ORNL/RUS-25
Cy. 31

ORNL
—
National Science Foundation
—
Environmental Program

MULTIREGION

A Simulation-Forecasting Model of BEA Economic Area Population and Employment

R. J. Olsen
G. W. Westley
H. W. Herzog, Jr.
C. R. Kerley
D. J. Bjornstad
D. P. Vogt
L. G. Bray
S. T. Grady
R. A. Nakosteen

OAK RIDGE NATIONAL LABORATORY
OPERATED BY UNION CARBIDE CORPORATION FOR THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161
Price: Printed Copy $12.00; Microfiche $3.00

ORNL/RUS-25

Contract No. W-7405-eng-26

MULTIREGION: A Simulation-Forecasting Model of BEA Economic Area Population and Employment

R. J. Olsen
G. W. Westley*
H. W. Herzog, Jr.
C. R. Kerley
D. J. Bjornstad
D. P. Vogt
L. G. Bray
S. T. Grady
R. A. Nakosteen

Regional and Urban Studies Section
Energy Division

*Computer Science Division

Work supported by the National Science Foundation RANN Program under NSF Interagency Agreement No. AAA-R-4-79

and

The Energy Research and Development Administration
Division of Technology Overview
Regional Studies Program

Date Published: October 1977

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
Operated by Union Carbide Corporation
for the Energy Research and Development Administration

ABSTRACT

This report documents the development of MULTIREGION — a computer model of regional and interregional socioeconomic development. The MULTIREGION model interprets the economy of each BEA economic area as a labor market, measures all activity in terms of people as members of the population (labor supply) or as employees (labor demand), and simultaneously simulates or forecasts the demands and supplies of labor in all BEA economic areas at five-year intervals. In general the outputs of MULTIREGION are intended to resemble those of the Water Resource Council's OBERS projections and to be put to similar planning and analysis purposes.

The report has been written at two levels to serve the needs of multiple audiences. The body of the report serves as a fairly nontechnical overview of the entire MULTIREGION project; a series of technical appendixes provide detailed descriptions of the background empirical studies of births, deaths, migration, labor force participation, natural resource employment, manufacturing employment location and local service employment used to construct the model.

FOREWORD

The research leading to the MULTIREGION model was sponsored by the National Science Foundation from 1971 through 1974, and by the ERDA Division of Technology Overview (formerly the Division of Biomedical and Environmental Research) from 1974 until present. While under NSF sponsorship, the work was part of the Regional Environmental Systems Analysis (RESA) Program, an interdisciplinary effort at ORNL consisting of parallel task teams carrying out investigations into socioeconomic, land-use, ecological, and sociopolitical topics for a 6500-square-mile region in East Tennessee. In addition to these efforts, a data management and computational systems task group provided electronic data processing support. For a complete list of all documents produced during this period, see Reflections on Regional Environmental Systems Analysis, ORNL/RUS-26, by C. E. Craven, Jr.

The outputs of the RESA project's socioeconomic task team include a number of formal and informal papers on varying aspects of regional analysis, but more importantly provided parameter estimates and techniques for projecting population and employment. These tools, and the experience gained in creating them, formed the foundation upon which our current regional projection system, MULTIREGION, was cast.

In 1974, as the RESA program was nearing completion, ERDA (then the Atomic Energy Commission) began encouraging the national laboratories to participate more heavily in socioeconomic assessment research, and it became apparent that the tools used in the East Tennessee analysis could be easily and fruitfully extended to the nation as a whole. This has since been accomplished — the end product is MULTIREGION.

We anticipate that MULTIREGION will prove to be a robust and invaluable tool within a hierarchy of models operating and planned at ORNL. Because the model allocates national activity levels, it can be employed to analyze the implications of alternative national scenarios at the regional level. We plan during the next year to operate at least one national model at ORNL to provide flexibility in the development of national scenarios.

A second major use of MULTIREGION is to drive regional energy demand forecasts. We believe that for small regions of the nation, levels of economic activity are prime determinants of energy demand, and we have developed a subregional energy simulation system that, like MULTIREGION, can analyze regional implications of national scenarios. This system, which will be documented in a later publication, requires as input MULTIREGION (or other) projections of regional population and employment.

Finally, a number of groups, both public and private, have expressed interest in possible extensions of MULTIREGION to incorporate such variables as number of households, housing demands, and income distribution within the projection system. One early request has been to extend the time frame of the model to 2020 to permit long-term simulations for ERDA policy purposes. We believe such extensions are both possible and desirable and will provide a firm basis for entertaining a wide range of questions concerning energy and other national policies at the regional level.

Over the past four years all authors of this document, with the exception of G. W. Westley (Computer Sciences Division), have been affiliated with the Regional Economic Group of the Energy Division. Present affiliations of non-ORNL authors are: R. J. Olsen, Senior Research Associate, Charles River Associates, Inc.; H. W. Herzog, Jr., Assistant Professor of Economics and Consultant, University of Tennessee and Energy Division, ORNL respectively; L. G. Bray, Economist, Tennessee Valley Authority; S. T. Grady, Staff Economist, Science Applications, Inc.; and R. A. Nakosteen, Consultant, Tennessee Valley Authority.

David J. Bjornstad, Leader
Regional Economic Analysis
Energy Division
Oak Ridge National Laboratory

ACKNOWLEDGMENTS

The authors extend their sincere thanks to their many colleagues at ORNL for invaluable assistance during the design, estimation, programming, and documentation of MULTIREGION. Appreciation is also expressed to those colleagues, both within and without the Laboratory, who reviewed numerous drafts of this manuscript. We would also like to thank Ms. Jackie Sims and Ms. Fay Ownby who conscientiously typed preliminary drafts of MULTIREGION. Finally, the authors extend a special thanks to Ms. Dovie Patterson for her devotion to the end, and specifically for her typing of this document — the end product of four years of work at ORNL.

CONTENTS

CONTENTS (cont'd.)

CONTENTS (cont'd.)

LIST OF FIGURES

LIST OF FIGURES (cont'd.)

LIST OF TABLES

LIST OF TABLES (cont'd.)

LIST OF TABLES (cont'd.)

LIST OF TABLES (cont'd.)

LIST OF TABLES (cont'd.)

LIST OF TABLES (cont'd.)

1. INTRODUCTION

It has often been said that there are no simple solutions, only intelligent choices. The socioeconomic analysis described in this report will not produce quick or simple solutions; it is intended, however, to make a modest contribution to intelligent choices.

For more than a decade there has been a growing recognition of the need for a national/regional impact accounting system that would apply consistent measures and procedures across functionally defined regions to evaluate the interregional trade-offs and displacements caused by policies and projects of national and regional origin.[1] We have tried to make a contribution to some of these common needs of public and private agencies by building upon their accumulated accomplishments and those of many skilled regional scientists, economists, and demographers. The result is a computer model of regional and interregional socioeconomic development — MULTIREGION — which interprets the economy of each BEA economic area as a labor market, measures all activity in terms of people as members of the population or as employees, and simultaneously simulates or forecasts the demands and supplies of labor in all BEA economic areas at five-year intervals. In general the outputs of MULTIREGION are intended to resemble those of the Water Resources Council's OBERS projections[2] and to be put to similar planning and analysis uses.

This research has been supported by the NSF-RANN program from 1971 through 1974 and by the ERDA Division of Technology Overview since July 1974 for public use. This document represents one aspect of a concerted effort to make these results available to as broad a user community as possible. This chapter summarizes our perceptions of user needs, the basic outlines of the methodology developed, some apparent requirements for technology transfer, and the plan of the remainder of this document.

1.1 USER NEEDS: THE CHALLENGE

It may appear trite to note that the economy of the nation at any one point in time is equal to the sum of the economies of its constituent regions. But, much economic policy making at the national level tends to proceed with insufficient attention to the fact that all areas do not respond equally to national stimuli. At the local level, decision making appears so diffuse that most of the actors tend to proceed as though their regions and agencies are relatively independent of occurrences in nearby areas. In fact, the participants at most levels recognize that regional systems are highly interdependent but they have simply not had the tools available that would allow them to come to realistic grips with questions of interregional trade-offs and displacements. Hence, the growing recognition of the need for a national/regional impact accounting system. Pending the development of such a system or systems, numerous private and public agencies proceed with economic policy analysis, physical and human resource planning, and numerous investments from a base of weak regional information.

An initial effort to better understand the information needs of regional decision makers seemed to indicate that most frequently they sought information on population, labor force, employment, industrial activity, and income.[3] From these data they appeared to be quite content to use relatively simple multipliers, ratios, or participation rates to derive numerous measures of natural, physical, and human resource requirements and impacts. Upon closer examination the core information requirements appear to be accurate and sufficiently detailed forecasts of regional population and employment, central requirements are forecasts of manpower, income, numbers of households, energy, etc., and peripheral requirements are forecasts of conditions that are almost unique to each application.

Another dimension of the information needs of regional decision makers concerns the uses to which the information may be put. Some regional questions deal with "What are conditions now?" or "What are conditions likely to be in the future if present circumstances continue to prevail?", while other questions deal with "What if ...?" For example, what if we build a new road or give a tax subsidy to industry? In general, the first set of questions could be addressed with information developed from relatively simple extrapolations of past trends, while the second "what if" set requires information based on some understanding of the structure of regional and interregional economic processes.

1.2 MULTIREGION: OUR RESPONSE

Our response to these information needs of regional decision makers has been to approach the core requirements through the creation of a socio-economic computer model — MULTIREGION — to forecast and simulate regional demographic and economic activity in terms of population and employment within the context of given national control totals.

We began by selecting those theoretical elements necessary to view a region's economy as a labor market (Fig. 1.1).[4] Basically, a region's labor supply may be affected through changes in mortality, fertility, migration, and labor participation while its labor demand may be affected through changes in its attractiveness as a location for natural-resource-based industries, manufacturing, and local service industries. Labor market equilibrating forces are imbedded in the sensitivities of each of these components of labor supply and demand to regional and interregional socioeconomic conditions.

Next, these labor market concepts and sensitivities were quantified by applying regression analysis techniques to existing Census of Population socioeconomic accounts aggregated to BEA economic areas — mutually exclusive functional economic areas that include the total land area and population of the United States (Fig. 1.2).[5] Interregional interdependence has been built into many of these analyses through the inclusion of measures of access to interregional markets by truck transportation. While the lack of appropriate regional data has at times constrained the endeavor, the results that have emerged do seem to form a meaningful and operational representation of regional and interregional labor market processes.

ORNL-DWG 77-12000

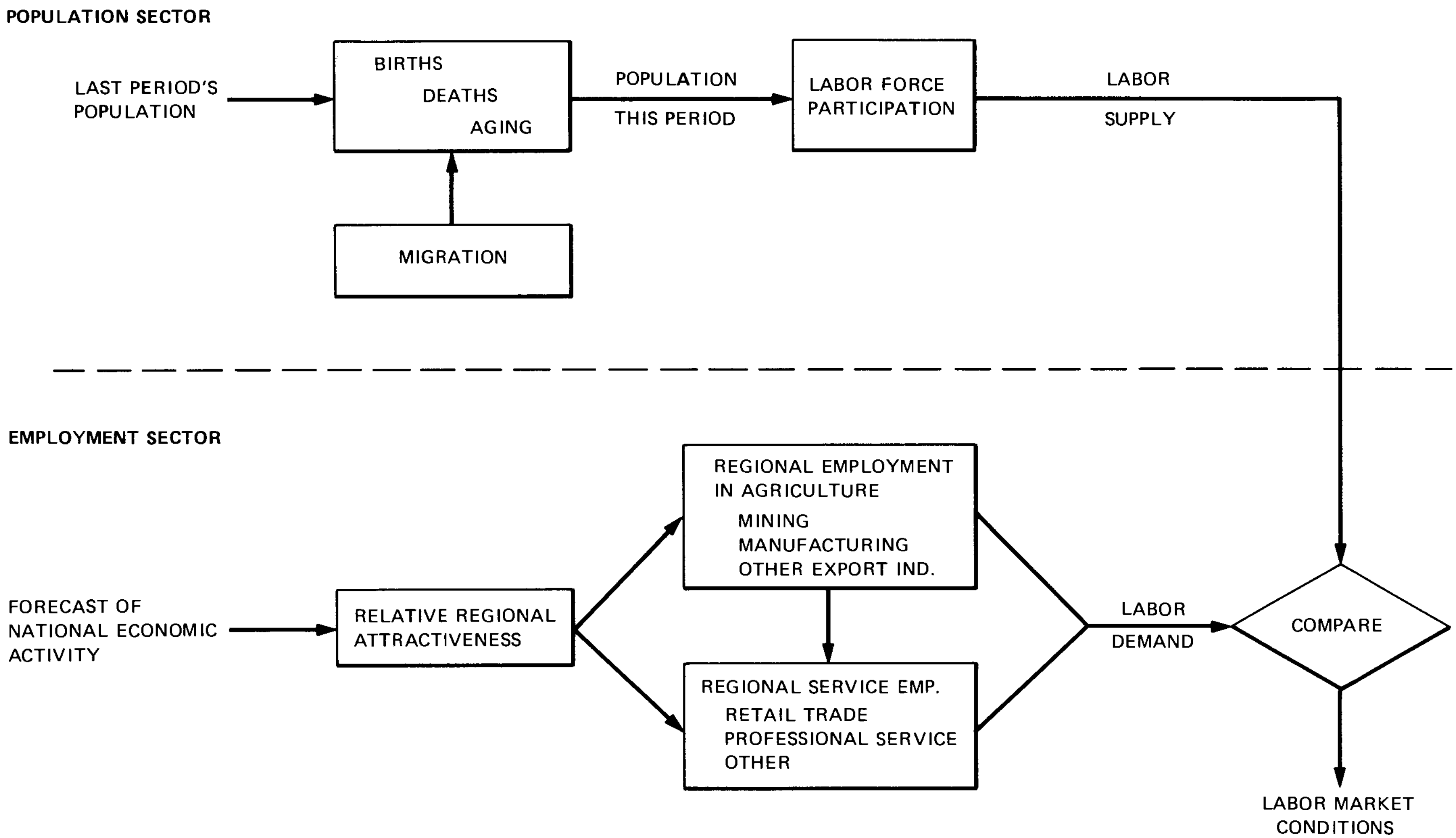


Fig. 1.1. A region's economy as a labor market.

ORNL-DWG 76-2734

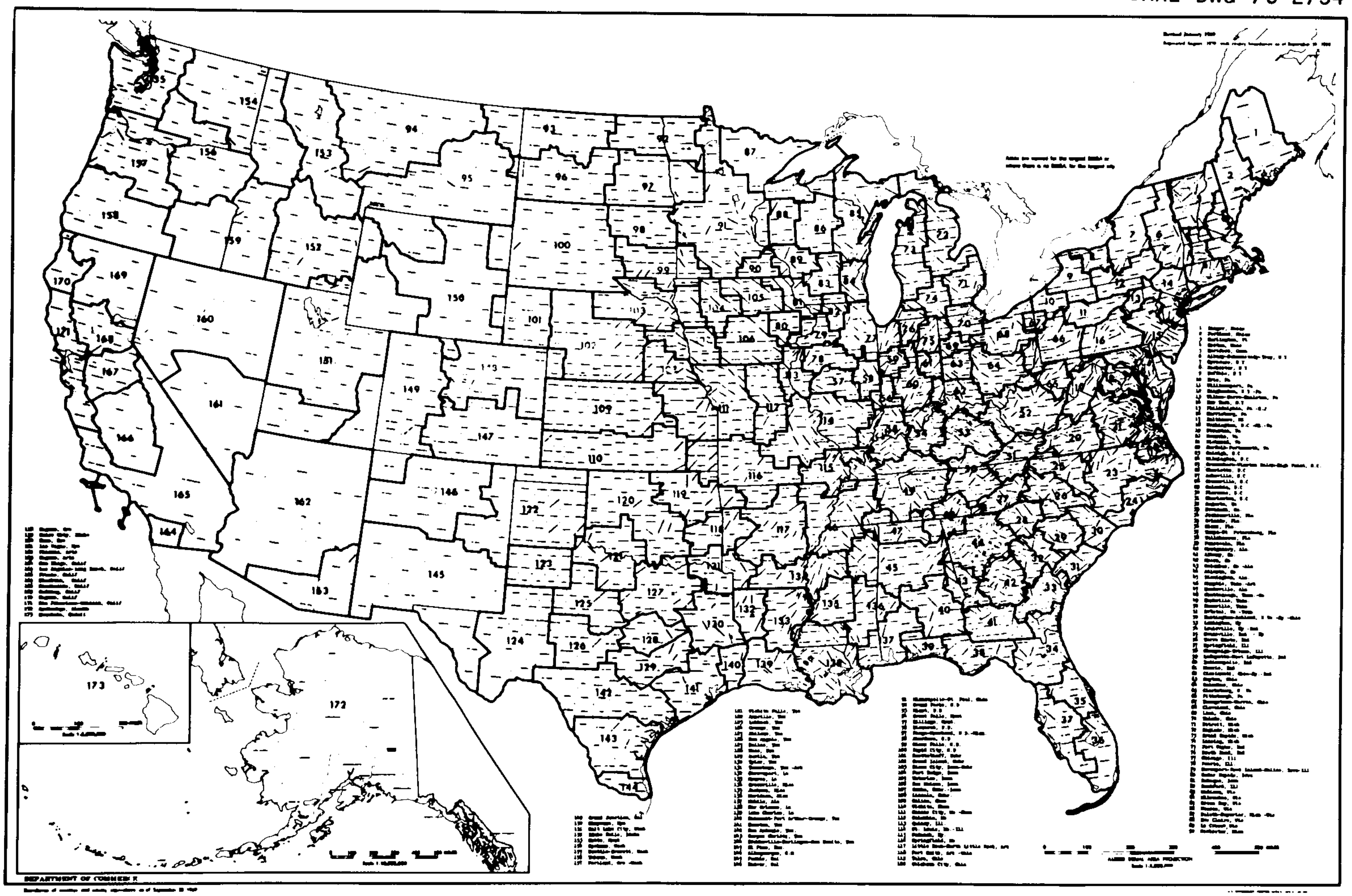


Fig. 1.2. BEA economic areas.

Finally, these empirical results for mortality, fertility, interregional migration, labor force participation, natural-resource-based employment, manufacturing employment, and local service employment have been assembled into a computer program or model of regional and interregional labor market equilibrating processes — a firm basis for extrapolations from the past and present to future regional socioeconomic conditions and impacts. MULTIREGION provides values for employment by 37 industry groups, population by 32 age and sex cohorts, and labor force by 16 age and sex cohorts for the U.S. as a whole (exogenously given) and each of the 173 BEA economic areas at five-year intervals.

At this time, MULTIREGION exists as a very active experiment in regional and interregional analysis. We hope it will continue to exist and evolve over time but the extent to which it does and the directions in which the experiment may move depends on its utility to a variety of user communities.

1.3 TRANSFER OF TECHNOLOGY

A major goal of most government-supported research and development projects is that the results be communicated to and used by as broad an audience as possible. We have found the transfer of technology to a large user community to be much more difficult, expensive, and time-consuming than could be imagined beforehand. From our experiences the ingredients necessary for a successful transfer to a substantial user community should include at least (1) a clear and complete documentation of research results and computer programs, (2) readily available data sets and computer programs to replicate and revise empirical results, (3) relatively simple computer codes and data bases designed for the modest computing facilities generally available to the user community, plus (4) much time and patience.

It is hoped that the present documentation of MULTIREGION will satisfy the first requirement. All data bases used in the background empirical analyses as well as the data bases and computer codes required to use MULTIREGION are being made available to the general public on a cost reimbursable basis through the Regional and Urban Studies Information Center of Oak Ridge National Laboratory. The MULTIREGION computer code has been written in FORTRAN IV, level H for use on IBM equipment with 550k bytes of core storage available, two tape drives, and one disc storage unit; computing facilities of these general dimensions are usually available at most state universities and public agencies. At this point we can neither assess the amount of time and patience required for successful technology transfer nor ensure their presence in the required amounts.

1.4 THE PLAN OF THIS BOOK

There has been a deliberate attempt to write this report at two levels to serve the needs of multiple audiences. The body of the report has been written at a fairly nontechnical level to serve as an overview of the entire MULTIREGION project; a series of technical appendixes have been included as detailed descriptions of the background empirical studies used to construct MULTIREGION. It is expected that the general reader and most potential users will be able to follow the discussions through essentially all chapters and that the most interested technical reader will have the fine details of the technical appendixes at his or her disposal.

In the chapters that follow, this report attempts to: (1) introduce the concept of functional economic areas, in general, and BEA economic areas, in particular; (2) describe the regional projections systems that are generally available to the public at the time of this writing; (3) enumerate the individual decisions that together have formed the general research strategy of this project; (4) highlight some of the dimensions of MULTIREGION including the general computational steps required to reconcile regional labor supplies and demands; (5) summarize the empirical results for each of the components of the population and employment sectors; (6) specify the precise requirements and procedures for using the model; (7) describe a possible national future; (8) present a possible regionalization of that national future; and (9) suggest some possible implications of our experiences for future research and development in interregional socioeconomic processes.

REFERENCES FOR CHAPTER 1

1. C. L. Leven, J. B. Legler, and P. Shapiro, *An Analytical Framework for Regional Development Policy* (Cambridge: MIT Press, 1970); D. H. Garnick, C. E. Trott, A. Olson, H. Hertzfeld, and V. Fahle, *Toward Development of a National-Regional Impact Evaluation System and the Upper Licking Area Pilot Study*, Staff Paper No. 18, Office of Business Economies, U.S. Department of Commerce, 1971; and W. Alonso, "Balanced Growth: Definitions and Alternatives," September 1973. Paper prepared for Oak Ridge National Laboratory in cooperation with the U.S. Department of Housing and Urban Development.

2. U.S. Water Resources Council, *1972 OBERS Projections: Economic Activity in the U.S.*, 7 volumes, U.S. Government Printing Office, April 1974.

3. While we conducted an informal survey of the needs of nearby decision makers, an excellent published statement can be found in S. Sonenblum, "The Uses and Development of Regional Projections," in H. S. Perloff and L. Wingo, Jr. (editors), *Issues in Urban Economics*, Baltimore, Maryland: The Johns Hopkins Press, 1968, pp. 141-186.

4. Many of our early decisions, including this one, were substantially influenced by the existence and clear documentation of the Battelle model of the economies of the Susquehanna River Valley. See H. R. Hamilton, S. Goldstone, F. Cesario, D. Sweet, D. Boyce, and A. Pugh, III, *A Dynamic Model of the Economy of the Susquehanna River Basin*, Battelle Memorial Institute, Columbus, 1966 and H. R. Hamilton, S. Goldstone, J. Milliman, A. Pugh, III, E. Roberts, and A. Zellner,

Systems Simulation for Regional Analysis: An Application to River-Basin Planning, Cambridge, Mass., M.I.T. Press, 1969. One of these authors has also prepared an interesting survey of the state of the art of large-scale regional economic modeling; see J. Milliman, "Large-Scale Models for Forecasting Regional Economic Activity: A Survey," in J. F. Kain and J. R. Meyer (editors), *Essays in Regional Economics*, Cambridge, Massachusetts: Harvard University Press, 1971, pp. 309-351.

5. BEA economic areas were defined by the Office of Business Economics (now the Bureau of Economic Analysis) of the U.S. Department of Commerce in 1969 and are finding increasing use as a geographic grid for regional economic analysis.

2. THE REGIONAL SETTING: BEA ECONOMIC AREAS

Because regional economic systems are very complex and interdependent, careful attention must be paid to the selection of spatial and theoretical perspectives that might illuminate the most important processes at work. BEA economic areas were selected as our spatial perspective because regional scientists are increasingly of the opinion that functional economic areas (FEA's) are the most useful geographic units for both regional economic analysis and policy prescription.[1] The selection of the BEA economic areas as the spatial units of analysis very naturally led to a theoretical perspective that views the economy of each region as a labor market.

This chapter begins with a brief review of the definition of functional economic areas, in general, and of BEA economic areas, in particular. Then, selected population, labor force and employment characteristics of BEA areas are described to reinforce the labor market perspective.

2.1 FUNCTIONAL ECONOMIC AREAS AND THE DEFINITION OF BEA ECONOMIC AREAS

Three broad types of regions can be distinguished: homogeneous regions (e.g., State Economic Areas or Standard Metropolitan Statistical Areas, SMSA's), nodal regions (e.g., BEA Economic Areas or functional economic areas), and planning regions (e.g., Economic Development Districts, states, or municipalities). While a high degree of correlation of behavior among its various parts is basic to the idea of a region,[2] it is the cause of the correlation which varies among these three types of regions. Firstly, it is the uniformity of characteristics among the component subregions that defines a homogeneous region; the uniformity of terrain, climate, industry mix, income level, or population density can be used to bind the component subregions together. Secondly, it is a complementarity of function between component subregions (especially between the core and periphery) that is used to define a nodal region; the complementarity of place of residence, place of work, and place of shopping ties the subregions together. Finally, it is the uniformity of public decision-making procedures that defines a planning region; a common set of administrative procedures, officials, and regulations binds the subregions together.

The functional interdependencies within nodal regions "are most clearly visible as flow phenomena — flows of population, goods and services, communications and traffic" with the heaviest flows tending to polarize toward and from one or two dominant centers, which are usually large cities.[3] The fundamental forces of transfer costs, scale economies, and density of market which may vary by industry, space, and time have led to a central-place theory[4] which suggests the partitioning of space into a hierarchy of trading areas. Each step up in the hierarchy involves a more complex mix of trading activities with greater emphasis on the most specialized urban activities. The urban center depends on the periphery as a source of demand for its more specialized goods and services (e.g., elaborate medical procedures), while the periphery depends on the urban center as its source of supply of these more specialized activities. Simultaneously, both the urban center and the periphery supply their own local areas with less specialized goods (e.g., groceries). The recognition of the fundamental importance of these functional interdependencies within and between nodal regions has led to increased research into the delineation of functional economic areas as a necessary first step in developing a viable regional development strategy for subnational areas of the United States.[5]

With strong impetus provided by the work of Karl Fox and Brian Berry, the task of defining functional economic areas (FEA's) of the U.S. has evolved through many useful stages. With the explicit assumption that "the scarcest commodity is time" and as a consequence that "people tend to arrange themselves into concentric circles around the center of their labor market areas, with 'distances' from the center <u>measured in terms of minutes</u>,"[6] Fox and Kumar defined fairly mutually exclusive FEA's for the state of Iowa. Choosing the central city to be an SMSA or a city of 50,000 or more persons, the Iowa FEA's were delineated on the basis of "one hour's driving time, which approaches the outer limit of the home-to-work commuting radius for workers employed in the central city."[7] Actual commuting patterns (from the 1960 Census of Population) and the existence of a consistent hierarchy of retail trade areas within Iowa gave strong support to the delineation of FEA's on the simplified basis of one hour's driving time.

The major thrust of Fox's work has been that FEA's, which can be meaningfully defined, "should be used explicitly for analyzing and implementing economic development programs of a type which rely heavily on local initiative and local recognition of mutual interests."[8] Furthermore, he believes the analytical use of other spatial units, such as the county, SMSA's, or State Economic Areas (SEA's), "impede(s) our understanding of spatial economic organization."[9]

A specific contribution of Berry to the evolution of FEA's was the application of commuting patterns to delineate the apparent functional regionalization of the U.S. in 1960. Defining a functional economic area to be "all those counties within a labor market for which the proportion of resident workers commuting to a given central county exceeds the proportion commuting to alternative central counties"[10] and using SMSA's, cities of 50,000 or more residents, and some regional centers of less than 50,000 as FEA central cities, Berry found that 350 FEA's so defined included 96 percent of the total U.S. population in 1960. In addition, Berry has suggested that FEA's that have considerable amounts of inter-area commuting could be clustered into "consolidated urban regions."

By starting with something like Berry's 350 FEA's it was likely that compromises and adjustments could produce a set of mutually exclusive areas that account for the total area and population of the U.S. In fact, in the latter half of the 1960's the Regional Economic Division of the Office of Business Economics (OBE — now the Bureau of Economic Analysis), U.S. Department of Commerce delineated functional economic areas to facilitate its program of regional measurement, analysis, and projection of economic activity. Preliminary definition of these economic areas was completed in September 1967, and a revised map dated January 1969 (see Fig. 1.2) shows 173 mutually exclusive functional economic areas that cover the whole of the continental U.S. (171) plus Alaska and Hawaii. A list of BEA area names is included in Table 2.1.

As with Berry's study, the OBE relied heavily on commuting patterns data from the 1960 Census of Population to delineate their FEA's. The mechanical procedures used were the following:

> First, economic centers were identified. Standard metropolitan statistical areas were chosen where possible. Each SMSA has a large city at its center which serves both as a wholesale and retail trade center and as a labor market center. However, not all SMSA's were made centers of economic areas because some are integral parts of larger metropolitan complexes. The New York City area, for instance, encompasses not only the New York City SMSA but also Jersey City, Newark, Patterson-Clifton-Passaic, Stanford, Norwalk and Bridgeport SMSA's. The Seattle economic area includes Seattle-Everett and the Tacoma SMSA's. In rural parts of the country, where there were no SMSA's, cities of from 25,000 to 50,000 population were utilized as economic centers provided that two other criteria were met. These other criteria were: (1) that the city form a wholesale trade center for the area, and (2) that the area as a whole have a population minimum of about 200,000 people. (There are some exceptions to the size criteria in sparsely populated areas.) After identifying economic centers, intervening counties were allocated to the centers. This assignment was made on the basis of comparative time and distance of travel to the economic centers, the journey to work pattern around the economic centers, the interconnection between counties because of journey to work, the road network, the linkage of counties by such other economic ties as could be found, and certain geographic features.
>
> In places where the commuting pattern of adjacent economic centers overlap, counties were included in the economic area containing the center with which there was the greatest commuting connection. In the case of cities where the commuting pattern overlapped to a great degree, no attempt was made to separate the two cities; instead, both were included in the same economic area.
>
> In the more rural parts of the country, the journey to work information was insufficient to establish boundaries of the economic areas. In these areas, distance of travel to the economic centers was the major determinant.[11]

Table 2.1. BEA area name list

BEA Number	BEA area name*	BEA Number	BEA area name*	BEA Number	BEA area name*
1	Bangor, Maine	59	Lafayette-West Lafayette, Ind.	117	Little Rock-North Little Rock, Ark.
2	Portland, Maine	60	Indianapolis, Ind.	118	Fort Smith, Ark.-Okla.
3	Burlington, Vt.	61	Muncie, Ind.	119	Tulsa, Okla.
4	Boston, Mass.	62	Cincinnati, Ohio-Ky.-Ind.	120	Oklahoma City, Okla.
5	Hartford, Conn.	63	Dayton, Ohio	121	Wichita Falls, Tex.
6	Albany-Schenectady-Troy, N.Y.	64	Columbus, Ohio	122	Amarillo, Tex.
7	Syracuse, N.Y.	65	Clarksburg, W. Va.	123	Lubbock, Tex.
8	Rochester, N.Y.	66	Pittsburgh, Pa.	124	Odessa, Tex.
9	Buffalo, N.Y.	67	Youngstown-Warren, Ohio	125	Abilene, Tex.
10	Erie, Pa.	68	Cleveland, Ohio	126	San Angelo, Tex.
11	Williamsport, Pa.	69	Lima, Ohio	127	Dallas, Tex.
12	Binghamton, N.Y.-Pa.	70	Toledo, Ohio	128	Waco, Tex.
13	Wilkes-Barre-Hazleton, Pa.	71	Detroit, Mich.	129	Austin, Tex.
14	New York, N.Y.	72	Saginaw, Mich.	130	Tyler, Tex.
15	Philadelphia, Pa.-N.J.	73	Grand Rapids, Mich.	131	Texarkana, Tex.-Ark.
16	Harrisburg, Pa.	74	Lansing, Mich.	132	Shreveport, La.
17	Baltimore, Md.	75	Fort Wayne, Ind.	133	Monroe, La.
18	Washington, D.C.-Md.-Va.	76	South Bend, Ind.	134	Greenville, Miss.
19	Staunton, Va.	77	Chicago, Ill.	135	Jackson, Miss.
20	Roanoke, Va.	78	Peoria, Ill.	136	Meridian, Miss.
21	Richmond, Va.	79	Davenport-Rock Island-Moline, Iowa-Ill.	137	Mobile, Ala.
22	Norfolk-Portsmouth, Va.	80	Cedar Rapids, Iowa	138	New Orleans, La.
23	Raleigh, N.C.	81	Dubuque, Iowa	139	Lake Charles, La.
24	Wilmington, N.C.	82	Rockford, Ill.	140	Beaumont-Port Arthur-Orange, Tex.
25	Greensboro-Winston-Salem-High Point, N.C.	83	Madison, Wis.	141	Houston, Tex.
26	Charlotte, N.C.	84	Milwaukee, Wis.	142	San Antonio, Tex.
27	Asheville, N.C.	85	Green Bay, Wis.	143	Corpus Christi, Tex.
28	Greenville, S.C.	86	Wausau, Wis.	144	Brownsville-Harlingen-San Benito, Tex.
29	Columbia, S.C.	87	Duluth-Superior, Minn.-Wis.	145	El Paso, Tex.
30	Florence, S.C.	88	Eau Claire, Wis.	146	Albuquerque, N.M.
31	Charleston, S.C.	89	La Crosse, Wis.	147	Pueblo, Colo.
32	Augusta, Ga.	90	Rochester, Minn.	148	Denver, Colo.
33	Savannah, Ga.	91	Minneapolis-St. Paul, Minn.	149	Grand Junction, Colo.
34	Jacksonville, Fla.	92	Grand Forks, N.D.	150	Cheyenne, Wyo.
35	Orlando, Fla.	93	Minot, N.D.	151	Salt Lake City, Utah
36	Miami, Fla.	94	Great Falls, Mont.	152	Idaho Falls, Idaho
37	Tampa-St. Petersburg, Fla.	95	Billings, Mont.	153	Butte, Mont.
38	Tallahassee, Fla.	96	Bismarck, N.D.	154	Spokane, Wash.
39	Pensacola, Fla.	97	Fargo-Moorhead, N.D.-Minn.	155	Seattle-Everett, Wash.
40	Montgomery, Ala.	98	Aberdeen, S.D.	156	Yakima, Wash.
41	Albany, Ga.	99	Sioux Falls, S.D.	157	Portland, Ore.-Wash.
42	Macon, Ga.	100	Rapid City, S.D.	158	Eugene, Ore.
43	Columbus, Ga.-Ala.	101	Scottsbluff, Neb.	159	Boise City, Idaho
44	Atlanta, Ga.	102	Grand Island, Neb.	160	Reno, Nev.
45	Birmingham, Ala.	103	Sioux City, Iowa-Neb.	161	Las Vegas, Nev.
46	Memphis, Tenn.-Ark.	104	Fort Dodge, Iowa	162	Phoenix, Ariz.
47	Huntsville, Ala.	105	Waterloo, Iowa	163	Tucson, Ariz.
48	Chattanooga, Tenn.-Ga.	106	Des Moines, Iowa	164	San Diego, Calif.
49	Nashville, Tenn.	107	Omaha, Neb.-Iowa	165	Los Angeles-Long Beach, Calif.
50	Knoxville, Tenn.	108	Lincoln, Neb.	166	Fresno, Calif.
51	Bristol, Va.-Tenn.	109	Salina, Kans.	167	Stockton, Calif.
52	Huntington-Ashland, W. Va.-Ky.-Ohio	110	Wichita, Kans.	168	Sacramento, Calif.
53	Lexington, Ky.	111	Kansas City, Mo.-Kans.	169	Redding, Calif.
54	Louisville, Ky.-Ind.	112	Columbia, Mo.	170	Eureka, Calif.
55	Evansville, Ind.-Ky.	113	Quincy, Ill.	171	San Francisco-Oakland, Calif.
56	Terre Haute, Ind.	114	St. Louis, Mo.-Ill.	172	Anchorage, Alaska
57	Springfield, Ill.	115	Paducah, Ky.	173	Honolulu, Hawaii
58	Champaign-Urbana, Ill.	116	Springfield, Mo.		

*Areas are named for the largest SMSA or, where there is no SMSA, for the largest city.
A map of BEA areas appears on page 1-4.

For a number of reasons, these BEA Economic Areas seem destined for a lifetime at least as useful and durable as that already experienced by SMSA's. First, BEA areas have been delineated for the entire United States whereas FEA's as defined by others have usually covered only a portion of the nation. Second, BEA areas incorporate many of the criteria often suggested for FEA delineation. Third, BEA areas have been used by the Regional Economics Division of BEA and the Economic Research Service of the U.S. Department of Agriculture in a joint venture in regional measurement, analysis, and projection of economic activity for the U.S. Water Resources Council.[12] In the process BEA's county personal income, employment, and population estimates have been cumulated to BEA areas and published with the likelihood that regional scientists will use these data and demand more on the same spatial grid for some time to come. Fourth, the BEA is currently attempting to implement a "National-Regional Impact Evaluation System" which will essentially be a simulation model of the macro economy of BEA areas.[13] Finally, the Bureau of the Census has published the Public Use Samples of Basic Records from the 1970 Census by "County Groups" which are very closely related to BEA areas. The nation has been divided into areas and sub-areas called "county groups" where "the 'areas' delineated correspond to economic areas designated by the Bureau of Economic Analysis (formerly the Office of Business Economics), Regional Economics Division [or occasionally combinations of related economic areas where necessary to meet (minimum of 250,000) population criteria]."[14] All of these characteristics and applications of BEA areas have strongly influenced our choice of this spatial unit of analysis.

2.2 POPULATION

Because they have been defined in large part on the basis of minimum commuting across boundaries, each BEA economic area tends to encompass the place of work and place of residence of its labor force and, thereby, qualifies as a labor market. Perhaps the best way to introduce BEA areas is to maintain the labor market perspective to describe significant patterns of population, labor force, and employment.[15]

2.2.1 Population size

The most natural starting point is population size. As the frequency distribution in Table 2.2 indicates, BEA areas range in size from about 100,000 persons to in excess of 10,000,000. More precisely, in 1970 BEA 101 — Scotts Bluff, Nebraska — was the smallest with a population of 105,000 while BEA 14 — New York — was the largest with 18,272,000. Obviously, most BEA areas lie in between these extremes — especially in the 300,000 to 2,000,000 range (125 areas) — but the largest areas do dominate the nation. For example, the New York area alone accounts for 9% of the nation's population and the ten largest account for 35%. BEA areas may be interpreted as labor markets but they are clearly of substantially different sizes.

Table 2.2. Population size distributions of BEA areas 1950, 1960, and 1970

Population size	Number of BEA areas 1950	1960	1970
Over 10,000,000	1	1	2
5,000,000 — 9,999,999	4	4	5
3,000,000 — 4,999,999	3	4	4
2,000,000 — 2,999,999	4	7	11
1,000,000 — 1,999,999	23	29	34
500,000 — 999,999	48	48	45
400,000 — 499,999	23	25	21
300,000 — 399,999	29	26	25
250,000 — 299,999	12	8	10
200,000 — 249,999	12	12	9
150,000 — 199,999	6	5	2
100,000 — 149,999	6	4	5
50,000 — 99,999	2	0	0
Total	173	173	173

Turning to population growth, which may be simply thought of as an added dimension of size, the compound annual population growth rates for the periods 1950-1960, 1960-1970, and 1970-1973 for each BEA area have been compiled in Table 2.3. By simply scanning this table, the substantial unevenness of growth over time and space becomes apparent. For example, four BEA areas that were growing more rapidly than the nation during the 1950's have actually lost population during the early 1970's — Cleveland, OH; Rockford, IL; Wichita, KS; and Seattle, WA. At the other extreme, thirteen BEA areas that were losing population in the 1950's have grown more rapidly than the nation during the early 1970's — Knoxville, TN; Bristol, VA-TN; Huntington and Clarksburg, WV; Lexington and Paducah, KY; Grand Forks, ND; Columbia and Springfield, MO; Tyler and Texarkana, TX; Little Rock, AR; and Fort Smith, AR-OK. While there are certainly more moderate examples, these extremes do illustrate the possibility that sharp reversals in regional growth can occur within relatively short periods of time.

Figures 2.1, 2.2, and 2.3 add visual reinforcement to these growth reversals as well as help to identify the regions of most persistent growth and decline. For example, growth has been rapid and continuous in most areas of the West, Southwest, central Texas and Florida but negative or slow in broad areas of the remainder of the nation. While some exceptions to slow growth have appeared over time in scattered locations in the upper Great Lakes region and in the vicinity of Washington, D.C., the most widespread improvement during the 1970-1973 period occurred throughout the interior South.

2.2.2 Population composition

Because the components of population change — fertility, mortality, and migration — tend to be age and sex specific, the nature and sources of growth usually affect population composition which further influences the nature of subsequent change. This idea may be illustrated through use of population age and sex pyramids, graphic forms that dramatize an important dimension of population composition while standardizing for size. In particular, consider the 1970 age and sex pyramids of BEA areas 13, 18, and 37 (Fig. 2.4) where the outline of the nation's pyramid has been superimposed to emphasize regional deviations. BEA 13, Wilkes Barre-Hazelton, PA, is representative of regions that have experienced periods of sustained absolute decline or rates of growth below the national average; the result is an over abundance of older persons (45 years old and above), an absence of children, and a shortage of young adults (20 to 35 year olds). BEA 18, Washington, D.C., is representative of regions that have experienced periods of sustained above average growth; the result is an abundance of young adults, middle aged persons, and children (sometimes), and a shortage of older persons. This same pattern is present for other rapidly growing areas such as Dallas, Houston, Atlanta, Las Vegas, Sacramento, etc.

Table 2.3. Annual compound population growth rates for BEA areas: 1950-60, 1960-70, 1970-73

BEA No.	Population (thous.)				Annual compound growth rate		
	1950	1960	1970	1973	50-60	60-70	70-73
1	311	337	321	334	0.8	-0.5	1.3
2	653	691	740	771	0.6	0.7	1.4
3	435	449	502	524	0.3	1.1	1.4
4	5173	5668	6338	6520	0.9	1.1	0.9
5	2078	2542	2966	3034	2.0	1.6	0.8
6	1130	1239	1332	1385	0.9	0.7	1.3
7	1167	1342	1445	1468	1.4	0.7	0.5
8	722	851	1016	1020	1.7	1.8	0.1
9	1499	1736	1789	1808	1.5	0.3	0.4
10	411	444	459	475	0.8	0.4	1.1
11	387	405	419	431	0.5	0.3	1.0
12	660	725	765	774	0.9	0.5	0.4
13	756	689	692	707	-0.9	0.0	0.8
14	14161	16406	18272	18277	1.5	1.1	0.0
15	5502	6481	7281	7409	1.7	1.2	0.6
16	1425	1581	1723	1782	1.0	0.9	1.1
17	1925	2348	2670	2744	2.0	1.3	0.9
18	1655	2260	3090	3224	3.2	3.2	1.4
19	337	361	395	412	0.7	0.9	1.5
20	717	768	831	856	0.7	0.8	1.0
21	784	889	1009	1033	1.3	1.3	0.8
22	839	1056	1232	1248	2.3	1.6	0.4
23	1351	1479	1621	1677	0.9	0.9	1.1
24	373	448	482	499	1.8	0.7	1.2
25	864	1016	1142	1188	1.6	1.2	1.3
26	1138	1285	1489	1556	1.2	1.5	1.5
27	357	359	391	405	0.1	0.9	1.1
28	677	741	817	870	0.9	1.0	2.1
29	469	551	610	643	1.6	1.0	1.7
30	397	406	400	418	0.2	-0.1	1.4
31	290	368	430	452	2.4	1.6	1.7
32	379	422	461	454	1.1	0.9	-0.5
33	366	403	417	417	1.0	0.3	-0.1
34	662	882	1051	1136	2.9	1.8	2.6
35	302	648	941	1066	7.9	3.8	4.2
36	775	1644	2430	2727	7.8	4.0	3.9
37	697	1299	1797	2129	6.4	3.3	5.8
38	255	310	344	373	2.0	1.0	2.7
39	204	313	382	411	4.3	2.0	2.5
40	667	669	686	709	0.0	0.3	1.1
41	438	453	460	480	0.3	0.2	1.4
42	436	469	496	507	0.7	0.6	0.8
43	425	462	488	471	0.8	0.6	-1.1

Table 2.3 (cont'd.)

BEA No.	Population (thous.)				Annual compound growth rate		
	1950	1960	1970	1973	50-60	60-70	70-73
44	1469	1793	2296	2467	2.0	2.5	2.4
45	1620	1680	1725	1775	0.4	0.3	1.0
46	1578	1613	1700	1757	0.2	0.5	1.1
47	498	552	671	693	1.0	2.0	1.1
48	604	650	718	764	0.7	1.0	2.1
49	1191	1280	1426	1512	0.7	1.0	2.0
50	894	876	904	964	-0.2	0.3	2.1
51	823	786	762	796	-0.5	-0.3	1.5
52	1525	1422	1309	1352	-0.7	-0.8	1.1
53	734	708	753	797	-0.4	0.6	1.9
54	900	1087	1220	1238	1.9	1.2	0.5
55	756	747	771	788	-0.1	0.3	0.8
56	254	250	252	255	-0.2	0.1	0.3
57	437	471	490	496	0.8	0.4	0.4
58	313	354	390	391	1.2	1.0	0.1
59	205	227	250	255	1.0	1.0	0.6
60	1107	1384	1613	1659	2.3	1.5	1.0
61	434	501	551	561	1.4	1.0	0.6
62	1440	1744	1889	1911	1.9	0.8	0.4
63	785	1002	1159	1165	2.5	1.5	0.2
64	1275	1552	1763	1826	2.0	1.3	1.2
65	377	333	326	344	-1.2	-0.2	1.8
66	3588	3749	3716	3714	0.4	-0.1	-0.0
67	633	749	770	783	1.7	0.3	0.5
68	3140	3898	4255	4210	2.2	0.9	-0.4
69	228	259	276	282	1.3	0.6	0.8
70	816	967	1054	1080	1.7	0.9	0.8
71	3652	4582	5207	5244	2.3	1.3	0.2
72	585	698	798	845	1.8	1.3	1.9
73	831	990	1124	1170	1.8	1.3	1.4
74	727	889	1034	1051	2.0	1.5	0.6
75	440	517	597	612	1.6	1.4	0.9
76	562	681	747	763	1.9	0.9	0.7
77	6039	7323	8193	8280	1.9	1.1	0.4
78	518	572	628	656	1.0	0.9	1.5
79	497	552	605	611	1.1	0.9	0.3
80	244	288	330	336	1.7	1.4	0.7
81	280	292	301	312	0.4	0.3	1.2
82	397	492	560	556	2.2	1.3	-0.2
83	325	377	455	473	1.5	1.9	1.3
84	1489	1848	2066	2110	2.2	1.1	0.7
85	759	831	926	961	0.9	1.1	1.2
86	307	322	350	371	0.5	0.8	2.0
87	417	449	429	433	0.7	-0.5	0.4

Table 2.3 (cont'd.)

BEA No.	Population (thous.) 1950	1960	1970	1973	Annual compound growth rate 50-60	60-70	70-73
88	205	205	219	237	0.0	0.7	2.6
89	254	257	269	279	0.1	0.5	1.2
90	200	230	245	254	1.4	0.6	1.3
91	2164	2528	2935	3015	1.6	1.5	0.9
92	229	223	220	233	-0.3	-0.1	1.9
93	178	189	182	185	0.6	-0.4	0.6
94	187	226	222	231	1.9	-0.2	1.3
95	213	245	246	258	1.4	0.1	1.5
96	147	149	144	147	0.1	-0.3	0.7
97	338	342	335	344	0.1	-0.2	0.9
98	151	142	132	135	-0.6	-0.7	0.7
99	360	372	365	368	0.3	-0.2	0.3
100	208	237	231	243	1.3	-0.3	1.6
101	114	116	105	104	0.1	-1.0	-0.4
102	336	322	323	329	-0.4	0.0	0.5
103	480	467	454	460	-0.3	-0.3	0.5
104	282	280	266	269	-0.1	-0.5	0.4
105	401	427	426	434	0.6	-0.0	0.7
106	728	759	782	812	0.4	0.3	1.3
107	631	720	794	847	1.3	1.0	2.2
108	301	320	323	336	0.6	0.1	1.2
109	376	379	349	349	0.1	-0.8	0.0
110	600	735	728	720	2.1	-0.1	-0.3
111	1773	2049	2249	2314	1.5	0.9	1.0
112	370	367	397	413	-0.1	0.8	1.3
113	299	301	299	297	0.0	-0.1	-0.2
114	2582	2945	3248	3242	1.3	1.0	-0.1
115	628	580	558	582	-0.8	-0.4	1.4
116	836	791	830	889	-0.6	0.5	2.3
117	777	771	864	928	-0.1	1.1	2.4
118	288	252	289	304	-1.3	1.4	1.7
119	814	891	1014	1055	0.9	1.3	1.3
120	999	1040	1156	1223	0.4	1.1	1.9
121	425	460	455	454	0.8	-0.1	-0.1
122	367	451	437	445	2.1	-0.3	0.6
123	251	326	328	343	2.7	0.1	1.4
124	207	337	319	321	5.0	-0.6	0.2
125	290	290	264	272	0.0	-0.9	1.0
126	134	126	124	127	-0.6	-0.1	0.6
127	1574	2063	2736	2799	2.7	2.9	0.8
128	351	374	403	447	0.6	0.8	3.5
129	416	452	559	631	0.8	2.2	4.1
130	537	518	553	587	-0.4	0.7	2.0

Table 2.3 (cont'd.)

BEA No.	Population (thous.) 1950	1960	1970	1973	Annual compound growth rate 50-60	60-70	70-73
131	364	315	329	345	-1.4	0.4	1.6
132	392	445	453	462	1.3	0.2	0.7
133	481	515	532	547	0.7	0.3	0.9
134	614	556	506	498	-1.0	-0.9	-0.5
135	464	489	510	526	0.5	0.4	1.0
136	418	402	393	404	-0.4	-0.2	1.0
137	525	664	724	759	2.4	0.9	1.6
138	1529	1884	2148	2232	2.1	1.3	1.3
139	531	655	748	764	2.1	1.3	0.7
140	297	373	394	397	2.3	0.5	0.3
141	1246	1758	2362	2519	3.5	3.0	2.2
142	845	1065	1229	1312	2.3	1.4	2.2
143	403	495	516	547	2.1	0.4	2.0
144	320	369	355	401	1.4	-0.4	4.2
145	440	646	681	730	3.9	0.5	2.4
146	358	500	572	634	3.4	1.4	3.5
147	347	424	509	561	2.0	1.8	3.3
148	838	1169	1523	1687	3.4	2.7	3.5
149	176	239	251	271	3.1	0.5	2.5
150	183	221	229	242	1.9	0.3	1.9
151	712	901	1061	1158	2.4	1.7	2.9
152	252	286	300	321	1.3	0.5	2.3
153	198	213	234	243	0.7	1.0	1.2
154	566	659	687	715	1.5	0.4	1.4
155	1532	1879	2363	2340	2.1	2.3	-0.3
156	365	398	406	418	0.9	0.2	1.0
157	1186	1348	1637	1737	1.3	2.0	2.0
158	362	458	541	584	2.4	1.7	2.6
159	205	241	265	294	1.7	0.9	3.5
160	104	150	206	233	3.8	3.2	4.2
161	86	166	317	353	6.7	6.7	3.7
162	541	945	1316	1523	5.7	3.4	5.0
163	207	357	454	533	5.6	2.4	5.5
164	556	1033	1357	1469	6.4	2.8	2.7
165	5160	8087	10436	10628	4.6	2.6	0.6
166	737	916	1036	1070	2.2	1.2	1.1
167	434	537	643	670	2.2	1.8	1.4
168	538	854	1089	1178	4.7	2.5	2.7
169	130	153	176	189	1.6	1.4	2.3
170	82	132	121	126	4.9	-0.8	1.3
171	2945	4001	5090	5267	3.1	2.4	1.1
172	128	226	300	330	5.8	2.9	3.2
173	499	632	768	832	2.4	2.0	2.7
Total	151870	179322	203794	209832	1.7	1.3	1.0

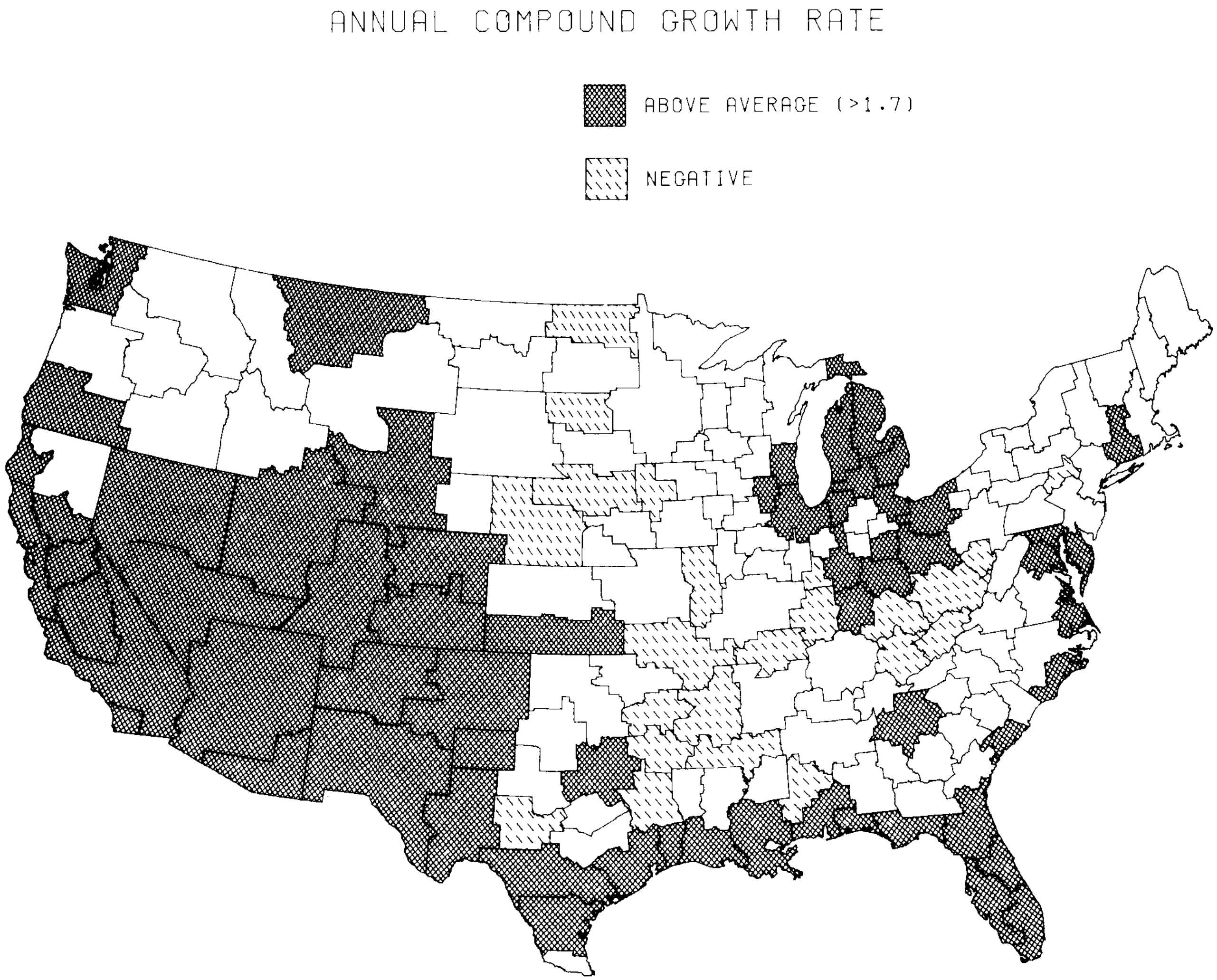


Fig. 2.1. Population growth: 1950 - 1960.

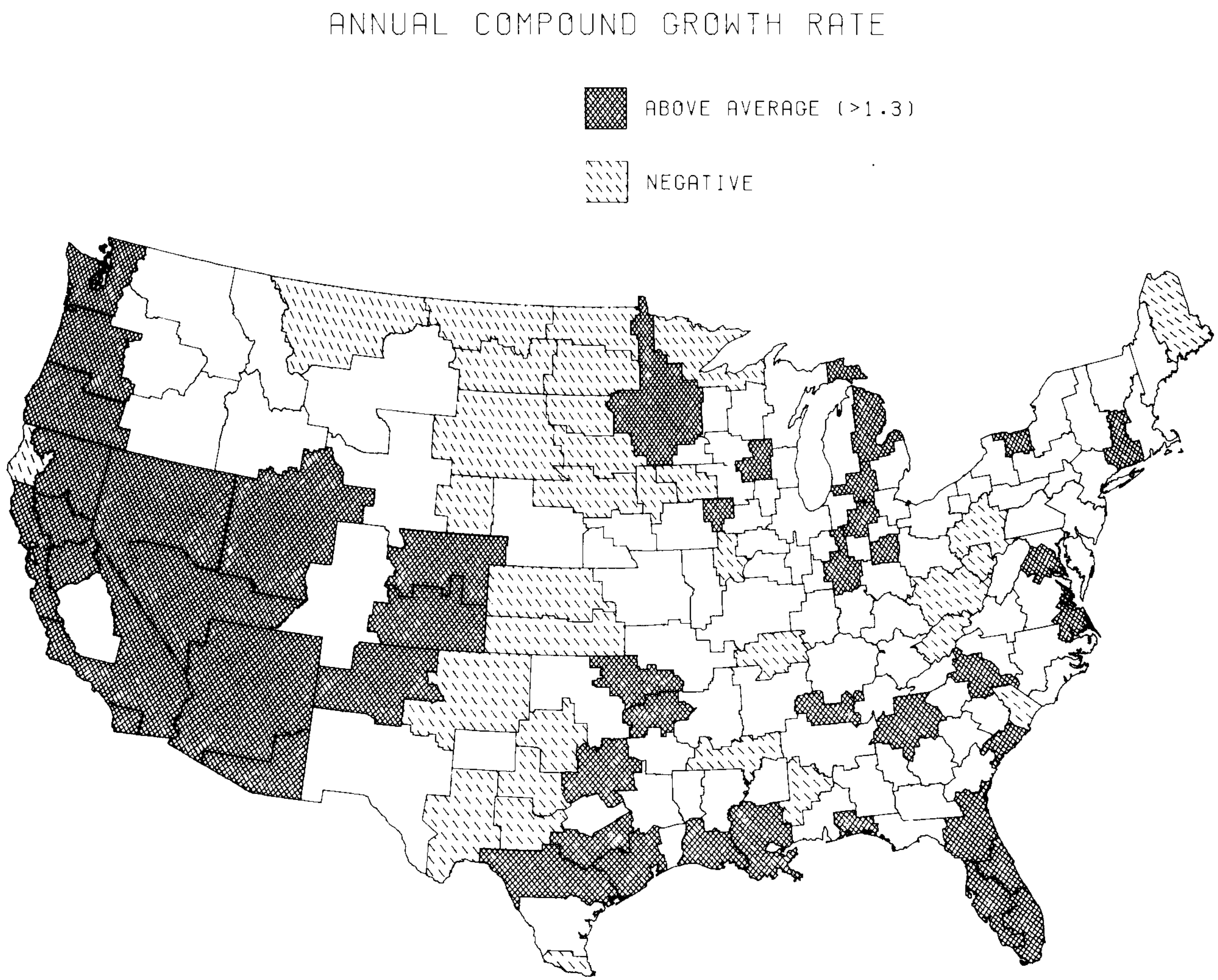


Fig. 2.2. Population growth: 1960 - 1970.

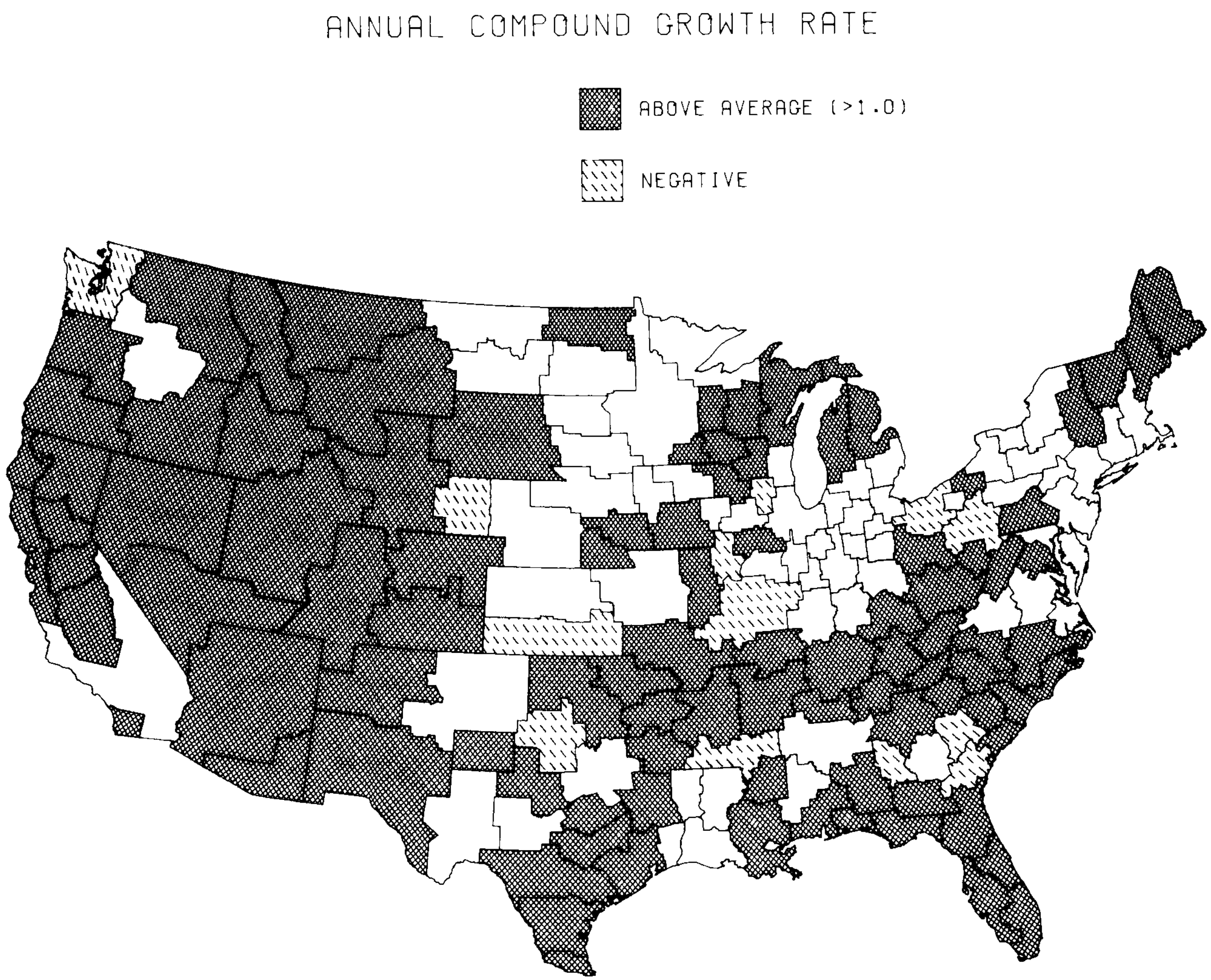
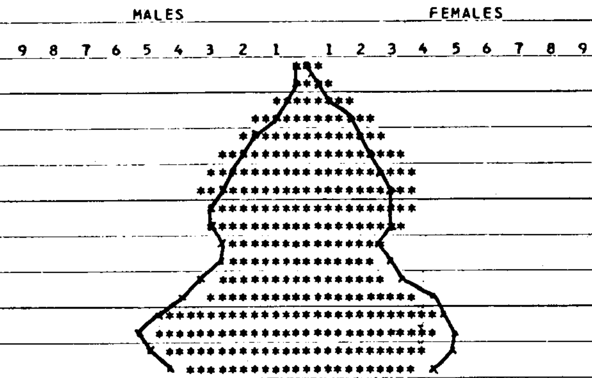


Fig. 2.3. Population growth: 1970 - 1973.

BEA NUMBER 13 --- WILKES-BARRE-HAZLETON, PA.

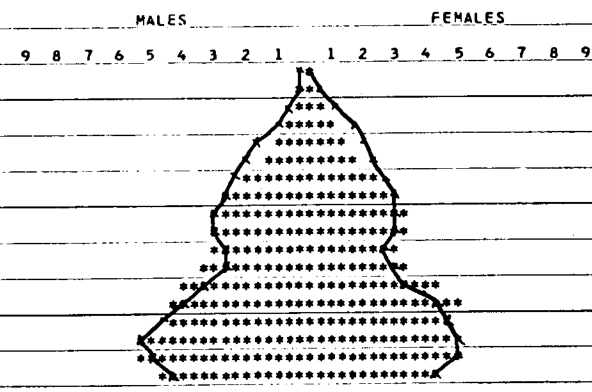
PERCENTAGE OF BEA 13 TOTAL 1970 POPULATION 692003.



POPULATION	%	AGE	AGE	%	POPULATION
2037	0.29	85+	85+	0.57	3965
3391	0.49	80-84	80-84	0.88	6099
6604	0.95	75-79	75-79	1.54	10626
10375	1.50	70-74	70-74	2.20	15194
13685	1.98	65-69	65-69	2.67	18464
18017	2.60	60-64	60-64	3.24	22413
21055	3.04	55-59	55-59	3.51	24284
22325	3.23	50-54	50-54	3.75	25983
21638	3.13	45-49	45-49	3.58	24801
20595	2.98	40-44	40-44	3.37	23291
16435	2.37	35-39	35-39	2.64	18255
15966	2.31	30-34	30-34	2.40	16637
18476	2.67	25-29	25-29	2.67	18453
21639	3.13	20-24	20-24	3.57	24677
29912	4.32	15-19	15-19	4.27	29564
31328	4.53	10-14	10-14	4.39	30375
28759	4.16	5-9	5-9	3.98	27566
25018	3.62	0-4	0-4	3.48	24101
327255	52.71	TOTAL	TOTAL	47.29	364748

BEA NUMBER 18 --- WASHINGTON, D.C.-MD.-VA.

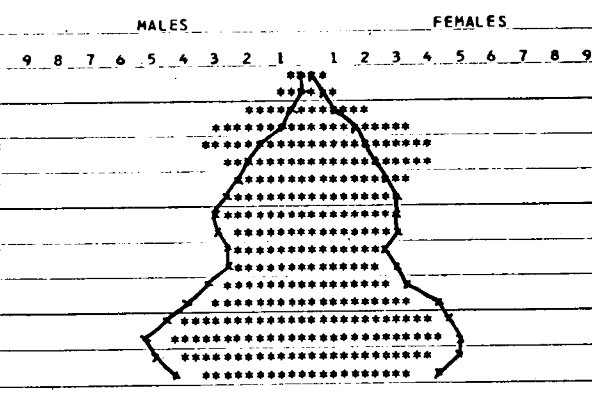
PERCENTAGE OF BEA 18 TOTAL 1970 POPULATION 3090163.



POPULATION	%	AGE	AGE	%	POPULATION
4489	0.15	85+	85+	0.33	10141
6388	0.21	80-84	80-84	0.45	13984
11924	0.39	75-79	75-79	0.71	21947
19865	0.64	70-74	70-74	1.02	31372
29325	0.95	65-69	65-69	1.28	39462
45570	1.47	60-64	60-64	1.72	53125
61223	1.98	55-59	55-59	2.16	66795
78636	2.54	50-54	50-54	2.67	82594
90917	2.94	45-49	45-49	3.24	100058
93578	3.03	40-44	40-44	3.14	96968
95478	3.09	35-39	35-39	3.06	94482
103709	3.36	30-34	30-34	3.35	103563
127354	4.12	25-29	25-29	4.35	134394
137269	4.44	20-24	20-24	5.05	156080
133583	4.32	15-19	15-19	4.52	139739
158684	5.14	10-14	10-14	4.97	153704
160444	5.19	5-9	5-9	5.01	154899
141509	4.58	0-4	0-4	4.43	136911
1499945	51.46	TOTAL	TOTAL	48.54	1590218

BEA NUMBER 37 --- TAMPA-ST. PETERSBURG, FLA.

PERCENTAGE OF BEA 37 TOTAL 1970 POPULATION 1797770.



POPULATION	%	AGE	AGE	%	POPULATION
8935	0.50	85+	85+	0.68	12139
17112	0.95	80-84	80-84	1.14	20517
35531	1.98	75-79	75-79	2.14	38476
52292	2.91	70-74	70-74	3.28	58898
59373	3.30	65-69	65-69	3.96	71140
49982	2.78	60-64	60-64	3.82	68693
43077	2.40	55-59	55-59	3.15	56548
44494	2.47	50-54	50-54	2.87	51613
45457	2.53	45-49	45-49	2.90	52138
44419	2.47	40-44	40-44	2.71	48706
39370	2.19	35-39	35-39	2.36	42487
39714	2.21	30-34	30-34	2.36	42377
44953	2.50	25-29	25-29	2.67	47927
51005	2.84	20-24	20-24	3.18	57167
68526	3.81	15-19	15-19	3.82	68596
77902	4.33	10-14	10-14	4.19	75284
72866	4.05	5-9	5-9	3.93	70583
60873	3.39	0-4	0-4	3.26	58600
855881	52.39	TOTAL	TOTAL	47.61	941889

Fig. 2.4. 1970 population age and sex pyramids for BEA economic areas #13, #18, and #37.

In contrast to the normal pattern of sustained rapid growth, the pyramid for BEA 37, Tampa-St. Petersburg, FL, represents the results of a very special or selective type of sustained growth. The movement of retirees to Florida's mild climate has resulted in an extreme abundance of persons aged 55 and above and a shortage in all other age groups. Where the cause of growth has been similarly age selective, e.g., colleges and universities or Armed Forces bases, appropriately abnormal population compositions result. However, it is interesting to note that the movements of retirees to the mild and arid Southwest and West must have been only a small part of the overall migratory streams to those areas because the population pyramids of places like Tucson and Phoenix closely resemble that of Washington, D.C.

While there are other dimensions to population composition, such as education, income, and race, these examples have focused on age because the components of population change are usually very age selective. As a result of past growth, there are substantial differences in population composition among BEA areas that will influence the nature of future population changes.

2.3 LABOR FORCE

The labor force is usually defined to include employed persons plus unemployed persons actively looking for work.[16] There are substantial differences among BEA areas in the relative size and composition of the labor force.

2.3.1 Labor force participation

Rather than study directly the absolute number of workers or man hours in the labor supply, most economists have tried to explain "labor force participation rates." If the noninstitutionalized population of working age (14 or more years old) is represented by P and the actual number of persons willing and able to work is designated by L, then

$$\text{Labor Force Participation Rate} = \frac{L}{P} \times 100 \; .$$

It is this ratio of L to P, termed the labor force participation rate (LPR), that may be examined across BEA areas.

Table 2.4 summarizes the variability in age and sex specific labor participation rates among BEA economic areas. The coefficients of variation imply relative stability across regions in the participation of males aged 25 through 64 and relative instability for all other age and sex groups. These last groups are most often referred to as discretionary workers because their participation tends to be positively correlated with work opportunities.

Table 2.4. Variability of labor force participation rates among BEA areas: 1960 and 1970 data.

Age group	Mean ($\bar{x}$)	Standard deviation (s)	Coefficient of variation ($s/\bar{x}$)
Males			
14-17	26.7	6.1	.23
18-24	76.5	7.3	.10
25-34	94.2	2.3	.02
35-44	94.9	2.1	.02
45-64	87.1	4.0	.05
65 & over	28.0	5.6	.20
Females			
14-17	14.6	4.9	.34
18-24	45.9	7.2	.16
25-34	39.1	7.4	.19
35-44	45.9	6.6	.14
45-64	43.0	5.5	.13
65 & over	10.0	1.8	.18

Figures 2.5 and 2.6 help to identify those regions with especially high or low labor force participation in 1970. Generally, there have been broad areas of especially low labor force participation in Appalachia, the Midsouth, the upper Great Plains, and the southern Rocky Mountains. Especially high participation has occurred in more scattered areas such as Hartford, Rochester, and Washington, D.C. in the Northeast; the Carolina-Georgia Piedmont, Dallas, and Houston in the South; Cleveland, Dayton, Ft. Wayne, Indianapolis, Milwaukee, and Minneapolis in the Great Lakes region; and Denver and Reno in the West. Obviously, some of these conditions result from the participation decisions of discretionary workers and are therefore the result of regional differences in the rate of economic development. But, in other areas particular industrial and institutional forces may be at work; for example, the clerical worker concentrations of the insurance industry in Hartford and government in Washington, D.C.

2.3.2 Labor force composition

Units of labor are obviously not homogeneous between or even within BEA economic areas. To some extent better labor might be a substitute for more labor for regional economic development. To even consider

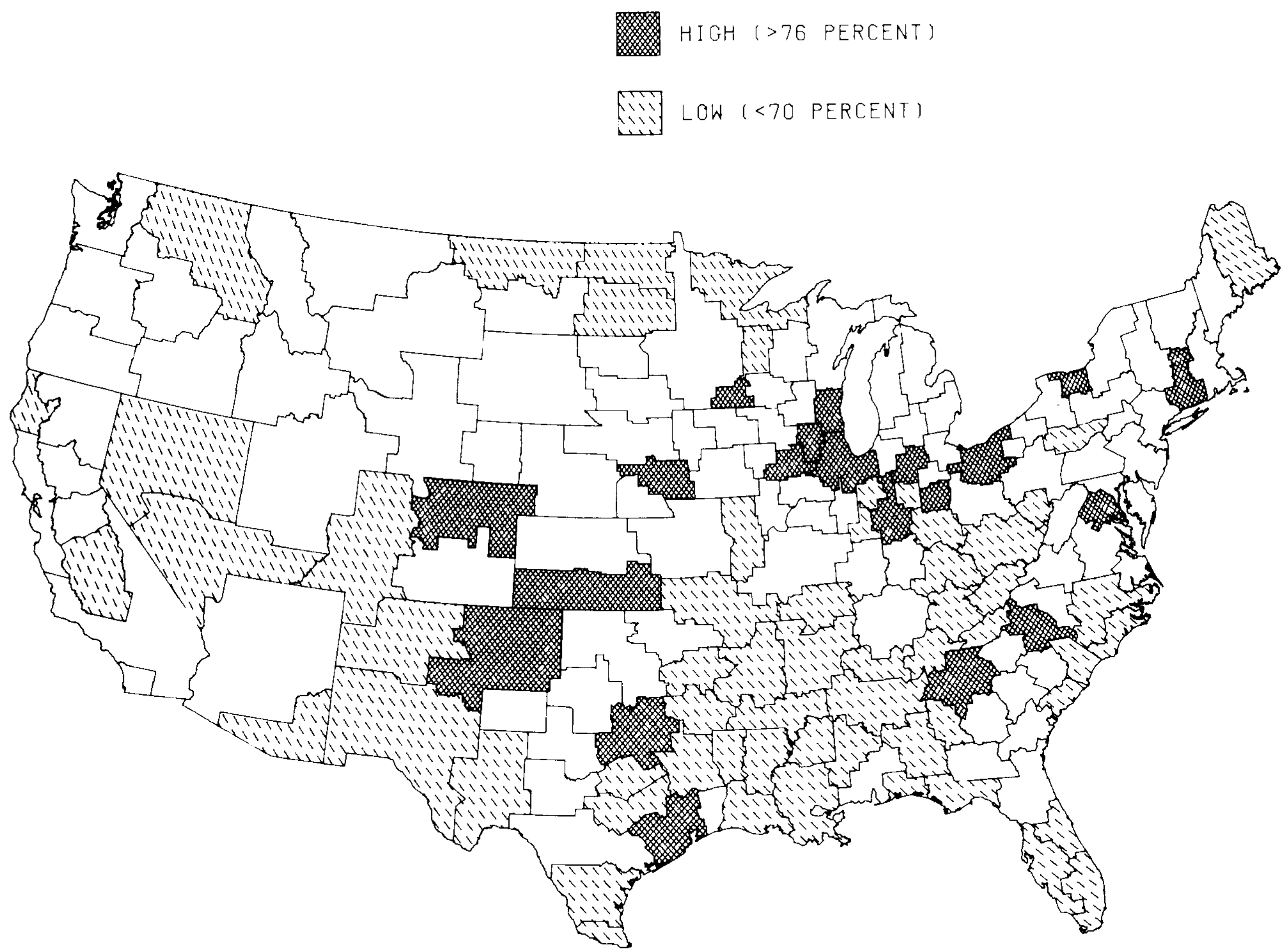


Fig. 2.5. Male labor force participation, ages 14 and over: 1970.

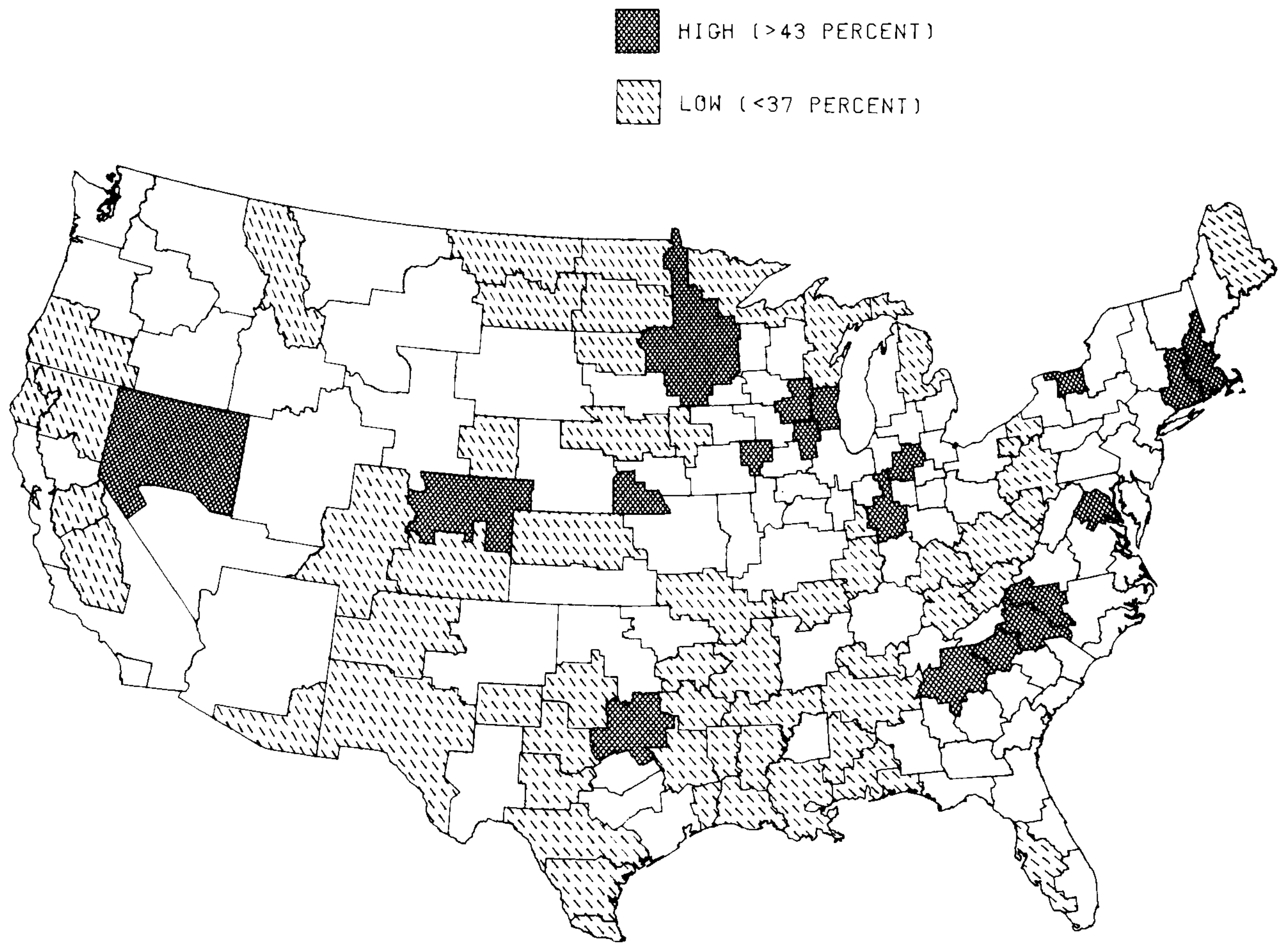


Fig. 2.6. Female labor force participation, ages 14 and over: 1970.

such differences in labor force composition, however, a method for equating different types of labor is necessary. One measure that has been proposed[17] focuses on the average skill level of employed persons and is defined to be

$$\text{Labor Skills Index}_{jt} = \frac{\sum_i W_{it} E_{ijt}}{\sum_i E_{ijt}}$$

where E_{ijt} represents employment in occupation i in BEA area j at time t and W_{it} is the national median real income of employed civilians in occupation i at time t. Thus, this index attempts to arrive at a satisfactory indicator of labor quality by assuming persons within occupations are homogeneous and that the skill content of occupations is proportional to differences in the national level of money income.

BEA area values of this labor skills index for 1960 are displayed in Fig. 2.7. Above average skill levels existed in the eastern industrial belt extending from Boston to Washington to Chicago, the three extended metropolitan areas on the Pacific coast, the Denver-Salt Lake City area, and in a handful of metropolitan areas scattered about the rest of the nation. Especially low skill levels existed in the agricultural areas of the Great Plains and Southeast. While these results should not be too surprising, the spatial distribution of recent changes (1960 to 1970) in labor skill levels may be. The portions of the 1960 to 1970 change in the labor skills index due solely to changes in occupation mix (i.e., with occupation income weights held constant at 1960 values) are graphed in Fig. 2.8. During the decade of the 1960's, there were especially large increases in labor skill levels across a broad section of the South, in Burlington, VT, northwest of Chicago, and in the northern Great Plains. But, there were also especially large decreases in labor skill levels in the general areas of Buffalo-Erie, Duluth-Superior, west Texas, and northern and southern California.

2.4 EMPLOYMENT

Regional population and employment growth undoubtedly proceed hand in hand. But, in some regions such as Florida and the Southwest population growth has seemed to precede and lead to subsequent employment growth while in many other regions such as Washington, D.C., employment growth has appeared to lead to subsequent population growth. While unraveling the causes and consequences of regional economic growth and development is indeed the subject matter of this report, the issue is complex and will not be addressed in this chapter. Instead, some facets of recent regional employment growth will be described at this point.

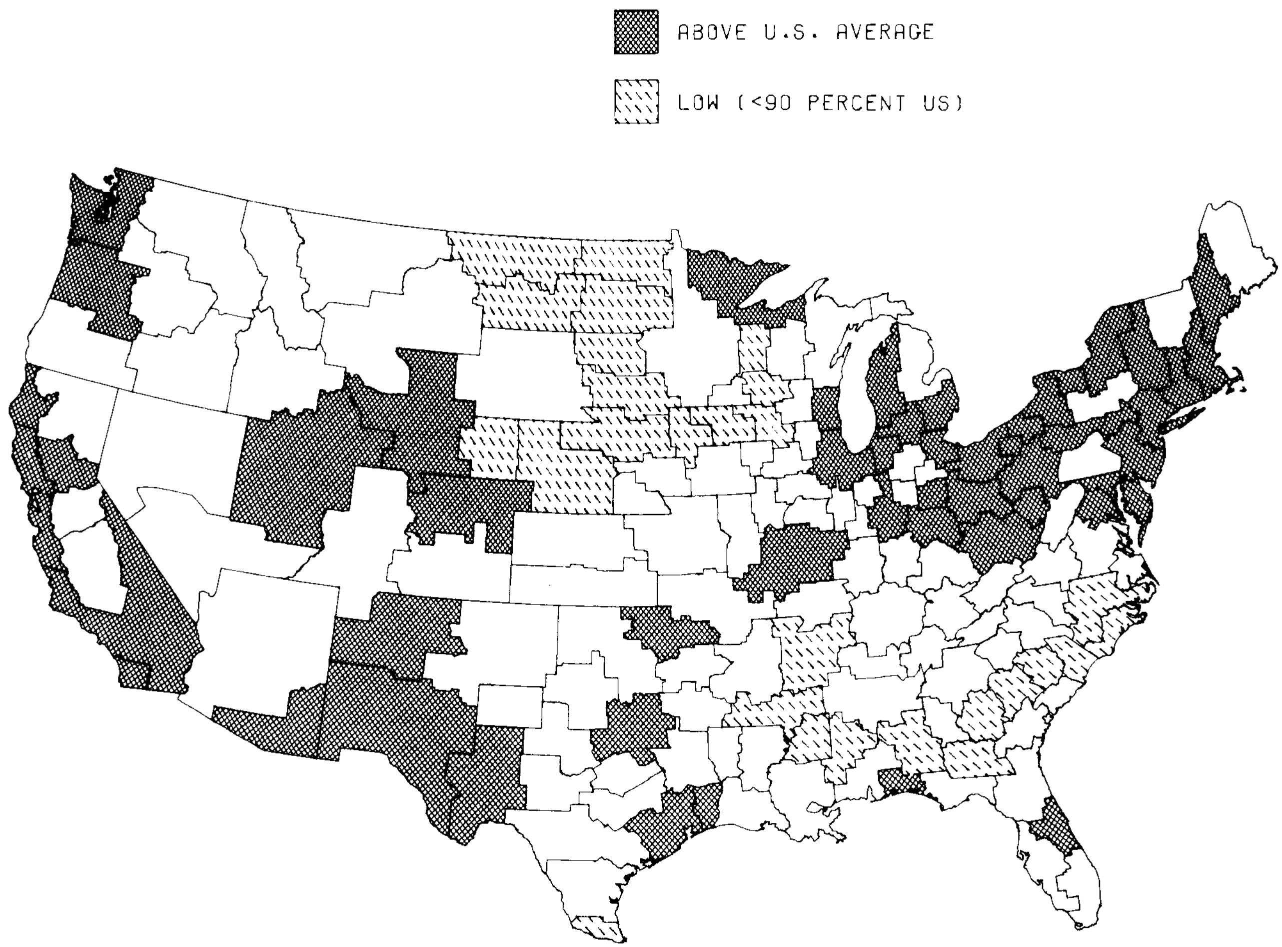


Fig. 2.7. Labor skills index relative to the U.S. average: 1960.

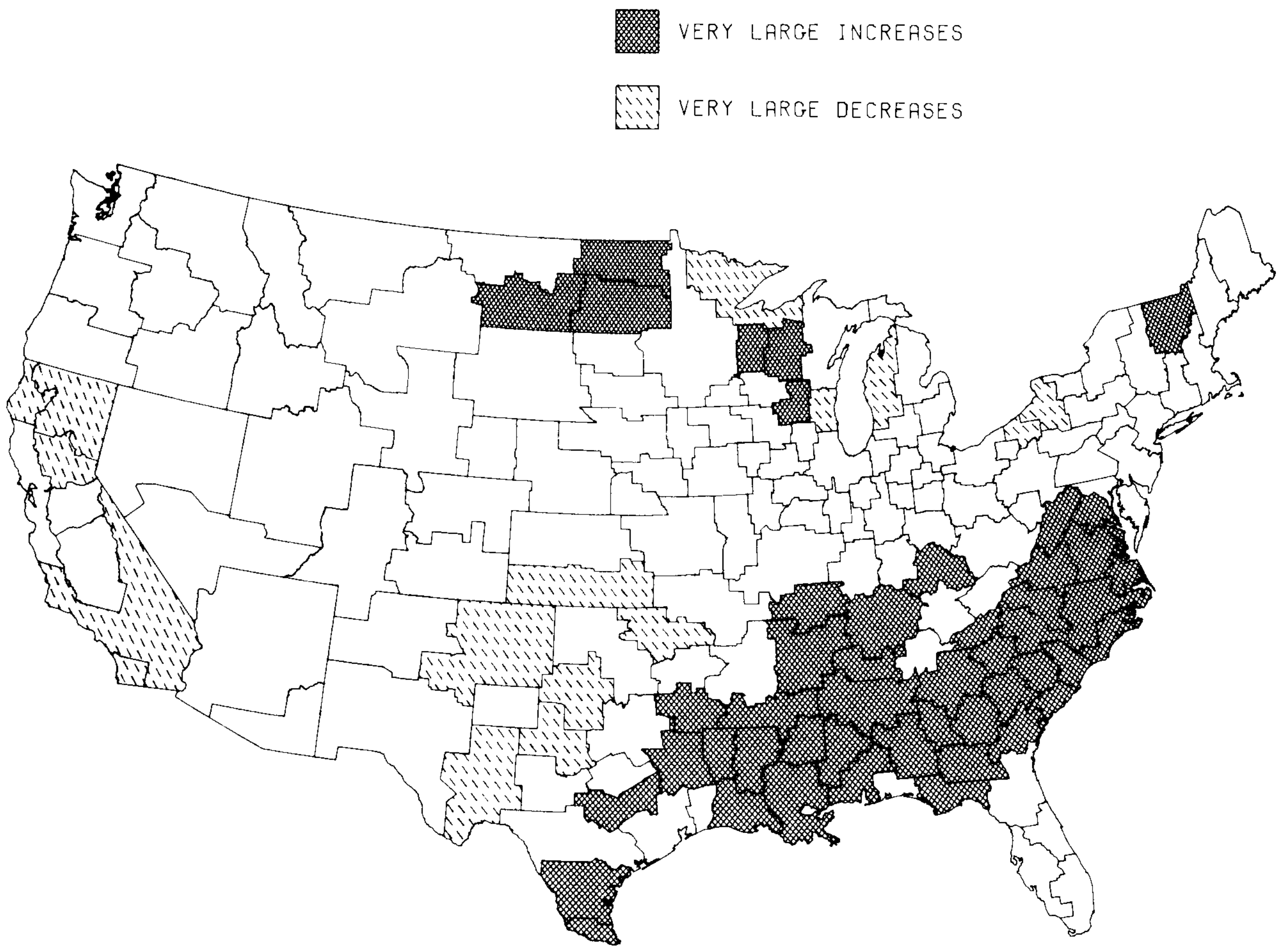


Fig. 2.8. Change in labor skills index due to changes in occupation mix: 1960 - 1970.

2.4.1 Components of regional employment growth

The historical relationship of regional growth to industrial structure has often been described with a technique known as shift and share analysis[18] which decomposes overall regional growth into a number of components. In particular, the difference between national and regional aggregate growth is usually decomposed into two parts — an "industry mix" (or share) effect and a residual "competitive" (or shift) effect. The basic assumption of this method is that regions should be expected to receive their share of the national growth of industries in which they are specialized. Thus, regions specialized in industries that have grown slowly at the national level would, as a consequence, be expected to grow slowly while regions specialized in fast growing industries would be expected to grow rapidly. To the extent that a region has grown more rapidly or more slowly than the rate suggested by its industry mix, that region has experienced a favorable or unfavorable "competitive" shift. Algebraically, the following identities hold:

$$d_{ij} \equiv g_{ij} + k_{ij} + c_{ij}$$

$$n_{ij} \equiv d_{ij} - g_{ij} \equiv k_{ij} + c_{ij}$$

$$c_{ij} \equiv n_{ij} - k_{ij}$$

where

d_{ij} = employment growth in sector $\underline{i}$ of region $\underline{j}$,

g_{ij} = national growth effect,

n_{ij} = net employment shift,

k_{ij} = industry mix effect, and

c_{ij} = competitive effect (a residual).

Figures 2.9, 2.10, and 2.11 display the net employment shift, industry mix, and competitive shift components of 1960 to 1970 BEA area employment growth, respectively. From Fig. 2.9, net employment growth was significantly positive (substantially above the national average) in the general areas of Washington, D.C., Atlanta-Huntsville, Florida, Houston and Dallas, Denver and Pueblo, Arizona, Nevada, and southern California; it was significantly negative in the large region running from west Texas to the upper Great Plains. These results closely correspond to the population growth rates previously shown in Fig. 2.2.

