average, reasonably trained and experienced transportation planner or analyst.

But there is a paradox here in that uanderstanding or comprehension must extend not only to the steps and mechanics of the technique, but also to the assumptions inherent in the technique. Although the number of assumptions may become more bewildering in the more complex techniques, they are, in many ways, clearer than the implicit assumptions involved in simple time-based trend projection or ratio techniques.

Inherent Biases or Limitations

Bias may be introduced from several sources. The most easily understood, perhaps, is bias inherent in the technique. As a simple example, projection of a trend that is based on historical data that show a consistent increase never will show a decrease. It may be argued that the technique should not have been used or that it is misapplied, but the point remains that the technique is biased toward continuation of past history.

Data may introduce a bias. One of the major problems in recent decennial censuses had been undercounting of some segments of the population. Projections using their proportion in the population, for example, may unwittingly project a continuation of that underrepresentation. This sort of problem is perhaps more significant and less easily compensated in characteristics of the population, such as birth rates, and migration and employment data.

Bias also may be introduced in computation. For example, suppose migration is tied to change in employment, and that a decrease in employment occurs if the population of a region declines. Both of these relationships sound reasonable, but their combined effect, in a declining economy, leads to a downward spiral of populations, quite out of proportion to the situation that is likely to occur in a region which is not a "closed" economy.

Ranking the methodologies or techniques on the criterion of bias presents a paradox. The simpler tend projection and ratio methods are subject to bias from data and assumptions that are masked by the simplicity of the technique. But the more complex techniques introduce more numerous opportunities for bias, although they make many of the individual assumptions and relationships more apparent.

All of the techniques, then, include some bias or opportunity for biased application. That some, such as the obvious in trend projection, are easily recognized underscores the necessity for the analyst to understand the relationships and data as well as possible and, perhaps most importantly, to review his results for reasonableness before blindly accepting the numbers produced by his computations.

Cost of Using the Methodology

This criterion overlaps to some extent with a number of the others, because money, in most cases, may be used as an alternative resource. Moreover, cost of use and ease of use frequently are virtually synonymous.

Perhaps the most obvious cost of use results from computational complexity or tediousness. In recent years, however, increasing availability of computers has transformed computational complexity and tediousness into the direct cost of computer use and, in some instances, programming. Those projections that are still done manually (or, obviously, with calculators) usually are limited to simple time-based trend projection and to rate-ratio-proportion models. At the other extreme are the econometric and input-output models that only are feasible due to the availability of computers. In between are shift-share and economic-base models and cohort-component demographic techniques. Isserman (*41*) reports on a comparison of several different curve forms using a computer program to fit time-series data, and illustrates the application of computers in techniques that might be assumed to be manual.

The detail required of the projection adds another dimension to the cost of use. Even the simplest time-series or ratio model becomes computationally overwhelming if the detail of the projections is increased: a two- or three-sector employment projec-

tion may be suitable for manual calculation, but a twenty- or thirty-sector model begins to demand considerable manual resources (and presents much higher probabilities of calculation error).

The second major category of resources that affects the cost of using any technique is the availability of data. The topic is treated more specifically in the section that follows, and it also was discussed indirectly earlier in the sections on the variables projected by various techniques and the potential for including other variables. As has often been observed, however, specific circumstances strongly affect the need for data. If data are easily available to support the specific needs for a given projection, the costs should be relatively low. Conversely, as modification or merging of diverse sources increases, costs go up. (Moreover, accuracy may go down, and additional assumptions may be introduced.) Perhaps the most expensive circumstance occurs when original data collection must be undertaken.

The definition of areas for data collection frequently causes problems that are somewhat unique to transportation planning. In many cases "study areas" are defined on the basis of an urbanized area boundary which ignores (with some justification in most instances) political unit boundaries. Even though the Census may provide some data for the "urbanized area," where it serves to define the "study area," many other sources of data commonly use county (and, hence, SMSA) or town and city boundaries as levels of aggregation. Where these do not fit the study area, additional costs are introduced.

In summary, the simpler models cost less to use: trend projection and rate-ratio-proportion. Of the balance, cohort-component population projection techniques also are relatively inexpensive because of their widespread use and availability of data and of "canned" computer calculation routines. Econometric and input-output models are expensive for at least two reasons: they require considerable data and they require considerable sophistication in calibration and use (and, hence, outside help in most cases). Incidentally, this is true not so much because of the complexity of relationships in these techniques, but because of the number and complexity of interrelationships and interdependencies. In between are shift-share and economic-based techniques. For these, and many of the other techniques as well, individual circumstances have a significant effect on cost of use, particularly desired detail and availability of data.

Input Data Availability

Data required for transportation planning projections may be divided into four groups when discussing availability (at the study area level):

- Demographic: population by age, sex, race, and so forth
  household, by size, income, auto ownership, number of persons employed
- Employment: by residence location, and industry or occupation
  by employment location and industry or occupation

The first three of these are available from the Census, but the last—by employment location—is available only from sources that are, at best, incomplete.

Of equal concern is the timeliness of the data. The full census is available only every 10 years. Intercensal updates are taken at sample rates that do not make use at the study area level easy or reliable, while nondecennial census employment data are incomplete or at too low a sample rate for direct use.

Finally, even the Census does not present data in the specific format needed for transportation planning projection-cross-classification.

Given this general situation then, how do different techniques compare and rate?

The simpler trend projection and rate-ratio-proportion models come out best, but only given reservations about detail and other criteria expressed above.

All of the employment projection techniques which work with employment at place of work force real struggles for data. Again, the simpler the model and the less detail required the easier the data assembly (and the fewer assumptions required).

Means of Monitoring Projections

Can the projections be monitored? This criterion, to a large extent, is independent of the methodology or technique used in making projections. Instead it is related to the variables or data that are projected. For example, population might be projected by any of the techniques described in Chapter Two, but monitoring of actual population change is limited to decennial or special censuses or to monitoring of a symptomatic variable, such as the issuance of building or occupancy permits, regardless of the projection technique.

The difficulty of monitoring changes in the variables used in transportation planning are similar, in many ways, to problems involved in establishing baseline data (or historical data) to be used in projection work. The discussion (below) on data for economic variables and automobile ownership includes specific discussion of the difficulties of obtaining current and usable information.

Methods for estimating intercensal population and income for small areas (smaller than states) are described and evaluated in a recent report (National Research Council, *192*) which was prompted by the revenue allocation formulas used for many federal programs and the long period between decennial censuses. This report does not address the criterion being discussed here. It does offer guidance for methods to prepare estimates that are, in effect, monitoring local area change.

In summary, just as there is no technique which is superior on criteria of data availability, there is none which is superior for ease of monitoring change. While specific circumsntaces and needs play a role in ease of monitoring, as they did in judging the utility of a technique according to its data requirements, the monitoring of change is largely independent of the projection technique.

Ratio Techniques—Demographic Projections

The ratio or step-down technique is limited in its applicability to projection of transportation-related variables, in a mechanical sense only by the availability of needed variables at the level of the parent area (or areas). Advantages and disadvantages relative to other criteria are discussed below, but if the analyst can define the variables or data he or she wishes to project, and their form,

then the capability to project them is limited only by the availability of the same variables in the same form for the parent area. (Presumably, the analyst's "ideal" definition of the variables would satisfy needs for additional or related variables and for other uses, such as an interface with an allocation model.)

Unfortunately, commonly available parent-area projections, such as those prepared by the Census or BEA, project variables in a form that is not immediately useful for transportation planning. Chapter Four describes several examples of agency ingenuity in transforming parent-area variables.

Ratios can be applied not only to total population (or employment, etc.), but just as well to separate cohorts (e.g., household types or age groups) and to socioeconomic characteristics of the population (e.g., income or car ownership). Thus, the approach is applicable to a range of transportation planning needs, wherever the basic assumptions apply, not just to projection of population size. It also can produce cross-tabulations, cell by cell, as long as the data necessary for calibration are available and the sizes of frequency counts within cells are large enough to provide statistical stability.

The ratio model employs a straightforward logic—as the parent area goes, so goes the study area. This logic is not so much right or wrong as it is dependent on the assumptions of past and future similarity between parent area and study area. That is, the presumed validity of the logic depends on (1) how similar the study area has been to the parent area in the past, and (2) to what extent the future fate of the study area is expected to be tied to the parent area in the same way. Similarity in the past, or orderly change, is necessary in order to calibrate the ratio or ratios between a study area variable or change and the parent area variable or change. The assumption of continued similarity in the future is necessary to have a reasonable basis for projection of the study area's share. In order for the ratio approach to be logically valid, therefore, the analyst is under an implied obligation to make a reasonable case that the study area has been and will continue to be "like" the parent area.

The model not only requires that a projection for the parent area is available but also that it is of "good quality." That assumption, in turn, depends on the logic and assumptions used in calculating the parent area projection.

The logic of the ratio method is transparent; but the assumptions may not be. It is easy to see in graphic or tabular form how the study area has shared in the parent's area population (or other) history and how it is projected to do the same in the future. What may not be transparent are the logic, assumptions, and data on which the parent area projections are based, unless the transportation analyst makes them transparent through his or her procedures and in presentations or written reports. The analyst should do so.

The independent variables projected for the parent area and the relationship of the study area to the parent area are certainly logical determinants of the study area variables if the basic assumptions of the method are valid. These variables, and the assumed relationship, are ill-suited, however, to express policy changes in the study area (for example, an economic development effort) or changes in assumptions about special factors (such as those that might affect the study area's birth rates, death rates, or migration rates). Judgment can be applied, of course, to adjust the extrapolation of future ratios, but the fuzzy linkage between the ratio being adjusted and the assumed event or policy affecting change makes such judgments highly uncertain.

On the other hand, this is not to say that ratios can only reflect past trends. A population projection for the parent area may be designed to reflect policies and other factors that also are expected to influence the study area. To this extent (i.e., by way of the parent area projection), the study area projection can be made to reflect policies and other assumptions about future departures from past trends. What is difficult to account for is the departure of study area trends from parent area trends.

The ratio model, like the others reviewed here, can be tested over an historical period for the study area and then compared in average accuracy and variation of accuracy to other approaches. Such comparisons help the analyst and user decide which approach or which combination of approaches to use. If a combination of approaches seems appropriate, the results of such tests might be used to determine the relative weight that is given to results of the separate approaches in combining them into a single projection of future population.

There is an inherent bias to ratio projection. The study area's future is fully determined by the future of its parent area. This bias casts a deterministic or fatalistic complexion on forecasts by ratio methods. Use of the ratio approach therefore should be limited to situations where such a submission of the study area's fate is acceptable.

With respect to the criterion of resources to support use of the model, the ratio method has much to recommend it. Generally, the required data are relatively few and easily available; the computation is easy. A time series of historical data on population size (or other characteristics) for both study and parent area is necessary to calibrate the value of the ratio or ratios. As noted above the only other prerequisite is a good quality projection for the parent area or areas. Although some transformation may be required, data and good quality projections frequently are available from Census or BEA or from state level agencies.

Ratio Techniques—Economic Projections

The advantages and disadvantages cited above, in the discussion of the use of ratio techniques in projecting population variables, are largely applicable in projecting economic variables. Obviously, and as is shown in each of the examples described in Chapter Four, the ratio technique may be applied to summary measures (total population, employment), to components (manufacturing employment), or to multipliers or coefficients (for example, in an input-output matrix or an econometric equation). The inherent assumption is always the same: that extrapolation of the relationship of the study area to the parent can be rationalized.

Shift-share analysis is a specific formulation based on ratios (or shares).

Stevens and Moore (*84*) provide a thorough recent review of shift-share analysis, particularly in a forecasting context. Their discussion concerns the assumptions and form of the technique.

The assumptions in the use of shift-share analysis for projection are basically the same as those in any extrapolative technique: that projected change in the variables of interest (regional share in employment and regional shift) may be based on a trend observed in historical data. (Alternatively, regional growth in an industry may be based on a parent area rate of change.) Regardless, as Stevens and Moore put it (p. 249), "there appears to be no solid theoretical basis for assuming constancy of shift,

even for a moderate-length five-year forecast." They also raise objections to assumptions regarding constant share.

The other issue which Stevens and Moore address (including a review of recent literature) is the basis and assumed relationship for projection. Applications of shift-share analysis have been made using historical data as well as projected data for a larger parent area. Rates of change (shift) have been projected using linear, constant or nonlinear functions, fit both graphically and with curve-fitting techniques. No clearly superior method appears to have emerged.

In summary, shift-share is straightforward and understandable (although it can be abused). As with simple extrapolation, unless some explicit assumption is introduced regarding change in share, time is the independent variable. Little empirical testing is reported (although Stevens and Moore report some comparison of forms and assumptions, mostly in a research context).

Shift-share requires comparatively little data, and the majority of it is readily available.

> . . . . [S]hift-share is a simple technique which relies on easily accessible published data, making it fast and reasonably accurate, given its cost . . . shift-share has not yet been subjected to the kind of critical empirical tests which would raise serious doubts in the minds of practitioners about the accuracy of forecasts made with this technique. This is because the literature has not concentrated on the absolute predictive performance of shift-share, but has almost exclusively dealt with the relative performance of alternative forecasting forms of this approach. Since practitioners have not had any clear indication of serious weaknesses in the forecasts made with shift-share, they have continued to rely on this technique because of the practical advantages mentioned above. (Stevens and Moore (*84*)

Shift-share produces estimates (or projections) of employment by sector. These are directly usable in transportation planning, given some technique for subarea disaggregation.

Independent Techniques—Demographic Projections

Extrapolation Models

As a logical model of change, simple extrapolation of a trend is of questionable validity. Time, the independent variable, is a weak and indirect proxy for the true factors underlying change. Whatever its validity, the model's logic is certainly transparent. It is easy for the analyst and user to see (literally, on a graph if desired) the relationship between time and size.

In a more important and fundamental sense, however, extrapolation techniques are not transparent at all. The linkages between the dependent variable and true underlying causes are hidden because the relationship with the independent variable, time, is not explicit. The analyst might counter this weakness of extrapolation to some extent by noting, for the user, what rates (i.e., birth, death, etc.) were prevalent in the historical period on which the model is calibrated. He or she might also note any historic events related to components of change. In this way, the user might better judge whether a similar combination of factors is likely for the projection period. Even then, the assumptions involved in extrapolation may or may not be reasonable; one cannot assess whether they are. The assumptions remain largely hidden behind the proxy variable, time. This is the case even when the analyst reveals the stream of rates and events that is parallel to the time stream on which the extrapolation model is calibrated.

As with the ratio model, the extrapolation model can be subjected to empirical verification by virtue of the calibration procedure.

As a group, extrapolation models have no inherent biases except for the complete reliance on past trends, without respect to assessment of the effect of the underlying variable composition or the rates of change within the components of population change.

Extrapolation is a basic and general forecasting method, applicable to almost any context, and not limited to forecasting population levels or even other demographic variables. It certainly is not limited to transportation planning.

Data requirements are even less for extrapolation than for ratio methods. Only historic data for the study area are required. Analogous historical data for the parent area or areas is unnecessary, as is an independent projection for the parent area (or areas). The computation for calibrating the chosen form of extrapolation model (or for calibrating several of them to compare how well they fit the data) is essentially the same as would be required to project ratios for the ratio method. Once calibrated, the models are easily used for calculating projections. It is simply a matter of plugging in the independent variable, the projection year, and calculating the value from a single equation.

An extrapolation model can be used to project any variable required for the transportation planning process, so long as the data are available for calibrating the model for a past period of time. Extrapolation can produce data for cells of cross-tabulation tables, or at least first cuts of them. They may have to be adjusted to sum to column and row totals, which might be projected independently.

Goldstein (*74*) evaluates a linear multiple regression model (and input-output and econometric models) for projection of employment in small areas. He concludes that the linear multiple regression model produces satisfactory results, given the resources and expertise required for either input-output or econometric techniques.

Component Methods

The component method has more logical validity than the ratio or trend projection techniques. It stimulates the underlying theoretical construct for demographic change—that population change must equal births, minus deaths, plus net migration. Even in this approach, however, most of the current techniques still conceive of migration as the *net* movement across study area boundaries, not as the combination of outmovers and inmovers.

The migration component is calibrated by residual methods rather than directly.

Conceptually, the model is quite clear. In application, however, it requires close study to trace the causes of population change by age-specific cohorts. The linkages to underlying causes are there to see, but the computational complexity of the model makes them more difficult to understand without careful scrutiny.

The implicit assumptions in the model are more reasonable than those embodied in the structure of the ratio and extrap-

olation models. It also is easier to represent societal and policy assumptions and see how they affect births, deaths, migration, and various age cohorts differently. This makes the component model a better tool than ratio and extrapolation models for testing the sensitivity of population projections to shifts in assumptions about underlying vital rates and migration rates.

The component model's output, as well as the input assumptions about age-specific rates of change in the components, can be subjected to empirical verification over an historical period (although, as noted above, the relative infrequency of the decennial census causes difficulty in identifying short-term changes).

The component model has no inherent biases. It has definite limitations for very small study areas, however; particularly, if they are integral parts of a large urban area. In such areas, population change may be more a function of housing markets than demographic factors of births, deaths, or even true migration (as opposed to short distance moves).

Unlike ratio and extrapolation methods, the component method is limited to population projection. It is not a general forecasting technique. Component techniques, in fact, rely on the more general extrapolation or ratio techniques for projecting vital rates and migration rates as inputs. Logistically the component method makes much tougher demands than ratio and extrapolation models. It requires more data and more calculation. Further, the required data on fertility and mortality often are more difficult to obtain than simple population level data necessary for the other two methods. The computation for a full-scale, long-range cohort-component projection virtually mandates a computer program and access to a computer with adequate memory. In any case, the input data on population levels and vital rates must be sought out and prepared by hand. Furthermore, the component method requires separate, supplemental projection of special populations whose change is not dependent on vital rates and migration in the normal way (e.g., institutional populations).

The cohort-component method projects composition of the population as well as its total size. Population composition might be a better basis for projections of other socioeconomic characteristics of the population, particularly those that are closely related to such transportation demand variables as auto ownership and trip-making behavior.

Independent Techniques—Economic Projections

The application of basic trend extrapolation to economic variables is subject to the same advantages and disadvantages as in its application to population.

Unlike population, however, a number of more elaborate methods for preparing independent projections of economic variables are available.

Economic Base Analysis

Despite the fact that they were published some years ago, articles by Gillis and Grigsby, Blumenfeld, Tiebout, Pfouts, and Pfouts and Curtis (all in Pfouts, *82*) more than adequately describe the theoretical and practical difficulties with economic base analysis.

Perhaps the most fundamental problem is both practical and theoretical: the notion that an area grows as the result of export activity ends up confounded in the obverse of the difficulty of migration estimation; while it may be possible to identify "export" or "basic" activities in a small, simple community, as the analysis area increases in size its very nature makes the proportion of "basic" activities smaller and more difficult to identify.

Simultaneously, the assumption of a constant (or relatively constant) positive relationship between service and basic employment can produce misleading conclusions:

> It is customary to use the number of service employees per one-hundred basic employees as the base-service ratio. Thus if a city had 160 service employees for every 100 basic employees in 1940 and had 200 service employees for every 100 basic employees in 1950, it had shown an increase of 40 service employees for every 100 basic employees during the decade. Then according to the economic base theory we would expect a diminution of economic activity and population because of the relative shrinkage of the economic base, or because of the shrinkage of the growth potential of the city. On the other hand, if the relative number of service employees declined during the decade we would expect an increase in economic activity and in population, according to economic base theory. Consequently our two series should show a negative correlation if the economic base theory were valid. An advocate of the economic base theory could argue that an increase in basic employment would bring about an increase in service employment in a subsequent time period. If we took the base-service ratio at the beginning of this second time period and at the end, we would find an increase in service employment, and (assuming no increase in basic employment in the second time period) we would find an increase in the base-service ratio. There would be an accompanying increase in population and a positive instead of negative correlation. This is, however, a short period of adjustment. The ability of service-type firms to come into and go out of existence is well known. If service employment increases relative to basic employment over a ten-year period, as population increases surely we have a contradiction of the economic base theory. If we do not, the economic base theory is so general as to be incapable of contradiction and hence cannot be viewed as a scientific hypothesis. (Tiebout, *82*)

Practical problems also have emerged. For example, measurement of employment in basic and service industries has been attempted by specifying entire industries as one or the other. However, while some are clear (barbershops are service), others are not (manufacture of a consumer good). This difficulty has been circumvented by estimating the proportion of employment in an industry which serves local demand as opposed to that which serves external or "export" demand. But this gets both difficult and subjective.

Economic base analysis, like shift-share, relies primarily on time as an independent variable, although change in basic industry may be related to secular growth in a "parent" region.

Multipliers and Input-Output

As the description of multipliers in Chapter Two implied, the concept or technique first was introduced to overcome some of the difficulties with the ratio of basic-to-service employment in economic base analysis. Because the income flows used in calculating the multiplier more accurately capture the total economic activity of the subarea, they permit calculation of a less ambiguous ratio or multiplier than employment. (See Tiebout in Pfouts (*82*), p. 341, for an example case study.)

The input-output matrix carries the concept of multipliers to a logical extreme in relating the local and "export" or external consumption and production of each industry to each other industry and to external demand.

Yet, input-output requires considerable amounts of data, sophisticated analytic techniques (and ability on the part of the analyst) and, frequently, critical assumptions about the coefficients ("multipliers") and the final demand vector.

Input-output (and simple multipliers) have a solid grounding in economic theory. Although the full input-output model is complex, the basic concept is understandable. Given the ability to project (or assume) values for final demand by industry and values of the coefficients (multipliers), numerous policies of interest to the transportation planner can be evaluated, at least in terms of activity by sector, using input-output.

The major problem with input-output (and with simpler multipliers, to a lesser degree) is the demand on resources and expertise required for their use.

Econometric Models

The excerpt (in Chapter Two) describing the general structure of econometric models serves to underscore the major difficulty with their use in projection work for transportation planning: they are complex, sophisticated, resource-consuming, and extraordinarily demanding of data.

Simultaneously, they are perhaps the most well-grounded in theory of all the economic models and, given the number of relationships involved, perhaps not overly difficult to grasp, at least in general terms.

The assumptions vary from model to model. It is important to note, though, that each of them includes relationships among its variables which either are fit using existing data (with an implicit or explicit assumption regarding future change) or are stated *a priori.* While not a criticism of econometric models (any more than of any other), it is important to recognize this dependence when it might be overlooked in the complexity and sophistication.

Although there are great differences among the models, in general they offer the most satisfactory solution for economic forecasting for transportation planning, based on the criteria introduced earlier, except for those relating to the difficulties of data collection and assembly, resource demands, fitting, computational demand, and required expertise. The isolated examples of their use in transportation planning have involved expert outside assistance and implied considerable resources. (See, for example, San Diego Comprehensive Planning Organization (*166, 168, 169, 170, 171, 172*) and the discussion in Chapter Four.)

Data for Economic Techniques

Historical and current demographic data for transportation planning are commonly and easily available, at least compared to economic data. A person is easy to recognize and count, but income and employment are not so simple.

The difficulties with income range from those of definition (salary is easy: what about noncash income? tips? dividends? out-of-state?) to those of reporting (tax laws make underreporting attractive, and income frequently is regarded as private information) or of change and comparability over time, given inflation.

Employment has definitional problems (full-time, part-time, primary job, second job), as well as locational problems. Moreover, for transportation planning purposes it usually is desirable to know employment at employment location (not residence) and transportation planning interview techniques and samples simply do not provide adequate employment data.

Yet, secondary sources are not entirely satisfactory either. Usually their data are collected for an entirely different purpose, such as social security or unemployment insurance records. Both of these examples do not cover the entire labor force and they use incompatible classification schemes. Sample surveys of employment (such as those performed by the Census) do not furnish data with sufficient geographic detail for most transportation planning.

Adams and Glickman (*68*) discuss the difficulties with data which occur in econometric modeling. Chapter Four describes the compromises and adaptations of data made by several planning agencies.

CHAPTER FOUR

APPLICATION IN PRACTICE

Chapters Two and Three have reviewed and evaluated methods or techniques that are available for, and commonly used in, projecting demographic and socioeconomic variables used in transportation planning. Only in the econometric models, such as the one employed by the BEA for the OBERS projections, are population, employment, and income (and other variables in some models) internal or endogenous to a "single model." But it should be recognized that the operation or implementation in a single computer program sometimes makes the "single model" more apparent than real. As was seen in Bolton's description of the "model-of-a-model" in Chapter Two, there are models within models, and the fact that linkages and flows of

information take place at high speed, internal to the program which contains the "models," does not make the "models" greatly different from those in which the analyst uses the output from one to enter another.

This chapter describes seven examples of forecasting and projecting demographic and socioeconomic variables in metropolitan planning organizations which perform transportation planning, among several planning activities. They are not intended as good or bad examples of practice. They represent solutions to the difficult problem of preparing projections, by planning professionals working in individual circumstances of resources, time, data, and staff. The MPO personnel provided information on their methodology in response to inquiry, which in turn was prompted by a general description of their projection and disaggregation procedures provided to researchers at the University of Florida (*101*). These seven were selected as examples for this chapter because they are well documented, illustrate different approaches to the common problem, and use a variety of the techniques described earlier.

As a final note before describing the procedures, the cohort-component population model (or a minor variation) is common to all of the examples. This reflects the fact that it has become the method of choice for virtually all demographic projection work. Where aggregate projections of population, and population characteristics, are used, they usually serve as checks for reasonableness, are intended only as "quick" preliminary projections or are used as "baseline" projections for comparison to the results from other methods. What is of interest in reviewing the various applications of cohort-component models is the source of fertility, mortality, and migration rates.

COHORT-COMPONENT MODEL AND RATIO TECHNIQUE

The projections prepared for the Indianapolis Regional Transportation and Development Study (IRTADS) involved, primarily, a cohort-component model for population and a ratio to, or "step-down" from, a parent area forecast for employment. As is frequently the case, the area for which the projection was prepared did not coincide with political unit boundaries: it included all of one county and small parts of two adjacent counties.

Population was forecast for 15 age groups by race and sex, yielding 60 total cohorts. Initial data (1970) were developed from Census data. For the partial county areas, "urban" population was identified by subtracting rural population from the total. Each cohort was identified as a percentage of total urban population in each county, and these percentages were applied to each county's part of the total study area population.

Fertility rates were taken from an earlier set of projections for which a set of rates had been derived from national (Census) rates. Although the average rate was slightly higher than recent local and state experience, the analysts reasoned that fertility was depressed currently by economic expectations and changes in lifestyle and that it would rise slightly over the period.

National (Census, 1972) survival rates were used and were assumed to remain constant throughout the projection period.

Migration was assumed to be net zero. The central county had lost a small amount of population during the previous decade, while the outlying counties and the SMSA (eight counties) had gained, as had the portions of the two outlying counties which were within the study area. The zero migration assumption was made because of (1) known movement within the study area from the central county and (2) the adequacy of land for development within the study area boundary.

Employment was forecast by a ratio to a parent-area forecast. Interestingly, four parent-area forecasts were available, and were evaluated for use: (1) OBERS, (2) a locally prepared forecast based on least squares equations fit to 1950–1972 historical data; (3) a locally prepared forecast based on a modification of the export-base multiplier method and an apportionment of state projections, and (4) a locally prepared forecast, again based on export-base multipliers, but developing multipliers from national forecasts by industry.

The OBERS and least-squares techniques produced, respectively, the highest and lowest projections (OBERS was 117 percent of the least-squares) with the other two between. Because the middle results seemed more reasonable and the staff regarded the export-base methodology as preferable, one of the two was selected (on a final basis of convenience because their results were so similar).

Total employment figures for the study area for 1964 and 1970 were used to establish ratios to employment in the area used in the parent forecast. These ratios showed a slight increase during the period which was extrapolated to 1980, then held constant to the end of the projection period (on the assumption that the study area share of SMSA employment would continue to increase, then level off).

The distribution of employment within ten industry groups was assumed to follow 1964–1970 trends, but at a slower rate through the projection period. The percentage change from 1964 to 1970 was extrapolated to a 10-year period, then divided by 2 and applied to the five projection points: 1975, 1980, 1985, 1990, 1995. The effect was to assume that the trend projections of proportions of employment by industry for 1980 would be reached, instead, in 1995. Special adjustments were made to account for 1964 to 1970 trends in two employment groups which were felt to be aberrant.

Results of the procedure were compared to another forecast, but no adjustments were felt to be necessary.

Total employment was forecast to rise from 45 percent to 50 percent of population by 1995, but no change in the net migration assumption was made, apparently because the increase was thought to be reasonable and in line with current trends in labor force participation.

Households (and housing units) were projected by, first, extrapolating the 1960–1970 ratio of population in households to total population, then dividing the household population by an assumed household size. The latter was obtained from a separate study of the local housing market and showed a slight decline. Housing units were projected by applying a historical vacancy rate which was assumed to decrease by about 10 percent by 1985, then hold constant. Housing unit type was forecast using 1960–1970 trends from the Census (for the central county: study area data were not available), and local records of construction and demolition since the Census.

Household automobiles were forecast by apportionment of a parent-area forecast which had been made for the SMSA using a least squares, linear model fit to 1962–1971 registration data. A ratio of household automobiles in the study area (from the transportation study area data for 1964 and 1970) to registrations in the three county parent-area was established and extrapolated (linear) to 1995.

School enrollment generally was projected by relating 1970 inventory data to age cohorts and assuming the ratios to hold constant. Data limitations prevented analysis of change (as above for other characteristics) and an adjustment was made to college-age attendance based on an anticipated increase and interviews with staffs of local higher education institutions.

COHORT-COMPONENT MODEL AND TREND EXTRAPOLATION

The Tri-State Regional Planning Commission, for the period 1977–2000, used a cohort-component demographic model, with migration dependent on employment projections. The latter, and other variables, were forecast by extrapolations (or modified extrapolations) of current rates or recent trends.

Population was projected using age-specific life expectancy rates from the Census, and fertility rates which assumed a short-run drop below replacement level, followed by a return to "replacement" rate midway through the period. Migration was assumed to respond to employment and natural change in population, conditioned by assumptions regarding labor force participation and other factors.

Employment was forecast independently by analysis of trends in regional employment change from 1958 to 1975, with emphasis on the period since 1970.

Labor force participation was assumed to hold constant at the 1970 rate, with increased female participation offset by earlier retirements and decreased participation by the 14 to 20 cohort. (These assumptions were based on Current Population Survey information.) A representative unemployment rate of 5.5 percent, based on early 1970's data, was assumed to decline to 4.0 percent by 1985–1990, then hold steady, and the dual job-holding rate was presumed to remain at the current 5.5 percent.

The *nonresident labor force* then was estimated for each period based on the labor force participation, unemployment, and dual job holding rates, adjusted for inmigration. Net migration then was determined by the relationship between the employment forecast and the inresident labor force forecast, inflated by the relationship of dependents to job-holders: if employment was greater, then net inmigration was assumed, and vice-versa if labor-force was greater. Historic migration rates were analyzed and applied independently to the over-65 group on the assumption that they are not responsive to employment. Allocation of migration to age-groups was based on a distributive system for the Boston SMSA; selected because it is a "slow growth" region similar to Tri-State.