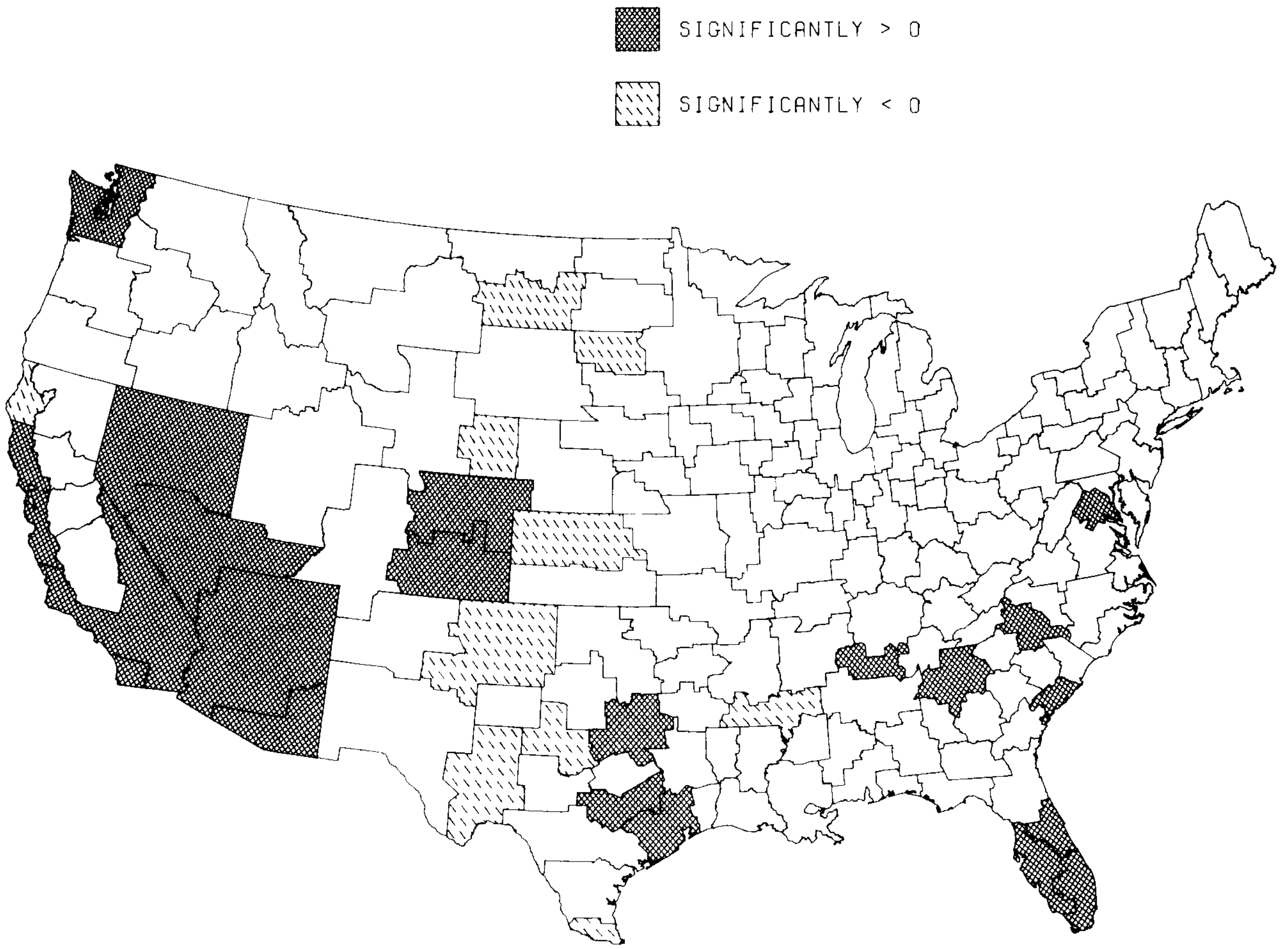


Fig. 2.9. Net employment shift: 1960 - 1970.

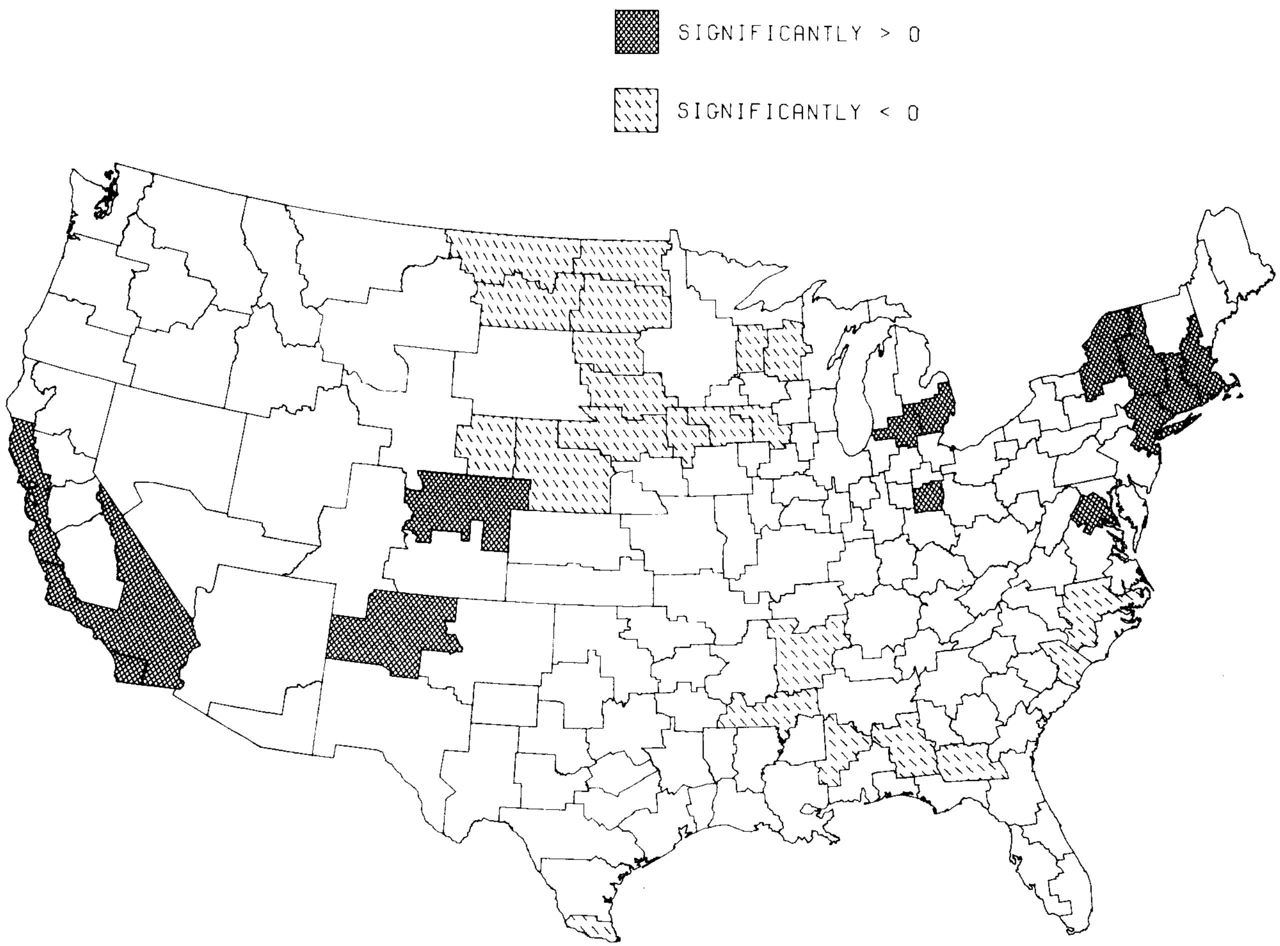


Fig. 2.10. Industry mix component of employment growth: 1960 - 1970.

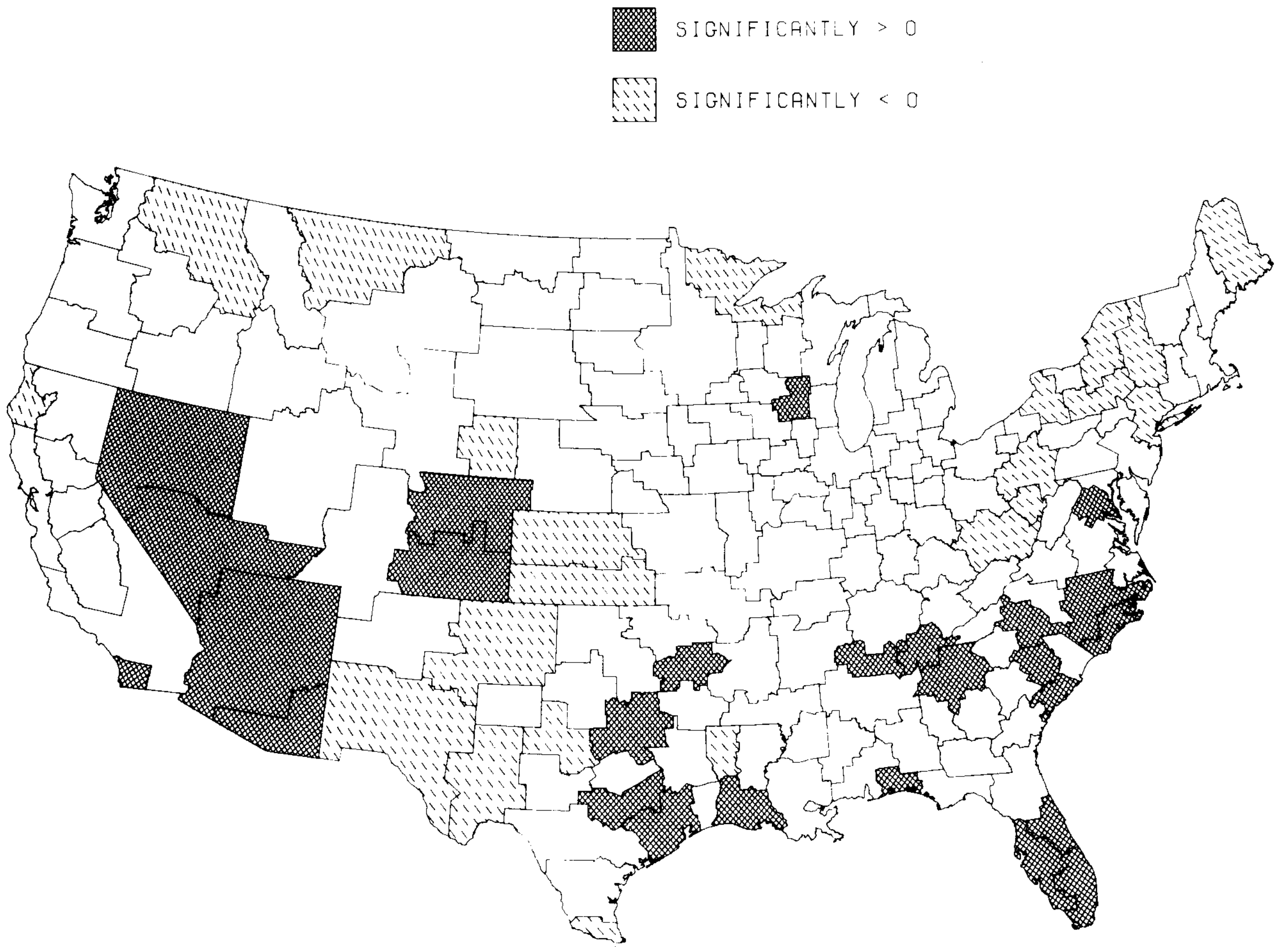


Fig. 2.11. Competitive shift component of employment growth: 1960 - 1970.

From Fig. 2.10, industry mix was especially favorable to growth, that is, weighted with fast growing industries, in a belt running from Boston to New York to Syracuse and in Detroit, Lansing, Dayton, Washington, D.C., Denver, Albuquerque, San Francisco, and southern California. Industry mix was especially unfavorable to growth in the heavily agricultural areas of the Great Plains and the Southeast.

When these two effects are put together, the residual or competitive shift component indicates that some areas grew rapidly in spite of unfavorable industry mix conditions while others grew slowly in spite of favorable conditions. Figure 2.11 indicates that especially favorable (positive) competitive shifts were widespread across much of the South, in Colorado, and in the Southwest while especially unfavorable (negative) competitive shifts were scattered across much of the Northeast and the area running from west Texas to the northern Great Plains. Of course, these results do not distinguish regions that have had positive competitive effects because people have caused jobs from those regions where jobs have attracted people.

2.4.2 Regional employment specialization

Shift and share analysis is a useful tool for making broad comparisons of regional employment growth patterns but the results depend on the degree of regional employment specialization. In this section the trends in regional specialization are examined through the use of employment location quotients which measure the relative under- or over-representation of an industry in a region. Algebraically,

$$\text{Location quotient}_{ij} = \frac{E_{ij}/E_j}{E_i^{us}/E^{us}} \times 100 ,$$

where

E_{ij} = employment in industry $\underline{i}$ in region $\underline{j}$,

E_j = total employment in region $\underline{j}$,

E_i^{us} = employment in industry $\underline{i}$ in the U.S., and

E^{us} = total employment in the U.S.

Thus, if an industry is overrepresented in a region the location quotient will exceed 100; if underrepresented, the value will be less than 100.

Summary statistics of the BEA area distributions of employment location quotients are presented in Table 2.5. While discussion will focus on the coefficients of variation, the unweighted means and standard deviations do deserve some comment. The mean values deviate from 100 only

Table 2.5. Summary statistics of the BEA area distributions of employment location quotients.

	Unweighted means ($\bar{x}$)			Standard deviations (s)			Coefficient of variation ($s/\bar{x}$)							National employment:	
	1950	1960	1970	1950	1960	1970	1950	Rank	1960	Rank	1970	Rank	1970/1950	1970/1950	Rank
1. Agriculture	162.90	175.79	188.28	95.21	125.46	157.51	.58	20(t)	.71	18	.84	17	1.45	.40	34
2. Forestry and fisheries	154.64	159.06	176.56	286.92	234.55	294.45	1.86	8	1.47	10	1.67	4	.90	.79	29
3. Mining	136.71	165.10	169.96	238.27	273.96	281.05	1.74	10	1.66	6	1.65	6	.95	.67	32
4. Contract construction	105.16	106.06	107.03	25.28	21.62	19.27	.24	31	.20	32	.18	32	.75	1.28	20
5. Food and kindred products	94.30	101.28	114.07	54.27	51.25	69.99	.58	20(t)	.51	22	.61	21	1.05	1.04	26
6. Textile mill products	78.70	96.19	106.70	203.81	264.73	284.16	2.59	3	2.75	2	2.66	2	1.03	.81	28
7. Apparel	45.34	64.12	84.54	62.94	80.51	102.43	1.85	9	1.26	13	1.21	11	.65	1.21	23
8. Printing and publishing	69.00	73.23	75.76	35.30	32.29	32.50	.51	24	.44	24	.43	25	.84	1.62	9(t)
9. Chemicals and allied products	72.83	77.48	79.71	80.08	92.26	87.59	1.10	15	1.19	14	1.10	12	1.00	1.57	14
10. Lumber products and furniture	140.34	146.17	148.09	193.76	220.98	203.82	1.38	13	1.51	8	1.38	9(t)	1.00	.86	27
11. Nonelectrical machinery	73.59	76.12	81.40	116.77	97.33	86.32	1.59	12	1.28	12	1.06	13	.67	1.61	11
12. Electrical equipment	57.66	62.50	74.40	112.75	83.63	77.57	1.96	7	1.34	11	1.04	14	.53	2.53	2
13. Motor vehicles and equipment	54.18	58.87	65.79	179.74	159.23	160.60	3.32	1	2.70	3	2.44	3	.73	1.22	22
14. Other transportation equipment	55.35	61.05	69.77	118.53	108.82	101.18	2.14	4	1.78	5	1.45	8	.68	2.44	3
15. Paper and allied products	92.19	102.31	108.00	151.91	153.68	149.48	1.65	11	1.50	9	1.38	9(t)	.84	1.45	15
16. Petroleum refining	83.72	97.46	97.46	261.44	276.79	289.74	3.12	2	2.84	1	2.97	1	.95	.77	30(t)
17. Primary metals	60.85	66.39	74.53	126.86	128.71	114.04	2.08	5	1.94	4	1.53	7	.74	1.08	25
18. Fabricated metals and ordnance	58.64	67.30	78.82	76.57	72.62	67.72	1.31	14	1.08	15	.86	16	.66	1.82	6
19. "All other" manufacturing	66.46	71.79	81.44	70.48	66.85	66.40	1.06	16	.93	17	.82	18	.77	1.29	19
20. Railroad	109.14	110.39	118.02	57.06	61.01	73.00	.52	23	.55	20	.62	20	1.19	.48	33
21. Trucking and warehousing	98.16	99.03	97.05	31.69	27.85	26.58	.32	26	.28	28	.27	27(t)	.84	1.62	9(t)
22. Other transportation services	72.77	72.00	70.39	47.25	49.35	46.30	.65	18	.69	19	.66	19	1.02	1.36	17
23. Communications	84.90	89.28	87.93	23.57	20.99	20.35	.28	28	.23	31	.23	31	.82	1.60	12
24. Public utilities	95.92	102.06	107.60	24.51	26.96	26.39	.26	30	.26	29	.25	29	.96	1.33	18
25. Wholesale trade	88.24	90.48	89.89	26.01	22.94	21.72	.29	27	.25	30	.24	30	.83	1.59	13
26. Retail trade	97.40	102.09	102.37	12.40	9.64	10.33	.13	34	.09	34	.10	34	.77	1.42	16
27. Finance, insurance, and real estate	72.39	78.14	79.27	26.79	22.53	21.17	.37	25	.29	26(t)	.27	27(t)	.73	2.01	4
28. Lodging and personal services	98.02	103.53	107.42	26.52	42.98	49.29	.27	29	.42	25	.46	24	1.70	1.18	24
29. Business and repair services	97.73	86.70	81.99	19.84	25.33	25.46	.20	32	.29	26(t)	.31	26	1.55	1.81	7
30. Amusement & recreation services	92.67	91.63	93.08	64.66	86.85	95.59	.70	17	.95	16	1.03	15	1.47	1.26	21
31. Private households	104.06	114.94	122.30	57.34	58.00	60.28	.55	22	.50	23	.49	22(t)	.89	.77	30(t)
32. Professional services	97.08	99.38	100.58	18.19	17.27	16.41	.19	33	.17	33	.16	33	.84	2.80	1
33. Public administration	95.30	97.12	96.82	58.01	51.15	47.76	.61	19	.53	21	.49	22(t)	.80	1.70	8
34. Armed Forces	125.51	127.37	127.37	259.16	207.61	211.40	2.06	6	1.63	7	1.66	5	.81	1.95	5
Coefficient of specialization	24.87	22.52	19.99	7.01	6.17	5.62	.28		.27		.28				

because the location quotients for individual regions have not been weighted by total employment size; too much significance should not be placed in the deviation of these mean values from 100. The standard deviation values begin to give insights to the extent of spatial concentration by industry; high values tend to indicate that an industry has been concentrated in a few places (e.g., mining, textile mill products, and petroleum refining) whereas low values tend to indicate that an industry has been dispersed almost in proportion to total employment or population (e.g., wholesale and retail trade and contract construction). Still, because the means about which these standard deviations were computed vary across industries and time, comparisons are not really proper.

Coefficients of variation put these measures of dispersion on a more comparable basis by standardizing for the size of the mean; comparisons of coefficients of variation can be made across time and industries. The coefficient of variation values have been ranked within each year from highest (most concentrated = #1) to lowest (most dispersed = #34); there have been quite a few changes in rank over time. The ratios of 1970 to 1950 coefficients serve to highlight the general trend toward less spatial concentration (or more spatial dispersion); the ratios are less than one for most industries. To further highlight the trend toward less spatial concentration, these ratios have been plotted against national employment growth in Fig. 2.12. The ratios for most industries have been near or below 1.0 regardless of their national growth rates. Exceptions worth noting are the growing spatial concentration of the rapidly growing business and repair services industry, the declining agriculture and railroad industries, and the moderately growing recreation related lodging and personal services and amusement and recreation services industries. As a result of these industry trends toward spatial dispersion, the economies of most regions are becoming more diversified; this is reflected in the declining mean value of the coefficient of specialization[19] shown at the bottom of Table 2.5.

2.5 LABOR MARKET CONDITIONS

Up to this point BEA area population, labor force, and employment patterns and trends have been described separately. In this section the combined effects of these separate elements upon labor market conditions are described. In particular, labor market tightness is defined in terms of the employment pressure index[20] and 1960 and 1970 conditions are contrasted.

The employment pressure index (EPI) is simply the ratio of the number of employed persons plus the Armed Forces to the number of persons of working age (15 through 64 years old); the ratio is expressed as a percentage. 1960 and 1970 BEA economic area values of the EPI are computer mapped in Figs. 2.13 and 2.14, respectively. Perhaps the most notable change has occurred in the West where generally tight labor market conditions prevailed in 1960 but where substantial areas of

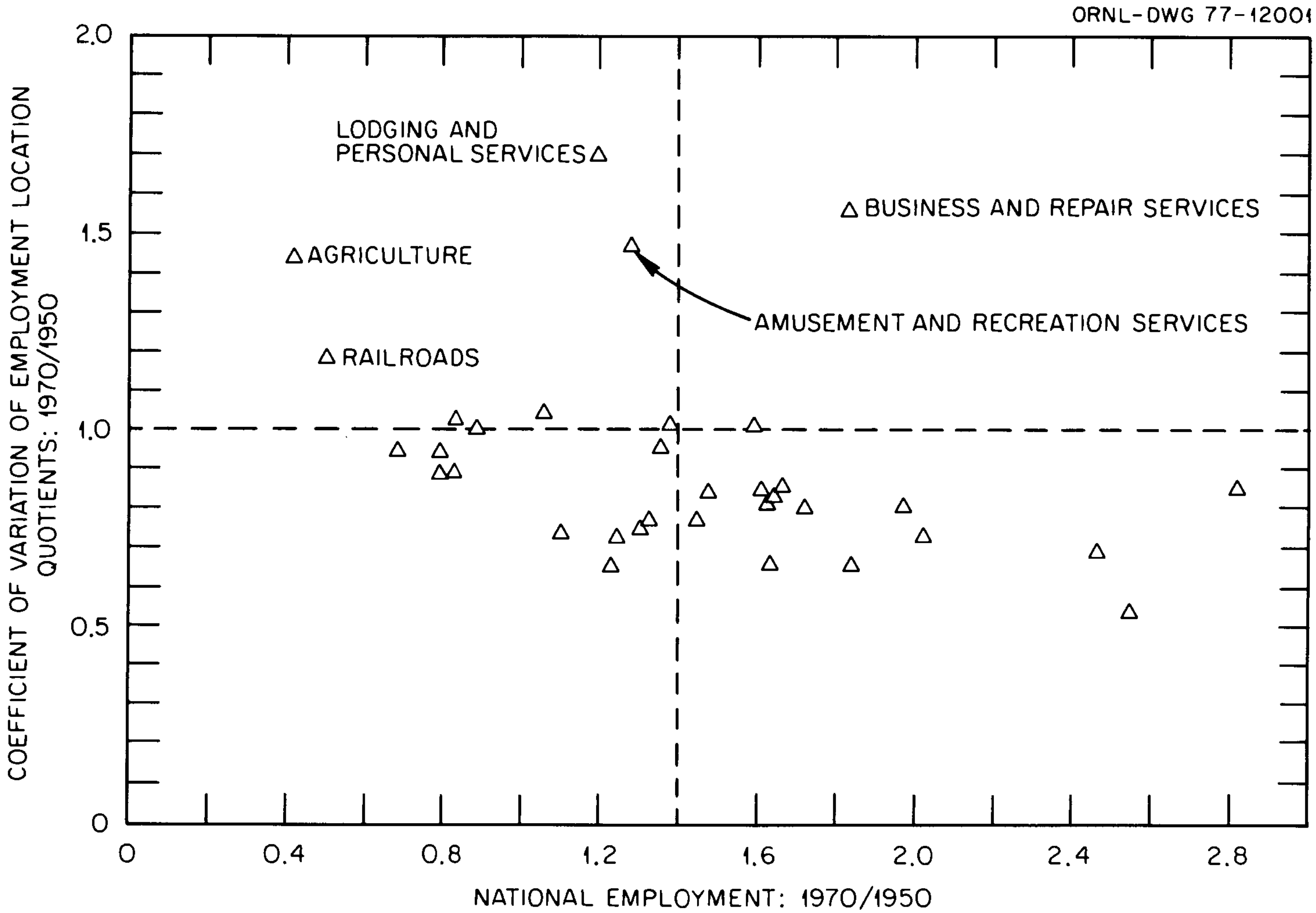


Fig. 2.12. Plot of coefficient of variation of employment location quotients 1970/1950 against national employment 1970/1950 for 34 industries.

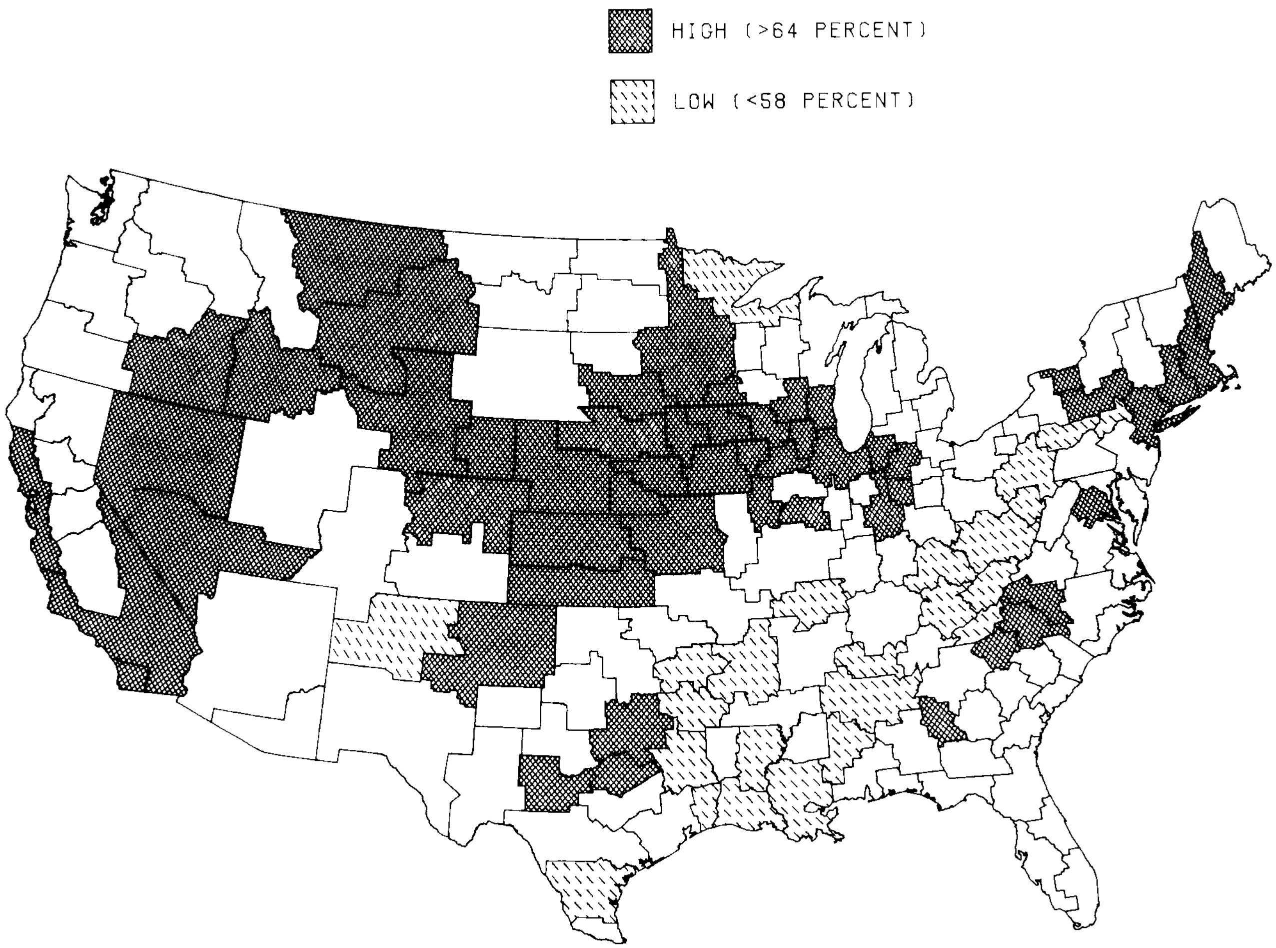


Fig. 2.13. Employment pressure index: 1960.

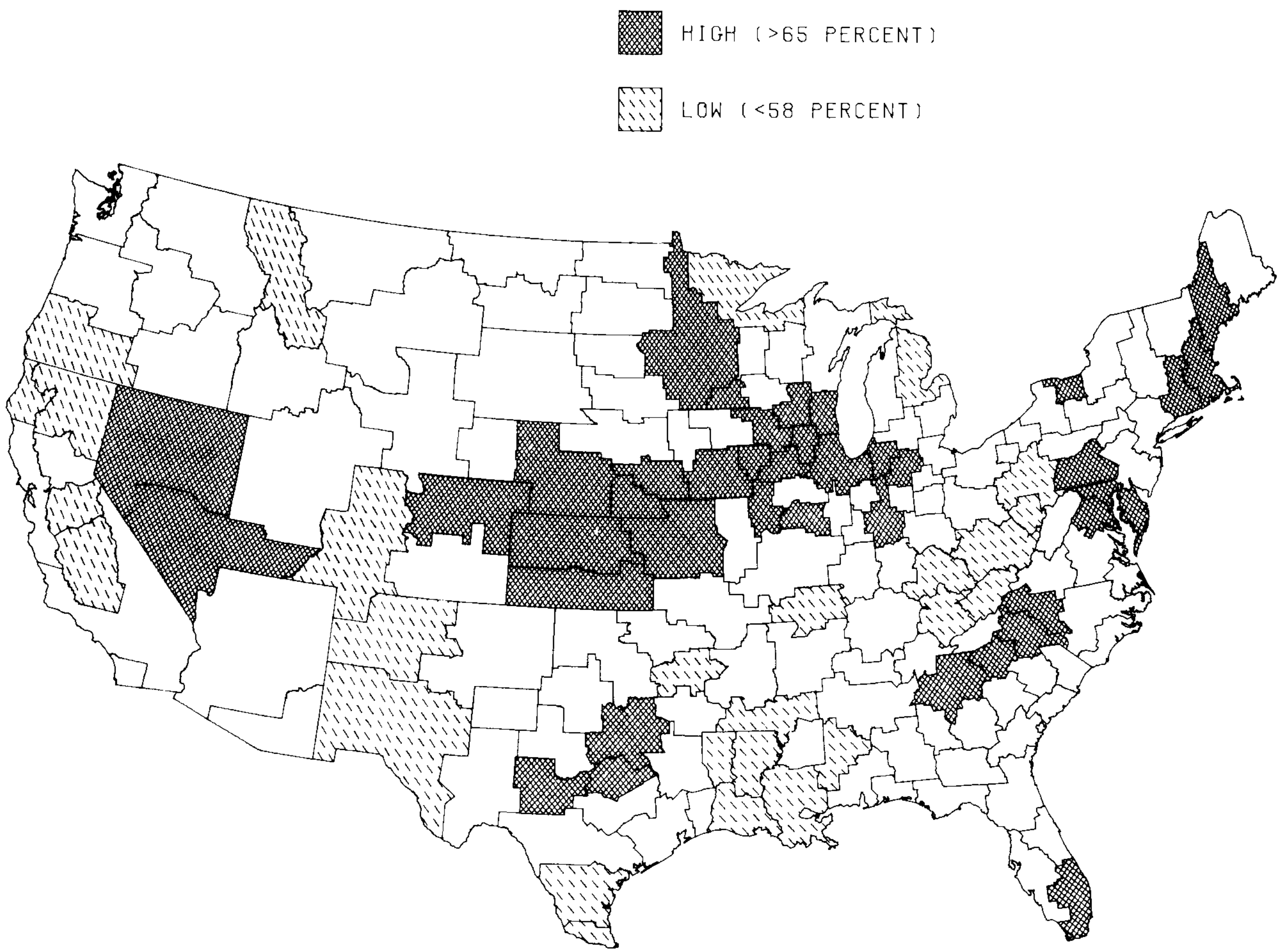


Fig. 2.14. Employment pressure index: 1970.

slack existed in 1970. This is no doubt the result of employment growing more slowly than population during this particular period.

In the South, labor market conditions showed broad improvement. There were fewer depressed areas in 1970 than in 1960 because employment grew more rapidly than population during the decade. In the Northeast, the geographic extremities around Washington, D.C., and northern Maine showed improvement but New York state declined. Labor market conditions in the Great Lakes region remained relatively unchanged but those in the Great Plains experienced a broad decline. While not without its own limitations, the employment pressure index is a useful device for combining the separate regional growth patterns of people and jobs.

REFERENCES FOR CHAPTER 2

1. Fox, Karl A., "A New Strategy for Urban and Rural America," *Appalachia,* 2(10), 10-13 (August 1969).

   Fox, Karl A., and T. Krishna Kumar, "Delineating Functional Economic Areas," in *Research and Education for Regional and Area Development,* Iowa State University Center for Agricultural and Economic Development, Iowa State University Press, Ames, 1969.

   Leven, Charles L., J. B. Legler, and P. Shapiro, *An Analytical Framework for Regional Development Policy,* MIT Press, Cambridge, 1970, Chapters 4 and 5.

2. Hoover, Edgar M., *An Introduction to Regional Economics,* Alfred A. Knopf, New York, 1971, p. 122.

3. Richardson, Harry W., *Regional Economics,* Praeger Publishers, New York, 1969, p. 227.

4. Hoover, p. 126.

5. C. L. Leven, et al., contains an excellent summary treatment of the research requirements for a viable development policy.

6. K. Fox and T. Kumar, p. 22.

7. Ibid., p. 18.

8. Ibid., p. 55.

9. Ibid., p. 15.

10. Berry, Brian J. L., P. G. Goheen, and H. Goldstein, *Metropolitan Area Definition: A Re-Evaluation of Concept and Statistical Practice*, Bureau of the Census, Working Paper 28, Washington, D.C., 1967, pp. 24-25.

11. Regional Economics Division, Office of Business Economics, U.S. Department of Commerce, "OBE Economic Areas of the United States," an unpublished paper dated September 1967 (revised January 1969), p. 2.

12. U.S. Department of Commerce and Natural Resource Division, Economic Research Service, U.S. Department of Agriculture, *1972 OBERS Projections of Economic Activity in the U.S. by Economic Area: Water Resources Regions, and Subareas: Historical and Projected, 1929-2020, Volumes 1-7*, U.S. Water Resources Council, Washington, D.C. (April 1974).

13. The conceptualization of their model is contained in D. H. Garnick, C. E. Trott, A. Olsen, H. Hertzfeld, and V. Fahle, "Toward Development of a National-Regional Impact Evaluation System and the Upper Licking Area Pilot Study," U.S. Department of Commerce, Office of Business Economics, Staff Paper in Economics and Statistics, No. 18, March 1971. Other analyses of BEA area growth are contained in B. J. L. Berry, *Growth Centers in the American Urban System*, Cambridge, Mallinger Publishing Company, 1973, and C. J. Sample, *Patterns of Regional Economic Change: A Quantitative Analysis of U.S. Regional Growth and Development*, Cambridge, Ballinger Publishing Co., 1974.

14. Bureau of the Census, *Public Use Sample of Basic Records from the 1970 Census: Description and Technical Documentation*, U.S. Department of Commerce, Washington, D.C., April 1972, pp. 4-5.

15. A complementary discussion may be found in Regional Economic Analysis Division, Bureau of Economic Analyses, "The BEA Economic Areas: Structural Changes and Growth, 1950-73," *Survey of Current Business*, Vol. 55, No. 11 (November 1975), pp. 14-25.

16. For a thorough discussion of various definitions of employment, unemployment, labor supply, etc. see President's Committee to Appraise Employment and Unemployment Statistics, *Measuring Employment and Unemployment* (U.S. Government Printing Office, 1962). The present discussion uses the U.S. Bureau of the Census definition of "persons in the labor force."

17. R. L. Raimon and V. Stoikov, "The Quality of the Labor Force," *Industrial and Labor Relations Review*, April 1967, pp. 391-413.

18. Traditional shift and share analysis is very adequately discussed and illustrated in H. S. Perloff, E. S. Dunn, Jr., E. E. Lampard, and R. F. Muth, *Regions, Resources, and Economic Growth* (Baltimore: Johns Hopkins Press, 1960) and Lowell D. Ashby, *Growth Patterns in Employment by County, 1940-50 and 1950-60* (Washington, D.C., U.S. Government Printing Office, 1965).

19. The coefficient of specialization is defined as:

$$\frac{\sum_{i=1}^{n} \left| \frac{E_{ij}}{E_j} - \frac{E_i^{us}}{E^{us}} \right|}{2} \times 100 \quad .$$

The larger the value of the coefficient, the more specialized is the region — that is, the more different the region's industry mix is from that of the nation.

20. See E. E. Cullison, "An Employment Pressure Index as an Alternative Measure of Labor Market Conditions," *The Review of Economics and Statistics*, Vol. LVII, No. 1 (February 1975), pp. 115-120.

3. REGIONAL PROJECTIONS MODELS

After a brief discussion of some of the dimensions by which regional models may be classified, this chapter reviews five existing regional projections systems to permit the reader to view MULTIREGION in better perspective. While many regional models exist, and even more have existed at some points in the past, the five selected for review tend to be those that have been implemented across all subnational areas of the United States (e.g., across all states) and those currently used or having the prospect of being used by a broad set of public and private users for a variety of regional planning and analysis purposes. It should also be pointed out that only two of these five models existed when the work on MULTIREGION began.

3.1 SOME DIMENSIONS OF REGIONAL MODELS

There are a number of dimensions by which regional models may be classified to highlight their similarities and differences. Without becoming involved in a potentially endless methodological discussion, we feel the reader may usefully classify regional models according to whether they (1) produce projections or forecasts, (2) are based on demographic and/or economic concepts, and (3) are regional or multiregional.

3.1.1 Projections versus forecasts

Although the distinction between regional projections and forecasts is apt to be more important to the maker than to the user, it deserves to be made. Shryock and Siegel[1] draw the distinction as follows: projections are the end products of models worked out to illustrate certain analytical relationships and may be based upon assumptions that appear to be likely or unlikely as of a given date whereas forecasts are projections based upon assumptions that are considered by the forecaster to be most likely to occur. Thus, by these criteria all forecasts are projections but not all projections are forecasts. To the maker of projections, the distinction is important because it permits experimentation and removes a degree of responsibility from the analyst's shoulders. But to the user community, the distinction is finely drawn and sounds artificial; in the absence of explicit forecasts, illustrative projections tend to be used as forecasts.[2] The reader may safely consider most regional models to be projections systems.

3.1.2 Demographic and/or economic concepts

Regional models are usually based on demographic and/or economic concepts. At one extreme there are naive demographic models which tend to assume that jobs follow people and focus on demographic trends in births, deaths, and migration. At the other extreme there are naive economic models that assume that people follow jobs and focus on economic events such as industrial location processes and consumption and investment decisions. Because the truth probably lies somewhere between these extremes, an increasing number of regional models attempt to include both demographic and economic concepts; but even in these cases, the end result can usually be described as mostly economic or mostly demographic rather than truly balanced.

3.1.3 Regional versus multiregional

Most regional models may be applied to one, most or all subnational regions (e.g., all states) at the same time but only a few models must be applied to all areas simultaneously because they embody a significant degree of interregional interdependence. Models of this latter type may be clearly classified as "multiregional."

3.2 FIVE REGIONAL PROJECTIONS MODELS

The five regional projections models that will next be reviewed are those of the Bureau of the Census (CENSUS), the National Planning Association (NPA), the Bureau of Economic Analysis (OBERS), Curtis Harris, Jr. (HARRIS), and Chase Econometric Associates, Inc. (CHASE). Each of these models has been implemented across all subnational areas (e.g., across all states) and the resulting projections are being used by a fairly broad user community. In addition to the brief specifications of some of the dimensions of each model found in Table 3.1, the reader should note that all of these models are regional allocation models in that they step-down or allocate predetermined national projections to regions.

3.2.1 Bureau of the Census

The Bureau of the Census uses a cohort-component demographic model to derive subnational population projections series.[3] The cohort-component model assumes that population "this period" is equal to population "last period" plus births, minus deaths, plus inmigrants, minus outmigrants, plus net immigrants for each age-sex cohort. Separate assumptions are made for each component of future population change — births, deaths, outmigration, inmigration and net immigration — as follows.

Births - State to national ratios of the general fertility rate are projected to reach unity in 50 years. The projected ratios are applied to previously estimated national fertility rates to derive fertility rates for states which are then applied to projections of the female population, aged 15 to 44, for each state to derive the projected number of births. Births by state are normalized so their sum over all states for each 5-year period equals a predetermined national total.

Deaths - A single set of national mortality (survival) rates is used for all states; no allowance is made for state differences because they are expected to have very little effect on the resulting population projections.

Table 3.1. Some dimensions of five regional projections models

Model	Subnational areas	Basic concepts	Multiregional (interregional interdependence)?	Time step	Basic items forecast
CENSUS	States	DEMOGRAPHIC	No	5-year intervals to 2020	population
NPA	States	ECONOMIC/demographic	No	5 years to 1985	population and employment
OBERS	BEA areas	ECONOMIC/demographic	No	5 years to 2020	population and earnings
HARRIS	Counties and BEA areas	ECONOMIC/demographic	Possibly	Annual to 1985	output, employment and population
CHASE	States and SMSA's	ECONOMIC	Possibly	Annual for 10 years	output, employment and income

Outmigration - Outmigrants are computed using rates observed for each state in a base period (e.g., 1965-1970). Projected outmigrants for all states in each 5-year period are summed to form a "pool" of migrants. Under Series I assumptions, out-migration rates are held constant over time; under Series II assumptions, they are assumed to converge to the base period national average rate.[4]

Inmigration - The estimated "pool" of migrants is next allocated to the states as inmigrants using the percentage distribution (shares) of the absolute number of inmigrants among the states observed in the base period (e.g., 1965-1970). Under Series I assumptions, in-migration shares are held constant over time; under Series II assumptions, they are assumed to converge toward the population distribution of the states. Thus, under Series II migration assumptions, in about 50 years, the number of persons migrating from a state would be matched by an equal number moving in, resulting in zero net migration for each state.

Net immigration from abroad - Net immigrants are allocated to the states according to the state of residence of the foreign-born residing in the U.S. in the base year (e.g., 1970) but residing abroad five years earlier (e.g., 1965).

3.2.2 National Planning Association

While the National Planning Association (NPA) periodically prepares forecasts of population, labor force, households, employment, personal income, and personal consumption expenditures for each of the 50 states, the driving force in their model is economics and the demographic dimension is reconciled to the needs of the regional economies. Because NPA's estimates of income and expenditures are really simple add-ons to their employment, labor force, and population projections, we focus our review on the latter. Historical analyses of each area to the nation are used in NPA's projections system as follows.[5]

Basic employment - Basic commodity producing industries include agriculture, forestry and fisheries, mining, and manufacturing. State employment projections for each basic industry are derived by applying the results of historic shift and share analysis (e.g., for 1965-1970) to each industry's base year (e.g., 1970) employment. The projections are normalized so the sum over states of projected employment in each industry equals predetermined national totals.

Service or non-basic employment - Service or noncommodity producing industries include: construction; transportation, communication, and public utilities; retail and wholesale trade; finance, insurance, and real estate; services; and civilian government. State employment projections for each service industry are derived by a multiplier concept. For historic years the multiplier ratios of employment in each service industry to total basic employment is formed for states and the nation and state values are related to national values. These region-nation relatives are trended for projections years. For a particular projections year the trended region-nation relative for each service industry is applied to the corresponding projected national multiplier to derive a regional multiplier which is applied to the sum of projected basic (commodity) employment for that region. After this process is repeated for each industry and state, the sum over states of employment in each service industry is forced to predetermined national totals.

Population - State population projections at five-year intervals are developed in two steps: first, a cohort-component method is used to project the "closed" (no migration) population of each state and second, net migration is set equal to whatever is necessary to eliminate the differences between projected employment and projected closed population labor force by state. Like the Bureau of the Census, NPA uses region-specific fertility rates and national mortality (survival) rates to project the number of births and deaths by state. These procedures are applied to base period (e.g., 1970) population by age and sex to project the closed population by state. Then region-specific projections of labor force participation by age and sex are applied to the projected closed population to derive estimates of labor supply by states under conditions of no migration.

Estimates of population migration are derived under the assumption that the labor force moves to accomodate employment opportunities. First, net population migration is derived from projected net labor force migration through the application of population/labor force ratios. Then projected net migration by age and sex is derived by using the age-sex pattern of migration by state observed during a historic period (e.g., 1965-1970). Throughout this process, estimates (summed over states) are frequently forced to national totals and interregional balances are enforced (i.e., the sum over states of net migration by age and sex must equal zero.

Other regional conditions - In general, other dimensions of regional activity — households, income, and expenditures — are projected from the already projected composition of population and employment through the application of trended ratios or rates sometimes normalized to corresponding national values.

3.2.3 Bureau of Economic Analysis

The OBERS projections of regional economic activity have been prepared for the U.S. Water Resources Council by the Department of Commerce's Bureau of Economic Analysis (formerly the Office of Business Economics) and the Department of Agriculture's Economic Research Service as a baseline for planning regional water resource use.[6] Once more, concepts from economic base theory are used to allocate national totals of employment and earnings to BEA economic areas after which regional population estimates are adjusted to meet regional economic needs.

Basic industry employment and earnings - Industries are divided into "basic" and "residentiary" categories like NPA and each category is treated separately. For each industry a separate curve is fitted to each region's shares of national total income and employment for the selected years for which data are available; a least-squares regression line is fitted to the logarithm of the percentange shares and the logarithm of time. These curves are then extended into the future and projected values of regional employment and earnings shares are read from the curve. These are examined for inconsistencies and irregularities and adjusted where necessary. The results are applied to predetermined national totals to derive regional projections of employment and earnings in absolute terms.

Residentiary industry employment and earnings - Projections of regional earnings and employment in each residentiary industry are derived separately using multiplier concepts and then reconciled where necessary. Historic employment and earnings location quotients are projected into the future under the assumption that they converge toward 1.0 over time. Projections of regional employment and earnings multipliers for each residentiary industry are derived by multiplying the projected location quotients by the corresponding projected national ratios of employment and earnings to total national employment and earnings. These multipliers are then applied to the regional total of already determined basic employment and earnings plus an estimate of total residentiary employment and earnings to project the absolute level of employment and earnings in each residentiary industry. All projected values are normalized so the sum over states equals predetermined national totals. In specific regions where some residentiary industries are serving export markets, exceptions are taken to these general procedures.

Population - Interregional migration is the most critical component of population change and the OBERS projections assume that except for retired persons, the principal motivating factor in migration is economic opportunity. Thus, the largest part of BEA area population is projected as a function of employment. This is accomplished by grouping population into three age cohorts — (1) the labor pool aged 15 to 64, (2) the pre-labor pool aged 0 to 14, and (3) the post-labor pool aged 65 and over — and projecting each separately. The regional ratios of labor pool to employment of the base period (e.g., 1970) and the regional ratios of pre-labor pool to labor pool are assumed to move toward national average values over time. Regions with large concentrations of post-labor pool populations in the past are assumed to have large concentrations in the future. At all stages, the across region sums of projected values are forced to predetermined national totals.

3.2.4 Curtis Harris, Jr.

Curtis Harris and associates at the University of Maryland have prepared a multiregional multi-industry model to forecast output, employment, population, earnings, personal income, consumption expenditures, government expenditures, investment and foreign exports at annual intervals for all counties and BEA economic areas in the U.S.[7] While the structure of the model is too complex to be recounted here in detail, the general steps in forecast preparation appear to be as follows.

Output and employment - Output by industry in period t is first determined for each region as a function of regional conditions in period t-1 including the costs of material and labor inputs, the transport costs of shipping the product out and inputs into the region, the size of local output and input markets, and the level of output in t-1. Once output by industry and region is determined, employment in general is estimated to be that amount necessary to produce the forecast output. All forecast values are normalized to sum across regions to predetermined national totals.

Population - Population is estimated for four age (0-14, 15-34, 35-64, and 65 and over) and two race cohorts by cohort-component methods where the numbers of births, deaths, and net migrants are forecast separately. Births during period t are related to the population aged 15 to 34 at t-1 and deaths during t by age and sex are related to the corresponding populations of these cohorts during t-1. The net migration of persons aged 15 to 34 and 35 to 64 is made a function of labor market conditions in t-1 and regional employment change during t. The net migration of persons aged 0 to 14 is made a function of the concurrent net migration of persons aged 15 to 64 and the net inmigration of persons 65 and over is dependent upon the number of persons 65 and over in each region in t-1. All forecast population values are forced to sum to predetermined national totals and net migration by cohort summed over regions must equal zero.

Other regional conditions - Regional estimates of total labor force, unemployment, income, personal consumption expenditures, and international trade are variously determined as functions of current and lagged conditions including output, employment and population.

In closing it must be pointed out that Harris has encountered certain difficulties in using the county version of this sophisticated model. First, it is noted that "in keeping with the overall assumption of no abrupt regional changes, certain [arbitrary] limits in forecast values were placed on changes in output, employment, earnings, and labor force"[8] which also led to adjustments in population forecasts. Second, the computation costs associated with recomputing the marginal transport costs of shipping products out and supplies into each region after each interation of the county model have been so high as to warrant the substitution of alternative procedures;[9] this leaves the multiregional character of the implemented model in question.

3.2.5 Chase Econometric Associates, Inc.

A regional economic forecasting service has recently been made available to subscribers by Chase Econometric Associates, Inc. Economic variables are forecast on an annual basis out ten years for each of the fifty states and for all SMSA's. While knowledge of the internal structure of the model is not generally available,[10] it does appear to be interregional in that the growth in each state is linked to the growth in competitive states. In addition, the model attempts to capture regional differences in the cyclical responsiveness of each industry. The forecasts are purely economic; population is not treated.

The model begins by forecasting output or value added by industry and region as a function of the relative profitability of doing business in each region and a general cyclical variable that represents the notion that recessions fall most heavily on those regions with the greatest concentration of obsolete facilities. Once output is forecast, employment is estimated as a function of output, relative regional labor costs, etc. Regional wage rates and personal income are forecast as functions of the regional rate of growth of output and national wage rates. Finally, other variables are forecast as functions of past and present regional levels of output, employment and income. Population is not treated.

3.3. OTHER REGIONAL PROJECTIONS MODELS

The five regional projections models that have been reviewed are rather unique in that they have been implemented across all subnational areas. Numerous other models do exist but they are operational for only one or a few subregions of the nation. Two classes of particular note are regional econometric and interindustry models.

3.3.1 Econometric models

Interest in regional macroeconometric models (especially for states) dates from the mid 1960's and probably arose from the qualified forecasting success of similar national models. Since that time models have been constructed for most states and for some smaller and larger areas. However, each of these modeling efforts has required a substantial front-end investment in the development of regional income and expenditure data that could be econometrically linked to national activity levels. As a result regional econometric models and data bases have almost always been custom-tailored for each region. The models are not sufficiently alike to permit their outputs to be meaningfully summed over regions. However, as first-generation models have now been completed for almost all states, this methodology may be experiencing a period of consolidation that promises more consistent work in the future.[11]

3.3.2 Interindustry models

Another type of model that has experienced increased use for forecasting and analysis on a region-by-region basis is the interindustry or input-output model. The approach's advantages are its richness of industrial and interindustry detail and its simple internal structure — an impact or forcasted activity level in one industry can be traced through to effects upon linked industries through simple matrix manipulations. However, its application requires a very substantial front-end investment in the development of regional (interindustry) accounts; the resulting models and data bases have as a consequence been custom-tailored for most regions.[12] Only recently has any substantial progress been made toward a consistent methodology for all regions (states).[13]

To provide regional forecasts or projections, interindustry models must be driven by forecasts of regional final demands and technological (interindustry) change. While some progress has been made toward internalizing these requirements,[14] the most common practice has been to rely on one or more of the regional projections models already mentioned.

3.4 DO WE NEED ANOTHER REGIONAL MODEL?

After being exposed to these models, the reader may justifiably ask, "Do we need another regional model? Do we need MULTIREGION?" In fact, we posed the same question in the spring of 1971. The answer at that time was a very clear "yes" because there was an obvious need for better assessments of the regional and interregional economic impacts of environmental policies and projects; the regional projections systems existing at that time, Census and NPA, could not meet this need. At the present more regional models exist but the answer remains unchanged. In part, this is because progress comes slowly but also because we have not had sufficient time to experiment with and judge the new alternatives.

REFERENCES FOR CHAPTER 3

1. U.S. Bureau of the Census, *The Methods and Materials of Demography* by H. S. Shryock, J. S. Siegel, and associates, second printing (revised), U.S. Government Printing Office, Washington, D.C., 1973, p. 771.

2. D. J. Bjornstad, C. H. Patrick, and K. P. Nelson, *State Population Projections: A Comparative Review of National Series and their Practical Usefulness*, ORNL-UR-120 (February 1975).

3. Their latest national projections are contained in U.S. Bureau of the Census, *Current Population Reports*, Series P-25, No. 601, "Projections of the Population of the United States: 1975 to 2050," U.S. Government Printing Office, Washington, D.C., 1975. Since the regional allocations of these projections are not yet complete, the most complete documentation of the regional model is found in U.S. Bureau of the Census, *Current Population Reports*, Series P-25, No. 375, "Revised Projections of the Population of States: 1970 to 1985," U.S. Government Printing Office, Washington, D.C., 1967. The regional model is also described in Shryock and Siegel, pp. 793-803.

4. By considering alternative migration assumptions, Census is able to create a range of regional population projections.

5. J. W. Lee and W. B. D. Hong, National Planning Association, *Regional Demographic Projections: 1960-85*, Report #72-R-1, Washington, D.C., 1972 and *Regional Economic Projections: 1960-85*, Report #73-R-1, Washington, D.C., 1973.

6. U.S. Water Resources Council, *1972 OBERS Projections of Economic Activity in the United States*, (based on Series "C" projected national population) 5 volumes, U.S. Government Printing Office, Washington, D.C., September 1972 and *1972 OBERS Projection of Economic Activity in the United States* (based on Series "E" projected national population) 7 volumes, U.S. Government Printing Office, Washington, D.C., April 1974.

7. C. C. Harris, Jr. and F. E. Hopkins, *Locational Analysis: An Interregional Econometric Model of Agriculture, Mining, Manufacturing, and Services*, Lexington, Mass: Heath Lexington Books, 1972, C. C. Harris, Jr., *The Urban Economies, 1985*, Lexington Books, 1973, and *Regional Economic Effects of Alternative Highway Systems*, Cambridge, Mass: Ballinger Publishing Company, 1974.

8. C. Harris, *The Urban Economies, 1985*, p. 137.

9. Harris, p. 132.

10. Chase Econometric Associates, Inc., *The Chase Econometrics Regional Forecasting Network*, 1975, 11 pages.

11. A paper by N. Glickman, "Son of 'The Specification of Regional Econometric Models'," *Papers of the Regional Science Association*, Vol. 32 (1974), pp 155-178, is a good introduction to regional econometric modeling and contains a thorough bibliography of published work through 1973.

12. P. Bourque and M. Cox, *An Inventory of Regional Input-Output Studies in the United States*, Occasional Paper No. 22, University of Washington Graduate School of Business Administration, 1970, F. Giarrantani, J. Maddy, and C. Socher, *Regional and Interregional Input-Output Analysis: An Annotated Bibliography*, Morgantown, West Virginia University Library, 1976, and H. W. Richardson, *Input-Output and Regional Economics*, London, Weidenfeld and Nicolson, 1972.

13. An extensive set of publications exist on the Multiregional Input-Output (MRIO) program including K. P. Polenske, *A Multiregional Input-Output Model for the United States*, Economic Development Administration, U.S. Department of Commerce, 1970, *The United States Multiregional Input-Output Model*, Lexington, Mass.; Heath Lexington Books, forthcoming, and R. C. Scheppach, Jr., *State Projections of the Gross National Product, 1970, 1980*, Lexington; Heath Lexington Books, 1972.

14. Consider, for example, W. Miernyk, K. Shellhammer, D. Brown, R. Coccari, C. Gallagher, and W. Wineman, *Simulating Regional Economic Development: An Interindustry Analysis of the West Virginia Economy*, Lexington, Heath Lexington Books, 1970 and H. Fullerton and J. Prescott, *An Economic Simulation Model for Regional Development Planning*, Ann Arbor Michigan; Ann Arbor Science Publishers, Inc., 1975.

4. RESEARCH STRATEGY

When the present research project began in earnest in the spring of 1971, the Nation was in the midst of a crisis of concern about the quality of our environment; as this is being written in the spring of 1976, we are experiencing a similar concern about our nation's ability to produce energy in the amounts required for a prosperous and independent future. This chapter reviews the research decisions made during the former period of greatest environmental concern that have led to a product — MULTIREGION — that is apt to be most heavily used for regional planning and analysis during the present period of public concern over energy. While everything has not worked out exactly as planned and much remains to be done, we are quite pleased that the research strategy set down during May 1971 has proved to be quite durable and suitable. This chapter reviews our early decisions to concentrate on the possible, to choose meaningful regional units, to use an empirical approach to model building, to maintain sufficient demographic and economic detail, to incorporate interregional interdependence, to concentrate on secular trends, and to adjust the empirical components as the model was assembled and tested.

4.1 CONCENTRATE ON THE POSSIBLE

Intellectually it is easy and perhaps necessary for a researcher to become very concerned with what information and analytical methods would be desirable for a thorough assessment of regional public policy questions. But, in the process one can very easily spend too much time exploring academic methodological questions to which the answers may not ultimately matter. Research experience may be the only effective control over these tendencies.

In the present instance our challenge was to contribute multidisciplinary insights and analytical quality to the public response to environmental issues. Our response was not independent of the personalities, disciplines, and institutions involved. An economist, land-use planner, ecologist, political scientist and systems analyst formulated a response within the high-technology tradition of Oak Ridge National Laboratory. In general, it was decided to integrate the contributions of these disciplines to environmental issues through regional systems simulations using computer models. A simple schematic of how these regional models were expected to interact and influence public policy appears in Fig. 4.1. Attention then quickly passed to the desirable internal details of each model and the linkages among them. It was at this point that the conceptual details of a regional socioeconomic model were specified as shown in Fig. 4.2. Similar blueprints for other components were drawn and taken together they formed Dynamic Regional Environmental Assessment Models — D.R.E.A.M.

The conceptual design of complex regional socioeconomic model is usually easy, their implementation is always difficult. In our case, some consideration was ititially given to the use of an elaborate macroeconometric and/or interindustry approach but the paucity of meaningful time-series

ORNL/DWG-71-10686

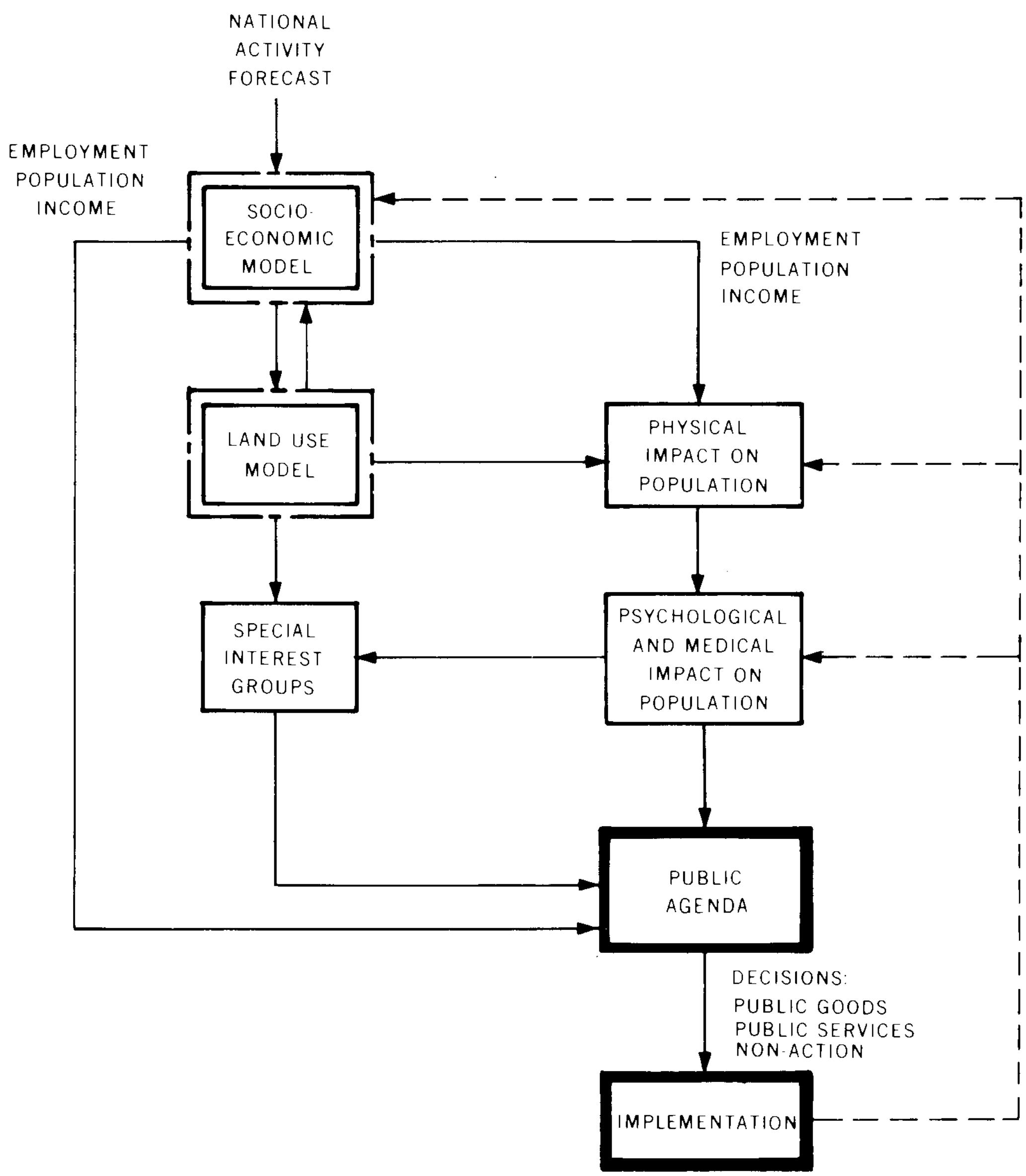


Fig. 4.1. Regional models and public policy.

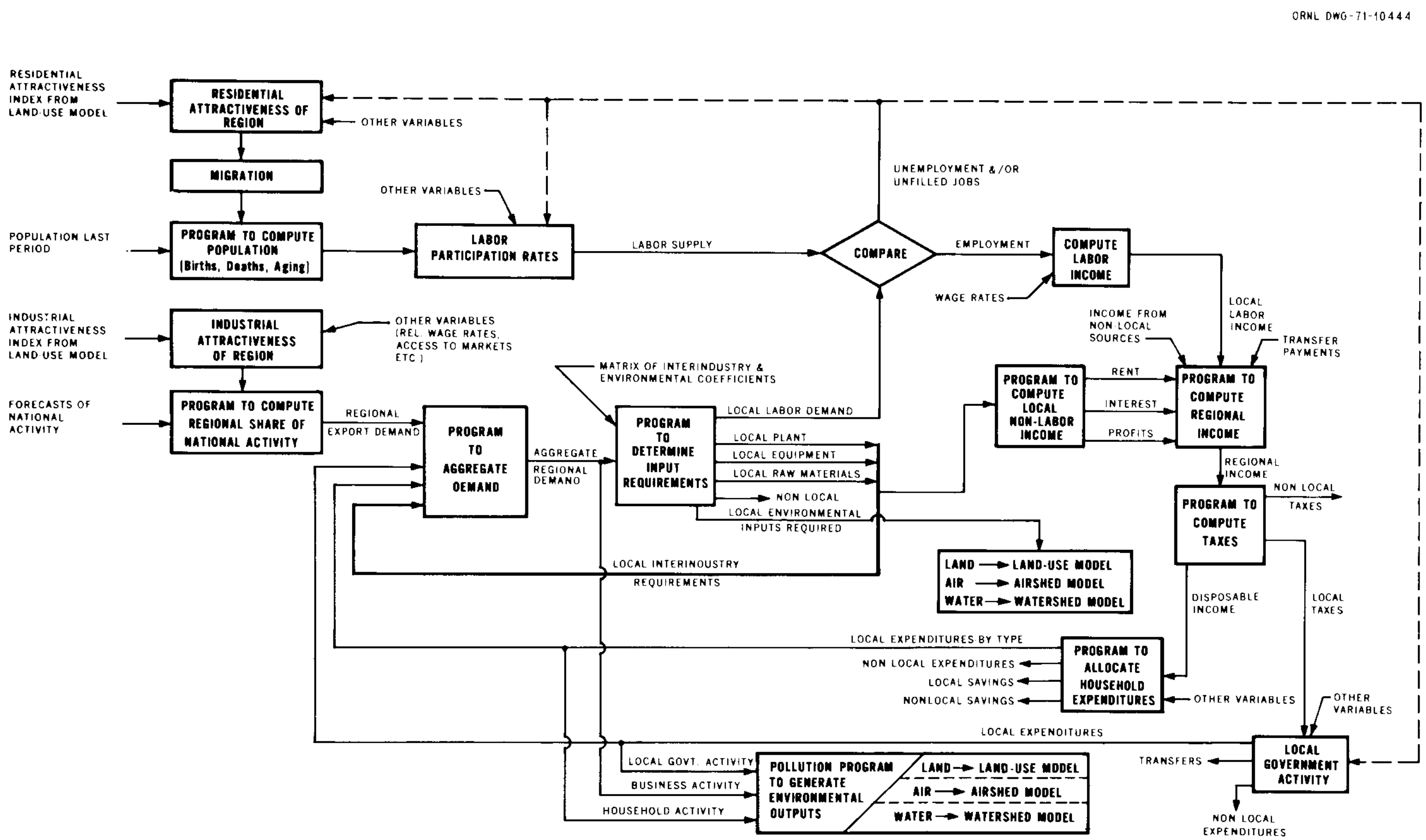


Fig. 4.2. Elements of a desirable regional socioeconomic model.

data for small multicounty areas led instead to the pragmatic approach outlined in Fig. 4.3. In this alternative a region's economy is viewed as a labor market and all activity is measured in terms of people as members of the population or as employees. The decision to view the regional economy as a labor market was greatly influenced by the existence of the Battelle model of the economies of the Susquehanna River Valley. While the Battelle model was not the only one available in 1971, and has apparently not been actively maintained or improved upon, it was at that time the best documented.[1] We did learn enough from Battelle's public documentation to determine that their approach was indeed possible. From that point on, we were able to concentrate on implementing a labor market model of BEA economic areas.[2]

4.2 CHOOSE MEANINGFUL REGIONAL UNITS

BEA economic areas were selected as the geographic unit of analysis because they incorporate many of the criteria of functional economic areas, and have been officially delineated for the entire United States. As functional economic areas, BEA areas contain both the place of work and place of residence of their populations and, thereby, reinforce their interpretation as labor markets for purposes of analysis. As officially delineated areas covering the entire U.S., they seemed assured of a long and useful lifetime because other agencies were likely to adopt the same spatial grid for public policy analysis.

But the choice of BEA areas was not without problems. Although they were officially designated in 1969, very few BEA area data were publicly available as of 1971. Our decision to use this spatial grid meant that a substantial effort had to be devoted to cumulate county data to BEA area units prior to beginning some of our empirical analyses. To date, such machine readable county data sources as the 1952, 1956, 1962, 1967, and 1972 County and City Data Books, the 1960 and 1970 Censuses of Population, and County Business Patterns have been cumulated to BEA areas.[3]

4.3 USE AN EMPIRICAL APPROACH TO MODEL BUILDING

At an early stage it was decided that an empirical approach to model building was to be used: the model was to be assembled from the results of formal econometric analyses of interregional migration, labor force participation, manufacturing employment, and local service employment. This decision was, in part, a reaction to the appearance in the early 1970's of a number of nonempirical systems simulation studies that claimed to show or represent the counter intuitive effects of various public policy options;[4] as researchers, we wanted to see evidence of these effects before embracing the idea.

This general empirical strategy led, in turn, to the following specific decisions.

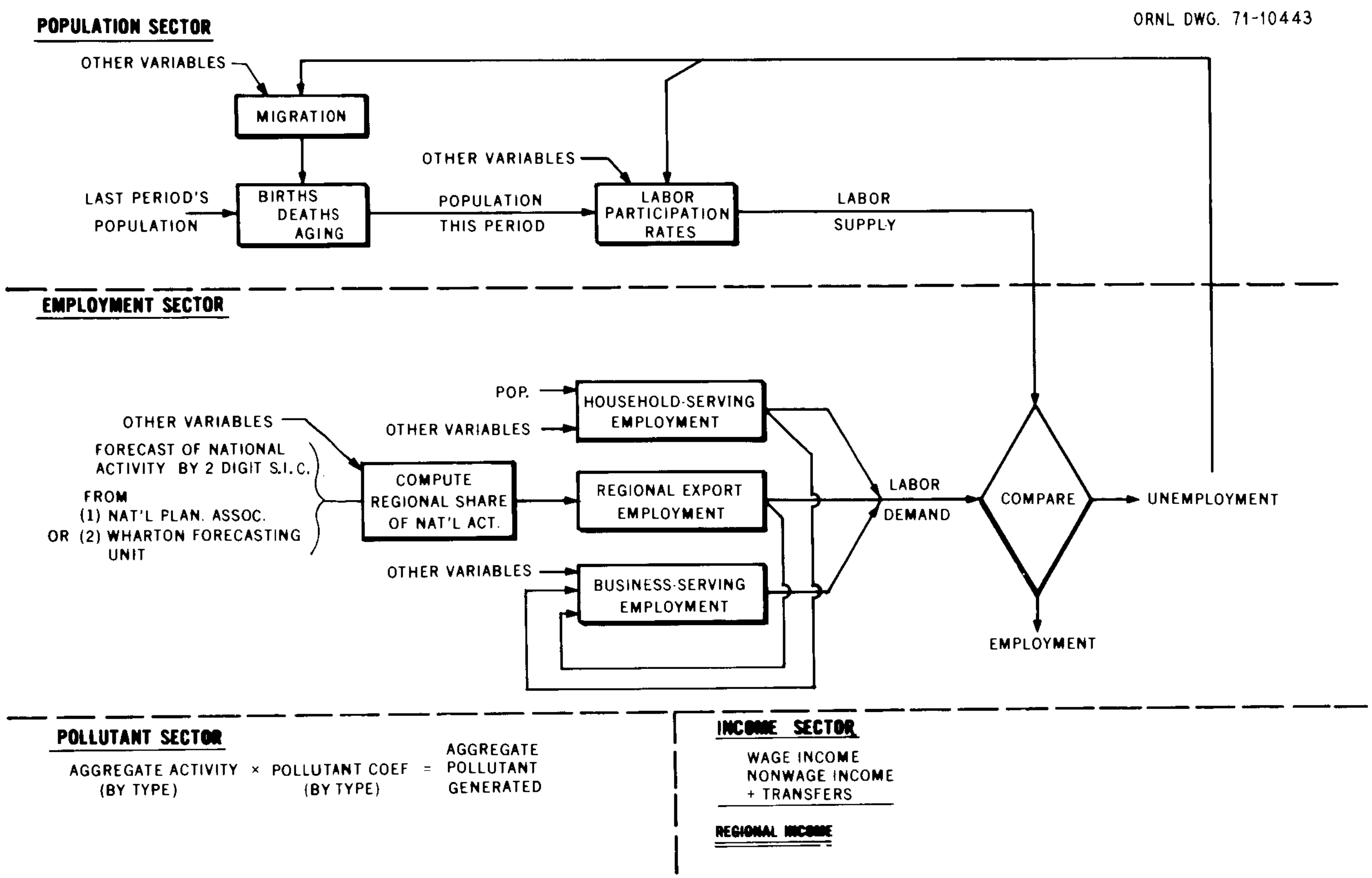


Fig. 4.3. A region's economy viewed as a labor market.

Census of Population data

In the absence of a more comprehensive regional socioeconomic accounting system, empirical analyses were to be confined to Census of Population data or non-Census data reconciled to Census definitions. To maximize the probability that the separate pieces of the model would ultimately fit together they had to be based on comparable terms; data from non-Census sources could be compiled but were not to be analyzed until they were reconciled where necessary to Census definitions.

Pooled cross-section data

The lack of meaningful time-series data for small regions has frequently confined regional analysis to cross-section data at one point in time. Yet we all know that variation over space is not the equivalent of variation over time. The attractiveness of augmenting the variation over space contained in cross-section data with some variation over time led to a pseudo time-series analysis through use of pooled cross-section data.[5] In addition to providing better estimates of the sensitivity of a dependent variable to changes in socioeconomic conditions, this procedure would permit the full use of the abundant supply of explanatory variables present in each cross-section to explain significant shifts over time.

Single-equation estimation procedures

Simple single-equation regression procedures such as the ordinary least squares (OLS) model were to be used for all initial investigations. As a starting point the overall model would be visualized as a series of single-equation submodels (e.g., the male in-migration rate submodel or the female labor force participation rate submodel) and the parameters of each equation would be estimated separately with the direction of causation assumed to run from the independent variables to the dependent variable. As the likely specification of the model and, thereby, the structure of regional economic development was better understood from the single-equation results, the model could be reestimated using simultaneous-equations regression methods.[6]

"Transformed" regression analysis

A "transformed" regression analysis would be used in those instances where the ordinary least squares (OLS) model gave results with extremely heteroscedastic residuals.[7] As a result of Census procedures, the observed values of many socioeconomic variables are derived from a 15% to 25% sample of households; for small geographic areas such as counties and some State Economic Areas (SEA's), these variables contain an intrisically large sampling error. Thus, since this sampling problem is most acute in SEA migration data,[8] a "transformed" regression model would be used where a weighted least squares procedure is applied to each observation of those variables subject to sampling error (i.e., resulting from the 15% to 25% sample in the Census). As a consequence of using the more appropriate "transformed" regression analysis rather than OLS, (1) parameter estimates would be different, (2) estimates of the standard errors of the parameters would be unbiased, and (3) statistical tests of parameter significance would be valid.

4.4 MAINTAIN SUFFICIENT DEMOGRAPHIC AND ECONOMIC DETAIL

There appears to be a natural tendency among many researchers to believe that more detail — greater spatial and/or sectoral disaggregation — will lead to more useful and better scientific results. When circumstances permit, it is the rare individual who can turn down 4-digit Standard Industrial Classification (SIC) detail in favor of 2-digit detail; the statistician's advice that it may be better to be vaguely right rather than precisely wrong is often not heeded.

In most regional analysis, however, the option of more detail is only available at extreme increases in cost; the problem most often is one of maintaining sufficient detail in the face of data constraints. In the present case, the decision to pool data from successive Censuses added to these data constraints as the information from each Census tended to be compiled differently. For example, because labor force participation was reported in greater age detail for 1970 than for 1960; we were limited to the six age cohorts common to both years. Also, since the 1970 Census included more industry breakdowns for the services sector and fewer for manufacturing than the 1960 Census, the common set of industry groups was fewer in number than for each census year separately.

While the decision was to proceed within each component of the model (e.g., within migration or labor force participation analyses) with the maximum detail common to both census years, it did not seem practical to restrict analyses to the level of detail common across concepts. For example, if one chose to restrict analysis to those age intervals for which data were available in common across births, deaths, migration, and labor force participation, only six age cohorts would be maintained — 0-14, 15-24, 24-34, 35-44, 45-64, and 65 and over. While this might appear to maintain sufficient detail for some purposes, very significant subinterval events such as a surge in births would be averaged into relative nonexistence because the model would age one-third of the 0-14 interval during each five-year time step.

Thus, it was decided that the empirical analysis of each component would proceed at the maximum detail allowed by the pooled data set; where differences in level of detail exist in adjacent concepts (e.g., migration and births and deaths), procedures would be designed into the computer program of MULTIREGION to achieve an appropriate matching. For example, forecast migration rates for 45-54 year olds would be partitioned into separate rates for 45-49 and 50-54 year olds.

Following these rules MULTIREGION tracks population for males and females separately within each of 16 age cohorts listed in Table 4.1. Because migration analyses could only be done for eleven age cohorts, rates forecast for the 45-54, 55-64, and 65 and over cohorts are mechanically adjusted

Table 4-1. Age detail maintained within the population sector

Population, births, and deaths	Five-year migration	Labor force participation
0-4	not appropriate	not appropriate
5-9	5-9	
10-14	10-14	14-17
15-19	15-19	18-24
20-24	20-24	
25-29	25-29	25-34
30-34	30-34	
35-39	35-39	35-44
40-44	40-44	
45-49	45-54	45-64
50-54		
55-59	55-64	
60-64		
65-69	65 and over	65 and over
70-74		
75 and over		

to apply to separate five-year intervals. Labor force participation analysis could only be done for six age cohorts so these results are applied to portions and aggregates of five-year population cohorts. For example, the labor force participation of 14-17 year olds is based on an estimate of the population aged 14 to 17 built up from one-fifth of the population aged 10 to 14 plus two-fifths of the population aged 15 to 19.

MULTIREGION tracks employment separately for each of 37[9] industry groups as listed in Table 4.2. At an early stage, it was decided that separate analytical procedures would apply to (1) export employment — the spatially sporadic activities generally oriented toward serving persons and businesses outside of the region, (2) local service employment — the more spatially ubiquitous activities generally oriented toward serving the region's population and businesses, and (3) natural-resource-based employment — agriculture, mining, and export recreation associated with facilities such as the Great Smoky Mountains National Park. While much time and energy could have been spent trying to distinguish between the local and export components of each industry, it was decided that each industry would be assigned to a category on an all-or-nothing basis in general according to the average size and regional variation of its employment location quotient as found in Table 2-4. The final assignments of each industry are found in Table 4-2.

Table 4-2. Industry detail maintained within the employment sector

Industry	Classification
Agriculture	
Forestry and fisheries	
Metal mining	
Coal mining	Natural resource
Crude petroleum and natural gas mining	
Nonmetallic, except fuels, mining	
Contract construction	Local
Food and kindred products	
Textile mill products	Export
Apparel	
Printing and publishing	Local
Chemicals and allied products	
Lumber products and furniture	
Nonelectrical machinery	
Electrical equipment	
Motor vehicles and equipment	
Other transportation equipment	Export
Paper and allied products	
Petroleum refining	
Primary metals	
Fabricated metals and ordnance	
All other manufacturing	
Railroad transportation	
Trucking and warehousing	
Other transportation services	
Communications	
Public utilities	
Wholesale trade	
Retail trade	
Finance, insurance, and real estate	Local
Lodging and personal services	
Business and repair services	
Amusement and recreation services	
Private households	
Professional services	
Public administration	
Armed forces	Exogenous

4.5 INCORPORATE INTERREGIONAL INTERDEPENDENCE

From the beginnings of this project, it has been our intuitive belief that the gradual completion of the Interstate highway system has had substantially different impacts on the economic development of various parts of the nation. For example, these highways have been replacing two-lane country roads in the South while they have usually paralleled turnpikes or four-lane highways in the Northeast. While low-wage labor, inexpensive electricity, and other important resources have existed in the South for a long time, why has rapid economic development only recently taken place? Have the Interstate highways stimulated the region's economic development through increased access to national markets?

To consider this question among others, it was decided that interregional economic interdependence would be built into the model through the use of appropriate measures of interregional access to markets. Specifically, market potentials defined in terms of access by the time of truck transportation would be included in the behavioral relationships wherever appropriate to consider the differential regional impacts of the gradual completion of the Interstate highway system.[10]

A corollary to this basic decision was that all regions had to be modeled or forecast simultaneously in a truly interdependent system. Thus, the commitment to true interregional interdependence was a commitment to all regions.

4.6 CONCENTRATE ON SECULAR TRENDS

MULTIREGION is intended to simulate secular economic developments rather than short-term business cycles. While this has always been the goal, the option of even considering short-term phenomena was closed by data restrictions. The most severe restriction is the lack of generally available data on interregional migration on an annual basis. Local labor markets like BEA areas are very "open" to the movement in or out of people and jobs even during the relatively short time span of a year or two. Unfortunately, the migration data that is available on an annual basis from the Continuous Work History Sample of Social Security card-holders is not yet satisfactorily understood.[11] Thus, it was decided that MULTIREGION would be programmed to operate in five-year time steps to 1985: or 1970, 1975, 1980, 1985. More recently that decision has been modified to complete the computer program in such a fashion that the model could be run out to the year 2020 with the explicit understanding that adjustments to the model would be necessary to properly represent probable technological and behavioral changes during more distant time periods.

4.7 ADJUST THE EMPIRICAL COMPONENTS AS THE MODEL IS ASSEMBLED AND TESTED

Because the ultimate test for any regional model must be its usefulness, scientific and other considerations may sometimes need to bend in favor of a more useful overall model. Just as the overall quality of a sports team may be different from the sum of the qualities of its individual members, the best overall model may not be formed from the best constituent parts.

Thus, we have always assumed that numerous adjustments would need to be made to the empirically derived components for the sake of a "good" overall model. While the exact nature of some of these adjustments could not be anticipated, it was generally assumed that MULTIREGION would be programmed where necessary to adhere to national control totals, interregional balances, floors and ceilings, and trends in the residuals about empirically fitted relationships. For example, the sum of agricultural employment over all BEA areas would have to equal a predetermined national total. Interregional balances would require, for example, that the sum over all BEA areas of 20 to 24 year-old male outmigrants equal the sum of 20 to 24 year-old male inmigrants. As an example of a floor, regional employment and unemployment rates could not be negative. Residuals or deviations about a fitted regression line, especially if they show some consistency over time for a given region, often have a story to tell us about the atypical nature of that region; frequently these historic deviations would have to be added to or substracted from the forecast values produced by the basic model to improve overall forecast accuracy.

Finally, it has always been assumed that the model would be used to track history (e.g., 1960 to 1970) and that the results of these experiments would be used to further adjust the parameters of the overall model. In particular, the model would be run from one known condition, 1960, through an intermediate unknown, 1965, to another known condition, 1970, where actual and forecast values would be compared and appropriate adjustments would be made to the overall system before moving on to true "futures".

REFERENCES FOR CHAPTER 4

1. H. R. Hamilton, S. Goldstone, F. Cesario, D. Sweet, D. Boyce, and A. Pugh, III, *A Dynamic Model of the Economy of the Susquehanna River Basin*, Battelle Memorial Institute, Columbus, 1966 and H. R. Hamilton, S. Goldstone, J. Milliman, A. Pugh, III, E. Roberts, A. Zellner, *Systems Simulation for Regional Analysis: An Application to River-Basin Planning*, Cambridge, Mass., M.I.T. Press, 1969.

2. In 1971, we decided to pursue this modeling activity because the only projections systems publicly available were those of the Bureau of the Census and the National Planning Association. Both of these systems used states as their geographic unit which seemed much too large for environmental analysis; neither was capable of examining policy options.

3. R. J. Olsen and G. W. Westley, *County Code Equivalents for Regional Analysis*, ORNL/NSF-EP-35 (1972), *1952, 1956, 1962, and 1967 County and City Data Books: Cumulations to OBE Areas*, ORNL/NSF-EP-31, 34 (1972), and with L. Bray, *1972 County and City Data Book: Cumulations to BEA Economic Areas*, ORNL/NSF-EP-79 (1974).

4. For example, J. W. Forrester, *Urban Dynamics*, Cambridge, Mass., M.I.T. Press, 1970 and *World Dynamics*, Cambridge, Mass., Wright-Allen Press, 1971. D. H. Meadows, et al., *The Limits to Growth*, New York, Universe Books, 1972.

5. L. R. Klein makes the following comment in a recent attempt to chart the future development of econometrics: "Since econometric methods are now being taken up in several countries that have a weak data base, it is likely that there should be more reliance on supplementary samples of cross-section data. These can, in principle, be obtained to fill in some irreparable time-series gaps. Research on pooling will be needed in these cases, and also research on drawing inferences from time sequences of cross sections should be further developed." L. R. Klein, "Whither Econometrics?" *J. Amer. Stat. Assoc.*, 66(434), pp 415-21 (June 1971). The same statement applies to regions of the U.S.

6. This step might have to wait until migration data are available for BEA economic areas.

7. In many econometric studies the assumption of a constant variance about the regression line is unrealistic. In the present case, the variance of the residuals was clearly negatively correlated with size of region measured by population.

8. The smallest SEA contained 7,797 households in 1970 and 6,068 in 1960 while the largest contained 3,892,447 in 1970 and 3,453,032 in 1960. The 25 percent (1960) and 15 percent (1970) sampling procedures used for place of residence should have resulted in approximately 1,170

households being sampled from the smallest SEA in 1970 and 863,258 from the largest SEA in 1960. Because migration data are not available for BEA areas we must use SEA data with its intrisically high sampling variability.

9. This level of industry detail is available only because (1) 1970 Census employment data were recompiled for the Bureau of Economic Analysis to provide a consistent set of data on employment by industry for 1940, 1950, 1960, and 1970 and (2) we have decomposed aggregate 1970 mining employment into four subindustries.

10. See Appendix H "Market Assessibility" for more details.

11. At an early stage of our analysis CWHS data for some multicounty areas in East Tennessee was prepared for us by the Tennessee Valley Authority but we were unable to reconcile those numbers to Census of Population data for the same areas and time period. Since that time some progress has been made toward understanding the nuances of CWHS data; see K. Nelson, *Evaluating Social Security Measures of Migration: Results for 28 SMSAs by Sex, Race, Age, and Earnings — 1965-1970*, (in preparation).

5. OVERVIEW OF THE MODEL

The purpose of this chapter is to highlight some of the dimensions of the computer program — MULTIREGION — that has resulted from the research strategy just outlined. This is done by briefly reviewing, (1) the elements of a region's economy when viewed as a labor market, (2) the general computational steps required to reconcile regional labor supply and demand, (3) the labor market equilibrating forces found in empirical analysis of population and employment, (4) the process of employment and population reconciliation embedded in MULTIREGION, and (5) the output that may be expected from a simulation or forecasting exercise.

5.1 A REGION VIEWED AS A LABOR MARKET

Although a complete and comprehensive theory of why and how regions grow and develop does not presently exist, many elements of such a theory have existed for some time.[1] The subset of these theoretical elements needed to view a region as a labor market are seen in Fig. 5.1. Basically, a region's labor supply may be affected by changes in mortality, fertility, migration, and labor force participation while its labor demand may be affected by changes in its attractiveness as a location for natural-resource-based industries, manufacturing, and local service industries.

The economist's classic supply/demand representation for labor markets (Fig. 5.2) leads one to expect both a price and quantity response to any disequilibrium situation. Starting from an equilibrium (w_o, q_o) defined by the intersection of demand and supply schedules D_o and S_o, an exogenous shift of the demand schedule to D_1 creates an excess demand (q_a - q_o) at the prevailing wage w_o. Under these circumstances and without the migration of jobs or people, market forces would tend to a new equilibrium (w_1,q_1) defined by the intersection of D_1 and S_o. The movement along S_o represents a price-induced increase in labor participation and the movement along D_1 represents a price-induced substitution of relatively less expensive inputs for labor in the production process. With the migration of jobs and people allowed for, a less severe change in price and quantity would result; D_1 shifts back to D_2 as the region becomes a less attractive location for industry and S_o shifts out to S_1 as people are attracted by the region's tight labor market conditions. The location of the final equilibrium really depends on the sensitivity of regional labor demands and supplies to changes in regional and interregional prices and socioeconomic conditions.

ORNL-DWG 76-5451

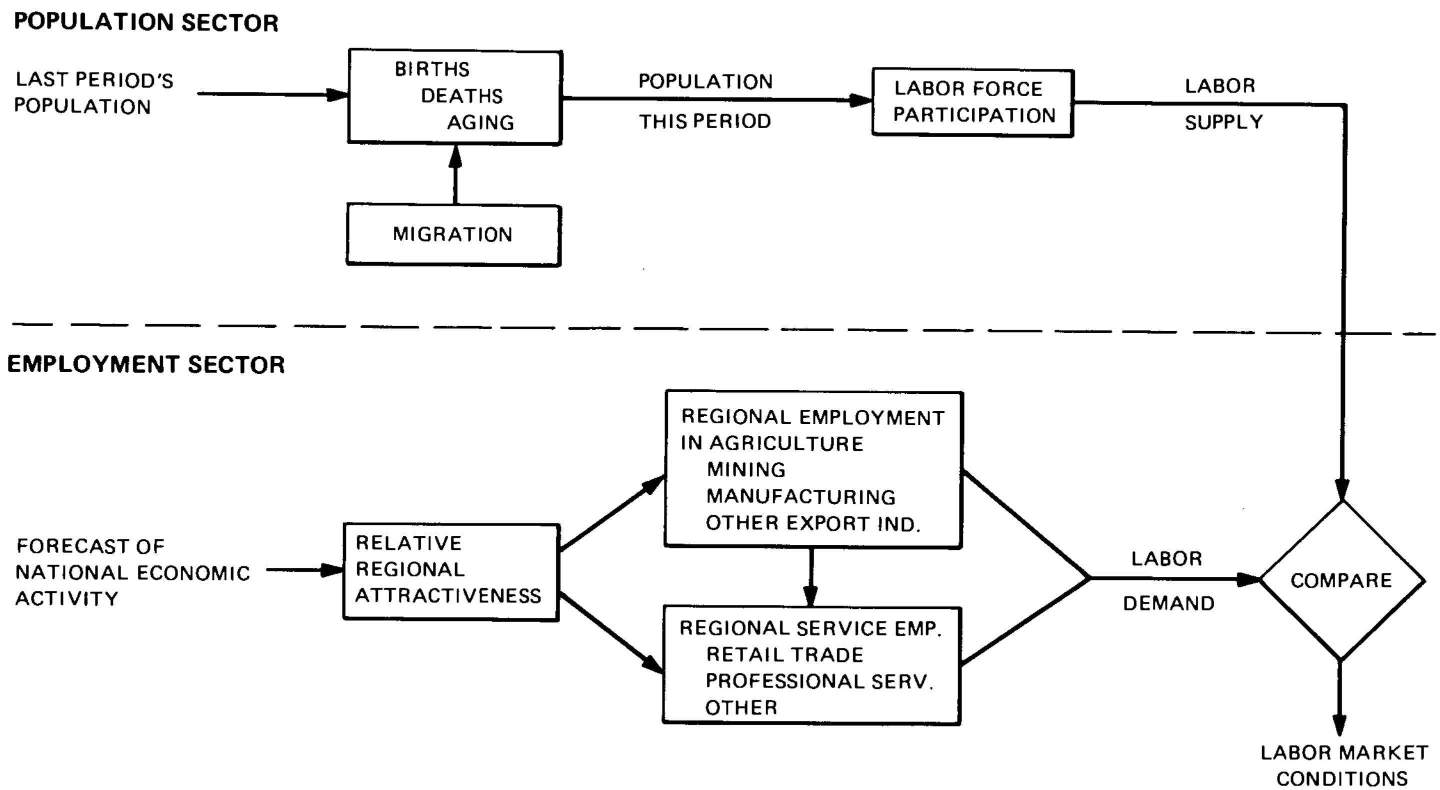


Fig. 5.1. A region's economy as a labor market.