Income was forecast based on trends in employment and productivity per employee. Historic data on regional productivity were related (in a log-linear equation) to national productivity in changes and forecast, based on national projections, with a short-term rate slightly below the national constant rate of +2.5 percent per year, followed by a return to the nominal rate for the region. Time series ratios of personal income to gross national product (national, 1959–1975) were extrapolated and applied to regional output (from employment and productivity, above) to obtain regional personal income totals. The rate of growth of personal income then was applied to household income.

The *number of households* was forecast based on extrapolation of historic trends in household size and population projections (above) with minor adjustments. Allocation of estimated households to income groups was performed using an interpolation technique to relate differential rates of change in income and number of households.

COHORT-COMPONENT MODEL, AND RATIO AND TREND EXTRAPOLATION

The Southwestern Pennsylvania Regional Planning Commission (SPRPC) initiated their forecasting procedure with *employment* for the six-county region around Pittsburgh (*181, 182*).

Initially, three forecasts of employment for the region were used, one prepared by the State of Pennsylvania, two from historic data for the region.

The two SPRPC forecasts were based on 1960–1974 data for (1) regional share of Pennsylvania employment and (2) absolute regional employment, both for 12 nonmanufacturing and 18 manufacturing industries. Trial fits were made to the data with five different "curves" (linear, parabolic, hyperbolic, exponential, and log). Curves were selected for each industry based on the standard error and correlation coefficient and all resulting curves (and their projections) were inspected for reasonableness and compared to the forecasts prepared by the State of Pennsylvania. Final forecasts by industry were selected from all three sources. Several categories were adjusted on the basis of other local evidence, and a special analysis of "government" employment was made to separate health-related, education, and other government. Separate linear models were fit for the latter categories.

For input to the population model, primary employment (agriculture, mining, all manufacturing) was related to total employment as a ratio. The historic data indicated that the ratio was increasing slowly but steadily, and examination of the results of the employment forecasts showed that they contained a similar trend to the year 2000.

Population was forecast in a four-step procedure. First, natural increase was forecast, by age and sex cohort, using Census Bureau birth rates and local mortality data. Fulltime primary employment rates (i.e., "first" jobs in fulltime equivalents) were prepared for each age-sex cohort based on 1970 Census data. Projected changes in these rates were prepared using Bureau of Labor Statistics data on national labor force participation. The *supply of fulltime primary workers* then was calculated as the product of the population and rate, by cohort.

Employment forecasts *by industry* were converted to employment *by occupation* using 1960 and 1970 Census data to create an occupation/industry matrix and calibrate a geometric (i.e.: compounded percent annual change) model. Employment by occupation was forecast for each 5-year point (1970–2000) by summing across industry. Fulltime employment rates for both sexes were derived for each occupation from home interview data (i.e., number of fulltime primary workers/number of total workers by sex and occupation). These rates then were applied to the forecasts of total employment by occupation (above) to derive the *demand for fulltime primary workers.*

The supply of and demand for fulltime workers were "matched" by occupation. The differences (positive or negative) with adjustments for changes in unemployment (up if there was a surplus; down if a deficiency) then were assumed to represent migration. A rate for number of dependents per primary fulltime worker was calculated for each age-sex cohort and applied, along

with an adjustment for group-quarter population, to the forecast of natural increase plus migration. Migration rates for the elderly, calculated from historic data, were prepared and applied to the 65 and over population, completing a 5-year cycle.

Household formation rates were derived from Census projections by age-sex cohort and applied to the population forecast to determine number of households.

Household income was forecast using a variation of the procedure suggested by the Federal Highway Administration (*119*). Change in regional per capita income was assumed to be linked to change in the Gross National Product (GNP), and differential rates of growth were assumed to apply to different income classes.

Distributions of households by income classes were prepared from historical data (1960 and 1970 Census, 1977 home interview), with classes standardized to constant dollar values (using the Consumer Price Index) to account for inflation. Annual percent changes in real income then were calculated for each of the classes.

Using historic data for the nation, state, and SMSA, a relationship was established between SMSA per capita income and GNP. This equation was used with national forecasts of GNP growth (from OBERS, other BEA, and several other sources, combined using local judgment) to forecast SMSA per capita income, which then was converted to household income using an average household size, predicted as a trend based on regional data. Average annual growth rates then were determined for each of several "sub-periods" within the overall projection period.

Differential growth adjustment factors were established for each income class or group, using the earlier analysis as a guide (above). These factors were combined with the average annual regional change and were used to adjust the values of the base period class boundaries. (For example, the first "class" in 1977 was households with an income less than $2,200. The overall growth rate for the first period, 1977 to 1980, was 0.08 percent per year, while the class adjustment factor was 1.2. The class annual growth then was 1.2×0.08, or 0.096. For the 3-year period, compounded, this is a total factor of 1.0029, and the new upper boundary is 1.0029×2200, or $2,206.) This procedure leaves the classes, and households within classes, intact.

COHORT-COMPONENT AND SHIFT-SHARE MODELS

The Northeastern Ohio Areawide Coordinating Council (NOACA) used a cohort-component model to project population and a shift-share model, related to national projections, for employment in the NOACA (Cleveland) region (*179*).

Survival rates for the cohort-component model were obtained from Census projection. Fertility rates were based on county-specific birth data obtained from the State, and were compared to historic and projected national rates to establish projected values. Both fertility and survival rates were established for age-sex-race cohorts and for each of the five counties in the NOACA region.

Migration data for the periods 1960 to 1970 by age and sex were obtained, (Bowles *196, 197*) along with post-1970 data from Census *Current Population Reports,* and projected for each county. (Each of the five counties in the NOACA area prepared the fertility, mortality, and migration rates for use in the cohort-component model. Regional totals were the sum of the county projections.)

The shift-share model used to forecast *employment* for 1980 and 1985 required local and national employment data, by industry and total, from two prior points in time, plus a forecast of national employment, by industry and total. Each industry then was forecast separately. (See Chapter Two on shift-share technique.)

Local employment data, by county, were obtained from the Ohio Bureau of Employment Services, while national data were from BLS publications. Four separate projections were made for each industry, using different pairs of prior time points. These projections then were averaged to minimize the effect of short-term fluctuations in the historic local employment data.

The BLS national employment projections were based on several assumptions about continuity of social and economic conditions, and, specifically, a 4 percent unemployment rate and a 3 percent inflation rate. NOACA added assumptions:

- Census Series E projections of demographic rates. The most critical is a fertility rate at replacement level.
- Labor force participation will continue to change in the pattern established in 1955–1972, tapering to zero change in 50 years.
- Average annual paid hours per worker are assumed to decline by 0.3 percent per year.
- Productivity will continue to increase at the historic rate of 2.7 percent per year.
- All levels of government will expand, but local and state will grow faster than federal. Federal, state, and local budgets will be approximately balanced by 1980 and 1985.
- Residential construction will remain a constant proportion of GNP after 1978.
- International trade will show a slight positive (export) surplus by 1980 and 1985.

A polynomial model, fit with least squares, was used to project employment trends by industry to 1990, 1995, 2000 because adequate national projections were not available to support the shift-share model.

County-level employment was disaggregated from regional totals, by industry, using data from the Ohio employment security agency for "wage and salary employment" and "covered workers." The former included a large proportion of all workers while the latter was reported at the county level. Basically, percentages from the "covered workers" data were used to disaggregate the former and, presumably, trended for disaggregation of forecast data.

The number and size of *households* were calculated from 1960 and 1970 Census data: for men the 1960–1970 change was halved and used for 1970–1975, while for women the 1960–1970 change in rate was assumed to occur again between 1970 and 1975. In effect, these assumptions continued the male rates, but doubled the female rates. Rates for black households were available only for 1970: these were increased 30 percent for females and held constant for men. White rates were calculated (from total and black rates), then all rates were rounded up and assumed constant for 1980 and 1985. Total households (heads) were calculated, and population (less group quarters) was used with households to calculate household size.

Regional household income was estimated by inflating 1970 Census income class boundary values, then assuming that the

proportion of households in each income range (by size) remains the same, interpolating to find new numbers of households in the old ranges. Median income was calculated using households within each range and assuming an even distribution of households by income within each range.

Automobiles per household were calculated at the zone level, based on projections of mean values of auto ownership (and household size) for the zone level (*119, 177*).

ECONOMETRIC MODELS

Kansas City (*175, 176*), San Diego (*167* through *174*), and Puget Sound (Seattle, *190*) all used econometric models to forecast population and employment (and income).

San Diego uses a model, prepared for its use by a private consultant, called Demographic and Economic Forecasting Model (1979 version) or DEFM79, which evolved from earlier versions and from IPEF, which is discussed below.

DEFM79 involves six sectors or submodels: population, employment, income, prices, public finance, and construction. Their relationships are shown in Figure 8 (from *169,* p. 1) and are described in the model by a set of simultaneous, nonlinear equations. Operation of the model is on an annual basis: that is, it is iterated year-by-year, rather than in 5- or 10-year increments as is frequently the case.

The *population* sector basically is a cohort component model, with migration divided into separate estimates for military-related, retirement-related, and employment-related groups. Military-related migration is determined outside the model, retirement- and employment-related migration both are sensitive to housing prices, while employment-related migration also is sensitive to local and national employment and to changes in local employment. Individual equations forecast *households, group quarters population, labor force participation,* and *school enrollment* based on trended values from current data.

Employment is forecast at the two-digit SIC-code level as a linear function of an index (for each industry) which, in turn, is based on one or more of several independent variables. For the majority of industries, these variables include the final demand coefficients for an input-output matrix for the region. Other independent variables used in index construction include national and local income level, population, disposable income, and local government expenditures.

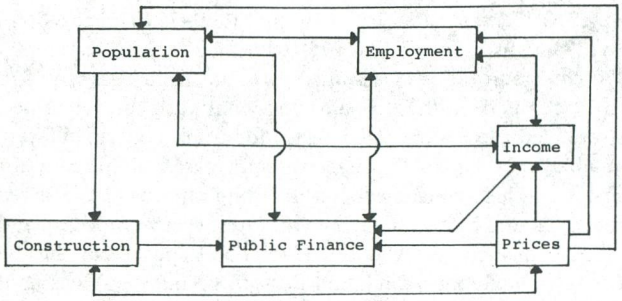


Figure 8. General relationships in demographic and economic forecasting model (San Diego CPO).

Income is a function of employment by industry, industry-specific payroll-per-employee, and trended wage rates, with special treatment for government and military categories. Income from sources other than payroll is based on a set of regression equations using historic relationships to other variables, some endogenous to the model, others externally supplied. Transfer income and taxes also are accounted for.

The *price* sector primarily is concerned with the housing market and construction cost. Forecasts are based on the historic relationship to changes in disposable income, construction costs, vacancy rates, wages rates, and the consumer price index.

Construction includes both residential and nonresidential. The former is related to national market conditions, local vacancy rates, change in the number of households and replacement of stock. Type of housing is related to households (by age-sex of head) through Census-based housing preference factors. Nonresidential construction is related to square feet per employee.

Public finance forecasts are based on a number of local tax rates, tied to other sectors in the model, and to assumptions that reflect constraints recently placed on taxes in the State of California. Relationships to variables in other sectors are based on assumptions of continuity of current levels or past trends.

This brief description does little more than outline the general relationships within the model: there are hundreds of equations and variables involved. However, two points may be made.

The first and most obvious is the complexity of the model, and the extent of the demands for detailed specification of relationships and for data. They, in turn, underscore the extent of resources, manpower and knowledge needed both to construct and operate such a model.

Second, and importantly, is the basic simplicity of the relationships within the model. A brief review of the narrative description of the six sectors reveals that the hundreds of submodels—the equations within DEFM79—involve the same basic models found in every forecasting technique: assumptions of continuity or change in relationships to other variables, expressed in linear or nonlinear equations; ratios/rates/proportions; step-downs from projections for larger areas.

Finally, it should be recognized that the econometric model formalizes or depends on several general techniques discussed in Chapter Three. The cohort-component model is immediately obvious, and an input-output model is behind employment forecasts (although it is adapted in a novel way).

The complex econometric model is distinguished by the fact that all of these relationships and "interrelationships" are prespecified and must work together. An obvious analogy is a complex machine built from individual mechanisms, each of which not only must function itself, but must function correctly with all of the other component mechanisms if the machine is to work correctly.

The Mid-America Regional Council used the Interactive Population and Employment Forecasting model (IPEF) to develop aggregate projections for the Kansas City Metropolitan Region.

Designed to produce medium-range to long-range demographic and employment forecasts, the IPEF model integrates two fundamental forecasting techniques: first, the cohort-survival method of population forecasting and second, an econometric approach to employment forecasting. As a result, IPEF is sensitive to the interdependence of demographic and economic forces within a particular region.

In the demographic sector, births are calculated from projec-

tions of U.S. fertility rates by age for females (from Census Current Population Reports). Deaths are calculated from national projections of survival rates by age and sex. Aging the previous period's population by five years, adding in the births and subtracting out the deaths results in the natural population by age and sex. The final component of population change, net migration, is determined endogenously by the model through the interaction between labor supply and demand.

The region's available labor supply is calculated by multiplying age specific labor force participation rates by the natural population by age and sex and summing over all age/sex groups. Through the application of an assumed unemployment rate, a net commuting rate, and a jobs per employee ratio this figure is converted to the maximum number of jobs that can be filled. This is the labor supply that is then compared to the labor demand defined by the employment forecast.

The econometric models used to forecast employment are calibrated on historical data (from "Employment and Earnings", BLS, and "County Business Patterns", Census) to find the past relationship between the dependent and independent variable. The relationships is then applied to exogenous projections of the independent variable to calculate projections of the dependent variable. In IPEF, the dependent variable is place-of-work employment for each industrial sector. The independent variable depends on whether the industry is classified as basic or local serving.

Basic industries are exporting industries. Since they serve national markets, employment in a basic industry at the regional level is assumed to serve exactly the same market as the employment in the same industry nationally. Because national projections of employment already exist (Monthly Labor Review, BLS), each KCMR basic industry is therefore forecast as a function of the same industry at the national level.

Local serving industries satisfy local demand for products. Since local demand for services can only be expressed through the expenditure of local income, service industries are forecast as a function of income. However, as income forecasts are not available, a proxy variable is used, namely population. Note that future year population has not as yet been estimated. Therefore, the natural population is used as a first approximation of it.

Once the industrial employment forecasts have been completed, they are summed to produce a total employment figure. This defines the demand for labor. To ensure a balance between the size of the population and labor force requirements, the labor supply and demand are compared, and labor supply adjusted to labor demand through changes in net migration. Any excess labor is assumed to migrate from the region, while any labor deficiencies are assumed to be met through in-migration. Labor force migrants are then converted to total migrants based on a total migrant to labor force migrant ratio derived from national data (CPR, Census) which is added to or subtracted from the natural population.

Such changes in the population result in a revised demand for the goods and services of the local serving sectors, whose employment forecast must also be adjusted. This changes the total employment and specifies that labor supply adjusts to labor demand through a different net migration level. Population changes once more and the process is iterated until an equilibrium is reached. Upon equilibrium, the whole process is repeated for the next five year period. (Turner (*175*), pp. 9–11)

An interesting problem related to the slow growth of the Kansas City region's economy required modifications to the original IPEF model. Each iteration of the model forecast an additional increment of net out-migration because of the projected slow rate of growth in basic employment. Over several iterations, this resulted in a "rapid and unrealistic decline in population." Analysis revealed an over-sensitivity to labor force participation rates, the unemployment and commuting rates, and the jobs per employee ratio. These oversensitivities required revisions in the equations and independent variables used in projection of the dependent variables and, because suitable forecasts of the independent variables were not available for the region, ultimate reliance on national level projections.

As described in the foregoing quotation, the basic models are cohort-component and econometric, based on a general basic/nonbasic concept. Other techniques and assumptions included:

- An ultimate overall fertility rate of 2.1 births/woman of child-bearing age, from the Census.
- Unemployment rates related to projections of national unemployment rates.
- Use of the national jobs per employee (multiple job holders) ratio.
- Continuation of the average net commuting rate observed in the region from 1970 to 1977.
- Projection of employment by industry, for fourteen industries, based on historic data from the Bureau of Labor Statistics, for the SMSA, from 1967 to 1977.
- National employment projections from the BLS to 1990, extended to 2000 by assuming continuation in the change in the *rate* of change in national employment by industry projected for 1980–1985 and 1985–1990.
- Base year data obtained from BEA tables, the Missouri Department of Employment Security and BLS.

The Puget Sound Council of Government's model, for the four-county Seattle area, is based on a state-level model and a regional model which uses the output of the state model.

The Washington Projection and Simulation Model (Bourque, *198;* Conway, *199*) is an interindustry econometric model of the state designed for economic forecasting and analysis.

. . . . Although the structure of the model, with close to 150 equations, might appear complicated, the view of the regional economic behavior underlying it is conceptually simple. WPSM essentially follows from economic base principles, which recognize two sets of economic demands placed upon the region, external (primarily export) demands and internal (nonbasic) demands.

. . . . [E]xport production is considered to be the principal driving force behind regional economic growth. As a matter of convention, exports here refer to foreign exports, exports to the rest of the United States, and federal government expenditures. The national economic environment largely determines the exports of regional industries. Specifically, exports are projected on the basis of national market demand, as represented by the output of the corresponding U.S. industries, and the extent to which Washington can satisfy these demands. Projections of U.S. industrial requirements, as well as other external economic variables, in turn originate from . . . an interindustry econometric model of the nation.

The local output required for export triggers the first set of internal demands, the regional interindustry demands. For example, the demand for regionally produced aircraft establishes a chain of demands that affects output in the local machinery and service industries, among others. The induced output in these sectors in turn sets up further intermediate demands, all of which are depicted by the equations in the output submodel. These input-output relations, which are modified over time by projections of interindustry coefficients, constitute the core of WPSM.

Industrial output and independently forecast changes in labor productivity combine to predict the number of jobs in each industry. This determines the number of persons employed in the economy, which, when coupled with predictions of employment and labor force participation rates, leads to projections of the labor force and resident population.

In the course of population, labor earns income, primarily in the form of wages, salaries, and proprietors' income. For each

private and public sector, Washington earnings are related to U.S. earnings. Separate equations determine property income, transfer payments, personal contributions to social insurance, and personal tax and nontax payments, which result in a determination of disposable income.

Disposable income and population become key factors explaining the second tier of internal demands, which includes the final demands of the consumption, investment, and state and local government sectors. Consumer spending is related directly to household disposable income and the prices of goods and services. Residential construction is linked to population and per capita income as well as to the current stock of housing, interest rates, and the cost of construction. Other private fixed investment and inventory change are essentially tied to industrial output levels. Disposable income influences state and local government expenditures, but factors such as school-age population and federal highway funding also enter into the determination.

At the same time that these feedback loops are operating to affect state production, so-called leakages occur in the system. These include savings, taxes, and imports, and represent income or revenue that is not redirected into the flow of locally oriented demands. (Watterson (*190*), Appendix)

The kinds of relationships described in WPSM are similar to those in DEFM79 and IPEF, although they certainly differ in detail and, importantly, are for a state-level economy, rather than one at the substate, multicounty level.

The second model which "steps down" the state forecast to the four-county region

. . . was developed by PSCOG to make use of the WPSM forecasting and simulation capabilities, by translating state-level jobs and income forecasts to the four-county regional level. The STEP model is also built upon an economic base framework. Jobs in each basic industry (i.e., those sectors that primarily serve demands external to the regional economy) are projected as a trend in the region's past share of state employment for that industry. Employment in each nonbasic industry (serving primarily local demands) is projected from the relationship between the nonbasic employment-personal income ratio in the region and the ratio in the state. Labor force and population are then projected from the sum of jobs in all industries and equations on unemployment and labor force participation rates. On the income side of the model, annual earnings per worker in each industry are projected from state average earnings in the same industry. Earnings include wages, salaries, other labor income, and proprietor's income. This model then sums earnings across all industries and projects personal income for the region. The STEP model consists of 76 equations (solved simultaneously), utilizes WPSM job and income forecasts, and predicts in 29 industries for 22 years. (Watterson, *190*)

SUMMARY

These seven examples of forecasting or projection techniques illustrate the diversity of methodology employed in different agencies. None of them offers a "how-to-do-it" example, but all of them illustrate the need to combine technique, data, and assumptions to produce a forecast of basically the same variables or data, and they offer alternative ways of doing that for consideration. Several observations may be made.

First, a review of even these general descriptions shows that the overall methodology is a combination of simple techniques. The earlier observation that econometric models are simply (or not so simply) combinations of hundreds of small models, which interact with each other, may be generalized to all of these seven examples. Nearly all of the techniques or methods reviewed in Chapter Two appear in one or more of these examples at some point.

Second, while it should be clear that the more sophisticated economic models are the most demanding of expertise and resources, most of the techniques require training, ingenuity, energy, and experience. Obviously, many of the simpler techniques require less of all of these, but in most cases there is less confidence in their results.

Third, no technique is better than the assumptions that are used in applying it. Analysts in most of the examples assumed moderate conditions of growth, unemployment, productivity change, and inflation for the period from the mid-1970's until (and beyond) the 1980's. But these assumptions were sufficiently erroneous that the data and the techniques were almost irrelevant.

Finally, regardless of how it is implemented, an implicit model similar to that illustrated in Figure 8 for DEFM79 is useful to the analyst. It illustrates a view of the interaction of a number of the sectors which are relevant to understanding the complex relationships in an urban-centered economy, and even if some of them are ignored in actual projection work, or assumed to be neutral in their effect, that is better than forgetting them completely.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDED RESEARCH

This chapter presents the conclusions which emanate from the research project. There were areas in the research which yielded answers, but for some of these, as well as others, additional research is suggested. The conclusions and recommended research are presented together for each section. The chapter addresses (1) the sensitivity of the outputs of the transportation planning process to the inputs to that process and (2) the projection techniques and data which can be used to prepare inputs.

SENSITIVITY OF THE TRANSPORTATION PROCESS TO SOCIOECONOMIC INPUTS

Conclusions

1. *The estimate of total population should be the principal variable of the socioeconomic variables assembled for the UTP Process.* The total trips generated in the UTP Process is very sensitive to the estimate of population. An error of 10 percent in population will generate an error of 10 percent in the total trips. If the overall population estimate is correct, errors in specification of the number of households will not greatly affect total trips because trips per household is a function of household size, and this compensates for errors in estimation of the number of households. This does not mean that household estimation is not necessary; indeed, characteristics of the household are fundamental to many attributes of travel behavior. It simply says, give first priority to making the best possible estimate of overall population.

2. *Improvement in estimates of total trips can be made if forecasts of households are stratified by auto ownership or income and/or family size.* Income and auto ownership are highly intercorrelated. If households are stratified by two variables, greater explanation of total trip generation will accrue by using *either* auto ownership *or* income with family size. The use of all three is not recommended because (1) the improvement in explanation of variation in total trips is marginal, and (2) the notion that a zone might be disaggregated into multiple discrete cells (for example, 60, given 3 levels of auto ownership, 5 levels of family size, and 4 levels of income) is impractical.

3. *Acceptable estimates of travel time and travel distance, based on households stratified by autos owned, income or family size, do not appear to be feasible.* Total travel distance or total travel time are important output variables from the UTP Process. It would serve as a useful check on that process if a reliable independent check could be made based simply on aggregate inputs such as households classified by autos owned, income, or family size, or some combination of these attributes. While the aggregate measures of travel distance and travel time are sensitive to socioeconomic variables, the explanation of variation among households is practically negligible.

4. *Household status—specifically, sex of head of household—is not a major socioeconomic variable needed for the UTP Process.* The household trip generation rates for households with a woman head were significantly lower than for households with a male head (only 44 percent as many trips). However, when differences in auto ownership and family size were accounted for, the difference in trip-making largely disappeared. (Households with a female head make about 99 percent as many trips as households headed by a male.)

Recommended Research

1. *The sensitivity of the Urban Transportation Process to socioeconomic inputs should be studied at the disaggregate (zonal) level.* The urban transportation planning process typically is a chain of models applied at a highly disaggregate level of geography and transport network. The output of this process is link or line volumes of people, vehicles, and (in some cases) goods. These volumes may be aggregated to obtain larger collective impacts for projects, corridors, communities, and entire regions. While there are a few aggregate models used for "sketch planning" to obtain preliminary result or to screen feasible plans or technologies, the UTPP essentially is a highly disaggregated process. No examination of this process at its disaggregate level was possible given the resources available for this research. Without reservation, the authors recommend that the sensitivity of the UTP Process to errors in zonal specification of socioeconomic data be considered for future research.

2. *The relationship of travel time and travel distance for households classified by geographic location and network supply to socioeconomic variables should be examined.* Notwithstanding that socioeconomic variables explained very little of the total time/distance variation among households, the subject is still worthy of further research. Estimates of time/distance for households classified by geographic location and/or network supply (accessibility) might vary by socioeconomic characteristics. Research in this area could lead to further understanding of aggregate estimates.

3. *Research should be undertaken to clarify and define the influence of labor force participation, unemployment, and work attendance on work trip making.* While current practice indicates that agencies are aware of the potential role of these variables in modifying estimates and projections of work-related travel, there has been very little research which analyzes their relationship to work-trip generation or to information from home interview surveys.

METHODOLOGY AND TECHNIQUE FOR PREPARING PROJECTION OF INPUTS TO THE TRANSPORTATION PLANNING PROCESS

Conclusions

1. *There is no single projection method or technique which is best for all situations and circumstances.* The variety of possible circumstances in which a transportation planner may wish to make projections is so great that it is virtually impossible to reach general conclusions or to make general recommendations about a single "best" technique. A large urban agency, such as one of those described in Chapter Four, commands personnel, time, expertise, and funding, which simply are not available in many agencies, let alone for the individual planning engineer who must make—or find—some sort of projection for a small urban area.

2. *National-level projections of population, income, and employment provide a rich resource for preparing local projections.* In part, this research project was begun because of the intent, expressed by the Federal government, to produce a uniform set of national, state, and local projections of population, employment, and income. The reaction of many local demographers and the changing administrative and political climate aborted plans for preparation of the joint projections, as well as the regulation requiring their use. That this occurred, though, does not reduce the utility of national projections and, as will be seen in other conclusions and recommendations that follow, their use is suggested in several situations.

3. *The cohort-component method for population projection should be used when resources permit.* The availability of tested and transferable computer programs, manuals, or documentation for the use of the technique, and tables of mortality and

fertility rates, make the use of the cohort-component technique feasible for a wide-range of applications. Extrapolation techniques (including regression using time as the independent variable) should be used only as a last resort.

4. *Projections of employment and income should be made by step-down or ratio techniques using OBERS or other national projections as a basis.* The OBERS projections are prepared by well-trained, competent economists using methodology and data normally not available to local or even state agencies. Moreover, they are based on state-of-the-art econometric theory and technique and are internally consistent. They also are published in disaggregations to the SMSA and part-SMSA level as well as for states and multicounty economic areas. Even if local expertise and experience indicate departures from OBERS projections, they provide an excellent basis for analyzing, understanding, and quantifying those departures. The only technically comparable projection method available to local engineers/planners (or their agencies) is the mounting of a full-scale econometric model. This is time- and resource-consuming and should be considered only by the largest agencies.

5. *State and other local agencies should be consulted prior to making projections of population, employment, income, auto ownership, or any other population characteristics.* Nearly every state and many local governments make projections of population, employment, income, automobile registrations, housing construction and demand, and other characteristics as part of their regular operations. While the projections may not provide precisely the data or format needed for transportation planning, in most cases they are very close or may be used easily as a basis for projection of closely symptomatic characteristics.

Recommended Research

1. *A concise manual outlining methodology for analysis and use of income projections in transportation planning (specifically, trip generation) should be prepared.* Chapter Four illustrates several methods of interpolating and estimating income in urban areas, in most cases using national projections as a basis for ratios. The confusion caused by the use of mean or median, family, household and per capita, wages and salaries versus total, categories and ranges and other qualifiers of "income" is enormous, and likely would be reinforced with more examples. This is *not* a recommendation to establish a single method for applying income in trip generation. It *is* a recommendation for a simply written but thorough guide to income analysis and projection, with a glossary of commonly used terms and illustrations of competent, correct methods of the use of income in transportation planning and trip generation.

2. *Techniques for projection of automobile ownership should receive specific attention.* The use of auto ownership as an independent variable in trip generation and mode choice modeling has many advantages over income. Methods of projecting auto ownership, however, either are directed toward the national level (the extrapolative models), are based on income, or are based on weak relationships to other variables. (While efforts to introduce multinomial logit models show promise, they are still research efforts and are quite complex.) Data to support analysis and projection are frequently stale or so aggregated as to be only marginally useful. Research specifically to support trip generation, based on cross-classification at the local level and state or national trends, should be undertaken.

APPENDIX A

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APPENDIX B

DETAILS OF SENSITIVITY ANALYSIS

As indicated in Chapter Two, following the description of the analysis of the sensitivity of total trips to various demographic and socioeconomic characteristics, similar analyses were performed for trips by purpose, travel distance, and travel time. (Table 16 in Chapter Two compares the resulting values.) This appendix discusses the details of these parallel analyses and concludes with the basic tabulations from which the analyses are drawn.

SENSITIVITY OF HOME-BASED WORK TRIPS

Sensitivity of Home-Based Work Trips to Household Size

In Table B-1 home-based work-trip rates per household are presented. Recall that if attendance was 100 percent, there was one worker per household and the work trip was from home-

Table B-1. Households and home-based work trips by family size (Buffalo, 1962).

Persons Per Household	Households Number	Percent	Trips	Trips/ Household
1	1.499	11.3	816	.544
2	3,519	26.5	4,708	1.338
3	2,543	19.2	5,051	1.986
4	2,402	18.1	5,192	2.162
5 and over	3,307	24.9	7,004	2.118
Total	13,272	100.0	22,771	1.716

Table B-2. Changes in household distribution by household size representing ± 10 percent of average household size.

	10% Decline in Household Size			10% Increase in Household Size		
Household Size	Changes in Households	Changes in Population	Total Households	Changes in Households	Changes in Population	Total Households
1	10	10	21	-9	-9	2
2	5	10	31	-3	-6	23
3	0	0	19	0	0	19
4	0	0	19	0	0	19
5	-4	-20	21	+3	+15	28
Total	11	0	111	-9	0	91

to-work and work-to-home; the rate would be 2.0. In other words, the concept is a round-trip notion, and the rates appear about twice one's intuitive expectation.

Note that while home-based work trips per household increases with increases in household size, the rate of increase decreases dramatically (flattens out in fact) beyond three persons per household. Clearly, a simple linear regression equation would not be suitable as a basis to examine the sensitivity of home-based work-trip rates to household size.

In Table B-2 two distributions of households are presented which represent, in effect, a 10 percent decrease in average household size (111 households with the same total population) and a 10 percent increase in household size (91 households with the same total population). Utilizing the rates of home-based trips per household by family size from Table B-1, the value for the decrease in household size is 176.25, and for the increase, 170.11, compared to 172.63 home-based work trips with no change in family size. The sensitivities therefore are −0.14 for increases at the mean and 0.21 for decreases in household size at the mean.

This discussion assumes that population is fixed, but the distribution of households by size varies. Alternatively it could be assumed that the number of households is fixed and family size is being estimated. Using the same distributions of households as in Table B-1, but setting them equal to 100 percent, an estimate can be obtained of the home-based work trip results from a 10 percent increase or decrease in household size, 187 and 159 respectively, compared to a no-change estimate of 173 (Table B-3). This gives a sensitivity of home-based work trips to household size of between 0.81 and 0.84, when number of households are fixed. Thus, as was the case with total trips, it appears that a better strategy for forecasting work travel is to fix population and estimate family size rather than to estimate *both* households and family size.

Sensitivity of Home-Based Work Trips to Autos Owned

The relationship of autos owned and the number of home-based work trips per household is shown in Table B-4. Each auto added gives an increase of one home-based work trip per household. The regression equation is

$$\text{Home-based work trips/household} = 0.774 + 0.992\ (\text{autos/household})$$

The sensitivity of work trips at a value of autos owned per household of one is equal to 0.56. It is possible, however, that car ownership may be a function of work trips rather than the other way around.

Sensitivity of Home-Based Work Trips to Income

A strong relationship between work trips and household income would be expected. The greater the income, the larger the number of trips. That is, people work to obtain income. The data on home-based work trips and income per household are given in Table B-5. The expected relationship is there, although it is a slightly nonlinear relationship with the rate of increase in home-based work trips declining with increased income per household. The linear regression of work trips per household by income is

$$\text{Home-based work trips/household} = 0.475 + 0.0002117\ (\text{income/household})$$

At an average household income of $6,000, the estimated home-based work trips per household would be 1.7455, while at an income of $6,600 the estimated home-based work trips would be 1.8725, or 7.28 percent greater, a sensitivity of 0.73.

Summary of Sensitivity of Home-Based Work Trips to Household Size, Cars Owned per Household, and Income

The sensitivity of home-based work trips to household size, cars owned, and income was found to be − (0.14–0.21), 0.56, and 0.73 respectively. The range for household size is based on the assumption of a fixed population, so that a decrease in family size leads to an increase in households. When households are fixed, the sensitivity for household size is 0.81–0.84.

In terms of explanatory power, income is superior with a coefficient of determination of 0.20, followed by autos at 0.16 and household size with 0.16.

Table B-3. Hypothetical distribution of 100 households by family size and resulting estimates of total house-based work trips.

HB Work Trips Per Households	Family Size	Base Distribution Households	Base Distribution Trips	Decrease of 10% in Household Size Households	Decrease of 10% in Household Size Trips	Increase of 10% in Household Size Households	Increase of 10% in Household Size Trips
.54	1	11	5.94	18.9	10.21	2.2	1.19
1.34	2	26	34.84	27.9	37.4	25.3	33.90
1.99	3	19	37.81	17.1	34.03	20.9	41.59
2.16	4	19	41.04	17.1	36.94	20.9	45.14
2.12	5	25	53.00	18.9	40.07	30.8	65.30
Total		100	172.63	99.9	158.65	100.1	187.12

Given the modest explanatory power of the three variables with regard to the variation in the rate of home-based work trips, as well as the fact that two of them, cars and income, would appear (theoretically) to be the result rather than the cause of work travel, it would appear obvious that the estimation be normalized in terms of direct estimates of employment, adjusted to represent home-based work travel.

SENSITIVITY OF HOME-BASED OTHER TRIPS

Sensitivity of Home-Based Other Trips per Household

Trips with either one end or the other at home, and with the purpose at the nonhome end other than work, constitute the largest of the three typical trip strata used in travel forecasting. The overall average trips per household for this category was 3.86 which is 55 percent of the average of all trips per household of 6.92. These trips are the shopping, social, recreation, personal business, etc., trips of the household and are distributed more uniformly throughout the day than are the work trips. Yet, because of their bulk, shorter average trip length, and so on, they traditionally are treated separately.

Sensitivity of Home-Based Other Trips to Family Size

Data on home-based other trips is given in Table B-6. Included in this table are the per capita rates of home-based other trips. From simple observation, it may be seen that the per capita rates are so very similar that estimates of total home-based other trips would be insensitive to differences in household size so long as the population is assumed to be fixed. However, if households are assumed to be fixed, the estimate of home-based other trips would be very sensitive to household size. A linear regression of home-based other trips per household by household size yields

$$\text{Household other trips/household} = -0.390 + 1.331\ (\text{household size})$$

Table B-4. Households, person-trips, and house-based work trips per household by cars per household (Buffalo, 1962).

Cars Per Household	Households	Person Trips	HB Work Trips Per Household
0	2,869	2,245	.783
1	8,098	14,149	1.747
2	2,305	6,377	2.767
Total	13,272	22,771	1.716

Table B-5. Households, home-based work trips, and home-based work trips per household by income.

Income Per Household	Households	Home Based Work Trips	HB Work Trips Per Household
0 - 3999	2,760	2,030	.736
4000 - 5999	3,187	5,505	1.727
6000 - 7999	2,421	5,010	2.069
8000 - over	2,861	7,009	2.450
Unreported - Unknown	2,043	3,217	1.575
Total	13,272	22,771	1.716

Table B-6. Households and home-based other trips by family size (Buffalo, 1962).

Persons Per Household	Households Number	Households Percent	Trips	Trips/ Household	Trips/ Capita
1	1,499	11.3	1,324	.883	.883
2	3,519	26.5	8,170	2,322	1.161
3	2,543	19.2	9,256	3.640	1.213
4	2,402	18.1	11,887	4.949	1.237
5 and over	3,307	24.9	20,589	6.226	1.245
Total	13,272	100.0	51,229	3.860	1.211

At a household size of 3.0, the trip estimate would be 3.604 and at a household size of 3.3, the trip estimate would be 4.003, a sensitivity of 1.11.

Sensitivity of Home-Based Other Trips to Autos Owned

The data for home-based other trips per household are presented in Table B-7. From the means it may be seen that the first auto adds about three home-based other (HBO) trips to 1.14 trips made by households with no auto. The addition of the second auto only adds two trips so there is a slightly nonlinear relationship. The slope of the linear regression equation

Table B-7. Households, house-based other person-trips, and home-based other person-trips per household by cars per household (Buffalo, 1962).

Cars Per Household	Households	Home Based Other Person Trips	Home Based Other Person Trips Per Household
0	2,869	3,278	1.143
1	8,098	33,674	4.158
2	2,305	14,277	6.194
Total	13,272	51,229	3.860

$$\text{HBO trips/household} = 1.306 + 2.526 \text{ (autos/household)}$$

averages these two increments for a value of 2.5. The estimate of trips at an auto ownership of one equals 3.83 and at an auto ownership of 1.1 equals 4.08, which is a sensitivity of 0.659.

Sensitivity of Home-Based Other Trips per Household to Income

Data for home-based other trips per household are given in Table B-8. Increases in income per household are associated with increases in HBO trips per household. The linear regression of HBO trips/household on income is:

$$\text{HBO trips/household} = 1.358 + 0.0004464 \text{ (income/household)}$$

At a household income of $6,000, the estimated HBO trips per household would be 4.036. At a household income 10 percent higher, $6,660, the HBO trips per household would be 4.304, which yields an estimate of sensitivity of 0.66.

Summary of Sensitivity of Home-Based Other Trips per Household to Household Size, Autos Owned, and Income

The sensitivity of HBO trips per household to autos owned and income was found to be negligible, 0.66 and 0.66, respectively. However, if households are fixed and household size estimated, the sensitivity to household size is 1.11.

In terms of explanatory power the coefficients of determination for household size, autos owned, and income are 0.18, 0.14, and 0.09, respectively.

SENSITIVITY OF NONHOME-BASED TRIPS

Sensitivity of Nonhome-Based Trips per Household

This category of trips seems to be almost an afterthought in the transportation planning process. In other words, these are the trips left over after disposing of the home-based round trips. They consist of trips between origins and destinations *other than* the home of the trip maker. They can be significant in volume. In Buffalo, the average per household is 1.41 or 20 percent of the overall mean of 6.92. Estimating their number as a function of the characteristics of the household in which the traveler resides gives little or no information on their actual geographic location. Others have been concerned about this trip category; in fact, about the notion of a trip as simply the connection between an origin and a destination. This concern seems outside the scope of this effort, however, and an analysis of the sensitivity of this category follows.

Table B-8. Households, home-based other person-trips, home-based other (HBO) person-trips per household by income.

Income Per Household	Households	Home Based Other Person Trips	HBO Person Trips Per Household
0 - 3999	2,760	5,539	2.007
4000 - 5999	3,187	12,065	3.786
6000 - 7999	2,421	11,635	4.806
8000 - over	2,861	15,866	5.546
Unreported or Unknown	2,043	6,124	2.998
Total	13,272	51,229	3.860

Table B-9. Nonhome-based trips per household by household size.

Household Size	Number of Households	Number of Trips	Trips per Household	Trips per Capita
1	1,499	620	.414	.414
2	3,519	3,485	.990	.495
3	2,543	3,662	1.440	.480
4	2,402	4,098	1.706	.427
5+	3,307	6,041	1.827	.365
Total	13,272	17,906	1.349	.423

Household Size

Table B-9 presents data on nonhome-based (NHB) trips and household size. Nonhome-based trips increase with household size but at a decreasing rate after two-person households. The previous analysis indicates that if population is held constant, the sensitivity of total trips to household size is quite small, and it is generally recommended that population be the basic element to be forecasted. However, if households are projected, the sensitivity to estimates of household size is relevant. The linear regression is

$$\text{NHB trips/household} = 0.2336 + 0.349 \text{ (household size)}$$

If household size is three, the estimate of NHB trips per household would be 1.28. With a 10 percent increase in household size to 3.3, the estimated NHB trips per household would be 1.385, which yields a sensitivity of 0.82.

Autos Owned

Data on NHB trips per household and autos are given in Table B-10. NHB trips clearly are closely related to autos owned. Only a quarter of a trip is generated by nonauto-owning households. The linear regression is

NHB trips/household = 0.224 + 1.214 (autos owned)

Each auto adds 1.2 trips to the household's trip generation. At an auto ownership of 1.0, the NHB trips per household would be estimated to be 1.437 trips, while at an auto ownership of 1.1, the NHB trip estimate would be 1.559, or a sensitivity of 0.84.

Nonhome-Based Trips and Income

Nonhome-based trips per household and income per household are presented in Table B-11. The linear regression equation is

NHB trips/household = 0.117 + 0.000218 (income/household)

The estimate of trips per household when household income equals $6,000 is 1.425 and when income equals $6,600, 1.556, or a sensitivity of 0.92.

Table B-10. Nonhome-based (NHB) trips per household by autos per household.

Cars Owned	Households	NHB Trips	NHB Trips per Household
0	2,869	773	.269
1	8,098	10,919	1.348
2	2,305	6,214	2.696
Total	13,272	17,906	1.349

Table B-11. Households, person-trips, and nonhome-based (NHB) person-trips per household by income.

Income per Household	Households	NHB Person Trips	Person Trips Per Household
0 - 3999	2,760	1,492	.541
4000 - 5999	3,187	3,617	1.135
6000 - 7999	2,421	4,348	1.796
8000 - over	2,861	6,376	2.229
Unreported or Unknown	2,043	2,073	1.015
Total	13,272	17,906	1.349

APPENDIX C

DATA RESOURCES

MATERIALS AVAILABLE FROM THE U.S. BUREAU OF THE CENSUS

The Bureau of the Census is, perhaps, the single best source of population and socioeconomic data for use in both establishing base conditions and in preparing projections. A number of specific products are discussed below. However, items 1 through 9 are (as of the time this report was printed) basic references.

1. *For information, and to order most census products:*
   Data User Services Division (DUSD)
   Customer Services (CS)
   Bureau of the Census
   Washington, DC 20233
   301/763-4100
2. *Comprehensive catalog of census products:*
   Bureau of the Census Catalog: 1982-83; from the Government Printing Office. Call/write DUSD/CS for price and stock number of *current catalog.*
3. *Census User's Guide:*
   Part A. Text, (S/N 003-024-03625) $5.50
   Supplement 1, (S/N 003-024-05004-8) $6.00
   Part C: Index to Summary Tape Files 1 to 4
   Call/write DUSD/CS, above, for information on Part C. All 3 parts are available from:
   Superintendent of Documents
   Government Printing Office
   Washington, DC 20402
4. *Regional offices of the Bureau have many publications, and may offer help and guidance:*
   Atlanta, GA 30309: Room 625, 1365 Peachtree St., N.E., telephone 404/881-2274
   Boston, MA 02116: 10th Floor, 441 Stuart St., telephone 617/223-0226
   Charlotte, NC 28202: Suite 800, 230 South Tryon St., telephone 704/371-6144

Chicago, IL 60604: Suite 1304, 55 East Jackson Blvd., telephone 312/353-0980

Dallas, TX 75242: Room 3C54, 1100 Commerce Street, telephone 214/767-0625

Denver, CO 80226: P.E. Box 26750, 7655 West Mississippi Ave., telephone 303/234-5825

Detroit, MI 48226: Federal Bldg. & U.S. Courthouse, Room 565, 231 West Lafayette St., telephone 313/226-4675

Kansas City, KS 66101: One Gateway Center, 4th and State Sts., telephone 913/236-3731

Los Angeles, CA 90049: Room 810, 11777 San Vicente Blvd., telephone 213/209-6612

New York, NY 10278: Federal Office Bldg., Room 37-130, 26 Federal Plaza, telephone 212/264-4730

Philadelphia, PA 19106: William J. Green Jr. Federal Bldg., Room 9244, 600 Arch St., telephone 215/597-8313

Seattle, WA 98109: Lake Union Bldg., 1700 Westlake Ave., North, telephone 206/442-7080

5. *Monthly product announcement list is available at no charge from:*

DUSD/Customer Services 301/763-4100

6. *Data Users' News makes available a monthly review of Census activities, products, and releases:*

Superintendent of Documents
Government Printing Office
Washington, DC 20402
202/783-3238

$20.00/year (checks payable to Superintendent of Documents) (Will take VISA or Master Card for telephone order)

7. *Telephone Contact List (names and phone numbers of Census staff familiar with specific topics) from:*

User Training Branch
DUSD (above)
301/763-1510

8. *State data centers are local sources of data and assistance: See Exhibit 1.*

9. *Transportation Planner's Guide to Using the 1980 Census:*

Mr. Dane Ismart
Urban Planning and Transportation Management Division
Office of Highway Planning
Planning Procedures Branch (HHP-24)
Federal Highway Administration
400 7th Street, S.W.
Washington, DC 20590
202/426-0150

10. *1980 Census Reports and Summary Tape Files:*

Exhibit 2 lists reports and tape files with anticipated release dates as of 1982. Details of release of particular files are reported in the Data Users' News and Monthly Product Announcement (item 6).

11. *Public User Microdata Samples from the 1980 Census:*

This rich data source is described in detail in the paper reproduced in Exhibit 3.

12. *Current Population Survey and Employment and Earnings:*

As is explained in Exhibit 4 from the Census Bureau, the "Current Population Survey" is conducted monthly by Census, primarily to furnish current information on employment and unemployment. The data collected serve as the basis for the Bureau of Labor Statistics publication, "Employment and Earnings."

Beyond the material presented in Exhibit 4, it is not possible to describe in detail here the potential of the CPS and information in Employment and Earnings. The supplementary surveys, which differ month to month, provide annual benchmarks of important socioeconomic and demographic data. Each March, for example, the CPS Annual Demographic Supplement obtains data on family characteristics, household composition, relationship to head, marital status, migration, income, weeks worked, time spent looking for work, and the occupation and industry of the job held longest during the year.

Most data are available for states and some are available for selected Metropolitan Statistical Areas. Sample records also are available on computer tape.

Perhaps the most important use of the CPS and employment data for the transportation planner is in tracing trends since the previous Census to (1) update his base data and (2) establish simple trends to be used as the basis for projection.

A full description of the Current Population Survey is available in:

"The Current Population Survey: Design and Methodology"
S/N 003-024-01490-4
Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402

For further information on the CPS contact:

Census
DUSD/CS (above)

"Employment and Earnings" is published monthly by the Bureau of Labor Statistics. It may be ordered from the Government Printing Office (202/783-3238 for ordering information).

13. *County Business Patterns:*

This item comprises a yearly set of reports (and tapes) providing extensive *county* data on business establishments and their employees and payroll for industries down to the four digit SIC level. Reports are issued for each State, the District of Columbia, Puerto Rico, and the United States as a whole.

Tapes of data (in greater detail than in the reports) also are available.

More information about CBP can be obtained from

Economic Surveys Division
Bureau of the Census
Washington, DC 20233
301/763-5430

or from DUSD/CS (above).

CBP reports current and prior year employment at the four-digit SIC code level for states and counties (2-digit SIC for selected SMSAs) as of mid-March each year.

As does the Current Population Survey, it provides an excellent basis for updating Census data and for determining trends.

14. *Economic and Agricultural Censuses:*

Each 5 years (1977, 1982) the Bureau conducts the Economic Censuses:

- Manufacturers
- Mineral Industries
- Construction Industries
- Retail Trade
- Wholesale Trade
- Service Industries

These Censuses concentrate on establishments and report the number, number of employees, and payroll information. In general, the level of disaggregation for which the data are available does not go below the SMSA, but for a "study area," the information which may be extracted regarding the status (and trends) of local activity by industry, employment, and payroll income can be invaluable.

The Census publication "Preview of the 1982 Economic Censuses" is reproduced in Exhibit 5 and describes them in greater detail. It also includes addresses and telephone numbers for further information.

15. *Current population estimates:*

The Census makes annual estimates of current population which also provide valuable information for updating Census data.

For 1981 and 1982 they were published in

"Estimates of the Population of States:
July 1, 1981 and 1982"
Current Population Reports, Series P-25, No. 927,

available from the U.S. G.P.O. (address above) for $1.75 (Cat. No. C3.186: P-25/927) Contact Census DUSD/CS for further information.

16. *Population projections:*

The Census Bureau regularly makes projections of population for the nation and for states. Although these do not provide detail to the county or SMSA level, they offer control totals and detail birth and survival rate assumptions that are needed for local projections. Examples of tables from two recent sets of projections are shown in Exhibit 6. They are:

Illustrative Projections of State Populations by Age, Race, and Sex: 1975 to 2000
Current Population Reports, Series P-25, No. 796.
Available from GPO.

Provisional Projections of the Populations of States by Age and Sex, 1980 to 2000
Current Population Reports, Series P-25, No. 937
GPO/Cat. No. C3.186: P25/937

A list of state offices (and representatives) which are members of the Federal-State Cooperative Program for Population Projections is given in Exhibit 7. These offices are excellent sources of current information on population projections.

INFORMATION AVAILABLE FROM THE BUREAU OF ECONOMIC ANALYSIS, U.S. DEPARTMENT OF COMMERCE

Perhaps the single best projection of employment is produced by the Bureau of Economic Analysis; the "OBERS Projections" of which the most recent was completed in 1980 (see Bibliography for citation).

Exhibit 8, reproduced from Volume I, describes the projection.

Illustrative state (District of Columbia) and SMSA tables are included in Exhibit 9.

INFORMATION AVAILABLE FROM STATE AGENCIES—NORTH CAROLINA AS AN EXAMPLE

1. *Labor Area Summary:*

The Employment Security Commission of the State of North Carolina regularly produces reports on employment and earnings for the state, for its planning regions, and for SMSA's. The reports are issued in several formats and quite likely will be different in other states. The examples which follow in Exhibit 10 illustrate the type of report, however. The corresponding agency in each state should have similar information.

2. *Industry and Occupational Projections:*

Again using North Carolina as an example, the Employment Security Commission also prepares projections of employment. In this case, and probably in most states, they are intended for use in manpower and job training planning. The methodology used in their preparation is quite different from that used, for example, by BEA in preparing the OBERS projections. However, the manpower-oriented projections do represent the considerable knowledge about and experience with local conditions found in similar state agencies. The NCESC only prepares 5-year projections, so they cannot be used *per se* for longer planning horizons.

An example table and a list of publications from a typical NC SMSA projection are shown in Exhibit 11.

3. *Population Estimates and Projections:*

The N.C. Department of Administration produces detailed (county-level) intercensal estimates of population as well as an independent projection of population at the county level. In N.C.'s case, these represent an independent set of projections that may be compared to other projections such as the Census Bureau's or OBERS'. Of particular interest are the methodologies and assumptions used in each. Sample pages from a set of N.C. estimates and projections are presented in Exhibit 12.

EXHIBIT 1

State Data Center Program

State Coordinating Organizations

Address List

January 1984

U.S. Department of Commerce • Bureau of the Census • Washington, D.C. 20233

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Alabama Public Library Service
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ALASKA

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EXHIBIT 2

Supplement to Data User News

1980 Census of Population and Housing

Revised February 1982

Tentative Publication and Computer Tape Program

The results of the 1980 census will be released as soon as they are tabulated and assembled. In this data dissemination program three major media will be utilized: printed reports, computer tapes, and microfiche.

The publications of the 1980 census are released under three subject titles, *1980 Census of Population and Housing, 1980 Census of Population,* and *1980 Census of Housing.* The description of the publication program below is organized in sections, by census title, followed by the reports under each title. It should be noted that a number of the population census reports contain some housing data and a number of the housing census reports contain some population data.

Following the description of the publication program are sections on computer tapes, maps, and microfiche, and a section listing the subject items included in the 1980 census.

The data product descriptions include listings of geographic areas for which data are summarized in that product. Note that the term "place" refers to incorporated places and census designated (or unincorporated) places, as well as towns and townships in 11 States (the 6 New England States, the 3 mid-Atlantic States, Michigan, and Wisconsin).

Order forms for these materials are available in most cases, subject to availability of the data product, from Data User Services Division, Customer Services, Bureau of the Census, Washington, D.C. 20233; Census Bureau Regional Offices; U.S. Department of Commerce District Offices; and State Data Centers. Inquiries concerning any phase of the data dissemination program may be addressed to Data User Services Division, Customer Services, Bureau of the Census, Washington, D.C. 20233. After publication, census reports are on file in many libraries and are available for examination at any Department of Commerce District Office or Census Bureau Regional Office.

The Bureau is continually reviewing its 1980 census publication and computer tape program. Changes may occur to content, schedules, and media as described in this leaflet. When dates are not shown below, schedules are in review. Revisions showing more complete scheduling will be issued as necessary.

REPORTS

1980 Census of Population and Housing

Preliminary Reports

Series PHC80-P — Preliminary Population and Housing Unit Counts

Issued: 10/80–2/81

These reports present preliminary population and housing unit counts as compiled in the census district offices. Counts are shown for the following areas or their equivalents: States, counties, county subdivisions, incorporated places, standard metropolitan statistical areas (SMSA's) as designated prior to the census, and congressional districts as delineated for the 96th Congress. There is one report for each State, the District of Columbia, Puerto Rico, Guam, Virgin Islands of the United States, and American Samoa, and a U.S. Summary report showing counts for the United States, regions, divisions, and States.

Advance Reports

Series PHC80-V — Final Population and Housing Unit Counts

To be Issued: 2/81 – early 1982

These reports present provisional population counts classified by race and Spanish origin and also final housing unit counts prior to their publication in the final reports. These figures supersede the preliminary counts published in the PHC80-P series. Final counts are shown for the following areas or their equivalents: States, counties, county subdivisions, incorporated places, and congressional districts as delineated for the 96th Congress. There is one report for each State, the District of Columbia, Puerto Rico, Guam, Virgin Islands of the United States, and American Samoa, and a U.S. Summary report showing counts for the United States, regions, divisions, States, and congressional districts.

U.S. Department of Commerce
BUREAU OF THE CENSUS

Final Reports

Series PHC80-1 — BLOCK STATISTICS

To be issued: early 1982–mid-1982

These reports present population and housing unit totals and statistics on selected characteristics which are based on complete-count data. Statistics are shown for individual blocks in urbanized areas, for selected blocks adjacent to urbanized areas, for blocks in places of 10,000 or more inhabitants, and for blocks in areas which contracted with the Census Bureau to provide block statistics. The set of reports consists of 375 sets of microfiche (no printed reports), and includes a report for each SMSA, showing blocked areas within the SMSA, and a report for each State and for Puerto Rico, showing blocked areas outside SMSA's, and a U.S. Summary which is an index to the set. In addition to microfiche, printed detailed maps showing the blocks covered by the particular report are available.

Series PHC80-2 — CENSUS TRACTS

To be issued: late 1982–mid-1983

Statistics for most of the population and housing subjects included in the 1980 census are presented for census tracts in SMSA's and in other tracted areas. Some tables show complete-count data and others, sample-estimate data. Most statistics are presented by race and Spanish origin for areas with at least a specified number of persons in the relevant population groups. There is one report for each SMSA, as well as one for most States and Puerto Rico covering the tracted areas outside SMSA's (designated selected areas).

Copies of tables containing complete-count data may be purchased at the cost of reproduction as each set of tables is completed. Completion dates range from early 1982 through mid-1982.

Series PHC80-3 — SUMMARY CHARACTERISTICS FOR GOVERNMENTAL UNITS AND STANDARD METROPOLITAN STATISTICAL AREAS

To be issued: Spring 1982–Fall 1982

Statistics are presented on total population and on complete-count and sample population characteristics such as age, race, education, disability, ability to speak English, labor force, and income, and on total housing units and housing characteristics such as value, age of structure, and rent. These are shown for the following areas or their equivalents: States, SMSA's, counties, county subdivisions (those which are functioning general-purpose local governments), and incorporated places. There is one report for each State, the District of Columbia, and Puerto Rico. This series does not include a U.S. Summary.

Copies of tables containing complete-count data may be purchased at the cost of reproduction as each set of tables is completed. Completion dates range from September 1981 through early 1982.

Series PHC80-4 — CONGRESSIONAL DISTRICTS OF THE 98th CONGRESS

To be issued: Spring 1982–late 1982

This report presents complete-count and sample data for congressional districts of the 98th Congress. The report reflects redistricting now underway in anticipation of the 1982 elections and the special needs of the congressional audience. One report will be issued for each of the 50 States and the District of Columbia.

Copies of tables containing complete-count data may be purchased at the cost of reproduction as each set of tables is completed. Completion dates range from early 1982 through mid-1982.

Series PHC80-SI-1 — PROVISIONAL ESTIMATES OF SOCIAL, ECONOMIC, AND HOUSING CHARACTERISTICS

To be issued: early 1982

This report presents provisional estimates based on sample data collected in the 1980 census. Data on social, economic, and housing characteristics are shown for the United States as a whole, each State, the District of Columbia, and SMSA's of 1,000,000 or more inhabitants. These data are based on a special subsample of the full census sample. The sample, which represents about 1.6 percent of the total population, was developed to provide users with early data on characteristics of the population and housing units.

EXHIBIT 2 (Continued)

1980 Census of Population

Final Reports

Volume 1.

CHARACTERISTICS OF THE POPULATION

This volume presents final population counts and statistics on population characteristics. It consists of reports for the following 57 areas: the United States, each of the 50 States, the District of Columbia, Puerto Rico, and the outlying areas of Guam, Virgin Islands of the United States, American Samoa, and the Trust Territory of the Pacific Islands. The volume consists of four chapters for each area, chapters A, B, C, and D. Chapters A and B present data collected on a complete count basis, and chapters C and D present estimates based on sample information, except for outlying areas where all data are collected on a complete-count basis. In the complete-count data presented there are some differences from the counts presented earlier in the PHC80-V reports because corrections were made for errors found after the PHC80-V reports were issued. Chapters B, C, and D present most statistics by race and Spanish origin for areas with at least a specified number of the relevant population groups.

The U.S. Summary reports present statistics for the United States, regions, divisions, States, and selected areas below the State level. The State or equivalent area reports (which include the District of Columbia, Puerto Rico, and outlying areas) present statistics for the State or equivalent area and its subdivisions.

Statistics for each of the 57 areas are issued in separate paperbound editions of chapters A, B, and C. Chapter D is to be issued on microfiche only.

Series PC80-1-A — Chapter A

NUMBER OF INHABITANTS

To be issued: 10/81—early 1982 — Final population counts are shown for the following areas or their equivalents: States, counties, county subdivisions, incorporated places and census designated places (and towns and townships in selected States), standard consolidated statistical areas (SCSA's), SMSA's, and urbanized areas. Selected tables contain population counts by urban and rural residence. Many tables contain historical statistics from previous censuses.

Series PC80-1-B — Chapter B

GENERAL POPULATION CHARACTERISTICS

To be issued: early 1982—mid-1982 — Statistics on household relationship, age, race, Spanish origin, sex, and marital status are shown for the following areas or their equivalents: States, counties (by rural residence), county subdivisions, places (and towns and townships in selected States) of 1,000 or more inhabitants, SCSA's, SMSA's, urbanized areas, American Indian reservations, and Alaska Native villages.

Series PC80-1-C — Chapter C

GENERAL SOCIAL AND ECONOMIC CHARACTERISTICS

To be issued: Fall 1982—early 1983 — Data for subjects shown in the PC80-1-B reports are presented in more detail in PC80-1-C. Also shown are statistics on nativity, State or country of birth, citizenship and year of immigration for the foreign-born population, language spoken at home and ability to speak English, ancestry, fertility, family composition, type of group quarters, marital history, residence in 1975, journey to work, school enrollment, years of school completed, disability, verteran status, labor-force status, occupation, industry, class of worker, labor-force status in 1979, income in 1979, and poverty status in 1979. Each subject is shown for some or all of the following areas or their equivalents: States, counties (by rural and rural-farm residence), places (and towns and townships in selected States) of 2,500 or more inhabitants, SCSA's, SMSA's, urbanized areas, American Indian reservations, and Alaska Native villages.

Series PC80-1-D — Chapter D

DETAILED POPULATION CHARACTERISTICS

To be issued: mid to late 1983 — Statistics on population characteristics are presented in considerable detail and cross-classified by age, race, Spanish origin, and other characteristics. Each subject is shown for the State or equivalent area, and some subjects are also shown for rural residence at the State level. Most subjects are shown for SMSA's of 250,000 or more inhabitants, and a few are shown for central cities of these SMSA's.

Series PC80-2 — Volume 2.

SUBJECT REPORTS

To be issued: beginning 1983 — Each of the reports in this volume focuses on a particular subject. Cross-tabulations of population characteristics are shown on a national, regional, and divisional level. A few reports show statistics for States, large cities, SMSA's, American Indian reservations, or Alaska Native villages. Separate reports are tentatively planned on any or all of the following characteristics: racial and ethnic groups, type of residence, fertility, families, marital status, migration, education, employment, occupation, industry, journey to work, income, poverty status, and other subjects.

Note that the preparation of subject reports is dependent upon availability of funding in 1983.

Series PC80-S1 — **SUPPLEMENTARY REPORTS**

These reports present special compilations of 1980 census statistics dealing with specific population subjects. The reports tentatively include the following:

To be issued:		
5/81	1. PC80-SI-1	Age, Sex, Race, and Spanish Origin of the Population by Regions, Divisions, and States: 1980
5/81	2. PC80-SI-2	Population and Households by States and Counties: 1980
7/81	3. PC80-SI-3	Race of the Population by States: 1980
9/81	4. PC80-SI-4	Population and Households for Census Designated Places: 1980
10/81	5. PC80-SI-5	Standard Metropolitan Statistical Areas and Standard Consolidated Statistical Areas: 1980
	6. Unassigned	Nonpermanent Residents by State and County: 1980
	7. Unassigned	Population and Housing Unit Counts for Identified American Indian Areas and Alaska Native Villages: 1980
	8. Unassigned	Persons of Spanish Origin by State: 1980

1980 Census of Housing

Final Reports

Volume 1.