ORNL-DWG 76-5450

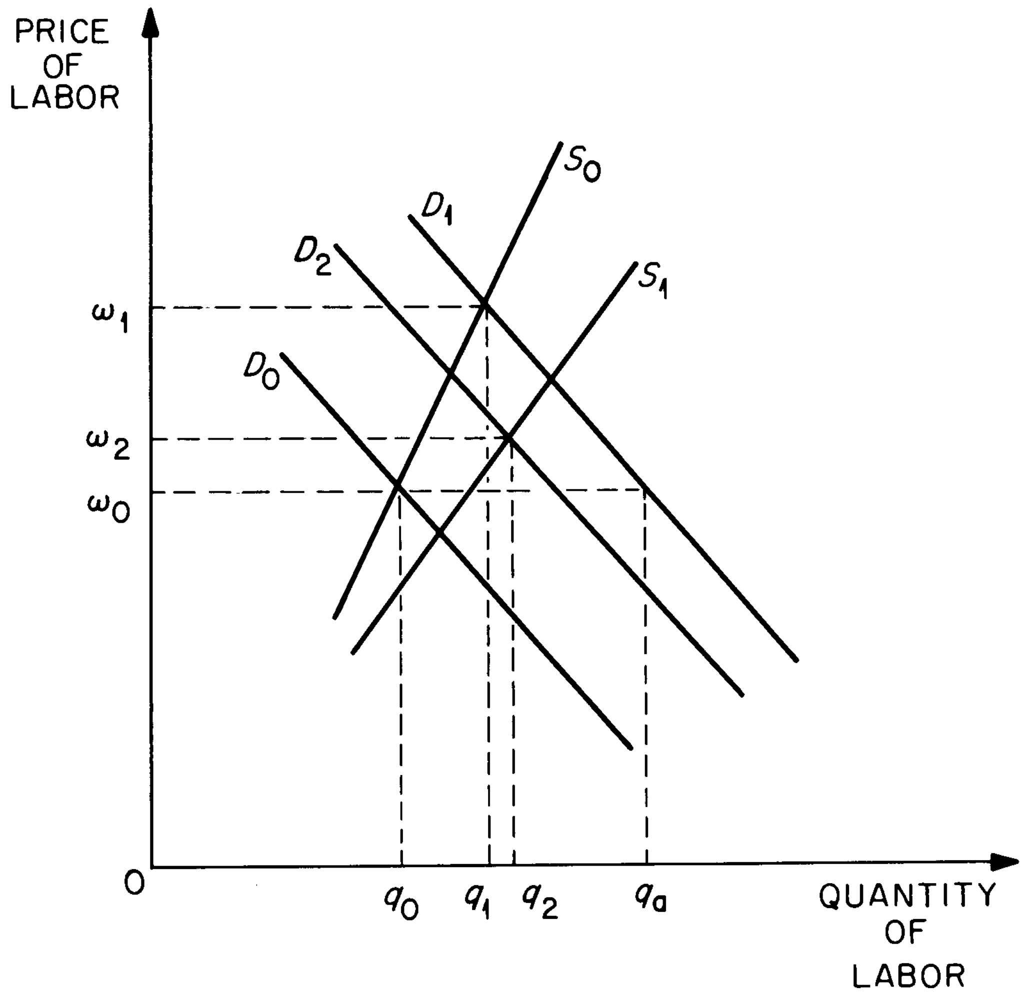


Fig. 5.2. The economist's supply-demand representation of a labor market.

As suggested by the research decisions enumerated in the last chapter, these labor market concepts and sensitivities have been quantified by applying regression analysis techniques to existing Census of Population socioeconomic accounts aggregated to BEA economic areas. While the lack of appropriate regional data has somewhat constrained the endeavor, the results that have emerged form a meaningful and operational representation of regional and interregional labor market processes — a firm basis for extrapolation from the past and present to future regional socioeconomic conditions and impacts. MULTIREGION is a computer program or model embodying these representations of regional and interregional labor market equilibrating processes.

5.2 THE OVERALL COMPUTATIONAL SEQUENCE

The computational process used by MULTIREGION to prepare regional forecasts of population and employment may be reviewed with the aid of Figs. 5.3 through 5.5. A few characteristics of MULTIREGION deserve mention at this time because they significantly impact the computational sequence. First, MULTIREGION operates in five-year time steps (1970, 1975, 1980, 1985, ----), even though some labor supply and demand components adjust to regional socioeconomic conditions contemporaneously, or at least, with a lag of less than five years. As a consequence, a multi-stage computation process (Figs. 5.3 and 5.4) is followed where last period values of some explanatory variables (e.g., labor market tightness and population density) are used to produce first-stage estimates of regional labor supply and demand; the first-stage labor market conditions then are used to compute revised regional estimates. The computation process then continues in this fashion through a user specified number of stages. Second, MULTIREGION operates within the context of a given national economy so that across-region sums of employment, population and labor supply are forced to predetermined national totals (the shadowed boxes in Fig. 5.5). Third, interregional migration balances are imposed so that across-region sums of outmigrants and inmigrants are equal. Finally, MULTIREGION imposes some ceilings and floors to regional labor market conditions to prevent irrational results such as negative unemployment rates.

During any five-year time step, computations for each BEA economic area proceed as follows: (1) trial population values are computed where population "this period" is assumed to equal population "last period," plus births, minus deaths, plus inmigrants, minus outmigrants; (2) trial labor supply values are computed by multiplying the estimated population by labor participation rates; (3) trial labor demand values are computed as the sum of forecasted agriculture and mining employment, the region's share of forecasted national manufacturing employment, and local service employment; (4) trial labor market conditions (e.g., unemployment rates) are computed by bringing together trial labor supply and demand values; and (5) final labor market conditions are computed by reiterating steps 1 through 4 a user specified number of times. At this point, regional and interregional conditions are recompiled and the computations for the next five-year time step may begin as is shown in Fig.5.4.

5.3 THE POPULATION SECTOR

At this point the labor market equilibrating forces identified by our empirical analyses need to be highlighted; more thorough discussion of these analyses are contained in subsequent chapters and in technical appendixes. We begin with the components of the population or labor supply sector — mortality and fertility, migration, and labor force participation.

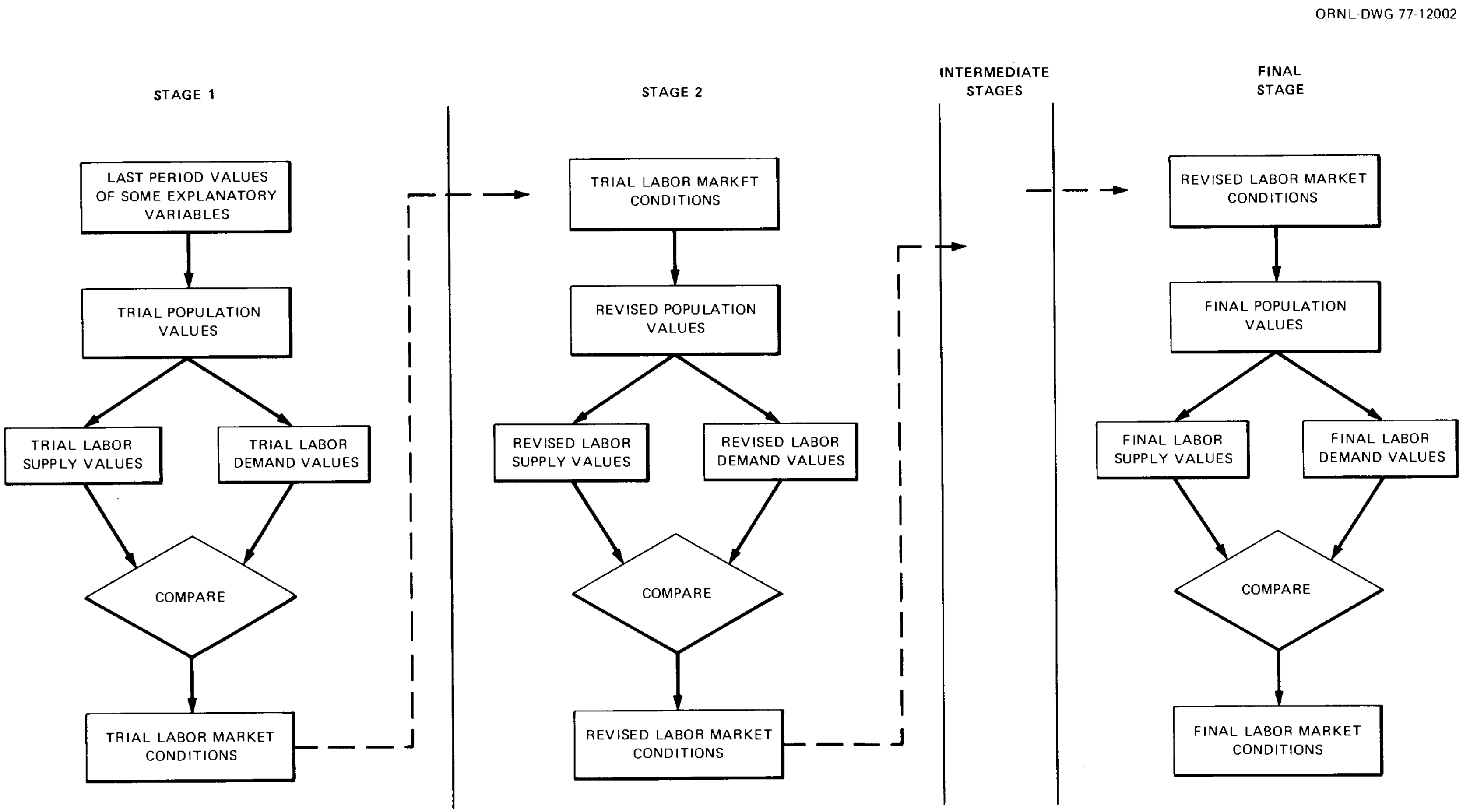


Fig. 5.3. Computations during a five-year time step.

ORNL-DWG 77-12003

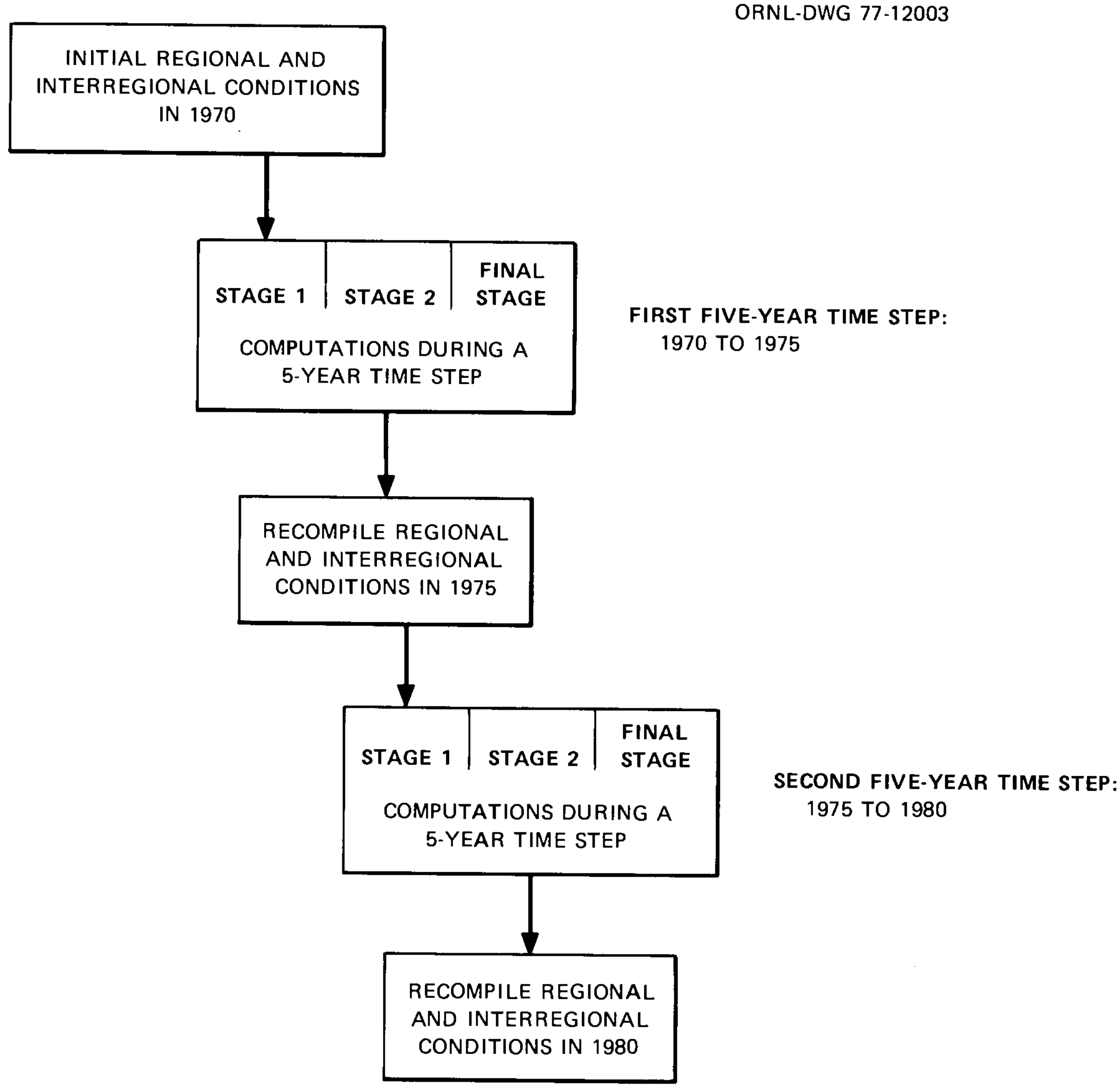
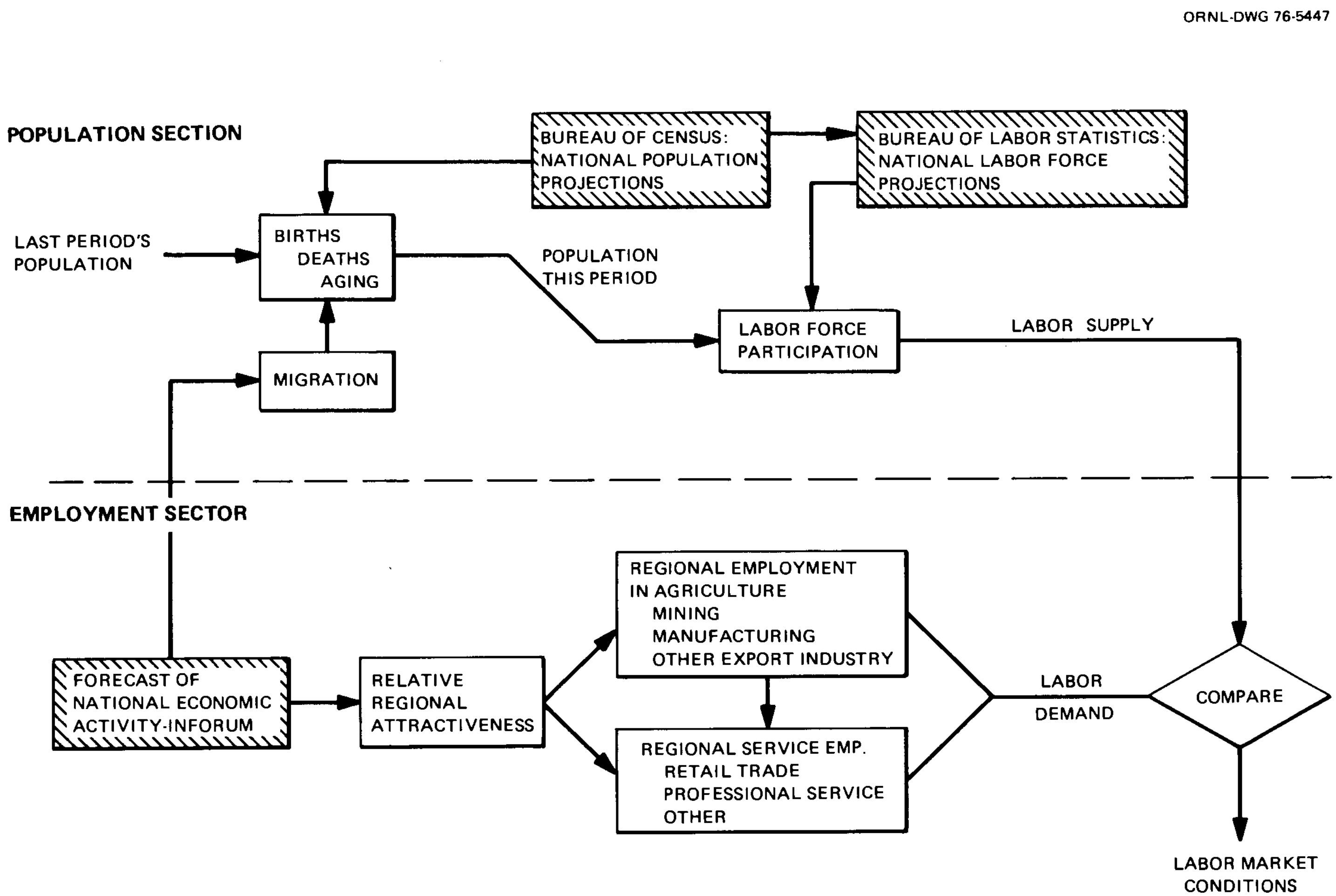


Fig. 5.4. Computational sequence during two five-year time steps.



Note: Predetermined national values indicated by shaded boxes.

Fig. 5.5. MULTIREGION within the context of a national economy

5.3.1 Mortality and fertility

Because mortality and fertility are age- and sex-specific, the overall numbers of births and deaths in a region are quite sensitive to the age-sex composition of the population as a whole. We have found age- and sex-specific mortality and fertility rates for individual BEA areas vary consistently over time from corresponding national averages. While these regional deviations are greater for births than for deaths, both show evidence of a slow decrease over time. The stability of these regional deviations and the slow decrease over time provide a solid basis for projecting regional fertility and mortality trends without references to labor market conditions.

5.3.2 Migration

Understanding the relationship of interregional population migration to changing regional socioeconomic conditions is of paramount importance. While most migration flows are selective of the younger, more educated, and more skilled elements of the population, the greatest need is to better understand how migration acts as a labor market equilibrating force. Our empirical results identify three important sources of this equilibrating role. First, when in-migration and out-migration relationships are taken together, tight local labor market conditions promote net inmigration; the effect is strongest for persons 20-29 years old and declines with increasing age. In this case, labor market conditions are defined as the difference between local and national labor market tightness. Labor market tightness is best measured in terms of a simple employment pressure index (EPI), the ratio of total employment plus Armed Forces personnel to the population of working age (ages 15-64); the higher the EPI, the tighter the labor market. Second, movers appear to exhibit a strong preference for regions with high interregional accessibility (not necessarily high population density), perhaps for the greater freedom of choice and lower risk they offer. Interregional accessibility is measured by a relative population potential variable, the share of the nation's population accessible to each BEA area by highway transport. Third, population density has a negative influence on inmigration and a positive influence on outmigration (except for 20-24 year olds). This seems to indicate that movers prefer ceterus paribus, less densely populated destinations with high interregional accessibility, a preference not inconsistent with increasing suburbanization and the growing suburb to suburb dominance of interregional migrations.

These results are significant for the estimation of regional futures with MULTIREGION in two ways. First, a tight regional labor market influences the estimation of net inmigration, both within and between five-year time steps. Second, increased interregional accessibility influences the estimation of net inmigration between five-year time steps. Together, these forces provide a substantial understanding of some contemporary dynamic regional processes. For example, as a region such as the Southeast experiences more than its proportional share of growth in interregional accessibility as a result of the completion of the Interstate highway network (an exogenous perturbation), industry locates there in response to better market accessibility (to be discussed below) tightening labor markets which increasingly and fairly promptly convert historically large net outmigration streams to net inmigration. This process is further reinforced, albeit with some delay, by the higher relative population potentials that result from growing regional populations that are more effectively tied together by the improved highway network.

5.3.3 Labor force participation

The responsiveness of labor force participation rates to changing socioeconomic conditions is probably not sufficiently appreciated. First, the positive impact of tight labor market conditions (again, best measured by EPI) on male and female labor participation can be especially significant for discretionary workers (all age groups except males aged 25 to 64). Second, the opportunity for females to work (measured by the "femininity" of an area's industrial structure — the actual percent of employed persons that are female) has a very important positive influence on female labor force participation as well as a negative influence on male participation.

The significance of the these results is the obvious flexibility of the regional labor supplies estimated with MULTIREGION. There are substantial changes in labor force participation as labor market tightness varies, and the response of female labor participation to the arrival of new female-intensive industries such as textiles and apparel can be so great that the unemployment rate may remain virtually unchanged. Both of these responses tend to make regional unemployment rates less than ideal targets for regional development planning and analysis and have led to the use of the EPI as our measure of labor market tightness. As a direct result of the use of EPI, labor force participation is carefully treated for the estimation of regional labor supplies, but it is of less consequence than the direct comparison of people and jobs (EPI) for the determination of regional and interregional socioeconomic growth and development.

5.4 THE EMPLOYMENT SECTOR

We now turn to the components of the employment or labor demand sector — natural-resource-based employment, manufacturing employment, and local service employment.

5.4.1 Natural-resource-based employment

Included in this category are agriculture, forestry and fisheries, four categories of mining, and employment related to the use of major outdoor recreation resources such as the Great Smoky Mountains National Park in Tennessee or the Yellowstone National Park in Montana-Wyoming. Because most of these natural resources are not spatially ubiquitous but exist only in certain places, the regional activity levels of these industries can be considered a function of the aggregate demands for their products and the relative regional costs to the user of exploiting the resources at different geographical locations. Because the relative regional costs of exploiting these resources change very slowly, the activity levels of these sectors can be treated fairly exogenously. MULTIREGION employs a formal shift-and-share framework for this purpose. Regional employment levels in each natural-resource-based industry are computed at the beginning of each five-year time step and do not change until the next time step begins; this sector has not been related to labor market conditions.

5.4.2 Manufacturing employment

Regional multiplier (or export base) models embody the argument that so much of the economic activity within small geographic areas is oriented toward serving markets outside the region that, in a very real sense, the activities of these export-oriented industries form the basis or foundation for the remaining local service industries. Within MULTIREGION, most manufacturing industries are considered to be export oriented and regions are assumed to be competing against each other in a game called "industrial location."

Simple regional attractiveness models have been used to estimate the relative importance of regional characteristics: (1) initial conditions, (2) interregional market accessibility, (3) market competition, (4) labor conditions, (5) natural and amenity resource availability, (6) financial resources and subsidies, and (7) the availibility of intermediate inputs to the periodic outcomes of the industrial location game. The empirical results imply that the most important determinants of the present locations of manufacturing employment have been the past locations of employment (initial conditions) and interregional market accessibility; other regional characteristics such as labor conditions and financial subsidies do not appear to be very important at the BEA economic area level.

The importance of initial conditions reinforces the idea that inertia is a very powerful force, but, in addition, the fact that the positive association between present and past employment locations has been significantly less than one-to-one for most industries provides a measure of broad trends toward spatial dispersion. After adjusting for initial conditions, interregional market size — measured in terms of access by truck transportation to final demand, intermediate suppliers, intermediate demanders and others in the same industry — has been the most important determinant of locational change. These results are used in MULTIREGION to consider and measure interregional interindustry linkages and effects.

Within MULTIREGION, a region's future manufacturing employment is estimated at the beginning of each five-year time step and is not altered until the next five-year time step. Thus, it is assumed that manufacturing location responds slowly to changing regional conditions. There may be substantial changes in the location of manufacturing employment over time, but they depend on each industry's trend toward spatial dispersion and changes in interregional market size. Because of this relatively slow response to changing conditions, MULTIREGION recompiles measures of interregional market size only at the end of each five-year time step (see Fig. 5.4).

5.4.3 Local service employment

This employment sector includes industries such as construction, transportation services, wholesale and retail trade, personal and professional services, and public administration. Nationally, service employment has been growing more rapidly than population or manufacturing employment. Regionally, there has been great variation among BEA areas in the amount of local service employment per capita but a general convergence of regions toward national per capita values.

Simple regional attractiveness models have been used to identify initial conditions and total regional employment growth as the major determinants of service employment location. Again, past employment location is the most important determinant of present location, reinforcing the importance of inertia but also capturing trends toward more spatial diffusion. Although local service industries are supposed to be spatially diffused by definition, there is significant evidence of further dispersion, perhaps attributable to a closer alignment over time of regional and national business and consumer tastes and/or a greater "taking in of one's own wash" by all regions. After adjusting for initial conditions, total employment growth is the most important determinant of locational change, which reinforces the notion that the size of regional "multiplier" effects depends on the size of the initial change.

After adjusting for initial conditions and total employment growth, about one-half of the local service industries exhibit a positive association with interregional market size, a negative association with population density, and a weak positive association with labor market tightness. While obviously of less importance than initial conditions and total employment growth, these relationships do have a role in reconciling the population and employment sectors.

Within MULTIREGION, regional service employment in each of sixteen industry groups is computed at the beginning of each five-year time step but after manufacturing and natural-resource-based employment. However, these service employment estimates are subject to revision in response to changing labor market conditions as the population and employment sectors are reconciled within each time step.

5.5 RECONCILING THE POPULATION AND EMPLOYMENT SECTORS

Table 5.1 summarizes the more important labor market equilibrating forces embedded in the population and employment sectors of MULTIREGION. By recalling the computational steps within MULTIREGION, this information may be used to more clearly state the population and employment reconciliation process within a five-year time step (the short term), between five-year time steps (the medium term), and over a series of time steps (the long term). Remember, a multi-stage computation process is followed within each five-year time step: last period values of some explanatory variables are used to produce first-stage estimates of regional population, labor supply and labor demand; these estimates then are recycled a number of times to

Table 5.1. Labor market equilibrating forces embedded in MULTIREGION

	Influenced by:	Contributes to the reconciliation of population/employment sectors during: Short term	Medium term	Long term
<u>Population sector</u>				
Mortality and fertility rates	trended deviations from the nation			
In- and out-migration rates	labor market tightness (EPI)	*	*	*
	population density (P.DEN)		*	*
	relative population potential (R.POT)		*	*
Labor force participation rates	labor market tightness (EPI)			
	industry mix			
<u>Employment sector</u>				
Natural-resource-based employment shares	exogenous shift and share analysis			
Manufacturing employment shares	initial conditions		*	*
	interregional market size		*	*
Local service employment shares	initial conditions		*	*
	total regional employment growth (TEG)	*	*	*
	labor market tightness (EPI)	*	*	*
	population density (L.C)	*	*	*
	relative population potential (R.POT)		*	*

Note: Short term = within a five-year time step.
Medium term = two or three five-year time steps.
Long term = four or more five-year time steps.

ultimately compute final regional values. After each five-year time step, all regional and interregional conditions are recompiled before the next time step is begun.

During the short term (one five-year time step), it is clear that migration and local service employment absorb the adjustments necessary to reconcile the population and employment sectors; their values are adjusted during the multi-stage computations of each five-year time step. While it is also true that labor force participation rates are adjusted at this point, they are of no importance to the reconciliation process because the employment pressure index is used to measure labor market tightness; they would have been very important had the unemployment rate been used. Labor force calculations are included only to provide labor supply information; they do not influence the major outputs (employment and population) of the model. In fact, the picture of a regional economy depicted in Fig. 5.1 has been revised to recognize the reduced importance of labor supply (Fig. 5.6).

During the medium term (2 or 3 five-year time steps), more components of each sector contribute to the reconciliation. Between five-year time steps migration, manufacturing employment, and service employment adjust to changing labor market conditions.

During the long term (4 or more five-year time steps), the fertility and mortality rates may remain exogenous but the absolute numbers of births and deaths in a region can vary enough because of underlying changes in population composition do contribute to the reconciliation of population and employment.

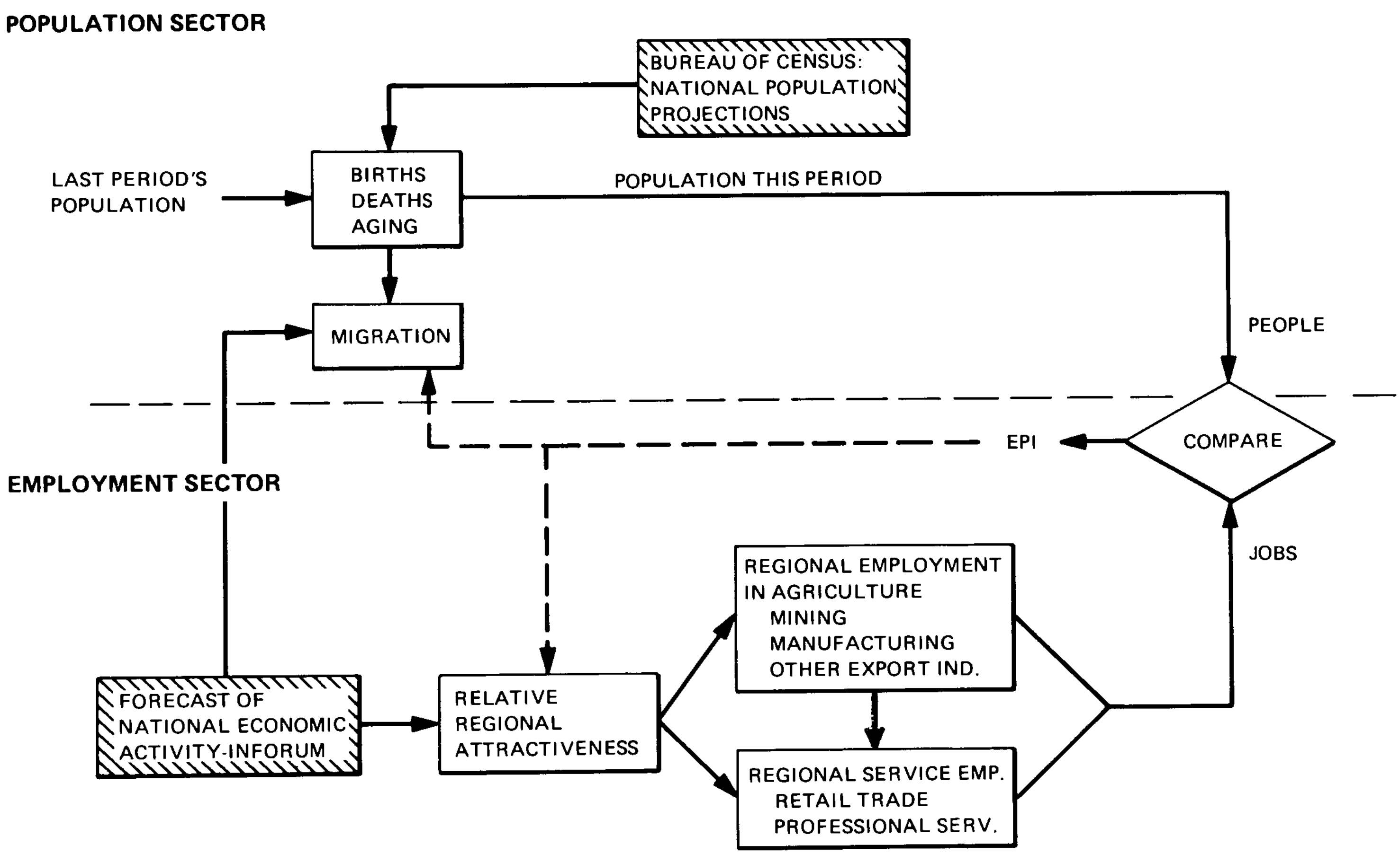
5.6 INTERREGIONAL INTERDEPENDENCE: ACCESS TO MARKETS

Interregional accessibility and interregional market size appear prominently in the empirical analyses of migration, manufacturing employment, and local service employment because they constitute a means of considering and measuring <u>interregional</u> linkages and effects. Since the gradual completion of the Interstate highway system has had a substantial and differential regional impact on the growth of market accessibility, a major effort was devoted to the measurement of the <u>time</u> of truck transport between the metropolitan centers of pairs of BEA areas.

These computed truck operating times for 1950, 1960, and 1970 with projections for 1980, when the Interstate system is expected to be complete, are used to define interregional market size for each BEA area according to the gravity and potential concepts of human interaction commonly used by regional scientists.

In particular, absolute and relative interregional market potentials are computed according to the formulas:

ORNL-DWG 76-5446



Note: Predetermined national values indicated by shaded boxes.

Fig. 5.6. MULTIREGION: the interaction of people and jobs.

$$\text{Absolute potential} = POT_{ik} = \sum_{j=1}^{171} (MASS_{jk}/D_{ij}^{\lambda_k}) \text{ for } D_{ij} \leq 8.3 \text{ hours}$$

$$\text{Relative potential} = R.POT_{ik} = POT_{ik}/MASS_{us,k}$$

where

POT_{ik} = the market potential for commodity k in BEA area i;

$MASS_{jk}$ = a measure of mass appropriate to commodity k in BEA area j (e.g., population or employment in an industry associated with commodity k as a buyer or seller);

D_{ij} = minimum truck operating time between i and j (where i = j, D_{ij} = 1/2 D_{ij} to the nearest BEA area); and

λ_k = distance decay coefficient that varies with the good being shipped.

While the exact definitions of particular interregional market potentials are provided in technical appendix E, it is important to note that the market potential in BEA area i varies directly with mass at area j and inversely with the time of truck transport between i and j. In general, a region becomes more attractive as a destination for migrants and as a location for industry when transportation improvements reduce interregional access times and population and employment grow in nearby regions. Because most regions are growing in attractiveness in this absolute sense, relative market potentials are used to argue that a region becomes more attractive only when its share of the total national market increases.

Within MULTIREGION, interregional market potentials are computed only at the end of each five-year time step for use as inputs to the determination of migration, manufacturing employment and local service employment during the next five-year time step. Thus, interregional effects are assumed to occur slowly in part for computational efficiency but more importantly because empirical studies have identified substantial periods of adjustment to changes in interregional accessibility. MULTIREGION assumes that changes in interregional accessibility have substantial and cumulative effects on regional growth and development in the medium and long term but not in the short term.

5.7 OUTPUTS OF MULTIREGION

In general the outputs of MULTIREGION are intended to resemble those of the OBERS projections and to be put to similar uses. Thus, selected historic and forecast values of employment by industry, population by age and sex and labor force by age and sex are provided for the U.S. as a whole and each of 173 BEA economic areas (see Table 5.2, 5.3, and 5.4). In

Table 5.2 Sample output: population by age and sex

United States or any BEA area	Employment and population by age and sex, historical and projected					
	Selected years, 1950-2020					
	1950	1960	1970	1975	1980	1985
Employment						
Employment/population ratio						
Total population						
Total males						
0-4						
5-9						
10-14						
15-19						
20-24						
25-29						
30-34						
35-39						
40-44						
45-49						
50-54						
55-59						
60-64						
65-69						
70-74						
75 and over						
Total females						
0-4						
5-9						
10-14						
15-19						
20-24						
25-29						
30-34						
35-39						
40-44						
45-49						
50-54						
55-59						
60-64						
65-69						
70-74						
75 and over						

Table 5.3. Sample output: employment by industry

United States or any BEA area						
Population and employment by industry, historical and projected	Selected years, 1950-2020					
	1950	1960	1970	1975	1980	1985
Population						
Employment/population ratio						
Per capita income (1967$)						
Total employment						
1 Agriculture						
2 Forestry and fisheries						
3 Metal mining						
4 Coal mining						
5 Crude petrol. and nat. gas mining						
6 Nonmetallic excl. fuels, mining						
7 Contract construction						
8 Food and kindred products						
9 Textile mill products						
10 Apparel						
11 Printing and publishing						
12 Chemicals and allied products						
13 Lumber products and furniture						
14 Nonelectrical machinery						
15 Electrical equipment						
16 Motor vehicles and equipment						
17 Other transportation equipment						
18 Paper and allied products						
19 Petroleum refining						
20 Primary metals						
21 Fabricated metals and ordnance						
22 All other manufacturing						
23 Railroad transportation						
24 Trucking and warehousing						
25 Other transportation						
26 Communications						
27 Public utilities						
28 Wholesale trade						
29 Retail trade						
30 Finance, insur. and real estate						
31 Lodging and personal services						
32 Business and repair services						
33 Amusement and recreation services						
34 Private households						
35 Professional services						
36 Public administration						
37 Armed Forces						

Table 5.4. Sample output: civilian labor force by age and sex

United States or any BEA area	Population, employment, and civilian labor force by age and sex, historical and projected — Selected years, 1950-2020					
	1950	1960	1970	1975	1980	1985
Employment						
Population						
Employment/population ratio						
Employment/C. labor force ratio						
Total civilian labor force						
Males						
16 & 17						
18 & 19						
20-24						
25-34						
35-44						
45-54						
55-64						
65 and over						
Females						
16 & 17						
18 & 19						
20-24						
25-34						
35-44						
45-54						
55-64						
65 and over						

addition, selected rates of growth and summary measures useful for cross-region comparisons may be tabulated and computer mapped using SYMAP or ORMIS (see Figs. 5.7 and 5.8). At present, interregional market potentials, industry location quotients, coefficients of specialization and shift-and-share components are available as summary measures.

5.8 COMPUTER REQUIREMENTS

The program MULTIREGION is written in FORTRAN IV to run on the IBM 360/91 under the H compiler.

The current version requires approximately 550k of core excluding any graphics. The time required on the model 91 to start in 1970 (base year) and forecast in five-year time increments to 1985 is approximately four and one-half minutes (excluding graphics). Another one and one-half minutes per plot is added for each year displayed with the graphics package in use at ORNL.

The program requires two data input tapes, one for the potential calculations and another for base year starting values. The graphics portion of the program requires an extensive data base involving the latitude and longitude outlines for counties. The program (excluding graphics) uses 5 scratch disk areas during the iterations. At present, a tape containing the basic information for each iteration is saved to allow the user the flexibility of writing their own output procession. However, a print routine exists in the program to output the results of each five-year time step for all or a selected group of BEA's.

The program is designed for batch mode operation but could easily (in theory) be put on a real time system that had the required core availability.

The graphics package currently used with the MULTIREGION program is called ORMIS — a locally developed system for geographics. This package, being developed by the Geographics Section, Mathematics Department, Computer Science Division, should be available in report form within the year.

REFERENCES FOR CHAPTER 5

1. Most of these elements are reviewed in H. W. Richardson, *Regional Growth Theory*, London: The Macmillan Press, Ltd., 1973.

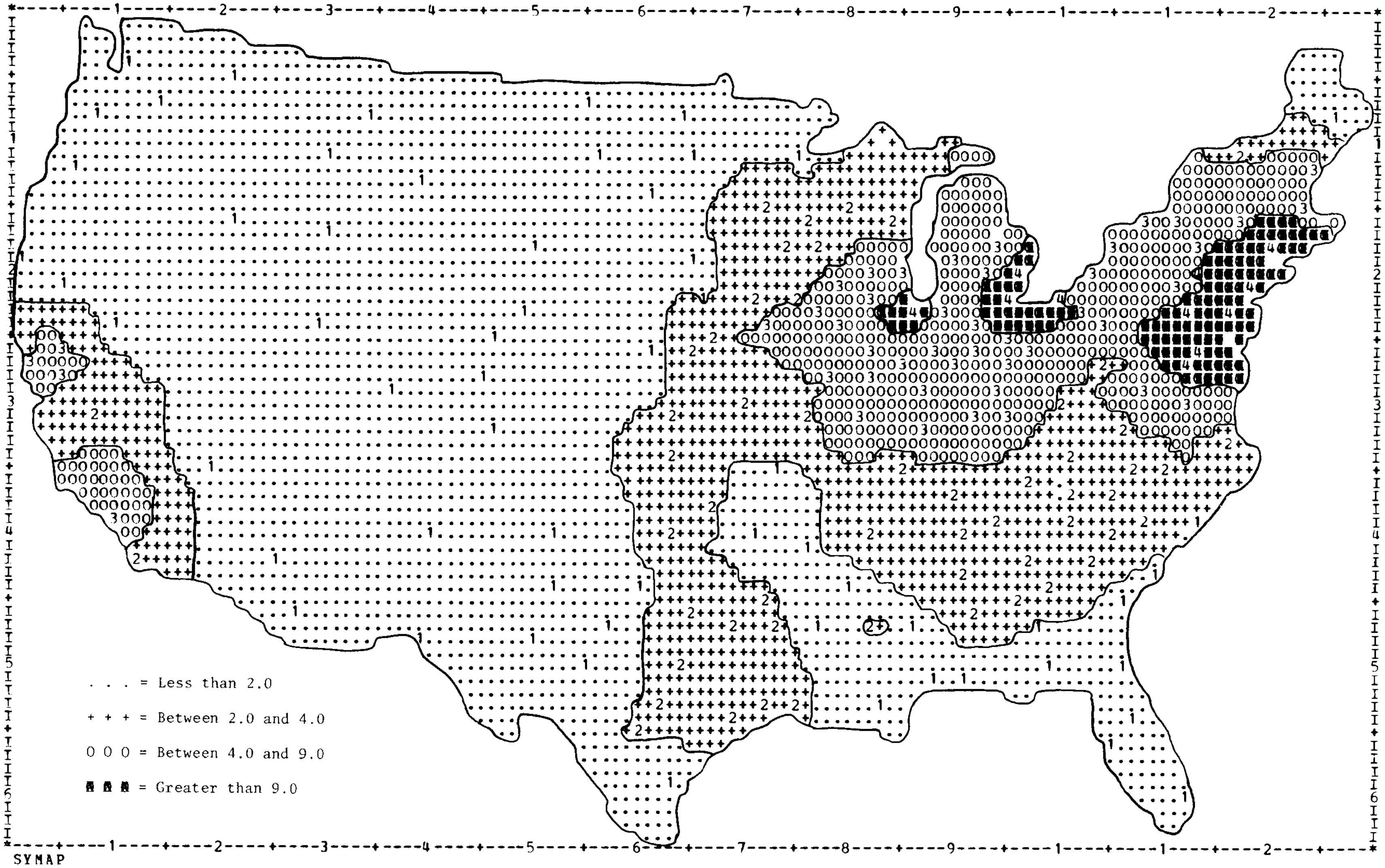


Fig. 5.7. 1970 relative final demand potential
for lumber products and furniture: SYMAP.

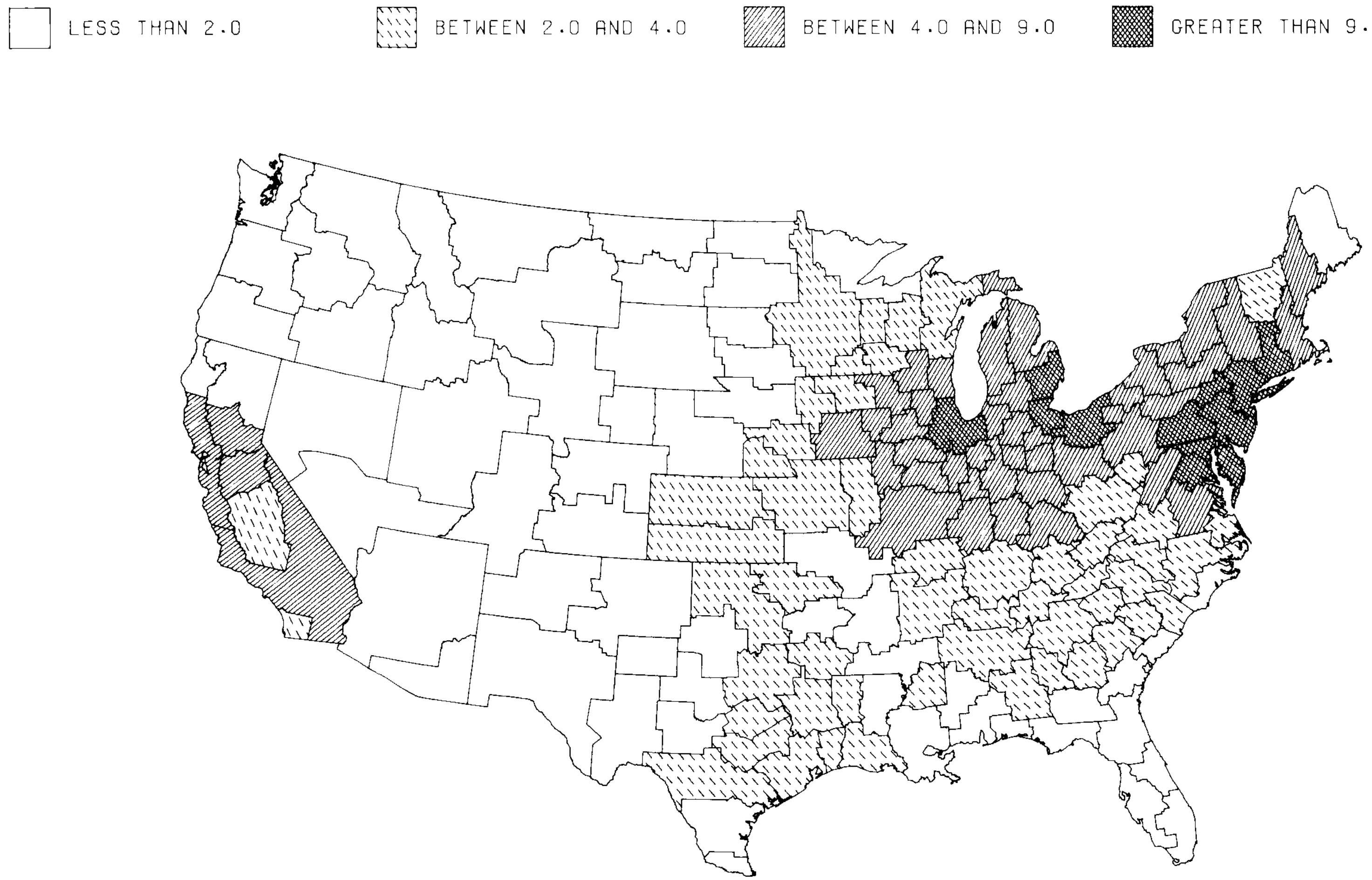


Fig. 5.8. 1970 relative final demand potential for lumber products and furniture: ORMIS.

6. THE POPULATION/PEOPLE/LABOR SUPPLY SECTOR

The empirical results used to form MULTIREGION are summarized in this and the following chapter. In this chapter the components of the population or labor supply sector – mortality, fertility, and immigration, interregional migration, and labor force participation – are reviewed; in Chapter 7 the components of the employment or labor demand sector are reviewed. While the discussions of each component are not exhaustive, they should provide the reader with an improved understanding of the nature of regional and interregional socioeconomic processes as well as more details about the computation methods within MULTIREGION. Complete documentation of the empirical studies of each component appear in technical appendixes A through C.

6.1 MORTALITY, FERTILITY, AND IMMIGRATION

6.1.1 Regional mortality and fertility trends

Age and sex specific insights to mortality and fertility trends are necessary to capture the sensitivity of overall births and deaths to changes over time in the age-sex composition of a region's population. We have searched for these insights by examining historical trends in national-regional mortality and fertility. By combining national birth rates by age of mother and national death rates by age and sex with BEA economic area population by age and sex for the same years, we have been able to compute the expected numbers of live births and deaths per BEA area for 1950, 1954, 1960, 1964, and 1969 under the assumption that national patterns hold in all regions. The comparison of actual and expected events provides a measure of regional deviations from national trends.

The ratios of (actual-expected)/expected live births and deaths for each BEA area and year have been calculated and, to control for annual aberrations in these events or data, three time-period moving averages have been created that roughly center upon 1955, 1960, and 1965. A number of comparisons of these ratios are exhibited in Tables 6.1 and 6.2. First, the frequency distributions for 1965 in Table 6.1 suggest a slight tendency for a representative BEA area to have mortality rates below and fertility rates above the nation's average (the distributions are slightly skewed). Second, 75% of BEA areas had mortality and fertility rates within ±20% of the national averages. While this does leave 25% of BEA areas with substantial deviations, these are amazingly consistent over time. Perhaps the most startling deviation is that for Hawaii's mortality which has consistently been 45% below that for the nation; does the "fountain of youth" exist on some of those islands?

The stability over time of some of these regional mortality and fertility patterns may be guaged from Table 6.2 which contrasts the smoothed 1955 and 1965 deviations. First, the mean regional deviation is larger for births than for deaths, has declined for both, but has declined more

Table 6.1. Frequency distributions of regional mortality and fertility deviations: BEA economic areas, 1965

Deviation from Nation	Mortality		Fertility	
Region-Nation / Nation	Frequency	Relative Frequency	Frequency	Relative Frequency
0.60 to 0.69	-	-	1	0.6
0.50 to 0.59	-	-	1	0.6
0.40 to 0.49	-	-	-	-
0.30 to 0.39	1	0.6	3	1.7
0.20 to 0.29	3	1.7	5	2.9
0.10 to 0.19	18	10.4	28	16.2
0.00 to 0.09	52	30.1	63	36.4
-0.10 to -0.01	79	45.7	65	37.6
-0.20 to -0.11	18	10.4	7	4.0
-0.30 to -0.21	-	-	-	-
-0.40 to -0.31	1	0.6	-	-
-0.50 to -0.41	1	0.6	-	-
Total	173	100.0	173	100.0

Table 6.2. Comparison of 1955 and 1965 regional mortality and fertility deviations: BEA economic areas

	Fertility	Mortality
Absolute value of deviations		
A. Mean value 1955	0.097	0.080
B. Mean value 1965	0.081	0.074
C. % 1965 mean is of 1955	83.5%	92.5%
D. # of increases	64	76
E. # of decreases	104	89
F. # of no change	5	8
Frequency of sign changes	25	17

rapidly for births than for deaths — signs of slow convergence to national averages. Second, the number of decreases in absolute value between 1955 and 1965 outnumbered the number of increases (especially for fertility) — another sign of slow convergence to national averages. Finally, the number of sign changes between 1955 and 1965 was small — a sign of stable deviations. The stability of these regional deviations and their slow decrease over time is of great interest because it provides a solid basis for projecting regional fertility and mortality trends without reference to regional socioeconomic conditions.[1] Within MULTIREGION, regional age and sex-specific mortality and fertility rates are assumed to slowly converge from their initial values toward national averages.

6.1.2 The regional destinations of immigrants

We are indeed a nation of immigrants. While the flow of immigrants to the U.S. has averaged only 400,000 persons per year for the last few years and is projected to remain at this level for the foreseeable future, there have been periods in our history such as 1907-1914 when the *annual* number of immigrants equalled 10-15 percent of our total population (Table 6.3). In addition, since immigrants have tended to concentrate in some regions of the U.S. almost to the exclusion of others, the immigrant nature of our population is most apparent in areas of the Northeast, California, Chicago, Detroit, Pittsburgh, Seattle, Miami, and our borders with Mexico; immigrants are conspicuous by their absence from the South and lower Great Lakes regions.

Within MULTIREGION we assume the first residence of new immigrants will be those cities or regions with large stocks of previous immigrants. Once established, however, new immigrants are expected to become a part of our normal internal migratory streams. The proportion of a region's 1970 population that was of foreign stock (i.e., the foreign-born population and the native population of foreign or mixed parentage) is presumed to give a rough measure of the concentrated pattern of immigrant destinations; no attempt has been made to distinguish among the likely regional destinations of immigrants from different origins.[2]

6.1.3 The order of demographic computations

In an effort to expose more of the computational process within MULTIREGION, the order of demographic computations is now reviewed. Basically, a cohort-component model is used where population "this period" is assumed to equal population "last period," plus births, minus deaths, plus inmigrants, minus outmigrants. But, the components of population change — births, deaths, aging, outmigration and inmigration — occur continuously and simultaneously over time and space while demographic computations occur sequentially and discontinuously. In these circumstances the order of the computations can have a substantial effect on the resulting projections. As a consequence particular attention has been paid to the order of regional demographic computations within MULTIREGION. They may be divided into four phases.

Table 6.3. Annual net immigrants to the United States for selected years: 1900-1970

Year	Immigrants* (thousands)	Population (millions)	Annual immigrants per 1000 population
1900	449	76.1	5.9
1907	1285	87.0	14.8
1910	1041	92.4	11.3
1914	1218	99.1	12.3
1921	805	108.5	7.4
1924	706	114.1	6.2
1930	242	123.1	2.0
1935	35	127.2	0.3
1940	77	132.1	0.6
1945	162	139.9	1.2
1950	299	151.7	2.0
1955	337	165.3	2.0
1960	327	179.3	1.8
1965	373	194.2	1.9
1970	428	203.2	2.1

*Immigrants are non-resident aliens admitted to the United States for permanent residence.

Source: U.S. Bureau of the Census, *Historical Statistics of the United States: Colonial Times to 1957* (1960) and *Statistical Abstract of the United States, 1971*.

Phase I - Preliminary Data Manipulation. Necessary information is prepared from national/regional data, estimates, and projections including (1) trended national/regional mortality and fertility adjustment factors, (2) regional immigration shares, (3) regional in- and out-migration rates by age and sex (to be discussed later), and (4) projected national total immigrants, births and deaths by age and sex.

Phase II - Allocation of immigrants. Regional immigration shares and the national age-sex distribution of immigrants are combined to increment base year regional populations for five years of net immigration.

Phase III - Track A. (Because the order of computation does matter, previous experience suggests two alternatives — A and B).

A1 - Aging. All population cohorts are aged five years. This leaves the 0-4 age cohorts vacant.

A2 - Mortality. National mortality rate projections are combined with trended national/regional mortality adjustment factors to reduce the post Phase II populations by five years' deaths. Across region sums are forced to national totals. The 0-4 cohorts remain vacant.

A3 - Migration. Regional in- and out-migration rates by age and sex (to be discussed in Section 6.2) are applied to the population of each region to generate estimates of five years' interregional movement. Across region sums of in-migrants by age and sex are reconciled to across region sums of out-migrants by age and sex (proportion in-migrants, out-migrants, or both). Adjusted net in-migrants by age and sex are added to regional populations. The 0-4 age cohorts remain vacant.

A4 - Fertility. Age specific national fertility rate projections are combined with trended national/regional fertility adjustment factors and applied to the five-year period average ([beginning plus ending]/2) regional female population of child bearing age (15-44 years old) to increase the 0-4 age cohorts for five years' live births (48.8% females). Across region sums are forced to national totals. One-half of the regional mortality rates by age (0-4) and sex are applied to estimate the five years' deaths within the earliest age cohort whose population has existed for only 2 1/2 years on average. Across region sums of 0-4 age cohort deaths are forced to national totals. Live births adjusted for deaths becomes the population of each 0-4 age cohort.

A5 - Balancing to nation. Across region sums by age and sex are forced to national totals by age and sex.

Phase III - Track B (Details as above.)

B1 - Aging

B2 - Migration

B3 - Mortality

B4 - Fertility

B5 - Balancing to nation

Phase IV - Reconciliation. The results of tracks A and B (A5 and B5) are reconciled by averaging the corresponding pairs of the 173 x 32 matrices and forcing the sums of these numbers across regions to national totals by age and sex.

6.2 INTERREGIONAL POPULATION MIGRATION

An understanding of how interregional population migration responds to changing socioeconomic conditions is one of the most critical components of MULTIREGION. For this reason, age- and sex-specific in- and out-migration rate functions have been estimated with the expectation that the results may be used to simulate and forecast population movements between BEA economic areas. The functions were estimated by applying transformed regression analysis[3] to pooled 1960 and 1970 census data for State Economic Areas (SEAs) and may be reported separately for persons 20 years old and above and for younger age groups. A brief review of past migration research is included in Appendix B.[4]

6.2.1 Persons 20 years old and above

Pooled cross-section analyses of migration were limited to 1960 and 1970 data for twenty-two age/sex cohorts beginning with age 5; whites and non-whites could not be studied separately because Census migration data were tabulated by race in 1970 but by color in 1960. Samples of the results for males 20 to 29 years old are presented in Table 6.4; a complete tabulation for all age/sex cohorts is included in Appendix B. In an effort to illustrate the relative importance of each explanatory variable to the determination of migration rates, the results are expressed in terms of Beta Coefficients which indicate the percent of a "typical" variation in the dependent variable associated with a "typical" variation in the explanatory variable; in both cases, a "typical" variation is equal to one standard deviation.[5]

Table 6.4. Beta coefficients for five-year migration rate functions for SEA's: transformed regression analysis of pooled cross-section data

Explanatory variable	(Comments for MULTIREGION computations)	Five year migration rates[A]			
		20-24 year old males		25-29 year old males	
		IN	OUT	IN	OUT
N-L EPI	(at T; use "trial" values)	-.120***	.036*	-.156***	.034**
R. POT (-5)	(at T-5; exogenous)	.004	-.080**	.086***	-.110***
P. DEN	(at T; use "trial" values)	-.057***	-.069***	-.071***	.056***
CLIM	(a constant)	.065***	.005	.094***	.030
M.S.	(at T; a constrained trend)	.265***	1.007***	.594***	.166***
A.F.	(at T; exogenous)	.618***	-.191***	.300***	.576***
COL	(at T; exogenous)	.411***	-.343***	.173***	.460***
POOLED (1960=0, 1970=1)		-.040***	.260***	.009	.009
REGION 1 NE		-.044***	-.039*	-.053***	-.029*
2 MA		-.050***	-.017	-.069***	-.024
4 SE		-.016	-.053	.022	-.008
5 PL		-.014	.120***	.009	.051***
6 SW		.047***	.059**	.089***	.100***
7 MTN		-.003	.014	.068***	.001
8 FW		.074***	.028	.170***	-.019
R^2		.837	.640	.738	.784
F-Value (degrees of freedom)		346.1 (15,996)	120.8 (15,996)	190.7 (15,996)	245.9 (15,996)

A - the number of migrants during the period T-5 to T divided by the population in T-5
* - significantly different from zero at the .10 level
** - significantly different from zero at the .05 level
*** - significantly different from zero at the .01 level

Our results include as explanatory variables the national minus local employment pressure index (N-L EPI), median years of school completed by persons 25 years old and over (MS), Armed Forces personnel as a percent of the population (AF), college students as a percent of the population (COL), population density (P.DEN), relative population potential (R. POT — a gravity model measure of potential interregional interaction and accessibility), a dummy variable for climate to identify regions with mild winters and especially frequent sunshine (CLIM), and regional dummy variables for all subregions of the nation (except the Great Lakes) as defined by the U.S. Department of Commerce.[6] The regional dummy variables were included at the last stage of the analysis as measures of longer term regional conditions (relative to the Great Lakes = 0) not captured by any of the other explanatory variables. While the classification is not everywhere clear, the reversal of signs between in-migration and out-migration analyses (see Table 6.4) seems to imply that R.POT, P.DEN, N-L EPI, AF, and COL are most frequently measures of "characteristics of place." The remaining variables — MS, CLIM, and regional dummies — behave most frequently as measures of "characteristics of persons."

The geographic mobility of at least two groups, Armed Forces personnel and college students, are not likely to be in response to economic conditions but are very unidirectional for specific age groups. Taken together the AF and COL variables seem to capture the very large and mostly unidirectional five-year flow of 20 to 24-year olds <u>toward</u> Armed Forces bases and <u>toward</u> college campuses as well as the smaller and less directed five-year flow of 25 to 29-year-olds <u>away</u> from these same institutions.

Since there has been extensive discussion of how education raises mobility, median years of school completed (MS) was included as an education variable. MS is clearly a "characteristics of persons" variable as its coefficients are uniformly positive and statistically significant for both in- and out-migration for all age and sex cohorts. Furthermore, the strength of the relationship is quite balanced between in- and out-migration while generally declining with age. But, persons 20 to 29-years-old do prove to be exceptions. For example, a representative region whose MS level is assumed to increase by one standard deviation might expect (1) a greater increase in out-migration (β = 1.007) than in-migration (β = .265) for males 20-24 years old and (2) a greater increase in in-migration (β = .594) than out-migration (β = .166) for males 25-29 years old. However, in all cases, including these exceptions, gross migration is increased by higher median schooling.

Since significant portions of recent population movements to the west, southwest, and south might reflect the pursuit of a more temperate climate and favorable living conditions rather than better economic opportunities, most migration analyses try to standardize for climate. We have introduced a simple climate variable (CLIM) to identify regions with relatively mild winters and abundant sunshine. CLIM is a compound dummy variable formed by summing two integer measures, mild winters and frequent sunshine,[7] for each region with the result that it has an integer range of variation from 0 for cold overcast SEA's to 3 for especially mild and sunny SEA's. CLIM has proved to be a statistically significant explanatory variable for both in- and outmigration; the effect of mild winters and abundant sunshine is stronger for inmigration than for outmigration but positive and significant for both. The positive association with outmigration while somewhat unexpected may suggest the following hypothesis: many persons of all ages move in the pursuit of a mild climate but some later find the climate to be not as favorable or not as important as they may have originally expected with the result that they move again. In sum, mild sunny climates do promote net inmigration by stimulating gross inmigration more than gross outmigration.

The employment pressure index (EPI) enters the migration analysis in the form of the difference between its national and local values (N-L EPI); the national value of EPI acts as a proxy for labor market conditions in alternative regions. The coefficients of the N-L EPI variable are negative and very significantly different from zero for inmigration as one would expect a priori; where employment conditions are better locally than at the alternatives, inmigration is promoted. Similarly, the N-L EPI coefficients are positive and significant in the out-migration equations for persons aged 20 to 29; tight local labor market conditions retard the outmigration of these persons, reinforcing the labor market equilibrating forces found for inmigration. In sum, when in-migration and out-migration functions are taken together, tight local labor market conditions promote net inmigration, the effect being strongest for persons 20-29 years old and declining with age.

By combining the familiar gravity-potential model with measures of motor vehicle operating times between cities that were sensitive to improvements to road conditions (i.e., the gradual completion of the Interstate highway system) and transport technology, estimates of the population potential of each SEA were derived for 1955 and 1965.[8] These estimates were then converted to relative population potentials (R.POT) by dividing by the corresponding total U.S. population; the result is a measure of the share of the nation's population that was accessible to each SEA by highway transportation.

The coefficients of the relative population potential (R.POT) variable are positive for inmigration and negative for outmigration implying that movers have a strong preference for regions with high interregional accessibility (not necessarily high population density) perhaps for the greater freedom of choice and lower risk they offer. In both cases, the effect diminishes with age. For example, a representative region experiencing a one standard deviation increase in R.POT might expect an increase in inmigration for 25 to 29 year-old males (Beta = .086) reinforced by a comparable decrease in outmigration (Beta = -.110); combined, these migration responses are among the strongest we have estimated. This requires that the notion of "characteristics of place" be expanded to include location relative to other places. Combining this concept with an explicit measure of population density can yield a substantial "deepening" of our understanding of recent rural-to-urban and metropolitan-to-metropolitan population movements.

In general, population density (P.DEN) has a negative influence on inmigration and a positive influence on outmigration (except for 20-24 year olds). The negative association with the outmigration of 20-24 year olds probably represents the rural-to-urban movement of younger persons during past decades. Taken together R.POT and P.DEN seem to indicate that movers prefer, ceterus paribus, less densely populated destinations with high interregional accessibility. This preference is not inconsistent with increasing suburbanization and the growing suburb-to-suburb dominance of intermetropolitan migrations.

The pooled variable (1960 = 0, 1970 = 1) was included to capture any time trend that remained after including all previously mentioned variables. Somewhat surprisingly, most coefficients were significantly different from zero and negative. The negative sign implies that after adjusting for changes in all of the variables considered, there has been a decline over time in the propensity to migrate. An important exception, however, is the positive trend for 20-24 year-old outmigrants; apparently young persons have been becoming substantially more mobile during the last decade and for reasons not completely picked up by such variables as COL, AF, and EPI.

In the last stage of our analysis regional dummy variables were included to capture the effects of longer-term regional conditions (relative to the Great Lakes = 0). Since these regional dummy variables had only limited intercorrelations with the previously included explanatory variables, their significance was generally not at the cost of other variables. Relative to the Great Lakes region (1) the Far West, Southwest, Mountain, and Southeast regions have higher in-migration rates, (2) the Middle Atlantic and New England regions have lower in-migration rates, (3) the Far West, Southwest, Mountain, Plains, and Southeast regions have higher out-migration rates, and (4) the New England and Middle Atlantic regions have lower out-migration rates. Given these results, would it be appropriate to conclude that these longer-term regional conditions reflect cultural differences among the Northeast, industrialized Midwest, and the rest of the nation?

6.2.2 Younger age groups

Basically, the in- and out-migration rates of each early age group have been regressed on the in and out rates, respectively, of their female parents' age groups.[9] In addition, since a large portion of the 18- and 19-year-olds are apt to move independently of their parents, the regression for the 15-19 age group includes the Armed Forces, college students, R.POT and the migration rates of the appropriate 20-24 age and sex group as explanatory variables.

Generally, the results include the positive association between the movement of parents and children that one would expect a priori although perhaps not as neatly and consistently as one might wish. The movements of the 15-19 age group showed the least consistent associations with the movements of parents but were very meaningfully correlated with the Armed Forces and college students variables.

6.2.3 Computational sequence

While the order of demographic computations has already been reviewed, the computational sequence for the migration component is now further exposed. Once more, a multi-stage computation process is used. Trial (last period) values of some explanatory variables are used to produce first-stage estimates of interregional migration, regional labor supply and labor market tightness (EPI) which are then used to compute revised estimates of interregional migration and regional labor supply. The computation process continues in this fashion through a user-specified number of stages. At all stages, across region sums of inmigrants by age and sex are forced to across region sums of outmigrants by age and sex (interregional balances). These migration computations within MULTIREGION may be divided into six phases.

Phase I - Preliminary Data Manipulation. Necessary information is prepared from national/regional data, estimates, and projections including (1) CLIM (a constant), (2) P.DEN, R.POT, and EPI (last period values), (3) COL, AF, and MS (constrained trends discussed further in Appendix B), and (4) damped values of regional dummy variables.

Phase II - Compute Trial Migration Rates. Regional in- and out-migration rates by age and sex are computed from Phase I data. At this point, the use of "transformed" regression analysis makes the preparation of forecasts slightly more complex, although more accurate than in the case of ordinary least squares. In particular, some of the forecast or lagged explanatory variables must be weighted before being combined with statistical coefficients and then the forecast migration rates must be unweighted before they are used. In addition, the forecast migration rates of some age groups are adjusted to component cohorts.

45-54 ⟹ 45-49, 50-54

55-64 ⟹ 55-59, 60-64

65 and over ⟹ 65-69, 70-74, 75 and over

Phase III - Alter Trial Migration Rates for the Size Difference of BEA's and SEA's. Apply a scalar equally to all trial migration rates to reduce the population flows for the fact that the land area of the average SEA is less than that of the average BEA area. While the exact value of the scalar is to be determined by trial and error, a theoretical argument can be made for a value close to 1.0.

Phase IV - Trial Gross Migrants by Age and Sex. Altered regional migration rates are applied to estimated population by age and sex. Across region sums of inmigrants by age and sex are forced to across region sums of outmigrants by age and sex (interregional balancing).

Phase V - Trial Labor Market Conditions. Trial labor supply (people) by sex is brought together with trial labor demand (jobs) to establish trial labor market conditions including EPI and P.DEN. Floors and ceilings are applied to some of these variables.

Phase VI - Final Migration, Labor Supply and Labor Market Conditions. Final values are computed by reiterating a user-specified number of times. Interregional balances, national control totals and regional ceilings and floors are imposed during each iteration.

6.3 LABOR FORCE PARTICIPATION

The responsiveness of labor force participation to changes in socioeconomic conditions is carefully treated within MULTIREGION for the estimation of regional labor supplies. But, as has already been mentioned in Chapter 5, the decision to use the employment pressure index (EPI) as the measure of labor market tightness makes the comparison of labor supply and labor demand less important than the direct comparison of people and jobs (EPI) for the determination of regional and interregional socioeconomic growth and development. Still, the obvious flexibility of regional labor supplies have received substantial attention; labor force participation rate (LPR) functions have been estimated by age and sex through an analysis of all 173 BEA areas using 1960 and 1970 data. A brief review of past labor force participation research is included in Appendix C.[10]

6.3.1 Relative labor force participation

During the 1960's the most striking change in national labor force participation patterns was the very rapid increase in participation by women against a backdrop of continued but less dramatic declines by men. Much of the very rapid increase in female participation has been associated with drastic declines in the birth rate and some delay in marriage among other factors.[11] However, special circumstances like the decline in the birth rate are not expected to continue and official projections propose much less dramatic change during the next two decades; the increase in female labor participation is expected to moderate. These nonlinear secular trends in national labor participation have important implications for regional analysis.

The absence of a time-series of participation data for regions has severely restricted any attempt to directly estimate nonlinear regional trends. As a consequence, we have assumed that regional secular trends generally follow national trends and have concentrated on explaining the deviations of regions from national norms through the use of relative (local/national) participation rates as dependent variables. Then, during projection periods, nonlinear secular trends embodied in national projections can be carried over to regions through the relative LPR variables.

Samples of the empirical results for males and females aged 18 to 34 are presented in Table 6.5; a complete tabulation for all age-sex cohorts is found in Appendix C. Again, the results are expressed in terms of Beta coefficients to illustrate the relative importance of each explanatory variable. The explanatory variables include the employment pressure index (EPI), median years of school completed by persons 25 years old and over (MS), female industry mix (FIM), Armed Forces personnel as a percent of the population (A.F.), college students as a percent of the population (COL), and regional dummy variables for all subregions of the nation (except the Great Lakes). Regional dummy variables were again included at the last stage of the analysis as measures of longer term regional conditions (relative to the Great Lakes = 0) not captured by any of the other explanatory variables.

The positive sign of the employment pressure index implies that a tight labor market will be associated with high labor force participation. The size of the EPI coefficients plus its range of variation in the sample suggest that its overall impact on male and female participation can be significant, especially for discretionary workers (all age-sex groups except males aged 25 to 64). The average Beta coefficient across the age-sex cohorts shown in Table 6.5 is approximately .5 which indicates that 50% of a standard deviation change in the dependent variable has been associated with a one standard deviation variation in EPI. One can consider these results to be evidence of the discouraged worker effect — slack times cause some potential workers to become so discouraged that they drop out of the labor force.

Median years of school completed by persons 25 years old and over (MS) appears to be a good measure of the long-term benefits of working (or the costs of not working). Since long-term market wage rates are highly correlated with median schooling, one could interpret the positive coefficient as saying that an increase in median schooling implies an increase in average skill and wage levels which are more directly responsible for drawing more persons into the labor force. Of course, other interpretations are possible. One could argue that more highly educated individuals by nature are more motivated and that this motivation is translated into higher levels of labor participation. Whichever interpretation one chooses, there does appear to be a statistically significant positive relationship between labor participation and regional education level for prime aged males (18-44) and young (14-17) females. In the example shown for males aged 25 to 34, the Beta coefficient implies that a one standard deviation increase in the level of MS would be associated with a 37% increase in relative LPR.

Statistically significant negative associations between LPR and education (MS) were found for females aged 25 through 44 and males 65 and over. These results might be rationalized as follows: (1) a substantial number of females living in areas of high median schooling are financially able to not work during their primary child rearing years while females living in areas of low median schooling cannot afford to stay at home and (2) some older males living in areas of high median schooling are financially able to not work in their later years. The impact of these effects can be fairly substantial as the results for females aged 25 to 34 indicate; a standard

Table 6.5. Beta coefficients for relative labor force participation rate functions, BEA economic areas: pooled cross-section data for 1960 and 1970

Explanatory variable	(Comments for MULTIREGION computation)	Dependent variable = local LPR/national LPR			
		Males		Females	
		18-24 years old	25-34 years old	18-24 years old	25-34 years old
EPI	(at T; exogenous to labor supply)	.429***	.468***	.504***	.555***
FIM	(at T; use "trial" values)	-.113**	-.379***	.632***	.807***
COL	(at T; exogenous)	-.716***	-.526***	-.107***	.031
A.F.	(at T; exogenous)	.405***	.033	-.286***	-.252***
M.S.	(at T; a constrained trend)	.136***	.372***	-.075	-.289***
Pooled (1960=0, 1970=1)		.395***	.375***	-.295***	-.448***
Region 1 NE		-.131***	.012	-.091***	-.064***
2 MA		-.151***	-.015	.016	-.012
4 SE		-.117***	-.042	-.422***	.390***
5 PL		-.054**	-.091**	-.070*	-.168***
6 SW		-.025	-.044	-.373***	.101***
7 MTN		-.033	-.088**	-.164***	.025
8 FW		.035	-.138***	-.136***	.200***
R^2		.817	.566	.676	.796
F-value (degrees of freedom)		119.1 (13,332)	35.7 (13,332)	56.3 (13,332)	104.5 (13,332)

* - significantly different from zero at the .10 level
** - significantly different from zero at the .05 level
*** - significantly different from zero at the .01 level

deviation increase in median schooling would be associated with 29% of a standard deviation decrease in participation.

The opportunity to work (somehow measured) should be very important in explaining female labor participation because of the rural and remote nature of many of the BEA areas in our sample. Originally, we thought either of two measures, percent of the population living in urbanized areas or population density, would capture the assumed greater work opportunities for women in urbanized areas, but a female industry mix (FIM) variable, which attempts to measure the "femininity" of an area's industrial structure, has shown to be much more important. FIM is defined as "the actual percent of employed persons that are female."[12] Perhaps the most pleasant surprise of our empirical efforts has been the importance of FIM in explaining LPR. While apparently of less importance to male than to female participation, the effect is important to both.

Again measured by Beta coefficients, a one standard deviation increase in female industry mix is associated with an 81% of a standard deviation increase in participation by females aged 25 to 34. The same increase in FIM would be associated with 38% of a standard deviation decrease in participation by males aged 25 to 34. Two special conditions considered in the analysis were the presence in a region of significant college or Armed Forces populations. A priori, either or both of these conditions should impact the LPR of persons aged 18 to 24 most significantly. Since attendance at college is a rather full-time endeavor, the presence of a large college population should reduce the participation rate of persons of college age. Indeed there is a statistically significant negative association between "college students as a percent of the population" (COL) and the participation of males aged 18 to 24 (Beta coefficient = -.716).

Since the age-sex specific LPR data provided by the Censuses of Population include Armed Forces personnel who have effective participation rates of 100% as part of the labor supply, one should expect the participation rates of prominent Armed Forces age-sex cohorts to be above average. In fact, the results for males aged 18 to 24 are positive and statistically significant. However, a negative association does exist between LPR and the presence of a large Armed Forces population for all females and for males aged 45 to 64. This is probably due to the inclusion of Armed Forces in the numerator of the employment pressure index (EPI). This measure of market tightness most likely overstates the demand for discretionary labor force members in regions with high concentrations of Armed Forces personnel.

The trend effect as represented by the coefficient of the "pooled" variable needs careful attention. Since the dependent variable is relative (regional/national) LPR, a negative pooled coefficient does not imply declining participation (negative secular trend) over time; the secular trend is embedded in national values (the denominator of the dependent variable). A negative coefficient does imply a trend toward more BEA areas with LPR rates below the national average whereas a positive coefficient implies a trend toward more BEA areas with LPR rates above the national average. In our empirical results negative coefficients were associated with female LPR functions and positive values with males. If these trends persist, a majority of BEA areas would have male participation above and female participation below the national average.

In the last stage of our analysis regional dummy variables were included to capture the effects of longer term regional conditions (relative to the Great Lakes =0). The regional dummy variables did contribute substantially to the overall explanatory power of the LPR functions of discretionary labor groups (all age-sex groups except males aged 25 to 44). Again the regional dummy variables had only limited intercorrelations with the previously included explanatory variables, so their significance was generally not at the cost of other variables. The results, however, are hard to generalize across regions. Relative to the Great Lakes region, (1) the participation of the youngest and oldest age groups is higher in the Plains and Mountain regions, (2) the participation of young females aged 14 to 24 is lower in the Southeast and Southwest regions, (3) participation is generally higher in the Far West, and (4) generally lower for young males and females aged 14 to 24 in the New England and Middle Atlantic regions.

6.3.2 The computational sequence

The decision to use the employment pressure index (EPI) as the measure of labor market tightness within MULTIREGION makes the comparison of labor supply and demand less important than the direct comparison of people and jobs (EPI) for the determination of regional economic conditions. As a result, regional labor supplies are estimated after all other conditions have been determined; a multi-stage computation process is not necessary. The labor supply computations that are required within MULTIREGION may be divided into four phases.

Phase I - Preliminary Data Manipulation. Necessary information is prepared from national/regional data, estimates, and projections including (1) EPI (current), (2) COL, AF, and MS (as per migration subroutine), (3) FIM (last period), (4) trended regional dummies, and (5) national total labor supply by age and sex in Census of Population terms.

Phase II - Compute Labor Participation Rates. Regional labor participation rates by age and sex are computed from Phase I data. Some age groups are split to match BLS categories: 18-24 split to 18-19 and 20-24 and 45-64 split to 45-54 and 55-64.

Phase III - Labor Supply by Age and Sex. Regional participation rates are applied to the estimated population by age and sex. Across region sums by age and sex are forced to national totals.

Phase IV - Labor Market Conditions. Regional labor supply is brought together with labor demand to establish male and female unemployment rates. Floors and ceilings (boundary conditions) may be applied to these variables.

REFERENCES FOR CHAPTER 6

1. There is a literature that attempts to relate fertility and mortality to socioeconomic conditions. For example, Marc Nerlove and T. Paul Schultz, *Love and Life between the Censuses: A Model of Family Decision Making in Puerto Rico, 1950-1960*, The Rand Corporation, RM-6322-AID, September 1970, and Harvey Leibenstein, "An Interpretation of the Economic Theory of Fertility: Promising Path or Blind Alley?" *Journal of Economic Literature*, Vol. XII, No. 2 (June 1974), pp. 457-479.

2. Should the origin composition of future immigration streams shift dramatically from the historic European emphasis (e.g. to Asia), a more refined treatment of immigrant destinations would be appropriate.

3. Because data from samples of extremely different sizes were being used, the residual variation about regression surfaces fitted by ordinary least squares methods varied systematically with SEA size measured in terms of population. As a consequence, a modified weighted least squares procedure has been used to weight or transform only those variables subject to sampling error (i.e., resulting from the 20 or 25 percent sample census enumeration procedure). Since this problem was most acute with SEA data, the transformed least squares procedure was used in all migration analyses.

4. More extensive literature reviews would include M. I. Greenwood, "Research on Internal Migration in the United States: A Survey," *Journal of Economic Literature*, Vol. XIII, No. 2 (June 1975), pp. 397-433; H. S. Parnes, "Labor Force Participation and Labor Mobility," *A Review of Industrial Relations Research*, Vol. I (1970), pp. 1-78; R. Paul Shaw, *Migration Theory and Fact: A Review and Bibliography of Current Literature*, Philadelphia, Regional Science Research Institute, 1975; and P. N. Ritchey, "Explanations of Migration," *The Annual Review of Sociology* (forthcoming).

5. Beta coefficients are especially useful where the units of measurement vary among variables so as to cloud their relative importances. A. S. Goldberger, *Economic Theory*, New York: J. Wiley and Sons, Inc., 1964, pp. 197-200.

6. As demarcated by the Regional Economics Division,
   New England (1) = ME, NH, VT, MA, CT, RI
   Mideast (2) = N.Y., PA, NJ, MD, DC, DL
   Great Lakes (3) = OH, IN, IL, MI, WI
   Southeast (4) = VA, WV, KY, TN, NC, SC, GA, AL, MS, FL, AR, LA
   Plains (5) = MN, ND, SD, IA, KS, NE, MO
   Southwest (6) = OK, TX, NM, AZ
   Mountain (7) = MT, CO, UT, ID, WY
   Far West (8) = WA, OR, CA, NV, AK, HI.

7. First for mild winters, a zero was assigned to SEA's with more than 3000 heating degree days per year, a one was assigned to SEA's with more than

1000 and up to 3000 heating degree days, and a two was assigned for 1000 or fewer degree days. Second for frequent sunshine, SEA's with less than 120 days with precipitation greater than .01 inches were assigned a one, zero otherwise. These two variables were then summed to form CLIM. All data were from the *National Atlas of the United States of America* (Washington, D.C.: U.S. Government Printing Office, 1970).

8. Precise formulations of these gravity-potential measures are included in Appendixes B and H.

9. The likely parent group has been defined to be the lower bound of an early age group plus 20 years to the upper bound plus 40 years. Thus, the parentage group for the 5-9 early age group has been defined as 25-49 years of age.

10. More extensive reviews would include H. H. Parnes, "Labor Force Participation and Labor Mobility," *A Review of Industrial Relations Research*, Volume I (1970), pp. 1-78, William G. Bowen and T. Aldrich Finegan, *The Economics of Labor Force Participation* (Princeton, Princeton University Press, 1969), and Jacob Mincer, "Labor-Force Participation and Unemployment: A Review of Recent Evidence," in Robert A. Gordon and Margaret S. Gordon (editors), *Prosperity and Unemployment* (New York: J. Wiley and Sons, 1966).

11. D. F. Johnston, "The U.S. Labor Force: Projections to 1990," *Monthly Labor Review*, July 1973, pp. 3-13.

12. Bowen and Finegan (1969) originally defined FIM so it would be interpreted as the fraction of local employment that one would expect to be held by females, given the area's industry mix and the nation's fraction female by industry. For our purposes the actual fraction female proved to be a simple and superior substitute.

7. THE EMPLOYMENT/JOBS/LABOR DEMAND SECTOR

In this chapter, we conclude the summary of empirical results used to form MULTIREGION by reviewing the components of the employment or labor demand sector. Conceptually, MULTIREGION distinguishes among: (1) export employment — the spatially sporadic activities generally oriented toward serving persons and businesses outside of the region, (2) local service employment — the more spatially ubiquitous activities oriented toward serving the region's population and businesses, and (3) natural-resource-based employment — agriculture, forestry and fisheries, mining, and export recreation activities. The empirical results for each of these components are briefly discussed to provide an improved understanding of regional and interregional employment processes and to clarify the details of the computation methods within MULTIREGION. Complete documentation of the empirical studies of each component appear in technical appendixes D through H.

7.1 NATURAL RESOURCE BASED EMPLOYMENT

Included in this category are agriculture, forestry and fisheries, mining, and employment related to major outdoor recreation resources such as the Great Smoky Mountains National Park in Tennessee and the Yellowstone National Park in Montana-Wyoming. Since most of these resources are not spatially ubiquitous but exist in only very special places, we view the regional activity levels of these industries as a function of the aggregate demands for their products and the relative regional costs to the user of exploiting the resources at different points in space. Thus, within MULTIREGION we estimate the interregional distribution of activity levels in these sectors fairly exogenously within a formal shift and share framework; regional employment levels in these sectors have <u>not</u> been related to labor market conditions. The formal model is applied to six industries — agriculture, forestry and fisheries, metal mining, coal mining, crude petroleum and natural gas mining, and nonmetallic, except fuels, mining. The absence of data for a formal "outdoor recreation" industry and the frequently seasonal nature of the activity has prevented the use of a shift and share model here, but we have experimented with a method of adjusting regional retail and service employment for the industry's presence (see Appendix G).

7.1.1 <u>A formal shift and share framework</u>

The formal shift and share model takes the form,

$$E^R_{i,75} = E^R_{i,70} \, (1 + r^{US}_{i,70,75} + C^R_{i,70,75}) \; ;$$

where

$E^R_{i,T}$ = employment in industry i in region R at time T

$$r_{i,70,75}^{US} = \frac{E_{i,75}^{US} - E_{i,70}^{US}}{E_{i,70}^{US}} \quad \text{and}$$

$C_{i,70,75}^{R}$ = region R's competitive or shift effect in industry i.

If $C_{i,70,75}^{R} = 0$, we have a constant share model; if $C_{i,70,75}^{R} = C_{i,65,70}^{R}$, we have a constant shift model; but if $C_{i,70,75}^{R}$ is made a function of certain fundamental interregional differences in the costs of resource exploitation, we have a variable shift model.[1]

To date we have proceeded with either constant share or constant shift models. However, by keeping the shift and share formulation within the computational sequence of MULTIREGION, we do maintain a formal structure through which additional exogenous shifts may be introduced (e.g., the possible switch to low-sulphur Western coals) as the need arises.

7.1.2 Agriculture

Regional employment in agriculture would appear to be changing in a very stable and predictable fashion over time. Indeed the summary statistics for BEA areas in Table 7.1 tend to confirm the idea of stability. But upon closer examination of individual BEA areas a substantial number of regions seem to have gained or lost position over time. Undoubtedly, some of these shifts have been due to regional differences in natural endowments (e.g., soils and weather) and production specialization (e.g., crops, dairy, livestock, or poultry). In fact, the significant degree to which regional production specialization exists[2] calls for an analysis of regional trends by individual production specialties.

Table 7.1. The range of variation of regional agriculture, forestry and fisheries employment shares: BEA economic areas, 1950, 1960, and 1970

	Low share (%)	High share (%)	Mean ($\bar{x}$)	Standard deviation (s)	Coefficients of variation ($s/\bar{x}$)
BEA share 1950	.045	2.73	.578	.409	.707
BEA share 1960	.046	2.67	.578	.405	.701
BEA share 1970	.062	2.63	.578	.407	.705

However, understanding the industry has been further complicated by the significant transitions begun in the mid-1970s. In late 1973, world market conditions began to place unusual demands on U.S. agriculture. U.S. grain stocks were depleted through a combination of exports, adverse weather conditions, and government policy. This has led to higher market prices, declining land retirement, and lower subsidy payments to farmers. While the end results of such significant alterations in market conditions are still in doubt, the decades ahead will undoubtedly witness upturns in wages and employment in some regions and subsectors of the agriculture industry.

In this environment of change, we have been reluctant to rely on historical trends or shift and share analysis results that embody fairly stable structural and regional conditions for forecasting purposes. In the absence of a satisfactory analysis of the complex relationships and changes involved, we are proceeding with the obviously simplistic assumption that 1970 regional employment shares will prevail in the future. We are prepared to override these assumptions as others prove more satisfactory.

7.1.3 Forestry and fisheries

Employment in the combined forestry and fisheries group is obviously more spatially concentrated than agriculture. Furthermore, the most intense concentrations appear to be in BEA areas along our coastlines such as Boston and Seattle. Unfortunately, the data for this combined industry group are apt to conceal the substantially different location patterns of its two constituent parts — forestry and fisheries. For example, the group's concentration in the Boston area may be mostly fishing while that in the Seattle area may be mostly forestry.

If consistent regional data were available separately for each of the industry group's components, a separate analysis of each would be appropriate. Since such data do not exist, we have again proceeded with the simplistic assumption that the 1970 regional employment shares of this obviously heterogeneous industry group will prevail in the future.

7.1.4 Mining

Nationally, mining employment has declined substantially since 1950, but the decrease has been concentrated in the coal mining subindustry. Regionally, mining employment shares have exhibited substantial variation over time as a consequence of the decline in coal mining and the relocation of employment in other subindustries as new resource locations have been exploited (e.g., Gulf of Mexico petroleum and natural gas deposits). Indeed the summary statistics for BEA areas in Table 7.2 confirm the notion of regional shifts in mining employment. The regional variation over time in the location of mining employment along with our strong interest in the regional mining of fuels have combined to argue against a summary treatment of mining as a whole.

Table 7.2. The range of variation of regional mining employment shares: BEA economic areas, 1950, 1960, 1970

	Low share (%)	High share (%)	Mean ($\bar{x}$)	Standard deviation (s)	Coefficients of variation ($s/\bar{x}$)
BEA share 1950	.003	11.36	.578	1.40	2.42
BEA share 1960	.005	6.80	.578	.97	1.68
BEA share 1970	.009	5.81	.578	.92	1.60

But a separate shift and share treatment of mining subindustries has been hindered by the absence of satisfactory regional data on the activity levels of each sector. In fact, we have only been able to estimate the BEA area employment shares by subindustry (metals; coal; petroleum, and natural gas; and nonmetals, excluding fuels) for one year – 1970.[3] Thus, we have been left with some disaggregation but no analysis. Again we have proceeded with the simple assumption that 1970 regional employment shares by subindustry will prevail in the future. But, we fully expect to frequently override these assumptions as some regional resources are depleted or become more expensive to extract and as new resource locations are exploited.

7.1.5 Computation sequence

While the formal shift and share model presented in Section 7.1.1 was in terms of the absolute numbers of employees, the computation of natural resource based employment within MULTIREGION is in terms of regional shares of national employment. This is accomplished by reordering the shift and share model to

$$\text{Share}_{R,i,75} = \text{Share}_{R,i,70} + \frac{E^R_{i,70}}{E^{US}_{i,75}} C^R_{i,70,75} ,$$

where

$$C^R_{i,70,75} = \frac{E^R_{i,75}}{E^R_{i,70}} - \frac{E^{US}_{i,75}}{E^{US}_{i,70}} = \text{region R's competitive or shift effect}$$

in industry i.

MULTIREGION is programmed to automatically assign a zero value to C^R_i for all regions and time periods. This assumption may be overridden by assigning nonzero values to the C_i^R of selected regions and time periods (e.g., a negative value for coal mining in BEA 52 — Huntington, West Virginia and a positive value in BEA 150 — Cheyenne, Wyoming to represent a shift from Appalachian to Western coal). However, when the C_i^R's of one or a few regions are set at nonzero values all other regions are usually affected. To minimize the amount of exogenous estimating of the C_i^R's of all regions, MULTIREGION is programmed to estimate natural resource-based employment in two steps. In the first step, the C_i^R's of some regions may be designated as nonzero and forecast shares are computed for each industry and region. However, since the C_i^R's of all regions have not been adjusted, the sum over all regions of the computed shares is not likely to equal one. Thus, the second and final step is to multiply the computed shares by forecast national employment to derive expected regional employment and then force the sum over all regions to equal the predetermined national total.

7.2 MANUFACTURING EMPLOYMENT

Within MULTIREGION most categories of manufacturing employment are assumed to have an export orientation that reaches across BEA economic area boundaries to provide strong interregional linkages. In addition, these industries are assumed to provide the basis or foundation for the remaining local service industries. As a result, regions appear to be competing against each other in a game called "industrial location."

7.2.1 Regional attractiveness models

While a broad goal of many regional scientists is to establish quantitative (rather than qualitative) statements about industrial location, most would agree that we are not yet able to formulate a satisfactory simultaneous equations model of this very complex interactive process. Thus, researchers have frequently proceeded using simpler regional attractiveness models to acquire some of the insights to regional economic development processes that are required for more complete and complex representations. Regional attractiveness models take the form:

$$\text{Relative Regional Attractiveness}_{Ri} = f(X_{R1}, \ldots, X_{RM})$$

or the linear form:

$$\text{R. Reg. Attract.}_{Ri} = \alpha_{io} + \alpha_{i1} X_{R1} + \ldots + \alpha_{iM} X_{RM}$$

where:

X_{Rj} = measures of region R's characteristics

e.g., Access to Final Markets
Access to Intermediate Markets
Access to Supplies (labor, etc.)

α_{ij} = parameters which reflect the importance of each characteristic to each industry.

At one and the same time, the strengths and weaknesses of this sort of model are its ability to encompass many alternative location theories without careful discrimination among them. However, the model does represent regions competing against each other in a game called "industrial location" and the results of the game may be tabulated periodically by an indicator such as $Share_{Ri}$, the share of total national employment in industry i that is in region R. Thus, $Share_{Ri}$ is a measure of how well region R is faring in the competitive industrial location game and should correlate highly with the region's endowments or characteristics (e.g., its access to markets and raw materials, its labor force characteristics, etc.).

Notable past efforts that have attempted to empirically test models of this general type include the works of Fuchs,[4] Spiegelman,[5] Burrows et al,[6] Bergsman et al,[7] and Harris and Hopkins.[8] Our analysis has approached the problem in a fashion similar to these previous efforts with a few notable differences. First, the spatial grid used was the set of 171 BEA economic areas. Second, relationships were statistically estimated using pooled cross-section data from the 1950, 1960, and 1970 Censuses of Population. Finally, a major effort was made to measure "access" to markets by truck transportation so that the differential regional impact of the gradual completion of the Interstate highway system could be considered. Separate location analyses were made for fourteen manufacturing industries.