CHARACTERISTICS OF HOUSING UNITS

This volume presents final housing unit counts and statistics on housing characteristics. It consists of reports for the following 57 areas: the United States, each of the 50 States, the District of Columbia, Puerto Rico, and the outlying areas of Guam, Virgin Islands of the United States, American Samoa, and the Trust Territory of the Pacific Islands. The volume consists of two chapters for each area, chapters A and B. Chapter A presents data collected on a complete-count basis. Chapter B presents estimates based on sample information, except for outlying areas where all data are collected on a complete-count basis. Both chapters present most statistics by race and Spanish origin for areas with at least a specified number of the relevant population groups.

The U.S. Summary report presents statistics for the United States, regions, divisions, States, and selected areas below the State level. The State or equivalent area reports (which include the District of Columbia, Puerto Rico, and outlying areas) present statistics for the State or equivalent area and its subdivisions.

Statistics for each of the 57 areas are issued in separate paperbound editions of chapters A and B.

Series HC80-1-A — Chapter A

GENERAL HOUSING CHARACTERISTICS

To be issued: early 1982—mid-1982 — Statistics on units at address, tenure, condominium status, number of rooms, persons per room, plumbing facilities, value, contract rent, and vacancy status are shown for some or all of the following areas or their equivalents: States, counties, county subdivisions, places (and towns and townships in selected States) of 1,000 or more inhabitants, SCSA's, SMSA's, urbanized areas, American Indian reservations, and Alaska Native villages. Selected tables contain housing characteristics for urban and rural areas.

Series HC80-1-B — Chapter B

DETAILED HOUSING CHARACTERISTICS

To be issued: Fall 1982—early 1983 — Some subjects included in the HC80-1-A reports are also covered in this report. Additional subjects covered include units in structure, year moved into unit, year structure built, heating equipment, fuels, air conditioning, water and sewage, gross rent, and selected monthly ownership costs. The statistics are shown for some or all of the following areas or their equivalents: States, counties, places (and towns and townships in selected States) of 2,500 or more inhabitants, SCSA's, SMSA's, urbanized areas, American Indian reservations, and Alaska Native villages. Selected tables show housing characteristics for rural-farm and rural-nonfarm residence at the State and county level.

EXHIBIT 2 (Continued)

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Series HC80-2 Volume 2.

METROPOLITAN HOUSING CHARACTERISTICS

To be issued: mid to late 1983 — This volume presents statistics on microfiche (tentatively, no printed reports planned) for most of the 1980 housing census subjects in considerable detail and cross-classification. Most statistics are presented by race and Spanish origin for areas with at least a specified number of the relevant population groups. Data are shown for States or equivalent areas, SMSA's and their central cities, and other cities of 50,000 or more inhabitants. There is one report for each SMSA, and one report for each State, the District of Columbia, and Puerto Rico. The set includes a U.S. Summary report showing these statistics for the United States and regions.

Series HC80-3 Volume 3.

SUBJECT REPORTS

To be issued: beginning 1983 — Each of the reports in this volume focuses on a particular subject. Detailed sample estimates and cross-tabulations of housing characteristics are provided on a national, regional, and divisional level. Separate reports are tentatively planned on housing of the elderly, mobile homes, and American Indian households.

Note that the preparation of subject reports is dependent upon availability of funding in 1983.

Series HC80-4 Volume 4.

COMPONENTS OF INVENTORY CHANGE

To be issued: late 1982 — This volume consists of two reports presenting statistics on the 1980 characteristics of housing units which existed in 1973, as well as on newly constructed units, conversions, mergers, demolitions, and other additions and losses to the housing inventory between 1973 and 1980. These reports present data derived from a sample survey conducted in the fall of 1980. Data are presented for the United States and regions. Some data are presented by inside and outside SMSA's and central cities.

HC80-5 Volume 5.

RESIDENTIAL FINANCE

To be issued: mid 1983 — This volume consists of one report presenting statistics on the financing of nonfarm homeowner, rental and vacant properties, including characteristics of the mortgage, property, and owner. The statistics are based on a sample survey conducted in the spring of 1981. Data are presented for the United States and regions. Some data are presented by inside and outside SMSA's and central cities.

HC80-SI-I **SUPPLEMENTARY REPORT—Selected Housing Characteristics by States and Counties: 1980**

Issued: 10/81 — This report presents statistics from the 1980 Census of Housing on general characteristics of housing units for the 50 States and the District of Columbia, counties, and independent cities.

1980 Census of Population and Housing

Evaluation and Reference Reports

Series PHC80-E **EVALUATION AND RESEARCH REPORTS**

These reports present the results of the extensive evaluation program conducted as an integral part of the 1980 census. This program relates to such matters as completeness of enumeration and quality of the data on characteristics.

Series PHC80-R **REFERENCE REPORTS**

These reports present information on the various administrative and methodological aspects of the 1980 census. The series includes:

PHC80-R1 **Users' Guide.**

To be issued: beginning early 1982 — This report covers subject content, procedures, geography, statistical products, limitations of the data, sources of user assistance, notes on data use, a glossary of terms, and guides for locating data in reports and tape files. The guide is issued in loose-leaf form and sold in parts (R1-A, -B, etc.) as they are prepared.

PHC80-R2 **History.**

To be issued: 1984 — This report describes in detail all phases of the 1980 census, from the earliest planning, and through all stages, to the dissemination of data and evaluation of results. It contains detailed discussions of 1980 census questions and their use in previous decennial censuses.

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PHC80-R3 **Alphabetical Index of Industries and Occupations.**

To be issued: beginning in 1980 with updates through 1983 — This report was developed primarily for use in classifying responses to certain census questions relating to an employer's kind of business and an employee's kind of work. The index lists approximately 20,000 industry and 29,000 occupation titles in alphabetical order.

PHC80-R4 **Classified Index of Industries and Occupations.**

To be issued: beginning in 1980 with updates through 1983 — This report defines the industrial and occupational classifications adopted for the 1980 Census of Population. It presents the individual titles that constitute each of the 231 industry and 503 occupation categories in the classification systems. The individual titles are the same as those shown in the Alphabetical Index. The 1980 occupation classification reflects the new U.S. Standard Occupational Classification (SOC). As in the past, the 1980 industry classification also reflects the Standard Industrial Classification (SIC).

PHC80-R5 **Geographic Identification Code Scheme.**

To be issued: Spring 1982 — This report identifies the names and related geographic codes for each State, county, minor civil division, place, region, division, SCSA, SMSA, American Indian reservation, and Alaska Native village for which the Census Bureau tabulated data from the 1980 census.

COMPUTER TAPES

Summary Tape Files—General

In addition to the printed and microfiche reports, results of the 1980 census also are provided on computer tape for the United States and Puerto Rico in the form of summary tape files (STF's). These data products have been designed to provide statistics with greater subject and geographic detail than is feasible or desirable to provide in printed and microfiche reports. The STF data are made available, subject to suppression of certain detail where necessary to protect confidentiality, at nominal cost.

There are five STF's, and the amount of geographic and subject detail presented varies. STF's 1 and 2 contain complete-count data, and STF's 3, 4, and 5 contain sample-estimate data. Note that the term "cells" used below refers to the number of subject statistics provided for each geographic area, and the number of cells is indicative of the complexity of the subject content of the file.

Additionally, each of the STF's consists of a set of tapes with geographic coverage varying by file within the set. These are issued a State at a time, followed by the national level tapes. More complete descriptions of the STF's than given in the summaries below can be found in the technical documentation for the specific file, and in the *1980 Census of Population and Housing Users' Guide.*

Summary Tape Files

STF 1 — To be available: 9/81—early 1982 — This file provides 321 cells of complete-count population and housing data. Data are summarized for the United States, regions, divisions, States, SCSA's, SMSA's, urbanized areas, congressional districts, counties, county subdivisions, places, census tracts, enumeration districts in unblocked areas, and blocks and block groups in blocked areas. This file set includes data shown in the PHC80-1, PHC80-3, and PC80-1-A reports.

STF 2 — To be available: early 1982—mid-1982 — This file contains 2,292 cells of detailed complete-count population and housing data, of which 962 are repeated for race and/or Spanish origin groups present in the tabulation area. Data are summarized for the United States, regions, divisions, States, SCSA's, urbanized areas, counties, county subdivisions, places of 1,000 or more inhabitants, census tracts, American Indian reservations, and Alaska Native villages. This file set includes data shown in the PHC80-2, PC80-1-B, and HC80-1-A reports.

STF 3 — To be available: Spring 1982—Fall 1982 — This file contains 1,126 cells of population and housing data estimated from the sample for the same area as in STF 1, excluding blocks. This file set includes data shown in the PHC80-3 reports. In addition, the Census Bureau is exploring the possibility of producing STF 3 data for 5-digit ZIP Code areas on a cost-reimbursable, special-tabulation basis.

STF 4 — To be available: mid-1982—late 1982 — This file is the geographic counterpart of STF 2, but the number of cells of data is approximately three times greater. STF 4 provides detailed population and housing data estimated from the sample, some of which are repeated for race, Spanish origin, and ancestry groups. Data are summarized for areas similar to those shown for STF 2, except that data for places are limited to those with 2,500 or more inhabitants. This file set includes data shown in the PHC80-2, PC80-1-C, and HC80-1-B reports.

EXHIBIT 2 (Continued)

STF 5
To be available: mid to late 1983

This file contains over 100,000 cells of population and housing data estimated from the sample and provides highly detailed tabulations and cross-classifications for States, SMSA's, and counties and cities of 50,000 or more inhabitants. Most subjects are classified by race and Spanish origin. This file set includes data shown in the PC80-1-D and HC80-2 reports.

Other Computer Tape Files

P.L. 94-171 Population Counts
Issued: 2/81–3/81

In accordance with Public Law (P.L.) 94-171, the Census Bureau provided population tabulations to all States for legislative reapportionment/redistricting. The file was issued on a State-by-State basis. It contains the final population counts classified by race and Spanish origin. The data are tabulated for the following levels of geography as applicable: States, counties, county subdivisions, incorporated places, census tracts, block groups, and blocks or enumeration districts. For States participating in the voluntary program to define election precincts in conjunction with the Census Bureau, the data are also tabulated for election precincts.

Master Area Reference File (MARF)
To be available: 9/81– early 1982

This geographic reference file is an extract of STF 1 designed for those who require a master list of geographic codes and areas, along with basic census counts arranged hierarchically from the State down to the block group and enumeration district level and is issued on a State-by-State basis. The file contains records for States, counties, county subdivisions, places, census tracts, enumeration districts in unblocked areas, and block groups in blocked areas. Each record shows the total population by five race groups, population of Spanish origin, number of housing units, number of households, number of families, and a few other items.

Geographic Base File/ Dual Independent Map Encoding—GBF/DIME
Beginning in 1978 periodic updates

These files are computerized representations of the Metropolitan Map Series, including address ranges and ZIP Codes, which generally cover the urbanized portions of SMSA's. GBF/DIME files are used to assign census geographic codes to addresses (geocoding). The files are issued by SMSA.

Public-Use Microdata Samples
To be available: mid-1982– late 1982

Public-use microdata samples are computerized files containing most population and housing characteristics as shown on a sample of individual census records. These files contain no names or addresses, and geographic identification is sufficiently broad to protect confidentiality.

There are three mutually exclusive samples, the A sample including 5 percent, and the B and C samples each including 1 percent of all persons and housing units. States and most large SMSA's will be identifiable on one or more of the files. Microdata files allow the user to prepare customized tabulations.

Census/EEO Special File
To be available: Fall 1982– early 1983

In addition to the regular summary tape files, the Bureau plans to prepare a "Census/EEO Special File." This public-use computer file will provide sample census data with specified relevance to EEO and affirmative action uses. The file will contain two tabulations, one with detailed occupational data and the other with years of school completed by age. The data in both tabulations will be crossed by sex and Hispanic origin or race for non-Hispanics. These data will be provided for all counties, for all SMSA's, and for incorporated places with a population of 50,000 or more.

MAPS

Maps necessary to define areas are generally published as part of the corresponding reports. Detailed map packages showing the blocks in the *1980 Census of Population and Housing Block Statistics* reports (PHC80-1) must be purchased separately. Maps necessary to define enumeration districts are available on a cost-of-reproduction basis.

MICROFICHE

Some of the computer tape products are available on microfiche. Like the summary tape file sets, the STF microfiche are issued a State at a time, followed by the national-level microfiche. These include:

STF 1A Microfiche—Data from the STF 1 file set are presented in tabular form for STF 1A summarization levels (block data from STF 1B are not included).

P.L. 94-171 Counts Microfiche—Data from the P.L. 94-171 file are presented in a listing format on microfiche. The microfiche was issued on a State-by-State basis.

EXHIBIT 3

6g

UNITED STATES DEPARTMENT OF COMMERCE
Bureau of the Census
Washington, D.C. 20233

PUBLIC-USE MICRODATA SAMPLES FROM THE 1980 CENSUS

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Revised January 1983

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OVERVIEW

Public-use microdata samples are computer tapes which contain records for a sample of housing units, with information on the characteristics of each unit and the people in it. In order to protect the confidentiality of respondents, the Bureau excludes identifying information from the records. Within the limits of the sample size and geographic detail provided, these tapes permit users with special needs to prepare virtually any tabulations of the data they may desire.

Three separate public-use microdata samples are available, each representing five percent or one percent of the population and housing of the United States:

- A Sample, 5%, identifying all States and various subdivisions within them, including most counties with 100,000 or more inhabitants;
- B Sample, 1%, identifying all metropolitan territory and most SMSAs individually, and groups of counties elsewhere;
- C Sample, 1%, identifying regions, divisions, and most States by type of area (urban/rural).

Three 1-in-1,000 samples are also available, one each extracted from the A, B, and C Samples.

All files are expected to be available in early 1983.

COMPARISON OF SUMMARY DATA AND MICRODATA

Figure 1 illustrates the basic distinctions between summary data and microdata. Summary data are the type of data found in census printed reports, summary tape files, microfiche, and most special tabulations. In summary data, the basic unit of analysis is a specific geographic area (for example, a census tract, county, or State) for which counts of persons or housing units in particular categories are provided. In microdata, the basic unit is an individual housing unit and the persons who live in it.

Figure 1. Comparison of Summary Data With Information on Microdata Files

SUMMARY DATA

- Basic unit is an identified geographic area
- Data summarized on people and housing in areas
- Available for small areas

Illustrative Summary Data

City	Total Pop.	Occupied Housing Units	Number of Persons Per Unit	Renter Occupied Units	Gross Rent: Under $80	Gross Rent: $80 – 99	Gross Rent: $100 – 149
Weston City	110,938	49,426	2.2	31 447	858	3,967	13,282
Smithville	21,970	7,261	3.1	2,492	37	190	1,766
Junction	17,152	5,494	2.7	822	11	29	238

PUBLIC-USE MICRODATA

- Basic unit is an unidentified housing unit and its occupants
- Unaggregated data to be summarized by the user
- Allows detailed study of relationships among characteristics
- Not available for small areas

Illustrative Microdata*

	State of Residence	Metro/nonmetro	Persons in household	Telephone	Plumbing	Rent	Automobiles	Household type	
Housing Unit #1	Virginia	Metro	3	Yes	Yes	$325	2	Married-couple family	F

	Relationship	Sex	Age	Race	Place of Birth	Years of School	Occupation	Earnings	
Person a	Householder	M	37	W	Kansas	12	Plumber	$22,100	B
Person b	Spouse	F	35	W	Virginia	12			
Person c	Child	M	6	W	Virginia	1			

Housing Unit #2	Virginia	Nonmetro	1	Yes	Yes	$150	1	Nonfamily householder	
Person a	Householder	F	62	B	Alabama	16	Elementary teacher	$15,300	Id
Housing Unit #3	Virginia	Metro	0	N/A	Yes	$205	N/A	Vacant	

*Public-use microdata samples do not actually contain alphabetic information. Such information is converted to numeric codes; for example, the State of Virginia has a numeric code of 51.

There are two types of microdata: confidential microdata and public-use microdata. Confidential microdata include census basic record tapes, computerized versions of the questionnaires collected from households, as coded and edited during census processing. The Census Bureau tabulates these confidential microdata in order to produce the summary data that go into the various reports, summary tape files (STFs), and special tabulations. Public-use microdata samples are extracts from the confidential microdata taken in a manner that avoids disclosure of information about identifiable households or individuals.

PROTECTING CONFIDENTIAL INFORMATION

Records on public-use microdata samples contain no names or addresses. Also, the Bureau limits the detail on place of residence, place of work, high incomes, and selected other items to further protect the confidentiality of the records. Microdata records identify no geographic area with fewer than 100,000 inhabitants. Microdata samples include only a small fraction of the population, drastically limiting the chance that the record of a given individual is even contained in a microdata file, much less identifiable.

USES OF MICRODATA FILES

Public-use microdata files essentially make possible "do-it-yourself" special tabulations. The 1980 files furnish almost the full richness of detail recorded on long-form questionnaires in the census. Subject to the limitations on sample size and geographic identification, it is possible for the user to construct a seemingly infinite variety of tabulations interrelating any desired set of variables. Users have the same freedom to manipulate the data that they would have if they had collected the data in their own sample survey, yet these files offer the precision of census data collection techniques and sample sizes larger than would be feasible in most independent sample surveys.

Microdata samples will be useful to users (1) who are doing research that does not require the identification of specific small geographic areas or detailed cross tabulations for small populations, and (2) who have access to programming and computer time needed to process the samples. Microdata users frequently study relationships among census variables not shown in existing census tabulations, or concentrate on the characteristics of certain specially defined populations, such as unemployed homeowners or families with four or more children.

SAMPLE DESIGN AND SIZE

Each microdata file is a stratified sample of the population, actually a subsample of the full census sample (19.4% of all households) that received census long-form questionnaires. Sampling was done household-by-household in order to allow study of family relationships and housing unit characteristics. Sampling of persons in institutions and other group quarters was done on a person-by-person basis. Vacant units were also sampled.

There are three independently drawn samples, designated "A," "B," and "C," each featuring a different geographic scheme, as discussed below. The B and Samples each contain 1 percent, i.e., one household for every one hundred households in the Nation. Samples from the 1970 and 1960 censuses also employed a 1-percent sample size. New for 1980 is a 5-percent sample, designated the A Sample, which includes over one-fourth of the households that received the census long-form questionnaire. Nationwide, the A Sample gives the user records for over 11 million persons and over 4 million housing units. (One could even use the A, B, and C Samples together, if there were an advantage in having a 7-percent sample, since there is negligible overlap among the samples.) On the other hand, since processing a smaller sample is less expensive, some users will be interested in one of the the one-in-a-thousand samples (extracts

EXHIBIT 3 (Continued)

of the 1-percent and 5-percent samples) which are also available from the Census Bureau.

The samples are self-weighting. The user can estimate the frequency of a particular characteristic for the entire population by tallying records from the microdata files and multiplying the result by the inverse of the sampling rate, e.g., multiplying raw counts from the 5-percent A Sample by 20.

Reliability improves with increases in sample size, so the choice of sample size must represent a balance between the level of precision desired and the resources available for working with microdata files. By using tables provided in the technical documentation for the public-use microdata samples, one can estimate the degree to which sampling error will affect any specific number prepared from a microdata file of a particular sample size. (It is also possible to estimate sampling error using 100 "random groups" identified on sample records.) Users of microdata files for State or SMSA estimates would normally use a 1- or 5-percent sample, while users concerned only with national figures can frequently get by with a 0.1 percent (one-in-a-thousand) sample. Even national users may need a 1-percent or 5-percent sample if they contemplate extremely detailed tabulations or are concerned with very small segments of the population, for example, males 65 years old or over of Polish ancestry. One of the examples in the documentation works through the selection of appropriate sample size in a particular study.

SUBJECT CONTENT

With only minor exceptions, microdata files contain the full range of population and housing information collected in the 1980 census: 503 occupation categories, age by single years up to 90, income by $10 intervals up to $75,000, and so forth. Because the samples provide data for all persons living in a sampled household, users can study how characteristics of household members are interrelated (for example, income and educational attainment of husbands and wives).

Information for each household in the sample appears on a 193-character record with housing items, followed by a variable number of 193-character records with person information, one record for each member of the household. Items on the housing record are listed on page 12; items on the population record are listed on page 13. Most of the data items coded on the microdata records correspond directly to responses listed on the census questionnaire. Categories are shown on the questionnaire. Categories are shown on the questionnaire facsimile shown in the 1980 census Users' Guide (PHC80-R1-A), p. 21-27. Other items requries write-in responses which Bureau personnel clerically coded to predefined categories at the Census Bureau. For example, the response of a person who wrote in "clarinetist" under occupation would have been coded to the category "Musicians and Composers," identified by code 186 in the occupation field on the microdata record. Category detail for selected items is spelled out in a list on pages 14-16.

Data users will frequently want to generate additional variables or otherwise recode these items. For instance, a user desiring data on years of school completed must construct this variable by interrelating the items on highest year of school attended and the completion of that year. Specifically, for every person now attending school or who failed to finish the last grade attended, year of school completed in one less than the highest year of school attended. Transformations such as these are discussed in an appendix to the documentation.

Figure 2. Comparison of Features on 1980 and 1970 Public-Use Microdata Samples

	1980 Samples			1970 Samples		
	A	B	C	State	County Group	Neigh Chars.
Sample Size	5% 0.1%	1% 0.1%	1% 0.1%	1-2% 0.1%	1-2% 0.1%	1-2% 0.1%
Areas Identified						
Divisions	X	-	X	X	-	X
States	51	20	28	51	4	-
SMSAs of 100,000+	180	282	-	-	125	-
Counties of 100,000+	350	236	-	-	104	-
Places of 100,000+	123	135	58	-	12	5
County Groups	1149	1253	-	-	409	-
Urbanized Areas	-	-	73	-	-	6
Metro/Nonmetro	-	X	-	23 States	-	-
Urban/Rural	-	-	X	42 States	-	X
Neighborhood Characteristics	-	-	-	-	-	X

There are no "missing data" categories in most items on these files. Substitutions or allocations have been made for any missing data resulting from incomplete questionnaires, inconsistent information or equipment malfunction. "Allocation flags" appear at the end of each record indicating each item which has been allocated. Thus, a user desiring to tabulate only actually observed values can ignore those cases with allocated values.

GEOGRAPHIC IDENTIFICATION

The A, B, and C Samples each feature a different geographic scheme:

o The A Sample, expected to be the most widely used because of its 5-percent size, identifies every State and almost all individual counties with 100,000 or more inhabitants (about 343 in all). In many cases individual cities or groups of places with 100,000 or more inhabitants are also identified.

Counties not separately identified have been grouped into analytic units proposed by State Data Centers. These frequently follow SMSA or State planning district boundaries. In New England, areas are defined in terms of cities and towns rather than counties.

The term "county group" is used loosely to apply to each of the areas identified on these files. A 3-digit number, unique within State, identifies each area.

o The B Sample identifies 282 SMSAs of 100,000 or more inhabitants. The remaining 36 SMSAs are paired together so that metropolitan and nonmetropolitan territory can be separately analyzed. Thirty-one States are not separately identified because they contain SMSAs which cross State boundaries and have fewer than 100,000 persons within a State. Many large cities, groups of cities, and counties are identified within large SMSAs. Outside SMSAs, counties are grouped according to State planning district or into other reasonable analytic units with populations of 100,000 or more.

o The C Sample identifies 27 States and the District of Columbia. The remaining States are shown in eight groups, none of which crosses a census region or division boundary (see H4, p. 14). Four type-of-area categories are shown throughout: central cities of urbanized areas, urban fringe (i.e., the

Figure 3. A Sample County Groups

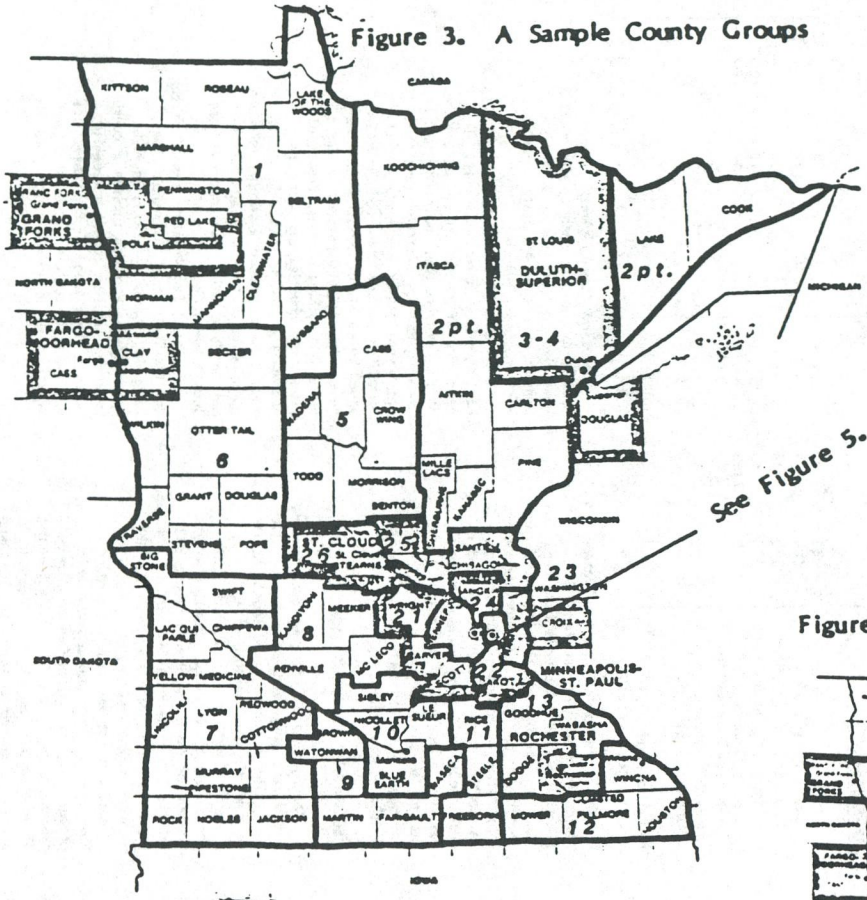
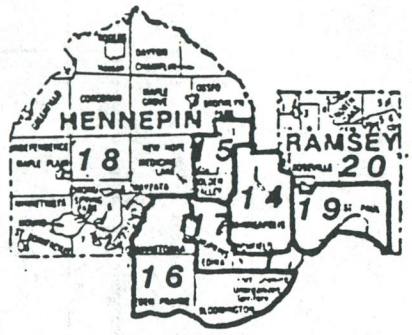


Figure 5. Inset to Figure 3.



See Figure 5.

Figure 6. Minnesota Development Regions

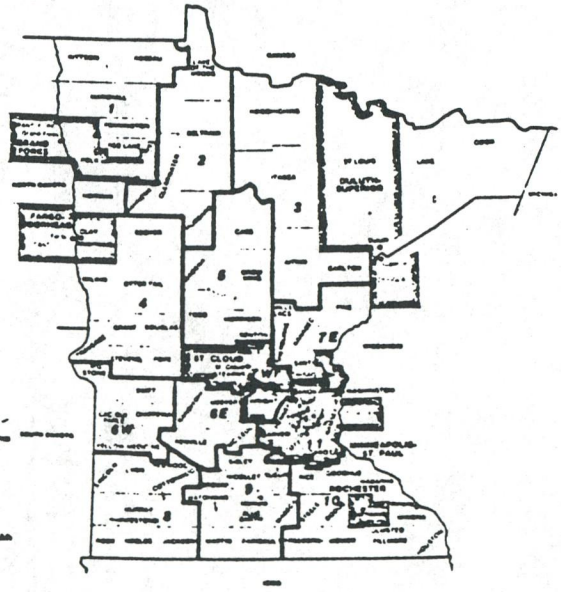


Figure 4. B Sample County Groups

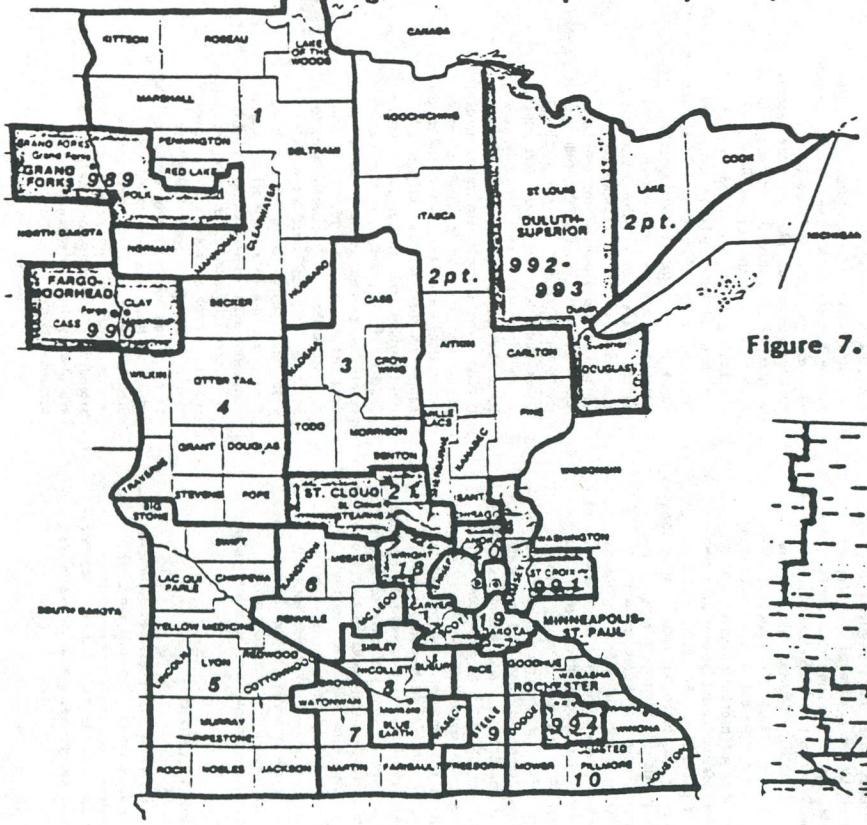


Figure 7. 1970 County Groups for Minnesota and Adjacent Area

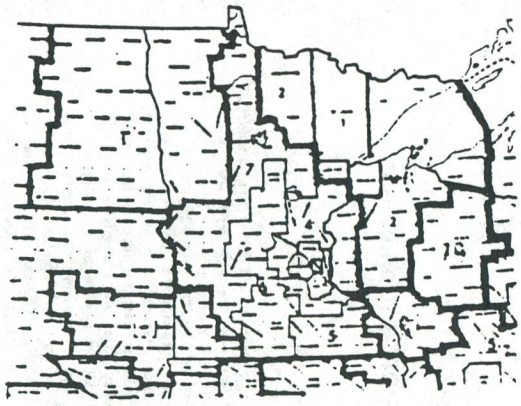


EXHIBIT 3 (Continued)

remainder of urbanized areas outside central cities), other urban, and rural. Seventy-three individual urbanized areas are shown, all of which have at least 100,000 inhabitants in the central city and another 100,000 in the urban fringe (except for two UAs with no urban fringe). The C sample includes every urbanized area with a total population over 800,000, and roughly half of the urbanized areas between 200,000 and 800,000.

The characteristics of the three different geographic schemes are compared in figure 2.

Nationwide maps in the GE-50 series, available in early 1983, will portray county group boundaries. The components of each county group are also derivable from a computerized County Group Equivalency File, available now on tape or microfiche. A sample printout is shown in figure 8.

The 1-in-1,000 samples extracted from the A, B, and C Samples have the same geography as the parent files.