7.2.2 Access to markets

Before examining empirical results we may usefully review the measures of interregional access to markets which constitute our means of considering and measuring interregional interindustry linkages and effects. Since the gradual completion of the Interstate highway system may have had a substantial and differential regional impact upon the growth of market accessibility, a major effort was devoted to the development of a measurement process which emphasized the time of truck transportation between metropolitan areas while standardizing for regional differences in terrain and changing conditions of truck operating speed, roadways, and congestion; the process is explained in detail in Appendix H. These computed truck operating times between over seven hundred city pairs for each of three years, 1950, 1960, and 1970 were then used to define interregional market demand and supply potentials for each BEA area for each of the three points in time.

The specific forms of the potential model used in this study were:

a. Final Demand Potentials — 1950, 1960, 1970

$$FDP_{ik} = \sum_{j=1}^{171} [(POP_j \times PCY_j)/(D_{ij}^{\lambda k})] \text{ for } D_{ij} \leq 8.3 \text{ hours,}$$ [9]

where

FDP_{ik} = final demand potential for commodity k in BEA area i

POP_j = population of the *jth* BEA economic area

PCY_j = per capita income of the *jth* BEA area[10]

D_{ij} = minimum truck operating time between i and j (where i = j, D_{ij} = 1/2 D_{ij} to the nearest BEA area), and

λ_k = distance decay coefficient which varies with the good being shipped.[11]

b. Intermediate Demand Potentials — 1950, 1960, 1970

$$IDP_{ikm} = \sum_{j=1}^{171} (EMP_{jm}/D_{ij}^{\lambda k}) \text{ for } D_{ij} \leq 8.3 \text{ hours,}$$

where

IDP_{ikm} = intermediate demand potentials in BEA area i for commodity k by industry m

EMP_{jm} = employment in industry m within BEA area j.

c. Intermediate Supply Potentials — 1950, 1960, 1970

$$ISP_{ik} = \sum_{j=1}^{171} (EMP_{jk}/D_{ij}^{\lambda k}) \text{ for } D_{ij} \leq 8.3 \text{ hours,}$$

where

ISP_{ik} = intermediate supply potential in BEA area i of commodity k.

d. Intermediate SELF Potential — 1950, 1960, 1970

$$I\text{-}SELF\text{-}P_{ik} = ISP_{ik} = \sum_{j=1}^{171} (EMP_{jk}/D_{ij}^{\lambda k}) \text{ for } D_{ij} \leq 8.3 \text{ hours,}$$

where

$I\text{-}SELF\text{-}P_{ik}$ = the combined intermediate supply <u>and</u> demand potential in BEA area i of industry k with itself.

Since truck operating times (D_{ij}) have been decreasing over time while population (POP_j), per capita income (PCY_j), and many employment categories (EMP_{jk} and EMP_{jm}) have been increasing, the (absolute) market potentials calculated according to the above formulas tend to be increasing for each BEA economic area and collinear among areas. To more clearly distinguish among BEA areas, we have defined a relative market potential to be a region's share of the total national market. Thus relative market potentials have been defined as:

$$Rel.FDP_{ik} = FDP_{ik} / (POP_{us} \times PCY_{us}),$$

$$Rel.IDP_{ikm} = IDP_{ikm} / EMP_{us,m},$$

$$Rel.ISP_{ik} = ISP_{ik} / EMP_{us,k}.$$

These values were computed directly for 1950, 1960, and 1970 and values for 1955 and 1965 were estimated by interpolation.

To repeat, emphasis was placed upon national measures of absolute and relative market potential because these variables constitute our means of considering and measuring interregional interindustry linkages and effects.

7.2.3 Empirical results

Simple regional attractiveness models have been used to estimate the relative importance of regional characteristics such as initial conditions, market accessibility, market competition, labor conditions, natural and amenity resource availability, financial resources and subsidies, and the availability of intermediate inputs.[12] Separate location analyses were made for each of fourteen manufacturing industry groups: (1) food products, (2) textiles, (3) apparel, (4) lumber products and furniture, (5) paper and allied products, (6) chemicals, (7) petroleum refining, (8) primary metals, (9) fabricated metals and ordnance, (10) nonelectrical machinery, (11) electrical equipment, (12) motor vehicles and equipment, (13) other transport equipment, and (14) all other manufacturing. While the results varied across industries, in general the most important determinants of the present locations of manufacturing employment have been the past locations of employment (initial conditions), recent trends toward spatial dispersion, and interregional market accessibility; other regional characteristics such as labor conditions and financial subsidies do not appear to have been very important at the BEA economic area level.

Before dipping into more specific empirical results it should be pointed out that we have attempted to gain insight to the determinants of the historical location of industry as well as the determinants of recent changes in location. In particular, we have distinguished two empirical models by choosing to include or exclude initial conditions — $S_{Ri}(t-10)$ — as an explantory variable. The resulting models are:

Model A [S_{Ri}(t)=f(other variables)]: Since the employment in manufacturing industry i in region R is made a function of conditions in region R except the presence of industry i ten years ago (initial conditions), the results of this model may be assumed to give insight to the determinants of the historical location of industry i.

Model B [S_{Ri}(t)= g(S_{Ri}(t-10), other variables)]: In a sense, the inclusion of S_{Ri}(t-10) standardizes the dependent variable for initial conditions so that the coefficients of all other variables give insight to the determinants of the more recent change in industry i employment in region R.

Except for the inclusion or exclusion of S_{Ri}(t-10), the same explanatory variables appear in both models A and B for each industry. In addition many common explanatory variables appear across industries. While the variables included were chosen through a long series of experiments, there remains room for further custom tailoring of the list of explanatory variables for each industry and the consideration of interaction terms and trended coefficients. Empirical results for the apparel and chemicals industries appear in Tables 7.3 and 7.4, respectively; complete results for all industries are contained in Appendix E.

7.2.3.1 Model A

At the risk of overgeneralizing from our narrow empirical results based as they are upon aggregated industry groups and broad regional conditions, the following insights to the determinants of the historic location of industry emerge from Model A. Interregional market size as measured by FDP, IDP, ISP, and I-SELF-P has been a very important determinant of the historic location of manufacturing employment: access to others in the same industry (I-SELF-P) has been most important, followed by access to final demand (FDP), intermediate suppliers (ISP), and intermediate demanders (IDP) in that order. In reviewing the Beta coefficients for these variables in Tables 7.3 and 7.4, the reader may wish to keep in mind that: (1) a large Beta value implies strong explanatory power, (2) a positive (negative) Beta value implies a period of adjustment of less (more) than the assumed five years, (3) high statistical significance implies rather uniform behavior across regions.

The coefficients of relative SELF potential are positive and large which may be interpreted as evidence of the historic importance of agglomeration economies, a shorter than five-year period of adjustment,

Table 7.3. Beta coefficients for manufacturing location functions — apparel: pooled 1960 and 1970 data for BEA economic areas

Explanatory variables	(comments for MULTIREGION computations)	Beta coefficients Model A	Beta coefficients Model B
Share (T-10)	(adjust coefficient for five-year lag)	---	.969ooo
R.FDP (-5)	(use last period's value)	-.365***	-.066***
R.ISP (-5) textiles	(use last period's value)	-.130***	.032***
R.I SELF P (-5)	(use last period's value)	.841***	.081***
Labor conditions (-5)			
STRIK	(exogenous)	-.069	.056***
EPI	(use last period's value)	.056	.019**
L.W.	(exogenous)	.020	.001
H.W.	(exogenous)	-.022	-.013*
Port activity	(exogenous)	.317***	.015
L.C. (pop.density)	(use last period's value)	.423***	-.021*
Region 1 NE		-.228***	.006
2 MA		-.337***	-.005
4 SE		-.122*	.045***
5 PL		-.047	.006
6 SW		-.071	.025**
7 MTN		-.043	.010
8 FW		-.102**	.033***
Pooled (1960=0, 1970=1)		-.070**	-.003
R^2		.754	.987
F-value (degrees of freedom)		58 (17,324)	1383 (18,323)

*Significantly different from zero at the .10 level.
**Significantly different from zero at the .05 level.
***Significantly different from zero at the .01 level.
oooSignificantly different from one at the .01 level.

Table 7.4. Beta coefficients for manufacturing location functions — chemicals: pooled 1960 and 1970 data for BEA economic areas

Explanatory variables	(comments for MULTIREGION computations)	Beta coefficients Model A	Model B
Share (T-10)	(adjust coefficient for five-year lag)	---	.924[ooo]
R.FDP (-5)	(use last period's value)	-.491***	-.086***
R.IDP (-5) textiles	(use last period's value)	-.060*	.030***
R.ISP (-5) petroleum refining	(use last period's value)	-.263***	.017
R.I SELF P (-5)	(use last period's value)	1.128***	.110***
Labor conditions (-5)			
STRIK	(exogenous)	-.153***	-.002
EPI	(use last period's value)	-.013	.007
L.W.	(exogenous)	-.020	-.006
H.W.	(exogenous)	-.045	.002
Port activity	(exogenous)	.404***	.058***
L.C. (pop. dentity)	(use last period's value)	.345***	-.005
Other - Emplanements	(exogenous)	.016	.007
Oil pipelines	(exogenous)	.121***	.006
CLIM	(a constant)	.102***	.027***
Region 1 NE		-.073***	-.001
2 MA		-.119***	-.025***
4 SE		-.068	-.010
5 PL		.027	.006
6 SW		-.017	-.009
7 MTN		.006	.009
8 FW		.016	.007
Pooled (1960=0, 1970=1)		-.080***	-.014*
R^2		.860	.986
F-value (degrees of freedom)		94 (21,320)	1019 (22,319)

*Significantly different from zero at the .10 level.
**Significantly different from zero at the .05 level.
***Significantly different from zero at the .01 level.
[ooo]Significantly different from one at the .01 level.

and rather uniform behavior across regions. The coefficients of FDP are generally negative but statistically significant which implies rather uniform behavior across regions with a period of adjustment of more than five years. The coefficients of IDP and ISP appear with a greater mixture of signs and generally lower statistical significance giving evidence of more variable response times and greater behavioral diversity across regions.

Regional labor market conditions appear to have made only a small contribution to the total explanation of historic manufacturing location. Within the labor conditions category, most industries have tended to avoid regions with above average strike activity, have been attracted to regions with tight labor markets (high EPI), and have been rather indifferent to the especially low wage (L.W.) or high wage (H.W., high skill) nature of a region's labor force.

Port activity and population density (LC-a proxy measure of land cost was measured by population/usable land) have exhibited substantial positive influences on historic location. While these two variables do seem to have captured different concepts in different industries, there is a high enough simple correlation between them (.62) to make one suspect that both variables may have frequently represented local market conditions; ports are generally densely populated points of product and resource trans-shipment which by their nature have created trade and manufacturing opportunities.

The remaining explanatory variables center about natural and amenity resource availability, long-term regional conditions, and a time trend; their importance varies substantially among industries. Of the "other" variables included in the chemicals example, the presence of oil pipelines and a mild climate were significant but not especially important determinants; however, coal and iron resources and forest resources were of much more importance to the primary metals and lumber products and furniture sectors, respectively. The regional dummy variables included as a measure of long-term regional conditions (relative to the Great Lakes = 0) not captured by any of the other explanatory variables generally did not have much impact on historical location but in the apparel example the New England and Middle Atlantic regions appeared to be at a disadvantage relative to the Great Lakes. The coefficients of the pooled variable are negative and statistically significant but generally not important; however, they do introduce the idea of shifting location relationships over time.

7.2.3.2 Model B

From the results of Model B, a number of insights to the determinants of recent changes in location emerge. Of greatest importance, past employment location has been the most important determinant of present location. The average Beta coefficient for Share (T-10) across all fourteen industry groups is .957 (.969 and .924, respectively for the apparel and chemicals examples) indicating an almost one-to-one correspondence between typical variations in Share (T) and Share (T-10). Inertia is a very powerful force.

In all but one of the industries considered, there appear to have been strong recent trends toward spatial dispersion. The coefficient of the S(T-10) variable is significantly less than one for all industries except "lumber products and furniture" where it is not significantly different from 1.0. In the examples given, the trend toward dispersion has been stronger for chemicals than for apparel.

After adjusting for initial conditions, interregional market size has been an important determinant of recent changes in manufacturing location, albeit of substantially less importance than in Model A. While some of the importance of relative SELF potential exhibited in the results for Model A has been drawn off through the inclusion of S(T-10), the coefficients generally remain positive and statistically significant giving evidence of the continued importance of agglomeration economies in recent locational change. The coefficients of FDP are generally negative but only occasionally statistically significant (they are significant in the apparel and chemicals examples) which implies a period of adjustment of more than five years with quite a bit of diversity of behavior across regions. The coefficients of the IDP and ISP variables again appear with a great mixture of signs and generally low t-values giving evidence of more variable response times or changing interindustry linkages and substantial behavioral diversity across regions. In summary, our empirical results do reinforce the idea that access to markets has been important to locational change.

Regional labor market conditions have made a small contribution to the explanation of locational change; only 1.5 percent of a typical variation in $Share_{Ri}$ was associated with a typical variation in general labor conditions. Within the labor conditions category, the most substantial and statistically significant associations are positive coefficients for the STRIK variable within the apparel (see Table 7.3), fabricated metals, and other transport equipment industry groups which might imply that these industries have found it difficult to leave highly unionized and strike-prone areas. Other subcategories of labor conditions do not yield substantially significant or intuitively meaningful associations.

Our empirical results suggest that port activity and population density are not generally important influences on locational change. In contrast to their historic importance, ports have had a significant positive influence on recent locational change only in the chemicals (see Table 7.4), primary metals, food, and electrical equipment industries and significant negative influence in the other transport equipment industry. Population density appears to have had a significant negative influence on recent locational change in the primary metals and other transport equipment industries and a positive influence in the electrical equipment industry. In the case of electrical equipment, it is likely the attraction to ports and population density again has been dictated by the trade and manufacturing opportunities created at major trans-shipment points.

Finally, of the remaining explanatory variables which encompass natural resource availability, long-term regional conditions and trends, only a few natural conditions are of much consequence to locational change. The presence of pulping wood has been important to the paper and allied products industry, mild climates have attracted the fabricated metals and chemicals industries, and the historically important forest resources and coal and iron resources have repelled the lumber products and furniture and primary metals industries, respectively.

7.2.4 Computation sequence

MULTIREGION assumes that manufacturing employment adjusts to regional socioeconomic conditions with a five-year lag. This assumption is not unrealistic because we are attempting to capture secular trends rather than cyclical behavior; in addition, it simplifies the computations within the model. In particular, if this assumption were not made, the repeated compilation of market potentials during a five-year time step would prove especially burdensome. As it is, these values are computed only once at the end of each time step.

MULTIREGION is programmed to use the empirical results from Model B to compute regional manufacturing employment in four phases.

Phase I - Preliminary data manipulation. Necessary information is prepared from national/regional data estimates, and projections including: (1) employment share (last period), (2) relative market potentials (last period values of FDP, IDP, ISP), (3) labor market conditions (last period values of STRIK, EPI, LW and HW), (4) trended regional dummies, and (5) national manufacturing employment by industry in Census of Population terms. For all industries, the S(T-10) coefficients and equation intercepts are adjusted for use with a five-year lag.

Phase II - Compute manufacturing employment shares. Regional manufacturing employment shares by industry are computed from Phase I data. Regional ceilings and floors (boundary conditions) are not violated.

Phase III - Manufacturing employment by industry. Regional employment shares are applied to forecasted national employment by industry to derive expected regional employment. The sums over all regions are forced to predetermined national totals.

Phase IV - Compute revised relative market potentials. At the conclusion of each time step, relative market potentials (FDP, IDP, ISP, SELF P) are computed using forecast regional employment by industry and truck operating times. In addition to being required inputs to the next time step, these revised market potentials may be used as added summary measures of regional economic change.

7.3 LOCAL SERVICE EMPLOYMENT

In keeping with the format of the manufacturing location analysis, we have resorted to the use of simple regional attractiveness models for local service employment. However, because of the postulated local orientation of the industries involved, only one explanatory variable reaches across BEA economic area boundaries to test for interregional linkages.

7.3.1 Regional multiplier models

Regional multiplier (or export base) models argue that so much of the economic activity within small geographic regions is oriented toward serving markets outside of the region that, in a very real sense, the activities of these export-oriented industries form the basis or foundation for the remaining local service industries. In its crudest form, regional multiplier analysis establishes a ratio between local service activity (L) and export activity (E). Any change in export activity may be multiplied by this base-service ratio L/E to estimate the impact on service activity. The total impact of a change in export activity is then the sum of the changes in export and service activity. More advanced forms of regional multiplier analysis could allow for autonomous services activity, service industry differentiation, nonconstant base-service ratios, induced export activity, and lagged responses.[13]

7.3.2 Empirical results

In an attempt to develop flexible base-service ratios that respond to changing socioeconomic conditions, simple regional attractiveness models have been estimated for each service industry using pooled 1960 and 1970 data for 171 BEA economic areas. In the process explanations have been sought for the great variation among BEA areas in the amount of local service employment per capita and the more or less rapid but general convergence of regions toward national per capita values.

Separate analyses were performed for sixteen industry groups: (1) construction, (2) printing and publishing, (3) railroad, (4) trucking and warehousing, (5) other transportation services, (6) communications, (7) public utilities, (8) wholesale trade, (9) retail trade, (10) finance, insurance, and real estate, (11) lodging and personal services, (12) business and repair services, (13) amusement and recreation services, (14) private households, (15) professional services, and (16) public administration. The dependent variables were expressed as regional shares, that is Share (T), and the explanatory variables were initial conditions (S(T-10), the five-year rate of growth of total regional employment (TEG), relative population potential (R. POT — a measure of potential interregional interaction and accessibility), median schooling (MS), the employment pressure index (EPI), population density (P.DEN), and regional dummy variables. Once more two empirical models have been distinguished by choosing to include or exclude initial conditions — S(T-10) — as an explanatory variable. Results for the "printing and publishing" and "trucking and warehousing" industries appear in Table 7.5 in terms of Beta coefficients; complete results for all industries appear in Appendix F.

7.3.2.1 Model A

The following insights to the historic location of local service employment emerge from Model A. Interregional market size as measured by R.POT has been a most important determinant of historic location. It has been most important for "trucking and warehousing" (see Table 7.5), important for most other industries, and least important for "other transportation services." Total employment growth (TEG), another dimension of market size, has been a much less important determinant of historic location; its coefficients are significant for only half the industry groups and even then its contribution to the overall explanation of location has been small.

Local market quality measured by a number of alternative concepts has been an important historic determinant. Labor market tightness (EPI) and a refined measure of population density (L.C) give evidence of having been important determinants for most industries; in the two examples of Table 7.5 the Beta values for population density were higher than for any other variable. Median schooling (M.S.) which usually serves as a good proxy for a region's long-term earning ability or permanent income level, does not appear to have been an important historic determinant; this suggests that a substantial portion of higher real per capita incomes may be expended for higher quality goods and services offered by a relatively constant number of vendors per capita.

Finally, regional dummy variables included as measures of long-term regional conditions influencing location suggest very few differences among the Great Lakes, New England, and Mideast regions. However, relative to the Great Lakes, BEA areas in all other regions except New England and the Mideast have experienced a greater presence of local service employment. It would appear that this could be due to the absence of a highly differentiated urban heirarchy within these regions (i.e., the BEA areas are of more equal size without dominant cities like Boston, New York, and Chicago) which has caused each BEA area to take care of more of its own local service needs.

7.3.2.2 Model B

The results for Model B indicate that past employment location is again the most important determinant of present employment location. The inclusion of the Share (T-10) variable reinforces the idea that inertia is a very powerful force. In addition, the coefficient of the Share (T-10) variable, especially where it may be significantly different from 1.0, sheds light on the recent trends toward spatial diffusion or concentration within an industry. While local service industries are supposed to be spatially diffused by definition, most industries considered have a coefficient significantly less than 1.0 indicating a further trend towards spatial dispersion; only two industries, "railroad" and "business and repair services," have coefficients significantly greater than 1.0 indicating a trend toward spatial concentration.

Table 7.5 Beta coefficients for local service employment functions — "Printing and Publishing" and "Trucking and Warehousing": pooled 1960 and 1970 data for BEA economic areas

Explanatory variables	(comments for MULTIREGION computations)	Printing and publishing: Model A	Printing and publishing: Model B	Trucking and warehousing: Model A	Trucking and warehousing: Model B
Share (T-10)	(adjust coefficient for five-year lag)	. ---	.977[ooo]	---	.995[ooo]
T.E.G. (T)	(at T; use "trial" values)	.020	.023***	.035	.032***
R.POT (-5)	(use last period's value)	.341***	.024***	.445***	.023*
M.S. (T)	(at T; a constrained trend)	-.030		-.069	
EPI (T)	(at T; use "trial" values)	.094**		.099**	.014*
L.C. (pop. density) (T)	(at T; use "trial" values)	.720***	.014**	.654***	-.011
Pooled (1960=0, 1970=1)		-.091*		-.092*	
Region 1 NE		-.059	*	-.054	
2 MA		-.062		-.089**	
4 SE		.103	.014*	.146**	.045***
5 PL		.182***	.016***	.205***	.010
6 SW		.190***	.014**	.233***	.024***
7 MTN		.164***	.011*	.198***	.015
8 FW		.078	.019***	.151***	.033***
R^2		.667	.996	.634	.989
F-value (degrees of freedom)		50.5 (13,328)	5315 (14,327)	43.6 (13,328)	2114 (14,327)

Note: Values less than .01 deleted.

*Significantly different from zero at the .10 level

**Significantly different from zero at the .05 level.

***Significantly different from zero at the .01 level.

[ooo]Significantly different from one at the .01 level.

After adjusting for initial conditions, total employment growth (TEG) seems to be the most important determinant of locational change; its coefficients are positive and statistically significant for all local service industries and the average Beta coefficient across industries is .039 (slightly lower in the examples given in Table 7.5). Interregional market size (R.POT) is significant for only half of the industry groups with an average Beta coefficient of .023. Because this measure ties regional economies together, the implication is that employment in wholesale trade, printing and publishing, finance insurance and real estate, public administration, trucking and warehousing, and retail trade would grow in regional centers such as Denver in response to growth in nearby areas such as Grand Junction and Cheyenne. While these interregional linkages are weaker than expected a priori, they are there and bear further investigation.

Most other explanatory variables are of minor importance. Market quality is conspicuous by its apparent lack of importance as a determinant of locational change, median schooling (MS) is not significant, there are some positive associations with labor market tightness (EPI), and population density has a negative association with about half of the industry groups (except printing and publishing) reinforcing the idea of spatial dispersion to less density populated BEA's.

Longer-term regional conditions captured by regional dummy variables (relative to the Great Lakes = 0) are generally not important across most industries except for the Southeast and Far West (also the Southwest in the examples given). All other things equal, BEA areas in these regions relative to those in the Great Lakes region have experienced an above average presence and increment of most local service industries.

7.3.3 Computation sequence

Within MULTIREGION local service employment is computed after natural-resource-based and manufacturing employment. Unlike the activity levels in these other two sectors which are estimated at the beginning of each five-year time step and are not altered until the next five-year time step begins, local service employment is subject to a multi-stage computation process. Trial (last period) values of some explanatory variables must be used to produce first-stage estimates of local service employment, regional labor demand and supply, and labor market tightness (EPI). Then these estimates of regional labor market conditions are used to compute revised estimates of regional service employment. The computation process continues in this fashion through a user specified number of stages. At all stages across region sums of service employment by industry are forced to predetermined national totals by industry and some regional ceilings and floors (boundary conditions) are imposed. The local service employment computations within MULTIREGION are made with the results from Model B and may be divided into five phases.

Phase I - Preliminary data manupulation. Necessary information is prepared from national/regional data, estimates, and projections including (1) employment share (last period), (2) MS (as per migration subroutine), (3) TEG, R.POT, L.C. and EPI (last period), (4) trended regional dummies, and (5) national service employment by industry in Census of Population terms. For all industries the S(T-10) coefficients and equation intercepts are adjusted for use with a five-year lag.

Phase II - Compute trial service employment shares. Regional service employment shares by industry are computed from Phase I data.

Phase III - Trial service employment by industry. Trial regional employment shares are applied to forecasted national employment by industry. Regional boundary conditions (especially minimum requirements) are not violated. Across region sums are forced to national totals.

Phase IV - Trial labor market conditions. Trial labor supply (population) is brought together with the sum of natural resource based employment, manufacturing employment and trial service employment to establish trial labor market conditions including EPI and P.DEN. Floors and ceilings are applied to some of these variables.

Phase V - Final service employment and labor market conditions. Final values are computed by reiterating Phases II through IV a user specified number of times. Across region sums of employment, population, and labor supply are forced to predetermined national totals and regional ceilings and floors (boundary conditions) are imposed during each iteration.

7.4 EXPORT RECREATION EMPLOYMENT

Conceptually, MULTIREGION distinguishes among export, local service, and natural resource-based employment. But, the absence of data for a formal "recreation" industry and the frequently seasonal nature of the activity has prevented an adequate treatment of export recreation within any of these three categories. A simple procedure for measuring and projecting the direct regional impacts of export recreation activity associated with the Great Smoky Mountains National Park is illustrated in Appendix G; the analysis includes a gravity-potential measure of visitor interaction within a regression model of regional retail-service activity.

For the purposes of MULTIREGION, analyses of all major recreation facilities in the U.S. would be especially desirable because they could provide a useful supplement to or even be incorporated directly into our representations of regional service industry behavior. But, at the present time such analyses are not possible due to the absence of readily accessible information on the origins of visitors to major export recreation facilities; such information is necessary to calibrate the gravity-potential model for different classes of recreation facilities. We can, however, present some evidence of how widespread export recreation activity is among BEA areas.

Because the analysis of export recreation activity is hindered by the absence of a formal "recreation" industry for statistical reporting purposes and the frequently seasonal nature of the activity, one must look to annual data on the more standard industry groups such as retail trade, lodging and personal services, and amusement and recreation services for evidence of the industry. For example, Table 7.6 contains the highest BEA area employment location quotients in these industries defined in terms of the highly seasonal (April) Census of Population data for 1970. While only those BEA areas having two or more location quotients ranking in the top ten are shown, one can easily relate BEA areas 35 (Orlando), 36 (Tampa), and 173 (Honolulu) with winter climates and ocean-oriented recreation, BEAs 160 (Reno) and 161 (Las Vegas) with legal gambling and nightclub entertainment, and BEA 149 (Grand Junction) with ski resorts and mountain recreation. If we had looked at annual data instead of the seasonal (April) data reported in the Census of Population, it would have been even more clear that there is a rather widespread presence of export recreation activity quite independent of the urban hierarchy and city size that deserves comprehensive analysis.

Table 7.6. Selected BEA economic area employment location quotients: Census of Population data for April 1970

BEA economic area	1970 employment location quotient in percent (rank)					
	Retail trade		Lodging and personal services		Amusement and recreation services	
# 35 — Orlando, FL	115	(17)	136	(10)	137	(9)
36 — Miami, FL	121	(6)	208	(3)	192	(4)
37 — Tampa, FL	127	(2)	158	(6)	156	(6)
122 — Amarillo, TX	117	(9)	142	(8)	84	(74)
149 — Grand Junction, CO	116	(13)	180	(5)	144	(7)
160 — Reno, NV	105	(71)	241	(2)	1183	(1)
161 — Las Vegas, NV	102	(87)	684	(1)	610	(2)
173 — Honolulu, HI	94	(136)	182	(4)	139	(8)

REFERENCES FOR CHAPTER 7

1. H. S. Perloff, E. S. Dunn, Jr., E. E. Lampard, and R. F. Muth, *Regions, Resources, and Economic Growth* (Baltimore: Johns Hopkins Press, 1960) and Lowell D. Ashby, *Growth Patterns in Employment by County, 1940-50 and 1960-60* (Washington, D.C., U.S. Government Printing Office, 1964) are good introductions to the shift and share model.

2. Estimates of BEA area agricultrual production specialization are available for 1949, 1954, 1959, 1964, and 1969 in a series of documents by R. J. Olsen and G. W. Westley, *1952, 1956, 1962, 1967, and 1972 County and City Data Books: Cumulations to BEA Areas,* ORNL-NSF-EP Nos. 31-34 (1972) and 79 (1974) available from NTIS.

3. Regional earnings by subindustry from the Water Resources Council's *OBERS Projections* were combined with relative national wage rates by subindustry to compute "adjusted" regional earnings by subindustry. For each BEA area a subindustry share of adjusted regional earnings was then computed and applied to total BEA area mining employment to estimate subindustry mining employment. These estimates were then adjusted to final values using a simple matrix balance routine.

4. Victor R. Fuchs, *Changes in the Location of Manufacturing in the United States Since 1929,* Yale University Press, New Haven, 1962.

5. R. G. Spiegelman, *A Study of Industry Location Using Multiple Regression Techniques,* Agricultural Economics Report 140, Economic Research Service, U.S. Department of Agriculture, 1968.

6. J. C. Burrows, C. E. Metcalf, and J. B. Kaler, *Industrial Location in the United States,* Heath Lexington Books, Lexington, Massachusetts, 1971.

7. Joel Bergsman, P. Greenston, R. Healy, *Research on Urban Economic Development and Growth Policy,* Urban Institute Paper 200-5 (Washington, D.C: The Urban Insititue, 1972) and *Determinants of Metropolitan Growth: 1965-70,* paper presented at the Regional Science Association meetings, Philadelphia, November 1972. G. Alperovich, J. Bergsman, and C. Ehemann, *An Econometric Model of Employment Growth in U.S. Metropolitan Areas,* Urban Institute Working Paper #0974-5(Washington, D.C.: The Urban Institute, 1975).

8. Curtis C. Harris, Jr. and F. E. Hopkins, *Location Analysis: An Interregional Econometric Model of Agriculture, Mining, Manufacturing, and Services,* Heath Lexington Books, Lexington, 1972.

9. The 8.3 hour criterion represents a slight adjustment of a subjectively chosen 8.0 hour criterion; other critical values could have been used.

10. Per capita income values were taken from the Water Resources Councils' *OBERS Projections*.

11. While the literature on the gravity model does include reference to how λ varies inversely with the value of the good being shipped, the "value of product" and alternative hypotheses are only now being subjected to systematic testing. A recent paper by William R. Black, "Interregional Commodity Flows: Some Experiments with the Gravity Model," *Journal of Regional Science*, Vol. 12, No. 1 (April 1972), pp 107-118, describes some systematic tests of these alternative hypotheses. The distance decay coefficients used in this study were derived from values found in the Black article by computing a weighted average of the values for component commodities of each industry group.

12. These are seven categories of regional characteristics; the empirical analyses were actually conducted in terms of numerous variables chosen to represent different facets of each category. Descriptions of all variables considered appear in Appendix E.

13. For a simple but eloquent discussion of export-base analysis see C. M. Tiebout, *The Community Economic Base Study*, Supplementary Paper No. 16, New York: Committee for Economic Development, 1962. Criticisms of export-base analysis have been assembled in R. W. Pfouts (ed.), *The Techniques of Urban Economic Analysis*, Chandler-Davis Publishing Co., West Trenton, N.J., 1960. A more mathematical elaboration of the evolution of base theory toward an integrated theory of regional growth may be found in H. Siebert, *Regional Economic Growth: Theory and Policy*, Scranton, Penn., International Textbook Co., 1969. A review of significant empirical export base studies is contained in Appendix F.

8. REQUIREMENTS AND PROCEDURES FOR USE OF THE MODEL

This chapter outlines the computer programs and data inputs required to use the MULTIREGION model as well as some of the procedural options that are available. This overview should meet the general needs of most interested readers but it is not intended to be a substitute for a user's manual that should be prepared as the computer code becomes final. While some of the details of the computer codes continue to change as we experiment with the model, the basic nature of the model is not expected to change much from the description in this report.

8.1 REQUIRED COMPUTER PROGRAMS

The complete MULTIREGION model requires five separate computer programs: MULTIREGION, INFORUM*, NETWORK, REPORTS, and GRAPHICS. While all of these could have been made subroutines of a much larger main program, the uneven frequency of use across programs combined with a strong desire to keep the system simple and within the capacity of the computing equipment generally available to a large user community led to the present strategy. Under normal circumstances MULTIREGION — which prepares and reconciles population and employment forecasts — would be used very frequently, INFORUM* and NETWORK — which are used to prepare alternative versions of some basic input conditions — would be used infrequently, and REPORTS and GRAPHICS — which prepare formal tabular reports and maps from the outputs of MULTIREGION — would be used with moderate frequency. By keeping these last four programs separate, the most frequently used MULTIREGION program can be exercised with substantial savings in core storage and operating times.

<u>MULTIREGION</u>. This computer program embodies the representations of labor market processes — mortality, fertility, migration, labor force participation, natural-resource-based employment, manufacturing location, and local service employment — discussed so extensively in Chapters 5 through 7 and in the technical appendixes. As represented in Fig. 8.1, the program requires two input tapes, an output tape and disk storage in addition to 550 k bytes of computer core. Because this program is used frequently to experiment with the sensitivity of the model's outputs to alternative assumptions and specifications, the outputs of most runs do not need to be saved in the form of extensive formal tabulations for each BEA area. Thus, a limited printed output option is available where the user usually chooses a few variables and requests a printout of their values for selected BEA areas and years. Sometimes, the entire output of a run is saved on computer tape to serve as inputs to the REPORTS and GRAPHICS programs.

Input tape # 1 contains general inputs such as national forecasts of population and employment (control totals) and historic regional conditions which are read and kept in computer core. Input tape # 2 contains the input data required for the estimation of regional manufacturing

ORNL-DWG 77-12004

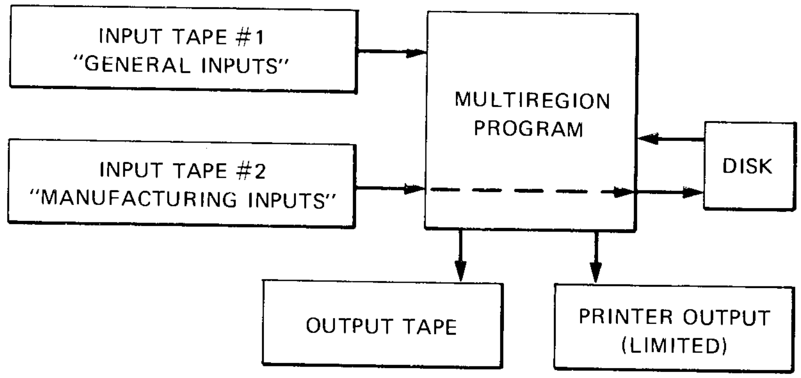


Fig. 8.1 A representation of the MULTIREGION Program.

employment such as historic employment shares, interregional accessibility matrices, and assumed regional labor conditions. These inputs are passed through core to a disk from which they subsequently are called and updated as needed. This was done to economize on core storage and to minimize the rewinding of tapes.

REPORTS and GRAPHICS. These programs (Fig. 8.2) convert the outputs of MULTIREGION into standard tabular and map formats similar to those at the end of Chap. 5. The user may choose from a list of standard reports for each BEA area or may prepare custom-tailored tabulations. Across BEA area results may be displayed with maps prepared by SYMAP or ORMIS. A modest amount of data transformation can also be performed in these programs to develop rates of growth, location quotients, etc.

ORNL-DWG 77-12005

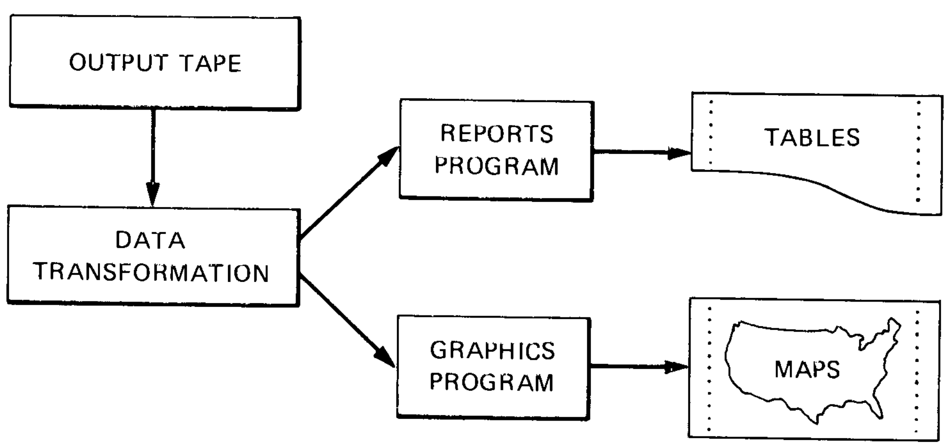


Fig. 8.2 A representation of the REPORTS and GRAPHICS Programs.

NETWORK. This program (Fig. 8.3) computes the minimum travel times (D_{ij}'s) between the metropolitan center of a BEA area and the centers of all other BEA areas within 8.3 hours travel for each of the years 1970, 1975, and 1980; by assumption, these travel times remain constant after 1980. Because these computations are quite time consuming, the NETWORK analysis is not used for each run of MULTIREGION. Instead, the results of baseline accessibility assumptions are stored on MULTIREGION's Input Tape #2. With this data standard market potentials may be computed and updated within MULTIREGION. On those rare occasions when the baseline assumptions need to be altered to represent such things as (1) a new interregional highway, (2) higher fuel costs, or (3) a new nationwide speed limit, the travel time matrices may be recompiled with NETWORK and added to Input Tape #2.

ORNL-DWG 77-12006

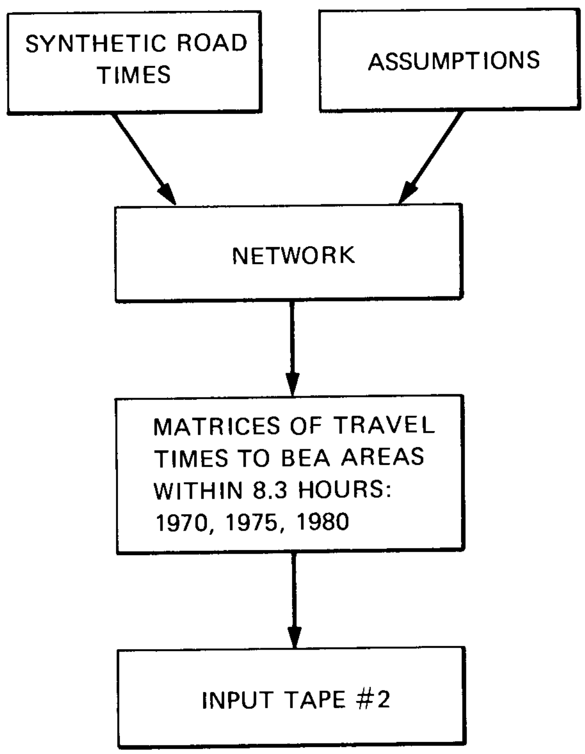


Fig. 8.3. A representation of the NETWORK program.

INFORUM.* This program aggregates and allocates INFORUM employment forecasts for 90 industry groups to the 37 used in MULTIREGION. In addition, these aggregated national employment forecasts in terms of BLS definitions are adjusted to conform to Census definitions.

8.2 REQUIRED DATA INPUTS

The data required to run the MULTIREGION program may be usefully partitioned into national and regional subsets. National values generally include the overall trends and control totals within which regional allocations take place while regional values include many of the determinants of regional employment and population shares. The required national data inputs (Table 8.1) center on the size and composition of population and employment. Population sector values are generally those developed by the Bureau of the Census (population, mortality, and fertility) and the Bureau of Labor Statistics (labor force) while employment sector values are derived from the INFORUM model. In addition, some values such as the national EPI may be derived implicitly but other values such as the national female industry mix (FIM — total and by industry) must be prepared by the user from historic trends or by assumption. Finally, because of the very special nature of their economies, the forecasts of the export base employment for Alaska and Hawaii must be provided exogenously.

The required regional data inputs are found in Table 8.2, where explanatory variables are listed for each component of the population and employment sectors. In general it can be assumed that historic BEA area data for each of these explanatory variables and most dependent variables (except migration) are available and form part of the inputs to MULTIREGION. For forecast periods some of these variables are truly endogenous while others are clearly and simply exogenous but there are a few variables that fall in the gray area between these extremes. For example, some explanatory variables are clearly exogenous within a particular five-year time step but partially or wholly endogenous over time. Because the user needs to be aware of the nature and extent of the items that must be forecast independent of the model, an imperfect classification scheme has been used in Table 8.2 to highlight these requirements.

The explanatory variables may be grouped as follows:

(A) Truly endogenous variables. The model may have to use last period conditions as "trial" values for the first iteration within each time step but thereafter the concurrent values of these variables are products of the model. Examples are the EPI and P.DEN variables.

(B) Lagged dependent variables. While these variables are technically exogenous, the user does not need to be concerned because the model automatically updates their

Table 8.1. Required national data inputs

Variable	Source
Employment by industry	INFORUM*
Population by age and sex Mortality Fertility	Bureau of the Census, Current Population Reports
Labor force by age and sex	Bureau of Labor Statistics*
College enrollments	Current Population Reports
Median schooling of persons aged 25 and over	Current Population Reports
Unemployment rate	INFORUM*
Percent of total employment that is female	User determined
Percent of employment in each industry that is female	User determined trends
Female unemployment rate	Implicit
Male unemployment rate	Implicit
Employment pressure index	Implicit

*Adjusted to Census of Population definitions.

Table 8.2. Required regional data inputs

Component and variable		Type of variable*	Component and variable		Type of variable*
Mortality and fertility			Manufacturing employment		
Regional relatives	(T)	D	SHARE	(T-5)	B
			R.FDP	(T-5)	B
Migration			R.IDP	(T-5)	B
N-L EPI	(T)	A	R.ISP	(T-5)	B
R.POT	(T-5)	B	R.I SELF P.	(T-5)	B
P.DEN	(T)	A	STRIK	(T-5)	C
CLIM	(T)	C	EPI	(T-5)	B
M.S.	(T)	D	L.W.	(T-5)	C
A.F.	(T)	C	H.W.	(T-5)	C
COL	(T)	D	PORT ACTIVITY	(T-5)	C
POOLED		D	L.C. (P.DEN)	(T-5)	B
REGION		C	OTHER	(T-5)	C
			POOLED		D
Labor force participation			REGION		C
EPI	(T)	B			
FIM	(T)	D	Local service employment		
COL	(T)	D	SHARE	(T-5)	B
A.F.	(T)	C	T.E.G.	(T)	A
M.S.	(T)	D	R.POT	(T-5)	B
POOLED		D	M.S.	(T)	D
REGION		C	EPI	(T)	A
			L.C.(P.DEN)	(T)	A
Natural resource-based employment			POOLED		D
SHARE	(T-5)	C	REGION		C
C_i^R	(T)	C			

* A = truly endogenous variable.

B = lagged dependent variable.

C = constants or constant share.

D = trended variables: simple or constrained.

values as it moves to subsequent time steps. Examples are lagged employment shares and market potentials.

(C) Constants or constant shares. Most of these exogenous variables should not concern the user unless he perceives a strong need to alter the constant. For example, the climate variable is not likely to change but the regional share of Armed Forces personnel might. PORT ACTIVITY, however, is a prime example of something we are temporarily treating as a constant that should be made more endogenous.

(D) Trended variables: simple or constrained. These exogenous variables may be of significant concern to the user if the output of MULTIREGION is especially sensitive to the particular values assumed or if the trend for a region may be expected to change suddenly. Regional mortality and fertility deviations are examples of simple trends. M.S., COL., and FIM are examples of constrained or modified trends in that regional values may be influenced by changes in other socioeconomic conditions but are forced to fit within overall national trends. The last property should ensure that the value for an individual region does not become unreasonable.

8.3 PROCEDURES FOR TUNING AND USING THE MODEL

Because the parameters of each of the components of MULTIREGION were estimated in isolation from all of the others as a series of single-equation submodels and with only a pseudo time-series analysis, the system as a whole was expected to behave somewhat differently than the simple sum of the parts. Thus there has always been concern for procedures to alter or override some parts of the model should it be necessary to tune the system as a whole or to allow for experimentation with alternative assumptions. Some of the more obvious procedures for holding the system together have already been mentioned and include national control totals, interregional balances, and floors and ceilings. For example, MULTIREGION has been programmed to force (1) the sum of employment in each industry over all BEA areas to predetermined national totals, (2) the sum over all BEA areas of 20 to 24 year-old male out-migrants to equal the sum of 20 to 24 year-old inmigrants, and (3) regional employment and unemployment to be positive values.

Given that the system does hold together, additional procedures have been included to "tune" the results and to allow for experimentation. Perhaps the most obvious tuning device is to alter the estimated parameters in the model, but other procedures are also possible. To date the adjustments to be described have been used to run the model from one known condition, 1960, through an intermediate unknown, 1965, to another known condition, 1970, where actual and forecast values could be compared to produce "reasonable" regional forecasts. The outputs of MULTIREGION are surprisingly robust with respect to many of the procedures to be described.

Regional convergence. Although not inevitable, it is rather commonly believed that the regional economies of the United States are becoming more alike and interdependent as they develop over time.[1] While this phenomenon has been an integral part of MULTIREGION's mortality and fertility computations, further convergence possibilities have been added to the regional dummy variables that were used at the last stage of each empirical analysis to capture the long-run conditions (relative to the Great Lakes region = 0) not picked up by other explanatory variables. Specifically, these dummy variables have been programmed for possible decay towards zero (so behavior within each region would become more like that within the Great Lakes area[2]) at rates of decay that may vary among the components (migration, labor force participation, etc.), and regions (New England, Middle Atlantic, etc.).

Residuals. The empirical relationships we have estimated are for an average or representative BEA area. It is rather common practice among forecasters to give explicit recognition to the fact that individual regions may consistently deviate from the average to increase forecast accuracy.[3] For example, the amusement and recreation services equation as estimated represents the likely employment response of an average BEA area but probably does not capture the uniqueness of the Las Vegas and Reno economies. To capitalize on known deviations of this sort, the 1970 residuals about the fitted regression lines are retained for use during the forecast period. The 1970 residuals are maintained in the labor force, manufacturing and local service sectors but are not available for use in the migration sector. In the migration sectors values approximating residuals have been estimated from the trackings of the model between 1960 and 1970 (and 1975). In all sectors, the option is allowed for the residuals to be maintained in full over time or they may be decayed at rates that can very among sectors and/or across regions.

Time shifts. While the behavioral relationships of the model have been estimated with pooled cross-section data to incorporate some of the insights of variation over time, we would be the first to admit that two cross sections ten years apart are a less reliable basis for determining time shifts than would be five or ten cross-sections if they were available. As a consequence, we have built in the option of moderating or turning off the influence of the time shift embedded in the coefficients of the POOLED variable. Once more, this can be done differentially among sectors and/or across regions.

Migration adjustments. Since interregional population migration data are not available for BEA areas, our analysis of SEA data was intended to produce a close but not perfect substitute.[4] Initially and quite naively, the simple areal difference between the average SEA and BEA area suggested a simple adjustment to the empirical results along the following lines. Since there are 171 continental BEA areas and 507 SEA's, the average BEA is approximately three times the size of an SEA. If people were uniformly distributed across space, we might assume that a BEA migration rate should be approximately one-third the size of the corresponding SEA rate. But since people are not uniformly distributed, a larger fraction such as one-half or three-fourths might be more appropriate.

More recently we have come to realize that these areal differences between BEAs and SEAs do not lead to a migration adjustment factor that is very substantially different from one.[5] As a consequence, the migration adjustment factor has been programmed to allow for differntial variations among regions and between inmigration and outmigration, but it is no longer expected to substantially alter the results of the model.

Controls on the rate of adjustment toward equilibrium. As we have gained experience with the properties of MULTIREGION through experimental trackings of historic regional growth and development (1960 to 1970), it has become clear that the basic model allows employment relocation to occur too quickly. In spite of our use of pooled cross-section data, the parameters of the relationships that make up MULTIREGION are still dominated by cross-section influences; the relationships within the model tend to define "desired" or "equilibrium" conditions. As a consequence, when the basic (unconstrained) model is used to track growth over time, too rapid a rate of adjustment toward equilibrium conditions prevails; this is especially true for local service employment but also holds for manufacturing.

Much of the overreaction of local service employment can be traced back to the number of iterations allowed during any five-year time step of the model. The larger is the number of iterations, the more local service employment adjusts in comparison to migration. Most of this overreaction can be controlled by setting the number of iterations to a low value (e.g., two iterations rather than ten).

Even after these adjustments, however, moderate overreaction remains in both the manufacturing and local service sectors. The nature of the excess adjustment may be sensed from Fig. 8.4 where the frequency distributions of actual and model-produced change in regional shares are contrasted for a representative industry. Note that the actual distribution is skewed and quite peaked with important and perhaps unique outliers. In general, the model produces a distribution which mimics the actual in shape (i.e., skewness) but forecasts more change. This model as well as any other also loses some portion of those unique outliers. In an effort to preserve the insights the model can yield about the relative growth in employment share among regions while slowing down the rate of adjustment, the following tuning device has been created.

$$\hat{S}_{Ri}^{t+5} = \lambda \, S_{Ri}^{t} + (1-\lambda) \, S_{Ri}^{t+5}$$

where

S_{Ri}^{t} = region R's share of national employment in industry i in year t,

S_{Ri}^{t+5} = forecast share for period t+5,

$\hat{S}_{Ri}^{t+5}$ = forecast share controlled for the rate of adjustment, and

λ = user specified weighting factor ($0 \leq \lambda \leq 1$).

Clearly, if $\lambda = .5$ this procedure amounts to the creation of a simple average of current and forecast shares but the ordering of change among regions specified by the basic (unconstrained) model is preserved. Other tuning devices such as the use of ceilings and floors cannot preserve these insights. Through repeated experiments, the user may select a λ value unique to each industry that most nearly replicates the actual distribution of change.

ORNL-DWG 77-12007

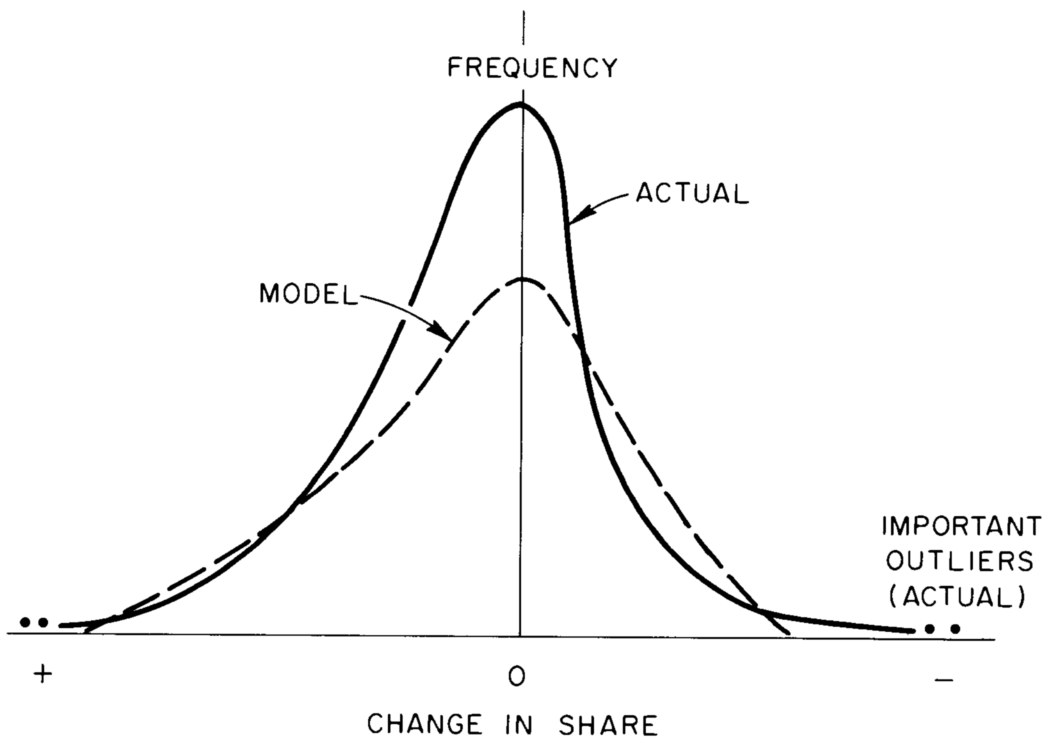


Fig. 8.4. Frequency distribution of change in share: model versus actual.

REFERENCES FOR CHAPTER 8

1. This topic is briefly discussed in E. M. Hoover, *An Introduction to Regional Economics*, New York: A. A. Knopf, Inc., 1971, pp. 240-42.

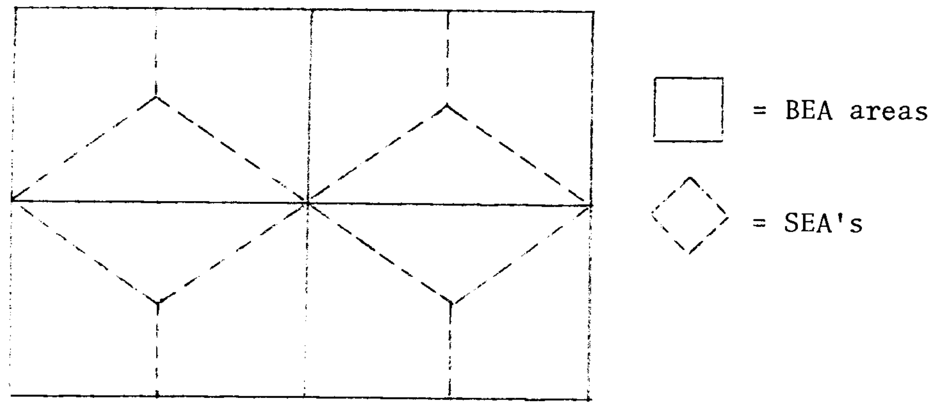
2. Should the outputs of the model prove to be sensitive to this procedure, it could be reprogrammed to decay all regions including the Great Lakes toward a national average.

3. For example, C. C. Harris, Jr., *The Urban Economies, 1985*, pp. 145-47.

4. It is true that BEA areas coinside with most "county groups" used for the *Public Use Sample* from the 1970 Census of Population. Thus, estimates of BEA inmigration are available for the 1965 to 1970 period from that source.

5. The migration equations used within MULTIREGION were estimated on the basis of 1960 and 1970 Census of Population data, reported on a State Economic Area (SEA) grid. There are 507 SEA's in the continental United States as compared to the 171 contiguous BEA economic areas which form the grid utilized by MULTIREGION. As a consequence, some migrations which occurred between SEA's, and thus were incorporated into our analysis, did not constitute migrations between BEA areas. For example, a person moving from Knox County, Tennessee to Whitley County, Kentucky would be migrating from one SEA to another, but would be moving within a BEA area. Therefore, it is necessary to adjust downward the estimated migration rates to accommodate the BEA area grid. The number of migrations "lost" by switching from the SEA to the BEA grid would determine the appropriate adjustment factor for our migration equations.

   As the data do not permit a direct observation of which inter-SEA migrations are, and are not, inter-BEA migrations, the derivation of the appropriate adjustment factor must proceed on logical, rather than empirical grounds. As a starting point, assume that the United States is a flat plain, homogeneous with respect to every variable that affects migration propensity; further, assume a total of 4 BEA areas, each containing 3 SEA's, or the ratio SEA/BEA areas = $507/171 \approx 3$ (see the diagram below); finally, assume that each SEA has a population of 100 people.



Now, let one person leave each SEA for every other SEA. From the point of view of any specific SEA, this yields 11 outmigrants and 11 inmigrants, or in- and outmigration rates of 11/100 (where the rate = # in (out) — migrants/population). If the same migration patterns are now examined on a BEA area grid, a typical BEA area will experience an outflow of 27 migrants, and an inflow of the same number (notice that in cumulating from SEA's to BEA areas, two out- and two inmigrations are lost for each SEA). The corresponding migration rates for the BEA area will be 27/300 or 9/100 for both in- and outmigration. Therefore, the migration rate for a typical region drops by only 2/11 when moving from the SEA to the BEA grid in our example. This would imply that an adjustment factor of 9/11 be used on the migration equations.

Using the same assumptions stated above, this SEA and BEA migration adjustment factor can be reduced to the following generalized form:

$$\frac{\left(\frac{m}{n}\right)\left(K-1\right)}{\frac{mK}{n}-1},$$

where

n = # of BEA areas in the continental U.S. (171)

m = # of SEA's in the continental U.S. (507)

K = # of BEA areas in example ($K \leq n$).

It can be seen that as K approaches 171, the adjustment factor approaches one. This implies that, granting the rather restrictive assumptions we have made, the migration adjustment factor should be very close to one.

The adjustment factor now being used within MULTIREGION has been amended according to one final consideration. Currently in the United States, most migrations take place between metropolitan areas (SMSA's). Nationwide, there are approximately three times the number of SMSA's per BEA area as there are SMSA's per SEA; this, of course, is a major source of "lost" migrations when moving from one spatial grid to the other: people moving between cities are less likely to be moving between BEA areas than between SEA's. In addition, the number of SMSA's per BEA area is not uniform across all BEA areas, ranging from a high of 2.4 in the Northeast Census Division to 0.6 in the Mountain Census Division. This leads to the conclusion that inter-SMSA migrations are far more likely to be <u>within</u> BEA areas in the Northeast, but <u>between</u> BEA areas in the mountain states; in other words, more migrations are "lost" in the Northeast Division than in the Mountain Division.

To allow for this uneven distribution of SMSA's across BEA areas, differential adjustment factors have been adopted, being lower (downward adjusting more) in areas such as the Northeast, where more migrations are lost converting from one grid to another, and higher (closer to one) in areas such as the Mountain States, where fewer migrations are lost.

9. A NATIONAL FUTURE

A systematic exploration of regional economic futures traditionally begins with an examination of probable national futures. Then a region's economic future is tied to or constrained to fit within this national setting. Thus, the results for regions become more or less dependent on the postulated national conditions. This chapter presents two existing projections of national demographic and economic trends prepared, respectively, by the Regional Economic Analysis Division of the Bureau of Economic Analysis and the Interindustry Economic Research Project of the University of Maryland. While both organizations have assumed the same national population future, their projection methods do yield somewhat different economic futures. In both cases, the emphasis is on projecting secular economic trends rather than short-term business cycles.

9.1 REGIONAL ECONOMIC ANALYSIS DIVISION, BUREAU OF ECONOMIC ANALYSIS (OBERS)

At an early stage in the preparation of the OBERS projections of regional economic activity, the staff of the Regional Economic Analysis Division of the Bureau of Economic Analysis prepared baseline projections of our national economy. While these projections were prepared in 1973 and might be somewhat revised if prepared today, the methods used would likely remain unchanged.[1] Basically the BEA staff moved from an assumed population projection to estimates of future gross product originating, earnings of persons, and employment by industry through a series of computational steps that can be separated into two stages. In the first stage, a projection of the most aggregate measure of economic activity — Gross National Product (GNP) — was prepared; in the second stage, this aggregate projection was elaborated upon and disaggregated to separate industry groups.

The national economy was assumed to accommodate to the needs of expected future populations in an environment characterized by no major wars, reasonable full employment, and continued technological progress and capital accumulation. The Series E population projections of the Bureau of Census were used as a starting point. Census projections are developed by a cohort component method where the components of population change — fertility, mortality, and net immigration — are projected separately.[2] The Series E projections combine standard mortality and net immigration assumptions with a total fertility rate of 2,100 births per 1,000 women to yield a population characterized by a stable number of births over time and a rapidly increasing number of deaths associated with an aging population. Under these assumptions the total U.S. population will reach 264.4 million in the year 2000.

Projections of age- and sex-specific labor force participation rates similar to those prepared by the Bureau of Labor Statistics (BLS)[3] were applied to the expected population of working age to derive an expected labor force. Under the assumption that a reasonably full level of employment — 4% unemployment rate — would be maintained through deliberate public policy, expected public and private employment in BLS terms[4] were derived from these labor force projections.

Historic trends in hours worked per man-year and GNP per man-hour were extrapolated to future years. Hours worked per man-year were assumed to decline at the rate of -.35% per year from 1971 to 2020; GNP per man-hour was assumed to increase at the rate of 2.90% per year for the private sector. These assumptions, plus a few others, were combined with projections of public and private employment to yield projections of constant dollar Gross National Product. By extrapolationing from past associations, expected GNP was converted into constant dollar personal income and constant dollar earnings.

These national aggregates were then disaggregated to 37 industry groups. The historic shares of each industry in the all industry total were computed separately for gross product originating, earnings of persons and employment and extrapolated to future years. Individually and in combination these industrial projections were examined for consistency and plausibility. Adjustments were made where necessary.

Finally, because the only industrially complete employment series for local areas (e.g., BEA areas) is from the Census of Population, projected national employment by industry in BLS terms was adjusted to conform to Census definitions.[5] These results are reproduced as Table 9.1. By broad industrial categories, BEA's projections foresee an absolute employment decline in the natural-resource-based agriculture, forestry and fisheries, and mining industries; a positive but below average employment growth in manufacturing; especially high employment growth in the services and finance, insurance, and real estate sectors; and about average growth in the remaining sectors.

9.2 INTERINDUSTRY ECONOMIC RESEARCH PROJECT, UNIVERSITY OF MARYLAND (INFORUM)

Detailed annual forecasts of the U.S. economy to 1985 or 1990 are prepared for both public and private clients by the Interindustry Economic Research Project of the University of Maryland on a semi-annual basis. These forecasts are prepared through the use of a dynamic interindustry model of the U.S. economy — INFORUM — that provides a degree of interindustry detail and consistency not available from other sources.[6] Given exogenous forecasts of selected demographic and economic conditions, the INFORUM model forecasts:

1) the sales of the products of 200 industries;
2) the distributions of the sales of each of the 200 products to;
   a) each of the other 199 industries,
   b) capital investment by each of 90 aggregated industry groups,
   c) construction by each of 28 types,
   d) government purchases by nine categories,
   e) inventory change,
   f) exports,
   g) imports,
   h) personal consumption,

Table 9.1 OBERS National Employment Projections

	1950	1960	1970	1980	1985	1990	2000	2010	2020
Population	151,325,798	179,323,175	203,235,298	223,532,000	234,517,300	246,039,000	263,830,000	281,368,000	297,146,000
Employment population ratio	.38	.37	.39	.43	.43	.43	.45	.45	.44
Total employment	57,474,912	66,372,649	79,306,527	96,114.000	101,121,000	106,388,000	117,891,000	128,018,000	130,534,000
Agriculture, forestry and fisheries	7,174,635	4,469,625	2,915,880	2,516,000	2,313,000	2,123,000	1,849,000	1,631,000	1,408,000
Agriculture	7,047,625	4,373,664	2,813,971	2,403,000	2,197,000	2,003,000	1,721,000	1,495,000	1,267,000
Forestry and fisheries	127,010	95,961	101,909	113,000	116,000	120,000	128,000	136,000	141,000
Mining	945,179	674,662	630,788	609,000	578,000	547,000	501,000	462,000	414,000
Metal	95,136	99,163	95,420	91,000	87,000	83,000	77,000	72,000	66,000
Coal	517,754	206,043	145,641	157,000	152,000	148,000	141,000	135,000	122,000
Crude petroleum and natural gas	236,632	261,934	273,214	241,000	223,000	204,000	177,000	155,000	135,000
Nonmetallic, except fuels	95,657	107,522	116,513	120,000	116,000	112,000	106,000	100,000	91,000
Contract construction	3,508,992	3,968,253	4,611,596	5,589,000	5,807,000	6,015,000	6,586,000	7,121,000	7,234,000
Manufacturing	14,801,078	18,244,900	19,837,208	22,112,000	22,609,000	23,106,000	24,169,000	25,016,000	24,526,000
Food and kindred products	1,434,112	1,898,661	1,882,339	1,871,000	1,815,000	1,758,000	1,661,000	1,570,000	1,426,000
Textile mill products	1,256,728	984,991	905,307	919,000	898,000	875,000	835,000	790,000	713,000
Apparel and other fabric products	1,079,790	1,212,412	1,278,838	1,395,000	1,396,000	1,393,000	1,383,000	1,261,000	1,257,000
Lumber products and furniture	1,209,021	1,101,970	978,393	1,036,000	1,024,000	1,010,000	988,000	962,000	886,000
Paper and allied products	475,462	602,535	686,610	814,000	839,000	863,000	916,000	957,000	935,000
Printing and publishing	867,142	1,194,832	1,191,624	1,455,000	1,516,000	1,592,000	1,732,000	1,854,000	1,845,000
Chemicals and allied products	668,641	902,114	987,728	1,231,000	1,320,000	1,412 000	1,599,000	1,780,000	1,895,000
Petroleum refining	291,761	294,054	256,486	274,000	269,000	264,000	256,000	253,000	240,000
Primary metals	1,183,763	1,272,286	1,211,851	1,120,000	1,068,000	1,017,000	937,000	867,000	777,000
Fabricated metals and ordnance	853,059	1,348,042	1,737,064	1,954,000	2,012,000	2,066,000	2,177,000	2,268,000	2,212,000
Machinery, excluding electrical	1,312,275	1,634,054	1,991,042	2,202,000	2,254,000	2,302,000	2,386,000	2,476,000	2,389,000
Electrical machinery and supplies	799,697	1,556,325	1,904,925	2,433,000	2,631,000	2,836,000	3,263,000	3,664,000	3,772,000
Motor vehicles and equipment	880,450	875,447	888,475	1,011,000	1,035,000	1,058,000	1,112,000	1,166,000	1,148,000
Transportation equipment, excluding motor vehicles	488,802	1,018,952	1,250,405	1,158,000	1,139,000	1,116,000	1,067,000	1,022,000	936,000
Other manufacturing	2,000,375	2,348,225	2,686,121	3,239,000	3,393,000	3,544,000	3,857,000	4,126,000	4,095,000
Transportation, communications and public utilities	4,513,645	4,650,643	5,186,101	6,105,000	6,406,000	6,723,000	7,409,000	8,089,000	8,302,000
Railroad transportation	1,408,293	979,544	636,572	478,000	415,000	359,000	269,000	202,000	150,000
Trucking and warehousing	713,077	949,781	1,082,530	1,332,000	1,407,000	1,482,000	1,639,000	1,781,000	1,796,000
Other transportation and services	875,827	930,648	1,109,287	1,298,000	1,368,000	1,437,000	1,573,000	1,701,000	1,766,000
Communications	719,883	855,414	1,073,663	1,474,000	1,620,000	1,776,000	2,107,000	2,443,000	2,588,000
Public utilities	796,565	935,256	1,284,049	1,523,000	1,596,000	1,669,000	1,821,0000	1,962,000	2,002,000
Wholesale and retail trade	10,739,659	12,287,854	15,576,796	19,396,000	20,227,000	21,034,000	22,522,000	23,634,000	22,768,000
Finance, insurance and real estate	1,947,942	2,820,517	3,838,387	5,240,000	5,698,000	6,178,000	7,198,000	8,175,000	8,491,000
Services	10,255,317	14,123,667	20,510,384	27,705,000	30,130,000	32,765,000	38,881,000	44,298,000	47,070,000
Lodging places and personal services	1,888,850	2,026,448	2,485,677	2,578,000	2,533,000	2,483,000	2,396,000	2,272,000	2,047,000
Business and repair services	1,332,787	1,682,922	2,490,132	3,828,000	4,376,000	4,989,000	6,306,000	7,692,000	8,336,000
Amusement and recreation services	501,640	525,543	650,862	805,000	835,000	863,000	912,000	940,000	905,000
Private households	1,663,974	1,992,599	1,211,301	998,000	896,000	803,000	737,000	615,000	459,000
Professional services	4,868,066	7,895,155	13,672,412	19,496,000	21,490,000	23,627,000	28,530,000	32,779,000	35,323,000
Government	3,588,465	5,132,528	6,199,387	6,842,000	7,353,000	7,897,000	8,776,000	9,592,000	10,321,000
Civilian government	2,550,752	3,341,911	4,201,652	5,275,000	5,786,000	6,330,000	7,209,000	8,025,000	8,754,000
Armed forces	1,037,713	1,790,617	1,997,735	1,567,000	1,567,000	1,567,000	1,567,000	1,567,000	1,567,000

3) employment by each of 90 aggregated industry groups; and

4) aggregates of some of these categories.

The model is composed of sets of structural relationships of varying degrees of complexity that have generally been estimated from historical data by econometric methods. These structural relationships include equations representing:

1) consumption expenditures per capita by product (131 of 200 sectors),
2) equipment investment (90),
3) construction investment (28),
4) inventory change (166 of 200 sectors),
5) imports (142 of 200 sectors),
6) exports (150 of 200 sectors),
7) government expenditures (9), and
8) labor productivity (90).

In addition, there are dynamic representations of the input-output coefficients of:

1) an A matrix (200 x 200) of sales to intermediate use,
2) a B matrix (200 x 90) of sales to capital equipment investment,
3) a C matrix (200 x 28) of sales to construction investment, and
4) a G matrix (200 x 9) of sales to governments.

To prepare forecasts with the INFORUM model, one must begin with exogenous forecasts of population by age, labor force, the number of households, defense spending by product, other government spending totals, interest rates, an index of construction costs, relative international prices, relative domestic prices, tax and depreciation rates, and the expected unemployment rate. With these "givens" in hand, "trial" values of disposable income and relative prices are used to compute personal consumption expenditures (PCE). Total PCE, the number of households and interest rates are used to determine nonindustrial construction expenditures which are then converted to product demands through the C matrix. Exogenous government demands are converted to product demands through the G matrix. Product outputs of previous periods, "trial" values of current output changes and assumed capital costs determine "trial" values of equipment expenditures and industrial construction which are converted to product demands through the B and C matrices. Total final demands by product are the sum of consumption, net exports, investment and government expenditures; the A matrix converts these final demands into required product outputs. A comparison of forecast and "trial" values of output change is made and the investment, construction and, ultimately, product output sectors are recomputed as necessary. Finally, the forecast changes in output and capital investment determine labor productivity which, when divided into output, determines employment and unemployment.

If the computed unemployeemnt rate deviates from the exogenously assumed value, the "trial" disposable income value is altered and the model recalculates all values until the "trial" and computed values are essentially the same. The model does converge because a higher disposable income indirectly leads to higher employment (lower unemployment) and vice versa. These procedures are justified under the assumption that Congress will consciously implement policies to assure that the target unemployment rate is realized. Thus, the purpose of this model is not to forecast aggregate GNP and employment conditions but to provide the industry and interindustry details consistent with these conditions.

For our purposes the INFORUM forecasts provide much more industry detail than we can handle regionally; we have aggregated and allocated INFORUM employment forecasts to the 37 industry groups used in MULTIREGION. In addition, these national forecasts of employment by industry in BLS terms have been adjusted to conform to Census definitions. The January 1976 INFORUM forecast[7] for 1975, 1980, and 1985 adjusted to 37 industry groups and Census definitions is found in Table 9.2.

As can be seen at the bottom of Table 9.2, this INFORUM forecast assumed Series E population levels, corresponding BLS labor force values and unemployment rates of 8.7% in 1975, 5.7% in 1980, and 5.6% in 1985. By broad industry groups, the INFORUM forecast includes an absolute employment decline in the agriculture, forestry and fisheries sector, essentially no employment change in the mining and government sectors, positive but below average employment growth in the manufacturing, construction and transportation, communications, and utilities sectors, and expecially high employment growth in the trade, services, and finance, insurance, and real estate sectors.

9.3 SOME OBSERVATIONS ON THE RESULTS AND APPROACHES

To paraphrase the words of C. Almon, "Do not expect to find startling, incredible prophesies of the future in either OBERS or INFORUM."[8] Both of these projections are based on past relationships that are expected to continue more or less unaltered into the future. Granted, the OBERS projections are based on relatively simple relationships while the INFORUM forecasts are based on more structurally complex and indirect relationships. But, as can be seen in Table 9.3 they are in substantial agreement about the probable size and composition of the U.S. economy in 1985. The choice of approaches thus may rest most heavily on the needs of the user community.

On the basis of cost alone, the OBERS national projections procedures are clearly less expensive. On the basis of other criteria, the choice is less clear. If the need is for repeated examinations of the impacts of alternative national policies or high interindustry detail to the year 1985, INFORUM would be clearly preferred; it was probably for these reasons that the Federal Energy Administration and the Environmental Protection Agency have chosen to use INFORUM in recent planning and analysis projects. If the need is for simple extrapolations to the year 2020 for sizing projects that can be repeatedly revised over time, the OBERS national projections would be preferred; the INFORUM system requires a substantial front-end investment in alternative representations of technological and behavioral relationships to yield reasonable results for such distant futures. But,

Table 9.2 INFORUM National Employment Forecasts

Variables	Values 1970	1975	1980	1985
Employment in Multiregion Sectors (thous.)*:				
Agriculture	2,753.0	2,358.1	1,929.2	1,601.9
Forestry and fisheries	97.0	79.9	66.5	55.2
Metal mining	95.0	71.8	75.7	76.5
Coal mining	146.0	144.9	155.1	164.6
Crude petroleum and natural gas mining	273.0	220.4	226.9	209.5
Nonmetallic excluding fuels mining	117.0	124.0	142.6	154.8
Contract construction	4,491.0	4,896.5	5,015.1	5,278.7
Food and kindred products	1,483.0	1,417.2	1,460.6	1,468.1
Textile mill products	1,025.0	912.6	966.9	907.9
Apparel	1,306.0	1,415.0	1,604.7	1,591.1
Printing and publishing	1,405.0	1,435.0	1,685.4	1,726.7
Chemicals and allied products	1,054.0	1,073.4	1,207.8	1,205.4
Lumber products and furniture	1,038.0	1,060.7	1,251.9	1,292.9
Non-electrical machinery	2,118.0	2,052.0	2,271.1	2,280.1
Electrical equipment	2,030.0	2,019.9	2,231.6	2,275.8
Motor vehicles and equipment	1,074.0	1,127.4	1,300.7	1,410.6
Other transportation equipment	1,198.0	1,065.9	1,125.4	1,125.2
Paper and allied products	691.0	655.9	744.1	767.8
Petroleum refining	225.0	211.8	206.1	190.0
Primary metals	1,286.0	1,297.1	1,383.7	1,392.1
Fabricated metals and ordnance	1,558.0	1,282.0	1,437.9	1,488.6
All other manufacturing	2,592.0	3,279.3	3,586.8	3,567.2
Railroad transportation	678.0	530.9	466.9	388.1
Trucking and warehousing	1,156.0	1,239.0	1,398.4	1,487.4
Other transportation	1,192.0	1,210.3	1,474.1	1,726.4
Communications	1,149.0	1,161.8	1,358.7	1,457.0

Table 9.2 (cont'd.)

Variables	Values 1970	1975	1980	1985
Public utilities	1,063.0	1,077.5	1,131.9	1,176.1
Wholesale trade	3,189.0	3,234.7	3,932.7	4,298.6
Retail trade	12,384.0	13,072.3	15,652.6	16,573.2
Finance, insurance, and real estate	3,907.0	4,253.6	5,011.4	5,520.6
Lodging and personal services	2,233.0	2,330.0	2,711.9	2,986.0
Business and repair services	2,409.0	2,938.2	3,522.0	3,885.1
Amusement and recreation services	632.0	612.3	652.2	654.4
Private households	1,284.0	1,147.2	1,118.3	1,084.1
Professional services	13,629.0	15,595.7	17,905.6	20,184.1
Public administration	4,339.0	4,581.7	5,007.3	5,309.5
Armed forces	1,999.0	1,435.8	1,404.5	1,366.6
Total employment	79,298.0	82,621.6	92,823.0	98,327.6
National Scenario Definition:				
Population (Series E), 10^6	204.8	213.9	224.1	235.7
Labor force (BLS), 10^6	85.9	93.8	101.8	107.7
Civilian unemployment rate	--	8.7	5.7	5.6
GNP, 10^9 (1972$)	--	1,188.2	1,443.4	1,608.6
Disp. per capita income (1958 $)	2,603.	2,845.	3,185.	3,345.

*Aggregated and allocated to Multiregion sectors and adjusted to Census definitions.

Table 9.3 A comparison of national employment projections to 1985: OBERS and INFORUM

	OBERS 1985/1970 (1)	INFORUM 1985/1970 (2)	(1)/(2) (3)
Total employment	1.275	1.240	1.03
Agriculture, forestry and fisheries	.793	.581	1.36*
Agriculture	.781	.582	1.34*
Forestry and fisheries	1.137	.569	2.00*
Mining	.916	.959	.96
Metal	.912	.805	1.13
Coal	1.044	1.127	.93
Crude petroleum and natural gas	.816	.767	1.06
Nonmetallic, except fuels	.996	1.323	.75*
Contract construction	1.259	1.175	1.07
Manufacturing	1.140	1.130	1.01
Food and kindred products	.996	.990	1.01
Textile mill products	.992	.886	1.12
Apparel	1.092	1.218	.90
Printing and publishing	1.272	1.229	1.04
Chemicals and allied products	1.336	1.144	1.17
Lumber products and furniture	1.047	1.246	.84*
Nonelectrical machinery	1.132	1.077	1.05
Electrical equipment	1.381	1.121	1.23*
Motor vehicles and equipment	1.165	1.313	.89
Other transportation equipment	.911	.939	.97
Paper and allied products	1.222	1.111	1.10
Petroleum refining	1.049	.844	1.24*
Primary metals	.881	1.083	.81*
Fabricated metals and ordnance	1.158	.955	1.21*
All other manufacturing	1.263	1.376	.92
Transportation, communication, and utilities	1.235	1.190	1.04
Railroad transportation	.652	.572	1.14
Trucking and warehousing	1.300	1.287	1.01
Other transportation services	1.233	1.448	.85*
Communications	1.509	1.268	1.19*
Public utilities	1.243	1.106	1.12
Wholesale and retail trade	1.299	1.340	.97
Wholesale trade		1.348	
Retail trade		1.338	
Finance, insurance, and real estate	1.484	1.413	1.05
Services	1.469	1.426	1.03
Lodging and personal services	1.019	1.337	.76*
Business and repair services	1.757	1.613	1.09
Amusement and recreation services	1.283	1.035	1.24*
Private households	.740	.844	.88*
Professional services	1.572	1.481	1.06
Government	1.186	1.053	1.13
Public administration	1.377	1.224	1.12
Armed forces	.784	.684	1.15

*Substantial differences: .88 $\geq$ ratio $\geq$ 1.18.

if the need is for national assessment procedures for long-term projects that are sequential in nature and not easily revised over time, such as energy research and development, the investment needed to alter INFORUM to consider alternative technological and behavioral options would probably be worthwhile. At present, researchers at Resources for the Future are completing a project which has attempted to alter INFORUM for such long-term purposes;[9] their results may do much to determine the extent to which public and private policymakers can expect to use highly structured economic models as tools for the assessment of very long-term national futures.

REFERENCES FOR CHAPTER 9

1. Our understanding of their methods is taken from Volume 1, "Concepts Methodology, and Summary Data" of the U.S. Water Resources Council, *OBERS Projections of Economic Activity in the U.S.*, Washington, D.C., U.S. Government Printing Office, April 1974, pp. 9-17.

2. The latest national projections are contained in U.S. Bureau of the Census, *Current Population Reports*, Series P-25, No. 601, "Projections of the Population of the United States: 1975 to 2050," U.S. Government Printing Office, Washington, D.C., 1975.

3. Denis F. Johnston, "The U.S. Labor Force: Projections to 1990," *Monthly Labor Review*, July 1973, pp. 3-13.

4. For a thorough discussion of various definitions of employment, unemployment, etc., see President's Committee to Appraise Employment and Unemployment Statistics, *Measuring Employment and Unemployment*, U.S. Government Printing Office, 1962. Basically, a person working at two jobs would be counted as two employees under BLS definitions, but the Census of Population would consider only his principal employment (one man, one job). In addition, there are some industrial classification differences.

5. BEA attempted to account for the fact that: (1) Census classifies government workers in the industry which best describes their activity and (2) Census employment relates to early April and varies in seasonal character across industries and areas.

6. A very thorough description of the 185 sector version of INFORUM is contained in C. Almon, Jr., M. B. Buckler, L. M. Horwitz, and T. C. Reimbold, *1985: Interindustry Forecasts of the American Economy*, Lexington, Massachusetts, Lexington Books, D. C. Heath and Company, 1974. Since that time, a 200 sector version has been developed and changes have been made to some components of the overall system. Documentation of these recent changes may be best obtained from the senior author at the Interindustry Economic Research Project.

7. The base case INFORUM forecasts are revised every six months. The present forecast was released at a users conference in College Park, Maryland on January 8, 1976.

8. Almon, et al., *1985: Interindustry Forecasts of The American Economy*, p. 1.

9. An initial effort to use the INFORUM model for long-term futures was undertaken by R. Ridker and Associates for the Commission on Population Growth and the American Future. The results are reported in R. G. Ridker (editor), *Population, Resources, and the Environment*, Vol. III of the Commission Research Reports, Washington, D.C., U.S. Government Printing Office, 1972. In particular see Chapter 2. R. G. Ridker, "The Economy, Resource Requirements, and Pollution Levels," Chap. 11, H. W. Herzog, Jr. and R. G. Ridker, "The Model" and Chap. 12, R. U. Ayers and I. Gutmanis, "Technological Change, Pollution and Treatment Cost Coefficients in Input-Output Analysis." A second generation of this effort is now being completed under Ridker's direction.

10. POSSIBLE REGIONAL REFLECTIONS OF A NATIONAL FUTURE

In this chapter we describe a possible regionalization of the INFORUM national forecast. MULTIREGION has been used to allocate national growth to 173 BEA economic areas after only a few simulation experiments and without introducing important subjective insights about likely events in particular regions and industries. While better forecasts will be made as the model is used less mechanically — as judgment is allowed a more proper role — the present results do constitute an interesting experiment.

We begin with a review of the results for population and employment following the format used in Chapter 2 to document historic trends. We conclude with a comparison with other forecasts.

10.1 POPULATION

The historic and forecast distributions of BEA areas by population size are shown in Table 10.1. Note how the number of BEA areas forecast to have populations of less than 500,000 persons continues its historic decline while the number of areas forecast to have populations of more than five million remains constant. This results in a forecast increase in the number of areas with populations between 500,000 and five million and especially at the upper end of this range — 3 to 5 million. The historic transition of the population of regions from small to medium to large is forecast to continue but many regions are not expected to take the last step from large to largest.

Table 10.1. Population size distributions of BEA areas 1950, 1960, 1970, and forecast 1980 and 1985

Population size	Number of BEA areas 1950	1960	1970	1980	1985
Over 10,000,000	1	1	2	2	2
5,000,000 — 9,999,999	4	4	5	5	5
3,000,000 — 4,999,999	3	4	4	8	11
2,000,000 — 2,999,999	4	7	11	9	11
1,000,000 — 1,999,999	23	29	34	34	31
500,000 — 999,999	48	48	45	51	53
400,000 — 499,999	23	25	21	24	20
300,000 — 399,999	29	26	25	17	20
250,000 — 299,999	12	8	10	11	10
200,000 — 249,999	12	12	9	6	4
150,000 — 199,999	6	5	2	2	3
100,000 — 149,999	6	4	5	4	3
50,000 — 99,999	2	0	0	0	0
Totals	173	173	173	173	173

Turning to population growth, the annual compound population growth rates for the historic periods 1950-60, 1960-70, and 1970-75 and for the forecast periods 1975-80 and 1980-85 have been compiled for each BEA area in Table 10.2. By scanning this table it can be seen that the historic unevenness of population growth over time and space is forecast to continue. In particular, note how the number of areas expected to experience negative growth (absolute population decline) is expected to increase over the period 1970-1980. In some areas like BEA 133 — Monroe, Louisiana — this would represent an entirely new experience but in other areas like BEA 103 — Sioux City, Iowa — it would simply represent a return to the pattern of the 1950s and 1960s after the temporary respite of positive growth experienced during the early 1970s.

Figures 10.1 and 10.2. add visual reinforcement to the forecast changes in population growth and should be viewed in conjunction with Figures 2.1, 2.2, and 2.3 from Chapter 2. While strong growth is forecast to continue across most areas of the West, Southwest, and Florida as it has since the 1950s, the most notable change is the substantial decline forecast for a growing number of BEA areas across the Plains region. In addition, the strong growth which appeared across broad areas of the South in the late 1960s and early 1970s is forecast to continue albeit with some reorderings among individual subregions; some BEA areas within the South are forecast to continue to grow at increasing rates relative to the nation while others are forecast to slow down.

10.2 EMPLOYMENT

Historically, regional population and employment growth have proceeded hand in hand. In some regions population growth has preceded and led to subsequent employment growth while in others employment growth has led to population growth. The analytical results lying behind the MULTIREGION computer program have contributed substantially toward an explanation of the order of growth within particular regions. This is not to say, however, that the explanation is complete.

The annual compound employment growth rates for the historic periods 1950-60 and 1960-70 and for the forecast periods 1970-75, 1975-80 and 1980-85 have been complied for each BEA area in Table 10.3. By scanning this table the unevenness of employment growth becomes apparent. During the forecast period, the model appears to discriminate well between broad areas of employment growth like the Southeast and decline like the Plains. But the rates of growth or decline forecast for some BEA areas seem unreasonable. As an up side example, the rate of growth of BEA 71 — Detroit — seems too high; examination of the underlying industry detail shows this to be due to too rapid a rate of growth of the region's motor vehicles sector. As down side examples, the rates of decline of agriculturally oriented BEAs 102 and 103 — Grand Island, Nebraska and Sioux City, Iowa — and forestry and metal mining oriented BEA 153 — Butte, Montana — seem extreme; inspection of the tables in Appendix D reveal strong positive trends in the regional shares of some natural resource-based industries while the present forecast has

Table 10.2. Annual compound population growth rates for BEA areas: 1950-60, 1960-70, and 1970-75 with forecasts for 1975-80 and 1980-85

	Population (thous.)						Annual compound growth rate (percent)				
	Actual				Forecast						
BEA No.	1950	1960	1970	1975*	1980	1985	50-60	60-70	70-75	75-80	80-85
1	311	337	321	346	354	368	0.8	-0.5	1.5	0.5	0.8
2	653	691	740	793	809	841	0.6	0.7	1.4	0.4	0.8
3	435	449	502	533	544	563	0.3	1.1	1.2	0.4	0.7
4	5173	5668	6338	6488	6687	6916	0.9	1.1	0.5	0.6	0.7
5	2078	2542	2966	3053	3233	3389	2.0	1.6	0.6	1.1	0.9
6	1130	1239	1332	1385	1426	1479	0.9	0.7	0.8	0.6	0.7
7	1167	1342	1445	1469	1534	1580	1.4	0.7	0.3	0.9	0.6
8	722	851	1016	1026	1086	1137	1.7	1.8	0.2	1.1	0.9
9	1499	1736	1789	1775	1836	1870	1.5	0.3	-0.2	0.7	0.4
10	411	444	459	472	477	487	0.8	0.4	0.5	0.2	0.4
11	387	405	419	433	439	446	0.5	0.3	0.7	0.2	0.3
12	660	725	765	774	788	796	0.9	0.5	0.2	0.4	0.2
13	756	689	692	709	708	717	-0.9	0.0	0.5	-0.0	0.2
14	14161	16406	18272	18027	18849	19306	1.5	1.1	-0.3	0.9	0.5
15	5502	6481	7281	7467	7795	8103	1.7	1.2	0.5	0.9	0.8
16	1425	1581	1723	1810	1860	1933	1.0	0.9	1.0	0.5	0.8
17	1925	2348	2670	2785	2939	3095	2.0	1.3	0.8	1.1	1.0
18	1655	2260	3090	3227	3571	3841	3.2	3.2	0.9	2.1	1.5
19	337	361	395	429	436	454	0.7	0.9	1.7	0.3	0.8
20	717	768	831	881	909	948	0.7	0.8	1.2	0.6	0.8
21	784	889	1009	1065	1121	1178	1.3	1.3	1.1	1.0	1.0
22	839	1056	1232	1296	1392	1463	2.3	1.6	1.0	1.4	1.0
23	1351	1479	1621	1751	1876	2000	0.9	0.9	1.6	1.4	1.3
24	373	448	482	521	550	577	1.8	0.7	1.6	1.1	1.0
25	864	1016	1142	1209	1260	1317	1.6	1.2	1.1	0.8	0.9
26	1138	1285	1489	1595	1662	1746	1.2	1.5	1.4	0.8	1.0
27	357	359	391	422	431	451	0.1	0.9	1.5	0.4	0.9

Table 10.2 (cont'd.)

BEA No.	Population (thous.) Actual 1950	1960	1970	1975*	Forecast 1980	1985	Annual compound growth rate (percent) 50-60	60-70	70-75	75-80	80-85
28	677	741	817	893	935	993	0.9	1.0	1.8	0.9	1.2
29	469	551	610	671	714	763	1.6	1.0	1.9	1.3	1.3
30	397	406	400	435	455	488	0.2	-0.1	1.7	0.9	1.4
31	290	368	430	470	507	540	2.4	1.6	1.8	1.5	1.3
32	379	422	461	467	497	515	1.1	0.9	0.3	1.3	0.7
33	366	403	417	427	452	465	1.0	0.3	0.4	1.2	0.6
34	662	882	1051	1211	1308	1436	2.9	1.8	2.9	1.6	1.9
35	302	648	941	1142	1203	1349	7.9	3.8	4.0	1.0	2.3
36	775	1644	2430	3007	3217	3675	7.8	4.0	4.3	1.4	2.7
37	697	1299	1797	2328	2324	2618	6.4	3.3	5.3	-0.0	2.4
38	255	310	344	396	427	467	2.0	1.0	2.8	1.5	1.8
39	204	313	382	425	476	520	4.3	2.0	2.2	2.3	1.8
40	667	669	686	726	768	806	0.0	0.3	1.1	1.1	1.0
41	438	453	460	485	516	541	0.3	0.2	1.0	1.2	1.0
42	436	469	496	513	538	559	0.7	0.6	0.7	1.0	0.8
43	425	462	488	482	513	525	0.8	0.6	-0.2	1.2	0.5
44	1469	1793	2296	2571	2776	3044	2.0	2.5	2.3	1.5	1.9
45	1620	1680	1725	1808	1876	1952	0.4	0.3	0.9	0.7	0.8
46	1578	1613	1700	1777	1876	1975	0.2	0.5	0.9	1.1	1.0
47	498	552	671	698	725	756	1.0	2.0	0.8	0.8	0.8
48	604	650	718	787	810	857	0.7	1.0	1.9	0.6	1.1
49	1191	1280	1426	1546	1609	1706	0.7	1.1	1.6	0.8	1.2
50	894	876	904	985	1013	1067	-0.2	0.3	1.7	0.6	1.0
51	823	786	762	815	821	850	-0.5	-0.3	1.3	0.2	0.7
52	1525	1422	1309	1364	1364	1384	-0.7	-0.8	0.8	-0.0	0.3
53	734	708	753	823	866	927	-0.4	0.6	1.8	1.0	1.4
54	900	1087	1220	1250	1310	1359	1.9	1.2	0.5	0.9	0.7
55	756	747	771	784	786	797	-0.1	0.3	0.4	0.1	0.3
56	254	250	252	250	251	254	-0.2	0.1	-0.2	0.1	0.2

Table 10.2 (cont'd.)

	Population (thous.)						Annual compound growth rate (percent)				
	Actual				Forecast						
BEA No.	1950	1960	1970	1975*	1980	1985	50-60	60-70	70-75	75-80	80-85
57	437	471	490	500	509	517	0.8	0.4	0.4	0.3	0.3
58	313	354	390	388	404	410	1.2	1.0	-0.1	0.8	0.3
59	205	227	250	253	267	275	1.0	1.0	0.2	1.1	0.6
60	1107	1384	1613	1669	1765	1855	2.3	1.5	0.7	1.1	1.0
61	434	501	551	551	564	569	1.4	1.0	-0.0	0.4	0.2
62	1440	1744	1889	1924	2005	2074	1.9	0.8	0.4	0.8	0.7
63	785	1002	1159	1156	1207	1234	2.5	1.5	-0.1	0.9	0.4
64	1275	1552	1763	1851	1952	2053	2.0	1.3	1.0	1.1	1.0
65	377	333	326	344	343	348	-1.2	-0.2	1.1	-0.1	0.3
66	3585	3749	3716	3656	3705	3710	0.4	-0.1	-0.3	0.3	0.0
67	633	749	770	780	789	799	1.7	0.3	0.3	0.2	0.2
68	3140	3898	4255	4210	4388	4492	2.2	0.9	-0.2	0.8	0.5
69	228	259	276	281	290	300	1.3	0.6	0.4	0.6	0.7
70	816	967	1054	1081	1128	1172	1.7	0.9	0.5	0.8	0.8
71	3652	4582	5207	5259	5620	5907	2.3	1.3	0.2	1.3	1.0
72	585	698	798	866	907	962	1.8	1.3	1.7	0.9	1.2
73	831	990	1124	1205	1252	1316	1.8	1.3	1.4	0.8	1.0
74	727	889	1034	1073	1150	1211	2.0	1.5	0.7	1.4	1.0
75	440	517	597	617	644	669	1.6	1.4	0.6	0.9	0.8
76	562	681	747	771	796	818	1.9	0.9	0.7	0.6	0.6
77	6039	7323	8193	8210	8672	9013	1.9	1.1	0.0	1.1	0.8
78	518	572	628	652	674	696	1.0	0.9	0.7	0.7	0.6
79	497	552	605	613	620	627	1.1	0.9	0.3	0.2	0.2
80	244	288	330	334	346	352	1.7	1.4	0.3	0.7	0.3
81	280	292	301	308	309	311	0.4	0.3	0.5	0.0	0.1
82	397	492	560	560	575	581	2.2	1.3	-0.0	0.5	0.2
83	325	377	455	483	523	558	1.5	1.9	1.2	1.6	1.3
84	1489	1848	2066	2115	2222	2318	2.2	1.1	0.5	1.0	0.9

Table 10.2 (cont'd.)

BEA No.	Population (thous.) Actual 1950	1960	1970	1975*	Forecast 1980	1985	Annual compound growth rate (percent) 50-60	60-70	70-75	75-80	80-85
85	759	831	926	976	999	1035	0.9	1.1	1.1	0.5	0.7
86	307	322	350	378	380	392	0.5	0.8	1.6	0.1	0.6
87	417	449	429	428	415	403	0.7	-0.5	-0.0	-0.6	-0.6
88	205	205	219	238	238	245	0.0	0.7	1.6	0.0	0.5
89	254	257	269	279	275	275	0.1	0.5	0.7	-0.2	-0.0
90	200	230	245	250	249	250	1.4	0.6	0.4	-0.0	0.0
91	2164	2528	2935	3057	3261	3454	1.6	1.5	0.8	1.3	1.2
92	229	223	220	229	231	234	-0.3	-0.1	0.8	0.1	0.3
93	178	189	182	183	189	191	0.6	-0.4	0.1	0.7	0.2
94	187	226	222	235	245	254	1.9	-0.2	1.1	0.8	0.7
95	213	245	246	269	284	302	1.4	0.1	1.7	1.1	1.2
96	147	149	144	151	150	153	0.1	-0.3	0.8	-0.1	0.3
97	338	342	335	344	343	341	0.1	-0.2	0.5	-0.1	-0.1
98	151	142	132	134	126	121	-0.6	-0.7	0.2	-1.2	-0.7
99	360	372	365	365	353	343	0.3	-0.2	0.0	-0.6	-0.6
100	208	237	231	247	259	272	1.3	-0.3	1.3	0.9	1.0
101	114	116	105	105	105	104	0.1	-1.0	-0.1	0.0	-0.2
102	336	322	323	330	325	323	-0.4	0.0	0.4	-0.3	-0.2
103	480	467	454	456	444	434	-0.3	-0.3	0.1	-0.5	-0.5
104	282	280	266	264	248	238	-0.1	-0.5	-0.1	-1.2	-0.9
105	401	427	426	430	425	421	0.6	-0.0	0.2	-0.2	-0.2
106	728	759	782	806	804	815	0.4	0.3	0.6	-0.1	0.3
107	631	720	794	834	837	861	1.3	1.0	1.0	0.1	0.6
108	301	320	323	336	344	347	0.6	0.1	0.8	0.5	0.2
109	376	379	349	349	342	336	0.1	-0.8	0.0	-0.4	-0.4
110	600	735	728	727	746	747	2.1	-0.1	-0.0	0.5	0.0
111	1773	2049	2249	2288	2373	2447	1.5	0.9	0.3	0.7	0.6

Table 10.2 (cont'd.)

BEA No	Population (thous.) Actual 1950	1960	1970	1975*	Forecast 1980	1985	Annual compound growth rate (percent) 50-60	60-70	70-75	75-80	80-85
112	370	367	397	420	423	436	-0.1	0.8	1.2	0.1	0.6
113	299	301	299	292	283	276	0.0	-0.1	-0.5	-0.6	-0.5
114	2582	2945	3248	3227	3343	3424	1.3	1.0	-0.1	0.7	0.5
115	628	580	558	585	592	610	-0.8	-0.4	0.9	0.2	0.6
116	836	791	830	901	894	922	-0.6	0.5	1.7	-0.2	0.6
117	777	771	864	960	997	1064	-0.1	1.1	2.1	0.8	1.3
118	288	252	289	338	341	370	-1.3	1.4	3.2	0.2	1.6
119	814	891	1014	1085	1121	1175	0.9	1.3	1.4	0.6	1.0
120	999	1040	1156	1239	1288	1355	0.4	1.1	1.4	0.8	1.0
121	425	460	455	457	469	470	0.8	-0.1	0.1	0.5	0.0
122	367	451	437	447	451	450	2.1	-0.3	0.5	0.1	-0.0
123	251	326	328	344	362	374	2.7	0.1	0.9	1.1	0.7
124	207	337	319	327	341	349	5.0	-0.6	0.5	0.8	0.4
125	290	290	264	275	276	278	0.0	-0.9	0.8	0.0	0.1
126	134	126	124	130	132	133	-0.6	-0.1	0.8	0.3	0.3
127	1574	2063	2736	2912	3265	3567	2.7	2.9	1.3	2.3	1.8
128	351	374	403	468	493	531	0.6	0.8	3.0	1.0	1.5
129	416	452	559	668	720	798	0.8	2.2	3.6	1.5	2.1
130	537	518	553	598	603	627	-0.4	0.7	1.6	0.2	0.8
131	364	315	329	350	350	362	-1.4	0.4	1.2	0.0	0.7
132	392	445	453	465	484	496	1.3	0.2	0.5	0.8	0.5
133	481	515	532	546	532	530	0.7	0.3	0.5	-0.5	-0.1
134	614	556	506	497	516	525	-1.0	-0.9	-0.4	0.8	0.3
135	464	489	510	548	577	613	0.5	0.4	1.5	1.0	1.2
136	418	402	393	411	429	445	-0.4	-0.2	0.9	0.8	0.7
137	525	664	724	781	835	893	2.4	0.9	1.5	1.4	1.4
138	1529	1884	2148	2250	2397	2538	2.1	1.3	0.9	1.3	1.2

Table 10.2 (cont'd.)

	Population (thous.)						Annual compound growth rate				
	Actual				Forecast		percent				
BEA No.	1950	1960	1970	1975*	1980	1985	50-60	60-70	70-75	75-80	80-85
139	531	655	748	774	822	852	2.1	1.3	0.7	1.2	0.7
140	297	373	394	402	411	423	2.3	0.5	0.4	0.4	0.6
141	1246	1758	2362	2689	2911	3239	3.5	3.0	2.6	1.6	2.2
142	845	1065	1229	1341	1441	1543	2.3	1.4	1.8	1.4	1.4
143	403	495	516	536	578	602	2.1	0.4	0.8	1.5	0.8
144	320	369	355	426	464	525	1.4	-0.4	3.7	1.7	2.5
145	440	646	681	766	860	952	3.9	0.5	2.4	2.3	2.0
146	358	500	572	657	713	791	3.4	1.4	2.8	1.6	2.1
147	347	424	509	577	608	655	2.0	1.8	2.5	1.1	1.5
148	838	1169	1523	1749	1905	2116	3.4	2.7	2.8	1.7	2.1
149	176	239	251	300	313	349	3.1	0.5	3.6	0.9	2.2
150	183	221	229	250	271	291	1.9	0.3	1.8	1.6	1.4
151	712	901	1061	1215	1333	1465	2.4	1.7	2.7	1.9	1.9
152	252	286	300	343	353	379	1.3	0.5	2.7	0.6	1.4
153	198	213	234	256	261	274	0.7	1.0	1.8	0.4	1.0
154	566	659	687	744	778	816	1.5	0.4	1.6	0.9	0.9
155	1532	1879	2363	2417	2565	2679	2.1	2.3	0.4	1.2	0.9
156	365	398	406	433	431	438	0.9	0.2	1.3	-0.1	0.3
157	1186	1348	1637	1777	1878	2006	1.3	2.0	1.7	1.1	1.3
158	362	458	541	617	649	701	2.4	1.7	2.7	1.0	1.5
159	205	241	265	312	328	362	1.7	0.9	3,3	1.0	2.0
160	104	150	206	250	268	300	3.8	3.2	4.0	1.4	2.3
161	86	166	317	384	428	487	6.7	6.7	3.9	2.2	2.6
162	541	945	1316	1659	1792	2062	5.7	3.4	4.7	1.6	2.9
163	207	357	454	564	605	687	5.6	2.4	4.4	1.4	2.6
164	556	1033	1357	1587	1744	1930	6.4	2.8	3.2	1.9	2.0
165	5160	8087	10436	10835	11790	12592	4.6	2.6	0.8	1.7	1.3

Table 10.2 (cont'd.)

	Population (thous.)						Annual compound growth rate (percent)				
	Actual				Forecast						
BEA No.	1950	1960	1970	1975*	1980	1985	50-60	60-70	70-75	75-80	80-85
166	737	916	1036	1111	1191	1262	2.2	1.2	1.4	1.4	1.2
167	434	537	643	707	752	804	2.2	1.8	1.9	1.2	1.3
168	538	854	1089	1215	1344	1480	4.7	2.5	2.2	2.0	1.9
169	130	153	176	199	208	223	1.6	1.4	2.4	0.9	1.4
170	82	132	121	130	144	153	4.9	-0.8	1.4	2.0	1.2
171	2945	4001	5090	5345	5880	6332	3.1	2.4	1.0	1.9	1.5
172	128	226	300	352	409	466	5.8	2.9	3.2	3.1	2.7
173	499	632	768	864	989	1096	2.4	2.0	2.4	2.7	2.1
U.S. Total	151870	179322	203794	213053	224132	235701	1.7	1.3	1.0	1.0	1.0

*Preliminary 1975 population from Federal-State Cooperative Program for Population Estimation, _Current Population Survey_.

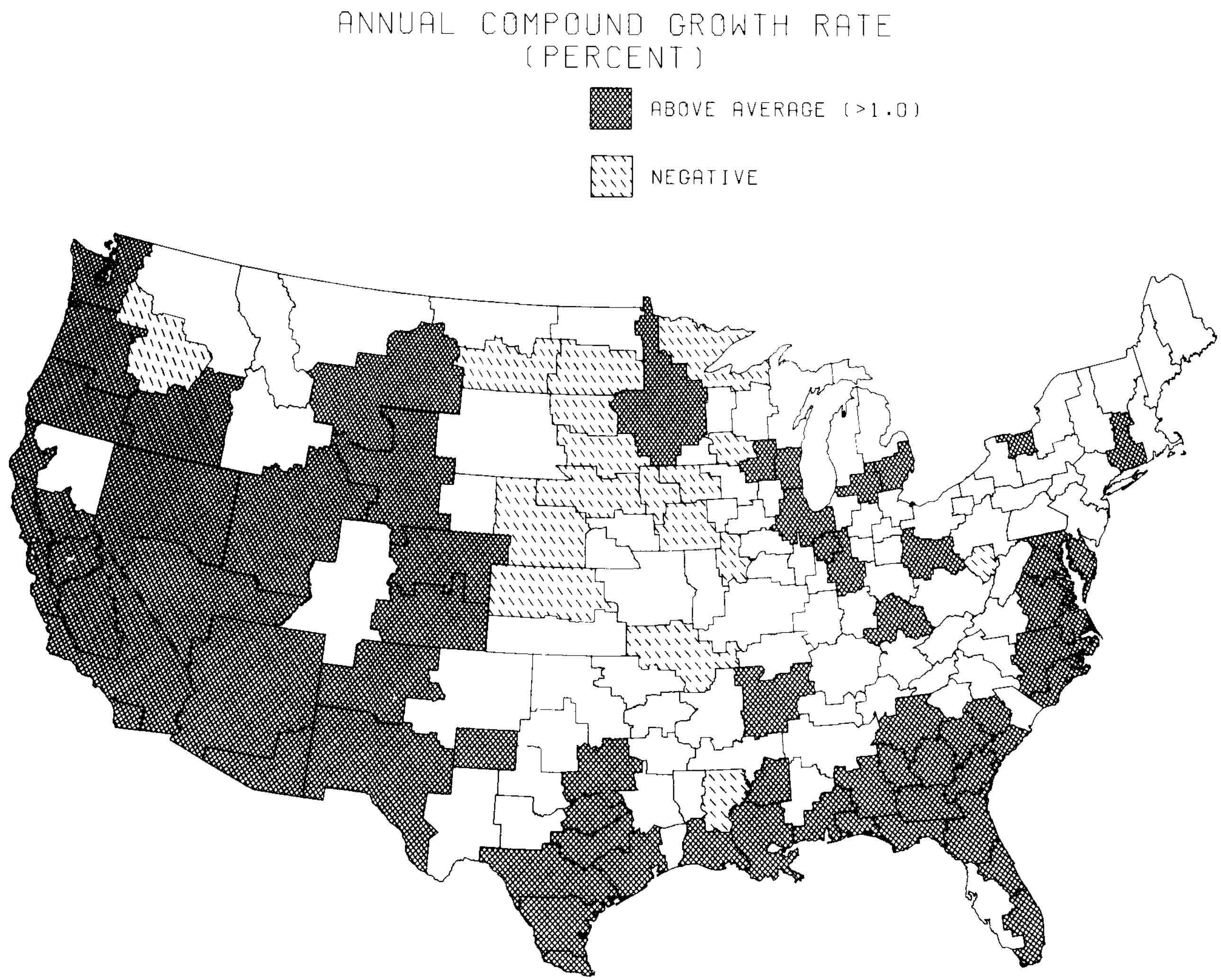


Fig. 10.1. Forecast population growth: 1975 - 1980.

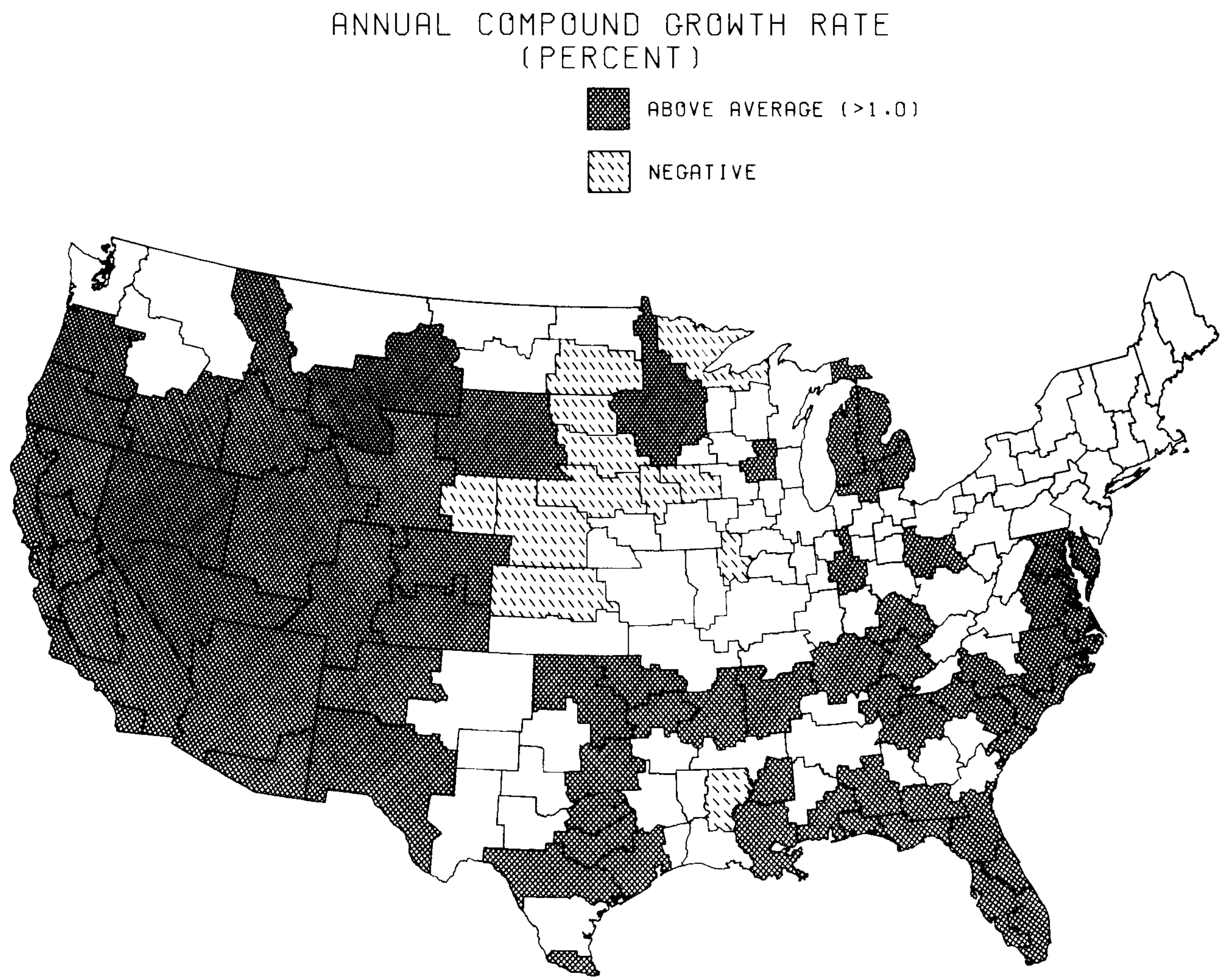


Fig. 10.2. Forecast population growth: 1980 - 1985.

Table 10.3. Annual compound employment growth rates for BEA areas: 1950-60 and 1960-70 with forecasts for 1970-75, 1975-80 and 1980-85

	Employment (thous.)						Annual compound growth rate (percent)				
	Actual			Forecast							
BEA No.	1950	1960	1970	1975	1980	1985	50-60	60-70	70-75	75-80	80-85
1	95	112	115	108	110	105	1.6	0.3	-1.2	0.3	-0.9
2	239	259	293	295	313	311	0.8	1.2	0.1	1.2	-0.1
3	155	162	192	194	201	194	0.4	1.7	0.2	0.7	-0.6
4	2039	2258	2639	2794	3172	3353	1.0	1.6	1.1	2.6	1.1
5	859	1015	1244	1313	1501	1602	1.7	2.0	1.1	2.7	1.3
6	444	461	519	532	583	606	0.4	1.2	0.5	1.9	0.8
7	437	486	542	543	577	582	1.1	1.1	0.0	1.2	0.2
8	286	326	410	455	524	561	1.3	2.3	2.1	2.9	1.4
9	579	634	679	682	740	753	0.9	0.7	0.1	1.6	0.4
10	150	152	170	170	182	184	0.1	1.1	-0.1	1.4	0.2
11	135	138	156	157	166	163	0.2	1.2	0.1	1.2	-0.4
12	249	267	288	282	284	266	0.7	0.8	-0.4	0.1	-1.3
13	268	245	274	281	313	329	-0.9	1.1	0.5	2.2	1.0
14	5836	6651	7409	7715	8694	9072	1.3	1.1	0.8	2.4	0.9
15	2207	2523	2931	3100	3545	3752	1.3	1.5	1.1	2.7	1.1
16	550	604	711	741	821	848	0.9	1.7	0.8	2.1	0.6
17	774	897	1087	1149	1316	1413	1.5	1.9	1.1	2.7	1.4
18	738	944	1358	1515	1823	2045	2.5	3.7	2.2	3.8	2.3
19	120	128	156	162	177	182	0.6	2.0	0.7	1.8	0.6
20	257	279	333	349	391	412	0.8	1.8	1.0	2.3	1.1
21	305	334	412	439	506	550	0.9	2.1	1.3	2.8	1.7
22	342	404	503	495	533	556	1.7	2.2	-0.3	1.5	0.9
23	477	508	636	673	770	835	0.6	2.3	1.1	2.7	1.6
24	136	162	197	192	205	210	1.8	2.0	-0.6	1.3	0.5
25	342	406	495	521	589	622	1.7	2.0	1.0	2.5	1.1

Table 10.3 (cont'd.)

BEA No.	Employment (thous.)						Annual compound growth rate (percent)				
	Actual			Forecast							
	1950	1960	1970	1975	1980	1985	50-60	60-70	70-75	75-80	80-85
26	446	501	654	696	802	855	1.2	2.7	1.2	2.9	1.3
27	117	120	148	156	178	195	0.3	2.0	1.1	2.6	1.9
28	263	292	346	361	407	431	1.0	1.7	0.9	2.4	1.2
29	164	198	244	252	280	300	1.9	2.1	0.7	2.1	1.4
30	135	129	144	152	177	208	-0.5	1.1	1.1	3.1	3.3
31	102	128	166	163	173	179	2.3	2.7	-0.5	1.3	0.7
32	142	151	180	183	203	223	0.6	1.8	0.3	2.1	1.9
33	129	139	155	151	159	163	0.7	1.2	-0.5	1.0	0.5
34	246	325	408	419	462	487	2.8	2.3	0.6	2.0	1.1
35	111	233	351	383	436	468	7.6	4.2	1.8	2.6	1.4
36	318	628	963	1102	1350	1528	7.0	4.4	2.7	4.1	2.5
37	256	441	615	677	794	875	5.6	3.4	1.9	3.3	2.0
38	87	106	127	126	132	135	1.9	1.8	-0.1	0.9	0.4
39	70	110	143	138	150	160	4.5	2.6	-0.6	1.7	1.2
40	237	233	256	257	281	300	-0.2	0.9	0.0	1.9	1.3
41	159	159	172	170	183	192	0.1	0.8	-0.3	1.5	0.9
42	155	162	185	188	206	222	0.4	1.3	0.4	1.8	1.5
43	169	175	195	191	207	226	0.4	1.1	-0.5	1.7	1.7
44	563	681	959	1087	1333	1512	1.9	3.5	2.5	4.2	2.6
45	543	555	621	646	731	782	0.2	1.1	0.8	2.5	1.4
46	546	537	603	644	743	812	-0.2	1.2	1.3	2.9	1.8
47	156	182	243	272	327	377	1.5	3.0	2.3	3.7	2.9
48	207	224	278	291	325	343	0.8	2.2	0.9	2.2	1.1
49	427	467	562	606	700	759	0.9	1.9	1.5	2.9	1.6
50	267	265	305	322	362	386	-0.1	1.4	1.1	2.4	1.3

Table 10.3 (cont'd.)

BEA No.	Employment (thous.) Actual 1950	1960	1970	Forecast 1975	1980	1985	Annual compound growth rate (percent) 50-60	60-70	70-75	75-80	80-85
51	246	226	250	264	296	316	-0.8	1.0	1.1	2.3	1.3
52	449	381	388	392	419	423	-1.6	0.2	0.2	1.4	0.2
53	227	216	257	278	320	355	-0.5	1.7	1.6	2.8	2.1
54	341	386	475	494	544	569	1.3	2.1	0.8	1.9	0.9
55	260	249	281	283	304	314	-0.4	1.2	0.2	1.4	0.6
56	90	86	94	90	99	115	-0.5	0.9	-0.8	1.8	3.1
57	165	175	197	195	202	203	0.6	1.2	-0.2	0.8	0.0
58	119	134	159	157	165	169	1.1	1.8	-0.2	0.9	0.5
59	76	83	101	97	102	106	1.0	1.9	-0.7	1.0	0.7
60	438	532	650	680	764	808	1.9	2.0	0.9	2.3	1.1
61	169	189	214	215	225	221	1.2	1.2	0.1	0.9	-0.4
62	549	628	711	732	807	834	1.4	1.3	0.6	2.0	0.7
63	307	373	463	480	520	529	2.0	2.2	0.7	1.6	0.3
64	463	549	674	716	807	854	1.7	2.1	1.2	2.4	1.1
65	119	101	107	105	111	111	-1.6	0.6	-0.3	1.0	-0.1
66	1255	1251	1320	1336	1453	1484	-0.0	0.5	0.2	1.7	0.4
67	240	260	285	280	297	297	0.8	0.9	-0.4	1.2	0.0
68	1259	1446	1680	1759	1977	2065	1.4	1.5	0.9	2.4	0.9
69	84	90	104	107	121	140	0.7	1.5	0.4	2.6	2.9
70	310	345	405	421	467	490	1.1	1.6	0.7	2.1	1.0
71	1436	1623	1968	2081	2493	2778	1.2	1.9	1.1	3.7	2.2
72	197	227	270	274	296	304	1.4	1.7	0.3	1.5	0.6
73	299	342	411	420	447	447	1.3	1.9	0.4	1.3	0.0
74	272	324	401	421	471	503	1.7	2.2	0.9	2.3	1.3
75	173	195	243	255	277	281	1.2	2.3	0.9	1.7	0.3

Table 10.3 (cont'd.)

BEA No.	Employment (thous.) Actual 1950	1960	1970	Forecast 1975	1980	1985	Annual compound growth rate (percent) 50-60	60-70	70-75	75-80	80-85
76	226	259	300	300	318	319	1.4	1.5	-0.0	1.2	0.1
77	2582	2933	3380	3537	3997	4189	1.3	1.4	0.9	2.5	0.9
78	201	214	251	250	260	261	0.6	1.6	-0.1	0.8	0.0
79	194	206	237	235	244	239	0.6	1.4	-0.2	0.7	-0.4
80	96	113	135	131	129	121	1.6	1.8	-0.5	-0.4	-1.2
81	105	105	112	106	107	105	-0.1	0.7	-0.1	0.2	-0.4
82	164	192	228	230	235	222	1.6	1.8	0.2	0.4	-1.1
83	127	145	187	196	214	227	1.3	2.6	0.9	1.8	1.2
84	625	718	841	869	957	995	1.4	1.6	0.7	2.0	0.8
85	272	284	334	337	359	363	0.4	1.6	0.2	1.3	0.2
86	114	112	127	122	122	116	-0.1	1.2	-0.8	0.0	-0.9
87	152	145	148	136	131	120	-0.4	0.2	-1.7	-0.7	-1.8
88	71	70	79	76	74	69	-0.2	1.2	-0.8	-0.5	-1.3
89	96	91	100	93	89	83	-0.5	1.0	-1.4	-0.9	-1.3
90	78	84	97	92	88	85	0.8	1.4	-1.1	-0.8	-0.8
91	839	935	1177	1279	1485	1613	1.1	2.3	1.7	3.0	1.7
92	81	76	77	71	67	62	-0.6	0.1	-1.7	-1.1	-1.6
93	62	61	63	55	53	50	-0.1	0.2	-2.5	-0.7	-1.3
94	73	83	84	74	70	65	1.3	0.1	-2.5	-1.1	-1.4
95	79	88	93	82	77	71	1.1	0.5	-2.4	-1.4	-1.5
96	53	52	50	44	42	38	-0.2	-0.3	-2.5	-1.1	-1.6
97	125	118	120	111	104	94	-0.5	0.1	-1.6	-1.2	-2.1
98	55	49	48	41	38	34	-1.1	-0.2	-3.0	-1.7	-2.2
99	136	133	137	126	117	104	-0.2	0.3	-1.7	-1.5	-2.4
100	77	84	85	76	72	68	0.8	0.2	-2.2	-1.0	-1.2

Table 10.3 (cont'd.)

BEA No.	Employment (thous.) Actual 1950	1960	1970	Forecast 1975	1980	1985	Annual compound growth rate (percent) 50-60	60-70	70-75	75-80	80-85
101	43	42	40	33	31	27	-0.1	-0.5	-3.7	-1.7	-2.2
102	127	119	126	115	105	93	-0.7	0.6	-1.8	-1.9	-2.4
103	180	167	170	157	147	131	-0.8	0.2	-1.6	-1.4	-2.2
104	104	99	99	88	84	77	-0.5	0.1	-2.3	-1.0	-1.7
105	154	154	161	151	147	138	0.0	0.4	-1.3	-0.4	-1.3
106	281	287	319	320	341	348	0.2	1.1	0.1	1.2	0.4
107	248	276	320	320	338	341	1.1	1.5	0.0	1.1	0.2
108	117	126	137	132	125	110	0.8	0.8	-0.7	-1.1	-2.6
109	140	143	137	122	116	110	0.2	-0.4	-2.3	-0.9	-1.2
110	227	276	290	273	270	254	2.0	0.5	-1.2	-0.2	-1.2
111	706	790	925	965	1095	1172	1.1	1.6	0.9	2.6	1.4
112	136	133	155	157	164	167	-0.2	1.5	0.3	0.8	0.4
113	112	110	115	106	108	105	-0.1	0.4	-1.6	0.3	-0.4
114	1002	1080	1237	1284	1456	1552	0.7	1.4	0.7	2.5	1.3
115	203	182	188	191	210	229	-1.1	0.4	0.2	1.9	1.7
116	290	272	298	299	311	310	-0.6	0.9	0.1	0.8	-0.1
117	256	254	307	323	360	383	-0.1	1.9	1.0	2.2	1.3
118	86	75	97	96	100	101	-1.3	2.5	-0.1	0.9	0.2
119	283	309	381	400	448	479	0.9	2.1	1.0	2.3	1.4
120	357	379	454	474	529	564	0.6	1.8	0.8	2.2	1.3
121	158	175	183	162	163	162	1.0	0.5	-2.5	0.2	-0.2
122	137	174	171	152	141	129	2.4	-0.2	-2.3	-1.5	-1.9
123	91	117	122	110	104	97	2.6	0.4	-2.1	-1.2	-1.3
124	76	123	123	108	108	103	4.9	-0.0	-2.5	-0.1	-0.8
125	104	108	102	86	84	82	0.4	-0.6	-3.3	-0.4	-0.5

Table 10.3 (cont'd.)

	Employment (thous.)						Annual compound growth rate (percent)				
	Actual			Forecast							
BEA No.	1950	1960	1970	1975	1980	1985	50-60	60-70	70-75	75-80	80-85
126	49	47	49	41	39	38	-0.5	0.4	-3.4	-0.8	-0.6
127	627	807	1155	1296	1566	1752	2.6	3.6	2.3	3.9	2.3
128	129	143	166	152	160	166	1.0	1.5	-1.8	1.0	0.8
129	145	160	217	232	256	272	1.0	3.1	1.3	2.0	1.2
130	183	174	198	201	219	231	-0.5	1.3	0.3	1.7	1.1
131	115	98	114	115	129	147	-1.6	1.5	0.3	2.3	2.7
132	133	147	153	145	154	157	1.0	0.4	-1.0	1.1	0.4
133	145	150	163	161	172	181	0.3	0.8	-0.1	1.3	1.0
134	197	172	159	159	180	216	-1.4	-0.8	0.0	2.5	3.7
135	162	163	177	184	208	236	0.0	0.8	0.8	2.5	2.6
136	139	125	131	129	137	143	-1.0	0.4	-0.3	1.3	0.8
137	184	223	252	255	284	310	1.9	1.2	0.2	2.2	1.8
138	530	608	717	756	866	938	1.4	1.7	1.1	2.7	1.6
139	162	195	245	240	255	259	1.9	2.3	-0.3	1.2	0.3
140	106	126	140	142	160	184	1.7	1.1	0.3	2.3	2.9
141	485	644	946	1074	1310	1482	2.9	3.9	2.6	4.1	2.5
142	309	373	451	458	504	532	1.9	1.9	0.3	1.9	1.1
143	132	155	176	170	173	171	1.7	1.2	-0.7	0.4	-0.2
144	99	115	101	95	100	104	1.5	-1.2	-1.2	1.0	0.8
145	159	228	236	225	236	241	3.7	0.3	-0.9	0.9	0.4
146	109	155	190	191	199	200	3.6	2.0	0.1	0.8	0.1
147	118	146	194	183	179	172	2.2	2.8	-1.2	-0.4	-0.7
148	325	452	626	690	809	893	3.4	3.3	2.0	3.2	2.0
149	60	79	87	81	79	76	2.7	1.1	-1.4	-0.6	-0.6
150	75	84	89	79	75	70	1.1	0.6	-2.2	-1.1	-1.3

Table 10.3 (cont'd.)

BEA No.	Employment (thous.) Actual 1950	1960	1970	Forecast 1975	1980	1985	Annual compound growth rate (percent) 50-60	60-70	70-75	75-80	80-85
151	240	310	391	408	447	464	2.6	2.4	0.8	1.9	0.7
152	87	101	113	105	102	98	1.4	1.2	-1.6	-0.4	-0.8
153	71	71	81	76	74	70	-0.0	1.4	-1.4	-0.5	-1.1
154	207	235	248	236	233	222	1.2	0.6	-1.0	-0.3	-1.0
155	591	706	927	984	1147	1257	1.8	2.8	1.2	3.1	1.9
156	130	141	148	140	141	136	0.8	0.5	-1.0	0.0	-0.7
157	451	495	631	674	773	834	0.9	2.5	1.3	2.8	1.5
158	132	160	193	190	194	188	1.9	1.9	-0.3	0.4	-0.6
159	74	90	104	94	90	85	2.0	1.4	-2.0	-0.9	-1.0
160	42	62	88	86	81	78	3.9	3.6	-0.7	-1.0	-0.9
161	32	67	132	141	157	169	7.5	7.0	1.2	2.3	1.4
162	178	323	485	536	623	677	6.1	4.1	2.0	3.1	1.7
163	67	123	162	158	160	159	6.3	2.8	-0.5	0.2	-0.2
164	224	418	566	561	615	646	6.4	3.1	-0.2	1.8	1.0
165	1992	3154	4160	4550	5405	5928	4.7	2.8	1.8	3.5	1.9
166	243	310	359	352	370	374	2.5	1.5	-0.4	1.0	0.2
167	152	185	224	225	239	245	2.0	1.9	0.1	1.1	0.5
168	199	317	403	426	489	541	4.7	2.4	1.1	2.8	2.0
169	47	54	61	56	56	53	1.3	1.2	-1.5	-0.2	-0.9
170	31	45	41	35	34	32	3.9	-1.0	-3.0	-0.7	-1.3
171	1183	1574	2083	2263	2666	2919	2.9	2.8	1.7	3.3	1.8
172	62	90	122	123	140	150	3.8	3.0	0.3	2.6	1.4
173	190	256	337	344	396	427	3.0	2.8	0.4	2.8	1.5
U.S Total	57474	66372	79306	82621	92823	98327	1.4	1.8	0.8	2.4	1.2

simply frozen the regional shares at their 1970 values. Irregularities such as these exist because the model has been used too mechanically to produce the present forecast. As MULTIREGION is employed more properly as a computational framework for managing the use of increasing amounts of judgment and insight about particular regions and industries, most of these problems will be minimized. Those that do remain will most likely be associated with regions whose industrial mix is highly concentrated.

Figures 10.3, 10.4, and 10.5 visually reinforce the forecast changes in employment growth when viewed in conjunction with Figure 2.9. The net shift component of employment growth has been plotted to emphasize regional deviations from the national average. Thus, our forecasts of extreme positive and negative growth in the South and Plains, respectively, are highlighted.

10.3 COMPARISON WITH OTHER FORECASTS

Even at this early stage of experimentation, it is tempting to compare the MULTIREGION forecasts with those of others. In this case the comparison is made with forecasts of the Bureau of Economic Analysis (OBERS)[1] and Curtis C. Harris, Jr. (Harris*).[2] Our purpose is not to criticize but to compare; both they and we will have changed our forecasts by the time these words are read.

Table 10.4 compares our 1985 population forecasts with OBERS-1985, and OBERS-1990 with Harris-1990. The relatives listed in columns A, B, and C of the table are also mapped in Figures 10.6, 10.7, and 10.8. By linking these pair-wise comparisons, some interesting observations may be made.[3]

Focusing on column A of Table 10.4 and Figure 10.6, we rather consistently forecast less population growth than OBERS in the lower Great Lakes and interior Southeast regions; population growth exceeding OBERS is forecast in the remaining portions of the Great Lakes and Southeast, and in the Southwest, Mountain, and Far West regions. The greatest relative differences between ORNL-1985 and OBERS-1985 appear to be concentrated in the Southwest, Mountain, and Far West regions.

The second relative, Column B of Table 10.4, provides a comparison of OBERS-1990 with Harris-1990 population forecasts. Column B and Figure 10.7 indicate substantial diversity within broad regions; however, OBERS tends to forecast less population growth than Harris* for areas along the Atlantic coast, near the Great Lakes and scattered through the rest of the county. OBERS projections exceed Harris* for interior areas of the East and South and selected areas of the Plains, Mountain, and Far West regions.

From Column C of Table 10.4 and Figure 10.8, we again forecast rather consistently less population growth than Harris* in the more urban areas of the East and in the Great Lakes region. Population growth exceeding Harris* is forecast across areas of the South and most of the Mountain and Far West regions; we also tend to forecast less growth than Harris* for the largest metropolitan areas.

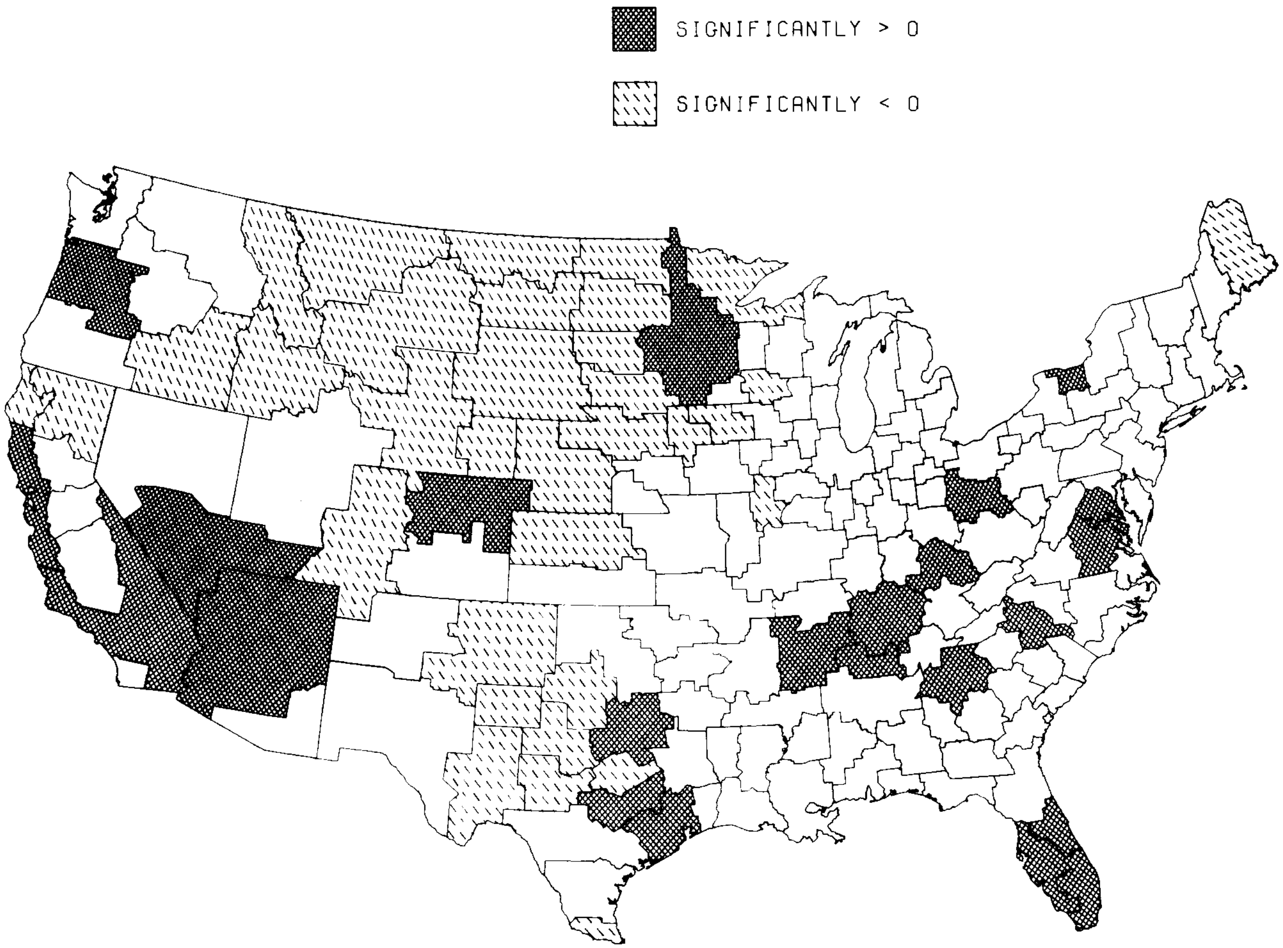


Fig. 10.3. Forecast net employment shift:
1970 - 1975.

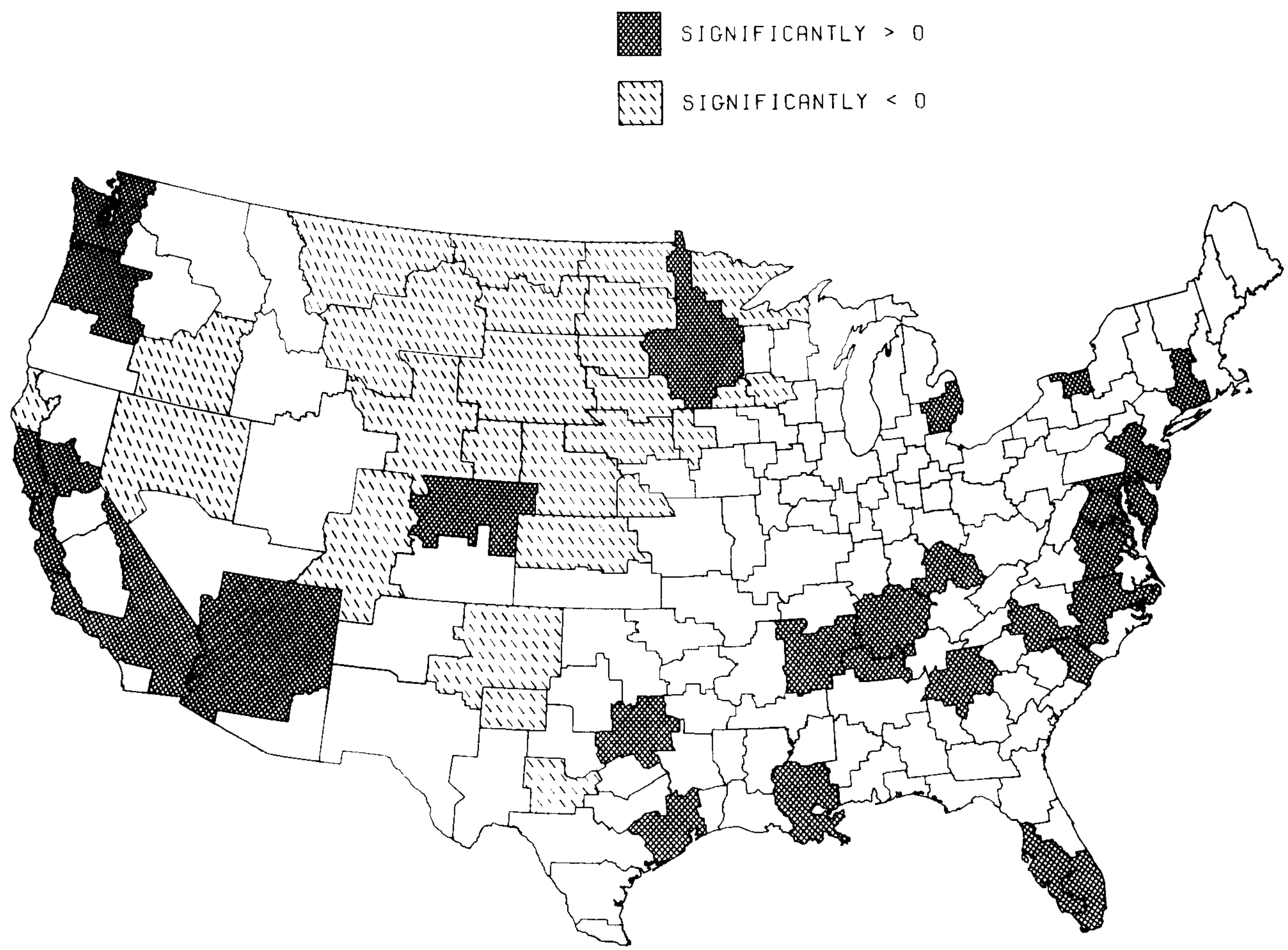


Fig. 10.4. Forecast net employment shift: 1975 - 1980.

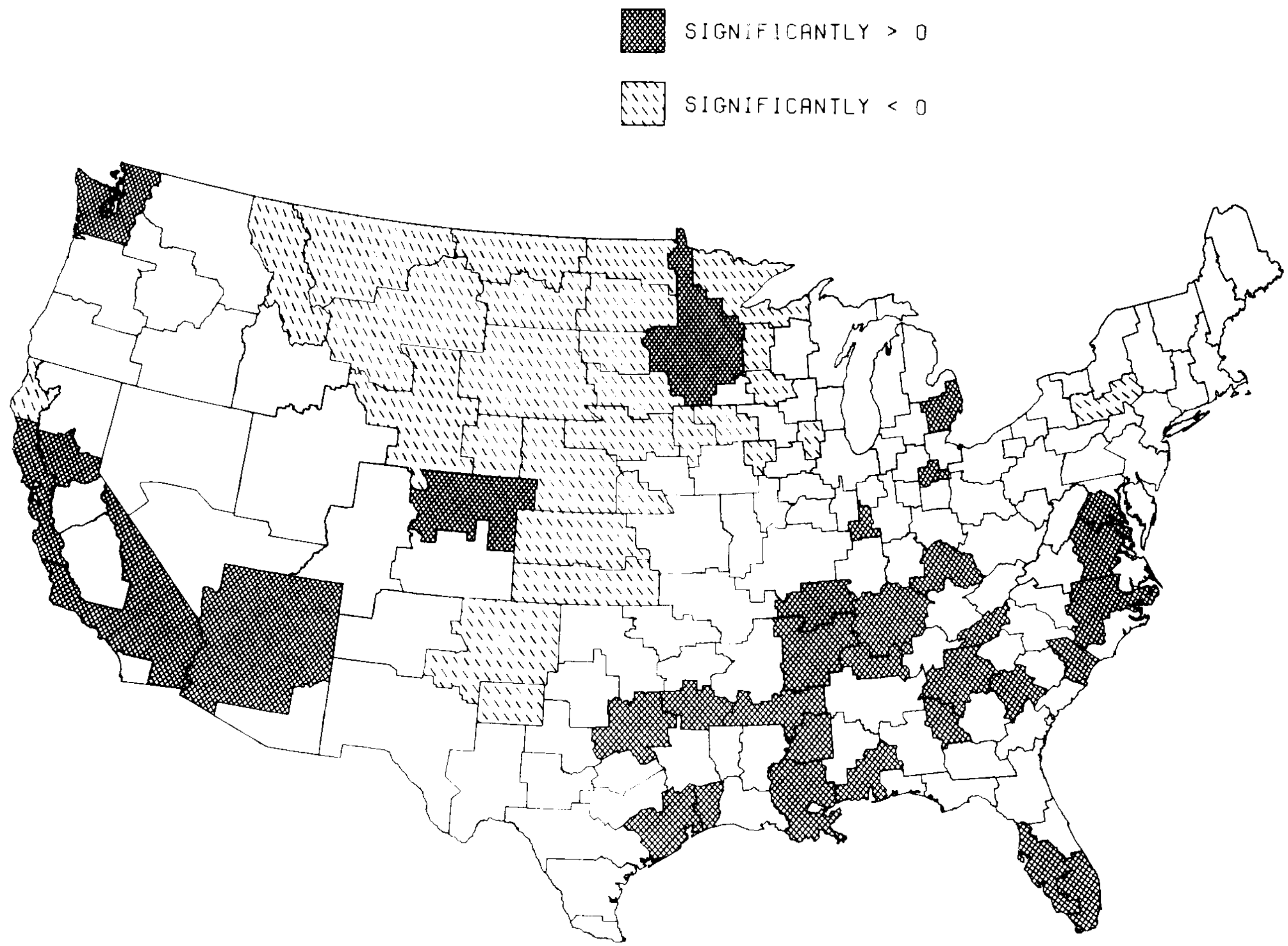


Fig. 10.5. Forecast net employment shift: 1980 - 1985.

Table 10.4. A comparison of alternative population forecasts for BEA areas to 1985 and 1990: ORNL, OBERS, and Harris*

	Population forecast (thous.)				Relatives: (A)	(B)	(C)
BEA No.	ORNL 1985	OBERS 1985	OBERS 1990	Harris* 1990	ORNL-85 / OBERS-85	OBERS-90 / Harris*-90	ORNL / Harris
1	368	299	297	307	1.23	0.97	1.19
2	841	759	774	690	1.11	1.12	1.24
3	563	563	580	651	1.00	0.89	0.89
4	6916	7376	7740	7192	0.94	1.08	1.01
5	3389	3385	3537	4359	1.00	0.81	0.81
6	1479	1487	1531	1547	0.99	0.99	0.98
7	1580	1565	1604	1672	1.01	0.96	0.97
8	1137	1311	1419	1197	0.87	1.19	1.03
9	1870	1786	1816	1905	1.05	0.95	1.00
10	487	540	565	482	0.90	1.17	1.06
11	446	442	450	430	1.01	1.05	1.05
12	796	792	805	678	1.00	1.19	1.19
13	717	828	872	694	0.87	1.26	1.09
14	19306	20724	21712	20687	0.93	1.05	0.98
15	8103	8333	8654	8825	0.97	0.98	0.95
16	1933	1996	2091	2176	0.97	0.96	0.93
17	3095	2940	3063	3165	1.05	0.97	1.02
18	3841	4214	4729	4389	0.91	1.08	0.98
19	454	484	515	494	0.94	1.04	0.98
20	948	1016	1074	1143	0.93	0.94	0.88
21	1178	1234	1311	1207	0.95	1.09	1.04
22	1463	1274	1326	1385	1.15	0.96	1.10
23	2000	1895	2009	1773	1.06	1.13	1.20
24	577	493	516	548	1.17	0.94	1.10
25	1317	1492	1610	1605	0.88	1.00	0.89

Table 10.4 (cont'd.)

BEA No.	Population forecast (thous.)				Relatives: (A)	(B)	(C)
	ORNL 1985	OBERS 1985	OBERS 1990	Harris* 1990	ORNL-85 / OBERS-85	OBERS-90 / Harris*-90	ORNL / Harris
26	1746	1812	1920	2030	0.96	0.95	0.91
27	451	468	490	478	0.96	1.03	0.99
28	993	1012	1080	1014	0.98	1.07	1.04
29	763	722	770	892	1.06	0.86	0.91
30	488	455	475	478	1.07	0.99	1.07
31	540	420	434	553	1.28	0.78	1.01
32	515	469	480	524	1.10	0.92	1.01
33	465	434	446	538	1.07	0.83	0.89
34	1436	1326	1426	1487	1.08	0.96	1.04
35	1349	1319	1440	1036	1.02	1.39	1.42
36	3675	3876	4408	3409	0.95	1.29	1.23
37	2618	2691	2968	2474	0.97	1.20	1.17
38	467	449	487	400	1.04	1.22	1.27
39	520	415	438	380	1.25	1.15	1.44
40	806	716	740	868	1.13	0.85	0.96
41	541	501	520	516	1.08	1.01	1.09
42	559	562	592	581	0.99	1.02	1.01
43	525	494	512	586	1.06	0.87	0.93
44	3044	3033	3329	2915	1.00	1.14	1.15
45	1952	1964	2030	2105	0.99	0.96	0.96
46	1975	1962	2058	1989	1.01	1.03	1.04
47	756	842	915	852	0.90	1.07	0.96
48	857	924	988	869	0.93	1.14	1.05
49	1706	1771	1907	1607	0.96	1.19	1.14
50	1067	1053	1094	919	1.01	1.19	1.21

Table 10.4 (cont'd.)

BEA No.	Population forecast (thous.) ORNL 1985	OBERS 1985	OBERS 1990	Harris* 1990	Relatives: (A) ORNL-85 / OBERS-85	(B) OBERS-90 / Harris*-90	(C) ORNL / Harris
51	850	939	988	745	0.90	1.33	1.20
52	1384	1300	1277	1333	1.06	0.96	1.02
53	927	917	970	756	1.01	1.28	1.30
54	1359	1501	1619	1445	0.91	1.12	1.01
55	797	901	936	779	0.88	1.20	1.06
56	254	270	276	278	0.94	0.99	0.93
57	517	593	632	489	0.87	1.29	1.13
58	410	429	444	391	0.96	1.14	1.09
59	275	267	275	287	1.03	0.96	0.99
60	1855	1944	2068	1985	0.95	1.04	0.99
61	569	610	622	619	0.93	1.00	0.94
62	2074	2154	2247	2461	0.96	0.91	0.88
63	1234	1335	1402	1615	0.92	0.87	0.80
64	2053	2189	2334	2003	0.94	1.17	1.09
65	348	360	365	349	0.97	1.05	1.01
66	3710	3804	3822	3447	0.98	1.11	1.08
67	799	857	877	828	0.93	1.06	0.99
68	4492	4676	4797	5608	0.96	0.86	0.82
69	300	306	320	272	0.98	1.18	1.15
70	1172	1242	1305	1264	0.94	1.03	0.97
71	5907	6066	6360	6636	0.97	0.96	0.93
72	962	899	938	925	1.07	1.01	1.08
73	1316	1235	1276	1536	1.07	0.83	0.88
74	1211	1235	1309	1495	0.98	0.88	0.86
75	669	724	776	781	0.92	0.99	0.92

Table 10.4 (cont'd.)

BEA No.	Population forecast (thous.) ORNL 1985	OBERS 1985	OBERS 1990	Harris* 1990	Relatives: (A) ORNL-85 / OBERS-85	(B) OBERS-90 / Harris*-90	(C) ORNL / Harris
76	818	819	849	871	1.00	0.97	0.97
77	9013	9425	9839	10273	0.96	0.96	0.92
78	696	716	748	650	0.97	1.15	1.12
79	627	634	641	657	0.99	0.98	0.97
80	352	367	380	306	0.96	1.24	1.19
81	311	311	317	329	1.00	0.96	0.96
82	581	623	647	676	0.93	0.96	0.89
83	558	582	631	541	0.96	1.17	1.12
84	2318	2219	2257	2504	1.04	0.90	0.94
85	1035	1006	1036	1020	1.03	1.02	1.05
86	392	378	390	416	1.04	0.94	0.97
87	403	411	406	392	0.98	1.04	1.02
88	245	243	250	248	1.01	1.01	1.01
89	275	281	285	282	0.98	1.01	0.99
90	250	275	287	238	0.91	1.21	1.10
91	3454	3471	3695	3451	1.00	1.07	1.07
92	234	202	200	215	1.16	0.93	1.08
93	191	156	150	190	1.22	0.79	0.97
94	254	208	209	266	1.22	0.79	0.96
95	302	250	250	267	1.21	0.94	1.13
96	153	134	134	137	1.14	0.98	1.11
97	341	320	316	305	1.07	1.04	1.11
98	121	115	113	117	1.05	0.97	1.02
99	343	370	370	318	0.93	1.16	1.08
100	272	210	207	196	1.30	1.06	1.37

Table 10.4 (cont'd.)

BEA No.	Population forecast (thous.) ORNL 1985	OBERS 1985	OBERS 1990	Harris* 1990	Relatives: (A) ORNL-85 / OBERS-85	(B) OBERS-90 / Harris*-90	(C) ORNL / Harris
101	104	90	87	99	1.15	0.88	1.01
102	323	306	304	289	1.05	1.05	1.11
103	434	440	433	439	0.99	0.99	0.97
104	238	270	272	245	0.88	1.11	0.98
105	421	421	417	415	1.00	1.00	1.00
106	815	860	882	772	0.95	1.14	1.08
107	861	866	898	858	0.99	1.05	1.04
108	347	342	349	270	1.02	1.29	1.31
109	336	322	314	331	1.04	0.95	0.99
110	747	633	627	804	1.18	0.78	0.92
111	2447	2555	2666	2933	0.96	0.91	0.87
112	436	447	462	401	0.97	1.15	1.12
113	276	314	320	282	0.88	1.13	1.00
114	3424	3550	3638	3661	0.96	0.99	0.96
115	610	627	644	643	0.97	1.00	0.97
116	922	918	940	934	1.00	1.01	1.01
117	1064	1029	1087	1145	1.03	0.95	0.98
118	370	336	351	369	1.10	0.95	1.05
119	1175	1142	1181	1241	1.03	0.95	0.98
120	1355	1385	1472	1515	0.98	0.97	0.95
121	470	423	427	528	1.11	0.81	0.90
122	450	398	391	398	1.13	0.98	1.11
123	374	298	289	330	1.26	0.88	1.10
124	349	286	285	312	1.22	0.91	1.11
125	278	257	256	248	1.08	1.03	1.11

Table 10.4 (cont'd.)

	Population forecast (thous.)				Relatives: (A)	(B)	(C)
BEA No.	ORNL 1985	OBERS 1985	OBERS 1990	Harris* 1990	ORNL-85 / OBERS-85	OBERS-90 / Harris*-90	ORNL / Harris
126	133	125	127	130	1.06	0.98	1.04
127	3567	3369	3646	3447	1.06	1.06	1.12
128	531	411	426	483	1.29	0.88	1.14
129	798	692	731	757	1.15	0.97	1.11
130	627	673	708	668	0.93	1.06	0.99
131	362	350	358	324	1.04	1.10	1.14
132	496	477	489	499	1.04	0.98	1.02
133	530	547	550	699	0.97	0.79	0.76
134	525	479	474	547	1.10	0.87	0.95
135	613	587	618	752	1.04	0.82	0.86
136	445	420	428	411	1.06	1.04	1.10
137	893	803	840	991	1.11	0.85	0.94
138	2538	2360	2440	3045	1.08	0.80	0.86
139	852	699	703	861	1.22	0.82	1.00
140	423	458	485	492	0.92	0.99	0.91
141	3239	3086	3363	3584	1.05	0.94	0.98
142	1543	1297	1353	1692	1.19	0.80	0.95
143	602	524	535	639	1.15	0.84	0.96
144	525	344	344	467	1.52	0.74	1.12
145	952	671	687	661	1.42	1.04	1.47
146	791	661	694	653	1.20	1.06	1.27
147	655	525	545	465	1.25	1.17	1.46
148	2116	2028	2162	2086	1.04	1.04	1.08
149	349	257	263	281	1.36	0.94	1.27
150	291	226	227	246	1.28	0.92	1.18

Table 10.4 (cont'd.)

BEA No.	Population forecast (thous.) ORNL 1985	OBERS 1985	OBERS 1990	Harris* 1990	Relatives: (A) ORNL-85 / OBERS-85	(B) OBERS-90 / Harris*-90	(C) ORNL / Harris
151	1465	1225	1303	1059	1.20	1.23	1.47
152	379	302	311	302	1.25	1.03	1.29
153	274	226	225	283	1.21	0.80	0.96
154	816	710	710	758	1.15	0.94	1.08
155	2679	2553	2668	3280	1.05	0.81	0.85
156	438	415	418	551	1.05	0.76	0.80
157	2006	1959	2064	2120	1.02	0.97	1.00
158	701	598	608	727	1.17	0.84	0.98
159	362	283	294	288	1.28	1.02	1.31
160	300	292	326	283	1.03	1.15	1.18
161	487	434	477	332	1.12	1.44	1.61
162	2062	1860	2062	1879	1.11	1.10	1.22
163	687	590	639	561	1.16	1.14	1.33
164	1930	1641	1777	1954	1.18	0.91	1.07
165	12592	12418	13085	14157	1.01	0.92	0.94
166	1262	1074	1093	1217	1.18	0.90	1.06
167	804	716	739	641	1.12	1.15	1.29
168	1480	1257	1319	1142	1.18	1.15	1.36
169	223	190	197	199	1.17	0.99	1.16
170	153	134	137	131	1.14	1.05	1.19
171	6332	6221	6635	6323	1.02	1.05	1.07
172	466	361	391	287	1.29	1.36	1.76
173	1096	910	979	1325	1.20	0.74	0.89
U.S. total	235701	234425	246034	246035			

Source: see references 1 and 2.

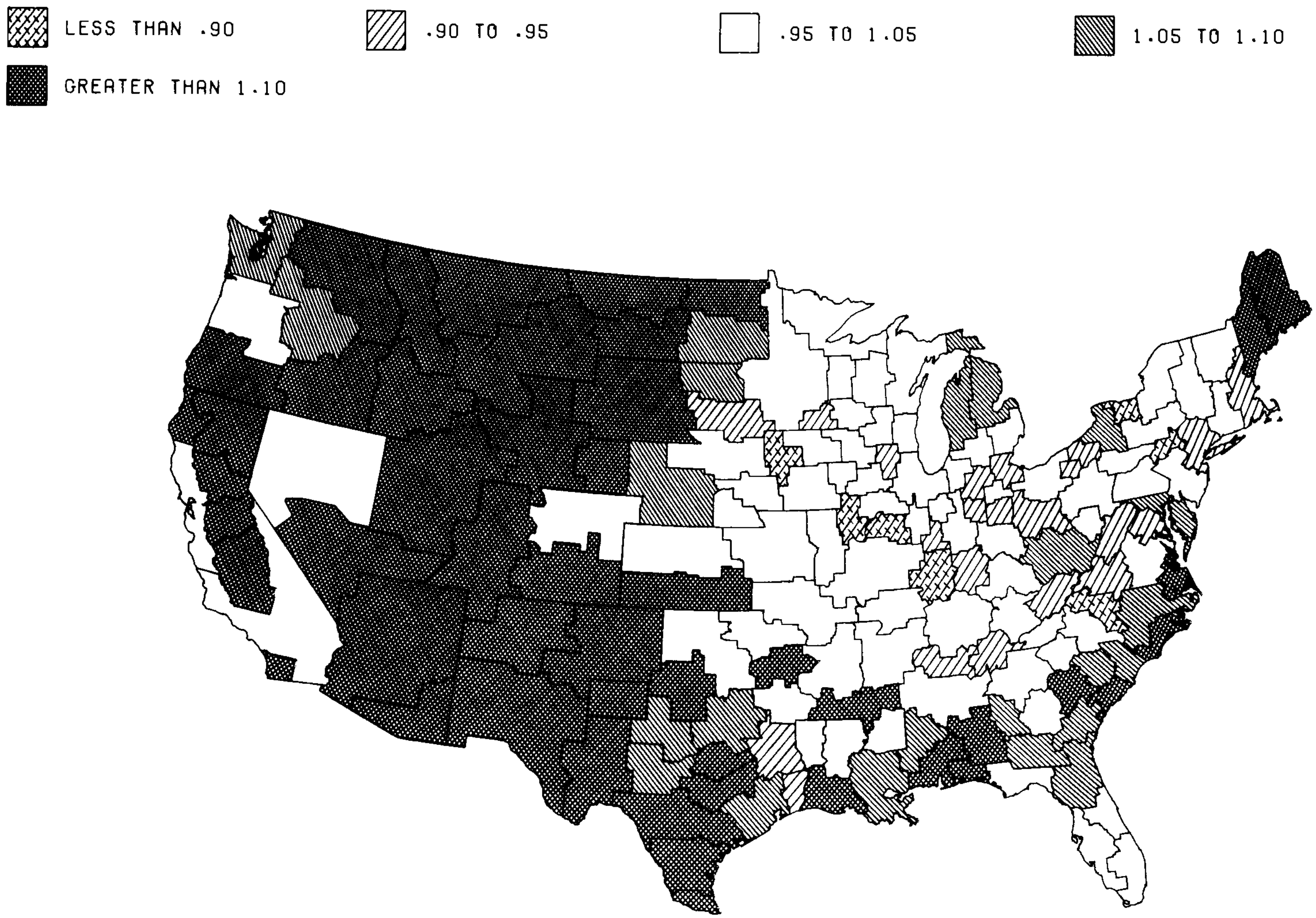


Fig. 10.6. Comparison of population forecasts for BEA areas: (ORNL-85)/(OBERS-85).

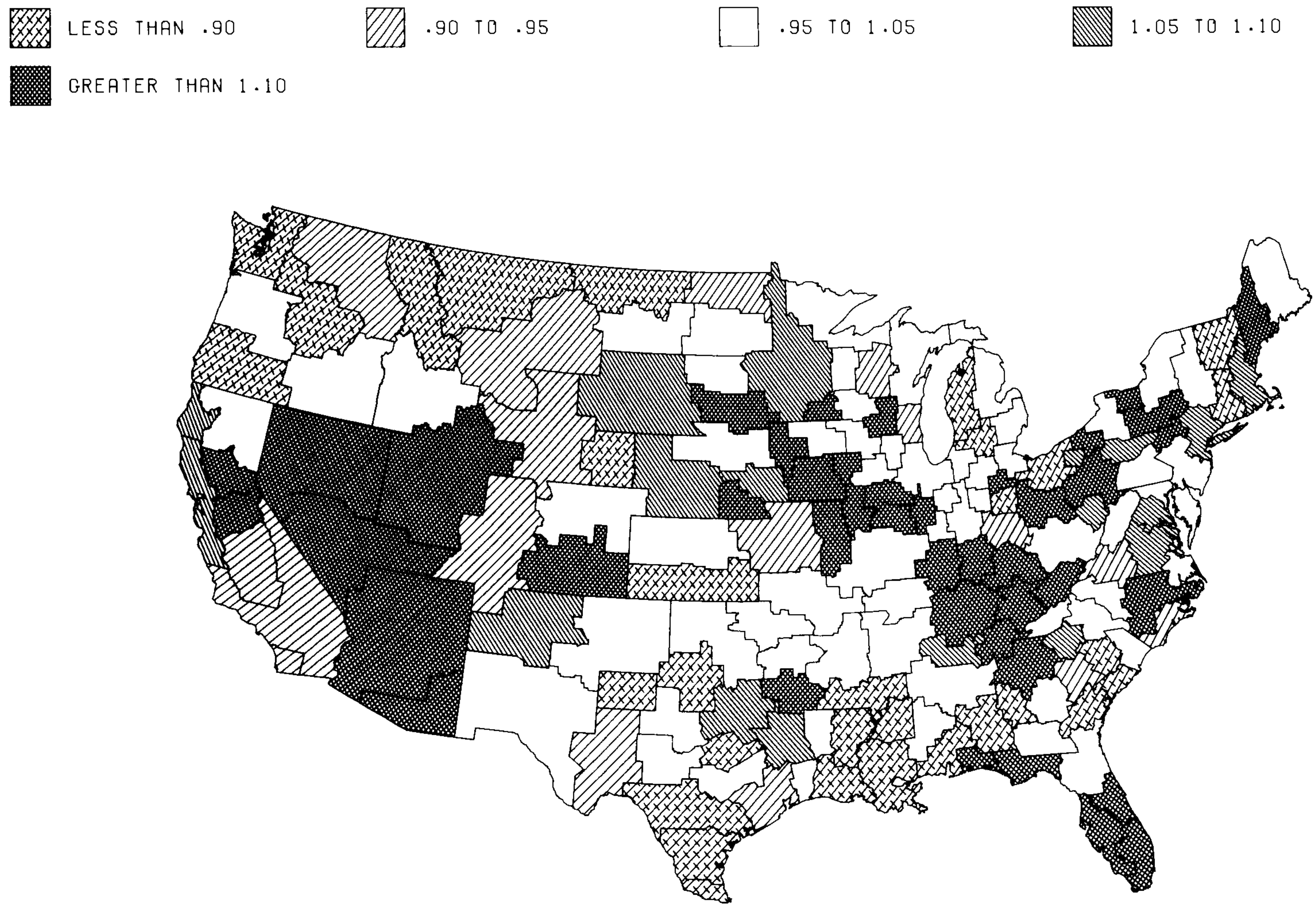


Fig. 10.7. Comparison of population forecasts for BEA areas: (OBERS-90)/(Harris-90).

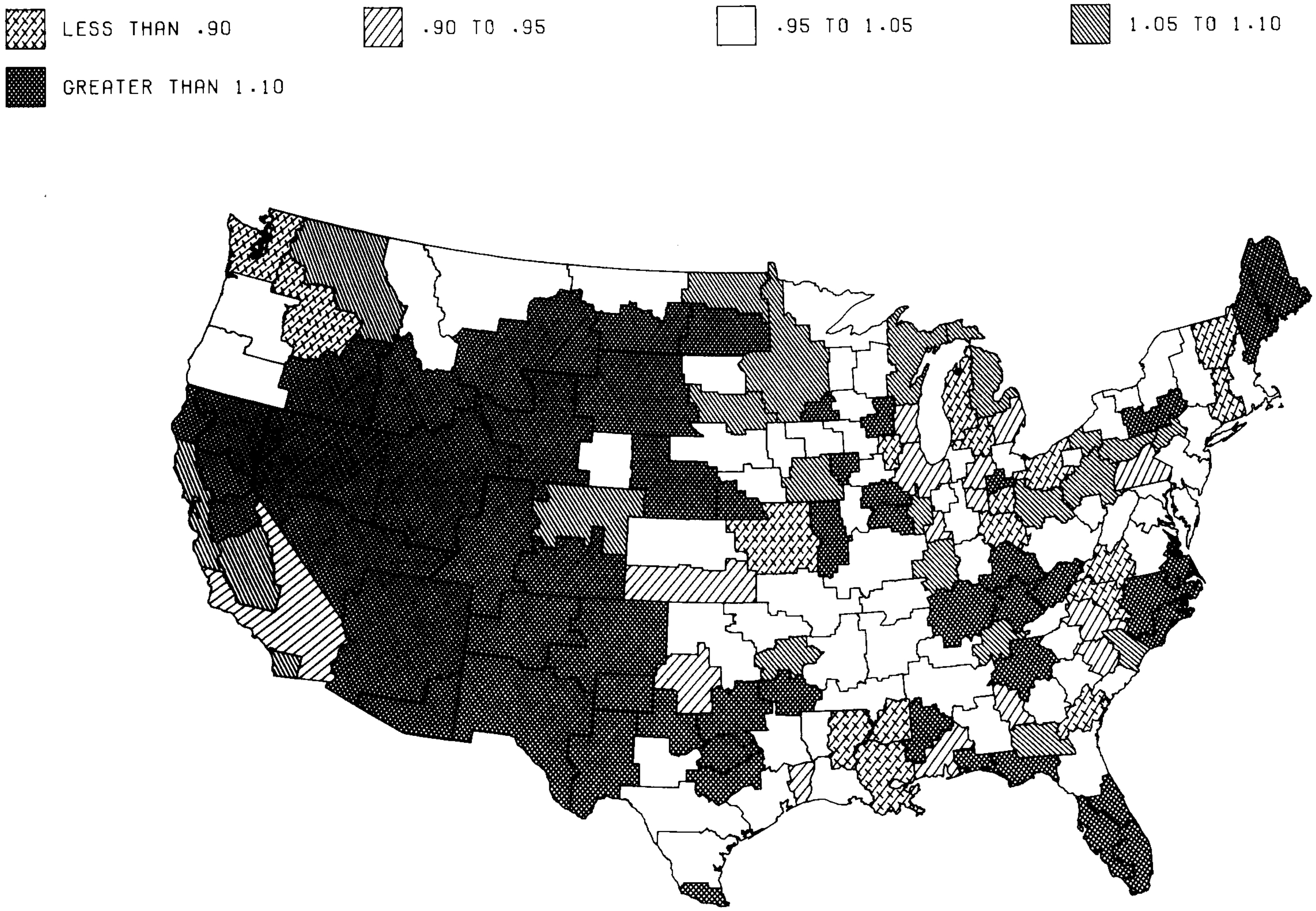


Fig. 10.8. Comparison of population forecasts for BEA areas: ORNL/Harris.

REFERENCES FOR CHAPTER 10

1. U.S. Water Resources Council, 1972 OBERS Projections: Economic Activity in the U.S., Volume 2, U.S. Government Printing Office, April 1974.

2. C. C. Harris, Jr., Regional Economic Effects of Alternative Highway Systems, Cambridge, Mass: Ballinger Publishing Company, 1974. The specific forecast selected for comparison is labelled "1990 Completed Interstate." Harris' forecasts summed to Series "E" population totals; we have normalized his values to total to Series "C".

3. Consistent population forecasts for 1985 are not available from Harris.* Therefore, comparisons between OBERS and Harris* are made with 1990 population values while synthetic comparisons between MULTIREGION and Harris* are based on the relationship:

$$\frac{\text{ORNL}}{\text{Harris}} = \left(\frac{\text{ORNL-85}}{\text{OBERS-85}}\right)\left(\frac{\text{OBERS-90}}{\text{Harris-90}}\right).$$

11. IMPLICATIONS FOR FUTURE RESEARCH AND APPLICATIONS

Our discussion can conclude as it began by noting that there is a recognized need for a national/regional impact accounting system to evaluate the interregional trade-offs and displacements caused by policies and projects of national and/or regional origin. MULTIREGION should make a modest contribution to the eventual dimensions of such an assessment system. The present document should be considered a progress report; the task has been a long and arduous one and we are only now beginning to understand some of the properties of the system we have created. Along the way we may have sought more science than circumstances would allow; a sparse regional data set has certainly not allowed many research degrees of freedom and the lack of controlled socioeconomic experiments prevents the validation of the model in the fashion of the physical and chemical sciences. Be the results mostly art or mostly science, as the chief architects of MULTIREGION, we would like to take this opportunity to point out some things we might do differently if given another chance. This chapter presents some possible changes and additions to MULTIREGION as it has been described in this document and then closes with a few brief observations on applications.

11.1 REVISIONS TO THE MODEL

It almost goes without saying that more reliable relationships could have been derived from a more complete regional data set. Perhaps the most important improvement would have been the distributed lag effects that could have been included in the behavioral relationships had true time-series data been available. But even within the confines of the data presently available, there are a number of revisions to the model that might be seriously considered. They involve the functional form of the relationships, the explanatory variables, the estimation procedures and the treatment of residuals.

Functional forms. Clearly, we have not experimented enough with alternative functional forms; simple linear relationships have been used throughout. Unfortunately economic theory does not provide much guidance here so the choice often becomes an empirical one based on "goodness of fit". While we do harbor doubts about how much goodness of fit should be pursued as a goal in an endeavor such as this, some more experimentation with nonlinear forms is obviously in order. In addition to simple transformations and interaction terms, special attention should be paid to time interactive variables[1] that might pick up some behavioral shifts between cross-sections. But, how should nonlinear results, if found, be used in a forecasting situation, that is, outside the range of historical observations? Caution must be followed because interactive or nonlinear terms have a tendency to dominate relationships after not so many time steps — a dominance perhaps not warranted by the sparse evidence in our sample.

A further consideration for the choice of functional forms stems from the fact that "representative" relationships seem to work well for average-sized BEA areas but less well for the largest (e.g., New York) and smallest (e.g., Grand Isle, Nebraska) areas. Thus, there is concern that some relationships should be "sized" to each BEA area. For example, the employment equations might be revised to use a location quotient (L.Q) as the proxy for relative regional attractiveness as follows:

$$\text{Relative Regional Attractiveness } R_i = f(X_{R1}, \ldots, X_{RM})$$

$$\text{L.Q.} = (E_i^R/E^R)(E^{us}/E_i^{us}) = f(X_{R1}, \ldots, X_{RM})$$

$$\text{SHARE}_{Ri} = (E^R/E^{us})f(X_{R1}, \ldots, X_{RM}) \quad .$$

Preliminary efforts along these lines have shown some promise but the gains have not been cost free since weighting by overall employment size increases the multicollinearity among the explanatory variables.[2] As our experiences with these alternative functional forms and the present MULTIREGION model grow it may be important to modify functional forms selectively for individual industries or concepts where the benefits to the system as a whole signficantly exceed the costs.

Explanatory variables. While much time, energy, and perhaps imagination has already gone into the definition and acquisition of explanatory variables, room for further improvements does exist. For example, we could be a bit more consistent in the dimensions we have used for variables. Social scientists are frequently guilty of combining variables of differing dimensional classes in an almost frantic search for associations or relationships. This ignores the experience of the physical sciences which shows that numerical laws should be expressed in terms of variables of similar dimensional classes; if relationships are not complete or dimensionally homogeneous, they will be sensitive to the units of measurement.[3] The most correct relationships are those stated in terms of quantities of the same character. It was for reasons such as these that the interregional market potential variables were expressed as relative potentials (a region's share of the total national market) when trying to explain regional employment shares. But we have been a bit inconsistent in our own applications of dimensional analysis (e.g., median schooling should frequently be considered relative to the corresponding national value). Our results could benefit from further dimensional consistency.

The explanatory variables could also be modified in other directions. For example, the market potential variables could explicitly include national interindustry coefficients in their formulations. This would allow for easier considerations of alternative technological assumptions in longer-term simulations with MULTIREGION. Also, the partitioning of the overall market potential variables into portions that are derived for local versus nearby areas would highlight important local interactions that are presently concealed within a single market access measure.[4]

Estimation Procedures. Clearly, if migration data were available for BEA areas rather than State Economic Areas, a simultaneous equations estimation procedure would be appropriate for the population migration and employment location relationships. Without BEA area migration data, simultaneous equations estimation procedures are not called for. But there may be some advantage to other estimation experiments based upon data subsets partitioned according to size of region or according to whether regions have been growing or declining.

In the first instance, a heirarchy of regions does exist in the U.S. with some regions being more specialized in some activities than others. In these circumstances, the separate estimation of relationships, such as those for local service activities with data subsets drawn according to region size, might be appropriate. Such procedures are certainly not without precedent and would undoubtedly result in "better" fits to historical data. But, they would probably complicate the computer program for MULTIREGION in that mechanisms would have to be included to switch some BEA areas from one equation to another during the process of growth and development. The possible improved performance of the overall model would need to be weighed against these added costs.

In the second instance, there may, in fact, exist an asymmetry of behavior between growing and declining areas that would warrant the separate estimation of relationships for each of these conditions. Again, these procedures would undoubtedly result in better fits to historical data but making them operational within MULTIREGION might be troublesome. In fact, it might be more desirable to design explanatory variables to pick up these behavioral asymmetries within the context of existing equations.

Residuals. Because the residuals or deviations about a fitted regression line continue to have a very important story to tell us about how atypical specific regions may be, they deserve a much more thorough and systematic treatment than we have been able to allow. This is especially true for those components of the model and geographic areas for which we are unlikely to receive additional information in the near future.

For example, we are not going to have BEA area population migration data at our disposal in the near future so an ad hoc procedure for effectively using the information that may be extracted from the geographic patterns of residuals from SEA analyses may be very significant. Similarly, we are not going to have much more information on the export recreation industry so we need to imaginatively use the information contained in the residuals from individual service industry equations to better understand and represent the economies of areas such as Las Vegas and Reno.

11.2 ADDITIONS TO THE MODEL

MULTIREGION has deliberatley focused on what appear to be the core information requirements of regional decision makers — forecasts of regional population and employment that are sensitive to alternative assumptions. But, to the extent that MULTIREGION can fulfill these needs and is used repeatedly to address similar regional questions, it may become economical to add the capability to generate some of the more central information requirements such as income estimates, pollutant loads, energy requirements, etc. In most instances these additions can take the form of relatively simple multipliers, ratios, or participation rates. In other instances, however, such as the elaboration of the local public sector to help forecast revenues and expenditures and assess public sector impacts, a rather significant amount of new research and development would be necessary because institutional arrangements do vary significantly from region to region.

11.3 APPLICATIONS

We continue to believe that MULTIREGION can make a modest contribution to intelligent public and private choices. It will not produce quick or simple solutions to the types of questions for which we seek even partial answers. Furthermore, the effective use of MULTIREGION will require a cautious blending of art and science for which experience has no substitute. The size of MULTIREGION's direct and indirect contribution to public and private decision making cannot be determined at this time but surely will depend on its appeal and availability to a broad user community. Through this documentation and the public availability of all data bases and computer programs,[5] we are trying to maximize the potential transfer of MULTIREGION to the user community. At the same time, there has been no conscious effort to maximize its appeal to particular users by including their preconceived notions about what may be important policy levers; the effort has been as scientifically objective as possible. MULTIREGION's appeal will depend upon how useful it proves to be over time.

At this point we are only beginning to understand the characteristics and properties of MULTIREGION and the complex interregional socioeconomic system it attempts to represent. We are not in a position to make sweeping statements about revolutionary insights to regional processes provided by this project but perhaps such insights will develop out of repeated applications of the model. However, we can say that our results to date are not inconsistent with the view that regional socioeconomic systems at the BEA economic area level of spatial detail are inherently insensitive to many of the policy options such as subsidies to industry available to local decision makers and quite sensitive to events like massive changes in interregional accessibility over which they have little control.

REFERENCES FOR CHAPTER 11

1. As the results of simple Chow tests indicate (Technical Appendixes, B,C,E, and F), the issue of the appropriateness of pooling cross-section data might be resolved by considering a slightly revised model that included selected slope interactive dummy variables. That is, α_1 (1+T)X might be used rather than α_1 X where T takes on the value 0 in 1960 and 1 in 1970.

2. See D. Vogt, "A Cross-Section Test of the Importance of Energy Prices and Availabilities to Manufacturing Location Patterns: Selected Energy-Using Industries," ORNL report in preparation.

3. P. W. Bridgman, Dimensional Analysis, New Haven: Yale University Press, 1922, P. C. Pankhurst, Dimensional Analysis and Scale Factors, London: Chapman and Hall, Ltd., 1964, and B. Ellis, Basic Concepts of Measurement, Cambridge: Cambridge University Press, 1966.

4. This procedure was used by G. Alperovich, J. Bergsman, and C. Ehemann in "An Econometric Model of Employment Growth in U.S. Metropolitan Areas," Urban Institute (Washington, D.C.: The Urban Institute, 1975) Working Paper #0974-5.

5. All data bases and computer programs are available on a cost reimbursable basis from the Regional and Urban Studies Information Center (RUSTIC) of Oak Ridge National Laboratory.

TECHNICAL APPENDIXES

Appendix A

DEMOGRAPHIC TRENDS

A.1 REGIONAL MORTALITY AND FERTILITY TRENDS

Age and sex specific insights to mortality and fertility are necessary to capture the sensitivity of overall births and deaths to changes over time in the age-sex composition of a region's population. We have searched for these age and sex specific insights by examining historical trends in national-regional mortality and fertility. We are aware of efforts to relate regional fertility and mortality to socioeconomic conditions[1] but the results to date seem too tentative for our purposes.

A.1.1 Vital events data

Vital events (births and deaths) are systematically recorded and tabulated by local (city and county) health departments for state and Federal agencies. Each state then publishes these data but with great variation among states in the level of spatial, racial, and sex detail provided. The Federal government publishes similar data with uniform detail across states but with a great time lag[2] and less than maximum detail. Our examination of mortality and fertility trends by BEA economic areas has relied most heavily upon the annual volumes of *Vital Statistics of the United States.*[3]

The accuracy of these data are worth some comment. Basically death registration in the United States is believed to be more complete than birth registration, although the difference may be small at present.[4] No systematic test of the completeness of death registration has been conducted. Estimates of birth registration completeness have been made and are summarized by color in Table A-1.1.[5] They show increasing completeness over time with nonwhites less adequately accounted for than whites. In addition to underregistration errors one may expect some biases in the reporting of characteristics of births and deaths such as the age or place of residence of the mother or the deceased. The accuracy of these data should be kept in mind when interpreting regional trends in mortality and fertility.

The actual number of live births and deaths as reported in *Vital Statistics of the United States* for the calendar years 1950, 1954, 1960, 1964, and 1969 are tabulated for BEA economic areas in Table A-1.2 (found at the end of this appendix).

A.1.2 Regional deviations from national trends: total live births and deaths

By combining national birth rates by age of mother and national death rates by age and sex with BEA economic area population by age and sex

Table A-1.1. Estimated percent completeness of birth registration, by color, for the United States: 1935 to 1968

Year	Total	White	Nonwhite
1968	99.1	99.4	97.5
1967	99.0	99.4	97.3
1965	98.9	99.3	96.9
1960	98.9	99.3	96.4
1955	98.6	99.2	95.5
1950	97.9	98.6	93.6
1945	95.7	97.0	87.6
1940	92.3	94.0	81.3
1935	90.7	92.4	79.9

Source: U.S. National Center for Health Statistics, *Vital Statistics of the United States, 1967*, Vol. 1, *Natality*, 1969, table 1-19, and unpublished records.

for the same years, we have been able to compute the expected numbers of live births and deaths per BEA area for 1950, 1954, 1960, 1964, and 1969 under the assumption that national patterns hold in all regions. The comparison of actual and expected events provides a measure of regional deviation from national trends.

The ratios of (actual-expected)/expected live births and deaths for each BEA area and year are found in Table A-1.3 (found at the end of this appendix). To control for annual aberrations in these events or data, three time period moving averages have been created that roughly center upon 1955, 1960, and 1965. These moving averages appear in Table A-1.4 and are the subject of subsequent discussions.

A number of comparisons of these ratios are exhibited in Table A-1.5 and A-1.6. First, the frequency distributions for 1965 in Table A-1.5 suggest a slight tendency for a representative BEA area to have mortality rates below the national average and fertility rates above the nation's (the distributions are slightly skewed). Second, 75% of BEA areas had mortality and fertility rates within ±20% of the national averages. This does leave 25% of BEA areas with substantial deviations that are amazingly consistent over time. Perhaps the most startling deviation is that for Hawaii's mortality. After adjustment for the age and sex composition of its population, Hawaii's mortality rate has consistently been fully 45% below that for the nation.[6] Perhaps the "fountain of youth" does exist on some of those islands. A graphic representation of regional mortality and fertility deviations is shown in Figures A-1 and A-2.