Subsequent to the production of the basic A, B, and C Samples, additional microdata files may be prepared. These include (1) new versions of the A Sample for selected large cities or SMSAs with codes for tract groups with over 100,000 inhabitants (cost-reimbursable); (2) a D Sample identifying "metropolitan statistical areas" (MSAs), i.e., redefined SMSAs, to be designated in 1983; (3) microdata files for Puerto Rico; and possibly other special-purpose files. (For more information call the author at 301/763-2005.)

EXAMPLE OF GEOGRAPHIC SCHEMES

Figures 3 and 4 portray county groups on the A and B Samples for an illustrative State, Minnesota. The solid lines are county group boundaries; the broader shaded lines show SMSAs.

On the A Sample, each of the State's counties of 100,000 or more population is identified: Anoka, Dakota, Hennepin, Ramsey, St. Cloud, St. Louis and Washington. The two large cities, Minneapolis and St. Paul, can each be identified since the remainders of their respective counties are both large enough. In fact Hennepin County is further subdivided by the identification of three groups of places outside Minneapolis (see figure 5), since each place group and the remainder of the county have more than the required 100,000 inhabitants. Outside of the large counties, county groups have been defined based on "Minnesota Development Regions" shown in figure 6. In some cases these regions were too small, as in the combination of regions 1 and 2 which are merged to form A Sample county group 001. In other areas, the regions could be further broken down, as in the subdivision of region 10 into three county groups (011, 012, and 013). Various other departures were made from the development regions to form desired analytic units within the population criterion.

As it happens, none of the Minnesota's SMSAs are identifiable on the A Sample. Rochester has fewer than 100,000 inhabitants and Grand Forks and Fargo-Moorhead SMSAs have fewer than 100,000 inhabitants in Minnesota. Parts of St. Cloud and Minneapolis-St. Paul SMSAs outside large counties have been combined. Only the Minnesota part of Duluth-Superior SMSA is shown.

County groups are infrequently composed of noncontiguous parts. For example, Lake and Cook Counties (combined population 17,135) are cut off from the remainder of their development region by the separate identification of St. Louis County. Still, the two parts of county group 002 together with county groups 003 and 004 (St. Louis County) do form a reasonable unit.

Many of the county groups on the B Sample are the same as on the A Sample. The most distinct difference is that all SMSA boundaries have been observed, as can be seen in figure 4. Each of the four SMSAs crossing State lines have been identified at the expense of recognizing the State line as a county group boundary. In records for these county groups, the regular State code for Minnesota (27) or the adjacent State

Figure 8 Sorted List From County Group Equivalency File

COMPONENTS OF A SAMPLE COUNTY GROUP 013

NAME	POPULATION	ST COU MCD	PL	SMSA	B A GRP S
DODGE COUNTY	14773	27 039			4 013 3
GOODHUE COUNTY	38749	27 049			4 013 3
OLMSTED COUNTY	92006	27 109		6820	4 013 3
WABASHA COUNTY	19335	27 157			4 013 3

POPULATION IN COUNTY GROUP: 164863
TYPE OF AREA: SMSA MIXED WITH NONMETROPOLITAN AREA
SMSA NOT IDENTIFIED

COMPONENTS OF A SAMPLE COUNTY GROUP 014

NAME	POPULATION	ST COU MCD	PL	SMSA	B A GRP S
MINNEAPOLIS CITY	370951	27 053	2585	5120	1 014

POPULATION IN COUNTY GROUP: 370951
TYPE OF AREA: SMSA CENTRAL CITY

is replaced with "99" so that the parts in different States cannot be distinguished. Since Rochester SMSA is too small to be identified separately, it has been combined with another small SMSA nearby: LaCrosse, Wisconsin SMSA.

C Sample geography is quite different. Minnesota is not shown separately, but is combined with six other States of the West North Central division. The Minneapolis-St. Paul urbanized area (UA) is separately identified, and since there is also a type-of-area indicator, one can distinguish the central city part of the UA from the remainder (i.e., urban fringe). All other urbanized areas in the State cannot be distinguished from urbanized areas elsewhere in the 7-state division.

MIGRATION AND PLACE-OF-WORK DATA

The A and B Sample county groups apply not only to 1980 residence, but also to place of work in 1980 and to place of residence in 1975. This makes possible the detailed analysis of migration and commuting patterns in terms of origin and destination. For instance, one can examine inmigrants to an area (i.e., people who lived in a different area in 1975) in terms of the States or metropolitan areas from which they came. Further, if one purchases data for the entire U.S., one can also examine the characteristics of outmigrants (i.e., persons who lived in a particular county group in 1975 who resided elsewhere in 1980). Similarly one can look at the characteristics of the work-force in an area using the county group of work, irrespective of whether workers reside in the same area.

Migration, place of work, and travel time to work appear on these files only for one-half of the sampled households. (Due to budgetary limitations, only part of the questionnaires could be coded.) Thus, the 5-percent sample includes only a 2½-percent sample for migration and place of work. Therefore, the user must double the normal weights to derive estimates. Raw counts from the files would be multiplied by 40 to estimate the total population.

CORRESPONDING MICRODATA FROM EARLIER CENSUSES

The Census Bureau created six separate 1-percent (one-in-a-hundred) samples from the 1970 census, three based on the 15-percent versions of the 1970 questionnaire, and three based on the 5-percent version. Geographic areas identified on 1970 and earlier microdata files were required to have at least 250,000 inhabitants. One geographic scheme employed in 1970 identified States, a second identified SMSAs with 250,000 or more inhabitants and similarly large county groups elsewhere, and the third identified only very large areas but included records for "neighborhood characteristics." A single one-in-a-hundred sample, identifying States, is available from the 1960 census. Characteristics of these 1970 geographic schemes are summarized in figure 2.

The files from 1960 and 1970 use basically similar formats. The 1980 microdata record layouts differ from their 1960 and 1970 counterparts; but, since most of the 1980 items were also included in the 1970 and 1960 censuses, these microdata files represent a rich resource for analysis of trends. Items which were added, dropped, or substantially changed between 1970 and 1980 are listed in figure 9.

The 1980 census glossary, included in file documentation or available as part of the Users' Guide, discusses historical comparability of 1980 data items in greater detail.

Geographic comparability is a larger problem. States can be identified on microdata from each census (the 1960 and 1970 State samples and the 1980 A Sample). Regions and divisions by type-of-area are derivable from the 1980 C Sample and the 1970 "Neighborhood Characteristics" Samples. Many, but far from all, counties of 250,000 or more population in 1970 are identified on the 1970 "County Group" Samples. These large counties typically are also shown on the 1980 A Sample (and frequently also the B sample); for example, Hennepin and Ramsey Counties in Minnesota. A three-county area on 1970 files consisting of Anoka, Dakota, and Washington Counties can also be reproduced in 1980, since each of those three counties qualifies for identification in 1980. B Sample county groups 992 and 993 (Duluth-Superior SMSA) have a 1970 counterpart because the 1970 file recognized all SMSAs of 250,000 or more population. SMSAs are not always directly comparable between 1970 and 1980, however, since roughly half of the SMSAs identified in 1970 files changed boundaries prior to the 1980 census. In other words, a 1970 SMSA identified as a county group may not match a 1980 SMSA shown on the B Sample. No individual place or place

Figure 9. 1970-1980 Subject Comparability

1980 Items Not on 1970 Files:

Ancestry
Boarded-up vacant unit
Carpooling
Condominium
Language spoken at home and ability to speak English
Hours usually worked per week last year
Public transportation disability
Selected monthly owner costs
Travel time to work (shown only for half of the sample)
Vans or light trucks available
Weeks unemployed last year

Concepts Substantially Changed:

Farm definition - old definition can be reconstructed
"Householder" replaces household head concept
Industry - many code changes; classification system changed somewhat
Occupation - classification system substantially changed
Poverty definition - some adjustments but old definition can be reconstructed
Race - several categories added; revised coding rules affect White and Other
Residence in 1975/Place of Work - broad categories in 1970, but coded to county group in 1980 on the A and B Samples (shown only for half of the sample)
Telephone in unit - narrower than telephone availability in 1970
Work disability - not counted if it has lasted less than six months

1970 Items Not On 1980 Files:

Basement
Battery radio
Birthplace of parents (allowing identification of "foreign stock")
Clothes dryer
Clothes washing machine
Dishwasher
Duration of disability
Home food freezer
Industry and occupation 5 years ago
Mother tongue
Owner-occupied cooperative/condominium
Second home
Television
Vocational training
Year moved into unit (retained for householders, deleted for other persons)

EXHIBIT 3 (Continued)

group was shown prior to 1980. Outside identified SMSAs there is almost no commonality between 1970 and 1980 county groups. 1970 county groups were based on "functional economic areas" defined by the Bureau of Economic Analysis. These frequently crossed State lines and involved grouping criteria unrelated to the administrative and local-interest factors that contributed to the definition of county groups in 1980.

Further information on the 1970 microdata files is contained in Public-Use Samples of Basic Records From the 1970 Census: Description and Technical Documentation and its three supplements, available for $5 from the address on p. 11. A map, 22 by 32 inches, defining areas identified on the 1970 County Group Samples is included with the documentation. Documentation for the 1960 microdata file is also available for $5.

Public-use microdata samples are being created from manuscript records of the 1940 and 1950 censuses, and will probably be available in spring, 1983. (For more information contact Barbara Aldrich at 301/763-2074.)

SOFTWARE CONSIDERATIONS

The microdata samples employ a hierarchical, nonrectangular file structure which cannot be handled directly by many common data processing software systems (such as BMD). Figure 1 suggests the hierarchical structure. As shown there, a household record, giving information about a particular household and housing unit, appears first and is followed by separate person records for each household member. Only a few users will be able to derive desired tabulations using only one type of record, since geographic information appears on the housing record and the key demographic information is on the person record.

In order to use many software packages, users have to create extract files with any desired household data repeated with each person's record. While this imposes an intermediate processing step on users of such software, it will benefit those users who are able to reduce significantly the size of the file. The Census Bureau's CENSPAC system, can be used to generate rectangular extract files.

Alternatively, users may obtain a software package capable of handling the hierarchical structure or prepare their own software. The Census Bureau offers such a software package called COCENTS, and others are available from commercial sources (for example, SAS and SPSS[x]). Descriptions of CENSPAC and COCENTS are available on request from the address on p.10.

Users frequently find it useful to verify their tabulations of microdata against other figures. A few control counts (e.g., number of records) are included with each tape ordered. Further, the user can compare microdata tallies against the full range of published data from the census, allowing, as appropriate, for sampling error. Care is required, however, since universes and categories must be defined in the same way in the user's tabulations as in the census reports.

TIMING AND COST

The A, B, and C Samples are expected to be available for the entire United States during the first few months of 1983. The files will initially be issued by State (or State group for the C Sample). The last files to be issued will be the B Sample file for county groups crossing State lines, and the nationwide 1-in-1,000 (0.1%) subsamples of the A, B, and C Samples.

These files are sold on 9-track computer tapes with choice of density (1600 or 6250 bytes per inch), recording language (EBCDIC or ASCII), labelling (standard labels or unlabelled), and blocking (any size up to 32617 characters evenly divisible by the 193-character record size).

Depending on the density and sample size selected, a nationwide public-use microdata sample could cost as little as $140 (a 1-in-1,000 sample on one tape at 6250 bpi) or as much as $14,140 (a 5-percent sample on 101 tapes at 1600 bpi). These figures are estimates subject to change. The 5-percent A Sample is issued by State, with each State requiring one to eight reels for a total of 101 tapes at 1600 bpi, or one or two reels per State for a total of 54 tapes at 6250 bpi. States can be "stacked" together reducing the total tapes required at 6250 bpi to 21, if the user is willing to wait until all States have been issued. Single-file tapes are priced at $140 per reel; "stacked" multiple-file tapes are priced at $165 per reel.

Estimated cost of nationwide samples

	1600 bpi		6250 bpi	
	tapes	cost	tapes	cost
5% Sample (A)	101	$14,140	21	$3,465
1% Sample (B or C)	19	$ 3,135	4	$ 660
0.1% Sample (A, B or C)	2	$ 280	1	$ 140

Many users will, of course, require only one or a few States, particularly users of the 5-percent A Sample. All individual State files require only a single reel of tape except for the following:

A Sample, 5%, 1600 bpi--8 tapes: California; 6 tapes: New York; 5 tapes: Texas; 4 tapes: Pennsylvania, Ohio, Illinois, Michigan, Florida; 3 tapes: New Jersey; 2 tapes: Connecticut, Massachusetts, Indiana, Wisconsin, Minnesota, Missouri, Maryland, Virginia, North Carolina, South Carolina, Georgia, Kentucky, Tennessee, Alabama, Louisiana, Oklahoma, Washington.

A Sample, 5%, 6250 bpi--2 tapes: California, New York, Texas

B Sample, 1%, 1600 bpi--2 tapes: New York, California

C Sample, 1%, 1600 bpi--2 tapes: New York, California, West North Central division (7 States combined).

The County Group Equivalency File is sold separately for $140.

DOCUMENTATION AND TRAINING

Public-use microdata sample documentation, consists of several parts: text, discussion of sampling variability with standard error tables, record layout ("data dictionary"), glossary of terms, and notes on the generation of common "derived" variables. The appendices include lists of States, SMSAs, counties and cities, and urbanized areas individually identified. The documentation package is sold for $5 per set by Customer Services. Maps defining county groups will become available as a supplement to the documentation in early 1983. A tape with the data dictionary in computerized form for use with CENSPAC will be available separately for $140.

Conferences entitled "Microdata from the 1980 Census" will be held in five cities in early 1983:

Washington, D.C.	Feb. 24, 1983
Pittsburgh, Pa.	Apr. 13, 1983
Atlanta, Ga.	May 10, 1983
Dallas, Tex.	May 26, 1983
San Francisco, Ca.	May 26, 1983

The fee is $25. For more information contact Dorothy Chin, User Training Branch, Data User Services Division, Washington, D.C. 20233 (301/763-1510).

For further information on file design or use, contact the author at 301/763-2005 or Jim Clark at 301/763-5242. Information on the availability of particular microdata files, as well as other ordering information can be obtained from:

Customer Services (Tapes)
Data User Services Division
Bureau of the Census
Washington, D.C. 20233
301/763-4100

Advance orders may be placed if desired. Full payment in advance or a deposit account is required. For more ½nformation, contact Customer Services.

EXHIBIT 3 (Continued)

ITEMS ON HOUSING RECORD

Character Location	Description
H1	Record Type (Housing Record)
H2	Sample Identifier
H3	Region/Division*
H4-5	State*
H6-8	County Group (A and B Samples only)
H9	Type of Area*
H10-13	SMSA (A and B Samples only)
H14-17	Urbanized Area (C Sample only)
H18-19	Subsample Number
H20-25	Housing Unit/CU Person Serial Number
H26-27	Number of Person Records Following This Housing Unit Record (up to 31)
H28	Type of Group Quarters*
H29	Tenure
H30	Seasonal and Migratory Vacancy Status
H31	Vacancy Type
H32	Boarded Up Status
H33	Duration of Vacancy
H34	Usual Home Elsewhere
H35	Condominium Status
H36-37	Units in Structure
H38-39	Units at Address
H40	Access
H41	Year Structure Built
H42	Stories in Structure
H43	Passenger Elevator
H44	Rooms
H45	Bedrooms
H46	Plumbing Facilities
H47	Kitchen Facilities
H48	Bathrooms
H49	Source of Water
H50	Sewage Disposal
H51	Air Conditioning
H52	Heating Equipment
H53	Fuels
H54	Water Heating Fuel
H55	Cooking Fuel
H56	Automobiles Available
H57	Trucks and Vans Available
H58	Telephone in Housing Unit
H59	Year Householder Moved into Unit
H60	Acreage of Property (H10a on questionnaire)
H61	Acreage of Property (H15a on questionnaire)
H62	Farm Status and Sales of Farm Products
H63	Commerical Establishment or Medical Office on Property
H64-65	Value
H66	Payment of Electricity
H67-69	Monthly Cost of Electricity (up to $200)
H70	Payment of Gas
H71-73	Monthly Cost of Gas (up to $150)
H74	Payment of Water
H75-77	Yearly Cost of Water (up to $500)
H78	Payment of Oil, Coal, Kerosene, Wood, Etc.
H79-82	Yearly Cost of Oil, Coal, Kerosene, Wood, Etc. (up to $2,000)
H83-86	Real Estate Taxes Last Year and Yearly Insurance Premiums Combined (up to $3,000)
H87	Mortgage Status
H88	Second or Junior Mortgage
H89-92	Total Monthly Payment to Lender (up to $1,500)
H93	Inclusion of Real Estate Taxes in Payment to Lender
H94	Inclusion of Insurance Premiums in Payment to Lender
H95-98	Selected Monthly Owner Costs (up to $2,000)
H99-100	Contract Rent
H101-103	Gross Rent (up to $999)
H104	Household Type*
H105	Presence and Age of Own Children*
H106	Number of Subfamilies in Family
H107-111	Household Income in 1979 (up to $75,000)
H112-116	Family Income in 1979 (up to $75,000)
H117 to H162	Allocation Flags for Housing Items
H163-193	Filler (zeroes)

*See p. 14

ITEMS ON PERSON RECORD

Character Location	Description
P1	Record Type (Person Record)
P2-3	Relationship
P4	Detailed Relationship*
P5	Subfamily Relationship*
P6	Subfamily Number
P7	Sex
P8-9	Age (up to 90)
P10	Quarter of Birth
P11	Marital Status
P12-13	Race*
P14	Spanish Origin
P15	Spanish Surname
P16-18	Ancestry--1st entry } 458 x 458
P19-21	Ancestry--2nd entry } combinations
P22-24	Place of Birth (51 States, 303 Countries)
P25	Citizenship
P26	Year of Immigration
P27	Language Spoken At Home Other Than English
P28-30	Language Spoken at Home (202 Categories)
P31	Ability to Speak English
P32-33	Children Ever Born
P34	Times Married
P35-36	Age at First Marriage
P37	Quarter of First Marriage
P38	Widowed
P39	School Enrollment and Type of School
P40-41	Highest Year of School Attended
P42	Finished Highest Grade
P43	Activity in 1975: In Armed Forces
P44	Activity in 1975: Attending College
P45	Activity in 1975: Working
P46	Migration/Place of Work/Travel Time Weight
P47-48	Residence in 1975
P49-51	Residence in 1975: County Group
P52	Residence in 1975: State-County Recode*
P53-54	Residence in 1975: SMSA recode*
P55-56	Place of Work: State
P57-59	Place of Work: County Group (A and B Sample)
P60	Place of Work: SMSA Recode (A and B Sample)*
P61	Place of Work: Central City Recode (C Sample only)*
P62	Place of Work: Place Size*
P63-64	Travel Time to Work
P65-66	Means of Transportation to Work
P67	Carpooling
P68	Carpool Occupancy
P69	Work Disability Status
P71	Public Transportation Disability Status
P72	Veteran Status
P73	Period of Service May 1975 or later
P74	Period of Service During Vietnam Era (August 1964-April 1975)
P75	Period of Service Between February 1955 and July 1964
P76	Period of Service During Korean Conflict (June 1950-January 1955)
P77	Period of Service During World War II (September 1940-July 1947)
P78	Period of Service During World War I (April 1917-November 1918)
P79	Period of Service During Any Other Time
P80	Year Last Worked
P81	Labor Force Status*
P82-83	Hours Worked Last Week
P84	Absent From Work Last Week
P85	Looking for Work
P86	Able to Take Job Last Week
P87-89	Industry (231 categories)
P90-92	Occupation (503 categories)
P93	Class of Worker
P94	Work Last Year
P95-96	Weeks Worked in 1979
P97-98	Usual Hours Worked Per Week in 1979
P99-100	Weeks Unemployed in 1979
P101-105	Wage or Salary Income in 1979**
P106-110	Nonfarm Self-Employment Income in 1979**
P111-115	Farm Self-Employment Income in 1979**
P116-120	Interest, Dividend, or Net Rental Income in 1979**
P121-124	Social Security Income in 1979
P125-128	Public Assistance Income in 1979
P129-133	All Other Income in 1979**
P134-138	Income From All Sources in 1979**
P139	Poverty Status in 1979 (Ratio of Family or Unrelated Individual Income in 1979 to Poverty Cutoff)*
P140 to P193	Allocation Flags for Population Items

*See p. 15-16.

**Most income categories shown up to $75,000.

EXHIBIT 3 (Continued)

DETAIL FOR SELECTED HOUSING ITEMS

Char. Loc.	Code	Description
H3		Region/Division
		Region/division not identifiable (selected SMSAs on B Sample, see List A)
		Northeast region:
	1	New England division
	2	Middle Atlantic division
		North Central region:
	3	East North Central division
	4	West North Central division
		South region:
	5	South Atlantic division
	6	East South Central division
	7	West South Central division
		West region:
	8	Mountain division
	9	Pacific division
H4-5		State
	01-56	FIPS State code
		State group code (C sample only):
	61	Maine-N.H.-Vt.
	62	Mass.-R.I.
	63	Minn.-Iowa-Mo.-Kans.-Neb.-S.D.-N.D.
	64	Md.-Del.
	65	Mont.-Idaho-Wyo.
	66	Utah-Nevada
	67	N.M.-Ariz.
	68	Alaska-Hawaii
	99	State not identified (selected SMSAs on B sample)
H8		Type of Area
	1	Central city of SMSA (selected SMSAs on A or B sample)
	2	In SMSA, outside central city (selected SMSAs on A or B sample)
	3	SMSA, central city/remainder not separately identified (separately identified selected SMSAs on A sample)
	4	Mixed SMSA/non-SMSA area (A sample only)
	5	Outside SMSAs (A or B sample)
	6	Central city of urbanized area (C sample only)
	7	Urban fringe (C sample only)
	8	Other urban (C sample only)
	9	Rural (C sample only)

Char. Loc.	Code	Description
H28		Type of Group Quarters
	0	n/a (housing unit)
	1	Inmate of mental hospital
	2	Inmate of home for the aged
	3	Inmate of correctional institution
	4	Inmate of other institution
	5	In military group quarters
	6	In college dormitory
	7	In rooming house
	8	Other in group-quarters, including noninmate living in institution
H104		Household Type
	0	n/a (vacant unit or group quarters)
	1	Married-couple family household
	2	Family household with male householder, no wife present
	3	Family household with female householder, no husband present
	4	Nonfamily household
H105		Presence and Age of Own Children
	0	n/a (nonfamily household, vacant unit or group quarters)
	1	Family with own children under 6 years only
	2	Family with own children 6 to 17 years only
	3	Family with own children, some 6 to 17 years and some under 6 years
	4	Family without own children

DETAIL FOR SELECTED POPULATION ITEMS

Char. Loc.	Code	Description
P2-3		Relationship to Householder
	00	Householder
		Family member other than householder:
	01	Spouse
	02	Child
	03	Brother or sister
	04	Parent
	05	Other relative (See P4)
		Person not related to householder:
	06	Roomer or boarder
	07	Partner or roommate
	08	Paid employee
	09	Other nonrelative
		In group quarters:
	10	Inmate
	11	Noninmate
P4		Detailed Relationship
	0	N/A (person not listed as "other relative" of householder)
	1	Son-in-law or daughter-in-law
	2	Grandchild
	3	Father-in-law or mother-in-law
	4	Brother-in-law or sister-in-law
	5	Nephew or niece
	6	Grandparent
	7	Uncle or aunt
	8	Cousin
	9	Other person related by blood or marriage
P5		Subfamily Relationship
	0	N/A (group quarters or not in a subfamily)
	1	Husband-wife in married-couple subfamily
	2	Parent in parent-child subfamily
	3	Child in subfamily

Char. Loc.	Code	Description
P12-13		Race
	01	White
	02	Black
	03	American Indian, Eskimo, Aleut
		Asian and Pacific Islander:
	04	Japanese
	05	Chinese
	06	Filipino
	07	Korean
	08	Asian Indian
	09	Vietnamese
	10	Hawaiian
	11	Other Asian and Pacific Islander, including Guamanian and Samoan
		Other (Race, n.e.c.):
	12	Spanish write-in entry
	13	Other
	14	
P52		Residence in 1975: State-County Record
	0	N/A (not included in migration/place of work/travel time sample, born April 1975 or later)
	1	Same house
		Different house:
	2	Same county
		Different county:
	3	Same State
		Different State:
	4	Region not specified (B Sample only)
	5	Northeast (A, C Samples only)
	6	North Central (A, C Samples only)
	7	South (A, C Samples only)
	8	West (A, C Samples only)
	9	Abroad

EXHIBIT 3 (Continued)

16

DETAIL FOR SELECTED POPULATION ITEMS

Char. Loc.Code	Description
P53-54	Residence in 1975: SMSA recode
0	N/A (C Sample, not included in migration/place of work/travel time sample, born April 1975 or later, or living abroad in 1975)
1	Living in same house in 1975
	Living in SMSA in 1980 (not applicable if H4=4, mixed metro/nonmetro areas on A Sample):
	Different house in same SMSA:
2	In central city(s)
3	Outside central city(s)
	Different house in different SMSA:
4	In central city(s)
5	Outside central city(s)
6	Outside any SMSA, or abroad
	Living outside SMSA in 1980 (not applicable if H4=4, mixed metro/nonmetro areas on A Sample):
7	Different house in central city of an SMSA
8	Different house in SMSA, outside central city
9	Outside an SMSA, or abroad
10	Living in a mixed metro/nonmetro area in 1980 (A Sample only)
P60	Place of Work: SMSA Recode (A and B sample)
	N/A (not included in migration/place of work/travel time sample, born April 1975 or later, or living abroad in 1975)
	Living in SMSA (not applicable if H4=4, mixed metro/nonmetro area on A Sample):
1	Working in same SMSA:
2	In central city, outside CBD
3	Outside central city
	Working in different SMSA:
4	In central city
5	Outside central city
6	Working outside any SMSA
	Living outside SMSA or in a mixed metro/nonmetro area (H4=4, A Sample only):
7	Working in central city of an SMSA
8	Working in an SMSA, outside central city
9	Working outside an SMSA

Char. Loc.Code	Description
P61	Place of Work: Central City Recode (C Sample only)
0	N/A (not included in migration/place of work/travel time sample, born April 1975 or later, or living abroad in 1975)
1	Working in the CBD of an urbanized area central city
2	Working in the remainder of a central city of an urbanized area (or anywhere in a central city with no CBD)
3	Working elsewhere
P62	Place of Work: Place Size
0	N/A (not included in migration/place of work/travel time sample, born April 1975 or later, or living abroad in 1975)
1	2,500 to 9,999
2	10,000 to 24,999
3	25,000 to 24,999
4	50,000 or more
5	Not in an identified place of 2,500 or more, or not reported at the place level
P81	Labor Force
0	N/A (under 16 years of age)
1	Employed, at work
2	Employed, not at work
3	Unemployed
4	Armed Forces, at work
5	Armed Forces, not at work
6	Not in labor force
P139	Poverty Status in 1979 (Ratio of Family or Unrelated Individual Income in 1979 to Poverty Cutoff
0	N/A (inmates of institutions, persons in military group quarters or in college dormitory, or unrelated individuals under 15 years of age)
	Below poverty level:
1	Below .75 of poverty cutoff (including no income or net loss)
2	.75 to .99
	Above poverty level:
3	1.00 to 1.24
4	1.25 to 1.49
5	1.50 to 1.99
6	2.00 or more

ORDER FORM

Census of Population and Housing, 1980:
Public-Use Microdata Samples
Technical Documentation (Preliminary)

Chapter 1. Introduction
Chapter 2. Processing the Data
Chapter 3. Accuracy of the Data
Chapter 4. Sample Design
Chapter 5. Record Contents
- Index to Data Fields
- Abbreviated List to Data Fields
- How to Use the Data Dictionary
- Data Dictionary
  - Housing Unit Record
  - Person Record

Appendixes:
- A. State and State Group Codes
- B. Standard Metropolitan Statistical Areas on The A and B Samples
- C. Areas for Which State Code is Not Shown on the B Sample
- D. Urbanized Areas on the C Sample
- E. Ancestry Codes
- F. Codes for Outlying Areas and Foreign Countries
- G. Codes for Languages Spoken at Home
- H. Industry Codes
- I. Occupation Codes
- J. Glossary
- K. Notes on Selected Data Items

Customer Services (Microfiche, Tapes and Maps)

Name
Organization
Address
City, State, ZIP
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Data User Services Division
Customer Services
Bureau of the Census
Washington, D.C. 20233
Phone: 301/763-4100

Date

CHECK ONE:
☐ Enclosed is check or money order, payable to "Commerce-Census"
☐ Charge to Census Bureau Deposit Account No. _____

Name of Data File, Documentation* Map (Series and Areas)	Order No.1/	No of Reels	No. of Map Sheets	No. of Document copies	Cost
Public-Use Microdata Sample Tech. Doc.				1	5 00
*One copy of the Technical Documentation is sent at no extra charge. With case orders additional copies are $5.00 each.				TOTAL $	

1/ Leave blank - will be filled by Census.

EXHIBIT 4

OVERVIEW

Current Population Survey, March 1980

Introduction

The Current Population Survey (CPS) is the source of the official Government statistics on employment and unemployment. The CPS has been conducted monthly for over 35 years. Currently, we interview about 68,000 households monthly, scientifically selected on the basis of area of residence to represent the Nation as a whole, individual States, and other specified areas. Each household is interviewed once a month for four consecutive months one year, and again for the corresponding time period a year later. This technique enables us to obtain month-to-month and year-to-year comparisons at a reasonable cost while minimizing the inconvenience to any one household.

Although the main purpose of the survey is to collect information on the employment situation, a very important secondary purpose is to collect information on the demographic status of the population, information such as age, sex, race, marital status, educational attainment, and family structure. From time to time additional qcestions are included on such important subjects as health, education, income, and previous work experience. The statistics resulting from these questions serve to update similar information collected once every 10 years through the decennial census, and are used by Government policymakers and legislators as important indicators of our Nation's economic situation and for planning and evaluating many Government programs.

The CPS provides current estimates of the economic status and activities of the population of the United States. Because it is not possible to develop one or two overall figures (such as the number of unemployed) that would adequately describe the whole complex of labor market phenomena, the CPS is designed to provide a large amount of detailed and supplementary data. Such data are made available to meet a wide variety of needs on the part of users of labor market information.

Thus, the CPS is the only source of monthly estimates of total employment (both farm and nonfarm); nonfarm self-employed persons, domestics, and unpaid helpers in nonfarm family enterprises; wage and salaried employees; and, finally, estimates of total unemployment.

It provides the only available distributions of workers by the number of hours worked (as distinguished from aggregate or average hours for an industry), permitting separate analyses of part-time workers, workers on overtime, etc. The survey is also the only comprehensive current source of information on the occupation of workers and the industries in which they work. Information is available from the survey not only for persons currently in the labor force but also for those who are outside the labor force. The characteristics of such persons - whether married women with or without young children, disabled persons,

students, older retired workers, etc., can be determined. Information on their current desire for work, their past work experience, and their intentions as to job seeking are also available.

The Annual Demographic File contains data collected from the March CPS supplement, the most comprehensive supplemental inquiry. In addition to the regular monthly demographic and labor force data described above, this file contains detailed family structure, marital status, education, income, work experience, and migration data for persons.

CPS Sample

The CPS sample is located in 644 sample areas comprising more than 1,000 counties and independent cities with coverage in every State and in the District of Columbia.

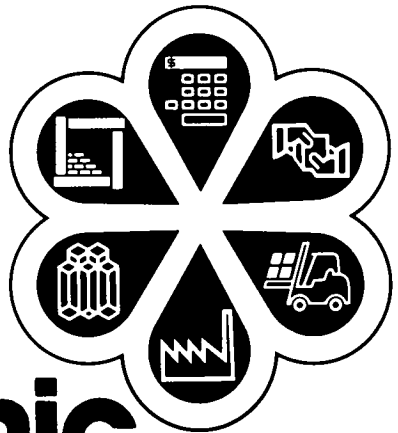
In all, some 84,000 housing units or other living quarters are assigned for interview each month; about 68,000 of them containing approximately 147,000 persons 14 years old and over are interviewed. Because of recent sample expansions, however, data are only tabulated for approximately 63,000 households containing 135,000 persons 14+. The remainder of the assigned housing units are found to be vacant, converted to nonresidential use, contain persons with residence elsewhere, or are not interviewed because the residents are not found at home after repeated calls, are temporarily absent, or are unavailable for other reasons.

The CPS sample is based on the civilian noninstitutional population of the United States. In March of each year supplemental data are obtained for Armed Forces members residing with their families in regular housing units. The Armed Forces members are not asked the monthly labor force questions. Another unique feature of the March supplement is the addition of a sample of Spanish households to increase the reliability of data on Spanish persons and households. All households identified in November of the previous year as housing at least one person of Spanish origin are reinterviewed in March. This results in the addition of about 2,500 households in the March CPS. The inclusion of the additional sample of Spanish households began in 1976. A more precise explanation regarding the CPS sample design is provided in Technical Paper 40 entitled The Current Population Survey: Design and Methodology.

For a more detailed discussion about the basic labor force data gathered on a monthly basis in the CPS survey--see Bureau of Labor Statistics Report No. 463 and Current Population Reports P-23, No. 62, issued jointly by the Bureau of Labor Statistics and the Bureau of the Census in October, 1976, and entitled Concepts and Methods Used In Labor Statistics Derived from the Current Population Survey.

EXHIBIT 5
EC-31 (9-82)

A Preview of the 1982 Economic Censuses



Census of Manufactures

Census of Mineral Industries

Census of Construction Industries

Census of Retail Trade

Census of Wholesale Trade

Census of Service Industries

Special Census Programs:

Enterprise Statistics

Transportation Surveys

Minority-Owned Business Enterprises

Women-Owned Businesses

Census of Outlying Areas

U.S. Department of Commerce
BUREAU OF THE CENSUS

This booklet provides a preview of the 1982 Economic Censuses, which will be conducted early in 1983 covering economic activities for 1982. It briefly describes their background, uses and legal authority; gives a brief description of their scope and the data which will be made available; summarizes major changes from the 1977 censuses; and provides a preliminary indication of the approximate schedule for release of the census results.

HISTORY AND BACKGROUND

The economic censuses constitute comprehensive and periodic canvasses of the Nation's industrial and business activities. The first economic census of the United States was conducted as part of the 1810 decennial census, when inquiries on manufacturing were included with the census of population. Minerals data were first collected in 1840; the first censuses of construction, and retail and wholesale trades were taken in 1929; and service industries were first included in 1933. An integrated program of economic censuses was begun for 1954. In that year, the censuses covered retail and wholesale trades, selected service industries, manufactures, and mineral industries. Transportation was first included with the 1963 censuses; the construction industries were added for 1967; the minority-owned businesses program, in 1972; and women-owned businesses in 1977.

In planning the 1982 Economic Censuses, the Census Bureau consulted with trade, business, and professional associations; individual business firms; unions; census advisory committees; government agencies; and others regarding questions to be asked and desired formats for publishing results. The Business Advisory Council on Federal Reports, comprised of representatives of each major field of business activity, reviewed the proposed questions; and the Census Bureau closely screened the questions to eliminate any not clearly in the public interest.

LEGAL AUTHORITY AND CONFIDENTIALITY

The economic censuses are required by law under title 13 of the United States Code, sections 131, 191, and 224, which requires that they be taken at 5-year intervals covering years ending in "2" and "7." The Census law imposes a joint obligation on firms to respond and on the Census Bureau to maintain the confidentiality of information reported to it. The law also specifies penalties for noncompliance and for disclosure of information by the Census Bureau. No data are published that could reveal the identity or activities of any specific individual or firm. Individual census questionnaires cannot be used for the purposes of taxation, investigation, or regulation. The law also affords the full protection of confidentiality to the file copy of a census questionnaire that is retained by the respondent.

PURPOSES AND USES

The economic censuses are a major source of facts about the structure and functioning of the Nation's economy and provide essential information for government, business, industry, and the general public.

EXHIBIT 5 (Continued)

FOR THE GOVERNMENT

- They provide an important part of the framework for such composite measures as the gross national product, input-output measures, indexes of industrial production, and indexes measuring productivity and price levels.
- Information taken from the censuses is used to establish sampling frames and as benchmarks for current surveys of business activity, which are essential for measuring short-term economic conditions.
- State and local governments use census data to assess business activities occurring within their jurisdictions.

IN THE PRIVATE SECTOR

- Companies use the data to forecast general economic conditions and sales; analyze sales performance; lay out sales territories; allocate funds for advertising; decide on locations for new plants, warehouses, or stores; and measure potential markets in terms of size, geographic areas, kinds of business, and kinds of products.
- Trade and professional associations use the information to study trends which may affect their industry.
- Business magazines use census statistics to provide technical background for articles.
- University and college professors apply census data in their teaching and research.

SCOPE AND CONTENT

Except for the major differences cited on page 7, the scope of the 1982 Economic Censuses is substantially similar to that of the 1977 Censuses. Tables 1 and 2 summarize the economic areas covered, which include over 7 million establishments, and the content of each census.

CLASSIFICATION SYSTEM

Statistics for the economic censuses are collected and summarized for publication primarily in terms of the "establishment." An establishment, as defined for census purposes, is a business or industrial unit at a single geographic location which produces or distributes goods, or performs services. When more than one economic activity is conducted at a single location, each activity is treated as a separate establishment if separate records are available and if the size of the individual activities is signicant.

Except for portions of the census of transportation, data for the economic censuses are tabulated on the basis of the Standard Industrial Classification (SIC) system, defined under the auspices of the Office of Management and Budget. The SIC system is used in the classification of establishments by the type of activities in which they are engaged. The SIC divides the Nation's economic activities into broad industrial divisions (such as manufacturing and retail trade), 2-digit major groups, 3-digit industry subgroups, and 4-digit detailed industries.

In some instances, more detailed classification has been devised for census purposes so that additional industries, kinds of business, or specific products can be identified within the SIC categories. In addition, the Census Bureau has developed a system of classifying manufactured products into approximately 1,600 5-digit product classes and about 13,500 7-digit products consistent with the SIC system.

Together with the complementary 1982 Census of Agriculture, which will be conducted concurrently, the censuses will cover over 800 of the approximately 1,000 industries within the SIC system.

Table 1
SIC COVERAGE IN THE 1982 ECONOMIC CENSUSES

Economic Areas	SIC Range	1982 Economic Censuses
Agriculture, forestry, fishing, hunting, and trapping	01, 02, 07, 08, 09	Not covered; parts included in the Census of Agriculture
Mining	10 thru 14	Census of Mineral Industries
Construction	15 thru 17	Census of Construction Industries
Manufacturing	20 thru 39	Census of Manufactures
Transportation, communication utilities	40 thru 49	Not covered except for special transportation surveys, and 422 and 4722 which are included in the Census of Service Industries
Wholesale trade	50 thru 51	Census of Wholesale Trade
Retail trade	52 thru 59	Census of Retail Trade
Finance, insurance, and real estate	60 thru 67	Not covered except for 6552, which is in the Census of Construction Industries
Services	70 thru 89	Census of Service Industries excludes 806, 821, 822, 863, 865, 866, and 88
Public administration	91 thru 97	Not covered; parts included in the 1982 Census of Governments
Nonclassifiable	99	Not covered

EXHIBIT 5 (Continued)

GEOGRAPHIC AREAS AVAILABLE

In general, the most detailed data will be published at the National level. In addition to National data, most statistics will be available for states, and many will be shown for cities and other places, counties, and standard metropolitan statistical areas. The level of geographic detail will vary by census, with fewer statistics appearing for smaller areas in order to avoid disclosing information for individual firms and to reduce overall publishing costs. The maximum detail, including data for major retail centers, will be available from the census of retail trade, which covers almost 2 million establishments. Data for selected small areas not included in the printed reports will be available on microfiche.

INFORMATION THAT WILL BE PROVIDED

Data items from the component censuses and special surveys will vary significantly with the characteristics of the industries. However, a number of key measures, such as sales (receipts or value of shipments), employment, and payroll, are almost universal.

Table 2
THE BASIC CENSUSES

Major data items	Retail trade	Wholesale trade	Service industries	Construction industries	Manufactures	Mineral industries
NUMBER OF ESTABLISHMENTS AND FIRMS						
All establishments	X		X	X		
Establishments with payroll	X	X	X	X	X	X
Establishments by legal form of organization	X	X	X	X	X	X
Firms	X	X	X		X	X
Single-unit and multi-unit firms	X	X	X		X	X
Concentration by major firms	X	X	X		X	
EMPLOYMENT						
All employees	X	X	X	X	X	X
Production (construction) workers				X	X	X
Employment size of establishments	X	X	X	X	X	X
Employment size of firms	X	X	X			
Production (construction) worker hours				X	X	X
PAYROLLS						
All employees, entire year	X	X	X	X	X	X
All employees, first quarter	X	X	X	X		
Production (construction) workers				X	X	X
Supplemental labor costs, legally required and voluntary	X	X	X	X	X	X

Table 2 – Continued
THE BASIC CENSUSES

Major data items	Retail trade	Wholesale trade	Service industries	Construction industries	Manufactures	Mineral industries
SALES RECEIPTS, OR VALUE OF SHIPMENTS						
All establishments	X		X	X		
Establishments with payroll	X	X	X	X	X	X
By product or line	X	X			X	X
By class of customer	X	X				
By size of establishments	X	X	X	X		
By size of firm	X	X	X			
OPERATING EXPENSES						
Cost of materials, etc.	X	X	X	X	X	X
Specific materials consumed (quantity and cost)					X	X
Cost of fuels				X	X	X
Electric energy consumed (quantity and cost)	X	X	X	X	X	X
Contract work		X		X	X	X
Products bought and sold					X	X
Advertising	X	X	X			
Rental payments, total	X	X	X	X	X	X
Buildings and structures	X	X	X	X	X	X
Machinery and equipment	X	X	X	X	X	X
Communication services	X	X	X	X	X	X
Purchased repairs	X	X	X	X	X	
CAPITAL EXPENDITURES						
Total	X	X	X	X	X	X
New, total	X	X	X	X	X	X
Buildings/equipment	X	X	X	X	X	X
Used, total	X	X	X	X	X	X
Buildings/equipment				X	X	X
DEPRECIABLE ASSETS, GROSS VALUE BUILDINGS/EQUIPMENT)						
Beginning of 1982	X	X	X	X	X	X
End of 1982	X	X	X	X	X	X
Depreciation (total and detail for buildings/equipment)	X	X	X	X	X	X
Retirements (total and detail for buildings/equipment)	X	X	X	X	X	X
INVENTORIES						
Beginning of 1982	X	X		X	X	X
End of 1982	X	X		X	X	X
By stage of fabrication					X	
OTHER						
Value added	X	X		X	X	X
Specialization by type of construction/manufacturing				X	X	
Type of operation		X				X
Floor space	X					
Central administrative offices and auxiliaries	X	X	X	X	X	X
Water use					X	X

EXHIBIT 5 (Continued)

SPECIAL CENSUS PROGRAMS

ENTERPRISE STATISTICS

A program in which the establishment data records from the basic censuses are regrouped under common ownership or control in order to show various economic characteristics of the owning or controlling firms. Data on separately reported auxiliary establishments of multiunit firms covered in the basic censuses are also included.

TRANSPORTATION SURVEYS

- Truck Inventory and Use Survey –
  Information on the physical characteristics and operational use of the Nation's more than 32 million private and commercial trucks.
- Commodity Transportation Survey –
  Statistics on the volume and characteristics of commodity shipments originated by manufactures.

SURVEY OF MINORITY-OWNED BUSINESS ENTERPRISES

Basic statistics including information on sales, employment, payroll, and legal form of organization, by industry and geographic area on businesses owned by Blacks, persons of Spanish origin, Asian Americans, American Indians, and other minorities.

SURVEY OF WOMEN-OWNED BUSINESSES

Basic statistics including information on sales, employment, payroll, and legal form of organization, by industry and geographic area on businesses owned by women.

CENSUS OF OUTLYING AREAS

- Puerto Rico
- Virgin Islands
- Guam
- Northern Mariana Islands

Statistics on retail and wholesale trade, selected service industries, manufactures, construction (but not mineral industries) similar to those provided for the United States in the basic censuses.

WHAT'S DIFFERENT FOR 1982?

While the censuses will be substantially similar to those for 1977, a number of changes are being made to the publication program and coverage to reflect the most important needs of data users, improvements in data processing techniques, and budgetary resources.

PUBLICATION DIFFERENCES

- Preliminary Industry Reports will be issued from the censuses of retail trade, wholesale trade, and service industries. In 1977 industry statistics were available only in reports for specific geographic areas or in subject reports for selected industries.
- Earlier Release of Census Results – Improvements in data processing techniques, more extensive use of forms specialized by industry, and short forms for small firms will permit publication of census results from 2 to 6 months earlier than for the 1977 censuses.

COVERAGE DIFFERENCES

- The Census of Service Industries will not include hospitals, elementary and secondary schools, colleges and universities, labor unions, and political organizations.
- The National Travel Survey, part of the 1977 Census of Transportation, will not be conducted for 1982.
- The Commodity Transportation Survey will be conducted one year later than the basic censuses.

PUBLICATIONS

- Printed Reports
- Microfiche
- Computer Tapes

The results of the 1982 Economic Censuses will be released in printed reports, on microfiche, and on computer tapes. Printed reports for the individual economic censuses usually consist of separate series for industries, geographic areas, subjects, and special reports. For some of these series, preliminary reports are issued several months prior to the final reports. After the final separate soft cover reports have been published, they are usually combined, assembled, and reissued in hard cover volumes. In many instances, these volumes may contain additional explanatory material and graphics not published previously in the individual reports.

Under present plans, the published material will also be made available on microfiche. Most of these same summary statistics will be available on public-use computer tapes. In addition, a number of unpublished data series, which provide more detail than the printed reports, are made available on both microfiche and public-use computer tapes.

EXHIBIT 5 (Continued)

Table 3
PRELIMINARY PUBLICATION SCHEDULE

Series	Estimated time of first publication in series					
	Early 1983	Late 1983	Early 1984	Mid 1984	Late 1984	1985
RETAIL TRADE						
Preliminary Industry		X				
Geographic Area		X				
Major Retail Centers			X			
Subject				X		
Merchandise Line Sales					X	
SERVICE INDUSTRIES						
Preliminary Industry		X				
Geographic Area		X				
Subject				X		
WHOLESALE TRADE						
Preliminary Industry		X				
Geographic Area		X				
Subject				X		
Commodity Line Sales					X	
CONSTRUCTION INDUSTRIES						
Preliminary Industry		X				
Preliminary Summary		X				
Final Industry			X			
Geographic Area				X		
Special					X	
MANUFACTURES						
Preliminary Industry		X				
Preliminary Geographic Area			X			
Preliminary Summary			X			
Final Industry				X		
Final Geographic Area					X	
Subject					X	
MINERAL INDUSTRIES						
Preliminary Industry		X				
Preliminary Summary			X			
Final Industry				X		
Geographic Area					X	
Subject					X	
SPECIAL CENSUS PROGRAMS						
Enterprise Statistics						X
Truck Inventory and Use	X					
Commodity Transportation Survey Industry Reports						X
Commodity Transportation Survey Geographic Area Reports						X
Outlying Areas		X				
Minority-Owned Business Enterprises					X	
Women-Owned Businesses					X	

MORE INFORMATION ON THE CENSUSES

There are a number of sources which will provide more detailed information about the content of the censuses and inform users of the availability of census results and how to obtain published reports and other data products.

- Mini-Guide to the 1982 Economic Censuses –
  This publication, scheduled for release in the summer of 1983, will provide more detailed information on the scope, coverage, classification system, data items, and publications available for each of the economic censuses and related surveys and special reports. A similar mini-guide to the 1977 Economic Censuses is currently available.
- Data User News –
  A monthly publication reporting plans for upcoming censuses and their data products, announcing conferences and workshops, describing major new data releases and reference materials, and providing answers to user questions. ($20 per year from the Superintendent of Documents, Government Printing Office, Washington, D. C. 20402.)
- Monthly Product Announcement –
  A monthly listing of the hundreds of new products – publications, microfiche, and computer tapes – made available during the previous month. Entries include GPO stock or catalog numbers, Census notations, file order numbers, and prices. Each announcement also includes order forms. (Free)

TO OBTAIN INFORMATION

Additional information is available from the Bureau of the Census, Washington, D.C. 20233.

- For **general information** about the censuses or the informational publications described, contact
  Data Users Services
  (301) 763–4100
- For **detailed information** about the contents or publications from specific censuses or programs, contact

Business Division
Retail Trade
(301) 763–7038
Wholesale Trade
(301) 763–5281
Service Industries
(301) 763–7039

Industry Division
Manufactures
Durable Goods Industries
(301) 763–7304
Nondurable Goods Industries
(301) 763–2510
Mineral Industries
(301) 763–5938

Construction Statistics Division
Construction Industries
(301) 763–5435

Economic Surveys Division
Transportation
(301) 763–1804
Enterprise Statistics
(301) 763–7086
Outlying Areas
(301) 763–7778
Minority-Owned Business Enterprises
(301) 763–7086
Women-Owned Businesses
(301) 763–7086

EXHIBIT 5 (Continued)

In addition, the Bureau has regional offices in the following large cities. The Information Services Specialists in these offices are of particular help in answering questions concerning the uses of census data.

Atlanta, GA 30309
1365 Peachtree Street,
NE., Room 625 (404) 881–2271

Boston, MA 02116
441 Stuart Street,
10th Floor
(617) 223–2327

Charlotte, NC 28202
230 South Tryon Street,
Suite 800
(704) 371–6142

Chicago, IL 60604
55 East Jackson Blvd.,
Suite 1304
(312) 353–6251

Dallas, TX 75242
1100 Commerce Street,
Room 3C54
(214) 767–0621

Denver, CO 80226
575 Union Blvd.,
P.O. Box 25207
(303) 234–3924

Detroit, MI 48226
Federal Building &
U.S. Courthouse,
Room 565,
231 West Lafayette
(313) 226–7742

Kansas City, KS 66101
One Gateway Center
4th and State Streets
(816) 374–4601)

Los Angeles, CA 90049
11777 San Vicente Blvd.,
Room 810
(213) 824–7317

New York, NY 10278
Federal Office Building,
Room 37–130,
26 Federal Plaza
(212) 264–3860

Philadelphia, PA 19106
William J. Green, Jr.,
Federal Bldg.,
600 Arch Street,
Room 9244
(215) 597–4920

Seattle, WA 98109
Lake Union Building,
1700 Westlake Avenue,
North (206) 442–7800

EXHIBIT 6

Table 1. Projections of the Total Population for

(In thousands. As of July 1, except as noted. Roman numeral II indicates national projection series II.

Line No.	Region, division, and State	Census, April 1970	Estimates, 1975	Projections, Series II-A 1980	1985	1990	1995	2000
1	United States, total	203,306	213,032	221,651	232,371	243,004	252,241	259,869
2	REGION:							
3	Northeast	49,061	49,456	50,198	51,479	52,847	54,008	54,854
4	North Central	56,593	57,637	58,915	60,866	62,863	64,513	65,787
5	South	62,813	68,045	72,037	76,597	81,036	84,960	88,335
6	West	34,838	37,899	40,501	43,431	46,259	48,759	50,890
7	NORTHEAST:							
8	New England	11,848	12,187	12,596	13,141	13,703	14,202	14,615
9	Middle Atlantic	37,213	37,269	37,602	38,338	39,144	39,806	40,239
10	NORTH CENTRAL:							
11	East North Central	40,266	40,946	41,920	43,371	44,847	46,072	47,005
12	West North Central	16,327	16,691	16,995	17,495	18,016	18,441	18,782
13	SOUTH:							
14	South Atlantic	30,678	33,658	36,027	38,648	41,182	43,441	45,400
15	East South Central	12,808	13,516	13,955	14,512	15,063	15,534	15,918
16	West South Central	19,327	20,869	22,055	23,437	24,791	25,985	27,017
17	WEST:							
18	Mountain	8,289	9,625	10,419	11,274	12,075	12,771	13,351
19	Pacific	26,549	28,274	30,082	32,157	34,184	35,988	37,539
20	NEW ENGLAND:							
21	Maine	994	1,058	1,094	1,143	1,192	1,237	1,273
22	New Hampshire	738	812	870	939	1,007	1,068	1,121
23	Vermont	445	472	497	528	560	589	614
24	Massachusetts	5,689	5,814	5,968	6,186	6,415	6,618	6,787
25	Rhode Island	950	931	961	1,000	1,040	1,076	1,107
26	Connecticut	3,032	3,100	3,206	3,345	3,489	3,614	3,713
27	MIDDLE ATLANTIC:							
28	New York	18,241	18,076	18,086	18,288	18,528	18,713	18,816
29	New Jersey	7,171	7,333	7,603	7,964	8,344	8,686	8,958
30	Pennsylvania	11,801	11,860	11,913	12,086	12,272	12,407	12,465
31	EAST NORTH CENTRAL:							
32	Ohio	10,657	10,735	10,933	11,251	11,570	11,823	11,999
33	Indiana	5,196	5,313	5,438	5,621	5,804	5,955	6,069
34	Illinois	11,113	11,198	11,376	11,688	12,015	12,286	12,491
35	Michigan	8,882	9,111	9,433	9,866	10,302	10,674	10,970
36	Wisconsin	4,418	4,589	4,740	4,945	5,156	5,334	5,476
37	WEST NORTH CENTRAL:							
38	Minnesota	3,806	3,921	4,040	4,209	4,382	4,525	4,637
39	Iowa	2,825	2,861	2,879	2,930	2,988	3,030	3,058
40	Missouri	4,678	4,767	4,882	5,051	5,226	5,377	5,506
41	North Dakota	618	637	630	631	633	633	631
42	South Dakota	666	681	674	676	679	680	679
43	Nebraska	1,485	1,544	1,577	1,628	1,679	1,720	1,755
44	Kansas	2,249	2,280	2,313	2,370	2,429	2,476	2,516
45	SOUTH ATLANTIC:							
46	Delaware	548	579	611	648	684	716	742
47	Maryland	3,924	4,122	4,397	4,721	5,048	5,348	5,612
48	District of Columbia	757	712	696	694	693	693	697
49	Virginia	4,651	4,981	5,261	5,585	5,899	6,178	6,414
50	West Virginia	1,744	1,799	1,809	1,837	1,869	1,895	1,912
51	North Carolina	5,084	5,441	5,712	6,026	6,332	6,602	6,830
52	South Carolina	2,591	2,816	2,978	3,164	3,346	3,508	3,644
53	Georgia	4,588	4,931	5,262	5,638	6,006	6,337	6,625
54	Florida	6,791	8,277	9,301	10,335	11,305	12,164	12,924
55	EAST SOUTH CENTRAL:							
56	Kentucky	3,221	3,387	3,500	3,647	3,796	3,925	4,032
57	Tennessee	3,926	4,173	4,345	4,552	4,755	4,934	5,085
58	Alabama	3,444	3,615	3,714	3,842	3,967	4,069	4,148
59	Mississippi	2,217	2,341	2,396	2,471	2,545	2,606	2,653
60	WEST SOUTH CENTRAL:							
61	Arkansas	1,923	2,110	2,193	2,292	2,390	2,474	2,545
62	Louisiana	3,645	3,806	3,930	4,090	4,245	4,373	4,471
63	Oklahoma	2,560	2,715	2,834	2,976	3,116	3,238	3,347
64	Texas	11,199	12,238	13,098	14,079	15,040	15,900	16,654
65	MOUNTAIN:							
66	Montana	694	746	766	793	821	844	862
67	Idaho	713	813	866	926	982	1,030	1,069
68	Wyoming	332	376	390	408	425	439	450
69	Colorado	2,210	2,541	2,765	3,007	3,237	3,440	3,615
70	New Mexico	1,017	1,144	1,198	1,262	1,322	1,371	1,409
71	Arizona	1,775	2,212	2,489	2,771	3,031	3,261	3,452
72	Utah	1,059	1,203	1,296	1,398	1,493	1,575	1,643
73	Nevada	489	590	649	709	764	811	851
74	PACIFIC:							
75	Washington	3,413	3,559	3,784	4,047	4,312	4,551	4,759
76	Oregon	2,092	2,284	2,437	2,610	2,781	2,933	3,066
77	California	19,971	21,198	22,538	24,081	25,588	26,927	28,083
78	Alaska	303	365	392	419	441	461	474
79	Hawaii	770	868	931	1,000	1,062	1,116	1,157

EXHIBIT 6 (Continued)

Regions, Divisions, and States: 1970 to 2000

Letters A, B, and C indicate interstate migration assumption. See text for explanations)

Projections--Continued										Line No.
Series II-B					Series II-C					
1980	1985	1990	1995	2000	1980	1985	1990	1995	2000	
221,651	232,371	243,004	252,241	259,869	221,651	232,371	243,004	252,241	259,869	1
										2
49,837	50,770	51,796	52,627	53,152	51,256	53,572	55,951	58,072	59,767	3
58,416	59,864	61,361	62,514	63,307	59,775	62,572	65,367	67,735	69,612	4
72,853	78,239	83,507	88,244	92,402	70,707	73,918	77,011	79,656	81,897	5
40,547	43,498	46,341	48,858	51,009	39,912	42,308	44,673	46,782	48,593	6
										7
12,559	13,070	13,600	14,068	14,449	12,644	13,246	13,867	14,417	14,855	8
37,278	37,700	38,196	38,559	38,703	38,612	40,326	42,084	43,655	44,912	9
										10
41,393	42,314	43,260	43,966	44,398	42,580	44,669	46,747	48,536	49,951	11
17,023	17,550	18,101	18,548	18,909	17,195	17,903	18,620	19,199	19,661	12
										13
36,540	39,675	42,727	45,494	47,949	34,847	36,269	37,622	38,746	39,666	14
14,108	14,822	15,526	16,142	16,661	14,001	14,606	15,193	15,699	16,124	15
22,205	23,742	25,254	26,608	27,792	21,859	23,043	24,196	25,211	26,107	16
										17
10,715	11,857	12,936	13,900	14,732	10,172	10,841	11,501	12,089	12,602	18
29,832	31,641	33,405	34,958	36,277	29,740	31,467	33,172	34,693	35,991	19
										20
1,120	1,196	1,273	1,344	1,405	1,091	1,140	1,191	1,236	1,274	21
869	935	1,002	1,061	1,113	841	881	923	961	991	22
492	517	543	567	586	489	513	538	560	578	23
5,978	6,209	6,450	6,664	6,842	6,029	6,312	6,606	6,865	7,073	24
962	1,003	1,045	1,084	1,117	967	1,014	1,061	1,104	1,141	25
3,138	3,210	3,287	3,348	3,386	3,227	3,386	3,548	3,691	3,798	26
										27
17,902	17,927	17,995	18,015	17,961	18,898	19,902	20,938	21,898	22,727	28
7,492	7,741	8,010	8,249	8,425	7,611	7,962	8,326	8,652	8,901	29
11,884	12,032	12,191	12,295	12,317	12,103	12,462	12,820	13,105	13,284	30
										31
10,738	10,861	10,988	11,054	11,051	11,134	11,644	12,144	12,569	12,895	32
5,369	5,481	5,595	5,680	5,731	5,517	5,778	6,038	6,262	6,441	33
11,259	11,454	11,665	11,824	11,923	11,660	12,246	12,833	13,350	13,777	34
9,275	9,546	9,814	10,018	10,148	9,529	10,049	10,562	11,007	11,356	35
4,752	4,972	5,198	5,390	5,545	4,740	4,952	5,170	5,348	5,482	36
										37
4,025	4,179	4,338	4,465	4,561	4,061	4,253	4,448	4,609	4,732	38
2,891	2,957	3,031	3,088	3,131	2,935	3,047	3,165	3,258	3,329	39
4,849	4,985	5,129	5,248	5,346	4,887	5,055	5,223	5,359	5,469	40
653	675	698	717	732	663	699	736	766	791	41
690	707	724	737	748	706	743	781	812	839	42
1,597	1,667	1,738	1,798	1,851	1,595	1,667	1,739	1,798	1,848	43
2,318	2,380	2,443	2,495	2,540	2,348	2,439	2,528	2,597	2,653	44
										45
600	626	651	673	689	602	630	658	681	697	46
4,353	4,637	4,928	5,198	5,436	4,289	4,489	4,683	4,847	4,964	47
685	667	651	636	627	745	781	812	837	861	48
5,334	5,730	6,117	6,465	6,768	5,189	5,433	5,664	5,858	6,008	49
1,844	1,907	1,973	2,030	2,076	1,845	1,908	1,971	2,027	2,071	50
5,790	6,185	6,573	6,922	7,226	5,647	5,883	6,102	6,284	6,426	51
3,025	3,261	3,494	3,707	3,893	2,945	3,097	3,241	3,367	3,472	52
5,302	5,721	6,133	6,508	6,840	5,155	5,412	5,654	5,867	6,047	53
9,607	10,941	12,207	13,355	14,394	8,430	8,636	8,837	8,978	9,120	54
										55
3,551	3,751	3,953	4,134	4,290	3,502	3,652	3,799	3,927	4,035	56
4,365	4,592	4,816	5,014	5,183	4,304	4,463	4,612	4,733	4,827	57
3,771	3,958	4,140	4,296	4,425	3,749	3,912	4,069	4,203	4,314	58
2,421	2,521	2,617	2,698	2,763	2,446	2,579	2,713	2,836	2,948	59
										60
2,224	2,353	2,479	2,592	2,690	2,174	2,256	2,336	2,404	2,463	61
3,932	4,096	4,255	4,386	4,486	3,983	4,201	4,417	4,607	4,768	62
2,854	3,016	3,178	3,321	3,449	2,799	2,906	3,007	3,069	3,162	63
13,195	14,277	15,342	16,309	17,167	12,903	13,680	14,436	15,111	15,714	64
										65
791	843	894	939	977	776	817	859	894	921	66
893	979	1,061	1,133	1,195	857	913	968	1,017	1,060	67
408	442	474	503	527	393	415	437	455	471	68
2,823	3,123	3,409	3,666	3,892	2,668	2,818	2,962	3,084	3,183	69
1,249	1,361	1,466	1,558	1,636	1,215	1,305	1,395	1,475	1,545	70
2,568	2,926	3,261	3,563	3,822	2,337	2,490	2,643	2,784	2,913	71
1,321	1,449	1,571	1,680	1,775	1,309	1,435	1,557	1,672	1,780	72
662	734	800	858	908	617	648	680	708	729	73
										74
3,656	3,792	3,936	4,060	4,161	3,697	3,869	4,042	4,191	4,310	75
2,437	2,610	2,781	2,935	3,070	2,355	2,446	2,533	2,603	2,655	76
22,386	23,767	25,111	26,297	27,309	22,342	23,678	24,994	26,175	27,192	77
412	455	491	521	544	397	433	470	504	534	78
941	1,017	1,086	1,145	1,193	949	1,041	1,133	1,220	1,300	79

EXHIBIT 7

April, 1983

FEDERAL-STATE COOPERATIVE PROGRAM
FOR POPULATION PROJECTIONS

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E - in Estimates COOP Program
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EXHIBIT 7 (Continued)

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EXHIBIT 7 (Continued)

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EXHIBIT 7 (Continued)

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Projections Branch Regional Economic Analysis Division Bureau of Economic Analysis BE-61 14th and K Streets, N.W. Washington, D.C. 20230	Mr. Ken Johnson (202) 523-0971 Mr. Hugh Knox (202) 523-0946
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Intergovernmental Affairs Division Office of Management & Budget NEOB Washington, D.C. 20503	Mr. Walter Groszyk (202) 395-3050

Office of Economic Growth and Employment Projections Bureau of Labor Statistics DOL Washington, D.C. 20212	Mr. Howard Fullerton (202) 272-5328

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1983-1984

State Chairperson:

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EXHIBIT 8

INTRODUCTION

This report presents projections of economic activity for the Nation, States, BEA economic areas, standard metropolitan statistical areas (SMSA's), and substate areas. Projections are presented for population, personal income, and employment and earnings (labor and proprietors' income), by industry. For the Nation and States, projections are presented for 1985, 1990, 1995, 2000, 2010, 2020, and 2030; historical data are presented for 1969, 1973, and 1978. For the other geographic areas, historical and projected data are presented for 1969, 1978, 1985, 1990, 2000, and 2030.