Table A-1.4. Smoothed regional deviations from nation 1955, 1960, and 1965

BEA	Smoothed fertility (50+54+60)/3	Smoothed fertility (54+60+64)/3	Smoothed fertility (60+64+69)/3	Smoothed mortality (50+54+60)/3	Smoothed mortality (54+60+64)/3	Smoothed mortality (60+64+69)/3
1	0.113	0.104	0.086	-0.009	0.017	0.020
2	-0.019	0.002	0.032	-0.001	0.023	0.026
3	0.060	0.030	0.025	0.001	0.024	0.020
4	-0.318	-0.297	-0.046	-0.267	-0.279	-0.028
5	-0.159	-0.125	-0.044	-0.121	-0.119	-0.049
6	-0.064	-0.048	0.013	0.030	0.032	0.044
7	0.006	0.018	0.039	0.009	0.031	0.031
8	-0.050	-0.024	0.006	-0.037	-0.034	-0.047
9	-0.026	-0.021	-0.014	0.042	0.051	0.046
10	-0.021	-0.026	-0.015	0.027	0.044	0.053
11	-0.102	-0.101	-0.063	-0.001	0.015	0.026
12	0.033	0.027	0.040	0.001	0.012	0.006
13	-0.233	-0.212	-0.143	0.176	0.178	0.153
14	-0.179	-0.138	-0.092	0.053	0.054	0.037
15	-0.116	-0.073	-0.045	0.089	0.085	0.073
16	-0.091	-0.086	-0.070	-0.004	-0.004	-0.002
17	-0.061	-0.024	-0.016	0.133	0.124	0.117
18	-0.030	-0.013	-0.017	0.055	0.053	0.046
19	-0.094	-0.108	-0.091	0.011	0.022	0.033
20	-0.093	-0.109	-0.094	0.045	0.041	0.053
21	-0.066	-0.052	-0.047	0.134	0.115	0.110
22	0.080	0.116	0.066	0.180	0.172	0.145
23	0.060	0.026	0.001	0.164	0.166	0.168
24	0.134	0.137	0.098	0.199	0.206	0.196
25	-0.133	-0.143	-0.109	-0.024	-0.008	0.022
26	-0.069	-0.094	-0.070	0.027	0.045	0.063
27	-0.098	-0.126	-0.103	-0.122	-0.108	-0.072
28	-0.098	-0.099	-0.076	0.071	0.074	0.111
29	0.101	0.061	0.021	0.196	0.177	0.150
30	0.173	0.145	0.115	0.359	0.358	0.334
31	0.154	0.131	0.145	0.339	0.305	0.264
32	0.165	0.135	0.066	0.232	0.224	0.209
33	0.102	0.103	0.107	0.269	0.242	0.235
34	0.025	0.040	0.042	0.126	0.119	0.117
35	-0.030	0.007	0.051	-0.115	-0.129	-0.108
36	-0.096	-0.097	-0.070	-0.103	-0.134	-0.126
37	-0.060	-0.057	-0.019	-0.126	-0.171	-0.158
38	0.021	-0.012	-0.030	0.010	0.034	0.039
39	0.151	0.131	0.103	0.054	0.026	0.045
40	0.073	0.045	0.077	0.124	0.123	0.135
41	0.202	0.188	0.187	0.159	0.136	0.135
42	0.059	0.051	0.070	0.131	0.138	0.141
43	0.063	0.097	0.103	0.157	0.159	0.169
44	-0.064	-0.082	-0.062	0.047	0.061	0.068
45	-0.011	-0.046	-0.030	0.056	0.056	0.069
46	0.118	0.121	0.128	0.040	0.045	0.052
47	-0.007	0.001	0.036	0.010	0.001	0.016
48	-0.036	-0.074	-0.055	0.045	0.043	0.050

Table A-1.4. (Cont'd)

BEA	Smoothed fertility (50+54+60)/3	Smoothed fertility (54+60+64)/3	Smoothed fertility (60+64+69)/3	Smoothed mortality (50+54+60)/3	Smoothed mortality (54+60+64)/3	Smoothed mortality (60+64+69)/3
49	-0.079	-0.091	-0.068	-0.001	-0.001	0.008
50	-0.035	-0.061	-0.063	0.018	0.013	0.023
51	-0.045	-0.100	-0.084	0.026	0.017	0.037
52	0.002	-0.045	-0.048	-0.007	-0.006	0.026
53	0.012	-0.025	-0.012	-0.040	-0.036	-0.025
54	0.069	0.057	0.044	0.027	0.030	0.035
55	0.008	-0.007	-0.017	-0.028	-0.020	0.001
56	-0.092	-0.115	-0.120	0.006	0.024	0.049
57	-0.049	-0.046	-0.035	-0.059	-0.044	-0.033
58	-0.110	-0.170	-0.190	-0.050	-0.060	-0.038
59	-0.045	-0.062	-0.049	-0.063	-0.053	-0.047
60	-0.004	0.004	0.008	0.010	0.016	0.024
61	-0.036	-0.033	-0.023	-0.037	-0.017	0.015
62	0.004	0.015	0.019	0.033	0.033	0.040
63	-0.005	-0.034	-0.045	-0.013	-0.011	-0.014
64	-0.045	-0.050	-0.050	-0.028	-0.006	0.007
65	-0.137	-0.152	-0.127	-0.046	-0.030	-0.003
66	-0.108	-0.112	-0.100	0.036	0.040	0.046
67	-0.053	-0.081	-0.088	-0.007	-0.001	0.013
68	-0.020	-0.027	-0.026	0.004	0.019	0.020
69	0.138	0.117	0.115	-0.073	-0.033	-0.005
70	0.037	0.012	0.009	0.007	0.006	0.008
71	0.025	0.010	0.003	0.022	0.024	0.018
72	0.154	0.126	0.116	-0.016	-0.012	-0.016
73	0.143	0.103	0.076	-0.037	-0.030	-0.040
74	0.015	-0.034	-0.051	-0.046	-0.038	-0.048
75	0.057	0.049	0.050	-0.032	-0.032	-0.043
76	0.046	0.010	0.016	-0.033	-0.022	-0.018
77	-0.042	-0.009	0.019	0.089	0.086	0.081
78	-0.050	-0.077	-0.080	-0.063	-0.066	-0.062
79	0.028	0.022	0.045	-0.059	-0.052	-0.036
80	-0.018	-0.055	-0.048	-0.131	-0.132	-0.121
81	0.197	0.185	0.177	-0.059	-0.070	-0.059
82	0.033	0.032	0.049	-0.065	-0.070	-0.057
83	0.039	-0.005	-0.061	-0.114	-0.117	-0.116
84	0.022	0.033	0.029	-0.030	-0.037	-0.050
85	0.162	0.149	0.110	-0.037	-0.040	-0.055
86	0.185	0.161	0.045	-0.102	-0.111	-0.115
87	0.121	0.073	0.027	0.0	0.008	-0.000
88	0.121	0.046	0.012	-0.103	-0.104	-0.088
89	0.099	0.051	0.015	-0.086	-0.086	-0.101
90	0.110	0.080	0.074	-0.138	-0.157	-0.164

Table A-1.4. (Cont'd)

BEA	Smoothed fertility (50+54+60)/3	Smoothed fertility (54+60+64)/3	Smoothed fertility (60+64+69)/3	Smoothed mortality (50+54+60)/3	Smoothed mortality (54+60+64)/3	Smoothed mortality (60+64+69)/3
91	0.098	0.065	0.044	-0.113	-0.106	-0.108
92	0.206	0.179	0.162	-0.107	-0.117	-0.098
93	0.310	0.294	0.250	-0.095	-0.069	-0.079
94	0.252	0.231	0.167	0.004	0.021	-0.002
95	0.136	0.047	-0.001	-0.068	-0.058	-0.069
96	0.246	0.220	0.166	-0.059	-0.068	-0.089
97	0.161	0.086	0.031	-0.152	-0.148	-0.163
98	0.163	0.131	0.125	-0.101	-0.099	-0.095
99	0.172	0.115	0.072	-0.144	-0.143	-0.155
100	0.320	0.339	0.309	-0.019	-0.009	-0.000
101	0.125	0.075	0.034	-0.116	-0.095	-0.097
102	0.098	0.042	0.017	-0.137	-0.124	-0.130
103	0.139	0.093	0.069	-0.130	-0.115	-0.100
104	0.133	0.091	0.070	-0.141	-0.120	-0.113
105	0.074	0.029	0.023	-0.138	-0.122	-0.112
106	-0.029	-0.073	-0.061	-0.091	-0.081	-0.077
107	0.060	0.070	0.074	-0.085	-0.063	-0.067
108	-0.057	-0.065	-0.085	-0.158	-0.137	-0.138
109	0.081	0.059	0.014	-0.156	-0.148	-0.148
110	0.057	0.022	-0.024	-0.100	-0.090	-0.093
111	-0.025	-0.030	-0.035	-0.047	-0.045	-0.042
112	-0.110	-0.130	-0.117	-0.124	-0.103	-0.070
113	-0.027	-0.035	-0.014	-0.042	-0.041	-0.016
114	-0.009	-0.001	0.004	0.015	0.021	0.021
115	0.010	-0.008	-0.015	-0.005	-0.001	0.027
116	-0.097	-0.130	-0.094	-0.081	-0.066	-0.048
117	-0.035	-0.015	0.023	-0.094	-0.067	-0.037
118	0.004	0.037	0.054	-0.158	-0.118	-0.087
119	-0.091	-0.132	-0.118	-0.083	-0.069	-0.069
120	-0.055	-0.067	-0.055	-0.106	-0.084	-0.069
121	-0.003	0.023	0.075	-0.151	-0.123	-0.098
122	0.029	0.027	0.058	-0.116	-0.096	-0.063
123	0.122	0.164	0.150	-0.063	-0.042	-0.025
124	0.089	0.040	0.044	-0.016	-0.045	-0.059
125	-0.073	-0.071	-0.014	-0.146	-0.132	-0.091
126	0.079	0.061	0.068	-0.131	-0.143	-0.092
127	-0.066	-0.083	-0.057	-0.063	-0.061	-0.040
128	0.029	0.061	0.056	-0.104	-0.091	-0.058
129	0.011	-0.040	-0.069	-0.082	-0.088	-0.098
130	-0.069	-0.093	-0.054	-0.082	-0.077	-0.063
131	-0.003	-0.005	0.040	-0.069	-0.045	-0.032

Table A-1.4. (Cont'd)

BEA	Smoothed fertility (50+54+60)/3	Smoothed fertility (54+60+64)/3	Smoothed fertility (60+64+69)/3	Smoothed mortality (50+54+60)/3	Smoothed mortality (54+60+64)/3	Smoothed mortality (60+64+69)/3
132	0.113	0.072	0.092	0.033	0.015	0.038
133	0.173	0.143	0.163	0.033	0.038	0.065
134	0.332	0.348	0.357	0.119	0.120	0.127
135	0.157	0.128	0.151	0.098	0.084	0.109
136	0.112	0.074	0.122	0.083	0.087	0.109
137	0.161	0.172	0.171	0.096	0.083	0.088
138	0.125	0.121	0.121	0.141	0.163	0.176
139	0.202	0.197	0.201	0.032	0.060	0.083
140	-0.003	-0.022	-0.031	-0.021	-0.046	-0.032
141	-0.001	-0.020	-0.026	0.013	0.005	0.010
142	0.210	0.182	0.185	-0.009	-0.043	-0.058
143	0.282	0.275	0.293	0.031	-0.004	-0.027
144	0.572	0.448	0.588	0.204	0.046	-0.080
145	0.337	0.320	0.340	0.049	-0.001	-0.021
146	0.295	0.237	0.201	0.115	0.053	0.018
147	0.103	0.040	0.019	-0.075	-0.074	-0.083
148	-0.001	-0.051	-0.070	-0.076	-0.064	-0.075
149	0.146	0.085	0.078	-0.023	-0.042	-0.049
150	0.103	0.079	0.037	-0.035	-0.027	-0.023
151	0.204	0.136	0.142	-0.106	-0.114	-0.130
152	0.258	0.176	0.164	-0.094	-0.097	-0.101
153	0.133	0.107	0.059	0.046	0.060	0.032
154	0.082	0.008	-0.049	-0.085	-0.074	-0.075
155	-0.016	-0.066	-0.055	-0.055	-0.053	-0.050
156	0.081	0.014	-0.038	-0.100	-0.089	-0.083
157	-0.006	-0.076	-0.092	-0.087	-0.074	-0.076
158	0.056	-0.010	-0.053	-0.099	-0.105	-0.116
159	0.105	0.046	0.039	-0.144	-0.127	-0.125
160	-0.001	0.033	0.004	0.093	0.112	0.108
161	0.153	0.182	0.145	0.071	0.044	0.051
162	0.147	0.131	0.141	0.036	-0.005	-0.023
163	0.117	0.075	0.060	-0.001	-0.015	-0.041
164	0.091	0.045	0.012	-0.092	-0.097	-0.105
165	-0.061	-0.043	-0.021	-0.074	-0.061	-0.060
166	0.083	0.053	0.054	-0.030	-0.024	-0.020
167	0.054	0.008	0.001	-0.039	-0.046	-0.048
168	0.044	0.005	-0.030	0.004	-0.002	-0.012
169	0.035	0.004	0.002	0.024	0.018	0.003
170	0.160	0.079	-0.012	0.053	0.054	0.046
171	-0.051	-0.064	-0.072	-0.044	-0.045	-0.058
172	0.267	0.399	0.617	-0.266	-0.267	-0.315
173	0.138	0.135	0.287	-0.486	-0.474	-0.451

Table A-1.5. Frequency distributions of 1965 deviation ratios
BEA economic areas

Deviation from Nation: Region-Nation / Nation	Mortality		Fertility	
	Frequency	Relative Frequency	Frequency	Relative Frequency
0.60 to 0.69	-	-	1	0.6
0.50 to 0.59	-	-	1	0.6
0.40 to 0.49	-	-	-	-
0.30 to 0.39	1	0.6	3	1.7
0.20 to 0.29	3	1.7	5	2.9
0.10 to 0.19	18	10.4	28	16.2
0.00 to 0.09	52	30.1	63	36.4
-0.10 to -0.01	79	45.7	65	37.6
-0.20 to -0.11	18	10.4	7	4.0
-0.30 to -0.21	-	-	-	-
-0.40 to -0.31	1	0.6	-	-
-0.50 to -0.41	1	0.6	-	-
Total	173	100.0	173	100.0

Table A-1.6. Comparison of deviations: 1955 and 1965
BEA economic areas

	Fertility	Mortality
Absolute value of deviations		
A. Mean value 1955	0.097	0.080
B. Mean value 1965	0.081	0.074
C. % 1965 mean is of 1955	83.5%	92.5%
D. # of increases	64	76
E. # of decreases	104	89
F. # of no change	5	8
Frequency of sign changes	25	17

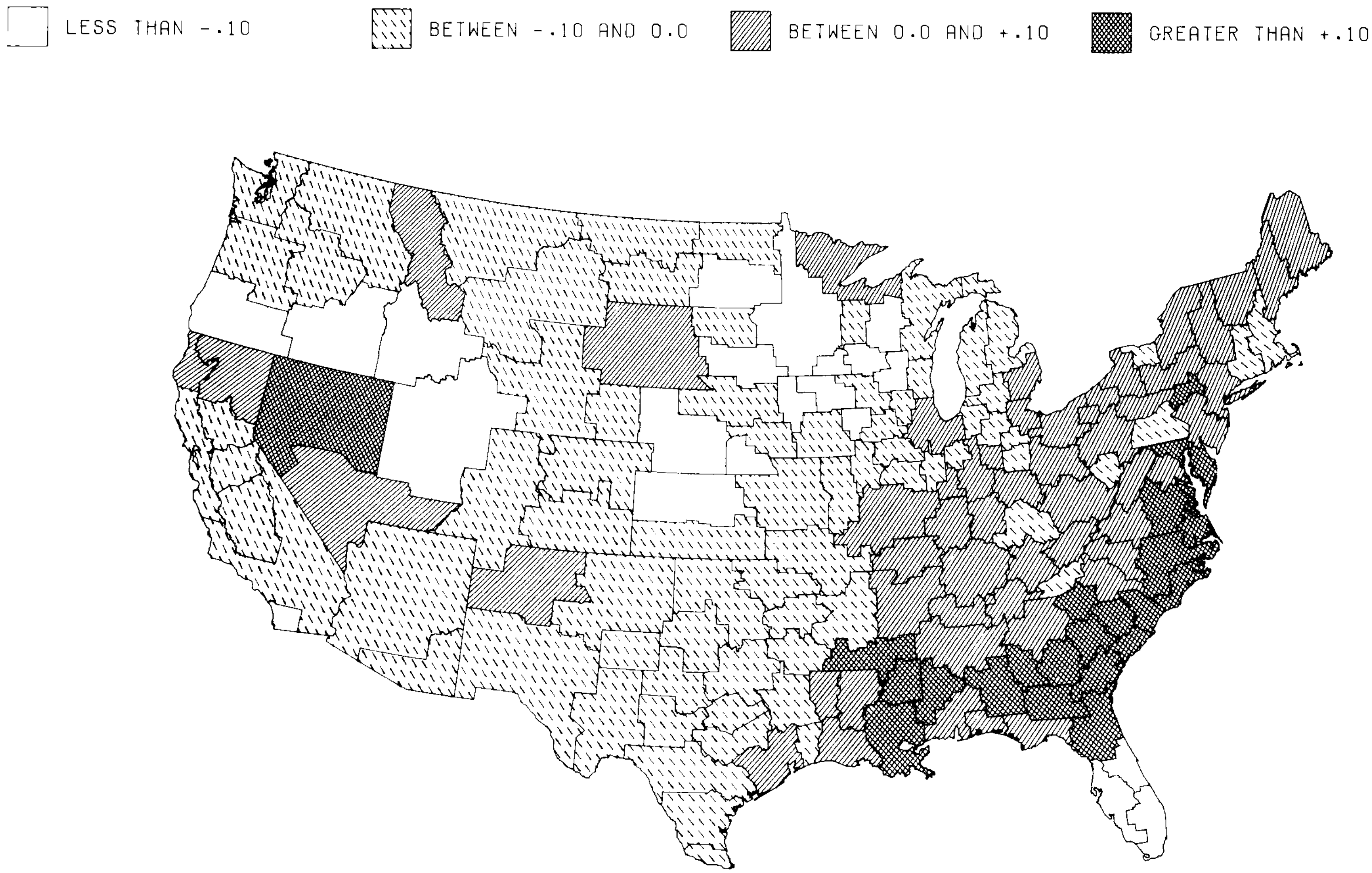


Fig. A-1. Mortality adjusted for age and sex:
1960 - 1969.

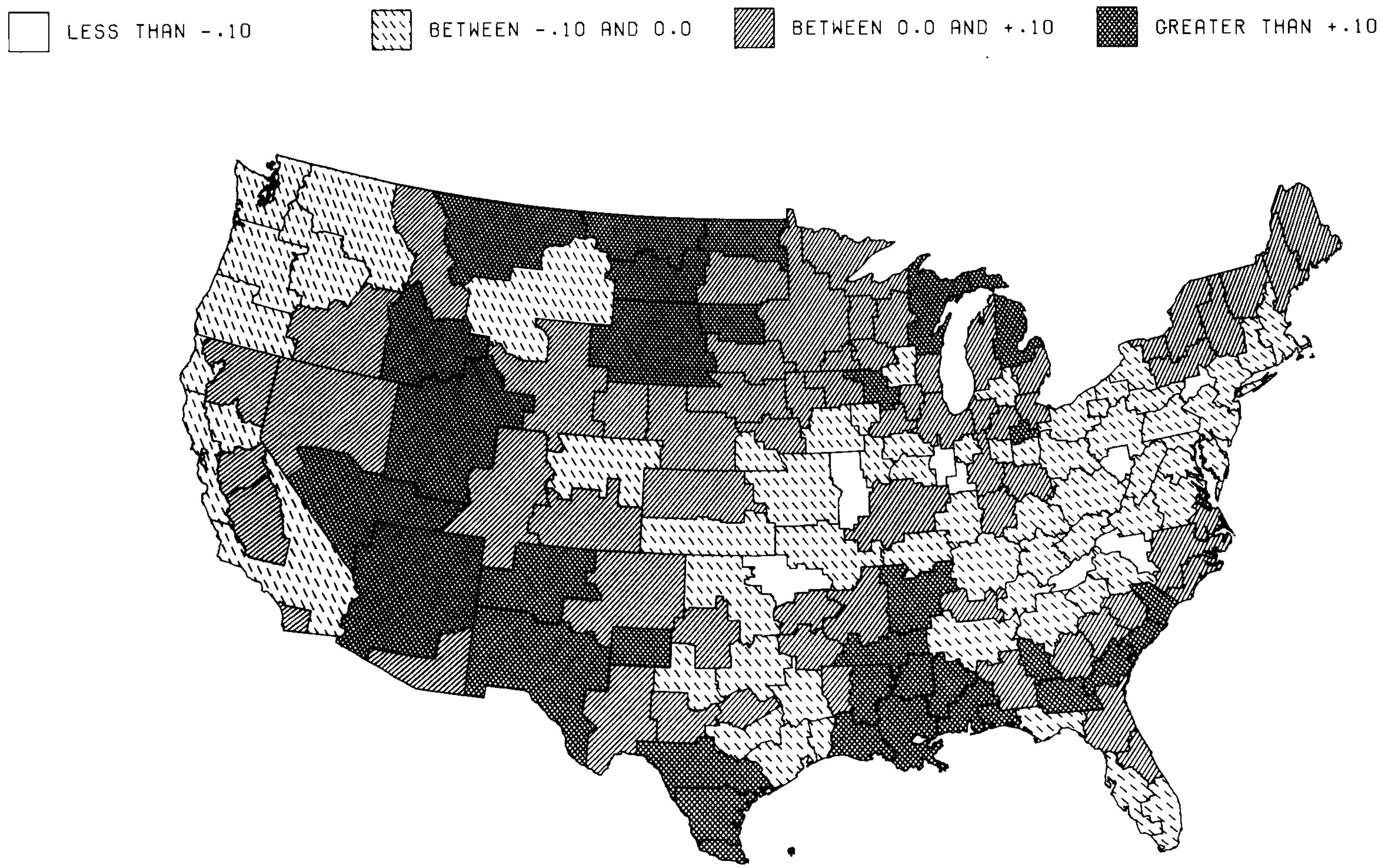


Fig. A-2. Fertility adjusted for age of mother: 1960 - 1969.

They emphasize the above average mortality of the southern coastal plain area and the below average mortality of the Plains area. The most urbanized areas of the country seem to have the lowest fertility rates while the most rural areas have the highest.[7]

The stability over time of some of these regional mortality and fertility patterns may be gauged from Table A-1.6 which contrasts the smoothed 1955 and 1965 deviations. First, the mean regional deviation is larger for births than for deaths, has declined for both, but is declining more rapidly for births than for deaths — signs of slow convergence to national averages. Second, the number of decreases in absolute value between 1955 and 1965 outnumbered the number of increases (especially for fertility) — another sign of slow convergence to national averages. Finally, the number of sign changes between 1955 and 1965 was small — a sign of stable deviations. The stability of these regional deviations and their slow decrease over time is of great interest because it provides a solid basis for projecting regional fertility and mortality trends.

A.2 NATIONAL TRENDS AND PROJECTIONS

A.2.1 Mortality rates

Projections of national age and sex-specific annual mortality rates (m_{ij}) may be obtained from projections of five-year survival rates (s_{ij}) published in *Current Population Reports*.[8] Symbolically,

$$m_{ij} = \frac{(1-s_{ij}) \times 1000}{5}$$

where

m_{ij} = expected annual number of deaths per 1000 persons in age cohort i and sex cohort j, and

s_{ij} = probability that a person of age cohort i and sex cohort j will survive the next five years.

The resulting mortality rate projections are found in Table A-2.1. These projections reflect, almost without exception, the assumption that age and sex-specific mortality rates will continue to decline but at a decreasing rate.

A.2.2 Fertility rates

Estimates and projections of national age-specific fertility rates are periodically prepared by the Bureau of the Census and published in *Current Population Reports*.[9] Based upon alternative assumptions about

Table A-2.1. National annual mortality rate projections derived from five-year survival rate tables

Age Cohorts	1970-1975	1975-1980	1980-1985	1985-1990	1990-1995	1995-2000	2000-2005
	Males						
0-4	4.49	4.22	4.03	3.83	3.63	3.42	3.32
5-9	0.71	0.67	0.64	0.60	0.56	0.53	0.51
10-14	0.44	0.43	0.42	0.41	0.41	0.40	0.39
15-19	0.99	0.94	0.89	0.85	0.80	0.77	0.76
20-24	1.92	1.80	1.71	1.61	1.52	1.42	1.38
25-29	2.11	1.99	1.89	1.79	1.70	1.60	1.55
30-34	2.06	1.95	1.87	1.79	1.71	1.63	1.59
35-39	2.58	2.44	2.34	2.26	2.17	2.08	2.03
40-44	3.79	3.61	3.49	3.35	3.24	3.13	3.09
45-49	5.85	5.65	5.47	5.31	5.14	5.01	4.94
50-54	9.02	8.82	8.66	8.45	8.29	8.09	8.05
55-59	13.82	13.48	13.25	13.02	12.71	12.47	12.32
60-64	21.38	20.58	20.17	19.67	19.17	18.56	18.32
65-69	31.29	30.28	29.50	28.87	28.15	27.42	26.92
70-74	44.13	42.66	41.76	40.70	39.87	38.89	38.45
75 & over	81.99	80.25	79.63	79.27	79.12	79.09	79.83

Age Cohorts	1970-1975	1975-1980	1980-1985	1985-1990	1990-1995	1995-2000	2000-2005
	Females						
0-4	3.56	3.33	3.17	3.01	2.84	2.66	2.58
5-9	0.55	0.52	0.50	0.47	0.44	0.42	0.41
10-14	0.29	0.29	0.28	0.28	0.27	0.27	0.27
15-19	0.44	0.42	0.40	0.38	0.36	0.35	0.34
20-24	0.67	0.64	0.61	0.58	0.56	0.53	0.51
25-29	0.80	0.76	0.74	0.72	0.69	0.66	0.65
30-34	1.04	1.00	0.97	0.94	0.92	0.89	0.87
35-39	1.48	1.42	1.38	1.34	1.30	1.27	1.25
40-44	2.22	2.13	2.07	2.00	1.94	1.88	1.86
45-49	3.34	3.22	3.12	3.02	2.92	2.84	2.80
50-54	4.95	4.80	4.67	4.53	4.40	4.27	4.22
55-59	6.96	6.79	6.67	6.54	6.39	6.25	6.17
60-64	10.28	10.05	9.95	9.83	9.69	9.50	9.42
65-69	15.79	15.49	15.26	15.14	14.97	14.77	14.61
70-74	24.28	23.87	23.70	23.41	23.30	23.11	23.00
75 & over	67.46	64.52	65.87	66.98	67.91	68.90	70.31

(1) the average number of children ever born to each female by age cohort (lifetime fertility) and (2) the points in the life cycle at which the children are most likely to be born (timing pattern), a range of possible fertility rate projection series may be prepared. Recent cohort fertility projections have been labelled as Series C (lifetime fertility of 2.8 children/woman), D (2.5 children/woman), E (2.1), and F (1.8). Under Series E, the total population of the U.S. would stabilize in the year 2037 at 275 million representing long-run zero population growth. Census practice is to use three of these cohort fertility series in a cohort component model of population change to create a range of population projections; recently Series D was used to project population under a high fertility assumption, Series F under a low fertility assumption, and Series E under a moderate or most likely fertility assumption. Obviously, separate fertility assumptions (series) may be applied to each age cohort when that assumption seems appropriate. Series E projections of fertility are found in Table A-2.2.

Table A-2.2. Estimates and projections of central birth rates by age of mother: United States, 1950-2005 (number of live births/year/1000 women)

Year	Age of mother 15-19	20-24	25-29	30-34	35-39	40-44	
1950	78.9	192.8	164.9	100.9	52.1	14.4	Actual
1955	90.3	236.3	187.0	114.9	58.3	15.4	Actual
1960	90.9	257.0	196.8	112.3	56.6	15.5	Actual
1965	73.4	194.0	161.4	94.7	46.3	12.8	Actual
1970	69.4	163.4	138.3	71.6	32.8	8.5	Actual
1975	52.2	135.2	113.3	56.7	24.2	6.0	Series "E" Projections
1980	53.8	148.1	118.4	58.1	23.6	5.7	Series "E" Projections
1985	53.8	153.1	123.6	59.4	23.0	5.4	Series "E" Projections
1990	53.8	153.1	125.3	60.7	22.4	5.2	Series "E" Projections
1995	53.8	153.1	125.3	61.0	21.8	4.9	Series "E" Projections
2000	53.8	153.1	125.3	61.0	21.6	4.7	Series "E" Projections
2005 & later	53.8	153.1	125.3	61.0	21.6	4.6	Series "E" Projections

A.2.3 Total population, births and deaths

Projections of the nation's population by age and sex are periodically prepared by the Bureau of the Census and published in *Current Population Reports*. The projections are developed by a cohort component method where the components of population change — fertility, mortality, and net immigration — are projected separately. Recent revisions of Census projections have focused on revising the alternative fertility assumptions with very slight updates of mortality rates; the net immigration assumed remains unchanged at 400,000 persons per year. Table A-2.3 summarizes the components of change of the latest Census Series "E" (most probable) population projection. It is characterized by a stable number of births over time and a rapidly increasing number of deaths associated with an aging population. Under these assumptions the total U.S. population will reach 264.4 million in the year 2000 (detailed composition shown in Table A-2.4).

Table A-2.3. Components of change
U.S. Population Projections: Series "E"

Period	Components of change (numbers in thousands)			Total Change
	Births	Deaths	Net Immigrants	
1960-1965	20,853	8,834	1,612	13,631
1965-1970	18,071	9,493	1,998	10,576
1970-1975	17,024	9,898	1,920	9,046
1975-1980	18,827	10,620	1,999	10,206
1980-1985	20,846	11,279	2,001	11,568
1985-1990	20,793	11,855	2,001	10,939
1990-1995	19,771	12,396	2,002	9,377
1995-2000	19,352	12,936	1,999	8,415

A.3 THE REGIONAL DISTRIBUTION OF IMMIGRANTS

We are indeed a nation of immigrants. While the flow of immigrants to the U.S. has averaged only 400,000 persons per year for the last few years and is projected to remain at this level for the foreseeable future, there have been periods in our history such as 1907-1914 when the *annual* number of immigrants equalled 10-15 percent of our total population (Table A-3.1). In addition, since immigrants have tended to concentrate in some regions of the U.S. almost to the exclusion of others, the immigrant nature of our population is most apparent in areas of the Northeast, California, Chicago, Detroit, Pittsburgh, Seattle, Miami, and our borders with Mexico. The proportion of a region's population that is of foreign stock (i.e., the foreign-born population and the native population of foreign or mixed parentage) gives a rough measure of the cumulative impact of immigration on regional population composition and confirms the concentrated pattern of immigrant destinations (Table A-3.2).

Table A-2.4 Estimates and Series E projections of the population of the United States (in thousands of persons as of July 1)

Sex and age	1960	1965	1970	1975	1980	1985	1990	1995	2000
Both sexes									
All ages	180,667	194,237	204,800	213,925	224,132	235,701	246,639	256,015	264,430
Under 5 years	20,337	19,781	17,184	16,763	18,566	20,565	20,531	19,546	19,152
5 to 9 years	18,812	20,369	19,876	17,318	16,907	18,707	20,704	20,673	19,694
10 to 14 years	16,924	19,042	20,805	20,062	17,497	17,088	18,885	20,880	20,849
15 to 19 years	13,455	17,010	19,285	20,943	20,221	17,668	17,262	19,057	21,048
20 to 24 years	11,124	13,753	17,176	19,404	21,067	20,355	17,823	17,424	19,216
25 to 29 years	10,940	11,357	13,758	17,312	19,544	21,202	20,501	17,990	17,599
30 to 34 years	11,978	11,100	11,520	13,802	17,418	19,639	21,290	20,599	18,110
35 to 39 years	12,543	12,026	11,208	11,604	13,822	17,409	19,615	21,259	20,580
40 to 44 years	11,678	12,413	11,918	11,117	11,548	13,741	17,287	19,471	21,102
45 to 49 years	10,915	11,411	12,210	11,790	10,956	11,385	13,540	17,023	19,173
50 to 54 years	9,657	10,381	11,059	11,773	11,450	10,651	11,077	13,171	16,557
55 to 59 years	8,477	9,645	9,992	10,620	11,229	10,933	10,182	10,599	12,607
60 to 64 years	7,144	7,380	8,656	9,247	9,854	10,433	10,175	9,494	9,901
65 to 69 years	6,293	6,579	6,831	7,686	8,228	8,795	9,332	9,122	8,532
70 to 74 years	4,769	5,379	5,634	5,863	6,452	6,930	7,437	7,913	7,759
75 years and over	5,623	6,609	7,691	8,621	9,371	10,199	10,999	11,794	12,551
Males									
All ages	89,318	95,578	100,217	104,377	109,240	114,917	120,376	125,122	129,439
Under 5 years	10,336	10,064	8,753	8,569	9,488	10,510	10,494	9,991	9,790
5 to 9 years	9,566	10,363	10,127	8,823	8,636	9,553	10,575	10,560	10,060
10 to 14 years	8,602	9,689	10,596	10,218	8,910	8,724	9,640	10,660	10,645
15 to 19 years	6,809	8,632	9,793	10,652	10,284	8,984	8,800	9,715	10,732
20 to 24 years	5,563	6,904	8,645	9,806	10,666	10,305	9,021	8,843	9,755
25 to 29 years	5,426	5,618	6,827	8,661	9,831	10,688	10,335	9,067	8,895
30 to 34 years	5,902	5,510	5,686	6,829	8,690	9,852	10,705	10,360	9,107
35 to 39 years	6,140	5,903	5,505	5,704	6,819	8,661	9,814	10,663	10,326
40 to 44 years	5,732	6,049	5,802	5,426	5,649	6,748	8,564	9,703	10,544
45 to 49 years	5,380	5,575	5,917	5,702	5,307	5,529	6,603	8,378	9,495
50 to 54 years	4,759	5,056	5,312	5,625	5,474	5,101	5,319	6,353	8,063
55 to 59 years	4,149	4,639	4,771	5,017	5,263	5,129	4,787	4,999	5,975
60 to 64 years	3,408	3,510	4,044	4,276	4,513	4,745	4,637	4,340	4,548
65 to 69 years	2,943	2,989	3,075	3,425	3,633	3,852	4,065	3,990	3,750
70 to 74 years	2,193	2,359	2,372	2,450	2,696	2,876	3,070	3,256	3,215
75 years and over	2,410	2,718	2,994	3,195	3,381	3,658	3,946	4,244	4,538
Females									
All ages	91,349	98,659	104,583	109,548	114,893	120,784	126,263	130,893	134,991
Under 5 years	10,001	9,716	8,430	8,194	9,078	10,055	10,037	9,555	9,361
5 to 9 years	9,246	10,007	9,749	8,495	8,271	9,154	10,130	10,113	9,633
10 to 14 years	8,322	9,353	10,209	9,844	8,587	8,364	9,245	10,220	10,204
15 to 19 years	6,645	8,378	9,492	10,291	9,937	8,684	8,462	9,342	10,316
20 to 24 years	5,561	6,849	8,531	9,598	10,401	10,049	8,801	8,581	9,461
25 to 29 years	5,514	5,739	6,931	8,651	9,714	10,515	10,165	8,923	8,704
30 to 34 years	6,076	5,591	5,834	6,973	8,728	9,786	10,585	10,239	9,003
35 to 39 years	6,403	6,123	5,703	5,899	7,004	8,748	9,801	10,596	10,254
40 to 44 years	5,946	6,364	6,116	5,691	5,899	6,993	8,723	9,768	10,558
45 to 49 years	5,535	5,837	6,293	6,089	5,649	5,856	6,937	8,645	9,678
50 to 54 years	4,898	5,325	5,747	6,148	5,976	5,551	5,758	6,818	8,494
55 to 59 years	4,328	5,005	5,221	5,603	5,966	5,804	5,396	5,600	6,632
60 to 64 years	3,735	3,870	4,612	4,971	5,341	5,688	5,538	5,153	5,354
65 to 69 years	3,350	3,590	3,756	4,261	4,595	4,942	5,267	5,132	4,782
70 to 74 years	2,577	3,020	3,263	3,413	3,757	4,054	4,368	4,657	4,543
75 years and over	3,212	3,892	4,697	5,426	5,991	6,541	7,052	7,550	8,013

Source: U.S. Bureau of the Census, Current Population Reports, Series P-25, Nos. 476 and 493 (1972).

Table A-3.1. Annual net immigrants to the United States
Selected years: 1900-1970

Year	Immigrants* (thousands)	Population (millions)	Annual immigrants per 1000 population
1900	449	76.1	5.9
1907	1285	87.0	14.8
1910	1041	92.4	11.3
1914	1218	99.1	12.3
1921	805	108.5	7.4
1924	706	114.1	6.2
1930	242	123.1	2.0
1935	35	127.2	0.3
1940	77	132.1	0.6
1945	162	139.9	1.2
1950	299	151.7	2.0
1955	337	165.3	2.0
1960	327	179.3	1.8
1965	373	194.2	1.9
1970	428	203.2	2.1

*Immigrants are non-resident aliens admitted to the United States for permanent residence.

Source: U. S. Bureau of the Census, *Historical Statistics of the United States: Colonial Times to 1957* (1960) and *Statistical Abstract of the United States, 1971*.

We may reasonably expect the first residence of new immigrants to be those cities or regions with large stocks of previous immigrants from similar origins. Once established, however, new immigrants may be expected to become a part of our internal migratory streams. If these expectations are partially correct, a region's share of new immigrants during time T (${}^{T}IM_R$) might be estimated by

$${}^{T}IM_R = \frac{{}^{T-5}A_R}{{}^{T-5}A} = \frac{{}^{T-5}POP_R}{{}^{T-5}POP} \cdot \frac{{}^{70}F_R}{{}^{70}F} = {}^{T-5}S_R \times \left(\frac{{}^{70}F_R}{{}^{70}F}\right)$$

where

${}^{T-5}S_R$ = region R's share of total U.S. population at T-5.

Table A-3.2. Percent of population of foreign stock: 1970
BEA economic areas

BEA Area	Percent of foreign stock	BEA Area	Percent of foreign stock	BEA Area	Percent of foreign stock	BEA Area	Percent of foreign stock	BEA Area	Percent of foreign stock
U.S.	16.50	35	10.71	70	11.35	105	12.28	140	4.03
1	18.07	36	31.45	71	22.31	106	8.42	141	9.05
2	20.07	37	15.72	72	14.75	107	13.36	142	19.89
3	20.13	38	3.46	73	15.37	108	12.98	143	19.27
4	32.98	39	5.27	74	10.61	109	10.66	144	42.50
5	30.63	40	1.67	75	5.63	110	6.27	145	28.04
6	21.45	41	1.11	76	11.07	111	7.08	146	7.04
7	19.67	42	1.41	77	24.87	112	3.93	147	11.72
8	22.93	43	3.09	78	8.11	113	4.97	148	13.54
9	23.98	44	2.76	79	12.60	114	8.35	149	7.12
10	14.25	45	1.71	80	9.02	115	1.27	150	10.54
11	9.32	46	1.94	81	8.95	116	3.50	151	12.91
12	12.91	47	1.79	82	13.39	117	2.28	152	9.46
13	26.95	48	1.20	83	13.36	118	2.21	153	16.73
14	36.86	49	1.72	84	19.76	119	3.13	154	14.76
15	19.98	50	1.28	85	16.24	120	3.99	155	20.46
16	6.11	51	1.17	86	17.38	121	4.98	156	13.25
17	9.70	52	1.86	87	28.76	122	4.84	157	15.40
18	12.71	53	1.40	88	15.86	123	6.49	158	10.69
19	2.00	54	3.56	89	13.53	124	7.93	159	10.25
20	1.50	55	1.92	90	14.27	125	4.18	160	14.80
21	3.82	56	4.63	91	17.49	126	8.35	161	12.71
22	5.71	57	7.27	92	24.68	127	5.16	162	14.59
23	2.31	58	6.74	93	22.52	128	7.43	163	22.91
24	2.62	59	4.67	94	17.65	129	9.13	164	20.80
25	1.45	60	4.55	95	16.20	130	1.49	165	26.28
26	1.41	61	2.81	96	26.14	131	1.10	166	20.62
27	1.73	62	6.26	97	22.06	132	2.22	167	21.66
28	1.30	63	5.46	98	20.56	133	1.61	168	17.92
29	2.51	64	5.27	99	18.43	134	1.33	169	11.28
30	1.14	65	6.16	100	12.93	135	1.01	170	14.38
31	3.65	66	20.25	101	14.19	136	0.82	171	27.13
32	2.61	67	20.68	102	12.30	137	3.09	172	10.90
33	2.46	68	18.39	103	15.97	138	4.97	173	33.30
34	5.55	69	4.28	104	13.24	139	2.29		

Source: R. J. Olsen, L. G. Bray, and G. W. Westley, *1972 County and City Data Book: Cumulations to BEA Areas (1974)*.

70_{F_R} = region R's percent of foreign stock in 1970.

70_F = nation's percent of foreign stock in 1970.

$T\text{-}5_{A_R}$ = region R's estimated foreign stock in T-5.

$T\text{-}5_A$ = nation's estimated foreign stock in T-5.

The age and sex distribution of immigrants to each region might be assumed to be that used by the Bureau of the Census for the nation as a whole.[10]

A.4 THE ORDER OF DEMOGRAPHIC COMPUTATIONS

The components of population change — births, deaths, aging, migration and immigration — occur continuously and simultaneously over time and space but demographic computations occur sequentially and discontinuously. In these circumstances the order of the computations can have a substantial effect on the resulting projections; this is especially true when the time step exceeds a year as it does in MULTIREGION. As a consequence particular attention has been paid to the order of regional demographic computations within MULTIREGION which may be divided into four phases.

Phase I - Preliminary Data Manipulation. Necessary information is prepared from the national/regional data, estimates, and projections already mentioned including (1) trended regional mortality and fertility adjustment factors, (2) regional immigration shares, (3) regional in- and out-migration rates by age and sex, and (4) projected national total immigrants, births, and deaths by age and sex.

Phase II - Allocation of immigrants. Regional immigration shares and the national age-sex distribution of immigrants are combined to increment base year regional populations for 5 years of net immigration.

Phase III - Track A (Because the order of computation does matter, previous experience suggests two alternatives — A and B).

A1 - Aging. All population cohorts are aged 5 years. This leaves the 0-4 age cohorts vacant.

A2 - Mortality. National mortality rate projections are combined with regional mortality adjustment factors to reduce the post Phase II populations by 5 years' deaths. Across region sums forced to national totals. The 0-4 age cohorts remain vacant.

A3 - Migration. Regional in- and out-migration rates by age and sex are applied to the population of each region to generate estimates of 5 years' interregional movement. Across region sums of in-migrants by age and sex are reconciled to across region sums of outmigrants by age and sex (proportion in-migrants, out-migrants, or both). Adjusted net in-migrants by age and sex are added to regional populations. The 0-4 age cohorts remain vacant.

A4 - Fertility. Age specific national fertility rate projections are combined with regional fertility adjustment factors and applied to the five-year period average [(beginning plus ending) /2] regional female population of child bearing age (15-44 years old) to increase the 0-4 age cohorts for 5 years' live births (48.8% females). Across region sums are forced to national totals. One half of the regional mortality rates by age (0-4) and sex are applied to estimate the 5 years' deaths within the earliest age cohort whose population existed for only 2-1/2 years on an average. Across region sums of 0-4 age cohort deaths are forced to national totals. Live births adjusted for deaths becomes the population of each 0-4 age cohort.

A5 - Balancing to nation. Across region sums by age and sex are forced to national totals by age and sex.

Phase III - Track B (Details as above)

B1 - Aging.

B2 - Migration.

B3 - Mortality.

B4 - Fertility.

B5 - Balancing to nation.

Phase IV - Reconciliation. The results of A5 and B5 are reconciled by averaging the corresponding pairs of the 173 x 32 matrices and forcing the sums of these numbers across regions to national totals by age and sex.

REFERENCES FOR APPENDIX A

1. For example, Marc Nerlove and T. Paul Schultz, *Love and Life between the Censuses: A Model of Family Decision Making in Puerto Rico, 1950-1960*, The Rand Corporation, RM-6322-AID, September 1970, and Harvey Leibenstein, "An Interpretation of the Economic Theory of Fertility: Promising Path or Blind Alley?" *Journal of Economic Literature*, Vol. XII, No. 2 (June 1974), pp. 457-479.

2. In early 1975, the 1969 edition of *Vital Statistics of the United States* was the latest available.

3. U.S. Department of Health, Education, and Welfare, Public Health Service (or National Center for Health Statistics) *Vital Statistics of the United States* (annual).

4. U.S. Bureau of the Census, *The Methods and Materials of Demography* (2 volumes) by Henry S. Shryock, Jacob S. Siegel, and Associates, second printing (revised), U.S. Government Printing Office, Washington, D.C., 1973, p. 391.

5. *Ibid.*, p. 464.

6. For a more in-depth analysis see Todd Fisher, "Hawaii: Growing Pains in Paradise," *Population Bulletin*, Vol. 29, No. 3 (1973).

7. Some of these contrasts might be softened if underrepresentation of the elderly and nonwhites in the Censuses of Population were corrected.

8. Bureau of the Census, *Current Population Reports* Series OP-25, No. 493, "Population Estimates and Projections" (December, 1972), p. 25.

9. *Ibid.*

10. Assumed distribution of future annual net immigration by age and sex (Rounded to nearest hundred. Age shown as of end of year of arrival.)

Age	Both Sexes	Male	Female
Total, all ages	400,000	186,200	213,800
Under 5 years	33,400	16,800	16,600
5 to 9 years	41,100	20,300	20,800
10 to 14 years	42,800	21,800	21,000
15 to 19 years	47,700	23,100	24,600
20 to 24 years	52,400	21,600	30,900
25 to 29 years	55,100	26,200	28,900
30 to 34 years	39,900	19,400	20,500
35 to 39 years	25,700	12,000	13,600
40 to 44 years	20,400	8,500	12,000
45 to 49 years	14,500	6,000	8,500
50 to 54 years	10,100	4,100	6,000
55 to 59 years	8,400	3,400	5,000
60 to 64 years	5,000	2,000	3,100
65 to 69 years	1,700	500	1,200
70 to 74 years	900	300	600
75 years & over	700	100	500

Source: *Current Population Reports*, Series OP-25, No. 493.

Table A-1.2. Vital events: 1950, 1954, 1960, 1964, and 1969, BEA economic areas

BEA	Actual births					Actual deaths				
	1950	1954	1960	1964	1969	1950	1954	1960	1964	1969
1	7,740	8,492	8,936	7,622	5,698	3,180	3,235	3,406	3,428	3,387
2	14,377	15,278	15,774	15,078	12,776	7,267	7,304	7,911	8,126	8,200
3	10,382	10,630	10,544	9,696	8,734	4,769	4,679	5,082	5,143	5,054
4	105,972	25,724	126,500	117,376	104,606	54,644	12,135	62,567	57,575	63,930
5	42,627	39,740	57,426	55,902	49,190	20,661	16,107	24,617	25,253	26,840
6	24,380	23,434	27,418	25,856	22,538	13,657	12,431	14,581	14,836	14,858
7	26,939	29,658	32,620	30,390	26,052	12,891	13,008	14,423	14,661	14,523
8	15,356	17,902	19,242	19,710	18,802	8,147	8,019	8,994	9,242	9,145
9	33,491	38,876	40,244	34,924	29,910	15,637	16,040	17,962	18,214	18,660
10	9,509	10,552	9,786	8,918	7,948	4,366	4,420	4,736	4,846	5,015
11	8,578	8,820	9,070	8,318	7,256	3,981	3,877	4,133	4,304	4,361
12	15,234	16,240	17,038	15,540	13,306	7,593	7,342	8,018	8,096	7,886
13	14,371	13,374	12,314	11,044	9,810	8,745	8,369	9,084	9,193	8,934
14	277,172	315,166	341,970	342,812	302,836	143,262	148,363	167,870	177,075	183,084
15	112,061	134,022	142,948	138,028	119,198	59,481	60,128	68,038	71,561	75,188
16	31,099	34,232	34,024	32,516	27,950	14,824	14,279	16,141	16,777	17,397
17	43,146	51,414	57,214	55,012	44,808	20,149	20,147	23,636	24,143	25,882
18	43,205	52,226	59,626	64,780	59,848	14,228	14,597	17,870	19,893	21,512
19	7,725	7,850	7,748	7,576	6,490	3,295	3,225	3,704	3,871	4,073
20	17,247	17,698	16,602	16,512	14,298	6,476	6,126	7,241	7,641	8,123
21	18,255	20,586	20,758	20,572	17,578	8,238	7,880	8,870	9,428	9,973
22	21,433	29,228	28,464	28,966	23,018	7,232	7,601	8,802	9,184	9,770
23	38,372	40,838	37,248	36,418	30,718	10,956	10,914	12,610	13,339	14,353
24	10,012	12,940	12,270	11,710	9,638	2,983	3,231	3,737	3,745	4,135
25	20,751	22,396	23,340	22,208	20,388	6,371	6,385	8,157	8,837	9,957
26	29,427	30,904	30,102	29,234	27,796	8,129	8,514	10,514	11,238	12,767
27	8,479	8,004	7,586	7,362	6,354	2,624	2,510	3,279	3,417	3,866
28	15,948	18,134	17,202	16,148	15,032	5,311	5,031	6,517	6,701	7,596
29	13,474	15,476	13,956	13,330	11,702	4,079	4,148	4,621	4,748	5,062
30	11,793	12,524	10,782	10,022	7,964	3,450	3,346	3,771	3,831	3,854
31	8,659	9,888	10,174	10,238	9,548	2,731	2,652	3,047	3,158	3,236

Table A-1.2. Vital events: 1950, 1954, 1960, 1964, and 1969, BEA economic areas (Contd.)

	Actual Births					Actual Deaths				
BEA	1950	1954	1960	1964	1969	1950	1954	1960	1964	1969
32	10,105	13,322	10,572	9,932	9,178	3,743	3,752	3,899	4,180	4,480
33	9,703	11,086	10,830	9,864	8,430	3,541	3,439	3,880	3,982	4,355
34	16,876	20,388	23,250	22,844	19,648	6,182	6,436	8,027	8,668	9,597
35	6,522	9,426	16,284	17,142	15,370	3,313	4,000	6,158	7,424	9,095
36	17,117	24,356	35,678	35,538	36,212	6,852	9,104	15,046	19,045	25,814
37	14,706	18,666	26,358	25,930	25,068	7,710	9,283	15,470	18,025	23,902
38	6,783	7,546	8,104	7,298	6,336	2,059	2,193	2,601	2,845	3,056
39	5,983	8,256	9,730	9,108	8,058	1,647	1,686	2,219	2,329	2,771
40	18,228	17,830	16,732	15,552	13,746	6,320	6,084	6,743	6,906	7,364
41	13,079	13,428	12,308	12,102	9,666	4,084	3,922	4,436	4,279	4,665
42	11,726	11,996	11,906	11,446	9,550	4,030	4,086	4,468	4,679	5,039
43	11,690	12,950	12,076	12,908	10,096	3,656	3,569	4,109	4,273	4,565
44	36,958	40,520	43,608	45,280	44,280	12,207	12,939	15,367	17,003	18,991
45	42,730	41,746	39,556	35,970	30,690	13,926	13,470	15,815	16,659	17,743
46	43,359	44,544	41,890	41,004	33,532	14,173	13,853	15,479	16,296	17,130
47	12,966	12,574	13,502	15,046	12,438	4,302	4,042	4,672	5,221	5,751
48	15,256	15,932	15,002	14,102	13,376	5,061	5,017	5,943	6,159	6,753
49	28,086	27,970	28,378	28,486	24,372	11,367	10,952	12,652	13,111	13,954
50	22,743	22,586	19,532	19,060	15,586	6,978	6,801	7,747	8,102	8,942
51	21,455	20,268	17,220	15,328	13,438	6,400	5,952	6,783	6,975	7,601
52	40,547	37,976	30,970	27,978	21,842	12,454	11,465	12,611	13,325	14,283
53	19,226	17,064	16,554	16,652	13,664	6,399	6,017	6,792	6,987	7,251
54	22,792	26,966	27,770	25,596	22,544	9,033	9,151	10,175	10,709	11,496
55	17,290	18,166	16,324	14,742	12,228	8,129	7,689	8,341	8,751	9,161
56	5,056	5,236	4,782	4,330	3,768	3,141	3,079	3,345	3,317	3,466
57	9,542	9,876	10,368	9,642	7,722	4,891	4,733	5,220	5,550	5,523
58	6,928	7,604	7,808	6,578	6,418	3,261	3,053	3,444	3,371	3,675
59	4,605	4,936	5,366	5,016	4,582	2,146	2,085	2,316	2.330	2,354
60	26,212	31,432	35,074	33,984	29,964	11,858	11,760	13,388	14,032	14,582
61	10,039	11,536	11,660	11,500	10,126	4,363	4,277	4,914	5,088	5,406
62	33,515	40,720	43,528	39,952	34,236	15,835	15,760	17,594	17,906	18,968
63	19,531	23,766	24,168	22,194	21,256	7,691	7,906	8,931	9,154	9,802
64	28,486	34,716	37,728	35,392	32,408	13,348	13,598	15,203	15,780	16,419

Table A-1.2. Vital events: 1950, 1954, 1960, 1964, and 1969, BEA economic areas (Contd.)

BEA	Actual births					Actual deaths				
	1950	1954	1960	1964	1969	1950	1954	1960	1964	1969
65	8,346	7,390	6,564	6,124	5,028	3,529	3,273	3,715	3,780	3,850
66	78,806	82,680	79,668	67,048	55,724	35,482	34,506	39,605	39,785	40,831
67	14,842	17,242	16,834	13,442	12,252	6,056	6,160	7,078	7,352	7,822
68	73,533	88,048	90,720	82,718	74,818	30,597	32,091	36,785	38,365	40,107
69	5,910	6,480	6,478	5,900	5,106	2,297	2,342	2,665	2,734	2,817
70	19,767	22,992	22,820	20,634	19,320	8,637	8,740	9,664	9,661	10,295
71	93,154	114,258	113,876	102,278	97,634	30,454	32,541	37,411	40,347	43,636
72	15,192	17,422	18,642	16,808	15,232	5,574	5,910	6,394	6,575	7,234
73	21,312	24,576	25,282	22,524	20,524	8,442	8,652	9,440	9,868	10,201
74	17,836	20,540	21,986	19,828	19,468	7,097	7,268	7,799	8,212	8,366
75	10,539	12,616	12,716	11,998	11,416	4,700	4,773	4,968	5,183	5,439
76	14,172	16,132	16,080	14,580	13,920	5,546	5,710	6,356	6,732	7,091
77	133,649	159,612	180,316	169,146	149,182	62,702	63,461	71,863	74,538	78,287
78	11,681	12,312	13,086	11,690	10,414	5,379	5,238	5,801	5,829	6,161
79	11,445	12,308	12,972	11,956	10,766	5,314	5,081	5,702	5,904	6,109
80	6,017	6,228	7,226	6,908	6,188	2,492	2,311	2,584	2,758	2,804
81	7,033	7,246	7,490	6,650	5,132	3,201	2,876	3,196	3,136	3,221
82	9,144	11,018	12,376	11,202	10,472	4,064	3,961	4,627	4,690	5,083
83	7,857	9,032	9,676	8,844	7,868	3,076	3,196	3,564	3,479	3,951
84	34,736	40,690	47,444	42,496	34,988	14,568	15,010	17,248	17,567	18,584
85	18,808	20,352	20,816	18,964	15,210	7,715	7,576	8,369	8,662	8,840
86	7,691	7,996	8,206	7,048	5,870	2,849	2,771	3,034	3,141	3,363
87	9,554	10,698	10,350	7,836	6,448	4,529	4,560	4,910	4,947	4,931
88	5,107	4,934	4,614	3,918	3,556	2,033	1,844	2,114	2,209	2,301
89	5,980	6,178	5,598	4,944	4,250	2,636	2,571	2,748	2,824	2,848
90	5,089	5,428	5,944	5,188	4,288	1,855	1,857	2,076	1,981	2,192
91	54,709	59,094	66,102	59,502	52,388	20,269	20,143	23,224	24,424	25,155
92	6,046	5,740	5,564	5,010	3,748	2,093	1,948	2,165	2,155	2,373
93	5,213	5,692	5,172	4,844	3,500	1,532	1,568	1,677	1,759	1,642
94	5,267	5,904	6,642	5,672	3,788	1,820	1,920	2,121	2,180	2,089
95	5,906	6,220	5,978	4,962	4,200	1,825	1,958	2,162	2,202	2,280
96	4,303	4,468	4,088	3,548	2,470	1,142	1,138	1,177	1,212	1,231
97	8,697	8,760	8,372	6,494	5,168	2,934	2,853	3,061	3,285	3,184

Table A-1.2. Vital events: 1950, 1954, 1960, 1964, and 1969, BEA economic areas (contd.)

BEA	Actual births 1950	1954	1960	1964	1969	Actual deaths 1950	1954	1960	1964	1969
98	3,980	3,708	3,250	2,872	2,166	1,399	1,287	1,449	1,496	1,483
99	9,801	9,504	9,042	7,578	5,638	3,114	3,098	3,452	3,485	3,526
100	6,032	6,964	7,222	6,618	4,624	1,909	1,865	2,244	2,199	2,211
101	3,070	3,170	2,790	2,262	1,676	903	989	1,003	1,089	1,173
102	8,017	8,036	6,900	5,852	5,018	3,318	3,285	3,477	3,717	3,691
103	12,242	12,162	10,868	9,106	7,372	4,495	4,429	4,812	4,943	5,161
104	7,039	6,930	6,364	5,146	3,898	2,704	2,651	2,904	3,079	3,070
105	9,922	9,872	10,120	8,384	6,948	3,797	3,659	4,153	4,303	4,310
106	16,503	16,558	16,874	14,210	12,998	7,786	7,546	8,411	8,348	8,320
107	15,199	16,740	18,550	17,356	14,128	6,174	6,319	7,199	7,392	7,406
108	6,414	6,694	7,410	6,404	4,880	3,021	3,001	3,362	3,446	3,325
109	8,882	9,618	8,476	7,140	5,100	3,537	3,604	3,855	3,912	4,038
110	14,468	19,018	17,508	14,352	12,604	5,522	5,899	6,449	6,741	7,069
111	38,318	45,720	48,428	42,884	38,752	19,902	19,841	21,673	22,230	23,134
112	6,976	6,954	7,252	6,572	6,132	4,304	4,108	4,523	4,710	4,905
113	6,203	6,352	6,062	5,574	4,732	3,841	3,573	3,818	3,772	4,007
114	58,147	66,416	69,120	63,460	54,942	27,574	28,331	31,111	32,374	34,232
115	14,167	14,118	12,176	11,044	8,820	6,344	5,904	6,677	6,899	7,278
116	16,704	15,166	14,616	13,158	12,216	9,232	9,229	10,088	10,393	11,183
117	17,837	17,246	17,478	17,898	15,066	6,400	6,412	7,674	8,286	9,123
118	6,328	6,086	4,752	5,734	4,658	2,479	2,371	2,815	3,157	3,223
119	18,022	18,926	18,936	17,140	16,798	7,224	7,647	8,492	9,166	9,990
120	22,853	23,634	23,022	22,060	19,474	8,536	8,911	10,349	10,722	11,717
121	9,311	9,874	11,522	10,094	8,172	3,309	3,404	3,983	4,220	4,490
122	9,694	10,276	11,852	10,512	8,104	2,547	2,559	3,246	3,528	3,760
123	7,243	8,606	9,682	9,870	6,738	1,708	1,690	2,351	2,567	2,480
124	6,422	8,076	9,446	7,888	6,292	1,310	1,460	1,832	1,951	2,128
125	6,488	6,080	6,472	5,604	4,274	2,448	2,374	2,813	2,965	3,292
126	3,404	3,186	2,892	2,532	2,008	1,162	1,031	1,286	1,283	1,507
127	36,559	44,706	49,528	48,580	53,490	13,710	14,556	17,528	19,369	23,002
128	7,991	9,394	8,306	8,854	7,210	3,159	3,120	3,778	3,897	4,354
129	10,153	11,278	10,658	10,150	10,226	3,667	3,760	4,225	4,462	4,910
130	11,585	11,184	10,358	9,246	8,828	4,653	4,558	5,343	5,640	6,204

Table A-1.2. Vital events: 1950, 1954, 1960, 1964, and 1969, BEA economic areas (contd.)

BEA	Actual births					Actual deaths				
	1950	1954	1960	1964	1969	1950	1954	1960	1964	1969
131	8,093	7,496	6,044	6,060	5,512	3,262	3,223	3,655	3,891	4,019
132	11,379	12,184	11,148	10,456	9,424	3,501	3,473	4,216	4,209	4,816
133	13,813	14,206	13,226	12,558	11,044	4,339	4,214	4,916	5,300	5,687
134	18,864	18,828	15,478	14,584	11,018	5,965	5,443	5,786	6,084	6,008
135	13,990	13,642	13,352	12,584	10,610	4,482	4,410	4,782	4,935	5,368
136	12,008	10,972	9,674	9,110	8,066	3,837	3,632	4,202	4,275	4,499
137	14,626	18,062	18,952	17,978	15,214	4,529	4,621	5,578	5,738	6,398
138	43,322	48,902	52,300	50,652	43,670	14,208	14,629	17,823	19,023	19,989
139	15,355	18,228	19,808	18,020	15,522	3,987	4,227	5,296	5,626	6,171
140	7,684	8,966	9,158	7,878	6,634	2,243	2,273	2,799	2,921	3,414
141	32,335	41,430	44,698	44,102	45,416	9,662	10,572	13,543	14,686	17,446
142	25,049	29,550	29,258	28,378	26,718	7,452	7,512	8,537	9,024	10,146
143	12,736	16,250	15,476	13,918	13,288	2,873	2,963	3,299	3,435	3,810
144	13,857	13,950	13,126	11,154	12,472	2,978	2,701	2,350	2,466	2,473
145	14,810	19,292	23,284	20,070	17,668	3,388	3,384	4,105	4,196	4,601
146	12,140	13,848	16,692	14,502	12,030	3,023	2,886	3,529	3,731	3,919
147	8,821	10,622	9,450	9,330	9,780	3,409	3,427	3,790	4,076	4,141
148	21,626	24,642	29,540	28,148	26,730	7,544	8,244	10,038	10,793	11,358
149	4,568	5,304	6,592	5,234	4,594	1,686	1,655	2,008	2,027	2,124
150	4,677	5,778	5,844	5,046	4,194	1,487	1,535	1,826	1,888	1,975
151	21,605	23,920	26,410	23,878	24,062	5,154	5,355	6,243	6,557	6,977
152	7,538	8,022	8,094	6,424	6,142	1,864	1,894	2,080	2,245	2,391
153	4,656	5,298	4,960	4,554	3,890	2,219	2,236	2,339	2,514	2,373
154	14,080	16,448	15,434	12,336	11,284	5,396	5,600	5,999	6,447	6,681
155	34,306	38,222	42,850	38,434	42,148	15,117	15,590	17,921	18,935	20,763
156	9,442	10,196	8,664	7,494	6,608	2,960	3,104	3,479	3,579	3,874
157	27,621	29,050	28,700	25,238	26,784	11,116	11,733	13,422	14,525	15,677
158	9,207	10,438	10,744	9,618	8,818	2,991	3,194	3,656	4,011	4,559
159	5,251	5,726	6,034	4,994	4,766	1,666	1,737	2,058	2,245	2,291

Table A-1.2. Vital events: 1950, 1954, 1960, 1964, and 1969, BEA economic areas (contd.)

	Actual births					Actual deaths				
BEA	1950	1954	1960	1964	1969	1950	1954	1960	1964	1969
160	2,266	3,206	3,586	4,004	3,486	1,087	1,169	1,519	1,700	1,833
161	2,361	3,636	4,434	6,684	6,348	763	842	1,269	1,672	2,127
162	14,979	19,362	26,926	27,228	26,014	4,745	5,195	7,350	8,828	10,375
163	5,844	7,458	9,834	9,076	8,268	1,677	2,017	2,796	3,249	3,656
164	14,072	20,628	26,928	24,454	24,258	4,721	5,611	7,616	8,448	10,056
165	113,232	150,348	189,430	197,942	190,628	48,658	55,345	69,627	78,436	86,975
166	20,117	21,608	23,214	21,966	19,176	5,847	6,071	7,533	8,302	8,832
167	10,816	12,058	12,346	11,410	11,112	4,089	4,263	5,065	5,491	6,027
168	13,273	16,212	21,520	20,776	17,628	5,575	6,081	7,481	8,443	9,094
169	3,121	3,310	3,260	3,186	2,806	1,302	1,321	1,411	1,630	1,748
170	2,160	2,986	3,456	2,654	2,070	872	903	1,092	1,152	1,128
171	68,080	79,140	92,056	92,584	85,848	27,696	29,850	35,683	39,053	42,217
172	4,010	7,038	7,562	7,274	7,000	1,253	1,204	1,319	1,438	1,000
173	14,067	16,202	17,206	17,368	15,648	2,919	3,213	3,541	3,645	4,076

Table A-1.3. (Actual - expected)/expected live births and deaths: 1950, 1954, 1960, 1964, 1969

	Births					Deaths				
	1950	1954	1960	1964	1969	1950	1954	1960	1964	1969
BEA 1	0.118	0.086	0.136	0.090	0.031	-0.045	0.015	0.002	0.034	0.023
BEA 2	-0.026	-0.054	0.023	0.036	0.036	-0.029	0.012	0.014	0.042	0.023
BEA 3	0.087	0.022	0.072	-0.004	0.007	-0.030	0.002	0.030	0.040	-0.010
BEA 4	-0.132	-0.808	-0.014	-0.069	-0.055	-0.041	-0.782	0.022	-0.078	-0.027
BEA 5	-0.151	-0.307	-0.019	-0.048	-0.064	-0.055	-0.274	-0.033	-0.050	-0.064
BEA 6	-0.046	-0.165	0.019	0.002	0.018	0.056	-0.016	0.051	0.060	0.022
BEA 7	-0.006	-0.032	0.057	0.030	0.030	-0.016	0.016	0.027	0.050	0.017
BEA 8	-0.087	-0.061	-0.001	-0.009	0.028	-0.033	-0.040	-0.037	-0.026	-0.078
BEA 9	-0.064	-0.030	0.015	-0.047	-0.010	0.026	0.054	0.047	0.052	0.038
BEA 10	-0.029	-0.009	-0.024	-0.044	0.024	0.007	0.047	0.026	0.058	0.075
BEA 11	-0.085	-0.142	-0.078	-0.082	-0.029	-0.003	0.007	-0.006	0.045	0.039
BEA 12	0.041	-0.004	0.061	0.024	0.035	-0.003	-0.001	0.008	0.028	-0.017
BEA 13	-0.236	-0.288	-0.174	-0.175	-0.080	0.173	0.171	0.185	0.179	0.094
BEA 14	-0.213	-0.200	-0.124	-0.090	-0.063	0.052	0.066	0.040	0.055	0.017
BEA 15	-0.174	-0.119	-0.054	-0.046	-0.035	0.095	0.093	0.078	0.085	0.055
BEA 16	-0.087	-0.098	-0.088	-0.072	-0.049	0.010	-0.017	-0.004	0.010	-0.011
BEA 17	-0.110	-0.075	0.003	0.001	-0.051	0.139	0.119	0.141	0.111	0.099
BEA 18	-0.059	-0.042	0.011	-0.007	-0.056	0.074	0.038	0.054	0.068	0.016
BEA 19	-0.041	-0.123	-0.117	-0.085	-0.072	0.008	-0.002	0.026	0.042	0.030
BEA 20	-0.039	-0.107	-0.134	-0.086	-0.062	0.074	0.011	0.051	0.062	0.046
BEA 21	-0.077	-0.070	-0.052	-0.035	-0.053	0.180	0.119	0.103	0.124	0.102
BEA 22	0.004	0.167	0.068	0.114	0.015	0.177	0.191	0.173	0.151	0.111
BEA 23	0.117	0.069	-0.005	0.014	-0.007	0.169	0.154	0.169	0.175	0.160
BEA 24	0.103	0.216	0.083	0.112	0.099	0.150	0.221	0.226	0.172	0.190
BEA 25	-0.104	-0.155	-0.141	-0.132	-0.054	-0.028	-0.061	0.017	0.020	0.028
BEA 26	-0.024	-0.084	-0.099	-0.098	-0.013	-0.001	0.014	0.068	0.054	0.068
BEA 27	-0.017	-0.143	-0.134	-0.102	-0.074	-0.130	-0.175	-0.062	-0.086	-0.067
BEA 28	-0.105	-0.082	-0.107	-0.108	-0.014	0.081	0.005	0.128	0.088	0.118
BEA 29	0.134	0.147	0.021	0.014	0.028	0.207	0.208	0.172	0.150	0.128

Table A-1.3. (Cont'd)

	Births					Deaths				
	1950	1954	1960	1964	1969	1950	1954	1960	1964	1969
BEA 30	0.217	0.197	0.106	0.135	0.105	0.357	0.342	0.379	0.352	0.270
BEA 31	0.199	0.157	0.105	0.132	0.198	0.387	0.317	0.314	0.283	0.194
BEA 32	0.123	0.319	0.052	0.033	0.112	0.245	0.265	0.185	0.223	0.220
BEA 33	0.087	0.114	0.104	0.090	0.127	0.302	0.256	0.248	0.222	0.234
BEA 34	0.006	0.014	0.055	0.050	0.022	0.140	0.106	0.131	0.120	0.099
BEA 35	-0.048	-0.113	0.070	0.065	0.019	-0.061	-0.157	-0.126	-0.105	-0.092
BEA 36	-0.110	-0.126	-0.051	-0.115	-0.044	-0.054	-0.148	-0.106	-0.147	-0.126
BEA 37	-0.059	-0.114	-0.006	-0.051	0.000	-0.056	-0.194	-0.128	-0.190	-0.155
BEA 38	0.046	-0.001	0.018	-0.052	-0.056	-0.012	0.017	0.026	0.058	0.033
BEA 39	0.144	0.187	0.123	0.082	0.104	0.098	0.010	0.055	0.014	0.065
BEA 40	0.140	0.035	0.045	0.056	0.130	0.134	0.115	0.123	0.131	0.150
BEA 41	0.270	0.192	0.145	0.227	0.189	0.169	0.141	0.166	0.101	0.138
BEA 42	0.107	0.024	0.046	0.082	0.082	0.122	0.147	0.125	0.142	0.155
BEA 43	0.076	0.078	0.035	0.179	0.096	0.165	0.140	0.165	0.172	0.171
BEA 44	-0.025	-0.088	-0.078	-0.080	-0.029	0.033	0.052	0.055	0.077	0.073
BEA 45	0.057	-0.049	-0.042	-0.046	-0.003	0.075	0.031	0.061	0.076	0.069
BEA 46	0.146	0.095	0.113	0.155	0.115	0.048	0.035	0.037	0.064	0.056
BEA 47	0.078	-0.078	-0.021	0.101	0.027	0.058	-0.018	-0.010	0.032	0.025
BEA 48	0.021	-0.043	-0.085	-0.094	0.013	0.048	0.026	0.061	0.042	0.047
BEA 49	-0.017	-0.122	-0.098	-0.053	-0.052	0.009	-0.021	0.008	0.010	0.005
BEA 50	0.035	-0.041	-0.099	-0.043	-0.047	0.030	0.007	0.017	0.016	0.036
BEA 51	0.050	-0.065	-0.119	-0.116	-0.018	0.056	-0.002	0.025	0.028	0.059
BEA 52	0.100	-0.013	-0.081	-0.041	-0.023	0.027	-0.027	-0.021	0.030	0.068
BEA 53	0.131	-0.068	-0.027	0.020	-0.030	-0.029	-0.061	-0.029	-0.017	-0.028
BEA 54	0.058	0.082	0.066	0.022	0.044	0.030	0.037	0.013	0.040	0.053
BEA 55	0.019	0.007	-0.003	-0.026	-0.021	-0.013	-0.035	-0.036	0.011	0.027
BEA 56	-0.070	-0.100	-0.105	-0.140	-0.115	-0.016	0.009	0.024	0.038	0.084
BEA 57	-0.032	-0.094	-0.022	-0.023	-0.059	-0.048	-0.062	-0.066	-0.003	-0.030
BEA 58	-0.079	-0.122	-0.130	-0.257	-0.182	-0.032	-0.071	-0.046	-0.062	-0.005
BEA 59	-0.024	-0.084	-0.027	-0.075	-0.044	-0.071	-0.070	-0.049	-0.039	-0.054
BEA 60	-0.022	-0.011	0.020	0.002	0.001	0.019	0.005	0.007	0.037	0.027
BEA 61	-0.031	-0.030	-0.048	-0.022	0.000	-0.044	-0.050	-0.017	0.016	0.046
BEA 62	-0.028	0.013	0.028	0.004	0.025	0.036	0.035	0.028	0.036	0.055

Table A-1.3. (Cont'd)

	Births					Deaths				
	1950	1954	1960	1964	1969	1950	1954	1960	1964	1969
BEA 63	-0.005	0.024	-0.033	-0.094	-0.009	-0.024	-0.004	-0.011	-0.017	-0.013
BEA 64	-0.062	-0.037	-0.035	-0.077	-0.038	-0.049	-0.019	-0.015	0.017	0.020
BEA 65	-0.078	-0.196	-0.137	-0.122	-0.123	-0.042	-0.074	-0.022	0.005	0.007
BEA 66	-0.118	-0.130	-0.076	-0.131	-0.092	0.037	0.020	0.050	0.049	0.040
BEA 67	-0.077	-0.038	-0.043	-0.162	-0.058	-0.004	-0.006	-0.011	0.015	0.035
BEA 68	-0.039	-0.005	-0.016	-0.060	-0.002	-0.014	0.016	0.011	0.030	0.020
BEA 69	0.155	0.127	0.132	0.093	0.119	-0.116	-0.072	-0.031	0.003	0.013
BEA 70	0.034	0.053	0.023	-0.039	0.042	-0.003	0.017	0.006	-0.004	0.021
BEA 71	-0.009	0.059	0.026	-0.054	0.038	0.023	0.040	0.003	0.028	0.022
BEA 72	0.159	0.142	0.160	0.075	0.113	-0.040	0.017	-0.025	-0.028	0.004
BEA 73	0.149	0.146	0.133	0.030	0.065	-0.045	-0.018	-0.047	-0.026	-0.046
BEA 74	0.036	0.008	0.002	-0.111	-0.044	-0.053	-0.023	-0.063	-0.027	-0.053
BEA 75	0.033	0.079	0.060	0.009	0.082	-0.035	-0.002	-0.059	-0.035	-0.035
BEA 76	0.070	0.055	0.014	-0.039	0.072	-0.040	-0.019	-0.040	-0.007	-0.008
BEA 77	-0.099	-0.060	0.033	0.001	0.022	0.098	0.093	0.077	0.087	0.078
BEA 78	-0.030	-0.090	-0.029	-0.113	-0.099	-0.058	-0.066	-0.065	-0.068	-0.053
BEA 79	0.035	-0.006	0.056	0.015	0.065	-0.048	-0.072	-0.056	-0.027	-0.026
BEA 80	0.049	-0.084	-0.018	-0.062	-0.064	-0.095	-0.151	-0.148	-0.098	-0.118
BEA 81	0.225	0.144	0.222	0.189	0.119	-0.033	-0.090	-0.054	-0.065	-0.059
BEA 82	0.002	0.024	0.073	-0.001	0.075	-0.053	-0.083	-0.059	-0.068	-0.044
BEA 83	0.040	0.028	0.049	-0.091	-0.142	-0.141	-0.099	-0.101	-0.150	-0.096
BEA 84	-0.017	-0.011	0.093	0.018	-0.025	-0.031	-0.025	-0.035	-0.052	-0.063
BEA 85	0.154	0.133	0.198	0.116	0.017	-0.030	-0.037	-0.043	-0.040	-0.081
BEA 86	0.187	0.135	0.232	0.116	0.088	-0.089	-0.103	-0.115	-0.115	-0.114
BEA 87	0.105	0.126	0.133	-0.040	-0.013	-0.011	0.016	-0.005	0.012	-0.008
BEA 88	0.181	0.074	0.109	-0.045	-0.027	-0.076	-0.138	-0.096	-0.077	-0.091
BEA 89	0.133	0.092	0.073	-0.011	-0.018	-0.085	-0.078	-0.094	-0.086	-0.124
BEA 90	0.146	0.062	0.123	0.054	0.044	-0.141	-0.135	-0.139	-0.196	-0.156
BEA 91	0.111	0.046	0.136	0.012	-0.016	-0.113	-0.121	-0.106	-0.092	-0.127
BEA 92	0.273	0.136	0.209	0.191	0.085	-0.092	-0.126	-0.104	-0.120	-0.071
BEA 93	0.358	0.335	0.236	0.311	0.202	-0.114	-0.074	-0.097	-0.035	-0.104
BEA 94	0.275	0.212	0.269	0.213	0.019	-0.018	0.029	0.001	0.032	-0.039
BEA 95	0.222	0.127	0.058	-0.044	-0.017	-0.093	-0.038	-0.072	-0.064	-0.070

Table A-1.3. (Cont'd)

	Births					Deaths				
	1950	1954	1960	1964	1969	1950	1954	1960	1964	1969
BEA 96	0.284	0.237	0.218	0.206	0.073	-0.047	-0.036	-0.093	-0.076	-0.098
BEA 97	0.209	0.126	0.149	-0.016	-0.039	-0.138	-0.147	-0.170	-0.126	-0.192
BEA 98	0.239	0.115	0.136	0.142	0.097	-0.081	-0.127	-0.096	-0.075	-0.115
BEA 99	0.243	0.121	0.152	0.073	-0.010	-0.151	-0.143	-0.139	-0.147	-0.178
BEA 100	0.318	0.321	0.321	0.376	0.231	-0.031	-0.049	0.023	0.000	-0.024
BEA 101	0.173	0.127	0.076	0.021	0.005	-0.146	-0.055	-0.146	-0.085	-0.059
BEA 102	0.142	0.092	0.059	-0.024	0.015	-0.140	-0.123	-0.149	-0.099	-0.141
BEA 103	0.179	0.115	0.123	0.042	0.043	-0.142	-0.125	-0.123	-0.097	-0.080
BEA 104	0.175	0.096	0.127	0.050	0.033	-0.148	-0.140	-0.135	-0.086	-0.117
BEA 105	0.121	0.016	0.085	-0.014	-0.001	-0.141	-0.152	-0.122	-0.093	-0.120
BEA 106	0.012	-0.076	-0.022	-0.120	-0.040	-0.100	-0.098	-0.074	-0.070	-0.087
BEA 107	0.052	0.018	0.109	0.083	0.029	-0.116	-0.082	-0.058	-0.050	-0.094
BEA 108	-0.059	-0.115	0.002	-0.082	-0.174	-0.175	-0.158	-0.140	-0.113	-0.161
BEA 109	0.094	0.102	0.048	0.027	-0.034	-0.168	-0.136	-0.164	-0.145	-0.135
BEA 110	0.222	0.150	0.0	-0.084	0.013	-0.114	-0.069	-0.116	-0.085	-0.077
BEA 111	-0.062	-0.022	0.010	-0.077	-0.038	-0.044	-0.038	-0.059	-0.037	-0.029
BEA 112	-0.097	-0.165	-0.068	-0.156	-0.127	-0.128	-0.133	-0.112	-0.063	-0.036
BEA 113	-0.002	-0.052	-0.027	-0.025	0.009	-0.036	-0.052	-0.039	-0.032	0.022
BEA 114	-0.037	-0.018	0.029	-0.014	-0.003	0.006	0.034	0.004	0.026	0.033
BEA 115	0.044	-0.001	-0.013	-0.010	-0.023	0.016	-0.031	-0.001	0.029	0.054
BEA 116	-0.035	-0.164	-0.091	-0.135	-0.055	-0.099	-0.072	-0.072	-0.053	-0.019
BEA 117	-0.007	-0.099	0.001	0.053	0.014	-0.112	-0.110	-0.059	-0.033	-0.019
BEA 118	0.058	0.005	-0.050	0.157	0.054	-0.169	-0.185	-0.120	-0.049	-0.093
BEA 119	-0.052	-0.113	-0.109	-0.173	-0.071	-0.104	-0.059	-0.086	-0.062	-0.060
BEA 120	-0.029	-0.080	-0.057	-0.063	-0.044	-0.141	-0.101	-0.076	-0.075	-0.055
BEA 121	-0.018	-0.073	0.082	0.061	0.083	-0.172	-0.152	-0.128	-0.090	-0.076
BEA 122	0.069	-0.033	0.050	0.064	0.060	-0.109	-0.147	-0.092	-0.048	-0.050
BEA 123	0.137	0.112	0.117	0.263	0.069	-0.039	-0.128	-0.023	0.026	-0.077
BEA 124	0.158	0.089	0.020	0.011	0.100	0.033	-0.017	-0.063	-0.056	-0.057
BEA 125	-0.022	-0.154	-0.042	-0.016	0.015	-0.139	-0.167	-0.131	-0.098	-0.043
BEA 126	0.115	0.020	0.101	0.063	0.041	-0.096	-0.193	-0.104	-0.131	-0.042
BEA 127	-0.079	-0.063	-0.056	-0.130	0.015	-0.061	-0.062	-0.067	-0.053	-0.001
BEA 128	0.018	0.084	-0.014	0.112	0.069	-0.112	-0.127	-0.073	-0.073	-0.029

Table A-1.3 (Cont'd)

	Births					Deaths				
	1950	1954	1960	1964	1969	1950	1954	1960	1964	1969
BEA 129	0.032	0.025	-0.023	-0.121	-0.064	-0.081	-0.071	-0.093	-0.100	-0.102
BEA 130	-0.037	-0.110	-0.060	-0.109	0.006	-0.079	-0.098	-0.068	-0.066	-0.056
BEA 131	0.043	-0.031	-0.020	0.036	0.104	-0.084	-0.074	-0.048	-0.013	-0.036
BEA 132	0.187	0.126	0.027	0.064	0.185	0.055	0.008	0.036	0.002	0.076
BEA 133	0.242	0.160	0.118	0.151	0.220	0.061	0.013	0.024	0.078	0.094
BEA 134	0.361	0.331	0.305	0.407	0.360	0.157	0.103	0.098	0.160	0.122
BEA 135	0.239	0.103	0.130	0.152	0.170	0.144	0.060	0.090	0.101	0.137
BEA 136	0.216	0.060	0.060	0.103	0.203	0.095	0.054	0.101	0.107	0.119
BEA 137	0.140	0.188	0.155	0.173	0.185	0.110	0.081	0.098	0.071	0.094
BEA 138	0.137	0.107	0.131	0.124	0.108	0.131	0.125	0.168	0.196	0.165
BEA 139	0.195	0.200	0.210	0.180	0.214	0.002	0.017	0.078	0.084	0.086
BEA 140	-0.004	0.006	-0.012	-0.061	-0.019	0.017	-0.043	-0.038	-0.057	-0.001
BEA 141	-0.021	0.028	-0.011	-0.078	0.011	0.013	0.003	0.022	-0.009	0.018
BEA 142	0.237	0.241	0.152	0.153	0.249	0.036	-0.007	-0.056	-0.067	-0.052
BEA 143	0.240	0.364	0.243	0.218	0.417	0.068	0.047	-0.022	-0.036	-0.024
BEA 144	0.747	0.542	0.426	0.377	0.960	0.419	0.255	-0.061	-0.055	-0.123
BEA 145	0.330	0.339	0.341	0.279	0.400	0.117	0.023	0.006	-0.032	-0.036
BEA 146	0.349	0.238	0.299	0.174	0.130	0.217	0.068	0.060	0.031	-0.038
BEA 147	0.148	0.177	-0.017	-0.040	0.113	-0.058	-0.066	-0.102	-0.055	-0.091
BEA 148	0.041	-0.044	-0.001	-0.107	-0.103	-0.095	-0.069	-0.064	-0.058	-0.103
BEA 149	0.186	0.092	0.160	0.003	0.071	0.008	-0.050	-0.026	-0.050	-0.070
BEA 150	0.083	0.141	0.084	0.011	0.016	-0.041	-0.041	-0.023	-0.017	-0.029
BEA 151	0.267	0.170	0.176	0.062	0.188	-0.100	-0.103	-0.116	-0.124	-0.151
BEA 152	0.302	0.231	0.242	0.054	0.195	-0.079	-0.081	-0.123	-0.087	-0.094
BEA 153	0.124	0.158	0.117	0.047	0.014	0.045	0.073	0.020	0.087	-0.012
BEA 154	0.099	0.122	0.026	-0.125	-0.049	-0.087	-0.057	-0.110	-0.055	-0.061
BEA 155	-0.004	-0.050	0.006	-0.153	-0.017	-0.057	-0.049	-0.058	-0.051	-0.041
BEA 156	0.124	0.116	0.004	-0.078	-0.039	-0.122	-0.083	-0.095	-0.089	-0.065
BEA 157	0.028	-0.027	-0.020	-0.181	-0.074	-0.105	-0.073	-0.084	-0.064	-0.079
BEA 158	0.103	0.056	0.008	-0.095	-0.072	-0.097	-0.081	-0.119	-0.116	-0.112
BEA 159	0.129	0.077	0.108	-0.046	0.054	-0.147	-0.144	-0.142	-0.096	-0.137

Table A-1.3. (Cont'd)

	Births					Deaths				
	1950	1954	1960	1964	1969	1950	1954	1960	1964	1969
BEA 160	-0.054	0.054	-0.003	0.047	-0.031	0.074	0.070	0.134	0.132	0.057
BEA 161	0.167	0.216	0.075	0.256	0.105	0.142	-0.002	0.072	0.063	0.019
BEA 162	0.168	0.095	0.179	0.118	0.126	0.114	-0.013	0.008	-0.010	-0.067
BEA 163	0.150	0.080	0.120	0.026	0.035	0.017	-0.010	-0.011	-0.023	-0.090
BEA 164	0.079	0.109	0.084	-0.057	0.010	-0.102	-0.095	-0.079	-0.116	-0.119
BEA 165	-0.087	-0.067	-0.029	-0.034	-0.000	-0.082	-0.064	-0.075	-0.045	-0.061
BEA 166	0.133	0.046	0.069	0.044	0.050	-0.016	-0.046	-0.029	0.003	-0.034
BEA 167	0.085	0.046	0.030	-0.053	0.025	-0.021	-0.039	-0.057	-0.041	-0.046
BEA 168	0.088	-0.007	0.052	-0.029	-0.114	0.032	0.006	-0.027	0.015	-0.024
BEA 169	0.092	0.020	-0.007	0.000	0.014	0.059	0.048	-0.035	0.040	0.005
BEA 170	0.185	0.203	0.091	-0.058	-0.068	0.079	0.043	0.037	0.083	0.019
BEA 171	-0.047	-0.079	-0.027	-0.086	-0.104	-0.039	-0.035	-0.057	-0.043	-0.074
BEA 172	0.096	0.454	0.252	0.491	1.108	-0.207	-0.270	-0.321	-0.209	-0.415
BEA 173	0.254	0.140	0.019	0.247	0.594	-0.501	-0.466	-0.492	-0.464	-0.397

Appendix B

INTERREGIONAL POPULATION MIGRATION

This appendix presents our latest empirical results on the subject of interregional population migration and how it may be related to changing socioeconomic conditions. Age- and sex-specific in- and out-migration rate functions have been estimated with pooled 1960 and 1970 Census data for State Economic Areas but may be used to simulate and forecast population movements between BEA Economic Areas.[1]

B.1 REVIEW OF PAST STUDIES

This survey of past research results is brief and confined to a commentary on the apparently meaningful associations that have been found between measures of population mobility and changes in socioeconomic conditions. Briefness is maintained because more comprehensive reviews of the literature exist.[2]

B.1.1 Two models of migration

Two general analytical models of migration have been used in past research — one in terms of the absolute number of migrants and the other in terms of rates of migration[3] (see Fig. B-1). Studies concerned with population movements between specific geographic regions usually emphasize the absolute number of migrants and try to explain the net or gross flows between paired locations. Generally, some variant of a gravity model is used to standardize for the fact that the absolute number of migrants is closely related to the size (mass) of the individual locations.[4] The second class of models concentrates on rates of migration for much the same reason — to standardize for the size (mass) of the sending body in the case of outmigration and for the size of the receiving body in the case of inmigration.

Each model has its advantages and disadvantages. Model A comes closest to the theoretical model of a rational decision maker considering specific paired alternatives, while Model B can only refer to alternative locations in a very imprecise "all other places but X" sense. Yet, Model B may permit a satisfactory explanation of migratory flows into and out of X without the time consuming examination of all alternative Y's as required by Model A. Furthermore, Model B leads to a probabilistic interpretation of mobility since the migration rate is defined as the number of movers divided by the pool of eligible movers [i.e., Out-Migration Rate(t) = # of Out-Migrants (t)/Population(t)].

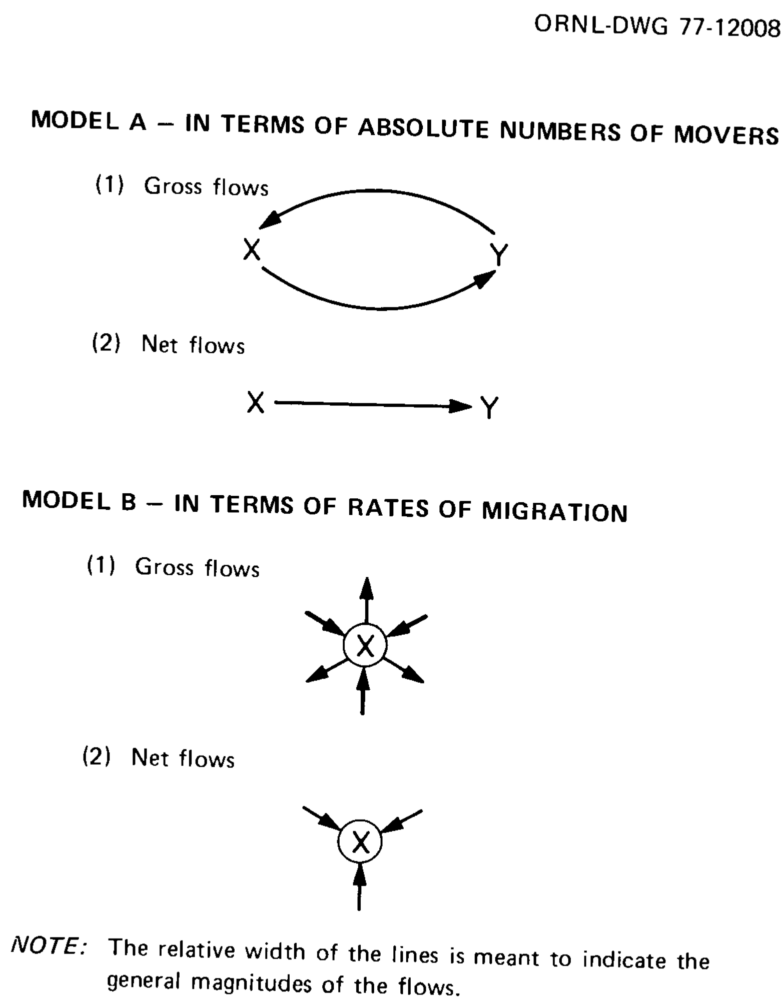


Fig. B-1. Two models of migration.

B.1.2 Basic hypothesis being examined

Sahota has observed after surveying a number of alternative theoretical explanations of systematic migration flows that "not only the consequences but also most of the explanatory variables in these approaches are the same. The differences arise mainly in emphasis and interpretation."[5] An oversimplified distillation of these approaches might read as follows: (1) individuals continuously make subconscious cost-benefit calculations to guide their decision making; (2) they approach the decision to move as they would any other investment in human capital, by estimating the streams over time of benefits and costs (monetary and nonmonetary) of moving to a number of alternative locations; (3) these streams of costs and benefits are then discounted to the present using a discount rate that reflects uncertainty; and (4) the move, if made, will be to that region for which the ratio of the present value of the benefits of moving to the present value of the costs exceeds one by more than that for all alternative destinations.

A few of the corollaries of this general approach or hypothesis are: (1) the young are apt to have generally higher propensities to move since they have a longer stream of benefits to discount and smaller psychic costs of moving; (2) since the costs and uncertainty of moving increase with distance, the amount of migration is apt to decrease with the distance between points; (3) the more educated, having better information about alternatives and perhaps less uncertainty, are more likely to move; and (4) persons having already experienced a move (perhaps even those who have gone away to college or the Armed Forces) have a more certain idea of the costs and benefits involved and are apt to move again.

It should be noted that most of these corollaries involve the characteristics of the potential mover rather than the characteristics of the competing places. It is for this reason that researchers have attempted to standardize for selected characteristics of persons so as to uncover the characteristics of places that determine migratory flows. The major purpose of the analyses has been to answer the question, "Do labor markets work well in allocating a scarce resource, labor, over space?" Unfortunately, since the characteristics of persons and places are highly intercorrelated, the question continues to be posed.

B.1.3 Data available to researchers

Since the nature of the data available puts severe constraints on research strategy, a brief review of data availability may improve the subsequent interpretation of comparative research results. While data range from information about a cross section of individuals, groups, or regions at one point in time to a continuous time-series monitoring of selected variables, it may be helpful to distinguish among the few types of data specifically available for geographic mobility analysis.[6]

First, there are disaggregated cross-section data on the individual and personal characteristics of persons at one point in time including some measurement of recent movements and/or planned movements. The One-in-a-Thousand Sample from the 1960 Census of Population[7] and a sample survey such as that reported by Lansing and Mueller[8] are fine examples of this type of data. While providing much useful information on the respondent's personal characteristics, analytically useful measurements of socioeconomic conditions within the respondent's local geographic area (e.g., the local unemployment rate) are not available from this source.

Second, there are aggregated cross-section data where the unit of observation is the county, state, state economic area, or metropolitan area. The Census of Population compiles the majority of its findings in this fashion. Very useful measurements of general socioeconomic conditions for geographic areas are available from this source, but possible important differences among individuals or small groups of individuals rapidly "wash out" as we aggregate to larger geographic areas.

Third, there are pooled cross-section data that approximate aggregate time-series data. For example, the combined data for the Knoxville SMSA from the 1940, 1950, 1960, and 1970 Censuses of Population form a rough time series. The pooled data set by necessity contains the strengths and weaknesses of the component cross sections with the additional loss of some useful information caused by changing definitions over time.

Fourth, a growing number of longitudinal studies that generate repeated observations over time of the characteristics of the same individuals may prove very useful in reconstructing migration decisions made by individuals over time. The Social Security Administration's Continuous Work History Sample[9] of one in one-hundred social security cardholders is a good example. The most significant shortcoming of these data is the lack of contemporaneous information on socioeconomic conditions.

Finally, there are true aggregate time series data most often unpublished but available for internal use by the telephone company, Internal Revenue Service, state motor vehicle licensing departments, etc. The main disadvantages of these data are their confidential nature, their unprocessed form, and the common lack of complementary and conteporaneous series on social conditions.

B.1.4 Results of previous studies

Given this variety of data and the general definitions of migration (absolute number of movers versus the relative incidence of movement), what are some of the general associations that have been found? In the absence of published results for the U.S. using true time-series data, our discussion is immediately confined to cross-section, pooled cross-section, and longitudinal analyses. Of these, studies based on cross-section data seem to have been most successful in the sense that a large amount of the variation in mobility seems to have been explained. But some confusion remains as to their interpretation. For example, how does one interpret the strong positive relationship between net (in) migration and the change in nonagricultural employment found by Lowry (1966); do new jobs induce inmigration or do inmigrants attract new jobs?[10]

A large portion of the explanatory ability of cross-section analysis is due to the relatively abundant supply of useful, although highly intercorrelated, measurements on possible explanatory variables. While these data may not always match the definitions preferred by the investigator, they are usually close enough to permit standardization for many differences in the socioeconomic environment. Thus, from cross-section analyses we have learned that: (1) the outmigrant "prefers nearby destinations, and prefers destinations with low unemployment rates and high wage rates;"[11] (2) "the highest propensities to migrate are found among young, single adults and among young adult couples with small children;"[11] (3) "there is a tendency for persons to move to more temperate climates and to areas frequently migrated to by earlier movers;"[12] (4) there is a strong positive relationship between schooling and the propensity to migrate;[13] and (5) there is a strong positive correlation between inmigration and the extent of urbanization or population size of the receiving area.[14]

But all of these results are not without some confusion. For example, because of the high intercorrelations among such variables as income, schooling, population size, and the extent of urbanization, the responsiveness of migration to income is especially sensitive to what other variables are simultaneously being considered.[15] Thus, while progress seems to be made, the intrinsic nature of social science research makes us more confident about stating the existence of these relationships than about interpreting some of them.[16]

Perhaps the most thorough cross-section study based on special sample surveys (i.e., not the Census of Population) is that reported by Lansing and Mueller. While special sample surveys are expensive, they do allow the researchers to be more careful about definitions and exactly what data are to be collected and for what purpose. For example, Lansing and Mueller defined mobility to "include only moves across the boundaries of labor market areas as defined by the Department of Labor (generally metropolitan areas)."[17] They stress that their work differed from the Census of Population in that "information about attitudes and motives is obtained here in addition to extensive information about migration history and the socioeconomic characteristics of the people studied."[18] Using standard Survey Research Center procedure, interviews and re-interviews were conducted over the period August 1962 through August 1963 which permitted distinctions about past mobility, present willingness to move, and subsequent moves.