This report is a major output of BEA's ongoing program of economic measurement, analysis, and projections. The projections program originated in 1964 under a cooperative agreement with the Water Resources Council (WRC). Upon enactment of the Water Resources Planning Act of 1965, the projections program became an integral part of the comprehensive water resources planning program and the periodic national assessments of water and related land resources. The types of users of the projections have steadily increased to include additional Federal agencies, State and local agencies, and a variety of private organizations.

Ten years ago, the projections program acquired the acronym "OBERS," reflecting a cooperative effort of the Office of Business Economics (now BEA) and the Economic Research Service (now the Economic Statistics and Cooperative Services) in the Department of Agriculture. Although the regional projections now are prepared solely by BEA, the OBERS name is retained for continuity.

The objectives of the OBERS program are the development and maintenance of (1) a current regional data base, with provisions for rapid and flexible data retrieval, (2) a set of both mid-term (5-year) and long-term (50-year) regional projections of population and economic activity, (3) analytical systems for the generation of the projections, and (4) analytical systems for special applications of the projections.

As new data become available and economic measures and projection methodologies are improved, revised projections are produced at periodic intervals. The analytical systems for applications provide systematic procedures for the analysis of alternative future scenarios.

Projections, by their nature, reflect the underlying data systems and methodologies. Many alternative projections are prepared by other public and private organizations. An alternative approach to the projection of State-level population is taken by the Bureau of the Census, which bases its projections on the cohort-component method of demographic analysis rather than on the extension of economic trends. This method requires the separate projection of trends in the three components of population change—fertility, mortality, and net migration—for each age, race, and sex group. In the BEA projections, in contrast, net migration is mainly dependent on projected economic growth. The current set of Census Bureau projections can be found in "Illustrative Projections of State Population: 1975 to 2000," *Current Population Reports*, Series P-25, No. 796, March 1979.

Scope of the Report

The scope of this report was determined by three considerations: the planning needs of the WRC and other Federal agencies; technical limitations on the extent of industrial and geographic detail in which economic information may be provided; and the amount of material that reasonably can be included in a manageable report.

The geographic areas for which data are presented are (1) the Nation, the 50 States, and the District of Columbia; (2) the 183 economic areas delineated by BEA; (3) the 266 SMSA's, as defined by the Office of Management and Budget as of December 1977; and (4) 585 substate areas, including (a) BEA economic areas that are entirely within one State and that have no SMSA's, (b) SMSA and non-SMSA parts of BEA economic areas that are entirely within one State, and (c) in cases where State boundaries divide economic areas and/or SMSA's, State parts of economic areas and/or SMSA's.

For each area, tables are organized to show (1) the levels of population and economic aggregates; (2) the industrial composition of economic activity; and (3) within States, the distribution, in summary form, of economic activity among the substate areas.

The amount of detail included in the projections varies by type of area because of the different methods used in projecting from the historical data. For States, population, by age and sex, personal income, by major income component, and earnings and employment for 57 industrial groups are presented. For economic areas, SMSA's, and substate areas, total population, total personal income, and earnings and employment for 14 major industrial groups are presented. Three sets of illustrative projections are presented for each geographic area except States.

All data are available on computer tapes from the Data and Systems Branch, READ, Bureau of Economic Analysis, U.S. Department of Commerce, Washington, D.C., 20230. Tapes may be purchased separately for each of the first three volumes and for the combination of volumes 4 through 11.

Organization of the Report

This report consists of 11 volumes. Volume 1 presents State projections and the underlying historical data, a detailed discussion of the concepts and the methodology used in preparing the State projections, summary national tables, and appendixes describing the statistical concepts and industrial groups used in the OBERS program. Volume 2 presents data for the economic areas, and volume 3, for the SMSA's. Volumes 4 through 11 present data for substate areas in each of eight major regions of the Nation. Each of these eight volumes presents data

EXHIBIT 8 (Continued)

for the Nation, a region, the States in the region, and the substate areas, as follows:

	Number of substate areas
Volume 4— BEA Region 1—New England	
Connecticut	5
Maine	4
Massachusetts	7
New Hampshire	5
Rhode Island	2
Vermont	4
Volume 5— BEA Region 2—Mideast	
Delaware	2
District of Columbia	1
Maryland	6
New Jersey	14
New York	16
Pennsylvania	23
Volume 6— BEA Region 3—Great Lakes	
Illinois	22
Indiana	24
Michigan	20
Ohio	27
Wisconsin	20
Volume 7— BEA Region 4—Plains	
Iowa	16
Kansas	9
Minnesota	13
Missouri	12
Nebraska	8
North Dakota	6
South Dakota	5
Volume 8— BEA Region 5—Southeast	
Alabama	15
Arkansas	11
Florida	22
Georgia	15
Kentucky	15
Louisiana	13
Mississippi	9
North Carolina	17
South Carolina	11
Tennessee	12
Virginia	14
West Virginia	14

	Number of substate areas
Volume 9— BEA Region 6— Southwest	
Arizona	4
New Mexico	5
Oklahoma	12
Texas	42
Volume 10—BEA Region 7—Rocky Mountain	
Colorado	9
Idaho	5
Montana	6
Utah	5
Wyoming	7
Volume 11—BEA Region 8—Far West and Region 9	
California	25
Nevada	4
Oregon	7
Washington	11
Alaska	2
Hawaii	2

Procedural Overview

The OBERS projections are prepared by what is commonly referred to as a "step-down" process. Briefly, step-down approaches to analytical problems are based on the premise that historical data for larger aggregates are generally more accurate than the same type of information for more detailed classifications. Thus, in the OBERS program, national projections are developed first, and these are then distributed among the States to arrive at the State-level projections. Similarly, in developing the national economic projections, aggregate Gross National Product (GNP) is projected first, and this total then is distributed among industrial groups.

The GNP projections are the basis for the derivation of other national measures, including total personal income and earnings and employment by industry. The national projections of earnings and employment are distributed to the States on an industry-by-industry basis, according to the historical record of each State's contribution to these national totals.

This volume focuses in detail on the procedures used to make the projections for the Nation and States. Following a discussion of the procedures for making the national projections, the second section discusses the procedures for making State projections of earnings, employment, population, and total personal income through 2000. The final section discusses the means by which all projections were extended beyond 2000.

EXHIBIT 9

State 11: District of Columbia

Table 1.—Population, Personal Income, Labor and Proprietors' Income, and Employment by Place of Residence, 1969-1978, and Projected, 1985-2030

	1969	1973	1978	1985	1990	1995	2000	2010	2020	2030
Total population (July 1)	762,000	736,148	673,523	641,464	638,965	633,588	632,752	637,809	656,706	674,145
Total personal income (thousands of 1972 dollars)	3,730,363	4,138,268	4,309,695	5,048,063	5,697,273	6,248,183	6,882,962	8,531,101	10,387,773	12,753,258
Total labor and proprietors' income	3,005,411	3,148,653	3,047,627	3,590,922	4,044,207	4,416,194	4,909,024	6,037,279	7,175,017	8,693,725
Property income and transfer payments	1,048,056	1,375,943	1,663,157	1,966,576	2,242,202	2,485,616	2,771,050	3,472,291	4,373,706	5,464,938
Less: Personal contributions for social insurance	323,145	388,307	401,078	509,436	589,137	653,628	797,113	978,472	1,160,952	1,405,407
Per capita income (1972 dollars)	4,895	5,619	6,399	7,870	8,916	9,862	10,878	13,376	15,818	18,918
Per capita income relative (U.S. = 1.00)	1.18	1.19	1.22	1.23	1.22	1.22	1.21	1.21	1.21	1.20
Total employment (job count)	372,667	354,593	346,344	371,844	374,752	371,477	370,134	371,454	364,660	362,640
Employment/population ratio	.49	.48	.51	.58	.59	.59	.58	.58	.56	.54
Employment/population ratio relative (U.S. = 1.00)	1.15	1.11	1.11	1.17	1.17	1.17	1.16	1.16	1.16	1.14

Table 2.—Population by Age and Sex by Place of Residence, 1970, and Projected, 1985-2030

	1970*	1985	1990	1995	2000	2010	2020	2030
Total population	756,510	641,464	638,965	633,588	632,752	637,809	656,706	674,145
Under 5 years	59,735	49,666	46,783	43,216	41,706	46,002	47,047	46,925
5 to 9	64,222	46,296	47,829	45,103	42,518	42,712	47,919	46,386
10 to 14	64,424	40,937	45,672	47,326	45,292	41,432	46,359	47,797
15 to 19	65,609	45,625	40,831	44,815	47,221	43,010	43,292	48,689
20 to 24	79,638	56,719	45,960	40,970	44,389	45,813	42,070	46,555
25 to 29	64,900	55,105	52,570	42,683	39,254	45,215	42,628	42,457
30 to 34	47,625	52,321	53,262	50,687	42,105	40,967	44,915	41,369
35 to 39	42,337	51,350	50,298	51,364	49,371	37,905	44,258	42,232
40 to 44	42,637	43,533	49,753	49,050	50,548	40,721	39,683	44,170
45 to 49	43,298	34,426	41,163	47,349	47,237	47,632	37,160	43,834
50 to 54	40,378	32,233	32,575	39,160	45,616	47,251	38,699	37,870
55 to 59	37,994	30,333	29,141	29,579	36,009	42,490	43,298	34,171
60 to 64	32,910	29,604	26,915	25,843	26,594	38,802	41,299	34,242
65 years and over	70,803	73,316	76,211	76,442	74,892	77,856	98,079	117,648
Male, all ages	351,491	293,006	290,624	286,725	285,503	287,851	298,549	306,306
Under 5 years	30,086	25,442	23,980	22,158	21,383	23,585	24,114	24,039
5 to 9	32,233	23,641	24,457	23,075	21,769	21,885	24,531	23,743
10 to 14	32,296	19,965	23,325	24,197	23,166	21,207	23,734	24,462
15 to 19	30,819	21,885	19,407	22,412	23,642	21,505	21,664	24,402
20 to 24	35,249	27,057	20,955	18,407	21,160	21,793	19,881	22,206
25 to 29	31,085	25,036	24,793	19,160	17,377	21,266	19,772	19,817
30 to 34	23,513	22,568	24,225	23,979	19,041	19,412	21,244	19,478
35 to 39	20,524	23,171	21,065	22,750	22,824	16,475	20,537	19,364
40 to 44	20,175	19,475	22,019	20,118	22,042	17,648	18,021	20,137
45 to 49	19,778	15,833	18,187	20,720	19,181	21,620	15,848	19,950
50 to 54	18,062	15,239	14,930	17,229	19,854	20,330	16,653	17,125
55 to 59	16,978	14,308	13,629	13,414	15,649	17,031	19,481	14,508
60 to 64	14,270	13,068	12,352	11,777	11,734	16,195	17,139	14,259
65 years and over	26,423	26,319	27,301	27,329	26,660	27,918	35,931	42,817
Female, all ages	405,019	348,458	348,341	346,863	347,249	349,958	358,158	367,839
Under 5 years	29,649	24,224	22,803	21,058	20,323	22,417	22,933	22,886
5 to 9	31,989	22,654	23,372	22,028	20,749	20,847	23,388	22,643
10 to 14	32,128	20,972	22,347	23,129	22,127	20,226	22,625	23,336
15 to 19	34,790	23,739	21,424	22,403	23,579	21,505	21,628	24,288
20 to 24	44,389	29,662	25,005	22,562	23,229	24,021	22,189	24,349
25 to 29	33,815	30,069	27,777	23,523	21,878	23,949	22,856	22,640
30 to 34	24,112	29,753	29,037	26,709	23,064	21,554	23,671	21,891
35 to 39	21,813	28,179	29,233	28,614	26,547	21,430	23,721	22,868
40 to 44	22,462	24,059	27,735	28,931	28,506	23,073	21,662	24,033
45 to 49	23,520	18,594	22,975	26,629	28,056	26,013	21,314	23,684
50 to 54	22,316	16,994	17,646	21,931	25,762	26,921	22,045	20,745
55 to 59	21,016	16,025	15,513	16,166	20,360	25,459	23,816	19,663
60 to 64	18,640	16,536	14,563	14,066	14,859	22,607	24,160	19,983
65 years and over	44,380	46,997	48,911	49,114	48,212	49,938	62,149	74,831

*1970 Census of Population(April 1)

EXHIBIT 9 (Continued)

State 11: District of Columbia

Table 3.—Labor and Proprietors' Income by Industry by Place of Work, 1969-1978, and Projected, 1985-2030

[Thousands of 1972 dollars]

	1969[1]	1973[1]	1978[2]	1985	1990	1995	2000	2010	2020	2030
Total labor and proprietors' income[3]	6,215,640	6,954,415	7,546,660	9,021,129	10,239,934	11,261,801	12,544,646	15,432,816	18,344,797	22,231,855
Agricultural production	0	0	0	0	0	0	0	0	0	0
Agricultural services, forestry, fisheries, and other	(D)	42,785	52,782	68,059	80,137	91,024	104,334	135,205	166,671	207,259
Agricultural services, forestry, and fisheries	(D)	1,647	1,403	1,463	1,542	1,629	1,740	2,013	2,261	2,671
Other[4]	30,879	41,138	51,379	66,596	78,595	89,395	102,594	133,192	164,390	204,588
Mining	(D)	928	1,906	2,626	3,029	3,579	4,246	5,432	6,547	7,778
Coal mining	0	0	(D)	242	265	314	357	452	578	723
Oil and gas extraction	(D)	(D)	1,304	1,852	2,128	2,514	2,997	3,792	4,485	5,204
Metal mining	0	(D)	(D)	267	304	340	384	483	563	713
Nonmetallic mining excluding fuels	0	(D)	(D)	267	332	411	508	705	901	1,138
Construction	192,559	261,970	172,190	198,954	213,906	223,485	235,321	265,726	294,554	339,107
Manufacturing	226,888	212,639	206,609	239,159	275,500	301,735	332,948	405,454	478,836	576,926
Nondurable goods	197,048	190,434	185,907	215,238	247,864	270,772	297,734	360,796	424,653	510,319
Food and kindred products	37,575	(D)	13,466	13,095	13,874	14,090	14,699	16,369	18,138	20,743
Tobacco products	0	0	(D)	508	633	777	930	1,249	1,555	1,908
Textile mill products	56	2	(D)	261	326	371	422	534	668	829
Apparel and other fabricated textile products	(D)	807	488	594	657	706	768	912	1,059	1,256
Paper and allied products	(D)	448	(D)	4,546	5,027	5,342	5,771	6,795	7,827	9,262
Printing and publishing	152,033	(D)	159,384	185,238	214,263	233,966	256,776	310,287	364,326	437,009
Chemicals and allied products	3,768	3,888	5,317	7,871	9,989	12,125	14,829	20,729	26,768	34,390
Petroleum refining	191	242	2,696	3,105	3,295	3,395	3,539	3,921	4,312	4,925
Rubber and miscellaneous plastics products	41	28	9	0	0	0	0	0	0	0
Leather and leather products	8	13	5	0	0	0	0	0	0	0
Durable goods	29,840	22,205	20,702	23,921	27,636	30,963	35,214	44,658	54,183	66,607
Lumber products excluding furniture and fixtures	(D)	559	475	544	603	656	722	873	1,025	1,231
Furniture and fixtures	953	91	127	152	170	185	205	248	292	350
Stone, clay, and glass products	4,589	4,380	(D)	3,485	4,216	4,914	5,777	7,668	9,588	12,040
Primary metals	(D)	1,511	(D)	7,883	9,980	12,085	14,760	20,470	26,283	33,501
Fabricated metals	3,623	(D)	2,054	2,377	2,528	2,515	2,523	2,611	2,677	2,881
Machinery excluding electrical machinery	2,217	999	1,279	1,396	1,455	1,366	1,294	1,179	1,033	934
Electrical machinery	6,914	4,246	3,940	3,008	3,374	3,637	3,938	4,653	5,362	6,358
Transporation equipment excluding motor vehicles	5,343	3,484	(D)	1,196	970	889	824	731	644	595
Motor vehicles and equipment	(D)	(D)	(D)	1,405	1,577	1,740	1,938	2,388	2,836	3,442
Ordnance[5]	(D)	0	0	0	0	0	0	0	0	0
Instruments	1,814	1,378	1,106	1,391	1,571	1,697	1,848	2,203	2,553	3,042
Miscellaneous manufacturing	(D)	1,964	(D)	1,082	1,192	1,279	1,385	1,634	1,888	2,233
Transportation, communication, and public utilities	374,789	386,238	411,576	526,789	605,361	665,954	738,118	902,993	1,065,708	1,263,225
Railroad transportation	31,095	25,953	(D)	51,597	54,953	57,881	61,576	69,919	78,389	89,422
Motor freight and warehousing	17,293	17,107	9,713	11,226	12,235	12,727	13,314	14,682	15,856	17,862
Local, suburban, and highway passenger transportation	50,705	17,302	19,121	18,091	19,114	20,269	21,715	25,186	28,754	33,591
Air transportation	13,757	33,387	(D)	15,292	16,651	17,123	17,541	18,622	19,227	20,770
Pipeline transportation	0	0	0	0	0	0	0	0	0	0
Transportation services	27,836	31,288	20,308	25,848	30,013	32,539	35,689	42,933	50,020	59,867
Water transportation	1,678	1,309	954	948	847	624	460	182	0	0
Communications	167,747	196,787	240,628	334,361	394,120	441,048	496,241	621,579	745,264	908,402
Electric, gas, and sanitary services	64,678	63,105	(D)	69,426	77,428	83,743	91,582	109,890	128,198	153,311
Wholesale trade	256,205	196,489	171,036	184,292	190,110	189,603	189,850	196,454	202,375	218,923
Retail trade	415,079	370,382	332,524	355,280	369,501	373,720	375,456	394,325	411,036	449,580
Finance, insurance, and real estate	290,519	306,466	342,965	421,707	482,789	532,067	593,052	730,102	865,714	1,049,751
Banking	57,171	72,403	(D)	122,070	147,718	170,310	198,404	259,586	320,750	401,015
Other credit and security agencies	60,824	67,129	(D)	106,639	122,096	134,973	150,771	188,685	222,414	270,491
Insurance	75,656	75,412	(D)	91,660	101,537	107,312	114,059	130,250	144,976	167,509
Real estate and combination offices	96,868	91,522	(D)	101,338	111,438	119,472	129,818	153,581	177,574	210,736
Services	1,296,288	1,440,813	1,846,181	2,389,886	2,819,788	3,200,589	3,654,823	4,686,028	5,718,676	7,085,733
Hotels and other lodging places	61,963	(D)	(D)	89,318	108,871	127,355	148,811	197,460	245,764	306,688
Personal and miscellaneous business and repair services	259,663	(D)	(D)	370,174	432,688	486,569	550,298	693,478	835,864	1,025,793
Auto repair services and garages	21,239	22,943	(D)	21,283	21,499	21,084	20,527	19,575	17,950	17,085
Amusement and recreation excluding motion pictures	17,800	16,545	13,035	14,855	15,839	16,055	16,257	16,997	17,414	18,702
Motion pictures	11,449	11,811	7,668	8,230	8,859	9,255	9,775	11,105	12,413	14,377
Private households	74,242	68,337	(D)	68,175	69,025	74,376	77,393	87,627	97,978	111,363
Medical and other health services	178,499	198,268	283,737	421,469	541,443	653,560	781,865	1,070,517	1,358,206	1,733,729
Private educational services	196,053	239,262	(D)	288,057	321,713	349,065	383,982	464,279	544,721	654,053
Nonprofit organizations	206,373	268,395	(D)	453,492	486,628	506,878	533,618	603,589	673,407	778,333
Miscellaneous professional services	269,007	309,519	432,951	654,833	813,025	956,392	1,132,297	1,521,401	1,914,959	2,423,610
Government	3,129,631	3,735,705	4,008,891	4,634,375	5,199,813	5,700,045	6,316,498	7,711,097	9,134,680	11,013,573
Federal civilian	2,528,532	2,909,827	3,221,487	3,751,316	4,196,304	4,587,113	5,067,928	6,160,355	7,266,251	8,732,267
Federal military	190,443	215,614	170,463	198,034	222,216	243,973	271,055	333,348	408,999	503,460
State and local	410,656	610,264	616,941	685,025	781,293	868,959	977,515	1,217,394	1,459,430	1,777,846

See footnotes on page 2

EXHIBIT 9 (Continued)

Table 4.—Employment by Industry by Place of Work, 1969-1978, and Projected, 1985-2030

[Total number of jobs]

	1969[1]	1973[1]	1978[2]	1985	1990	1995	2000	2010	2020	2030
Total employment	647,198	623,664	654,397	693,440	705,912	704,799	707,499	710,205	697,293	692,967
Agricultural production	0	0	0	0	0	0	0	0	0	0
Agricultural services, forestry, fisheries, and other	(D)	2,183	2,680	2,657	3,137	3,132	3,128	3,122	3,112	3,106
Agricultural services, forestry, and fisheries	(D)	231	240	217	209	204	200	194	184	178
Other[4]	1,952	1,952	2,440	2,440	2,928	2,928	2,928	2,928	2,928	2,928
Mining	(D)	77	98	134	136	140	146	145	143	138
Coal mining	0	0	(D)	14	13	13	13	13	13	13
Oil and gas extraction	(D)	(D)	74	82	83	84	87	83	78	72
Metal mining	0	(D)	(D)	7	7	7	7	7	7	7
Nonmetallic mining excluding fuels	0	(D)	(D)	31	33	36	39	42	45	46
Construction	20,143	22,236	15,212	15,553	14,964	14,175	13,507	12,544	11,535	10,926
Manufacturing	20,451	16,704	15,245	15,148	15,485	15,217	15,007	14,727	14,258	14,011
Nondurable goods	17,809	14,886	13,713	13,658	13,981	13,727	13,524	13,257	12,825	12,595
Food and kindred products	3,510	(D)	1,015	845	791	748	708	652	623	602
Tobacco products	0	0	(D)	16	17	18	20	21	22	22
Textile mill products	27	2	(D)	24	25	27	28	30	32	33
Apparel and other fabricated textile products	(D)	107	81	93	97	97	98	100	99	99
Paper and allied products	(D)	62	(D)	317	310	299	288	283	270	262
Printing and publishing	13,564	(D)	11,844	11,866	12,198	11,960	11,760	11,486	11,070	10,848
Chemicals and allied products	299	293	311	392	440	478	525	592	620	643
Petroleum refining	3	5	97	100	98	95	92	88	84	82
Rubber and miscellaneous plastics products	10	2	0	0	0	0	0	0	0	0
Leather and leather products	7	3	7	5	5	5	5	5	5	4
Durable goods	2,642	1,818	1,532	1,490	1,504	1,490	1,483	1,470	1,433	1,416
Lumber products excluding furniture and fixtures	(D)	49	45	44	43	43	43	42	41	40
Furniture and fixtures	128	14	14	12	12	11	10	9	8	8
Stone, clay, and glass products	457	330	(D)	179	186	188	190	194	191	191
Primary metals	(D)	69	(D)	469	509	543	578	625	652	672
Fabricated metals	328	(D)	243	229	209	183	160	127	102	85
Machinery excluding electrical machinery	170	64	78	73	68	57	49	36	26	19
Electrical machinery	666	399	284	184	185	179	173	165	153	147
Transporation equipment excluding motor vehicles	246	144	(D)	46	32	27	22	15	10	7
Motor vehicles and equipment	(D)	(D)	(D)	30	30	30	29	29	28	28
Ordnance[4]	(D)	0	0	0	0	0	0	0	0	0
Instruments	168	144	103	114	117	116	115	114	109	107
Miscellaneous manufacturing	(D)	201	(D)	110	113	113	114	114	113	112
Transportation, communication, and public utilities	35,276	29,293	27,087	28,025	27,901	27,284	26,813	26,069	24,927	24,226
Railroad transportation	3,297	2,025	(D)	3,158	2,886	2,728	2,542	2,265	2,046	1,850
Motor freight and warehousing	2,339	2,095	1,343	1,418	1,384	1,309	1,247	1,144	1,031	963
Local, suburban, and highway passenger transportation	6,321	2,797	2,540	2,205	2,138	2,085	2,035	1,962	1,887	1,822
Air transportation	1,121	1,546	(D)	814	769	696	631	528	431	370
Pipeline transportation	0	0	0	0	0	0	0	0	0	0
Transportation services	2,773	2,911	1,658	1,957	2,100	2,128	2,186	2,252	2,209	2,195
Water transportation	132	110	78	67	52	35	23	8	0	0
Communications	13,495	12,930	12,765	14,295	14,519	14,368	14,305	14,201	13,778	13,577
Electric, gas, and sanitary services	5,798	4,879	(D)	4,111	4,053	3,935	3,844	3,709	3,545	3,449
Wholesale trade	20,739	15,327	12,944	12,427	11,789	10,881	10,055	8,830	7,727	7,033
Retail trade	67,003	56,691	52,572	52,739	50,192	46,944	43,709	38,926	34,086	31,088
Finance, insurance, and real estate	34,498	33,044	33,099	35,720	36,467	35,930	35,834	35,396	34,095	33,559
Banking	6,057	6,468	(D)	8,941	9,675	9,928	10,333	10,832	10,861	10,999
Other credit and security agencies	5,337	5,939	(D)	6,834	6,938	6,834	6,793	6,712	6,666	6,729
Insurance	7,273	6,428	(D)	6,754	6,637	6,309	6,040	5,618	5,107	4,806
Real estate and combination offices	15,831	14,209	(D)	13,191	13,217	12,859	12,668	12,234	11,461	11,025
Services	172,774	168,920	196,905	223,499	234,195	238,015	243,388	250,746	248,745	250,016
Hotels and other lodging places	11,113	(D)	(D)	11,687	12,655	13,169	13,718	14,574	14,573	14,701
Personal and miscellaneous business and repair services	36,582	(D)	(D)	43,491	45,684	46,309	47,408	48,728	47,589	47,266
Auto repair services and garages	3,320	3,387	(D)	2,776	2,510	2,215	1,942	1,505	1,115	860
Amusement and recreation excluding motion pictures	2,323	1,870	1,648	1,660	1,588	1,443	1,313	1,105	899	768
Motion pictures	1,309	1,529	1,117	992	938	874	817	740	673	630
Private households	20,908	18,474	(D)	13,429	11,768	10,816	9,664	7,947	7,022	6,210
Medical and other health services	16,415	18,526	26,573	33,440	38,379	41,797	45,062	50,183	51,780	53,828
Private educational services	29,268	26,503	(D)	29,987	29,542	28,835	28,379	27,680	26,719	26,178
Nonprofit organizations	32,071	36,185	(D)	43,254	43,549	42,459	41,808	40,804	38,488	37,246
Miscellaneous professional services	19,465	20,545	30,375	42,803	47,582	50,098	53,277	57,480	59,887	62,329
Government	274,009	279,189	298,555	307,538	311,646	313,081	315,912	319,700	318,665	318,864
Federal civilian	200,253	197,327	224,245	230,991	233,056	233,246	234,304	235,849	234,633	234,386
Federal military	26,398	23,403	21,498	21,416	21,416	21,416	21,416	21,416	21,416	21,416
State and local	47,358	58,459	52,812	55,131	57,174	58,419	60,192	62,435	62,616	63,062

See footnotes on page 2

EXHIBIT 9 (Continued)

SMSA 8840: Washington, District of Columbia—Maryland—Virginia

Table 1.—Population, Personal Income, and Labor and Proprietors' Income, 1969 and 1978, and Projected, 1985-2030

	Historical		No-change-in-share				Low-change-in-share				Moderate-change-in-share			
	1969[1]	1978[2]	1985	1990	2000	2030	1985	1990	2000	2030	1985	1990	2000	2030
Population (July 1)	2,855,340	3,016,762	3,110,879	3,235,253	3,410,792	3,895,685	3,224,899	3,391,184	3,609,358	4,143,373	3,262,605	3,466,318	3,748,596	4,373,699
	Thousands of 1972 dollars													
Total personal income (place of residence)	14,706,090	20,631,764	26,218,961	30,868,890	40,176,046	80,306,790	27,076,398	32,189,030	42,243,284	84,604,082	27,357,114	32,816,526	43,665,945	88,885,810
By place of work														
Total labor and proprietors' income[3]	12,679,922	17,138,072	21,426,138	24,960,842	32,093,521	61,266,508	21,987,782	25,825,384	33,454,027	64,197,063	22,172,652	26,239,578	34,400,560	66,875,264
Agricultural production	27,250	30,222	34,061	36,302	42,233	68,010	33,869	36,059	41,946	67,627	33,806	35,944	41,750	67,283
Nonfarm	12,652,672	17,107,850	21,392,077	24,924,539	32,051,268	61,218,498	21,953,913	25,789,325	33,412,082	64,129,436	22,138,846	26,203,635	34,358,811	66,807,981
Private	6,929,233	9,810,518	12,783,472	15,160,993	19,938,332	39,381,233	13,272,122	15,918,056	21,138,615	41,976,285	13,433,350	16,282,251	21,978,299	44,378,391
Agricultural services, forestry, fisheries, and other[4]	50,452	77,083	97,618	113,668	144,865	276,616	101,077	118,687	151,897	288,993	102,108	120,909	156,448	299,576
Mining	14,488	9,373	16,544	21,905	31,005	64,141	13,655	17,009	23,032	46,771	13,555	16,377	21,052	40,400
Construction	751,898	912,220	1,128,695	1,302,593	1,651,609	3,077,640	1,133,920	1,310,234	1,663,287	3,102,205	1,134,934	1,312,370	1,667,747	3,114,041
Manufacturing	491,489	624,555	768,908	889,388	1,111,752	2,025,950	844,100	1,002,431	1,278,886	2,346,804	866,048	1,053,420	1,393,993	2,647,890
Nondurable goods	302,562	351,384	415,356	477,319	580,317	1,013,193	455,882	538,708	671,305	1,187,519	465,880	563,553	729,928	1,344,353
Durable goods	188,927	273,171	353,553	412,069	531,434	1,012,757	388,218	463,723	607,581	1,159,285	400,168	489,868	664,065	1,303,537
Transportation and public utilities	678,826	962,400	1,254,587	1,478,424	1,915,837	3,674,596	1,296,741	1,542,955	2,016,767	3,888,115	1,312,145	1,576,567	2,091,820	4,095,827
Wholesale trade	470,730	644,659	811,561	934,027	1,186,033	2,212,520	873,196	1,027,060	1,328,150	2,500,908	894,157	1,073,172	1,430,599	2,775,962
Retail trade	1,234,497	1,518,545	1,858,755	2,117,552	2,623,686	4,722,887	1,930,514	2,224,579	2,784,582	5,044,419	1,954,354	2,275,924	2,896,035	5,338,422
Finance, insurance, and real estate	620,042	874,093	1,158,798	1,384,032	1,830,452	3,641,815	1,179,054	1,415,683	1,880,987	3,752,510	1,185,739	1,430,704	1,915,452	3,851,729
Services	2,616,811	4,187,591	5,688,005	6,919,404	9,443,095	19,685,068	5,899,866	7,259,418	10,011,028	21,005,559	5,970,310	7,422,809	10,405,153	22,214,544
Government	5,723,439	7,297,332	8,608,605	9,763,547	12,112,957	21,837,265	8,681,791	9,871,269	12,273,466	22,153,151	8,705,496	9,921,384	12,380,512	22,429,591
Federal civilian	3,935,272	4,980,146	5,888,337	6,645,359	8,180,714	14,514,730	5,929,392	6,705,697	8,271,239	14,694,933	5,942,469	6,733,234	8,330,272	14,848,818
Federal military	734,895	580,813	674,757	757,151	923,559	1,715,428	674,757	757,151	923,559	1,715,428	674,757	757,151	923,559	1,715,428
State and local	1,053,272	1,736,373	2,045,512	2,361,037	3,008,683	5,607,108	2,077,642	2,408,421	3,078,668	5,742,790	2,088,271	2,430,999	3,126,681	5,865,345

Table 2.—Employment by Industry by Place of Work, 1969 and 1978, and Projected, 1985-2030

[Total number of jobs]

	Historical		No-change-in-share				Low-change-in-share				Moderate-change-in-share			
	1969[1]	1978[2]	1985	1990	2000	2030	1985	1990	2000	2030	1985	1990	2000	2030
Total employment	1,410,000	1,680,858	1,853,989	1,935,015	2,028,538	2,117,794	1,909,634	2,011,730	2,126,757	2,231,642	1,928,056	2,048,772	2,195,850	2,337,937
Agricultural production	7,942	7,053	6,510	6,247	5,953	5,198	6,466	6,194	5,898	5,152	6,452	6,169	5,860	5,111
Nonfarm	1,402,058	1,673,805	1,847,479	1,928,768	2,022,586	2,112,596	1,903,168	2,005,536	2,120,859	2,226,489	1,921,604	2,042,602	2,189,989	2,332,826
Private	841,624	1,059,719	1,205,885	1,275,218	1,354,376	1,431,710	1,255,487	1,343,955	1,442,864	1,534,865	1,271,945	1,377,266	1,505,423	1,631,724
Agricultural services, forestry, fisheries, and other[4]	5,387	7,030	7,269	7,901	7,977	7,822	7,818	8,626	8,833	8,679	7,983	8,949	9,389	9,416
Mining	1,481	882	1,289	1,464	1,592	1,871	1,038	1,107	1,146	1,178	1,039	1,074	1,050	1,015
Construction	80,267	90,594	98,620	100,714	101,532	100,021	98,911	101,080	101,964	100,498	98,943	101,130	102,025	100,568
Manufacturing	47,604	53,029	55,703	57,070	57,176	56,084	61,633	64,986	66,618	65,944	63,323	68,492	73,027	75,084
Nondurable goods	29,231	30,147	30,785	31,442	30,996	29,760	34,243	36,099	38,610	35,701	35,082	37,961	40,190	40,995
Durable goods	18,373	22,882	24,918	25,628	26,180	26,324	27,391	28,887	30,009	30,244	28,241	30,531	32,837	34,089
Transportation and public utilities	66,322	68,272	72,823	74,621	76,293	76,090	75,492	78,176	80,657	80,854	76,471	80,034	83,921	85,520
Wholesale trade	40,774	50,749	58,606	59,102	62,136	64,717	61,074	65,207	69,831	73,397	62,598	68,244	75,409	81,735
Retail trade	200,193	245,001	274,885	287,323	299,643	303,890	285,961	302,495	318,786	325,335	289,650	309,802	332,113	345,058
Finance, insurance, and real estate	73,076	90,474	106,549	113,932	121,409	129,630	108,451	116,588	124,819	133,629	109,078	117,847	127,138	137,202
Services	326,520	453,688	532,141	573,092	626,617	691,785	555,109	605,690	670,210	745,350	562,861	621,694	701,350	796,127
Government	560,434	614,086	641,594	653,550	668,210	680,886	647,681	661,581	677,995	691,625	649,659	665,337	684,567	701,102
Federal civilian	325,615	363,497	377,385	381,675	386,113	389,958	380,131	385,275	390,515	394,884	381,004	386,917	393,389	399,102
Federal military	108,108	72,001	71,725	71,725	71,725	71,725	71,725	71,725	71,725	71,725	71,725	71,725	71,725	71,725
State and local	126,711	178,588	192,484	200,150	210,371	219,203	195,824	204,581	215,754	225,015	196,930	206,694	219,453	230,274

See footnotes on page 2

EXHIBIT 10

LABOR AREA SUMMARY

RALEIGH-DURHAM STANDARD METROPOLITAN STATISTICAL AREA

Durham, Orange, and Wake Counties

August, 1981

Employment Developments

During August, 1981, total employment in the Raleigh-Durham SMSA was estimated at 280,200, a decrease of 700 workers since July, 1981. "All other" nonfarm employment experienced the greatest decline with a loss of 500 workers while farm employment lost 400 workers. Nonfarm wage and salary employment registered a slight increase of 200 workers during this time. Industry employment by place of work showed an increase of 100 workers in manufacturing employment, while nonmanufacturing employment gained 200 workers. Worker losses in service (-300), government (-200), and other durable goods were offset by gains in trade (+700), apparel (+100), and other nondurable goods (+100).

Total employment in the area has increased by 7,100 workers since mid-August, 1980. Payroll losses were evident in government (-1,300) and contruction (-400). These losses were partially offset by gains in transportation, communication, and public utilities (+400), service (+300), trade (+200), electrical machinery (+200), textiles (+200), and apparel (+200).

Manpower Resources

As of mid-August, 1981, total unemployment in the Raleigh-Durham SMSA was estimated at 12,600 workers, representing 4.3 percent of the civilian labor force of 292,800. Total unemployment decreased by 1,000 workers since July, a 7.4 percent decline. Since August, 1980, total unemployment in the area has decreased by 500 workers, a 3.8 percent decrease. The August, 1980, unemployment rate of 4.3 percent is 0.3 percentage points lower than both the previous month and the year-ago figures.

Of the seven SMSA's in the State, Raleigh-Durham had the lowest unemployment rate at 4.3 percent. The rates for the other SMSA's were as follows: Charlotte-Gastonia, 4.7; Asheville, 5.4; Greensboro-Winston Salem-High Point, 5.6; Wilmington, 7.0; Burlington, 7.8; and Fayetteville, 8.7. The State unemployment rate for August, 1981, was estimated at 5.7 percent, while the National unadjusted rate was 7.2 percent.

Characteristics of the insured unemployed are not available. However, characteristics of these persons filing applications with the Job Service offices in the area are available. The following table reveals that at the end of August, 1981, approximately 55.5 percent of all available applicants were female, while 53.8 percent were minority. Approximately 14.2 percent of all available applicants were under age 22, while 14.8 percent were age 45 or older. Additional data reveal that 34.4 percent were disadvantaged, while 14.9 percent were veterans.

CIVILIAN LABOR FORCE 1/
Raleigh-Durham SMSA
(Durham, Orange, and Wake Counties)

August, 1981

ITEM	NUMBER OF WORKERS			CHANGE TO CURRENT MONTH FROM:			
				July, 1981		Aug., 1980	
	Aug. 1981	July 1981	Aug. 1980	Net	%	Net	%
CIVILIAN LABOR FORCE 2/	292,800	294,500	286,200	-1,700	-0.6	+6,600	+2.3
UNEMPLOYMENT, TOTAL	12,600	13,600	13,100	-1,000	-7.4	-500	-3.8
Percent of Civilian Labor Force	4.3	4.6	4.6	-0.3	XXX	-0.3	XXX
EMPLOYMENT, TOTAL	280,200	280,900	273,100	-700	-0.2	+7,100	+2.6
Agricultural	8,000	8,400	8,000	-400	-4.8	0	0
Nonagricultural Wage & Salary	244,500	244,300	237,100	+200	+0.1	+7,400	+3.1
All Other Nonagricultural 3/	27,700	28,200	28,000	-500	-1.8	-300	-1.1
INDUSTRY EMPLOYMENT BY PLACE OF WORK 4/							
Manufacturing	44,400	44,300	44,300	+100	+0.2	+100	+0.2
Durable Goods	26,500	26,600	26,300	-100	-0.4	+200	+0.8
Electrical Machinery	9,200	9,200	9,000	0	0	+200	+2.2
Other Durable Goods 5/	17,300	17,400	17,300	-100	-0.6	0	0
Nondurable Goods	17,900	17,700	18,000	+200	+1.1	-100	-0.6
Food & Kindred Products	3,300	3,300	3,400	0	0	-100	-2.9
Textile Mill Products	3,700	3,700	3,500	0	0	+200	+5.7
Apparel	2,200	2,100	2,000	+100	+4.8	+200	+10.0
Other Nondurable Goods 6/	8,700	8,600	9,100	+100	+1.2	-400	-4.4
Nonmanufacturing	217,200	217,000	218,100	+200	-0.1	-900	-0.4
Construction	12,800	12,800	13,200	0	0	-400	-3.0
Trans., Comm. & Pub. Utilities	14,200	14,200	13,800	0	0	+400	+2.9
Trade	51,900	51,200	51,700	+700	+1.4	+200	+0.4
Fin., Ins., & Real Estate	15,900	15,900	16,000	0	0	-100	-0.6
Service & Miscellaneous 7/	55,400	55,700	55,100	-300	-0.5	+300	+0.5
Government	67,000	67,200	68,300	-200	-0.3	-1,300	-1.9

1/ Reflects 1980 Benchmark Data.
2/ Data based on place of residence.
3/ Includes nonagricultural self-employed workers, unpaid family workers, and domestic workers in private households.
4/ Industry segments are not additive to the "Nonagricultural Wage and Salary Employment" shown under civilian labor force since labor force data are by "Place of Residence."
5/ Includes Lumber & Wood; Furniture; Stone, Clay, & Glass; Primary & Fabricated Metals; Nonelectrical Machinery; Transportation Equipment; Instruments; and Miscellaneous Manufacturing.
6/ Includes Tobacco Manufacturing; Paper; Printing; Chemicals; Rubber & Miscellaneous Plastic Products.
7/ Includes Services, Except Domestic; Agricultural Services; Forestry; and Mining.

EXHIBIT 10 (Continued)

Occupational Category and Selected Characteristics of Active Applicants in Raleigh-Durham SMSA

DOT* CODE	Occupational Cat. Active Applicants	Total Act. Applicants	Male	Female	Under 22	45 & Older	Minority
	Total	16,459	7,332	9,127	2,344	2,435	8,861
0-1	Prof., Tech., & Mgr.	2,214	1,159	1,055	45	299	632
20-24	Clerical	2,785	536	2,249	444	275	1,322
25-29	Sales	566	323	243	72	111	158
3	Services	2,901	778	2,123	420	546	2,243
4	Farm, Fish., & For.	296	200	96	58	86	183
5	Processing	305	147	158	37	64	196
6	Machine Trades	870	544	326	90	132	414
7	Benchwork	1,205	235	970	112	243	646
8	Structural Work	1,664	1,598	66	179	289	712
9	Miscellaneous Occ.	1,375	1,138	237	211	189	828
	Entry	2,095	642	1,453	669	167	1,390
	Invalid Occupational Codes	183	32	151	7	34	137

*Dictionary of Occupational Titles

Available Job Opportunities

Many of the job opportunities in the Raleigh-Durham SMSA remain unfilled due to a mis-match of employer requirements and applicant skills and abilities. As can be seen by the following table, almost 53 percent of the job orders on file in the area's Job Service offices have been open for 30 days or more and are classified as hard-to-fill. Jobs listed with the area's Job Service offices at the end of August, 1981, are shown in the following table.

OCCUPATIONAL CATEGORY	Unfilled Openings	Open for 30 Days or More	% Hard to Fill	Total	Ratio to Unfilled Openings
Prof., Tech., & Mgr.	261	132	50.6	2,214	8.5
Clerical	355	216	60.8	2,785	7.8
Sales	44	20	45.5	566	12.9
Domestic	1	1	100.0	284	284.0
Service, Except Domestic	164	80	48.8	2,617	16.0
Farm., Fish., & For.	30	23	76.7	296	9.9
Processing	71	69	97.2	305	4.3
Machine Trades	55	26	47.3	870	15.8
Bench Work	143	56	39.2	1,205	8.4
Structural Work	134	56	41.8	1,664	12.4
Miscellaneous	69	23	33.3	1,375	19.9
Totals	1,327	702	52.9	14,181	10.7

Employment and Unemployment Outlook

If historical trends continue, total employment in the area should increase over the next three months, with a smaller increase expected within six months. Total unemployment in the area is expected to be somewhat below current levels over the next three months. However, seasonal factors should contribute to a rise in these totals within six months.

Hours and Earnings

The average hourly earnings of production worker in manufacturing industries in the Raleigh-Durham area increased by six cents an hour from mid-July to mid-August, 1981, rising from $6.77 to $6.83. Average hourly earnings have increased by 61¢ an hour since mid-August, 1980, rising from $6.22 at that time. From July to August the average weekly earnings of factory workers in production rose $3.06, from $268.09 to $271.15. The over-the-year change was an increase of $26.08, increasing from $245.07 last August. The average weekly hours worked by manufacturing production workers during mid-August, 1981, was 39.7, up 0.1 hours from mid-July, 1981, and up 0.3 hours from mid-August, 1980.

EXHIBIT 10 (Continued)

AVERAGE WEEKLY EARNINGS, AVERAGE WEEKLY HOURS, AND AVERAGE HOURLY EARNINGS
OF PRODUCTION WORKERS IN SELECTED MANUFACTURING INDUSTRIES

RALEIGH-DURHAM SMSA

August, 1981

INDUSTRY	AVERAGE WEEKLY EARNINGS			AVERAGE WEEKLY HOURS			AVERAGE HOURLY EARNINGS		
	Aug. 1981 1/	July 1981	Aug. 1980	Aug. 1981 1/	July 1981	Aug. 1980	Aug. 1981 1/	July 1981	Aug. 1980
MANUFACTURING, TOTAL	$271.15	$268.09	245.07	39.7	39.6	39.4	$6.83	$6.77	$6.22
Durable Goods	273.53	270.47	261.62	39.7	39.6	41.2	6.89	6.83	6.35
Electrical Machinery	269.58	267.72	238.64	38.9	38.8	38.0	6.93	6.90	6.28
Nondurable Goods	267.70	265.59	228.84	39.6	39.7	37.7	6.76	6.69	6.07
Food & Kindred Products	196.35	185.67	184.37	36.7	35.5	36.8	5.35	5.23	5.01
Textile Mill Products	242.13	245.92	203.84	40.9	42.4	38.1	5.92	5.80	5.35
Apparel & Related Products	159.90	162.31	146.06	37.1	38.1	35.8	4.31	4.26	4.08

1/ Preliminary estimates

EXHIBIT 11

SELECTED LIST OF RELEVANT PUBLICATIONS

The following is a partial list of publications that may be helpful to manpower planners. The covered area such as a state, a standard metropolitan statistical area, a planning region, or a county, varies for each publication. (A list of the counties by planning region may be found in the adjoining Appendix Table B.) These publications are available from the Labor Market Information Division, Employment Security Commission of North Carolina, Post Office Box 25903, Raleigh, North Carolina 27611. A complete list of the Division's publications is found in their Catalog of Publications and Releases.

1. Results of OES surveys of Occupational Employment for industries in
   A. Trade
   B. Manufacturing
   C. Government
   D. Regulated Industries
   E. Nonmanufacturing

2. North Carolina Labor Force Estimates by County, Area, and State. A labor force study in which monthly and annual average employment by major industry divisions, and unemployment are shown for the State, each county, and each multi-county labor area for the preceding calendar year.

3. Preliminary Civilian Labor Force Estimates. A monthly report showing preliminary labor force, total employment, total unemployment and unemployment rates for the State and for each of the 100 counties.

4. Active Job Applicants Registered for Work with Employment Security Commission Offices and Residing in the Area of _____. A special report prepared upon request depicting the number of actively registered job applicants available for work within a commuting radius of any designated town or industrial site in the State. Report includes a map of the area, total population of the area, and number of high school graduates entering the labor force. (Map Job)

5. Active Applicants Registered for Work with ESC Offices by Applicants' County of Residence. A table and map depicting the number of job applicants actively registered with ESC offices by applicant's county of residence. Serves as an indicator of labor supply.

6. Labor Area Summary or Labor Market Newsletters. A monthly or bimonthly report for selected labor areas of the State which includes a narrative analysis and supporting statistical data on employment and unemployment trends in the area.

7. Registered Applicants and Job Openings. A quarterly summary report of job applicants and job openings for selected occupations. Report shows number of applicants registered to date during fiscal year and number actively registered at close of month, with a female breakout. Also, shows nonfarm job openings received and filled during fiscal year and number unfilled at end of month, with a breakout showing those openings which remained unfilled for 30 days or more.

8. Characteristics of Active Applicants by county. A special report which presents socio-economic data on applicants registered with the Employment Security Commission by applicant's county of residence.

APPENDIX TABLE A
OCCUPATIONAL EMPLOYMENT AND ANNUAL AVERAGE JOB NEEDS 1/
RALEIGH-DURHAM SMSA

OCCUPATION	NONAGRICULTURAL WAGE AND SALARY EMPLOYMENT			ANNUAL AVERAGE JOB NEEDS 1978-1985		
	1978	PROJECTED 1985	AVERAGE ANNUAL PERCENT INCREASE 1978-1985	TOTAL JOB NEEDS	EXPANSION NEEDS	REPLACEMENT NEEDS
TOTAL,ALL OCCUPATIONS	247,900	319,350	4.1	18,547	10,207	8,340
PROFESS,TECHN,& KINDRED WORKERS	54,850	68,320	3.5	3,654	1,924	1,730
ENGINEERS	3,310	5,125	7.8	326	259	67
CHEMICAL ENGINEERS	55	75	5.3	4	3	1
CIVIL ENGINEERS	555	750	5.1	43	28	15
ELECTRICAL ENGINEERS	1,030	1,755	10.1	124	104	20
INDUSTRIAL ENGINEERS	280	425	7.2	25	20	5
MECHANICAL ENGINEERS	350	510	6.7	30	23	7
OTHER ENGINEERS	1,020	1,575	7.8	98	79	19
ALL OTHER ENGINEERS	1,010	1,565	7.8	98	79	19
LIFE & PHYSICAL SCIENTISTS	645	840	4.4	42	28	14
AGRICULTURAL SCIENTISTS	55	75	4.9	5	3	2
LIFE SCIENTISTS	130	170	4.3	11	6	5
BIOLOGICAL SCIENTISTS	130	165	4.4	11	6	5
CHEMISTS	330	435	4.5	21	15	6
LIFE,PHYSICAL SCIENTISTS,NEC	55	70	3.9	2	2	0
MATHEMATICAL SPECIALISTS	165	225	5.6	12	9	3
STATISTICIANS	100	135	5.5	8	5	3
ENGINEERING,SCIENCE TECHNS	3,380	4,705	5.6	247	189	58
DRAFTERS	650	955	6.8	53	44	9
ELECTRICAL,ELECTRONIC TECHNS	725	1,050	6.4	55	46	9
ELECTRICAL & ELECTRONIC TECHN	670	975	6.6	52	44	8
BROADCAST TECHNICIANS	50	65	4.3	3	2	1
MECHANICAL ENGINEERING TECHNS	55	95	10.1	7	6	1
SURVEYORS	160	230	6.7	15	11	4
ENGINEERING,SCIENCE TECHNS,NEC	1,725	2,275	4.6	113	79	34
CIVIL ENGINEERING TECHNICIANS	85	125	6.8	8	6	2
ALL OTHER ENG TECH	855	1,170	5.3	62	45	17
ALL OTHER SCI TECH	760	930	3.6	41	27	14
MEDICAL WORKERS,EX TECHNS	5,935	7,885	4.7	500	279	221
DENTISTS	120	160	4.9	8	6	2
DIETITIANS	150	205	4.9	15	7	8
NURSES, PROFESSIONAL	3,715	4,975	4.9	340	181	159
PHARMACISTS	280	365	4.2	26	12	14
PHYSICIANS,MED & OSTEOPATH	1,110	1,480	4.7	72	53	19
THERAPISTS	505	630	3.6	35	18	17
OCCUPATIONAL THERAPISTS	60	80	5.2	5	3	2
MANUAL ARTS,MUSIC,REC THERAPI	85	115	4.9	7	4	3
SPEECH & HEARING CLINICIANS,E	205	225	1.4	10	3	7
PHYSICAL THERAPISTS	90	120	4.9	7	4	3
INHALATION THERAPISTS	60	80	4.8	5	3	2
HEALTH TECHNOLS & TECHNS	4,100	5,515	4.9	374	202	172
CLINICAL LAB TECHNOLS,TECHNS	630	835	4.7	50	30	20
MEDICAL LAB TECHNOLOGISTS	345	460	4.6	27	16	11

1/ Occupations with 1978 employment of less than 50 were suppressed and data for both 1978 and 1985 were rounded; therefore, detail occupations may not add to summary totals.

EXHIBIT 12

METHOD IV. UPDATE OF 1977 ESTIMATES

For each county the 1977 certified estimate for each city is subtracted from the 1977 county total to give a 1977 estimate of the non-municipal area of the county. The 1978 non-municipal population estimate is obtained from this 1977 estimate in a manner analogous to Method III.

These four methods are then averaged to yield an unadjusted non-municipal estimate for each county.

The non-municipal estimate is added to the sum of unadjusted municipal estimates, and this total is compared with the independent 1978 provisional county population estimate. Adjustments are made in each city and non-municipal estimate to force the total to equal the 1978 county value. If a city has conducted a special census or survey, that city is excluded from the adjustment procedure.

These adjusted totals for municipalities comprise the 1978 final municipal population estimates which are used to allocate those State revenues shared on the basis of municipal population.

TABLE I

POPULATION ESTIMATES FOR NORTH CAROLINA MUNICIPALITIES AND PROVISIONAL ESTIMATES FOR COUNTIES

1978 Permanent Resident Population
(Including the 1978 Population Living in Areas Annexed Through July 1, 1979)

	1978 ESTIMATES	1970 CENSUS	% CHANGE
NORTH CAROLINA	5,577,000	5,084,411	9.7
ALAMANCE COUNTY	98,000	96,502	1.6
Alamance	330	*	*
Burlington	37,690	35,930	4.9
Elon College	2,420	2,150	12.6
Gibsonville (Part)	1,040	842	23.5
Graham	9,380	8,172	14.8
Haw River	2,110	1,944	8.5
Mebane (Part)	3,140	2,387	31.5
ALEXANDER COUNTY	22,600	19,466	16.1
Taylorsville	1,330	1,231	8.0
ALLEGHANY COUNTY	8,800	8,134	8.2
Sparta	1,560	1,304	19.6
ANSON COUNTY	23,500	23,488	0.1
Ansonville	790	694	13.8
Lilesville	650	641	1.4
McFarlan	140	140	0.0
Morven	610	562	8.5
Peachland	530	556	-4.7
Polkton	1,030	845	21.9
South Wadesboro	90	109	-17.4
Wadesboro	4,260	3,977	7.1
ASHE COUNTY	20,800	19,571	6.3
Jefferson	1,030	943	9.2
Lansing	300	283	6.0
West Jefferson	920	889	3.5
AVERY COUNTY	13,800	12,655	9.0
Banner Elk	1,140	754	51.2
Crossnore	280	264	6.1
Elk Park	540	503	7.4
Newland	740	524	41.2
Seven Devils (Part)	0	*	*
BEAUFORT COUNTY	40,000	35,980	11.2
Aurora	710	620	14.5
Bath	230	231	-0.4
Belhaven	2,390	2,259	5.8
Chocowinity	620	566	9.5
Pantego	220	218	0.9
Washington	9,310	8,961	3.9
Washington Park	560	517	8.3

	1978 ESTIMATES	1970 CENSUS	% CHANGE
BERTIE COUNTY	21,200	20,528	3.3
Askewville	270	247	9.3
Aulander	1,200	947	26.7
Colerain	410	373	9.9
Kelford	250	295	-15.3
Lewiston	360	327	10.1
Powellsville	280	247	13.4
Roxobel	370	347	6.6
Windsor	2,410	2,199	9.6
Woodville	250	253	-1.2
BLADEN COUNTY	29,200	26,477	10.3
Bladenboro	2,100	783	168.2
Clarkton	750	662	13.3
Dublin	320	283	13.1
East Arcadia	600	556	7.9
Elizabethtown	3,910	1,418	175.7
Tar Heel	100	87	14.9
White Lake	290	232	25.0
BRUNSWICK COUNTY	32,700	24,223	35.0
Belville	70	59	18.6
Boiling Spring Lakes	910	245	271.4
Bolivia	220	185	18.9
Calabash	200	154	29.9
Caswell Beach	70	28	150.0
Holden Beach	170	136	25.0
Long Beach	2,090	493	323.9
Navassa	420	487	-13.8
Ocean Isle Beach	220	78	182.1
Shady Forest	20	17	17.6
Shallotte	810	597	35.7
Southport	3,080	2,220	38.7
Sunset Beach	140	108	29.6
Yaupon Beach	650	334	94.6
BUNCOMBE COUNTY	154,400	145,056	6.4
Asheville	60,800	57,929	5.1
Biltmore Forest	1,470	1,298	9.4
Black Mountain	4,280	3,204	33.6
Jupiter	230	208	10.6
Montreat	720	581	23.9
Weaverville	1,450	1,280	13.3
Woodfin	2,990	2,831	5.6

NORTH CAROLINA COUNTY POPULATION PROJECTIONS

	July 1, 1978	July 1, 1979	April 1, 1980	July 1, 1981	July 1, 1982	July 1, 1983	July 1, 1984	July 1, 1985	April 1, 1990
Alamance	100,000	100,400	100,800	101,000	101,200	101,400	101,600	101,800	102,600
Alexander	23,000	23,400	23,600	24,200	24,700	25,100	25,600	26,000	28,400
Alleghany	9,100	9,200	9,300	9,500	9,600	9,800	9,900	10,000	10,700
Anson	24,200	24,300	24,400	24,600	24,700	24,900	25,100	25,200	25,500
Ashe	20,400	20,500	20,500	20,700	20,800	21,000	21,100	21,200	21,700
Avery	14,600	14,800	15,000	15,300	15,600	15,900	16,200	16,500	17,800
Beaufort	39,700	40,200	40,500	41,300	41,900	42,500	43,100	43,800	46,500
Bertie	21,000	21,100	21,100	21,300	21,500	21,700	21,900	22,100	22,500
Bladen	29,400	29,800	30,100	30,800	31,300	31,900	32,500	33,000	35,200
Brunswick	36,000	37,200	38,100	41,200	43,700	46,200	48,600	51,200	64,300
Buncombe	152,900	153,900	154,700	155,800	156,600	157,400	158,200	159,000	162,900
Burke	66,100	66,800	67,200	68,100	68,700	69,400	70,000	70,700	74,100
Cabarrus	79,700	80,300	80,800	81,500	82,000	82,600	83,200	83,700	86,100
Caldwell	61,700	62,200	62,700	63,400	64,000	64,600	65,200	65,800	68,500
Camden	5,800	5,900	5,900	6,000	6,100	6,100	6,200	6,200	6,500
Carteret	37,900	38,600	39,100	40,300	41,200	42,100	43,100	44,000	48,600
Caswell	19,900	20,100	20,100	20,300	20,500	20,600	20,700	20,900	21,400
Catawba	102,000	103,500	104,600	106,200	107,500	108,800	110,000	111,300	117,700
Chatham	30,600	30,700	30,800	30,900	31,000	31,100	31,200	31,200	31,500
Cherokee	17,800	18,000	18,200	18,500	18,700	18,900	19,200	19,400	20,400
Chowan	11,600	11,700	11,800	12,000	12,100	12,200	12,400	12,500	13,100
Clay	5,700	5,700	5,800	5,900	5,900	6,000	6,100	6,200	6,600
Cleveland	80,100	81,000	81,600	82,900	83,800	84,800	85,800	86,800	91,300
Columbus	52,300	53,000	53,400	54,600	55,500	56,400	57,300	58,200	62,000
Craven	71,000	71,900	72,700	74,100	75,300	76,500	77,700	78,800	82,800
Cumberland	239,600	245,100	249,200	251,200	252,700	254,300	255,900	257,500	265,800
Currituck	11,200	11,600	11,900	13,400	14,600	15,800	16,900	18,100	24,400
Dare	10,300	10,700	10,900	11,800	12,500	13,100	13,800	14,500	18,000
Davidson	103,000	104,000	104,800	105,700	106,400	107,200	107,900	108,600	112,200
Davie	22,200	22,600	22,900	23,600	24,100	24,700	25,200	25,800	28,500
Duplin	40,400	40,700	40,900	41,400	41,800	42,300	42,700	43,100	44,600
Durham	145,100	146,900	148,200	150,100	151,600	153,100	154,600	156,100	163,200
Edgecombe	55,100	55,400	55,700	56,300	56,900	57,400	57,900	58,400	60,300
Forsyth	231,000	233,100	234,700	236,900	238,600	240,400	242,200	244,000	252,800
Franklin	28,400	28,600	28,700	29,000	29,300	29,500	29,800	30,100	31,100
Gaston	158,100	159,400	160,400	161,700	162,700	163,700	164,600	165,600	169,500
Gates	8,300	8,300	8,300	8,300	8,300	8,300	8,300	8,200	8,100
Graham	6,700	6,700	6,700	6,800	6,800	6,800	6,800	6,900	6,800
Granville	32,700	32,700	32,700	32,700	32,700	32,700	32,700	32,700	32,500
Greene	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,800	14,700
Guilford	306,100	308,700	310,700	312,700	314,200	315,800	317,400	319,000	326,700
Halifax	55,100	55,200	55,300	55,700	56,000	56,200	56,500	56,800	57,200
Harnett	55,500	56,200	56,700	57,800	58,800	59,700	60,600	61,500	65,800
Haywood	44,400	44,800	45,000	45,500	45,800	46,200	46,500	46,900	48,300
Henderson	51,300	52,200	53,000	54,500	55,700	57,000	58,200	59,500	65,700

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