Among the most interesting general observations of Lansing and Mueller are: (1) that their more extensive exploration of reasons for moving "had the effect of increasing the proportion of moves for which an economic reason was given;"[19] (2) while there are sharp declines in mobility with age and education, rational interpretations of these effects are difficult although not impossible; and (3) given the importance of age and education, "unless these variables are somehow taken into account it is difficult to draw conclusions about the importance of other (socioeconomic) characteristics known to be associated either with age or with education or with both."[20] In addition to the importance of age and education, Lansing and Mueller's multivariate analyses, which emphasize the characteristics of persons rather than of places,[21] infer that mobility is related to race, occupation, home ownership, and degree of urbanization.

Studies based on data with a heavy longitudinal emphasis have almost exclusively used the Social Security Administration's Continuous Work History Sample (SWHS). While much of the early work has concentrated on deriving measures of migratory flows from CWHS data and reconciling these measures to those from other sources such as the Census of Population,[22] an important exception has been work done at the Office of Business Economics (now the Bureau of Economic Analysis)[23] as part of a larger regional model building activity.[24]

Since the BEA model will attempt to estimate outmigration and then assign outmigrants to destinations rather than estimate place-to-place flows directly, much attention has been paid to the possibility of using CWHS data to estimate outmigration as a function of local economic conditions. Some early results of this work have been reported by Trott (August 1971). When analyzing outmigration of white males from large BEA economic areas during the period 1963-66, he found consistent, across age cohorts, and significant positive associations between out-migration rates and (1) the ratio of new labor supply to new employment and (2) the percentage change in employment between 1950 and 1960. He also found consistent, across age cohorts, and significant negative associations between out-migration rates and (1) the ratio of employment in BEA area i to employment in the average BEA area and (2) the population to employment ratio (the inverse of a crude labor participation measure). In both instances the first association was to be expected a priori but the second should have been of a positive sign. These early results have been encouraging in that (1) migration data from a new source are being analyzed, (2) geographic areas (BEA economic areas) more meaningful than State Economic Areas are being used as the geographic grid, and (3) much of the variation in outmigration seems to be explained by local and national economic conditions. However, some problems remain: (1) some of the variables, especially growth in employment, enter the relationships with consistently incorrect signs and (2) Trott has confined his list of potential explanatory variables almost exclusively to those that can be constructed from subsets of his employment data. Most of these problems should disappear over time, however, as we gain a better understanding of the nuances of CWHS data and as a greater variety of socioeconomic data are cumulated to BEA economic areas for use as explanatory variables.

To summarize past research results with all sorts of data, we may say that progress has been made in the analysis of geographic mobility. A number of apparently meaningful relationships have been derived that lend support to the contention that the incidence of geographic mobility does vary in understandable ways with changes in the socioeconomic environment. However, our growing understanding of migration has most recently derived from the empirical "deepening" and "broadening" of existing concept rather than from any new theoretical construct.

B.2 RESEARCH METHODS

B.2.1 Census data for State Economic Areas

Our analysis has been confined to cross-section migration data from the 1960 and 1970 Censuses of Population for each of the approximately 510 State Economic Areas (SEA's) because satisfactory data were not available for BEA economic areas. SEA's are relatively homogeneous county or multi-county subdivisions of States. Each Standard Metropolitan Statistical Area (SMSA) or portion thereof within a state is an SEA; the remaining non SMSA portion of each state is subdivided into relatively few homogeneous parts with each part having certain significant characteristics which distinguish it from adjoining areas.[25] In contrast BEA economic areas are also multi-county areas but each includes a metropolitan center surrounded by a more rural fringe. However, experience has shown that the result of SEA migration analysis may be applied to BEA areas as long as the analysis does not distinguish between metropolitan and nonmetropolitan SEA's.

The definition of place of residence was that of the U.S. Census of Population:[26]

> Place of residence at time of census--Each person enumerated was counted as an inhabitant of his usual place of abode, generally the place where he lived and slept. This place was not necessarily the same as his legal residence, voting residence, etc.
>
> In the application of this rule, persons were not always counted as residents of the places where they happened to be found by the census enumerators or received a census questionnaire in the mail. Persons temporarily away from their usual place of residence--in a hospital, in a hotel, visiting another home, abroad on vacation--were allocated to their homes.
>
> Certain groups in the population were allocated to a place of residence according to special rules. Persons in the Armed Forces quartered on military installations in the United States were enumerated as inhabitants of the places where their installations were located; college students as inhabitants of the places where they resided while attending college; crews of U.S. merchant vessels in harbor as inhabitants of the ports where their vessels were berthed; crews of U.S. naval vessels not deployed to an overseas fleet were enumerated as inhabitants of the home port of the vessel; inmates of institutions as inahbitants of the places where the institutions were located; persons without a usual place of residence and persons staying overnight at a mission, flophouse, jail, etc. as inhabitants of the places where they were enumerated.
>
> American citizens abroad for an extended period (in the Armed Forces, working at civilian jobs, studying in foreign universities, etc.) are not included in the population of the United States or any subnational geographic area, but are tallied as the overseas population.

Place of residence in 1965 (1955)[27] was used in conjunction with residence in 1970 (1960) to determine the number of migrants into and out of SEA's during the five-year period. While these data are apt to underestimate the actual number of moves because (1) some persons made more than one move during the five-year period, (2) other persons moved but returned to the same house during the period, and (3) only persons surviving (living) in 1970 could report their moves,[28] they represent our most comprehensive estimates of interregional mobility and were used to compute age- and sex-specific in- and out-migration rates for each SEA. An estimate of 1965 (1955) population by age and sex was used as the basis for 1965-70 (1955-60) gross migration rates.

Table B-2.1 summarizes the variability in migration rates among the SEA's of our sample. One should note the substantial range of variation within and among age/sex cohorts and the greater interregional variation in in-migration as opposed to out-migration rates. It is the variability within age/sex cohorts that we have sought to relate to changing economic conditions. The variability among age/sex cohorts suggests separate treatment of each cohort.

B.2.2 The basic model

As a starting point a simple single-equation model of migration has been postulated where the direction of causation is assumed[29] to run from the independent variables (right side) to the dependent variables (left side), in- or out-migration rates. Symbolically the model is

$$\text{(Model 1)} \quad \begin{aligned} \text{INMIG} &= f(\text{C.PLAC}, \text{C.PERS}, u) \\ \text{OUTMIG} &= g(\text{C.PLAC}, \text{C.PERS}, v) \end{aligned}$$

where INMIG represents the five-year rate of inmigration to a particular State Economic Area (SEA) and OUTMIG represents the five-year rate of outmigration from an SEA. "C.PLAC" represents measures of the characteristics of the place, such as the unemployment rate, while "C.PERS" represents measures of the characteristics of the persons, such as median years of schooling. u and v are random variables that represent the cumulated effects of omitted explanatory variables, measurement errors in INMIG and OUTMIG, and the basic random element in human behavior.

While one might choose to group the explanatory variables in some other way, the distinction between "C.PLAC" and "C.PERS" is useful. In general, the economic theory of migration suggests that a particular C.PLAC measure should be positively correlated with INMIG while negatively correlated with OUTMIG, or vice versa. For example, a high unemployment rate should both raise outmigration and lower inmigration. On the other hand, a particular C.PERS measure should be positively (or negatively) correlated with both OUTMIG and INMIG. For example, a high level of education should raise both outmigration and inmigration.

While it appears appropriate to fit Model I separately to 1960 and 1970 census data for State Economic Areas, the attractiveness of augmenting

Table B-2.1. Variability of SEA migration rates 1960 and 1970 data.

Age Group	Mean ($\bar{x}$)		Standard Deviation (s)		Coefficient of Variation ($s/\bar{x}$)	
	M	F	M	F	M	F
Inmigrants						
5-9	20.0	19.8	9.9	9.8	.495	.495
10-14	16.2	16.0	8.9	8.7	.549	.544
15-19	20.3	20.2	12.5	10.7	.616	.530
20-24	34.4	34.4	18.6	14.8	.541	.430
25-29	30.9	28.8	11.7	11.6	.379	.403
30-34	23.5	20.6	10.2	9.7	.434	.471
35-39	18.5	15.8	9.3	8.5	.503	.538
40-44	14.6	12.4	8.0	7.3	.548	.589
45-54	11.1	10.1	6.7	6.5	.604	.644
55-64	8.6	8.9	6.4	7.1	.744	.798
65+	8.1	8.9	7.1	6.5	.877	.730
Outmigrants						
5-9	19.9	19.8	7.3	7.4	.367	.374
10-14	15.9	15.9	6.1	6.0	.384	.377
15-19	20.6	20.6	6.0	6.7	.291	.325
20-24	41.6	41.5	14.7	15.6	.353	.376
25-29	34.3	30.7	16.1	11.2	.469	.365
30-34	23.8	20.5	8.3	7.0	.349	.341
35-39	18.2	15.8	6.5	6.0	.357	.380
40-44	14.4	12.4	5.5	4.9	.382	.395
45-54	10.8	9.9	4.2	3.9	.389	.394
55-64	7.8	8.2	3.2	3.3	.410	.402
65+	7.3	8.3	2.8	3.0	.384	.361

the variation over space contained in cross-section data with some variation over time has suggested that Model I can be modified to use pooled cross-section data. The revised model is

(Model II) INMIG = f(C.PLAC, C.PERS, Pooled, u)
OUTMIG = g(C.PLAC, C.PERS, Pooled, v)

where the pooled variable is a shift factor which takes on the value 0 for observations during 1960 and the value 1 for observations during 1970. A more complete rationale for this procedure was discussed in Chapter 4.

B.2.3 "Transformed" regression analysis

Early in our attempts to fit and test both Models I and II it became apparent that the Ordinary Least Squares (OLS) Regression Model assumption that u has a constant variance was not being met. The residual variation about our fitted regression line varied systematically with SEA size measured in terms of population. A moment's thought will confirm that this is just what one should expect when using data from samples whose size varies from a low of 1200 to a high of 863,200 as it did in our study area;[30] one can reasonably expect the smaller samples to contain an intrinsically larger variability simply due to sampling error which is known to be reduced in size as the sample size increases.

In these circumstances, the use of a Weighted Least Squares (WLS) Model is more appropriate. However, since it seemed appropriate to weight or transform only those variables subject to sampling error (i.e., resulting from the 15 or 25 percent sample census enumeration procedure), the modified WLS procedure we have used may be best termed a Transformed Least Squares (TLS) model. As a consequence of using the more appropriate TLS instead of the inappropriate OLS: (1) the parameter estimates from the use of our sample of data are different; (2) our estimates of the standard errors of our parameters are unbiased; and (3) as a result of (2), our statistical tests of parameter significance are valid. All of the empirical results discussed below are the result of using the TLS procedure where each observation of only those variables subject to sampling error have been weighted by the $\sqrt{P_i/\Sigma_i P_i}$ where P_i is the population of the i-th SEA;[31] OLS estimates are presented in Tables B-3.14 and B-3.15 in Sect. B.3.4 below but are not discussed.

B.3 EMPIRICAL RESULTS: POOLED CROSS-SECTION RESULTS BY AGE AND SEX

B.3.1 Persons 20 years old and above

Our pooled cross-section analysis of migration was limited to 1960 and 1970 data for twenty-two age/sex cohorts beginning with age 5.[32] We could not study whites and non-whites separately because Census migration data were tabulated by race in 1970 but by color in 1960.[33] Empirical results for persons 20 years old and above are presented in Tables B-3.1 (in-migration) and B-3.4 (out-migration); those for younger age cohorts will be presented in Section B.3.2 below.

Our results include as explanatory variables the national minus local employment pressure index (N-L EPI),[34] median years of school completed by persons 25 years old and over (MS), Armed Forces personnel as a percent of the population (AF), college students as a percent of the population (COL), population density (P.DEN), relative population potential (R.POT - a gravity model measure of potential interregional interaction and accessibility), a dummy variable for climate to identify regions with mild winters and especially frequent sunshine (CLIM), and regional dummy variables for all subregions of the nation (except the Great Lakes) as defined by the U.S. Department of Commerce.[35,36] The regional dummy variables were included at the last stage of the analysis as measures of longer term regional conditions (relative to the Great Lakes = 0) not captured by any of the other explanatory variables. While the classification is not everywhere clear, the reversal of signs between in-migration and out-migration analyses seems to imply that R.POT, P.DEN, N-L EPI, AF, and COL are most frequently measures of "characteristics of place." The remaining variables - MS, CLIM, and regional dummies - behave most frequently as measures of "characteristics of persons." The relative magnitudes of the explanatory variables for SEAs and their range of variation among BEAs is shown in Table B-3.3.

The geographic mobility of at least two groups, Armed Forces personnel and college students, are not likely to respond to economic conditions. Since the relative presence of these two groups varies between State Economic Areas and over time, we have attempted to standardize for their presence by including Armed Forces and college students variables.[37] Both variables enter both in- and out-migration functions with sizable and significant positive coefficients implying that the presence of a college or Armed Forces base substantially raises both in- and out-migration rates. In addition, the presence of a college or Armed Forces base substantially lowers the out-migration rate of persons aged 20 to 24.

A more tangible appreciation of the importance of these and other explanatory variables to the determination of migration rates may be obtained by examining the quantitative effect on migration of reasonable changes in socioeconomic conditions, changes that are well within the ranges of variation among BEA areas. The easiest way to do this is through the use of Beta Coefficients[38] which indicate the percent of a "typical" variation in the dependent variable associated with a "typical" variation in the explanatory variable (in both cases, a "typical" variation is equal to one standard deviation). Thus, Beta coefficients are reported in Tables B-3.2 (in-migration) and B-3.5 (out-migration). They indicate that a representative region experiencing a one standard deviation increase in the presence of Armed Forces personnel should expect (1) a substantial increase in in-migration (Beta = .618, 61.8% of a standard deviation) augmented by a reduction in out-migration (Beta = -.191) for 20 to 24 year old males and (2) a substantial increase in out migration (Beta = .576) partially offset by an increase in in-migration

Table B-3.1. Five-year in-migration rate functions for SEA's: persons 20 years old and over, transformed regression analyses of pooled cross-section data for 1960 and 1970.

										Region (relative to GL = 0)								
	Intercept	CLIM	MS	R.POT	AF	COL	N-L EPI	P.DEN	POOLED	1 NE	2 MA	4 SE	5 PL	6 S W	7 MTN	8 FW	$\bar{R}^2$	F-value (degrees of freedom)
Male - Inmigration																		
20-24 years old	.374	.072	.849	.147	5.405	3.424	-33.475	-.005	-.070	-.173	-.137	-.030	-.035	.131	-.012	.236	.837	346.1
	(7.41)	(3.87)	(13.05)	(.18)	(43.45)	(21.25)	(-8.37)	(-3.90)	(-2.74)	(-3.05)	(-3.01)	(-.73)	(-.72)	(2.36)	(-.17)	(4.13)		(15, 996)
25-29	.175	.080	1.525	2.247	2.016	1.107	-33.419	-.005	.012	-.163	-.146	.131	.017	.192	.211	.415	.738	190.7
	(3.55)	(4.41)	(24.11)	(2.75)	(16.66)	(7.06)	(-8.59)	(-3.59)	(.50)	(-2.95)	(-3.01)	(.79)	(.36)	(3.55)	(3.14)	(7.45)		(15, 996)
30-34	.182	.088	.984	2.079	1.455	.719	-22.716	-.005	-.110	-.075	-.074	.085	.024	.245	.259	.472	.607	105.0
	(3.97)	(5.21)	(16.68)	(2.73)	(12.87)	(4.92)	(-6.26)	(-4.15)	(-4.75)	(-1.45)	(-1.80)	(.54)	(4.86)	(4.86)	(4.15)	(9.09)		(15, 996)
35-39	.152	.088	.753	1.444	1.328	.433	-17.251	-.004	-.109	-.053	-.044	.071	-.044	.206	.219	.421	.553	84.5
	(3.67)	(5.80)	(14.16)	(2.10)	(13.05)	(3.28)	(-5.27)	(-3.84)	(-5.22)	(-1.14)	(-1.19)	(2.12)	(-.102)	(4.53)	(3.88)	(8.98)		(1[illegible] 996)
40-44	.073	.086	.708	1.325	1.015	----	-15.097	-.003	-.075	-.057	.042	-.080	-.019	.186	.191	.397	.518	78.6
	(1.99)	(6.34)	(14.46)	(2.16)	(11.15)		(-5.19)	(-3.34)	(-4.32)	(-1.37)	(-1.27)	(2.69)	(.41)	(4.58)	(3.81)	(9.50)		(14, 997)
45-54	.071	.076	.516	.654	.637	----	-12.251	-.002	-.069	-.044	-.022	.068	-.027	.147	.144	.353	.467	64.2
	(2.26)	(6.58)	(16.66)	(1.25)	(8.22)		(-4.94)	(-2.58)	(-4.67)	(-1.26)	(-.76)	(2.68)	(-.88)	(4.26)	(3.36)	(9.92)		(14, 997)
55-64	.065	.070	.374	-.156	.379	----	-6.958	-.002	-.043	-.003	.025	.052	-.063	.076	.037	.259	.308	33.2
	(1.92)	(7.17)	(11.06)	(-.27)	(4.49)		(-2.58)	(-1.89)	(-2.67)	(-.09)	(.81)	(1.87)	(-1.91)	(2.02)	(.79)	(6.68)		(14, 997)
65 and over	.043	.108	.437	-.592	.440	----	-7.613	-.003	-.039	.020	.065	.034	-.093	.020	-.022	.224	.266	27.2
	(1.05)	(7.11)	(10.74)	(-.86)	(4.33)		(-2.34)	(-2.35)	(-2.03)	(.42)	(1.74)	(1.01)	(-2.34)	(.44)	(-.40)	(4.80)		(14, 997)
Mean Value																		
Unweighted		.813	10.8	.032	1.147	2.607	.031	2.78										
Weighted		.813	.424	.032	.043	.103	.0011	2.78										

Note: t-values are in parentheses

Table B-3.1. (continued)

										Region (relative to GL = 0)								
	Intercept	CLIM	MS	R.POT	AF	COL	N-L EPI	P.DEN	POOLED	1 NE	2 MA	4 SE	5 PL	6 SW	7 MTN	8 FW	$\bar{R}^2$	F- Value (degrees of freedom)
Female - Inmigration																		
20-24 years old	.406	.063	1.097	.508	2.748	3.025	-42.84	-.004	-.039	-.262	-.227	-.042	.044	.114	.074	.318	.768	223.6
	(7.78)	(3.27)	(16.32)	(.59)	(21.38)	(18.17)	(-10.36)	(-2.80)	(-1.49)	(-4.47)	(-4.82)	(-1.01)	(.87)	(1.98)	(1.03)	(5.38)		(15, 996)
25-29	.162	.085	1.248	2.814	1.839	1.090	-27.01	-.006	.015	-.091	-.125	.031	.053	.218	.279	.500	.688	149.8
	(3.28)	(4.66)	(19.66)	(3.44)	(15.16)	(6.94)	(-6.92)	(-4.52)	(.59)	(-1.64)	(-2.82)	(.783)	(1.11)	(4.02)	(4.15)	(8.95)		(15, 996)
30-34	.154	.082	.808	2.009	1.474	.614	-18.65	-.005	-.088	-.046	-.065	.067	.026	.224	.241	.464	.583	95.4
	(3.60)	(5.24)	(14.68)	(2.83)	(14.00)	(4.50)	(-5.51)	(-4.42)	(-4.10)	(-.95)	(-1.68)	(1.93)	(.63)	(4.76)	(4.14)	(9.58)		(15, 996)
35-39	.135	.080	.659	1.420	1.256	.312	-15.73	-.004	-.133	-.054	-.043	.055	.003	.182	.197	.394	.539	79.9
	(3.54)	(5.74)	(13.43)	(2.24)	(13.39)	(2.57)	(-5.21)	(-4.09)	(-6.95)	(-1.26)	(-1.24)	(1.79)	(.09)	(4.36)	(3.99)	(9.12)		(15, 996)
40-44	.071	.077	.599	1.033	.917	-----	-14.544	-.003	-.082	-.047	-.030	.057	-.018	.159	.169	.381	.511	76.4
	(2.13)	(6.28)	(18.19)	(1.86)	(11.14)		(-5.52)	(-3.09)	(-5.22)	(-1.24)	(-.98)	(2.11)	(-.55)	(4.33)	(3.72)	(10.07)		(14, 997)
45-54	.070	.074	.484	.496	.608	-----	-11.864	-.002	-.069	-.044	-.014	.041	-.038	.122	.111	.331	.438	57.2
	(2.24)	(6.40)	(15.53)	(.94)	(7.81)		(-4.76)	(-2.61)	(-4.68)	(-1.23)	(-.51)	(1.63)	(-1.25)	(3.50)	(2.60)	(9.24)		(14, 997)
55-64	.057	.101	.430	-.117	.433	-----	-7.968	-.002	-.049	.002	.034	.036	-.071	.054	.024	.280	.300	31.9
	(1.48)	(7.11)	(11.27)	(-.18)	(4.54)		(-2.61)	(-2.11)	(-2.69)	(.05)	(.96)	(1.14)	(-1.90)	(1.27)	(.46)	(6.39)		(14, 997)
65 and over	.032	.086	.497	.123	.528	-----	-11.782	-.002	-.041	-.016	.045	.041	-.064	.058	.017	.260	.335	37.4
	(.88)	(6.29)	(13.64)	(.20)	(5.80)		(-4.04)	(-2.28)	(-2.36)	(-.38)	(1.37)	(1.37)	(-1.80)	(1.43)	(.34)	(6.21)		(14, 997)

Table B-3.2. Beta coefficients for five-year in-migration rate functions for SEA's: transformed regression analysis of pooled cross-section data.

									Region (relative to GL = 0)						
	CLIM	MS	R.POT	AF	COL	N-L EPI	P.DEN	POOLED	1 NE	2 MA	4 SE	5 PL	6 SW	7 MTN	8 FW
Male - Inmigration															
20-24 years old	.065	.254	.004	.618	.411	-.120	-.057	-.040	-.044	-.050	-.016	-.014	.047	-.003	.074
25-29	.094	.594	.086	.300	.173	-.156	-.071	.009	-.053	-.069	.022	.009	.089	.068	.170
30-34	.137	.503	.105	.284	.147	-.139	-.094	-.109	-.032	-.046	.078	.016	.149	.110	.253
35-39	.162	.455	.086	.307	.105	-.125	-.092	-.128	-.027	-.032	.077	-.003	.148	.109	.267
40-44	.184	.497	.092	.272		-.127	-.083	-.102	-.034	-.036	.101	-.013	.155	.111	.292
45-54	.201	.448	.056	.211		-.127	-.068	-.116	-.032	-.023	.106	-.030	.152	.103	.321
55-64	.249	.338	-.014	.131		-.076	-.057	-.075	-.002	.027	.084	-.074	.082	.027	.246
65 and over	.254	.339	-.045	.130		-.091	-.072	-.059	.013	.061	.047	-.093	.018	-.014	.182

Table B-3.2. (continued)

									Region (relative to GL = 0)						
	CLIM	MS	R.POT	AF	COL	N-L EPI	P.DEN	POOLED	1 NE	2 MA	4 SE	5 PL	6 SW	7 MTN	8 FW
Female - Inmigration															
20-24 years old	.066	.379	.017	.362	.419	-.177	-.049	-.026	-.076	-.095	-.026	.020	.047	.021	.115
25-29	.109	.528	.117	.298	.185	-.137	-.091	.012	-.032	-.064	.024	.029	.110	.098	.222
30-34	.141	.456	.112	.318	.139	-.126	-.103	-.097	-.022	-.044	.067	.019	.150	.112	.275
35-39	.163	.439	.093	.320	.083	-.125	-.100	-.172	-.030	-.034	.066	.033	.145	.109	.275
40-44	.184	.468	.080	.274		-.136	-.078	-.124	-.031	-.028	.080	-.018	.148	.109	.312
45-54	.200	.428	.043	.206		-.126	-.070	-.119	-.033	-.015	.066	-.044	.128	.082	.307
55-64	.249	.347	-.009	.134		-.077	-.063	-.077	.001	.033	.051	-.074	.052	.016	.237
65 and over	.214	.409	.010	.166		-.166	-.067	-.065	-.011	.045	.060	-.068	.057	.012	.225

Table B-3.3. The relative magnitudes of the explanatory variables for SEA's and their range of variation among BEA areas.

Variable	SEA Mean Value: Data Set	SEA Mean Value: Transformed Regression Analysis	Variation among BEA Areas — 1970: High	Variation among BEA Areas — 1970: Low
CLIM	.813	.813	3	0
AF	1.147	.043	10.46	0.01
COL	2.607	.103	9.87	0.57
MS	10.8	.424	12.5	9.5
R.POT	.032	.032	.123	.001
P.DEN	2.78	2.78	18.31	.04
EPI	-----	-----	.691	.481
N-L EPI	.031	.0011	-.058	.152
INMIG 20-24 (M)	34.36	1.291		
INMIG 25-29 (M)	30.94	1.164		
INMIG 30-34 (M)	23.51	.873		
OUTMIG 20-24 (M)	41.57	1.504		
OUTMIG 25-29 (M)	34.32	1.245		
OUTMIG 30-34 (M)	23.81	.878		

Table B-3.4. Five-year out-migration rate functions for SEA's: persons 20 years old and over, transformed regression analysis of pooled cross-section data for 1960 and 1970.

	Intercept	CLIM	MS	R.POT	AF	COL	N-L EPI	P.DEN	POOLED	Region (relative to GL = 0): 1 NE	2 MA	4 SE	5 PL	6 SW	7 MTN	8 FW	$\bar{R}^2$	F-value (degrees in freedom)
Male - Outmigration																		
20-24 years old	.621	.004	2.441	-1.97	-1.213	-2.075	7.261	-.005	.324	-.113	-.033	-.071	.225	.120	.040	.064	.640	120.8
	(11.40)	(.21)	(34.89)	(-2.18)	(-9.06)	(-11.97)	(1.69)	(-3.18)	(11.86)	(-1.85)	(-.68)	(-1.63)	(4.31)	(2.01)	(.54)	(1.04)		(15, 996)
25-29	.643	.024	.411	-2.77	3.738	2.849	7.000	.004	.012	-.087	-.048	-.011	.098	.208	.002	-.046	.784	245.9
	(14.92)	(1.53)	(7.41)	(-3.87)	(35.24)	(20.74)	(2.05)	(3.36)	(.53)	(-1.79)	(-1.24)	(-.32)	(2.36)	(4.40)	(.03)	(-.94)		(15, 996)
30-34	.401	.026	.788	-1.543	1.432	1.129	-6.994	.008	-.129	-.121	-.091	.231	.092	.224	.126	.140	.819	305.5
	(15.65)	(2.80)	(23.91)	(-3.63)	(22.73)	(13.83)	(-3.45)	(11.40)	(-10.01)	(-4.24)	(-3.95)	(1.12)	(3.73)	(8.04)	(3.60)	(4.83)		(15, 996)
35-39	.288	.026	.782	-1.163	1.038	.393	-10.170	.006	-.113	-.103	-.070	.013	.060	.181	.113	.161	.790	254.5
	(12.95)	(3.17)	(27.33)	(-3.15)	(18.96)	(5.55)	(-5.78)	(10.09)	(-10.07)	(-4.12)	(-3.51)	(.75)	(2.82)	(7.42)	(3.72)	(6.38)		(15, 996)
40-44	.195	.017	.694	-.618	.945	------	-7.524	.005	-.073	-.101	-.067	.028	.044	.175	.128	.186	.786	265.8
	(10.73)	(2.54)	(38.47)	(-2.03)	(20.94)		(-5.21)	(9.09)	(-8.46)	(-4.89)	(-4.08)	(1.89)	(2.50)	(8.70)	(5.13)	(8.98)		(14, 997)
45-54	.148	.012	.525	-.442	.460	------	-5.723	.003	-.068	-.074	-.049	.028	.036	.157	.124	.196	.740	206.2
	(9.84)	(2.23)	(35.06)	(-1.75)	(12.30)		(-4.78)	(7.22)	(-9.51)	(-4.33)	(-3.60)	(2.28)	(2.43)	(9.39)	(5.98)	(11.40)		(14, 997)
55-64	.069	.006	.466	.078	.188	------	-5.561	.003	-.061	-.068	-.045	.032	.022	.137	.088	.187	.760	230.0
	(5.69)	(1.41)	(38.67)	(.39)	(6.25)		(-5.77)	(8.81)	(-10.65)	(-4.92)	(-4.12)	(3.25)	(1.86)	(10.22)	(5.31)	(13.58)		(14, 997)
65 and over	.008	-.003	.646	.495	.137	------	-7.144	.004	-.061	-.074	-.057	-.000	.005	.088	.058	.138	.834	362.5
	(.64)	(-.72)	(51.93)	(2.36)	(4.40)		(-7.18)	(11.38)	(-10.30)	(-5.15)	(-5.03)	(-.00)	(.41)	(6.37)	(3.40)	(9.63)		(14, 997)

Table B-3.4. (continued)

	Intercept	CLIM	MS	R.POT	AF	COL	N-L EPI	P.DEN	POOLED	Region (relative to GL = 0): 1 NE	2 MA	4 SE	5 PL	6 SW	7 MTN	8 FW	$\bar{R}^2$	F-value (degrees of freedom)
Female - Outmigration																		
20-24 years old	.897	.006	1.45	-3.235	-.158	-.965	14.304	-.004	.280	-.127	-.084	-.116	.310	.101	.042	.109	.447	55 5
	(15.99)	(.27)	(20.11)	(-3.47)	(-1.14)	(-5.40)	(3.22)	(-2.66)	(9.92)	(-2.02)	(-1.67)	(-2.58)	(5.74)	(1.64)	(.55)	(1.72)		(15, 996)
25-29	.559	.020	.570	-2.030	1.553	2.611	-2.556	.005	-.016	-.092	-.070	-.010	.132	.195	.056	.051	.819	305.1
	(18.38)	(1.75)	(14.57)	(-4.02)	(20.77)	(26.96)	(-1.06)	(6.62)	(-1.07)	(-2.71)	(-2.56)	(-.42)	(4.52)	(5.86)	(1.35)	(1.48)		(15, 996)
30-34	.330	.023	.757	-1.120	1.166	.727	-8.383	.006	-.100	-.114	-.087	.012	.087	.199	.121	.166	.813	294.4
	(14.78)	(2.81)	(26.35)	(-3.02)	(21.23)	(10.22)	(-4.75)	(10.27)	(-8.94)	(-4.55)	(-4.32)	(.69)	(4.06)	(8.13)	(3.99)	(6.58)		(15, 996)
35-39	.283	.015	.657	-.953	1.050	.216	-8.663	.004	-.124	-.102	-.060	.002	.057	.159	.101	.162	.785	246.9
	(14.73)	(2.07)	(26.59)	(-2.99)	(22.22)	(3.52)	(-5.70)	(8.12)	(-12.88)	(-4.73)	(-3.49)	(.14)	(3.09)	(7.54)	(3.89)	(7.44)		(15, 996)
40-44	.187	.012	.567	-.478	.677	-----	-5.711	.003	-.079	-.077	-.048	.020	.054	.172	.126	.196	.756	224.8
	(11.59)	(2.06)	(35.49)	(-1.77)	(16.94)		(-4.47)	(6.59)	(-10.37)	(-4.25)	(-3.31)	(1.55)	(3.45)	(9.67)	(5.70)	(10.68)		(14, 997)
45-54	.151	.008	.465	-.244	.384	-----	-4.855	.003	-.073	-.072	-.048	.012	.034	.142	.112	.195	.742	202.2
	(11.17)	(1.66)	(34.72)	(-1.08)	(11.46)		(-4.53)	(6.81)	(-11.40)	(-4.72)	(-3.89)	(1.08)	(2.62)	(9.49)	(6.05)	(12.70)		(14, 997)
55-64	.083	.002	.523	.059	.186	-----	-5.095	.003	-.070	-.081	-.048	.009	.017	.115	.080	.170	.782	259.7
	(6.68)	(.45)	(42.23)	(.28)	(6.01)		(-5.15)	(9.53)	(-11.88)	(-5.70)	(-4.24)	(.92)	(1.38)	(8.37)	(4.66)	(11.98)		(14, 997)
65 and over	.069	-.002	.568	.081	.168	-----	-6.40	.004	-.051	-.062	-.033	.004	.014	.084	.054	.140	.805	299.6
	(5.60)	(-.44)	(46.41)	(.39)	(5.48)		(-6.54)	(11.75)	(-8.69)	(-4.43)	(-2.96)	(.40)	(1.16)	(6.17)	(3.22)	(9.96)		(14, 997)

Table B-3.5. Beta coefficients for five-year out-migration rate functions for SEA's: transformed regression analysis of pooled cross-section data.

	CLIM	MS	R.POT	AF	COL	N-L EPI	P.DEN	POOLED	Region (relative to GL = 0) 1 NE	2 MA	4 SE	5 PL	6 SW	7 MTN	8 FW
Male - Outmigration															
20-24 years old	.005	1.007	-.080	-.191	-.343	.036	-.069	.260	-.039	-.017	-.053	.120	.059	.014	.028
25-29	.030	.166	-.110	.576	.460	.034	.056	.009	-.029	-.024	-.008	.051	.100	.001	-.019
30-34	.050	.490	-.095	.340	.281	-.052	.175	-.156	-.064	-.069	.026	.074	.167	.065	.091
35-39	.061	.603	-.088	.306	.122	-.094	.167	-.169	-.067	-.066	.019	.060	.166	.072	.130
40-44	.049	.655	-.058	.341		-.085	.152	-.133	-.080	-.077	.047	.054	.197	.100	.184
45-54	.048	.658	-.055	.221		-.086	.133	-.165	-.078	-.075	.063	.058	.234	.128	.258
55-64	.029	.697	.012	.108		-.100	.155	-.177	-.085	-.082	.086	.042	.245	.109	.294
65 and over	-.012	.780	.058	.063		-.103	.167	-.143	-.074	-.084	0.0	.008	.127	.058	.174

Table B-3.5. (continued)

	CLIM	MS	R.POT	AF	COL	N-L EPI	P.DEN	POOLED	Region (relative to GL = 0) 1 NE	2 MA	4 SE	5 PL	6 SW	7 MTN	8 FW
Female -Outmigration															
20-24 years old	.008	.719	-.158	-.030	-.192	.085	-.071	.269	-.053	-.051	-.104	.199	.060	.017	.057
25-29	.031	.299	-.105	.311	.549	-.016	.102	-.017	-.041	-.044	-.010	.090	.122	.024	.028
30-34	.051	.548	-.080	.323	.211	-.073	.160	-.141	-.070	-.076	.016	.082	.172	.073	.127
35-39	.040	.593	-.085	.362	.078	-.094	.136	-.218	-.078	-.066	.003	.067	.191	.076	.154
40-44	.042	.645	-.054	.294		-.078	.117	-.174	-.074	-.067	.041	.079	.233	.118	.234
45-54	.035	.648	-.034	.204		-.081	.124	-.197	-.085	-.080	.030	.062	.235	.129	.286
55-64	.009	.726	.008	.099		-.085	.160	-.189	-.094	-.081	.023	.030	.191	.091	.248
65 and over	-.008	.754	.011	.085		-.102	.187	-.130	-.069	-.053	.010	.024	.133	.060	.195

(Beta = .300) for 25 to 29 year old males. Similarly, a representative region experiencing a one standard deviation increase in college presence might expect (1) a substantial increase in in-migration (Beta = .411) augmented by a reduction in out-migration (Beta =-.343) for 20 to 24 year old males and (2) an increase in out-migration (Beta = .460) offset to a lesser extent by an increase in in-migration (Beta = .173) for 25 to 29 year old males. Thus, taken together the AF and COL variables seem to capture the very large and mostly unidirectional five-year flow of 20 to 24 year olds toward Armed Forces bases and toward college campuses as well as the smaller and less directed five-year flow of 25 to 29 year olds away from these same institutions. For persons 30 years old and above the effects are more modest, raising both in- and out-migration about equally, and decline with age.

Since there has been extensive discussion of how education raises mobility, we have on previous occasions[39] examined three alternative measures of education: (1) median years of school completed by those 25 years old and over, (2) percent of the population 25 years old and over with some college, and (3) an index of male skills.[40] However, in the present analysis we have only considered median years of school completed (MS) as our education variable. MS is clearly a "characteristic of persons" variable as its coefficients are uniformly positive and statistically significant for both in- and out-migration for all age and sex cohorts. Furthermore, the strength of the relationship is quite balanced between in- and out-migration while generally declining with age. However, some of the exceptions for persons 20 to 29 years old are worth noting. For example, a representative region whose MS level is assumed to increase by one standard deviation might expect (1) a greater increase in out-migration (Beta = 1.007) than in-migration (Beta = .254) for males 20-24 years old, (2) a greater increase in in-migration (Beta = .594) than out-migration (Beta = .166) for males 25-29 years old, and (3) a more balanced increase in both (Beta = .503 in, Beta = .490 out) for males 30-34 years old. However, in all cases, including these exceptions, gross migration is increased by higher median schooling.

Since significant portions of recent population movements to the West, Southwest and South might reflect the pursuit of a more temperate climate and favorable living conditions rather than better economic opportunities, most migration analyses try to standardize for climate. We have introduced a simple climate variable (CLIM) to identify regions with relatively mild winters and abundant sunshine. CLIM is a compound dummy variable formed by summing two integer measures, mild winters and frequent sunshine,[41] for each region with the result that it has an integer range of variation from 0 for cold overcast SEAs to 3 for especially mild and sunny SEAs. CLIM has proved to be a statistically significant explanatory variable for both in- and out-migration; the effect of mild winters and abundant sunshine is stronger for in-migration than for out-migration but positive and significant for both. The positive association with out-migration while somewhat unexpected may suggest the following hypothesis: many persons of all ages move in the pursuit of a mild climate but some later find the climate to be not as favorable or not as important as they may have originally expected with the result that they move again. Contrasting two representative regions that are alike except for climate, we might expect the region where CLIM = 2 rather than 1 to experience 7% more in-migration of 25 to 29 year old males and 2% more out-migration of the same group.[42] In sum, mild sunny climates do promote net in-migration by stimulating gross in-migration more than gross out-migration.

The employment pressure index (EPI) remains our preferred measure of labor market tightness. It enters the migration analysis in the form of the difference between its national and local values (N-L EPI); the national value of EPI acts as a proxy for labor market conditions in alternative regions. The coefficients of the N-L EPI variable are negative and very significantly different from zero for in-migration as one would expect a priori; where employment conditions are better locally than at the alternatives, in-migration is promoted. Similarly, the N-L EPI coefficients are positive and significant in the out-migration equations for persons aged 20 to 29; tight local labor market conditions retard the out-migration of these persons, reinforcing the labor market equilibrating forces found for in-migration. Unfortunately, however, the N-L EPI coefficients are negative and significant in the out-migration equations for persons aged 30 and above, partically offsetting the labor market equilibrating forces found for in-migration. In sum, when in-migration and out-migration functions are taken together, tight local labor market conditions promote net in-migration, the effect being strongest for persons 20-29 years old and declining with age.[43]

Because it examined paired alternative locations, one of the advantages of the analytical migration Model A as described in section B.1.1 (above) was the explicit opportunity to include a measure of the distance between X and Y to represent the costs and risks of moving, the extent of knowledge about alternatives, etc; in general the closer are X and Y, *ceterus paribus*, the greater are the opportunities for interaction (migration). Our present study appears to mark one of the first times such a measure of potential interaction has been meaningfully included in an empirical representation of Model B.[44] By combining the familiar gravity-potential model with measures of motor vehicle operating times between cities that were sensitive to improvements in road conditions (i.e., the gradual completion of the interstate highway system) and transport technology, estimates of the population potential of each SEA were derived for 1955 and 1965.[45] These estimates were then converted to relative population potentials (R.POT) by dividing by the appropriate total U.S. population; the result is a measure of the share of the nation's population that was accessible to each SEA by highway transportation.

The statistically significant coefficients of the relative population potential (R.POT) variable are positive for in-migration and negative for out-migration implying that movers have a strong preference for regions with high interregional accessibility (not necessarily high population density) perhaps for the greater freedom of choice and lower risk they offer. In both cases, the effect diminishes with age. For example, a representative region experiencing a one standard deviation increase in R.POT might expect an increase in in-migration for 25 to 34 year old males (Beta ≈ .095) reinforced by a comparable decrease in out-migration (Beta ≈ -.105); combined, these migration responses are among the strongest we have estimated. This requires that the notion of "characteristics of place" be expanded to include location relative to other places. Combining this concept with an explicit measure of population density can yield a substantial "deepening" of our understanding of recent rural to urban and metropolitan to metropolitan population movements.

Thus, let us turn to population density (P.DEN), a strong characteristics of place measure. P.DEN has a negative influence on in-migration and a positive influence on out-migration (except for 20-24 year olds). The negative association with the out-migration of 20-24 year olds probably represents the rural to urban movement of younger persons during past decades. Taken together R.POT and P.DEN seem to indicate that movers prefer, *ceterus paribus*, less densely populated destinations with high interregional accessibility. This preference is not inconsistent with increasing suburbanization and the growing suburb to suburb dominance of intermetropolitan migrations.[46]

The pooled variable (1960 = 0, 1970 = 1) was included to capture any time trend that remained after including all previously mentioned variables. Somewhat surprisingly, most coefficients were significantly different from zero and <u>negative</u>. The negative sign implies that after adjusting for changes in <u>all of</u> the variables considered, there has been a decline over time in the propensity to migrate. An important exception, however, is the positive trend for 20-24 year old out-migrants; apparently young persons have been becoming substantially more mobile during the last decade and for reasons not completely picked up by such variables as COL, AF, and EPI.

In the last stage of our analysis regional dummy variables were included to capture the effects of longer-term regional conditions (relative to the Great Lakes = 0) not captured by any of the other explanatory variables. Since the regional dummy variables had only limited intercorrelations with the previously included explanatory variables,[47] their significance was generally not at the cost of other variables. Relative to the Great Lakes region (1) the Far West, Southwest, Mountain, and Southeast regions have higher in-migration rates, (2) the Middle Atlantic and New England regions have lower in-migration rates, (3) the Far West, Southwest, Mountain, Plains, and Southeast regions have higher out-migration rates, and (4) the New England and Middle Atlantic regions have lower out-migration rates. Given these results, would it be appropriate to conclude that these longer-term regional conditions reflect cultural differences among the Northeast, industrialized Midwest, and the rest of the nation?

B.3.2 Younger age groups

Basically, the in- and out-migration rates of each early age group have been regressed on the in and out rates, respectively, of their female parents' age groups.[48] In addition, since a large portion of the 18 and 19 year olds are apt to move independently of their parents, the regression for the 15-19 age group includes the Armed Forces, college students, R.POT, and the migration rates of the appropriate 20-24 age and sex group as explanatory variables. These empirical results are presented in Tables B-3.6, B-3.7, and B-3.8.

Generally, the results include the positive association between the movement of parents and children than one would expect a priori although perhaps not as neatly and consistently as one might wish. Most of the occasional negative associations tended to be insignificantly different from zero. The movements of the 15-19 age group showed the least consistent associations with the movements of parents but were very meaningfully correlated with the Armed Forces and college students variables.

The signs of the Armed Forces and college students variables consistently change between in- and out-migration functions for the oldest teenage group. This switching of signs is the result of the older teenager's migratory flow having been unidirectional toward Armed Forces bases and toward college campuses. Furthermore, even for older teenagers who were not college students themselves, the presence of a college campus probably made a SEA more stimulating and, therefore, acted to reduce out-migration and increase in-migration.

B.3.3 A simple Chow test: Is pooling appropriate?

While it does not completely resolve the issue, we have performed a simple Chow test[49] to determine if the two subsets (cross-section estimates) could have been drawn from the same population. Thus, the null hypothesis is that the coefficients from the two cross-sections are not significantly different,

$$H_0: \beta_i^{60} = \beta_i^{70}$$

and the alternative hypothesis is that at least one of the coefficients is significantly different,

$$H_1: \beta_i^{60} \neq \beta_i^{70}.$$

The test does not resolve the issue of the appropriateness of pooling cross-sections because a slightly revised model including selected slope interactive dummy variables would reverse the results in the case where only a few coefficients were significantly different between the subsets (cross-sections).

The results of these simple Chow tests applied to the above described migration rate functions are found in Table B-3.9. The results simply suggest that there are some age groups for which pooling may not be appropriate - that at least one of the coefficients is slightly different. Since we have been unable to test this hypothesis more completely

Table B-3.6. Five-year in-migration rate functions for SEA's: younger age groups, transformed regression analyses of pooled cross-section data for 1960 and 1970.

	Intercept	Males in 20-24	Females in 20-24	Females in 25-29	Females in 30-34	Females in 35-39	Females in 40-44	Females in 45-54	Females in 55-64	AF	COL	R.POT	POOLED	Region (relative to GL = 0) 1 NE	2 MA	4 SE	5 PL	6 SW	7 MTN	8 FW	$\bar{R}^2$	F-value (degrees of freedom)
Male - Inmigration																						
5-9 years old	.064	-----	-----	.098	.369	.495	.295	-.189	-----	-----	-----	-----	-.073	-.031	-.026	-.050	-.019	-.036	-.038	.016	.977	3229
	(8.98)			(6.16)	(9.35)	(11.35)	(5.65)	(-4.98)					(-13.43)	(-2.72)	(-2.95)	(-7.14)	(-2.33)	(-3.97)	(-3.25)	(1.53)		(13, 998)
10-14	.002	-----	-----	-----	.196	.478	.367	.059	-----	-----	-----	-----	-.006	-.020	-.023	-.031	-.011	-.019	-.021	.028	.977	3599
	(.25)				(8.10)	(12.68)	(8.01)	(1.79)					(-1.24)	(-1.99)	(-2.95)	(-5.15)	(-1.52)	(-2.40)	(-2.08)	(3.04)		(12, 999)
15-19	.114	.304	-----	-----	-----	.347	.126	-.197	.269	1.05	.581	-.085	-.117	-.076	-.030	-.060	-.056	-.087	-.062	-.051	.886	483
	(4.23)	(12.81)				(3.71)	(.91)	(-1.176)	(3.45)	(8.82)	(5.30)	(-1.55)	(-8.16)	(-2.47)	(-1.22)	(-2.72)	(-2.12)	(-2.94)	(-1.61)	(-1.51)		(16, 995)
Female - Outmigration																						
5-9 years old	.053	-----	-----	.126	.338	.466	.303	-.175	-----	-----	-----	-----	-.072	-.026	-.020	-.044	-.015	-.027	-.029	.031	.977	3263
	(7.47)			(8.04)	(8.64)	(10.77)	(5.84)	(-4.65)					(-13.24)	(-2.23)	(-2.28)	(-6.30)	(-1.76)	(-3.00)	(-2.52)	(2.94)		(13, 998)
10-14	-.005	-----	-----	-----	.241	.394	.359	.107	-----	-----	-----	-----	-.005	-.015	-.021	-.033	-.007	-.032	-.017	.025	.977	3499
	(-.80)				(9.89)	(10.36)	(7.75)	(3.23)					(-1.11)	(-1.50)	(-2.76)	(-5.40)	(-.89)	(-4.05)	(-1.64)	(2.67)		(12, 999)
15-19	.086	-----	.394	-----	-----	.260	.025	-.003	.147	-.108	.476	-.043	-.110	-.013	.012	-.009	-.036	.026	-.039	-.027	.916	681
	(4.44)		(19.54)			(3.86)	(.25)	(-.03)	(2.57)	(-1.93)	(5.82)	(-3.00)	(-10.60)	(-.60)	(.68)	(-.54)	(-1.92)	(-1.18)	(-1.42)	(-1.13)		(16, 995)

Table B-3.7. Five-year out-migration rate functions for SEA's: younger age groups, transformed regression analyses of pooled cross-section data for 1960 and 1970.

	Intercept	Males out 20-24	Females out 20-24	Females out 25-29	Females out 30-34	Females out 35-39	Females out 40-44	Females out 45-54	Females out 55-64	AF	COL	R.POT	POOLED	Region (relative to GL = 0) 1 NE	2 MA	4 SE	5 PL	6 SW	7 MTN	8 FW	$\bar{R}^2$	F-value (degrees of freedom)
Male - Outmigration																						
5-9 years old	.003	-----	-----	.039	.393	.602	.209	-.044	-----	-----	-----	-----	-.044	-.005	-.009	-.031	-.012	-.032	-.023	.007	.962	1941
	(.42)			(3.18)	(12.23)	(14.77)	(3.86)	(-.89)					(-7.79)	(-.41)	(-1.00)	(-4.42)	(-1.44)	(-3.46)	(-1.93)	(.65)		(13, 998)
10-14	-.039	-----	-----	-----	.163	.493	.333	.217	-----	-----	-----	-----	.009	-.003	-.010	-.022	-.010	-.021	-.034	-.009	.964	2200
	(-6.10)				(7.66)	(14.72)	(7.53)	(5.32)					(2.06)	(-.34)	(-1.40)	(-3.78)	(-1.47)	(-2.77)	(-3.42)	(-.97)		(12, 999)
15-19	-.044	.160	-----	-----	-----	.437	.321	.088	.722	-.803	-.367	.560	-.013	.040	.026	-.024	-.005	-.093	-.049	-.099	.910	629
	(-2.43)	(18.75)				(8.02)	(3.80)	(.89)	(10.89)	(-16.07)	(-7.41)	(2.11)	(-1.28)	(2.18)	(1.76)	(-1.82)	(-.31)	(-5.11)	(-2.14)	(-4.86)		(16, 995)
Female - Outmigration																						
5-9 years old	.003	-----	-----	.034	.409	.579	.203	-.046	-----	-----	-----	-----	-.040	.004	-.008	-.027	-.007	-.020	-.010	.026	.966	2210
	(.47)			(2.98)	(13.72)	(15.29)	(4.03)	(-1.00)					(-7.67)	(.33)	(-1.01)	(-4.13)	(-.83)	(-2.32)	(-.87)	(2.58)		(13, 998)
10-14	-.026	-----	-----	-----	.170	.500	.274	.211	-----	------	-----	-----	.010	-.008	-.012	-.019	-.007	-.022	-.028	.009	.968	2529
	(-4.51)				(8.82)	(16.48)	(6.81)	(5.72)					(2.70)	(-.89)	(-1.84)	(-3.75)	(-1.11)	(-3.17)	(-3.16)	(1.08)		(12, 999)
15-19	-.052	-----	.241	-----	-----	.081	.403	.269	.509	-.122	-.517	.615	.002	.027	-.008	.022	.011	-.023	.003	-.041	.924	751
	(-3.62)		(33.82)			(1.95)	(6.27)	(3.53)	(10.34)	(-3.32)	(-13.76)	(3.02)	(.34)	(1.94)	(-.67)	(2.14)	(.90)	(-1.64)	(.17)	(-2.67)		(16, 995)

Table B-3.8. Beta coefficients for younger age group migration rate functions for SEA's: transformed regression analyses of pooled cross-section data

	Males	Females											Region (relative to GL = 0)						
	20-24	20-24	25-29	30-34	35-39	40-44	45-54	55-64	AF	COL	R.POT	POOLED	1 NE	2 MA	4 SE	5 PL	6 SW	7 MTN	8 FW
Male - Inmigration	Males in	Females in																	
5-9 years old	----	----	.127	.359	.408	.207	-.117	----	----	----	----	-.078	-.015	-.017	-.049	-.014	-.024	-.017	.009
10-14	----	----	----	.214	.442	.289	.041	----	----	----	----	-.007	-.010	-.017	-.034	-.009	-.014	-.011	.018
15-19	.469	----	----	----	.241	.074	-.103	.154	.186	.108	-.031	-.105	-.030	-.017	-.050	-.033	-.048	-.024	-.025
Female - Inmigration																			
5-9	----	----	.164	.330	.385	.213	-.109	----	----	----	----	-.077	-.012	-.013	-.043	-.010	-.018	-.013	.018
10-14	----	----	----	.265	.366	.284	.075	----	----	----	----	-.006	-.008	-.016	-.036	-.005	-.024	-.009	.016
15-19	----	.630	----	----	.216	.018	-.002	.100	-.023	.105	-.051	-.118	-.006	.008	-.009	-.026	-.017	-.018	-.016
Male - Outmigration	Males out	Females out																	
5-9	----	----	.051	.373	.459	.126	-.022	----	----	----	----	.059	-.003	-.007	-.038	-.011	-.026	-.013	.005
10-14	----	----	----	.184	.448	.241	.128	----	----	----	----	.014	-.002	-.010	-.032	-.011	-.021	-.023	-.007
15-19	.264	----	----	----	.330	.192	.043	.354	-.209	-.100	.038	-.017	.023	.022	-.029	-.004	-.076	-.028	-.071
Female - Outmigration																			
5-9	----	----	.045	.393	.446	.124	-.023	----	----	----	----	-.054	.002	-.007	-.033	-.006	-.017	-.006	.019
10-14	----	----	----	.199	.469	.203	.128	----	----	----	----	.017	-.006	-.013	-.029	-.008	-.022	-.020	.008
15-19	----	.400	----	----	.074	.292	.159	.302	-.038	-.171	.050	-.004	.190	-.008	.032	.012	-.022	.002	-.036

Table B-3.9. Chow tests for the equality of subsets of coefficients: five-year migration rate functions for SEA's, transformed regression analyses of 1960 and 1970 data

Equation	F	Prob. F/H_o
Inmigration		
Males:		
5-9	19.6082	.0000
10-14	3.3698	.0003
15-19	16.2974	.0000
20-24	4.6088	.0000
25-29	1.8774	.0250
30-34	2.3463	.0037
35-39	3.2086	.0001
40-44	2.5404	.0022
45-54	1.3230	.1923*
55-64	0.7737	.6900*
65 and over	0.4630	.9449*
Females:		
5-9	18.1918	.0000
10-14	2.1859	.0133
15-19	18.2830	.0000
20-24	4.1657	.0000
25-29	1.3858	.1525*
30-34	2.3333	.0039
35-39	3.6003	.0000
40-44	2.0012	.0179
45-54	1.1790	.2888*
55-64	0.9352	.5157*
65 and over	0.3975	.9708*
Outmigration		
Males:		
5-9	14.4915	.0000
10-14	1.6210	.0871*
15-19	9.6947	.0000
20-24	14.1811	.0000
25-29	4.8332	.0000
30-34	1.1649	.2964*
35-39	2.2490	.0055
40-44	1.1185	.3382*
45-54	1.0037	.4455*
55-64	1.7078	.0538*
65 and over	0.9066	.5460*
Females:		
5-9	9.8164	.0000
10-14	0.7116	.7295*
15-19	7.3163	.0000
20-24	8.2027	.0000
25-29	2.7881	.0006
30-34	1.4023	.1445*
35-39	2.4616	.0023
40-44	1.7743	.0422
45-54	1.4888	.1146*
55-64	2.2889	.0058
65 and over	2.4274	.0034

*Cannot reject the null hypothesis that the slope coefficients in the two regressions are the same (at the 5% level).

by experimenting with interactive dummy variables attached to particular coefficients, we have tabulated the results of the most recent 1970 cross-section estimates (Tables B-3.10 through B-3.13) which could be considered as a first (although not a preferred) alternative to the pooled results in their present form. As time permits, we will reappraise the appropriateness of the pooled model through tests of interactive dummy variables.

B.3.4 Ordinary least squares estimates

While we have relied on the Transformed Least Squares (TLS) model described in Section B.2.3 (above) to fit the migration rate functions to historical data, the reader may wish to examine the Ordinary Least Squares (OLS) results for persons 20 years old and above in Tables B-3.14 and B-3.15.

B.4 COMPUTATIONAL SEQUENCE: POPULATION MIGRATION

B.4.1 A consequence of using "transformed" regression analysis

The use of "transformed" regression analysis makes the preparation of forecasts slightly more complex, although more accurate, than the use of ordinary least squares results. In the ordinary least squares case the estimated coefficients are combined with forecasts of independent variables ($\hat{X}$'s) to prepare a computed dependent variable ($\hat{Y}_c$). That is,

$$\alpha_0 + \alpha_1\hat{X}_1 + \alpha_2\hat{X}_2 \Longrightarrow \hat{Y}_c \ .$$

In the "transformed" regression case, this same process yields a calculated $\hat{Y}'_c$. That is,

$$\beta_o + \beta_1\hat{X}_1 + \beta_2\hat{X}'_2 \Longrightarrow \hat{Y}'_c$$

where $\hat{X}'_2 = \lambda\hat{X}_2$ and $\hat{Y}'_c = \lambda\hat{Y}_c$. One must then derive the variable of interest, $\hat{Y}_c$, by dividing $\hat{Y}'_c$ by λ.

Thus, the preparation of a forecast with the results of a "transformed" regression analysis requires the following steps:

(1) Forecast $\hat{X}_1$ and $\hat{X}_2$ (or use lagged values where appropriate)

(2) Transform $\hat{X}_2$ to $\hat{X}'_2$ by multiplying $\hat{X}_2$ by $\lambda = \sqrt{P_i/\sum_i P_i}$

(3) Compute $\hat{Y}'_c$

$$\beta_o + \beta_1\hat{X}_1 + \beta_2\hat{X}'_2 \Longrightarrow \hat{Y}'_c$$

Table B-3.10. Five-year in-migration rate functions for SEA's: persons 20 years old and over, transformed regression analyses of data for 1970

	Intercept	CLIM	MS	R.POT	AF	COL	N-L EPI	P.DEN	Region (relative to GL = 0) 1 NE	2 MA	4 SE	5 PL	6 SW	7 MTN	8 FW	$\bar{R}^2$	F-value (degrees of freedom)
Male - Inmigration																	
20-24 years old	.439 (5.94)	.038 (1.54)	.641 (7.39)	-.295 (-.29)	5.255 (28.84)	3.613 (19.53)	-55.593 (-6.16)	-.008 (-4.23)	-.157 (-2.10)	-.111 (-1.83)	-.013 (-.23)	-.006 (-.09)	.193 (2.64)	-.018 (-.19)	.216 (2.84)	.862	218.8 (14, 491)
25-29	.221 (2.90)	.042 (1.65)	1.549 (17.32)	2.250 (2.12)	2.048 (10.90)	1.058 (5.55)	-54.727 (-5.88)	-.006 (-3.40)	-.144 (-1.86)	-.133 (-2.13)	.045 (.80)	.048 (.70)	.236 (3.12)	.235 (2.47)	.481 (6.14)	.768	116.1 (14, 491)
30-34	.135 (2.07)	.058 (2.66)	.810 (10.59)	2.325 (2.56)	1.329 (8,27)	.890 (5.46)	-33.687 (-4.23)	-.006 (-3.80)	-.042 (-.63)	-.068 (-1.28)	.121 (2.55)	.065 (1.13)	.302 (4.66)	.289 (3.55)	.516 (7.70)	.645	63.6 (14, 491)
35-39	.120 (2.20)	.065 (3.58)	.564 (8.77)	1.503 (1.97)	1.107 (8.19)	.616 (4.49)	-23.002 (-3.43)	-.005 (-3.68)	-.031 (-.55)	-.036 (-.81)	.092 (2.29)	.028 (.57)	.246 (4.52)	.232 (3.38)	.420 (7.46)	.592	51.0 (14, 491)
40-44	.047 (.96)	.065 (3.96)	.661 (15.80)	1.297 (1.88)			-20.455 (-3.39)	-.004 (-3.18)	-.036 (-.72)	-.048 (-1.18)	.093 (2.58)	.004 (.10)	.218 (4.43)	.192 (3.13)	.387 (7.64)	.552	46.6 (13, 492)
45-54	.044 (1.05)	.062 (4.40)	.472 (13.20)	.626 (1.06)			-18.509 (-3.58)	-.003 (-2.45)	-.027 (-.63)	-.030 (-.87)	.070 (2.26)	-.015 (-.41)	.154 (3.66)	.136 (2.59)	.337 (7.78)	.504	38.5 (13, 492)
55-64	.047 (.93)	.077 (4.61)	.331 (7.75)	.059 (.08)			-4.834 (-.79)	-.002 (-1.94)	.008 (.15)	.019 (.45)	.045 (1.22)	-.047 (-1.04)	.084 (1.67)	.049 (.78)	.257 (4.98)	.301	16.3 (13, 492)
65 and over	.020 (.33)	.093 (4.60)	.404 (7.87)	-.299 (-.35)	(2.48)		-6.229 (-.84)	-.003 (-2.22)	.026 (.42)	.056 (1.14)	.025 (.57)	-.075 (-1.40)	.043 (.71)	.002 (.02)	.231 (3.72)	.276	14.4 (13, 492)

Table 6-3.10. (continued)

	Intercept	CLIM	MS	R.POT	AF	COL	N-L EPI	P.DEN	Region (relative to GL = 0) 1 NE	2 MA	4 SE	5 PL	6 SW	7 MTN	8 FW	$\bar{R}^2$	F-value (degrees of freedom)
Female - Inmigration																	
20-24 years old	.528 (6.78)	.028 (1.07)	.791 (8.66)	-.065 (-.06)	2.982 (15.55)	3.389 (17.41)	-78.764 (-8.29)	-.006 (-3.15)	-.246 (-3.12)	-.187 (-2.94)	-.013 (-.23)	.056 (.80)	.153 (1.98)	.030 (.31)	.313 (3.91)	.803	143.4 (14, 491)
25-29	.203 (2.63)	.053 (2.05)	1.230 (13.56)	2.826 (2.62)	1.938 (10.17)	1.125 (5.82)	-48.702 (-5.16)	-.007 (-3.72)	-.061 (-.78)	-.108 (-1.70)	.058 (1.03)	.075 (1.09)	.267 (3.47)	.306 (3.17)	.581 (7.32)	.719	89.8 (14, 491)
30-34	.146 (2.46)	.057 (2.89)	.634 (9.10)	2.066 (2.49)	1.360 (9.29)	.796 (5.35)	-28.391 (-3.91)	-.006 (-4.11)	-.026 (-.43)	-.068 (-1.41)	.077 (1.77)	.044 (.84)	.246 (4.16)	.248 (3.35)	.480 (7.87)	.626	58.8 (14, 491)
35-39	.085 (1.80)	.053 (3.38)	.475 (8.54)	1.322 (2.00)	1.047 (8.97)	.516 (4.35)	-19.691 (-3.41)	-.004 (-3.66)	-.031 (-.65)	-.044 (-1.15)	.077 (2.23)	.033 (.79)	.214 (4.55)	.177 (2.99)	.354 (7.28)	.590	50.5 (14, 491)
40-44	.040 (.90)	.059 (4.03)	.543 (14.63)	.947 (1.55)	.791 (7.31)		-19.993 (-3.73)	-.003 (-2.98)	-.029 (-.66)	-.034 (-.96)	.071 (2.21)	-.005 (-.12)	.181 (4.15)	.162 (2.97)	.350 (7.79)	.547	45.6 (13, 492)
45-54	.040 (.94)	.060 (4.29)	.427 (11.98)	.589 (1.00)	.541 (5.21)		-15.221 (-2.96)	-.002 (-2.42)	-.030 (-.71)	-.023 (-.65)	.046 (1.48)	-.027 (-.72)	.132 (3.16)	.115 (2.19)	.321 (7.45)	.473	33.9 (13, 492)
55-64	.041 (.74)	.084 (4.57)	.371 (7.91)	.170 (.22)	.311 (2.28)		-5.500 (-.81)	-.003 (-2.13)	.012 (.22)	.021 (.46)	.027 (.66)	-.056 (-1.13)	.063 (1.14)	.042 (.61)	.286 (5.04)	.301	16.3 (13, 492)
65 and over	.002 (.04)	.077 (4.26)	.466 (10.09)	.354 (.47)	.47 (3.48)		-12.054 (-1.81)	-.003 (-2.24)	-.007 (-.13)	.041 (.92)	.040 (1.00)	-.046 (-.95)	.077 (1.42)	.050 (.74)	.273 (4.88)	.351	20.5 (1[illegible], 492)

Table B-3.11. Five-year out-migration rate functions for SEA's: persons 20 years old and over, transformed regression analyses of data for 1970

	Intercept	CLIM	MS	R.POT	AF	COL	N-L EPI	P.DEN	Region (relative to GL = 0) 1 NE	2 MA	4 SE	5 PL	6 SW	7 MTN	8 FW	$\bar{R}^2$	F-value (degrees of freedom)
Male - Outmigration																
20-24 years old	.695 (9.29)	-.005 (-.20)	2.947 (33.54)	-.547 (-.52)	-2.246 (-12.17)	-2.41 (-12.85)	59.454 (6.50)	-.004 (-2.30)	-.009 (-.12)	-.045 (-.73)	-.155 (-2.83)	.390 (5.87)	.097 (1.30)	.129 (1.38)	.084 (1.10)	.774	120.4 (14, 491)
25-29	.646 (10.25)	.014 (.68)	.239 (3.23)	-2.060 (-2.34)	3.118 (20.05)	3.310 (20.96)	39.529 (5.13)	.005 (3.04)	-.014 (-.22)	-.070 (-1.36)	-.047 (-1.02)	.164 (2.93)	.152 (2.43)	-.012 (-.15)	-.107 (-1.64)	.832	173.7 (14, 491)
30-34	.232 (5.72)	.048 (3.51)	.746 (15.65)	-.951 (-1.68)	1.428 (14.27)	1.144 (11.26)	-3.694 (-.74)	.007 (7.37)	-.067 (-1.63)	-.085 (-2.55)	.036 (1.20)	.102 (2.82)	.227 (5.62)	.179 (3.53)	.186 (4.47)	.842	187.4 (14, 491)
35-39	.130 (3.63)	.049 (4.11)	.724 (17.26)	-.552 (-1.11)	.968 (10.99)	.487 (5.44)	-6.234 (-1.43)	.005 (5.26)	-.043 (-1.18)	-.053 (-1.81)	.032 (1.24)	.073 (2.29)	.194 (5.45)	.177 (3.96)	.205 (5.57)	.798	138.3 (14, 491)
40-44	.079 (2.65)	.032 (3.20)	.706 (27.84)	-.122 (-.29)	.841 (11.39)		-2.404 (-.66)	.004 (4.93)	-.074 (-2.42)	-.070 (-2.84)	.032 (1.48)	.052 (1.97)	.190 (6.37)	.164 (4.39)	.204 (6.66)	.788	140.8 (13, 492)
45-54	.050 (1.96)	.024 (2.80)	.528 (24.47)	.009 (.02)	.451 (7.18)		-2.835 (-.91)	.002 (3.67)	-.052 (-2.00)	-.054 (-2.58)	.025 (1.33)	.046 (2.01)	.155 (6.12)	.152 (4.77)	.200 (7.67)	.732	103.2 (13, 492)
55-64	-.017 (-.88)	.008 (1.14)	.483 (28.76)	.506 (1.83)	.132 (2.70)		-1.468 (-.61)	.002 (4.80)	-.074 (-3.66)	-.063 (-3.90)	.026 (1.76)	.038 (2.13)	.135 (6.86)	.122 (4.93)	.197 (9.71)	.771	127.1 (13, 492)
65 and over	-.072 (-3.47)	-.001 (-.13)	.651 (37.24)	.763 (2.65)	.054 (1.06)		-.871 (-.34)	.004 (7.37)	-.062 (-2.94)	-.072 (-4.24)	-.004 (-.25)	.015 (.83)	.090 (4.39)	.080 (3.11)	.142 (6.69)	.838	195.6 (13, 492)

Table B-3.11. (continued)

	Intercept	CLIM	MS	R.POT	AF	COL	N-L EPI	P.DEN	Region (relative to GL = 0) 1 NE	2 MA	4 SE	5 PL	6 SW	7 MTN	8 FW	$\bar{R}^2$	F-value (degrees of freedom)
Female - Outmigration																
20-24 years old	.969 (11.80)	.008 (.28)	1.851 (19.20)	-1.914 (-1.67)	-.978 (-4.83)	-1.299 (-6.32)	74.299 (7.40)	-.004 (-1.94)	-.024 (-.29)	-.071 (-1.06)	-.227 (-3.78)	.423 (5.79)	.060 (.73)	.107 (1.04)	.096 (1.14)	.581	48.6 (14, 491)
25-29	.539 (10.77)	.021 (1.26)	.485 (8.26)	-1.726 (-2.473)	1.277 (10.35)	2.858 (22.82)	6.732 (1.101)	.006 4.79	-.066 (-1.31)	-.044 (-1.08)	-.028 (-.78)	.138 (3.10)	.162 (3.26)	.048 (.77)	.031 (.60)	.843	188.7 (14, 491)
30-34	.199 (5.43)	.038 (3.12)	.720 (16.78)	-.719 (-1.41)	1.228 (13.62)	.812 (8.86)	-8.331 (-1.86)	.006 (6.15)	-.081 (-2.18)	-.090 (-3.01)	.017 (.63)	.084 (2.60)	.203 (5.57)	.161 (3.52)	.205 (5.46)	.831	172.4 (14, 491)
35-39	.139 (4.61)	.031 (3.06)	.587 (16.61)	-.568 (-1.35)	.977 (13.17)		-4.395 (-1.19)	.003 (3.66)	-.062 (-2.02)	-.049 (-1.99)	.016 (.74)	.060 (2.23)	.159 (5.30)	.121 (3.21)	.163 (5.26)	.786	128.6 (14, 491)
40-44	.065 (2.50)	.026 (2.98)	.569 (25.74)	.020 (.05)	.606 (9.40)		.577 (.18)	.002 (2.99)	-.045 (-1.69)	-.048 (-2.23)	.033 (1.72)	.066 (2.86)	.188 (7.23)	.165 (5.08)	.189 (7.08)	.756	117.4 (13, 492)
45-54	.049 (2.21)	.018 (2.42)	.466 (24.93)	.234 (.76)	.348 (6.39)		.556 (.21)	.002 (3.38)	-.051 (-2.29)	-.054 (-2.98)	.006 (.39)	.044 (2.23)	.139 (6.34)	.138 (5.03)	.191 (8.43)	.740	107.9 (13, 492)
55-64	-.013 (-.64)	.007 (1.05)	.534 (31.57)	.519 (1.86)	.085 (1.72)		2.815 (1.15)	.003 (6.05)	-.082 (-4.07)	-.070 (-4.26)	-.005 (-.35)	.023 (1.32)	.108 (5.45)	.115 (4.63)	.176 (8.62)	.799	150.1 (13, 492)
65 and over	-.019 (-.93)	.004 (.53)	.570 (33.31)	.572 (2.03)	.025 (.50)		4.740 (1.92)	.004 (8.06)	-.043 (-2.08)	-.051 (-3.11)	.006 (.39)	.037 (2.04)	.093 (4.64)	.082 (3.25)	.152 (7.33)	.810	161.3 (13, 492)

Table B-3.12. Five-year in-migration rate functions for SEA's: younger age groups, transformed regression analyses of data for 1970

		Males in	Females in										Region (relative to GL = 0)								
	Intercept	20-24	20-24	25-29	30-34	35-39	40-44	45-54	55-64	AF	COL	R.POT	1 NE	2 MA	4 SE	5 PL	6 SW	7 MTN	8 FW	$\bar{R}^2$	F-value (degrees of freedom)
Male - Inmigration																					
5-9 years old	.026 (3.02)	----	----	.122 (6.94)	.374 (9.06)	.293 (5.67)	.269 (4.75)	-.063 (-1.37)	----	----	----	----	-.019 (-1.38)	-.010 (-.97)	-.034 (-3.99)	-.016 (-1.57)	-.017 (-1.53)	-.019 (-1.37)	.017 (1.38)	.976	1704.9 (12, 493)
10-14	.013 (1.75)	----	----	----	.187 (6.27)	.447 (9.54)	.343 (6.77)	.106 (2.63)	----	----	----	----	-.028 (-2.28)	-.021 (-2.26)	-.034 (-4.49)	-.012 (-1.34)	-.012 (-1.24)	.001 (.08)	.022 (1.99)	.976	1799.1 (11, 494)
15-19	.126 (3.66)	.257 (8.68)	----	----	----	.164 (1.55)	.291 (1.98)	-.185 (-.97)	.231 (2.75)	.798 (5.87)	.639 (5.31)	-1.103 (-2.31)	-.108 (-3.01)	-.043 (-1.46)	-.070 (-2.64)	-.062 (-1.96)	-.091 (-2.52)	-.074 (-1.60)	-.073 (-1.82)	.888	260.1 (15, 490)
Female - Inmigration																					
5-9 years old	.021 (2.45)	----	----	.152 (8.65)	.317 (7.64)	.301 (5.80)	.266 (4.69)	-.036 (-.78)	----	----	----	----	-.025 (-1.84)	-.012 (-1.17)	-.035 (-4.06)	-.014 (-1.44)	-.023 (-2.05)	-.014 (-1.01)	.027 (2.12)	.977	1724.5 (12, 493)
10-14	.002 (.32)	----	----	----	.230 (7.90)	.358 (7.84)	.360 (7.31)	.144 (3.68)	----	----	----	----	-.012 (-.98)	-.017 (-1.90)	-.033 (-4.58)	.002 (.23)	-.024 (-2.48)	-.001 (-.06)	.026 (2.39)	.977	1925.0 (11, 494)
15-19	.074 (2.68)	----	.332 (12.29)	----	----	.123 (1.44)	.018 (.15)	.111 (.73)	.144 (2.10)	.000 (.00)	.580 (5.95)	-1.023 (-2.70)	-.001 (-.03)	.010 (.42)	-.003 (-.12)	-.017 (-.67)	.010 (.34)	.007 (.19)	-.019 (-.58)	.909	325.3 (15, 490)

Table B-3.13. Five-year out-migration rate functions for SEA's: younger age groups, transformed regression analyses of data for 1970

		Males out	Females out										Region (relative to GL = 0)								
	Intercept	20-24	20-24	25-29	30-34	35-39	40-44	45-54	55-64	AF	COL	R.POT	1 NE	2 MA	4 SE	5 PL	6 SW	7 MTN	8 FW	$\bar{R}^2$	F-value (degrees of freedom)
Male - Outmigration																					
5-9 years old	-.012 (-1.30)	----	----	.048 (3.68)	.439 (12.05)	.339 (6.82)	.276 (4.34)	.036 (.60)	----	----	----	----	.027 (1.87)	.007 (.68)	-.009 (-1.06)	-.006 (-.59)	-.031 (-2.61)	-.017 (-1.12)	.014 (1.09)	.968	1250.0 (12, 493)
10-14	-.025 (-3.41)	----	----	----	.165 (6.57)	.427 (10.26)	.365 (6.87)	.256 (5.03)	----	----	----	----	-.009 (-.70)	-.009 (-1.02)	-.018 (-2.47)	-.014 (-1.62)	-.011 (-1.09)	-.024 (-1.90)	-.016 (-1.46)	.971	1491.4 (11, 494)
15-19	-.096 (-3.99)	.170 (16.95)	----	----	----	.377 (5.57)	.403 (4.02)	.180 (1.54)	.502 (6.49)	-.497 (-7.88)	-.323 (-5.82)	.926 (3.00)	.020 (.87)	.010 (.51)	.002 (.11)	.029 (1.40)	-.047 (-2.00)	.010 (.32)	-.075 (-2.93)	.927	416.2 (15, 490)
Female - Outmigration																					
5-9 years old	-.012 (-1.43)	----	----	.029 (2.46)	.465 (14.00)	.381 (8.40)	.261 (4.50)	-.005 (-.10)	----	----	----	----	.022 (1.66)	.002 (.22)	-.010 (-1.21)	-.006 (-.57)	-.029 (-2.72)	-.003 (-.25)	.021 (1.77)	.974	1524.1 (12, 493)
10-14	-.017 (-2.44)	----	----	----	.181 (7.69)	.465 (11.93)	.301 (6.04)	.195 (4.10)	----	----	----	----	-.001 (-.09)	-.007 (-.75)	-.016 (-2.24)	.003 (.41)	-.018 (-1.90)	-.014 (-1.17)	.011 (1.06)	.973	1618.8 (11, 494)
15-19	-.067 (-3.14)	----	.211 (22.67)	----	----	.191 (3.38)	.355 (4.26)	.236 (2.42)	.574 (9.24)	-.055 (-1.10)	-.523 (-11.41)	.600 (2.32)	.063 (3.27)	.001 (.09)	.041 (2.89)	.035 (2.06)	-.017 (-.89)	.024 (.99)	-.042 (-1.98)	.934	464.7 (15, 490)

Table B-3.14. Five-year in-migration rate functions for SEA's: persons 20 years old and over, ordinary least squares regression analyses of pooled cross-section data for 1960 and 1970

	Intercept	CLIM	MS	R.POT	AF	COL	N-L EPI	P.DEN	POOLED	Region (relative to GL = 0)							$\bar{R}^2$	F-value (degrees of freedom)
										1 NE	2 MA	4 SE	5 PL	6 SW	7 MTN	8 FW		
Male - Inmigration																		
20-24 years old	-15.254	.994	3.43	-19.987	4.974	3.328	-19.027	-.136	-4.482	-4.424	-2.395	2.468	.308	5.762	-.355	3.859	.826	314.6
	(-5.11)	(2.39)	(12.64)	(-1.08)	(47.19)	(27.18)	(-7.08)	(-4.63)	(-6.94)	(-3.46)	(-2.33)	(2.54)	(.28)	(4.59)	(-.23)	(3.01)		(15, 996)
25-29	-17.449	1.097	3.973	20.043	1.758	.826	-31.293	-.137	-1.986	-4.341	-3.048	3.470	.554	6.541	5.427	7.578	.614	105.8
	(-6.27)	(2.82)	(15.69)	(1.16)	(17.89)	(7.23)	(-12.49)	(-4.99)	(-3.30)	(-3.64)	(-3.17)	(3.82)	(.54)	(5.58)	(3.72)	(6.35)		(15, 996)
30-34	-14.833	1.232	3.171	13.058	1.176	.695	-24.315	-.139	-5.089	-2.448	-1.484	4.874	.571	8.336	6.791	9.237	.526	73.8
	(-5.49)	(3.27)	(12.91)	(.78)	(12.34)	(6.27)	(-10.00)	(-5.22)	(8.71)	(-2.11)	(-1.59)	(5.54)	(.58)	(7.33)	(4.80)	(7.98)		(15, 996)
35-39	-15.397	1.390	2.860	1.743	1.090	.468	-18.188	-.118	-4.972	-1.899	-.686	4.321	-.350	7.068	5.431	8.347	.506	67.9
	(-6.15)	(3.98)	(12.55)	(.11)	(12.32)	(4.55)	(-8.07)	(-4.78)	(-9.17)	(-1.77)	(-.79)	(5.29)	(-.38)	(6.70)	(4.14)	(7.77)		(15, 996)
40-44	-18.249	1.520	2.820	13.457	.748		-13.184	-.088	-4.521	-2.086	-.699	4.770	-.379	6.508	4.817	8.041	.480	65.8
	(-8.45)	(4.95)	(14.67)	(.99)	(9.66)		(-6.69)	(-4.09)	(-9.66)	(-2.21)	(-.92)	(6.66)	(-.47)	(7.05)	(4.19)	(8.53)		(14, 997)
45-54	-14.159	1.310	2.195	1.400	.432		-11.669	-.064	-3.885	-1.562	-.200	4.061	-.592	5.410	3.719	7.626	.451	58.5
	(-7.60)	(4.95)	(13.24)	(.12)	(6.47)		(-6.87)	(-3.43)	(-9.62)	(-1.92)	(-.31)	(6.57)	(-.85)	(6.79)	(3.75)	(9.37)		(14, 997)
55-64	-11.670	1.705	1.756	-10.801	.150		-4.066	-.054	-2.865	-.150	.730	3.272	-1.289	3.574	.853	5.583	.299	30.3
	(-5.79)	(5.95)	(9.78)	(-.85)	(2.07)		(-2.21)	(-2.66)	(-6.55)	(-.17)	(1.03)	(4.89)	(-1.71)	(4.14)	(.79)	(6.34)		(14, 997)
65 and over	-15.069	2.126	2.056	-14.697	.118		-4.487	-.060	-3.271	.625	1.792	3.218	-1.814	2.389	-1.012	4.645	.250	23.8
	(-6.49)	(6.44)	(9.94)	(-1.00)	(1.42)		(-2.12)	(-2.56)	(-6.50)	(.62)	(2.20)	(4.18)	(-2.09)	(2.40)	(-.82)	(4.58)		(14, 997)

Table B-3.14. (continued)

	Intercept	CLIM	MS	R.POT	AF	COL	N-L EPI	P.DEN	POOLED	Region (relative to GL = 0)							$\bar{R}^2$	F-value (degrees of freedom)
										1 NE	2 MA	4 SE	5 PL	6 SW	7 MTN	8 FW		
Female - Inmigration																		
20-24 years old	-19.565	.826	4.272	-21.133	2.284	2.816	-38.041	-.135	-3.861	-6.837	-4.313	2.767	2.250	5.360	1.715	5.227	.743	192.4
	(-6.79)	(2.05)	(16.30)	(-1.18)	(22.46)	(23.83)	(-14.67)	(-4.76)	(-6.19)	(-5.54)	(-4.34)	(2.95)	(2.13)	(4.42)	(1.14)	(4.23)		(15, 996)
25-29	-14.736	1.126	3.477	23.281	1.554	.793	-29.183	-1.63	-1.425	-2.781	-2.659	3.017	1.449	7.306	7.560	9.740	.571	88.2
	(-5.03)	(2.75)	(13.06)	(1.28)	(15.04)	(6.61)	(-11.08)	(-5.66)	(-2.25)	(-2.22)	(-2.63)	(3.16)	(1.35)	(5.93)	(4.93)	(7.76)		(15, 996)
30-34	-13.470	1.181	2.764	13.406	1.206	.603	-20.195	-.135	-4.193	-1.621	-1.313	4.110	.682	7.533	6.504	9.622	.516	70.8
	(-5.21)	(3.27)	(11.76)	(.84)	(13.22)	(5.69)	(-8.68)	(-5.34)	(-7.50)	(-1.46)	(-1.47)	(4.88)	(.72)	(6.93)	(4.81)	(8.68)		(15, 996)
35-39	-15.231	1.350	2.644	12.084	1.011	.348	-15.042	-.110	-5.767	-1.838	-.708	3.934	.138	6.511	5.212	8.019	.503	67.2
	(-6.61)	(4.20)	(12.61)	(.85)	(12.43)	(3.68)	(-7.25)	(-4.84)	(-11.57)	(-1.86)	(-.89)	(5.24)	(.16)	(6.71)	(4.32)	(8.11)		(15, 996)
40-44	-15.92	1.356	2.463	8.044	.691		-13.763	-.076	-4.418	-1.722	-.365	3.848	-.453	5.647	4.143	7.990	.488	67.9
	(-8.15)	(4.88)	(14.16)	(.65)	(9.84)		(-7.72)	(-3.86)	(-10.43)	(-2.02)	(-.53)	(5.93)	(-.62)	(6.75)	(3.98)	(9.36)		(14, 997)
45-54	-13.772	1.329	2.102	.991	.373		-10.314	-.062	-3.826	-1.370	-.075	3.246	-.827	4.750	2.89	7.040	.417	51.0
	(-7.39)	(5.02)	(12.67)	(.08)	(5.58)		(-6.07)	(-3.34)	(-9.47)	(-1.69)	(-.11)	(5.25)	(-1.19)	(5.96)	(2.92)	(8.65)		(14, 997)
55-64	-14.022	1.949	2.013	-9.186	.167		-4.525	-.061	-3.301	.127	1.061	3.070	-1.442	3.074	.290	6.014	.281	27.8
	(-6.20)	(6.06)	(10.00)	(-.64)	(2.05)		(-2.19)	(-2.69)	(-6.74)	(.129)	(1.34)	(4.09)	(-1.71)	(3.18)	(.24)	(6.09)		(14, 997)
65 and over	-16.618	1.683	2.264	-4.491	.215		-10.364	-.055	-3.356	-.389	1.425	3.401	-1.359	2.900	-.396	5.385	.325	34.2
	(-8.22)	(5.86)	(12.58)	(-.35)	(2.96)		(-5.62)	(-2.74)	(-7.66)	(-.44)	(2.01)	(5.07)	(-1.80)	(3.35)	(-.37)	(6.10)		(14, 997)

Table B-3.15. Five-year out-migration rate functions for SEA's: persons 20 years old and over, ordinary least squares regression analyses of pooled cross-section data for 1960 and 1970

	Intercept	CLIM	MS	R.POT	AF	COL	N-L EPI	P.DEN	POOLED	Region (relative to GL = 0) 1 NE	2 MA	4 SE	5 PL	6 SW	7 MTN	8 FW	R^2	F-value (degrees of freedom)
Male - Outmigration																		
20-24 years old	75.489	-1.427	-2.491	-166.429	-.917	-2.142	-29.374	-.178	17.162	-2.379	-2.021	-8.258	7.114	2.277	7.960	3.553	.489	63.6
	(18.78)	(-2.54)	(-6.81)	(-6.68)	(-6.46)	(-12.99)	(-8.12)	(-4.51)	(19.73)	(-1.38)	(-1.46)	(-6.30)	(4.83)	(1.35)	(3.78)	(2.06)		(15, 996)
25-29	46.718	-.337	-2.120	-133.300	4.013	3.174	-5.489	-.023	4.561	-2.277	-1.801	-3.038	3.654	6.329	4.966	-.104	.711	163.7
	(14.09)	(-.73)	(-7.03)	(-6.49)	(34.27)	(23.34)	(-1.84)	(-.72)	(6.36)	(-1.60)	(-1.57)	(-2.81)	(3.01)	(4.53)	(2.86)	(-.07)		(15, 996)
30-34	17.266	-.002	.385	-71.331	1.541	1.106	-16.057	.074	-2.419	-3.282	-2.278	.476	3.117	7.408	6.337	3.898	.654	125.6
	(9.23)	(-.01)	(2.27)	(-6.16)	(23.34)	(14.42)	(-9.54)	(4.04)	(-5.98)	(-4.09)	(-3.53)	(.78)	(4.55)	(9.41)	(6.47)	(4.86)		(15, 996)
35-39	5.448	.176	1.155	-49.980	1.038	.299	-13.512	.061	-3.065	-2.475	-1.490	1.128	2.324	6.131	4.848	3.938	.581	91.9
	(3.36)	(.78)	(7.82)	(-4.97)	(18.11)	(4.49)	(-9.24)	(3.81)	(-8.72)	(-3.55)	(-2.66)	(2.13)	(3.90)	(8.97)	(5.70)	(5.65)		(15, 996)
40-44	3.588	-.016	.982	-33.395	.951		-11.381	.043	-2.145	-2.583	-1.478	1.362	1.542	5.652	4.921	4.581	.594	104.0
	(2.72)	(-.09)	(8.37)	(-4.01)	(20.09)		(-9.46)	(3.24)	(-7.50)	(-4.49)	(-3.19)	(3.11)	(3.13)	(10.02)	(7.01)	(7.95)		(14, 997)
45-54	4.143	-.085	.634	-28.452	.467		-9.124	.029	-1.852	-1.945	-1.109	.942	1.124	4.871	4.526	4.916	.559	90.3
	(3.93)	(-.57)	(6.75)	(-4.27)	(12.34)		(-9.48)	(2.76)	(-8.09)	(-4.22)	(-2.99)	(2.69)	(2.85)	(10.79)	(8.06)	(10.67)		(14, 997)
55-64	2.586	-.157	.496	-12.572	.197		-7.352	.037	-1.626	-1.658	-.991	.884	.537	4.062	2.896	4.708	.511	74.5
	(3.08)	(-1.32)	(6.63)	(-2.37)	(6.53)		(-9.60)	(4.40)	(-8.93)	(-4.53)	(-3.36)	(3.17)	(1.71)	(11.31)	(6.48)	(12.84)		(14, 997)
65 and over	-.288	-.253	.753	1.352	.122		-5.818	.061	-1.753	-1.418	-1.116	.005	.003	2.478	1.725	3.468	.472	63.6
	(-.37)	(-2.29)	(10.88)	(.28)	(4.38)		(-8.20)	(7.86)	(-10.40)	(-4.18)	(-4.09)	(.02)	(.01)	(7.45)	(4.17)	(10.21)		(14, 997)

Table B-3.15. (continued)

	Intercept	CLIM	MS	R.POT	AF	COL	N-L EPI	P.DEN	POOLED	Region (relative to GL = 0) 1 NE	2 MA	4 SE	5 PL	6 SW	7 MTN	8 FW	$\bar{R}^2$	F-value (degrees of freedom)
Female - Outmigration																		
20-24 years old	90.575	-1.795	-4.067	-224.789	.300	-1.002	-21.683	-.201	17.285	-3.574	-3.428	-10.803	9.912	1.762	9.292	4.184	.478	60.8
	(20.95)	(-2.98)	(-10.34)	(-8.39)	(1.97)	(-5.65)	(-5.57)	(-4.73)	(18.48)	(-1.93)	(-2.30)	(-7.67)	(6.25)	(.97)	(4.10)	(2.26)		(15, 996)
25-29	28.580	-.349	-.433	-105.575	1.662	2.794	-16.282	-.003	1.568	-2.630	-1.601	-1.125	4.382	6.801	5.105	1.845	.688	146.7
	(11.92)	(-1.04)	(-1.98)	(-7.11)	(19.63)	(28.40)	(-7.54)	(-.15)	(3.02)	(-2.56)	(-1.94)	(-1.44)	(4.98)	(6.74)	(4.06)	(1.79)		(15, 996)
30-34	10.939	.025	.771	-56.011	1.183	.594	-13.386	.055	-2.182	-3.079	-1.984	.517	3.043	6.532	5.549	4.131	.610	103.7
	(6.53)	(.11)	(5.06)	(-5.39)	(19.98)	(8.63)	(-8.87)	(3.33)	(-6.02)	(-4.28)	(-3.43)	(.95)	(4.95)	(9.26)	(6.32)	(5.75)		(15, 996)
35-39	6.855	-.104	.875	-44.976	1.078	.183	-13.667	.032	-3.272	-2.570	-1.462	.607	2.032	5.377	4.341	4.066	.608	103.1
	(4.76)	(-.52)	(6.68)	(-5.04)	(21.21)	(3.10)	(-10.55)	(2.25)	(-10.50)	(-4.16)	(-2.94)	(1.29)	(3.85)	(8.87)	(5.76)	(6.58)		(15, 996)
40-44	5.581	-.101	.640	-30.33	.667		-9.123	.019	-2.020	-2.003	-1.048	.784	1.829	5.488	4.909	5.171	.555	89.0
	(4.58)	(-.58)	(5.90)	(-3.94)	(15.25)		(-8.20)	(1.54)	(-7.64)	(-3.76)	(-2.45)	(1.94)	(4.02)	(10.52)	(7.57)	(9.71)		(14, 997)
45-54	5.145	-.210	.484	-24.031	.389		-8.927	.019	-1.832	-1.848	-1.090	.449	1.104	4.525	4.373	5.146	.557	89.6
	(5.22)	(-1.50)	(5.52)	(-3.87)	(11.01)		(-9.93)	(1.88)	(-8.58)	(-4.30)	(-3.15)	(1.37)	(3.00)	(10.74)	(8.34)	(11.96)		(14, 997)
55-64	5.324	-.254	.340	-16.122	.215		-8.583	.042	-1.536	-1.948	-1.101	-.067	.267	3.325	2.809	4.480	.491	68.8
	(6.07)	(-2.04)	(4.35)	(-2.91)	(6.84)		(-10.73)	(4.80)	(-8.08)	(-5.09)	(-3.58)	(-.23)	(.82)	(8.86)	(6.02)	(11.70)		(14, 997)
65 and over	6.039	-.360	.270	-15.110	.219		-11.249	.049	-.747	-1.252	-.705	-.265	.253	2.461	2.158	3.725	.433	54.3
	(7.06)	(-2.96)	(3.55)	(-2.80)	(7.13)		(-14.42)	(5.70)	(-4.03)	(-3.35)	(-2.35)	(-.94)	(.79)	(6.73)	(4.74)	(9.97)		(14, 997)

(4) Convert $\hat{Y}'_c$ to $\hat{Y}_c$

$$\hat{Y}_c = \hat{Y}'_c/\lambda.$$

B.4.2 Computation sequence

In MULTIREGION we assume that labor supply (migration and labor participation) generally adjusts to regional socioeconomic conditions contemporaneously (i.e., without a lag). This is not a bad assumption when the time step is five years but it does mean a multi-stage computation process must be used. Trial (last period) values of some explanatory variables must be used to produce first-stage estimates of interregional migration, regional labor supply and labor market tightness (EPI). Then, these estimates of regional labor market conditions are used to compute revised estimates of interregional migration and regional labor supply. The computation process continues in this fashion through a user-specified number of stages. At all stages across region sums of inmigrants by age and sex are forced to across region sums of outmigrants by age and sex (interregional balances). The migration computations may be divided into six phases.

Phase I - Preliminary Data Manipulation. Necessary information is prepared from national/regional data, estimates and projections including (1) CLIM (a constant), (2) PDEN, RPOT, and EPI (last period), (3) COL, AF, and MS (trend estimates--see below), and (4) damped regional dummies.

Trend estimates of AF, COL and MS may be approached as follows:

AF - Absolute numbers of AF (1975)/BEA may be computed by applying 1970 share of AF/BEA to total national AF assumed by INFORUM. Absolute numbers per BEA area can then be divided by 1970 population to approximate % AF (1975).

COL - Current Population Reports (CPR) projects national college enrollments to 1990. One projection series would be[50]

Year	National College Enrollment
1950	2,214,000
1960	3,570,000
1970	7,413,000
1975	9,147,000
1980	10,284,000
1985	10,207,000
1990	10,397,000

Given these estimates it might be sufficient to assume that (1) there will be no new remotely located state universities as in the 1960's and (2) the community college movement will advance so that absolute numbers of COL (1975)/BEA may be computed by applying an altered 1970 share of COL/BEA to the 1975 national total from CPR. The altered 1970 share might be defined as:

$$\left[\frac{\lambda\ \text{1970 Share COL} + \text{1970 Pop Share}}{\lambda + 1}\right]$$

where $\lambda = 3$ or 4. Absolute numbers per BEA area can then be divided by 1970 populations to approximate % COL (1975).

MS - Current Population Reports projects national educational attainment to 1990.[51] The median schooling estimates implied by their projections are

Year	MS
1950	9.3
1960	10.5
1970	12.2
1975	12.3
1980	12.4
1990	12.6

These estimates suggest a topping out of what has been a rather rapid growth in MS. We also have the following regression results for 1970 and 1960 BEA area data:

$$\underset{}{MS70} = \underset{(13.045)}{4.834} + \underset{(17.220)}{.639\ MS60} + \underset{(1.511)}{.388}\ \frac{POP\ 70}{POP\ 60}$$

$$\underset{(-.713)}{-.111\ Reg\ 1}\quad \underset{(-.124)}{-.013\ Reg\ 2}\quad \underset{(-6.207)}{-.536\ Reg\ 4}$$

$$\underset{(-.350)}{-.031\ Reg\ 5}\quad \underset{(-5.651)}{-.494\ Reg\ 6}\quad \underset{(-3.035)}{-.372\ Reg\ 7}$$

$$\underset{(-3.943)}{-.422\ Reg\ 8}\qquad R^2 = .859$$

It is tempting to try to combine this information as follows:

(1) alter the regression equation for a five-year time step,
(2) use the regression results to estimate 1975 MS/BEA area, and
(3) force the weighted (by POP) average of these estimates to equal the CPR estimate for 1975.

Phase II - Compute Trial Migration Rates. Regional in- and out-migration rates by age and sex are computed from Phase I data. Some age groups are split.

45-54 ⟹ 45-49, 50-54

55-64 ⟹ 55-59, 60-64

65 and over ⟹ 65-69, 70-74, 75 and over

Approximations to 1970 and 1975 residuals for BEA areas are retained but may decay over time. Values approximating residuals have been estimated from the trackings of the model between 1960 and 1970 (and 1975).

Phase III - Alter Trial Migration Rates for the Size Difference of BEA's and SEA's. Apply a scalar equally to all trial migration rates to reduce the population flows for the fact that the land area of the average SEA is less than that of the average BEA area. While the exact value of the scalar is to be determined by trial and error, a theoretical argument can be made for a value close to 1.0 (see reference 5, Chap. 8).

Phase IV - Trial Gross Migrants by Age and Sex. Altered regional migration rates are applied to estimated population by age and sex. Across region sums of inmigrants by age and sex are forced to across region sums of outmigrants by age and sex (interregional balancing--3 options are (a) proportion INS, (b) proportion OUTS, (c) proportion both).

Phase V - Trial Labor Market Conditions. Trial labor supply (people) by sex is brought together with trial labor demand (jobs) to establish trial labor market conditions including (1) EPI, (2) male and female unemployment rates, and (3) female industry mix (FIM). Floors and ceilings are applied to some of these variables.

Phase VI - Final Migration, Labor Supply and Labor Market Conditions. Final values are computed by reiterating Phases II through V a user-specified number of times. Interregional balances, national control totals and regional ceilings and floors are imposed during each iteration.

REFERENCES FOR APPENDIX B

1. Since the land area of the average SEA is less than that of the average BEA area, the SEA results will most likely overestimate the extent of BEA in- and out-migration but there is no satisfactory substitute procedure until migration data are more available for BEA areas. See reference 4, Chapter 8.

2. For example, M. I. Greenwood, "Research on Internal Migration in the United States: A Survey," Journal of Economic Literature, Vol. XIII, No. 2 (June 1975), pp. 397-433; H. S. Parnes, "Labor Force Participation and Labor Mobility," A Review of Industrial Relations Research, Vol. I (1970) pp. 1-78; R. Paul Shaw, Migration Theory and Fact: A Review and Bibliography of Current Literature, Philadelphia, Regional Science Research Institute, 1975.

3. I. S. Lowry, Migration and Metropolitan Growth: Two Analytical Models (San Francisco: Chandler Publishing Co., 1966).

4. W. Isard, Methods of Regional Analysis (Cambridge: M.I.T. Press, 1960) especially Chapter 11, "Gravity, Potential, and Spatial Interaction Models."

5. G. S. Sahota, "An Economic Analysis of Internal Migration in Brazil," Journal of Political Economy, Vol. 76, No. 2 (March/April 1968) p. 221.

6. One should note that there are no formal event reporting requirements for migration such as those that exist for reporting births and deaths.

7. U.S. Bureau of the Census, U.S. Census of Population and Housing: 1960, 1/1,000 and 1/10,000, Two National Samples of the Population of the United States: Description and Technical Documentation.

8. J. B. Lansing and E. Mueller, The Geographic Mobility of Labor (Ann Arbor: Institute for Social Research, 1967).

9. For excellent discussions of the advantages and disadvantages of the Continuous Work History Sample, see U.S. Bureau of the Census, Current Population Reports, Series P-23, No. 31, "Use of Social Security's Continuous Work History Sample for Population Estimation," U.S. Government Printing Office, Washington, D.C., 1970; K. P. Nelson "Evaluating Social Security Measures of Migration: Basic Considerations" Oak Ridge National Laboratory-UR-119 (January 1975); and K. P. Nelson, "Evaluating Social Security Measures of Migration: Results for 28 SMSAs by Sex, Race, Age and Earnings--1965-70" ORNL-UR-127 (in preparation).

10. See R. F. Muth, "Migration: Chicken or Egg?" Southern Economic Journal Vol. XXXVII, No. 3 (Jan. 1971) pp. 295-306, for an interesting discussion of this particular question and L. D. Olvey, "Regional Growth and Interregional Migration--Their Pattern of Interaction" Review of Regional Studies, Winter 1972, pp. 139-163 for an empirical test.

11. Lowry (1966), pp. 94-95.

12. M. J. Greenwood, "Lagged Response in the Decision to Migrate," Journal of Regional Science, Vol. 10, No. 3 (1970) pp. 375-384. Migration over well-trodden paths has been rationalized by arguing that the greater the past migration from area X to area Y, the greater and better will be the information flowing from Y to X.

13. Samuel Bowles, "Migration as Investment: Empirical Tests of the Human Investment Approach to Geographic Mobility," Review of Economic and Statistics, Vol. LII, No. 4 (Nov. 1970) pp. 356-362, and Michael J. Greenwood, "An Analysis of the Determinants of Geographic Labor Mobility in the United States," Review of Economics and Statistics, Vol. LI, No. 2 (May 1969) pp. 189-194.

14. Greenwood (1969 and 1970).

15. Greenwood (1969), p. 191. The income coefficient is very sensitive to the inclusion of the migratory stock variable. Also, see Edward Miller, "Determinants of Out-Migration," November 1971.

16. H. S. Parnes (1970), p. 30.

17. Lansing and Mueller (1967) p. 12. Comment added.

18. Lansing and Mueller (1976) p. 7.

19. Lansing and Mueller (1967) p. 39.

20. Lansing and Mueller (1967) p. 44. For example, the influence of race, which is highly correlated with education, is difficult to interpret.

21. The only references to characteristics of place are to (1) family ties, (2) community ties, and (3) a number of alternative measures of urbanization.

22. For examples, see reference 9 (above) and Peter A. Morrison, "Movers and Stayers: An Analysis Based on Two Longitudinal Data Files," Rand Corporation, Paper P-4409, December 1970. The Morrison paper includes some preliminary analyses using CWHS data and concentrates on chronic movers.

23. Charles E. Trott, "An Analysis of Out-Migration," paper presented at the annual meetings of the American Statistical Associations, Fort Collins, Colorado, August 25, 1971, and "Differential Responses in the Decision to Migrate," paper presented at the Regional Science Association meetings, Ann Arbor, Michigan, November 12, 1971.

24. The outlines of the contemplated National-Regional Impact Evaluation System (NRIES Model) are given in U.S. Department of Commerce, Office of Business Economics, "Toward Development of a National-Regional Impact Evaluation System and the Upper Licking Area Pilot Study," Staff paper in Economics and Statistics, No. 18 (March 1971) authored by Daniel H. Garnick, Charles E. Trott, Allan Olson, Henry Hertzfeld, and Vernon Fahle.

25. "State economic areas were originally delineated for the 1950 census. The 1960 set of State economic areas represented a limited revision of the 1950 areas in order to take into account changes in the definitions of standard metropolitan statistical areas and to create areas for Alaska and Hawaii. The 1970 set of State economic areas is the same as in 1960, except for the designation of Brown County, Wisconsin, as a separate SEA. Thus, there are 510 SEA's in 1970 instead of the 509 in 1960." U.S. Census of Population: 1970 PC(2)-2E "Migration Between State Economic Areas" Appendix A. The lack of revision of SEA boundaries for the 1970 Census suggests that this spatial grid is being phased out and will probably not be used in the 1980 Census.

26. U.S. Bureau of the Census, 1970 Census Users Guide, U.S. Government Printing Office, Washington, D.C., 1970, p. 93.

27. The data on residence in 1965 (1955) were derived from answers to questions asked of all persons in a 15 (25) percent sample of households in 1970 (1960).

28. The underestimate due to the death of the migrant before April 1, 1970 should be correlated with mortality rates--high relative underestimation for those cohorts with high mortality.

29. We do recognize that this assumption is not completely correct where many labor market conditions are determined simultaneously through the dynamic interaction of labor demand and supply.

30. The smallest SEA in our sample contained 7,797 households in 1970 and 6068 in 1960 while the largest contained 3,892,447 in 1970 and 3,453,032 in 1960. The 25 percent (1960) and 15 percent (1970) sampling procedures used for place of residence response should have resulted in approximately 1170 households being sampled from the smallest SEA in 1970 and 863,258 from the largest SEA in 1960.

31. W. Bowen and T. A. Finegan in The Economics of Labor Force Participation, (Princeton, Princeton University Press, 1969) occasionally used a similar procedure. Data for each decade are weighted equally even though it would appear appropriate to give the 1970 observations greater weight than those for 1960; the unresolved question is how much more 1970 data should be weighted.

32. U.S. Bureau of the Census, U.S. Census of Population: 1960, Subject Reports, Mobility for States and Economic Areas. Final Report PC(2)-2-B, and U.S. Census of Population: 1970, Subject Reports, Migration Between State Economic Areas Final Report PC(2)-2E.

33. While differences in propensities to migrate are frequently found in the raw data on white and nonwhite movers, after standardization for education, age, etc., most of the differences tend to disappear. In an earlier study (R. J. Olsen, "Migration To and From State Economic Areas in the Interior Southeast: An Experiment Using Pooled Cross-Section Data" The Review of Regional Studies, Volume III, Number 1, (1973), pp. 67-68) the percent nonwhite variable was included as a tentative "characteristic of persons" measure to see if any residual differences could be found. Generally, no racial difference in propensity to move could be found.

34. See W. E. Cullison "An Employment Pressure Index as an Alternative Measure of Labor Market Conditions," The Review of Economics and Statistics, Vol. LVII, No. 1 (February 1975), pp. 115-120.

35. As demarcated by the Regional Economics Division,
New England (1) = ME, NH, VT, MA, CT, RI
Mideast (2) = N.Y., PA, NJ, MD, DC, DL
Great Lakes (3) OH, IN, IL, MI, WI,
Southeast (4) = VA, WV, KY, TN, NC, SC, GA, AL, MS, FL, AR, LA
Plains (5) = MN, ND, SD, IA, KS, NE, MO,
Southwest (6) = OK, TX, NM, AZ
Mountain (7) = MT, CO, UT, ID, WY
Far West (8) = WA, OR, CA, NV, AK, HI

36. The simple intercorrelation coefficients from a transformed regression analysis were--

	CLIM	MS	R.POT	AF	COL	N-L EPI	P.DEN	Pooled
CLIM	1.00							
MS	-.08	1.00						
R.POT	-.52	.33	1.00					
AF	.21	.14	-.08	1.00				
COL	-.03	.69	.25	.07	1.00			
N-L EPI	.17	-.09	-.19	.34	-.12	1.00		
P.DEN	-.15	.40	.35	.02	.27	-.14	1.00	
Pooled	.00	.09	.21	-.00	.34	.04	.02	1.00

37. The college students variable has only been included in the first four age cohorts.

38. Beta coefficients are especially useful where the units of measurement vary among the variables so as to cloud their relative importances. A. S. Goldberger, Econometric Theory, New York: J. Wiley and Sons, Inc., 1964, pp. 197-200.

39. R. J. Olsen (1973)

40. The definition of male skills used was similar to that proposed by R. L. Raimon and V. Stoikov, "The Quality of the Labor Force," Industrial and Labor Relations Review, April 1967, pp. 391-413.

41. First for mild winters, a zero was assigned to SEA's with more than 3000 heating degree days per year, a one was assigned to SEA's with more than 1000 and up to 3000 heating degree days, and a two was assigned for 1000 or fewer degree days. Second for frequent sunshine, SEA's with less than 120 days with precipitation greater than .01 inches were assigned a one, zero otherwise. These two variables were then summed to form CLIM. All data were from The National Atlas of the United States of America (Washington, D.C.: U.S. Government Printing Office, 1970).

42. For CLIM these values were obtained by using coefficient values from Tables B-3.1 and B-3.4 and the mean values of dependent variables from Table B-3.3 as follows:

Dependent Variable (D.V.)	Δ in weighted D.V.	%Δ from mean of D.V.
INMIG 25-29 (M)	.080(1.00) = .080	(.080/1.164)100 = 6.9%
OUTMIG 25-29 (M)	.024(1.00) = .024	(.024/1.245)100 = 1.9%

43. The absolute values of the Beta coefficients averaged over the male age cohorts are .120 for inmigration and .074 for outmigration.

44. See G. Alperovich, J. Bergsman, and C. Ehemann, "An Econometric Model of Migration Between U.S. Metropolitan Areas" Working Paper #0974-4 Washington, D.C., The Urban Institute, April 1975 for some additional uses of the potential concept in migration analyses.

45. The specific form of the potential model used was

$$\text{Potential}_i = \sum_{j=1}^{171} M_j/D_{ij}$$

where D_{ij} = minimum time of truck transport in hours between the metropolitan centers of each pair of BEA areas, D_{ii} = 1/4 the access time to the nearest BEA center; and D_{ij} > 8.3 hours excluded. See Appendix H for a further discussion of these measures of accessibility.

M_j = the mass of BEA area j. In this application we have used population as the measure of mass.

These BEA area estimates were assigned to the metropolitan SEA's that were the centers of BEA areas, nonmetropolitan SEA's were assigned values by interpolation over space.

46. W. Alonso has argued that in the foreseeable future the dominant force shaping the overall U.S. population distribution will be the migratory cross-currents among metropolitan areas. See his "Policy Implications of Intermetropolitan Migration Flows," in Economic Development Administration, U.S. Department of Commerce, Proceedings of Regional Economic Development Research Conference, April 19, 1972, pp. 143-151, and "The System of Intermetropolitan Population Flows" pp. 323-334, in U.S. Commission on Population Growth and the American Future, Population Distribution and Policy, Sara Mills Mazie, Editor, Volume V of Commission research report's, Washington, D.C.: Government Printing Office, 1972.

47. The simple intercorrelation coefficients from a transformed regression analysis were –

	CLIM	MS	R.POT	AF	COL	N-L EPI	P.DEN	Pooled
REGION 1	.24	.06	.18	.02	.05	-.11	.03	.00
2	-.36	.20	.56	-.04	.09	-.08	.25	.00
4	.20	-.18	-.22	.08	-.18	.20	-.08	.00
5	.08	-.07	-.20	-.07	-.04	-.13	-.07	.00
6	.37	-.05	-.25	.07	-.01	.09	-.07	.00
7	-.01	-.06	-.25	-.01	.03	-.02	-.05	.00
8	.11	.11	-.20	.14	.13	.08	-.04	.00

48. We have initially defined the likely parent group to be the lower bound of an early age group plus 20 years to the upper bound of an early age groups plus 40 years. Thus, the parent age group for the 5-9 early age group has been defined as 25-49 years of age.

49. Chow, Gregory C.: "Tests of Equality Between Subsets of Coefficients in Two Linear Regressions," Econometrica 28 (1960), pp. 591-605. Also see Franklin M. Fisher, "Tests of Equality Between Sets of Coefficients in Two Linear Regressions: An Expository Note," Econometrica 38 (1970) pp. 361-366, and James L. Murphy, Introductory Econometrics, Homewood, Ill.: Richard D. Irwin, Inc., 1973, pp. 232-245. The present test was prepared by David Vogt of ORNL.

50. Current Population Reports series P-20 and series P-25 #473 as cited in the 1973 Statistical Abstract of the U.S., p.110. Two alternative projection series for college enrollments are developed (series E1 and E2). Under both series, age specific enrollment rates are assumed to continue to rise but series #1 assumes the relatively rapid historic growth rate will continue while series #2 assumes a more moderate growth (the average of #1 and actual 1970). Series E2 is included in the text.

51. Current Population Reports series P-25 #476 and series P-20 #243 as cited in the 1973 Statistical Abstract of the U.S., p. 114. Two alternative projections series of school attainment are developed (series 1 and 2). Series #2 assumes higher termination rates. Median values from series #2 estimates are included in the text.

Appendix C

LABOR FORCE PARTICIPATION

This appendix summarizes our latest econometric results on the subject of regional labor force participation and how it varies with changing socioeconomic conditions. The resulting age- and sex-specific labor participation rate functions estimated with pooled 1960 and 1970 Census data help to explain why simple concepts such as unemployment rates are frequently elusive targets for regional development planning.

C.1 REVIEW OF PAST STUDIES

Because more comprehensive reviews of the literature exist,[1] this survey of past research is brief and confined to a general commentary on the apparently meaningful associations that have been found between measures of labor force participation and changes in socioeconomic conditions.

C.1.1 Labor participation defined

Rather than study directly the absolute number of workers or man hours in the labor supply, most past studies have tried to explain "labor force participation rates." If the noninstitutionalized civilian population of working age (14 or more years old) is represented by P and the actual number of persons willing and able to work is designated by L, then

$$\text{Labor Force Participation Rate} = \frac{L}{P} \times 100.$$

It is this ratio of L to P, termed the (civilian) labor force participation rate (LPR), which economists have attempted to relate to a number of measures of changing conditions in the socioeconomic environment.

C.1.2 Data available to researchers

Since the general nature of the data used puts severe constraints on research strategy, a brief survey of data availability may improve the interpretation of comparative research results. Parnes (1970) finds it helpful to distinguish among five types of data available for the analysis of labor force participation. First, there are disaggregated cross-section data on the individual and family characteristics of individuals at one point in time. The One-in-a-Thousand Sample from the 1960 Census of Population[2] is a fine example of this type of data. Analytically useful measurements of the socioeconomic conditions within the respondent's local geographic area (e.g., the local unemployment rate), however, are not available from this source.

Second, there are aggregated cross-section data where the unit of observation is the county, state, or metropolitan area. The Census of Population compiles the majority of its findings in this fashion. Very useful measurements of general socioeconomic conditions for geographic areas are available from this source, but possibly important differences between individuals or small groups of individuals rapidly "wash out" as we aggregate to larger geographic areas.

Third, there are pooled cross-section data that approximate aggregate time-series data. The combined data for Knox County, Tennessee, from the 1940, 1950, 1960, and 1970 Census of Population would be a good example. The pooled data by necessity will contain the strengths and weaknesses of the individual component cross-sections with the additional loss of some useful information caused by changing definitions over time.

Fourth, a growing number of longitudinal studies which generate repeated observations over time of the characteristics of the same individuals may prove very useful in reconstructing the labor force decisions made by an individual or group of individuals over time. The Social Security Administration's Continuous Work History Sample[3] of one-in-hundred Social Security card-holders is a good example.

Finally, there are true aggregate time-series data most closely approached by the labor force, employment, and earnings statistics published by the U.S. Department of Commerce in the monthly Survey of Current Business. The main disadvantages of this type of data are its lack of geographic detail and complementary series on social conditions.

C.1.3 Results of time-series studies

Given this variety of data resources and the definition of labor force participation rates (LPR), what are some of the general associations that have been found? Most researchers have tended to subdivide their sample by race, sex, age, marital status, etc., and then relate the LPR of each subgroup to economic variables such as unemployment rates and wage rates. Thus, after standardizing for selected sociocultural conditions, the greatest amount of attention has been paid to how sensitive various components of the labor supply have been to general labor market conditions. The theoretical rationale of labor participation sensitivity to market conditions is contained in two hypotheses. The "discouraged worker" hypothesis suggests a positive relationship between labor participation and labor market tightness; during slack times some (marginal or secondary) persons already in the labor force will become discouraged about employment prospects and choose to drop out completely. Simultaneously, those persons who would otherwise be entering the labor force are so discouraged about job prospects that they postpone their entrance to avoid the social stigma of unemployment. The "additional worker" hypothesis suggests that unemployment of primary breadwinners within a family will cause other family members, wives, children, and the elderly, to seek employment, causing the size of the unemployed and the labor force to increase. While the first hypothesis suggests a positive and the second a negative correlation between labor market tightness and labor force size, there is no reason why the two hypotheses cannot coexist.

In fact, analysis using monthly time-series data seems to strongly confirm both hypotheses. Altman[4] found a positive correlation between gross additions to the labor force of married women and the unemployment rate for married men. Dernburg and Strand[5] appear to have found very strong evidence of both the discouraged- and the additional-worker hypotheses — the first from a statistically significant positive relationship between labor participation[6] and the employment to population ratio (a measure of labor tightness) and the second from a significant positive relation between labor participation and a relative measure of unemployment compensation exhaustions[7] which is supposed to represent the pressure on additional workers to enter the labor force. In addition, the positive sensitivity of LPR to labor market tightness seems to hold for all age-sex groups except for prime-aged (25-54) males.

An examination of annual time-series data by Mincer (1966) has led him to observe that (1) powerful trend factors and institutional changes dominate the behavior of labor force groups, (2) disaggregation seems to yield less clear response patterns, and (3) nonwhite female participation varies inversely with the business cycle. From these observations together with other scattered information, Mincer concludes that "the 'additional worker' is more likely to be a low-income person than the 'discouraged worker'."[8]

C.1.4 Results of cross-section studies

While studies based on cross-section data seem to have been most successful in the sense that less unexplained variation in participation rates remains after the analysis, there does seem to be some confusion as to their interpretation. For example, almost all cross-section analyses yield strong negative relationships between labor participation and unemployment, but does this represent a short-run reaction of participation to temporarily high or low unemployment? Bowen and Finegan felt the strong evidence of the discouraged worker effect found in their cross-section analysis "...raise serious doubts whether the additional worker effect dominated the participation response of any demographic group, regardless of how narrowly it might be defined."[9] On the other hand, Mincer has argued[10] that interarea differences in unemployment rates represent long-run rather than short-run (transitory) differences between areas. He further argues that the application of cross-section parameters to the forecasting of behavior over time would strongly overestimate many of the participation responses. Fortunately, Parnes[11] senses increasing agreement among economists that cross-section analysis alone cannot completely explain short-term, transitory movements in labor participation.

A large portion of the explanatory ability of cross-section analysis is probably due to the relatively abundant supply of useful measurements on possible explanatory variables. While these data may not always match the definitions preferred by the investigator, the definitions are usually close enough to permit standardizing for many differences in the socioeconomic environment. Thus, from cross-section analysis we have learned that education, marriage (for males), good health, etc., raise labor participation and that marriage and children and the high cost of domestic servants lower labor participation of females. Among the most interesting explanatory variables included in cross-section analysis has been Bowen and Finegan's constructed "industry-mix" variable which attempts to measure the "feminity" or "masculinity" of an area's industrial structure. They concluded that a more feminine industry mix leads to higher female labor participation.

In sum, progress does seem to have been made. A number of apparently meaningful relationships have been derived from both time-series and cross-section data which support the general contention that we do in fact have a "flexible" labor supply - one which seems to vary in understandable ways with changes in the socioeconomic environment. Yet the intrinsic nature of social science research makes us more confident about stating the existence of these relationships than about interpreting some of them.[12]

C.2 RESEARCH METHODS

C.2.1 Census data for BEA economic areas

Our analysis has been confined to cross-section data from the 1960 and 1970 Census of Population cumulated to the 173 BEA economic areas. Thus, the definitions used for employment, unemployment, labor force, etc., are those of the U.S. Census of Population:[13]

> Employed - Employed persons comprise all civilians 14 years old and over who were either (a) "at work"--those who did any work for pay or profit, or worked without pay for 15 hours or more on a family farm or in a family business, or (b) were not looking for work but had a job or business from which they were temporarily absent because of bad weather, industrial dispute, vacation, illness, or other personal reasons.
>
> Unemployed - Persons are classified as unemployed if they were civilians 14 years old and over and not "at work" but looking for work. A person is considered as looking for work not only if he actually tried to find work during the reference week but also if he had made such efforts recently (i.e., within the past 60 days) and was waiting the results of these efforts. ...Persons waiting to be called back to a job from which they had been laid off or furloughed were also counted as unemployed.
>
> Labor Force - The labor force includes all persons classified as employed or unemployed...and also members of the Armed Forces. ...The "civilian labor force" comprises only the employed and unemployed components of the labor force.

Not in Labor Force - This category consists of all persons 14 years old and over who are not classified as members of the labor force...

Table C-2.1 summarizes the variability in labor participation rates among the BEA areas of our sample. One should note the relative stability of labor participation of males aged 25 through 64 and the relative instability of all other age groups. It is this variability which we seek to relate to changing socioeconomic conditions.

Table C-2.1. Variability of LPR within BEA economic areas 1960 and 1970 data

Age Group	Range Low	Range High	Mean ($\bar{X}$)	Standard Deviation (s)	Coefficient of Variation ($s/\bar{X}$)
Males					
14-17	11.9	43.9	26.7	6.1	.23
18-24	53.1	94.9	76.5	7.3	.10
25-34	84.9	99.1	94.2	2.3	.02
35-44	86.9	98.2	94.9	2.1	.02
45-64	73.3	93.9	87.1	4.0	.05
65 & over	12.7	43.3	28.0	5.6	.20
Females					
14-17	5.0	26.6	14.6	4.9	.34
18-24	28.4	64.1	45.9	7.2	.16
25-34	23.1	61.3	39.1	7.4	.19
35-44	28.2	65.5	45.9	6.6	.14
45-64	25.4	57.0	43.0	5.5	.13
65 & over	4.5	18.5	10.0	1.8	.18

C.2.2 The basic model

As a starting point a simple single-equation model of labor participation is postulated where the direction of causation is assumed[14] to run from the independent variables (right side) to the dependent variable (left side), labor participation rate. Symbolically the model is

(Model I) $$LPR = f(T, B, Op., Sp., u).$$

LPR represents labor participation rates as reflected in census definitions and calculated above. T is some measure of labor market tightness perhaps measured by the unemployment rate. B represents a measure of the benefits of working such as a measure of monetary reward (e.g., the money wage rate). Op. is a measure of work opportunities reflected perhaps in the area's population density. Sp. is a measure of special conditions affecting regional labor participation such as percent of the population enrolled in school. u is a random variable that represents omitted explanatory variables, measurement errors in LPR, and the basic random element in human behavior. *A priori*, economic theory suggests a positive correlation between LPR and most of the explanatory variables, T, B, and Op. The nature of the relationship between LPR and Sp. would vary from one special circumstance to another.

While it appears appropriate to fit Model I separately to the 1960 and 1970 cross-section data for BEA economic areas, the attractiveness of augmenting the variation over space contained in cross-section data with some variation over time suggests that Model I be modified to use pooled cross-section data. The revised model is

(Model II) LPR = g(T, B, Op., Sp., Pooled, u).

The Pooled variable is a shift factor which takes on the value 0 for observations during 1960 and the value 1 for observations during 1970. A more complete rationale for this procedure was discussed in Chapter 4.

C.2.3 A revised model: region versus nation

During the decade of the 1960's the most striking change in labor force participation patterns was the very rapid increase in participation by women against a backdrop of continued but less dramatic declines by men. Much of the very rapid increase in female participation has been associated with drastic declines in the birth rate and some delay in marriage among other factors.[15] However, since special circumstances like the decline in the birth rate are not expected to continue, official projections propose much less dramatic change during the next two decades; the increase in female labor participation is expected to be moderate. These nonlinear secular trends in national labor participation, which can be seen in Fig. C-1 and Table C-2.2, have important implications for our regional analyses.

We have pooled data from two successive censuses for reasons already mentioned to create a psuedo time-series analysis, albeit one with observations at only two points in time. However, two points can not uniquely determine a nonlinear trend; Model II can only yield a linear estimate of a secular trend. In fact, the empirical results for Model II do include statistically significant negative trend coefficients for males of all ages and positive trend coefficients for females aged 18 to 34.

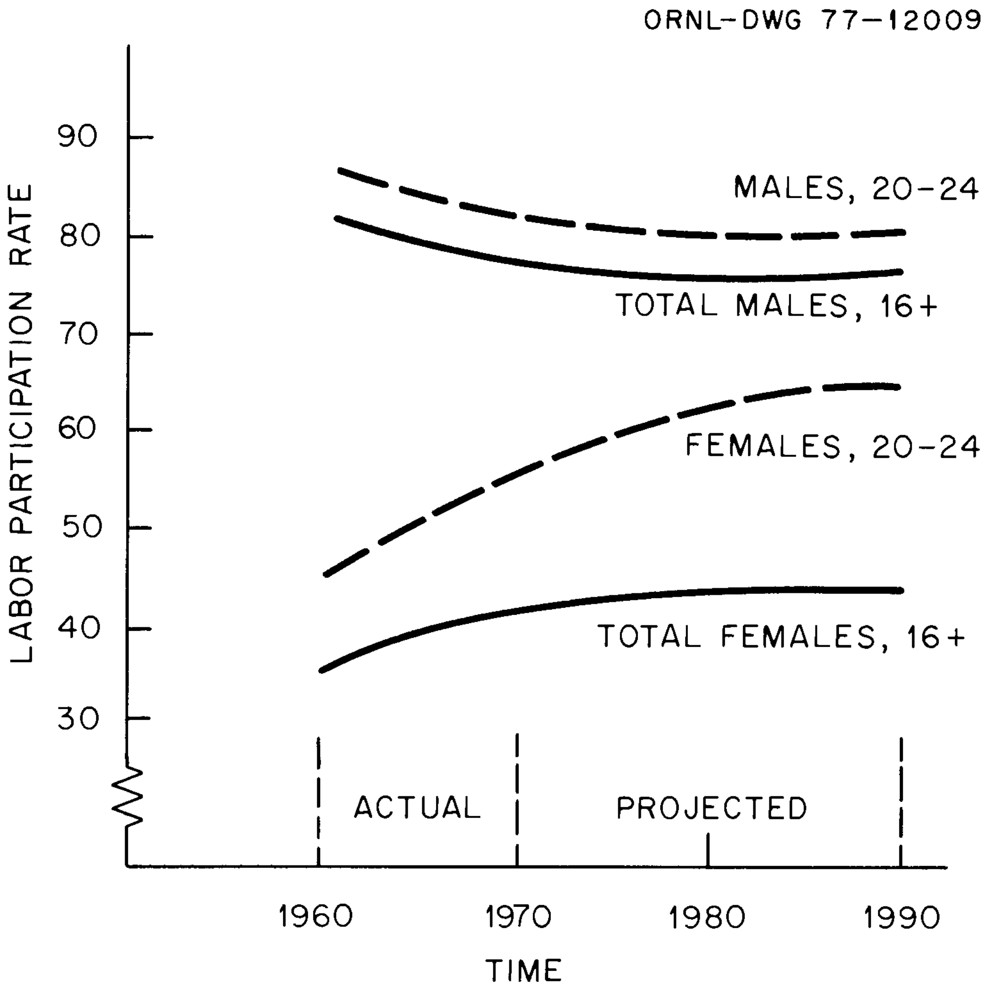


Fig. C-1. National labor force participation trends for selected age-sex groups: 1960-1990.

Table C-2.2. National labor force participation trends by age and sex, 1960 to 1990

Age-sex cohort	Labor force participation rates*				
	Actual		Projected		
	1960	1970	1980	1985	1990
Males					
Total, 16 years & over	82.4	79.2	78.0	78.3	78.4
16 to 19 years	58.6	57.5	56.0	55.5	55.4
20 to 24 years	88.9	85.1	83.0	82.5	82.1
25 to 34 years	96.4	95.0	94.6	94.4	94.4
35 to 44 years	96.4	95.7	95.1	94.9	94.7
45 to 54 years	94.3	92.9	91.9	91.7	91.5
55 to 64 years	85.2	81.5	79.1	78.1	77.5
65 years & over	32.2	25.8	21.2	20.0	19.3
Females					
Total, 16 years & over	37.1	42.8	45.0	45.6	45.9
16 to 19 years	39.1	43.7	45.5	46.4	47.0
20 to 24 years	46.1	57.5	63.4	64.9	66.2
25 to 34 years	35.8	44.8	50.2	50.9	51.5
35 to 44 years	43.1	50.9	53.2	54.4	55.2
45 to 54 years	49.3	54.0	56.2	57.4	58.0
55 to 64 years	36.7	42.5	44.7	45.4	45.8
65 years & over	10.5	9.2	8.6	8.5	8.3

* BLS definition

Source: Denis F. Johnston, "The U.S. Labor Force: Projections to 1990," Monthly Labor Review, July 1973, pp. 3-13. Reprinted as U.S. Bureau of Labor Statistics, Special Labor Force Report #156.

However, as Fig. C-2 illustrates, the use of these linear trend coefficients during a projection period would underestimate the future participation of males and overestimate that of females.

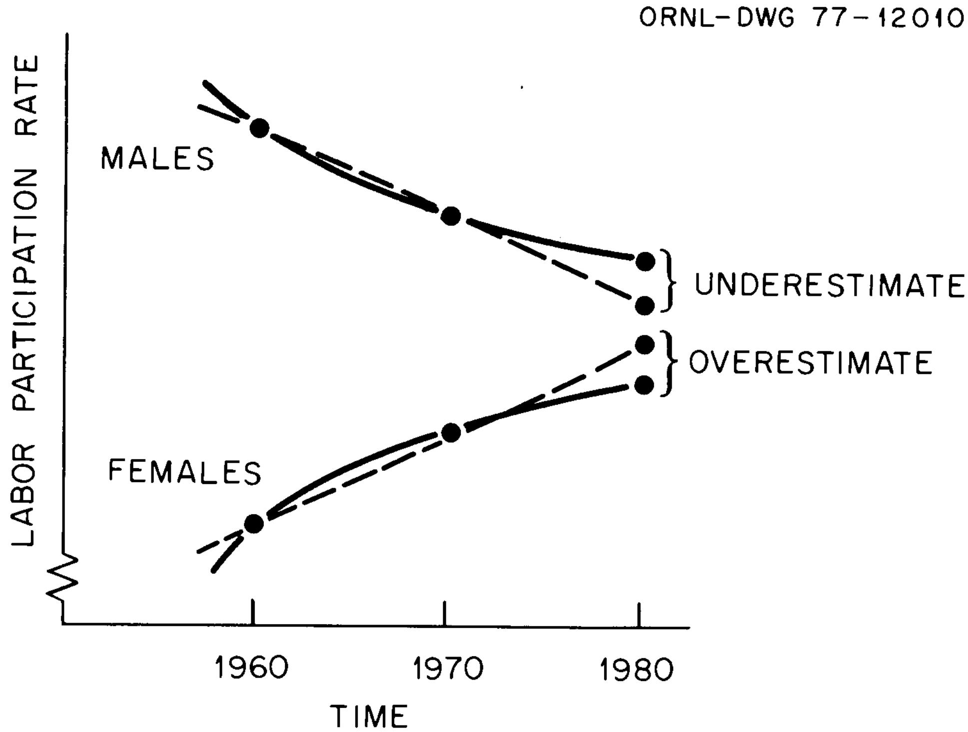


Fig. C-2. The effect of a linear trend coefficient on LPR projection.

Since the option of estimating a nonlinear trend is foreclosed by the absence of age-specific participation data for regions in the 1950 Census of Population, we have assumed that regional secular trends generally follow national trends and have concentrated on explaining the deviation of regions from national norms through the use of a revised Model III. The revised model is

$$\text{(Model III)} \qquad \frac{\text{LPR (Region)}}{\text{LPR (Nation)}} = \text{LPR Relative} = h(\text{T, B, Op., Sp., Pooled, u}).$$

During a projection period we will carry nonlinear secular trends embodied in national projections over to regions through the LPR Relative variable.

C.3 POOLED CROSS-SECTION RESULTS BY AGE AND SEX

Our latest results with Model III are reported in Tables C-3.1 and C-3.3. They include as explanatory variables the employment pressure index (EPI),[16] median years of school completed by persons 25 years old and over (MS), female industry mix (FIM), Armed Forces personnel as a percent of the population (A.F.), college students as a percent of the population (COL), and regional dummy variables for all subregions of the nation (except the Great Lakes) as defined in Fig. C-3.[17] The regional dummy variables were included at the last stage of the analysis as measures of longer term regional conditions (relative to the Great Lakes = 0) not captured by any of the other explanatory variables. Finally, the magnitude of the coefficients in Table C-3.1 are not sufficient to establish the relative importance of each explanatory variable because the units of measurement vary among the variables. Thus, Beta coeffients which indicate the percent of a "typical" variation (one standard deviation) in the dependent variable associated with a "typical" variation (one standard deviation) in the explanatory variable are reported in Table C-3.2.

The employment pressure index (EPI) is our preferred measure of labor market tightness. Its positive sign implies that a tight labor market will be associated with high labor force participation. The size of the EPI coefficients plus its range of variation in the sample suggest that its overall impact on male and female LPR can be significant, especially for discretionary workers (all age-sex groups except males aged 25 to 64). The average absolute values of the EPI Beta coefficients across the twelve age-sex cohorts is .578 which indicates that 57.8% of a standard deviation change in the dependent variable was associated with a standard deviation variation in EPI. One can consider these results to be evidence of the discouraged worker effect.

Median years of school completed by persons 25 years old and over (MS) appears to be a good measure of the long-term benefits of working (or the costs of not working). Since long-term market wage rates are highly correlated with median schooling, one could interpret the positive coefficient as saying that an increase in median schooling implies an increase in average skill and wage levels which are more directly responsible for drawing more persons into the labor force. Of course other interpretations are possible. One could argue that more highly educated individuals by nature are more motivated and that this motivation is translated into higher levels of labor participation. Whichever interpretation one chooses, there does appear to be a statistically significant positive relationship between labor participation and education level for prime aged males (18-44) and young (14-17) females. In terms of coefficient size, however, the relationship is generally weak; the average absolute value of the Beta coefficients for MS is only .160.

Statistically significant negative associations between LPR and education (MS) are apparent for females aged 25 through 44 and males 65 and over. We might try to rationalize these results as follows: (1) a substantial number of females living in areas of high median schooling are financially

Table C-3.1. Labor force participation rate functions with regional shifts
Dependent variable = local LPR/national LPR
BEA economic areas: 1960 and 1970 data

				Explanatory variables						Regional shift variables (Great Lakes = 0)						
Dependent variable	$\bar{R}^2$	F value*	Intercept	EPI	COL	AF	MS	FIM	Pooled	Reg. 1 N. Eng.	Reg. 2 M. Atl.	Reg. 4 S.E.	Reg. 5 Plains	Reg. 6 S.W.	Reg. 7 Mtn.	Reg. 8 F. West
Males																
14-17		76.8	-.639	3.786	0.021	0.001	-0.001	-0.020	0.010	-0.041	-0.143	-0.058	0.127	0.004	0.180	0.063
	.741		(-4.424)	(16.733)	(3.453)	(0.302)	(-0.123)	(-5.216)	(0.370)	(-1.028)	(-5.117)	(-2.073)	(5.753)	(0.156)	(5.860)	(2.286)
18-24		119.1	0.434	0.960	-0.040	0.017	0.010	-0.002	0.068	-0.067	-0.047	-0.023	-0.013	-0.003	-0.009	+0.011
	.817		(9.478)	(13.380)	(-21.114)	(14.878)	(3.081)	(-1.996)	(7.805)	(-5.251)	(-5.328)	(-2.571)	(-1.917)	(-0.799)	(-1.244)	(1.168)
25-34		35.7	0.830	0.284	-0.008	0.0003	0.008	-0.002	0.017	0.002	-0.001	-0.002	-0.006	-0.003	-0.009	-0.011
	.566		(43.562)	(9.504)	(-10.084)	(0.778)	(5.483)	(-4.340)	(4.820)	(0.322)	(-0.336)	(-0.597)	(-2.104)	(-0.925)	(-2.166)	(-2.948)
35-44		44.8	0.823	0.266	-0.001	-0.0003	0.007	-0.002	0.003	-0.001	-0.0002	-0.009	-0.004	-0.004	-0.006	-0.007
	.622		(49.695)	(10.256)	(-1.542)	(-0.868)	(6.008)	(-4.126)	(0.904)	(-0.267)	(-0.073)	(-2.875)	(-1.668)	(-1.452)	(-1.611)	(-2.208)
45-64		78.6	0.692	0.661	0.003	-0.001	0.002	-0.004	0.006	-0.004	0.006	-0.035	-0.007	-0.010	-0.0003	-0.007
	.745		(25.229)	(15.374)	(2.687)	(-1.946)	(1.178)	(-5.310)	(1.166)	(-0.523)	(1.507)	(-6.531)	(-1.789)	(-2.158)	(0.050)	(-1.295)
65 & over		33.2	-0.220	3.708	0.022	0.004	-0.054	-0.019	0.135	0.039	0.039	0.061	0.112	0.189	0.140	0.043
	.548		(-1.501)	(16.152)	(3.604)	(1.100)	(-5.104)	(-4.912)	(4.838)	(0.947)	(1.375)	(2.139)	(4.999)	(7.529)	(4.506)	(1.519)
Females																
14-17		82.7	-1.063	3.378	0.012	-0.016	0.032	-0.008	-0.089	0.138	-0.168	-0.241	0.269	-0.165	0.273	0.033
	.755		(-5.062)	(10.268)	(1.425)	(-3.110)	(2.081)	(-1.411)	(-2.224)	(2.363)	(-4.135)	(-5.937)	(8.404)	(-4.590)	(6.109)	(0.820)
18-24		56.3	-0.412	1.520	-0.008	-0.016	-0.008	0.016	-0.068	-0.063	0.007	-0.110	-0.024	-0.127	-0.081	-0.053
	.676		(-5.013)	(11.817)	(-2.362)	(-7.890)	(-1.284)	(8.358)	(-4.386)	(-2.747)	(0.419)	(-6.960)	(-1.886)	(-9.043)	(-4.651)	(-3.373)
25-34		104.5	-0.774	1.987	0.003	-0.016	-0.035	0.028	-0.123	-0.052	-0.006	0.121	-0.067	0.041	0.015	0.092
	.796		(-10.020)	(16.412)	(0.868)	(-8.755)	(-6.205)	(13.457)	(-8.390)	(-2.432)	(-0.395)	(8.109)	(-5.653	(3.092)	(0.907)	(6.257)
35-44		89.0	-0.672	1.911	-0.001	-0.012	-0.010	0.018	-0.082	0.010	-0.002	0.084	-0.071	0.023	0.024	0.076
	.768		(-10.437)	(18.955)	(-0.251)	(-7.988)	(-2.132)	(10.666)	(-6.694)	(0.566)	(-0.199)	(6.744)	(-7.275)	(2.049)	(1.787)	(6.160)
45-64		133.0	-0.665	2.039	0.007	-0.006	0.002	0.012	-0.088	0.065	0.023	-0.014	-0.046	-0.022	0.023	0.037
	.833		(-12.736)	(24.935)	(3.075)	(-4.366)	(0.510)	(8.250)	(-8.915)	(4.505)	(2.318)	(-1.382)	(-5.793)	(-2.463)	(2.086)	(3.690)
65 & over		28.3	-0.603	3.008	0.013	0.006	-0.001	-0.009	0.035	0.090	0.033	-0.021	0.042	0.035	0.046	-0.009
	.507		(-3.871)	(12.334)	(2.022)	(1.695)	(-0.089)	(-2.243)	(1.188)	(2.070)	(1.094)	(-0.709)	(1.792)	(1.321)	(1.386)	(-0.302)
Explanatory variables $\bar{X}$				.614	2.490	1.235	10.971	34.052	.5							
s				.038	1.53	2.10	1.15	3.99								

*Degrees of freedom = 13,332.

Table C-3.2 Beta coefficients, labor force participation rate functions with regional shifts
Dependent variables, local LPR/national LPR
BEA economic areas: 1960 and 1970 data

Dependent variable	Explanatory variables						Regional shift variables (Great Lakes = 0)						
	EPI	COL	AF	MS	FIM	Pooled	Reg. 1 N. Eng.	Reg. 2 M. Atl.	Reg. 4 S.E.	Reg. 5 Plains	Reg. 6 S.W.	Reg. 7 Mtn.	Reg.8 F. West
Males													
14-17	.637	.139	.010	-.006	-.352	.022	-.030	-.172	-.112	.192	.006	.185	.082
18-24	.429	-.716	.405	.136	-.113	.395	-.131	-.151	-.117	-.054	-.025	-.033	.035
25-34	.468	-.526	.033	.372	-.379	.375	.012	-.015	-.042	-.091	-.044	-.088	-.138
35-44	.472	-.075	-.034	.381	-.336	.066	-.010	-.003	-.188	-.067	-.065	-.061	-.096
45-64	.581	.107	-.063	.061	-.356	.070	-.015	.035	-.351	-.059	-.079	.002	-.046
65 & over	.813	.192	.047	-.354	-.438	.385	.037	.061	.153	.221	.367	.187	.072
Females													
14-17	.380	.056	-.098	.106	-.093	-.130	.068	-.135	-.313	.273	-.165	.187	.029
18-24	.504	-.107	-.286	-.075	.632	-.295	-.091	.016	-.422	-.070	-.373	-.164	-.136
25-34	.555	.031	-.252	-.289	.807	-.448	-.064	-.012	.390	-.168	.101	.025	.200
35-44	.683	-.010	-.245	-.106	.681	-.381	.016	-.006	.347	-.230	.071	.053	.210
45-64	.763	.100	-.114	.022	.448	-.431	.107	.063	-.060	-.156	-.073	.053	.107
65 & over	.648	.112	.076	-.006	-.209	.099	.084	.051	-.053	.083	.067	.060	-.015

Table C-3.3. Labor force participation rate functions without regional shifts
Dependent variable = local LPR/national LPR
BEA economic areas: 1960 and 1970 data

Dependent variable	$\bar{R}^2$	F value*	Explanatory Variables: Intercept	EPI	COL	AF	MS	FIM	Pooled
MALES									
Male 14-17	0.653	109.315	-0.551	4.049	0.031	0.007	0.020	-0.036	0.063
			(-3.538)	(17.824)	(4.629)	(1.779)	(2.044)	(-10.363)	(2.172)
Male 18-24	0.786	212.017	0.473	0.950	-0.039	0.018	0.013	-0.005	0.078
			(10.255)	(14.125)	(-19.668)	(16.015)	(4.376)	(-4.841)	(9.001)
Male 25-34	0.557	73.339	0.828	0.302	-0.008	0.00001	0.006	-0.002	0.018
			(46.089)	(11.521)	(-10.435)	(0.023)	(5.365)	(-5.227)	(5.476)
Male 35-44	0.613	92.163	0.808	0.294	-0.0007	-0.0007	0.008	-0.002	0.004
			(51.711)	(12.919)	(-0.997)	(-1.693)	(7.976)	(-6.602)	(1.416)
Male 45-54	0.700	134.861	0.629	0.732	0.005	-0.002	0.009	-0.006	0.008
			(22.643)	(18.079)	(3.889)	(-2.801)	(5.176)	(-9.651)	(1.476)
Male 65+	0.443	46.732	1.701	3.514	0.022	0.009	-0.053	-0.021	0.146
			(0.112)	(15.888)	(3.443)	(2.316)	(-5.556)	(-6.315)	(5.145)
FEMALES									
Female 14-17	0.068	90.317	-1.459	4.691	0.037	-0.016	0.090	-0.043	0.011
			(-5.896)	(18.000)	(3.535)	(-2.669)	(5.796)	(-7.872)	(0.238)
Female 18-24	0.563	75.000	-0.670	1.964	-0.003	-0.021	0.003	0.012	-0.054
			(-7.532)	(15.153)	(-0.870)	(-9.428)	(0.509)	(6.269)	(-3.246)
Female 25-34	0.682	124.130	-0.571	1.292	-0.006	-0.012	-0.044	0.040	-0.167
			(-6.343)	(9.849)	(-1.670)	(-5.255)	(-7.876)	(19.890)	(-9.896)
Female 35-44	0.643	104.562	-0.571	1.344	-0.008	-0.009	-0.013	0.028	-0.125
			(-7.656)	(12.373)	(-2.507)	(-4.953)	(-2.688)	(17.069)	(-8.985)
Female 45-64	0.777	201.344	-0.790	1.884	0.005	-0.006	0.015	0.014	-0.117
			(-14.060)	(23.034)	(2.158)	(-4.157)	(4.347)	(11.252)	(-11.171)
Female 65+	0.496	57.686	-0.664	3.141	0.015	0.006	0.007	-0.012	0.039
			(-4.526)	(14.682)	(2.453)	(1.535)	(0.720)	(-3.755)	(1.432)

*Degrees of freedom = 6,339.

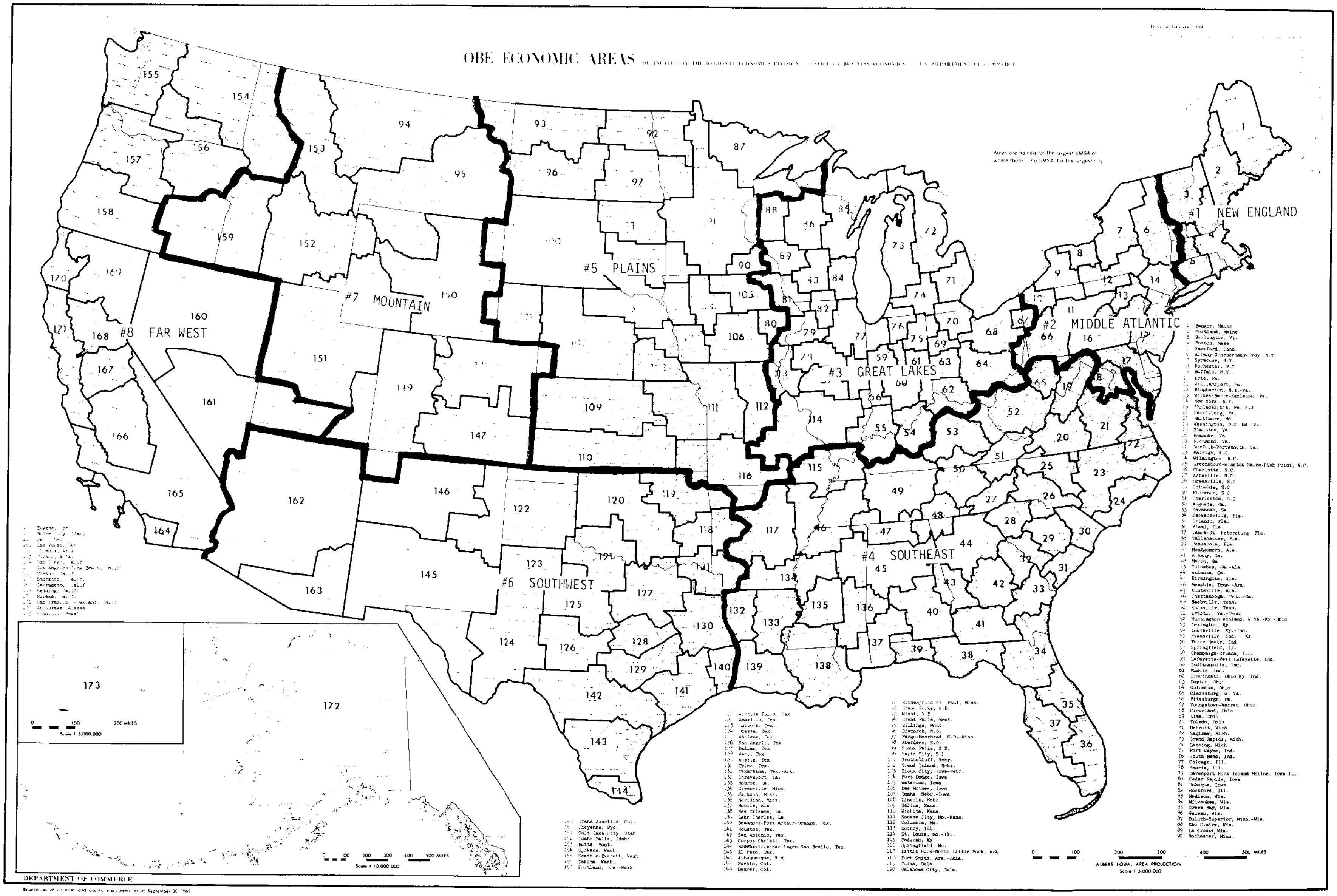


Fig. C-3. Subregions of the U.S.

able to not work during their primary child rearing years while females living in areas of low median schooling cannot afford to stay at home and (2) some older males living in areas of high median schooling are financially able to not work in their later years. The impact of these effects can be fairly substantial; a standard deviation increase in median schooling would be associated with 28.9% of a standard deviation decrease in participation by females aged 25 to 34.

We originally thought the opportunity to work (somehow measured) would be very important in explaining <u>female</u> labor participation because of the rural and remote nature of many of the BEA areas in our sample. We thought either of two measures, percent of the population living in urbanized areas or population density, would capture the assumed greater work opportunities for women in urbanized areas, but our industry mix variable, which attempts to measure the "feminity" of an area's industrial structure, has shown to be much more important. We originally defined Female Industry Mix in a manner identical to Bowen and Finegan (1969).

$$\text{Female Industry Mix}_j = \frac{\sum_i \text{Total Emp}_{ij} \times \text{NFF}_i}{\sum_i \text{Total Emp}_{ij}}$$

where Total Emp_{ij} represents total employment in industry i in region j and NFF_i is the fraction of national employment in industry i that is female. Female Industry Mix by this definition would be interpreted as the fraction of local employment that one would <u>expect</u> to be held by females, given the area's industry mix. As our work progressed, however, the "actual percent of employed persons that are female" proved to be a simple and superior (within MULTIREGION) substitute for Bowen and Finegan's more complex variable.

Perhaps the most pleasant surprise of our empirical efforts has been the importance of FIM in explaining LPR. While apparently of less importance to male participation than to female participation, the effect is important to both. Again measured by Beta coefficients, a one standard deviation increase in female industry mix is associated with an 80.7% of a standard deviation increase in participation by females aged 25 to 34. The same increase in FIM would be associated with 40% of a standard deviation decrease in participation by males aged 14 to 17 and 65 and over.

Two special conditions considered in the analysis were the presence in a region of significant college or Armed Forces populations. <u>A priori</u>, either or both of these conditions should impact the LPR of persons aged 18 to 24 most significantly. Since attendance at college is a rather full time endeavor, the presence of a large college population should reduce the participation rate of persons of college age. Indeed there is a statistically significant negative association between "college students as a percent of the population" (COL) and the participation of males aged 18 to 24 (Beta coefficient = -.716). As an aside, the presence of large college populations do seem to raise, albeit by a small amount, the participation of older persons (aged 45 or more) and of males aged 14 to 17.

Since the age-sex specific LPR data provided by the Censuses of Population include Armed Forces personnel who have effective participation rates of 100% as part of the labor supply, one should expect the participation rates of prominent Armed Forces age-sex cohorts[18] to be above average. In fact, the results for males aged 18 to 24 are positive and statistically significant. However, a negative association does exist between LPR and the presence of a large Armed Forces population for all females and for males aged 45 to 64. This is probably due to the inclusion of Armed Forces in the numerator of the employment pressure index (EPI). This measure of market tightness may overstate the demand for discretionary labor force members in regions with high concentrations of Armed Forces personnel.

The trend effect as represented by the coefficient of the "pooled" variable needs careful attention. Since the dependent variable in Model III is relative (regional/national) LPR, a negative pooled coefficient does not imply declining participation (negative secular trend) over time; the secular trend is embedded in national values (the demoninator of the dependent variable). A negative coefficient does imply a trend toward more BEA areas with LPR rates below the national average whereas a positive coefficient implies a trend toward more BEA areas with LPR rates above the national average. In our empirical results negative coefficients were associated with female LPR functions and positive values with males. If these trends persist, a majority of BEA areas would have male participation above and female participation below the national average.

In the last stage of our analysis regional dummy variables were included to capture the effects of longer term regional conditions (relative to the Great Lakes = 0) not captured by any of the other explanatory variables. The regional dummy variables did contribute substantially to the overall explanatory power of the LPR functions of discretionary labor groups (all groups except males aged 25 to 44).[19] Since the regional dummy variables had only limited intercorrelations with the previously included explanatory variables,[20] their significance was generally not at the cost of other variables. The results, however, are hard to generalize across regions. Relative to the Great Lakes region, (1) the participation of the youngest and oldest age groups is higher in the Plains and Mountain regions, (2) the participation of young females aged 14 to 24 is lower in the Southeast and Southwest regions, (3) participation is generally higher in the Far West, and (4) generally lower for young males and females aged 14 to 24 in the New England and Middle Atlantic regions.

C.4 A SIMPLE CHOW TEST: IS POOLING APPROPRIATE?

While it does not completely resolve the issue, we have performed a simple Chow test[21] to determine if the two subsets (cross-section estimates) could have been drawn from the same population. Thus, the null hypothesis is that the coefficients from the two cross-sections are not significantly different

$$H_o: \beta_i^{60} = \beta_i^{70} \quad ,$$

and the alternative hypothesis is that at least one of the coefficients is significantly different

$$H_1: \beta_i^{60} \neq \beta_i^{70} \quad .$$

The test does not resolve the issue of the appropriateness of pooling cross-sections because a slightly revised model including selected slope interactive dummy variables would reverse the results in the case where only a few coefficients were significantly different between the subsets (cross-sections). The results of these simple Chow tests applied to the labor force participation equations are found in Table C-4.1. The results simply suggest that pooling may not be appropriate - that at least one of the coefficients is significantly different. Since we have been unable to test this hypothesis more completely by experimenting with interactive dummy variables attached to particular coefficients, we have tabulated the results of the most recent 1970 cross-section estimates (Table C-4.2) which could be considered as a first (although not a preferred) alternative to the pooled results in their present form. As time permits, we will reappraise the appropriateness of the pooled model through tests of interactive dummy variables.

C.5 COMPUTATION SEQUENCE: LABOR SUPPLY

In MULTIREGION we assume that labor supply adjusts to regional socio-economic conditions contemporaneously (i.e., without a lag). But, the decision to use the employment pressure index (EPI) as the measure of labor market tightness within MULTIREGION makes the comparison of labor supply and demand less important than the direct comparison of people and jobs (EPI) for the determination of regional economic conditions. As a result, regional labor supplies are estimated after all other conditions have been determined; a multi-stage computation process is not necessary. The labor supply computations that are required within MULTIREGION may be divided into four phases.

Table C-4.1. Chow test for equality of subsets of coefficients: labor force participation.

Equation	F	Prob. F/H_o
Males:		
14-17	4.0072	.0000
18-24	5.0479	.0000
25-34	2.0865	.0174
35-44	1.8333	.0418
45-64	2.6011	.0029
65 and over	0.6942	.7581*
Females:		
14-17	1.5146	.1169*
18-24	3.1266	.0005
25-34	6.4555	.0000
35-44	4.6640	.0000
45-64	2.1909	.0120
65 and over	1.2891	.2228*

*Cannot reject the null hypothesis that the slope coefficients in the two regressions are the same (at the 5% level).

Table C-4.2 Labor force participation rate functions with regional shifts
Dependent variable = local LPR/national LPR
BEA economic areas: 1970 data

	$\bar{R}^2$	F. Value (d.c.)	Inter-cept	EPI	COL	AF	MS	FIM	Regional Shift Variables (Great Lakes = 0) 1 NE	2 ME	4 SE	5 PL	6 SW	7 MT	8 FW
Males															
14-17	.792	50.78	-.98	3.225	.008	-.010	.043	-.013	-.05	-.13	-.08	.10	-.02	.14	.06
			(-4.75)	(11.88)	(1.26)	(-2.43)	(2.95)	(-2.64)	(-.95)	(-3.84)	(-2.36)	(3.76)	(-2.77)	(3.86)	(1.92)
18-24	.863	84.20	.44	1.051	-.034	.020	.010	.003	-.07	-.05	-.02	-.02	-.01	-.02	.01
			(6.23)	(11.29)	(-15.45)	(13.94)	(2.07)	(-1.81)	(-4.19)	(-4.40)	(-1.80)	(-2.38)	(-.57)	(-1.28)	(1.14)
25-34	.602	20.14	.83	.274	-.007	.000	.007	-.001	-.00	-.01	-.01	-.01	-.01	-.01	-.02
			(27.08)	(6.83)	(-7.12)	(.42)	(3.50)	(-2.02)	(-.18)	(-1.36)	(-1.18)	(-1.76)	(-1.90)	(-2.03)	(-3.71)
35-44	.673	27.39	.77	.246	-.001	.000	.010	-.001	-.00	-.00	-.01	-.00	-.01	-.01	-.01
			(28.25)	(6.85)	(-1.36)	(-.56)	(5.50)	(-1.56)	(-.72)	(-.71)	(-2.55)	(-1.32)	(-1.88)	(-1.28)	(-2.37)
45-64	.782	47.95	.61	.706	.003	-.001	.006	-.003	-.01	.01	-.04	-.01	-.01	.00	-.01
			(12.73)	(11.29)	(1.88)	(-1.47)	(1.92)	(-2.96)	(-.50)	(.70)	(-4.95)	(-1.04)	(-1.99)	(.29)	(-.90)
65 & over	.572	17.81	-.07	3.811	.020	.007	-.065	-0.018	.03	.02	.01	.13	.18	.12	.05
			(-.27)	(11.14)	(2.51)	(1.38)	(-3.56)	(-2.82)	(.51)	(.57)	(.33)	(3.86)	(4.59)	(2.67)	(1.08)
Females															
14-17	.812	57.61	-1.55	3.391	.011	-.026	.051	-.003	.13	-.15	-.26	.26	-.16	.17	.03
			(-5.06)	(8.44)	(1.14)	(-4.14)	(2.37)	(-.34)	(1.76)	(-2.94)	(-5.10)	(6.21)	(-3.53)	(3.16)	(.50)
18-24	.751	40.32	-.40	1.623	-.007	-.014	-.000	.012	-.08	-.02	-.08	-.02	-.10	-.06	-.02
			(-3.64)	(11.31)	(-2.16)	(-6.19)	(-.04)	(4.47)	(-2.92)	(-1.33)	(-4.53)	(-1.53)	(-6.20)	(-3.08)	(-.84)
25-34	.814	58.30	-.59	1.968	.004	-.015	-.034	-.020	-.07	-.03	.11	-.04	.05	.03	.09
			(-5.56)	(14.13)	(1.24)	(-7.22)	(-4.60)	(7.73)	(-2.64)	(-2.01)	(5.94)	(-3.25)	(2.92)	(1.44)	(4.96)
35-44	.754	40.87	-.43	1.808	.002	-.013	-.014	.013	.00	-.02	.08	-.06	.02	.04	.07
			(-4.29)	(13.77)	(.49)	(-6.40)	(-2.03)	(5.25)	(.04)	(-1.50)	(4.53)	(-4.67)	(1.42)	(2.11)	(4.13)
45-64	.864	84.64	-.54	2.066	.008	-.007	-.007	.008	.06	.02	-.02	-.04	-.03	.02	.03
			(-7.01)	(20.36)	(3.37)	(-4.38)	(-1.26)	(4.39)	(3.27)	(1.85)	(-1.35)	(-4.20)	(-2.71)	(1.63)	(2.11)
65 & over	.443	10.59	-.52	2.662	.008	.004	-.011	-.001	.06	-.02	-.04	.05	.04	.01	-.03
			(-1.90)	(7.43)	(.95)	(.72)	(-.58)	(-.13)	(.95)	(-.45)	(-.92)	(1.31)	(1.03)	(.30)	(-.62)

Phase I - Preliminary Data Manipulation. Necessary information is prepared from national/regional data, estimates, and projections including (1) EPI (current), (2) COL, AF, and MS (as per migration subroutine), (3) FIM (last period), (4) trended regional dummies, and (5) national total labor supply by age and sex in Census of Population terms.[22]

Phase II - Compute Labor Participation Rates. Regional labor participation rates by age and sex are computed from Phase I data. Some age groups are split to match BLS categories: 18-24 split to 18-19 and 20-24, and 45-64 split to 45-54 and 55-64.

Phase III - Labor Supply by Age and Sex. Regional participation rates are applied to the estimated population by age and sex. Across region sums by age and sex are forced to national totals.

Phase IV - Labor Market Conditions. Regional labor supply is brought together with labor demand to establish male and female unemployment rates. Floors and ceilings (boundary conditions) may be applied to these variables.[23]

REFERENCES FOR APPENDIX C

1. H. S. Parnes, "Labor Force Participation and Labor Mobility," *A Review of Industrial Relations Research,* Volume I (1970), pp. 1-78, William G. Bowen and T. Aldrich Finegan, *The Economics of Labor Force Participation* (Princeton, Princeton University Press, 1969), and Jacob Mincer, "Labor-Force Participation and Unemployment: A Review of Recent Evidence," in Robert A. Gordon and Margaret S. Gordon (eds.), *Prosperity and Unemployment* (New York: J. Wiley and Sons, 1966).

2. Bureau of the Census, *U.S. Census of Population and Housing: 1960, 1/1,000 and 1/10,000, Two National Samples of the Population of the United States: Description and Technical Documentation.*

3. An excellent discussion of the advantages and disadvantages of this set of data may be found in U.S. Bureau of the Census, *Current Population Reports,* Series P-23, No. 31, "Use of Social Security's Continuous Work History Sample for Population Estimation," U.S. Government Printing Office, Washington, D.C., 1970.

4. S. Altman, *Unemployment of Married Women,* unpublished Ph.D. Dissertation, University of Chicago, 1963.

5. T. Dernburg and K. Strand, "Cyclical Variation in Civilian Labor Force Participation," *Review of Economics and Statistics,* Volume 46 (November 1964), pp. 378-391; and "Hidden Unemployment 1953-62: A Quantitative Analysis by Age and Sex," *American Economic Review,* Volume 56 (March 1966), pp. 71-95. Criticisms of their model and results appear in the appendix to Chapter 16 of Bowen and Finegan (1966) and in Mincer (1966).

6. Dernburg and Strand awkwardly define labor participation as the ratio of group i's civilian labor force (L_i) to total population (P). They then try to correct for age distribution by including P_i/P as an explanatory variable.

7. The actual variable used is a ratio of new (monthly) unemployment compensation exhaustions to total population with a two-month *lead.*

8. Mincer (1966), p. 95.

9. Bowen and Finegan (1960), p. 487.

10. Mincer (1966), p. 80.

11. Parnes (1970), p. 18.

12. Parnes (1970), p. 30.

13. U.S. Bureau of the Census, *U.S. Census of Population: 1960, Volume I, Characteristics of the Population, Part 44, Tennessee*, pp. xv-xvixx. See President's Committee to Appraise Employment and Unemployment Statistics, *Measuring Employment and Unemployment* (U.S. Government Printing Office, 1962) for a thorough discussion of various definitions of employment, unemployment, etc.).

14. We do recognize that this assumption is not completely correct where many labor market conditions are determined simultaneously through the dynamic interaction of labor demand and supply.

15. Denis F. Johnston, "The U.S. Labor Force: Projections to 1990," *Monthly Labor Review*, July 1973, pp. 3-13.

16. See W. E. Cullison, "An Employment Pressure Index as an Alternative Measure of Labor Market Conditions," *The Review of Economics and Statistics*, Vol. LVII, No. 1 (February 1975), pp. 115-121.

17. The simple intercorrelation of the basic explanatory variables was as follows:

	EPI	COL	AF	MS	FIM	Pooled
EPI	1.000					
COL	.098	1.000				
AF	.126	-.113	1.000			
MS	.445	.543	.053	1.000		
FIM	.133	.534	.227	.360	1.000	
Pooled	.051	.587	.005	.541	.788	1.000

18. Age distributions of the Armed Forces can be found in the *1970 Census of Population*, Subject Report PC(2)-6A, *Employment Status and Work Experience*.

Age	Male	Female
16 & over	1,978,755	46,468
16 & 17	24,034	304
18 & 19	261,760	8,552
20 & 21	479,905	9,149
22-24	442,803	8,347
25-29	252,041	5,086
30-34	186,143	4,072
35-39	174,958	2,929
40-44	82,799	2,766
45-49	41,748	2,091
50-54	22,270	1,525
55-59	5,791	650
60-64	2,089	456
65 & over	2,414	541

19. Compare the results of Tables C-3.1 and C-3.3.

20. The simple intercorrelations were:

	EPI	COL	AF	MS	FIM
1. N.Eng.	.11	.05	-.02	.09	.05
2. M.Atl.	.06	.02	-.10	.07	.08
3. G. Lakes			Not included		
4. S.E.	-.34	-.21	.13	-.54	.26
5. Plains	.22	.05	-.14	.12	-.17
6. S.W.	-.13	-.03	.12	-.05	-.01
7. Mtn.	.04	.06	0.0	.21	-.08
8. F.W.	-.01	.06	.22	.27	.02

21. Chow, Gregory C., "Tests of Equality between Subsets of Coefficients in Two Linear Regressions," *Econometrica* 28 (1960), pp. 591-605. See also Franklin M. Fisher, "Tests of Equality between Sets of Coefficients in Two Linear Regressions: An Expository Note," *Econometrica* 38 (1970), pp. 361-366, and James L. Murphy, *Introductory Econometrics*, Homewood, Ill.; Richard D. Irwin, Inc., 1973, pp. 232-245. The present test was prepared by David Vogt of ORNL.

22. The Census/BLS ratios in column (6) of the following tables may be used for this conversion.

Males							
	1960:			1970:			
Age group:	BLS	Census	Ratio: census / BLS	BLS	Census	Ratio: census / BLS	(6) / (3)
	(1)	(2)	(3)	(4)	(5)	(6)	
16-17	45.9	36.7	.800	46.7	36.4	.779	.974
18-19	73.1	66.4	.908	68.8	60.2	.875	.964
20-24	88.9	86.1	.969	85.1	80.9	.951	.981
25-34	96.4	94.9	.984	95.0	94.0	.989	1.005
35-44	96.4	95.6	.992	95.7	94.9	.992	1.000
45-54	94.3	93.3	.989	92.9	92.6	.997	1.008
55-64	85.2	83.3	.978	81.5	80.6	.989	1.011
65+	32.2	30.6	.950	25.8	25.0	.969	1.020
Total 16+	82.4	80.4	.976	79.2	76.8	.970	.994

	Females						
	1960:			1970:			
Age group:	BLS	Census	Ratio: census/BLS	BLS	Census	Ratio: census/BLS	(6)/(3)
	(1)	(2)	(3)	(4)	(5)	(6)	
16-17	28.6	20.9	.731	34.6	23.6	.682	.933
18-19	51.0	46.4	.910	53.4	47.6	.891	.979
20-24	46.1	44.9	.974	57.5	56.3	.979	1.005
25-34	35.8	35.2	.983	44.8	45.2	1.009	1.026
35-44	43.1	42.6	.988	50.9	50.6	.994	1.006
45-54	49.3	46.7	.947	54.0	52.9	.980	1.035
55-64	36.7	35.0	.954	42.5	42.4	.998	1.046
65+	10.5	10.4	.990	9.2	10.0	1.087	1.098
Total 16+	37.1	35.7	.962	42.8	41.6	.972	1.101

23. Likely floors and ceilings may be developed from the historical frequency distributions of measures such as the BEA area unemployment rate and the employment pressure index (EPI).

Census unemployment rate	Frequency BEA areas 1950	1960	1970
1.0- 1.4	2		
1.5- 1.9	5		
2.0- 2.4	8	1	
2.5- 2.9	15	1	11
3.0- 3.4	30	10	20
3.5- 3.9	20	19	32
4.0- 4.4	22	17	25
4.5- 4.9	16	26	25
5.0- 5.4	16	19	23
5.5- 5.9	8	27	11
6.0- 6.4	9	15	9
6.5- 6.9	5	11	3
7.0- 7.4	5	7	2
7.5- 7.9	6	6	3
8.0- 8.4	1	6	4
8.5- 8.9			1
9.0- 9.4		2	
9.5- 9.9		3	
10.0-10.4			
10.5-10.9	2		2
11.0-11.4			
11.5-11.9			
12.0-12.4	1		

(continued)

23. (continued)

Employment Pressure Index	Frequency BEA areas		
	1950	1960	1970
46.0-46.9		1	
47.0-47.9			
48.0-48.9		1	1
49.0-49.9	3		
50.0-50.9	6	1	
51.0-51.9	1	2	1
52.0-52.9	5	3	3
53.0-53.9	5		1
54.0-54.9	5	2	2
55.0-55.9	13	4	4
56.0-56.9	13	6	7
57.0-57.9	21	6	8
58.0-58.9	27	19	9
59.0-59.9	21	13	12
60.0-60.9	22	10	10
61.0-61.9	14	20	14
62.0-62.9	10	21	18
63.0-63.9	3	19	26
64.0-64.9	2	16	17
65.0-65.9		16	12
66.0-66.9		8	12
67.0-67.9		3	12
68.0-68.9			3
69.0-69.9			1

Appendix D

NATURAL-RESOURCE-BASED EMPLOYMENT

Conceptually MULTIREGION distinguishes among: (1) export (manufacturing) employment, (2) local service employment, and (3) natural-resource-based employment. Included in this last category are agriculture, forestry and fisheries, mining, and employment related to major outdoor recreation resources such as the Great Smoky Mountains National Park. Since most of these natural resources are not spatially ubiquitous but exist in only very special places, MULTIREGION estimates the interregional distribution of employment in these sectors exogenously by using a formal shift and share framework. This appendix reviews our treatment of six employment sectors — agriculture, forestry and fisheries, metal mining, coal mining, crude petroleum and natural gas mining, and nonmetallic (except fuels) mining. An example of a method for export recreation is given in Appendix G.

D.1 A FORMAL SHIFT AND SHARE FRAMEWORK

Since most natural resources are not spatially ubiquitous but exist in only very special places, we have viewed the regional activity levels of natural-resource-based industries as a function of the aggregate national demands for their products and the relative regional costs to the user of exploiting the resources at different points in space. Thus, we have chosen to estimate future interregional distributions of natural-resource-based employment exogenously within a formal shift and share framework while maintaining further options of assuming (1) a constant share, (2) a constant shift, or (3) a variable shift within each industry.

The formal shift and share model takes the form

$$E^R_{i,75} = E^R_{i,70} (1 + r^{US}_{i,70,75} + C^R_{i,70,75})$$

where

$E^R_{i,T}$ = employment in industry i in region R at time T,

$r^{US}_{i,70,75} = \dfrac{E^{US}_{i,75} - E^{US}_{i,70}}{E^{US}_{i,70}}$, and

$C^R_{i,70,75}$ = region R's competitive or shift effect in industry i.

If $C^R_{i,70,75} = 0$, we have a constant share model; if $C^R_{i,70,75} = C^R_{i,65,70}$, we have a constant shift model; but if $C^R_{i,70,75}$ is made a function of certain fundamental interregional differences in the costs of resource exploitation, we have a variable shift model. We are basically proceeding with a constant share or shift model which we can override as the need arises while pursuing the development of a variable shift model.

For some employment groups, we have performed traditional shift and share analysis[1] and even experimented with more modern variants[2] in an attempt to gain a better understanding of the components of historical regional growth; for other employment groups data limitations prevented any significant historical analyses. Perhaps because we do recognize the perils of using historical shift and share results for projection purposes,[3] we are proceeding, even in the cases where these results exist, with a simple but naive constant shares projection model (i.e., $C^R_{i,70,75} = 0$).

However, by keeping the shift and share formulation within the computational sequence of MULTIREGION, we do maintain a formal structure through which exogenous shifts may be introduced (e.g., the possible switch to low-sulphur Western coals).

D.2 AGRICULTURAL EMPLOYMENT

At first blush, regional employment in agriculture[4] would appear to be changing in a very stable and predictable fashion over time. After all, has there not been an almost fifty percent decline during each of the past two decades in both national and regional employment in agriculture that would suggest constant regional shares over time? Indeed, the summary statistics for BEA areas found in Table D-2.1 tend to confirm this idea of stability.

Table D-2.1 The range of variation of regional agriculture, forestry and fisheries employment shares: BEA economic areas, 1950, 1960, and 1970

	Low share (in percent)	High share (in percent)	Mean ($\bar{x}$)	Standard deviation (s)	Coefficients of variation ($s/\bar{x}$)
BEA share 1950	.045	2.73	.578	.409	.707
BEA share 1960	.046	2.67	.578	.405	.701
BEA share 1970	.062	2.63	.578	.407	.705

However, an examination of the regional employment shares and location quotients found in Table D-2.2 create some mixed impressions. Areas with a substantial concentration in agriculture have tended to maintain it over time (e.g., BEAs 91, 111, and 114) and areas without have tended to maintain that, but a substantial number of BEA areas seem to have gained or lost position (e.g., BEAs 14, 23, 40, 46, 134). Undoubtedly, some of these shifts have been due to regional differences in natural endowments (e.g., soils and weather) and production specialization (e.g., crops, dairy, livestock, or poultry). The extent of regional specialization in 1969 can be gleaned from Table D-2.3; a comparison with earlier years[5] would be one way of assessing the extent of regional structural change within agriculture. Obviously, a greater understanding of the regional agriculture industry might also be derived from an analysis of regional trends within individual production specialties.

However, understanding the industry has been further complicated by the significant transitions begun in the mid-1970s. In late 1973, world market conditions began to place unusual demands on agriculture in the U.S. U.S. grain stocks were depleted through a combination of exports, adverse weather conditions, and government policy. This has led to higher market prices, declining land retirement, and lower subsidy payments to U.S. farmers. While the end results of such significant alterations in market conditions are still in doubt, the decades ahead will undoubtedly witness upturns in wages and employment in some regions and subsectors of the agriculture industry.

Due to these significant transitions, we are somewhat reluctant to rely on historical trends embodying fairly stable structural and regional conditions for forecasting purposes. But, since a satisfactory analysis of the complex relationships involved has been outside the scope and funds of this study,[6] we are proceeding with the obviously simplistic assumption that 1970 regional employment shares will prevail in the future. We are prepared to override these assumptions as we or others provide a satisfactory understanding of the changing structure of the regional agriculture industry.

D.3. FORESTRY AND FISHERIES EMPLOYMENT

Employment in the combined forestry and fisheries group[7] is obviously more spatially concentrated than agriculture. Furthermore, the most intense concentrations appear to be in BEA areas along our coastlines (see Table D-3.1); for example, the Boston BEA area (#4) had 3.9% of the nation's 1970 total employment in this industry group and the Seattle BEA area (#155) contained 4.1%. Unfortunately, the data for this combined industry group are apt to conceal the substantially different location patterns of its two constituent parts — forestry and fisheries. For example, the group's concentration in the Boston area may be mostly fishing while that in the Seattle area may be mostly forestry.

If regional data were available separately for each of the industry group's components, a separate analysis of each would be appropriate. Since

Table D-2.2. Agricultural employment: regional shares and location quotients for BEA economic areas

BEA area	Regional share of national employment (%)			Location quotient (%)		
	1950	1960	1970	1950	1960	1970
1	.22	.21	.22	132	122	147
2	.21	.22	.25	50	56	66
3	.38	.41	.39	139	164	155
4	.53	.60	.76	14	17	22
5	.44	.52	.60	29	33	37
6	.40	.43	.46	51	61	69
7	.62	.67	.74	80	90	105
8	.30	.34	.36	59	68	67
9	.41	.44	.51	40	45	57
10	.15	.15	.15	59	63	69
11	.13	.13	.13	54	62	66
12	.52	.56	.54	118	136	146
13	.16	.18	.17	34	48	48
14	.89	1.16	1.54	8	11	16
15	.95	1.11	1.28	24	28	33
16	.72	.85	.99	75	92	107
17	.77	.88	.95	56	64	67
18	.38	.43	.53	29	29	29
19	.40	.40	.38	188	204	187
20	.71	.68	.49	157	160	113
21	.65	.60	.49	120	117	91
22	.46	.47	.36	76	76	55
23	2.42	2.40	1.82	289	309	221
24	.62	.61	.47	258	247	184
25	.81	.78	.62	136	125	96
26	.88	.61	.47	112	80	55
27	.39	.29	.22	189	154	114
28	.54	.33	.22	116	74	48
29	.67	.54	.37	232	179	116
30	.96	.86	.52	403	432	279
31	.27	.20	.13	151	102	62
32	.59	.44	.28	236	188	118
33	.49	.39	.40	215	181	197
34	.40	.42	.56	93	84	105
35	.26	.42	.63	133	118	138
36	.38	.84	1.16	67	87	93
37	.45	.73	1.20	101	108	150
38	.31	.30	.32	202	183	195
39	.10	.07	.09	78	43	47
40	1.09	.78	.51	261	219	152
41	.92	.78	.79	332	320	354
42	.63	.44	.37	231	176	155
43	.38	.25	.17	127	93	68
44	1.11	.71	.70	113	68	56
45	1.74	1.13	.73	183	133	91
46	2.78	2.45	1.48	291	298	190
47	.90	.61	.41	328	219	128
48	.55	.39	.30	151	114	83
49	1.77	1.58	1.27	237	221	175
50	.71	.56	.41	152	137	102
51	.67	.60	.42	156	174	130
52	.76	.40	.26	96	69	52
53	1.23	1.06	.90	308	320	271
54	.72	.72	.65	121	121	106
55	.72	.68	.64	158	178	175

Table D-2.2 (continued)

BEA area	Regional share of national employment (%)			Location quotient (%)		
	1950	1960	1970	1950	1960	1970
56	.20	.20	.17	125	147	140
57	.40	.44	.47	138	162	185
58	.30	.34	.35	143	164	169
59	.23	.25	.26	173	195	198
60	.59	.64	.61	77	79	73
61	.24	.26	.24	82	91	87
62	.78	.78	.71	81	81	77
63	.36	.39	.40	66	67	67
64	.73	.65	.57	90	77	65
65	.17	.11	.08	83	74	55
66	.65	.62	.65	29	32	38
67	.13	.13	.14	30	33	38
68	.81	.91	1.03	36	41	47
69	.24	.23	.22	159	164	160
70	.40	.42	.38	74	80	72
71	.47	.53	.59	18	21	23
72	.51	.42	.35	148	119	100
73	.56	.48	.50	106	91	94
74	.40	.43	.43	84	87	82
75	.40	.38	.37	130	129	116
76	.36	.40	.37	91	102	95
77	.88	1.08	1.22	19	24	27
78	.41	.48	.50	117	146	152
79	.42	.53	.55	123	169	180
80	.36	.42	.46	215	244	264
81	.60	.75	.86	322	465	588
82	.35	.44	.47	120	150	158
83	.48	.54	.56	214	240	232
84	.62	.66	.78	56	60	72
85	.77	.78	.79	161	179	184
86	.53	.56	.54	265	325	328
87	.22	.14	.10	83	64	54
88	.35	.38	.37	278	353	358
89	.47	.52	.56	282	371	432
90	.37	.42	.46	270	328	367
91	2.47	2.75	2.74	168	192	180
92	.55	.59	.51	385	509	509
93	.41	.43	.46	372	457	567
94	.28	.35	.44	220	275	405
95	.33	.39	.48	234	288	395
96	.38	.47	.46	407	589	709
97	.78	.89	.86	357	487	556
98	.37	.43	.50	382	561	798
99	.80	.98	1.09	334	483	611
100	.42	.47	.61	306	367	552
101	.23	.28	.30	299	426	570
102	.74	.89	.97	330	488	595
103	1.05	1.28	1.43	332	501	649
104	.58	.69	.74	320	454	576
105	.71	.89	.91	263	375	435
106	.98	1.08	1.17	200	246	284
107	.73	.84	.99	167	197	239
108	.49	.54	.61	237	278	342
109	.74	.81	.95	302	369	536
110	.63	.68	.84	159	162	223
111	1.70	1.72	1.77	138	142	148
112	.67	.66	.68	281	323	336
113	.40	.45	.45	205	263	302
114	1.42	1.34	1.37	81	81	85

Table D-2.2 (continued)

BEA area	Regional share of national employment (%)			Location quotient (%)		
	1950	1960	1970	1950	1960	1970
115	1.08	.90	.63	303	322	258
116	1.33	1.08	.94	262	259	242
117	1.03	.75	.70	229	192	177
118	.36	.20	.19	239	171	153
119	.73	.52	.60	147	109	122
120	1.00	.85	.86	160	146	146
121	.47	.43	.48	168	162	203
122	.43	.58	.83	179	218	374
123	.36	.59	.66	222	327	419
124	.15	.21	.25	114	113	157
125	.34	.36	.41	185	215	310
126	.19	.20	.25	220	282	390
127	.98	.91	.91	89	74	60
128	.40	.39	.34	177	178	157
129	.50	.49	.44	196	199	156
130	.60	.41	.34	187	153	132
131	.50	.30	.27	249	201	182
132	.36	.22	.16	153	97	81
133	.61	.47	.42	239	204	201
134	1.28	1.06	.65	369	404	316
135	.83	.65	.40	291	259	172
136	.71	.43	.23	289	222	134
137	.38	.24	.20	119	71	62
138	1.06	.73	.63	114	78	68
139	.62	.57	.53	219	192	167
140	.07	.06	.06	35	33	32
141	.56	.69	.75	65	70	61
142	.71	.76	.74	131	133	127
143	.35	.41	.37	152	172	163
144	.50	.65	.58	288	370	443
145	.28	.31	.34	101	88	111
146	.23	.12	.13	118	52	53
147	.30	.30	.33	142	134	131
148	.55	.65	.85	97	94	104
149	.27	.25	.28	252	203	245
150	.17	.19	.24	128	151	206
151	.43	.45	.56	103	95	111
152	.40	.52	.66	259	340	448
153	.16	.17	.20	128	160	185
154	.47	.60	.78	130	168	243
155	.43	.48	.60	41	44	50
156	.43	.58	.71	190	267	371
157	.66	.69	.86	83	91	105
158	.21	.23	.33	91	93	130
159	.30	.39	.43	230	282	323
160	.08	.09	.13	109	96	111
161	.06	.07	.08	96	67	48
162	.44	.72	.73	140	146	116
163	.07	.12	.15	63	62	71
164	.15	.21	.33	38	32	45
165	1.22	2.09	2.67	35	43	49
166	.89	1.51	1.93	210	317	416
167	.54	.70	.90	202	247	309
168	.40	.53	.70	114	110	134
169	.10	.12	.15	115	142	189
170	.04	.04	.05	66	58	98
171	.81	1.09	1.57	39	45	58
172	.04	.02	.02	32	14	13
173	.43	.36	.46	130	92	106

Table D-2.3. Percent of the value of agricultural products from crops, dairy, livestock, and poultry: BEA economic areas, 1969

BEA area	Crops	Dairy products	Livestock and livestock products	Poultry and poultry products
1	56.63	12.58	2.55	27.57
2	11.64	22.59	4.10	60.94
3	5.06	81.15	9.92	2.83
4	39.83	26.64	8.08	25.22
5	42.46	29.46	5.40	22.37
6	13.81	69.22	10.21	6.37
7	10.14	73.36	10.75	5.44
8	50.18	29.50	12.67	7.47
9	26.52	56.43	11.83	4.78
10	28.09	54.35	12.98	3.70
11	18.93	57.76	14.76	7.77
12	9.53	71.50	11.24	7.14
13	18.00	57.15	11.98	12.22
14	45.31	24.67	7.52	22.33
15	50.05	25.39	11.58	12.81
16	17.72	36.55	26.15	19.39
17	28.97	17.11	8.82	44.70
18	35.10	25.76	36.25	1.84
19	16.75	15.74	31.08	35.81
20	48.37	20.72	24.64	4.45
21	44.83	15.89	27.32	9.52
22	68.42	2.81	21.95	5.13
23	71.10	3.40	12.36	11.93
24	58.04	1.68	11.16	28.11
25	32.53	11.53	10.26	45.05
26	19.90	18.72	14.44	45.71
27	34.51	27.93	14.84	21.24
28	32.14	17.43	22.89	26.36
29	44.54	14.64	15.14	23.68
30	80.74	1.36	7.88	8.40
31	52.57	5.54	22.55	16.68
32	39.74	14.16	23.38	19.51
33	36.24	2.97	30.25	25.84
34	28.89	11.86	25.28	32.06
35	77.08	4.54	9.91	8.13
36	77.69	10.64	10.90	0.71
37	64.68	9.64	11.97	12.73
38	52.93	7.66	28.99	8.72
39	56.35	9.42	24.51	8.07
40	35.56	9.00	34.89	17.80
41	60.50	2.68	28.26	5.91
42	42.93	11.32	22.87	20.21
43	24.95	8.93	40.77	22.41
44	4.47	7.39	9.12	78.11
45	19.46	10.73	18.53	50.35
46	76.73	3.82	16.43	2.55
47	28.56	8.64	30.01	32.13
48	11.75	11.94	15.83	60.01
49	29.79	18.45	46.09	4.64
50	24.79	22.74	33.20	18.44
51	31.55	29.12	33.77	4.65
52	21.17	22.88	34.47	19.47
53	45.83	10.20	41.79	1.66
54	34.02	20.29	39.64	5.55
55	46.13	3.97	40.98	8.56

Table D-2.3 (continued)

BEA area	Crops	Dairy products	Livestock and livestock products	Poultry and poultry products
56	54.58	3.33	39.78	2.11
57	70.98	0.89	26.88	1.20
58	77.29	1.23	19.76	1.72
59	53.74	1.80	41.96	2.35
60	42.54	5.57	48.05	3.58
61	45.09	8.05	42.35	4.36
62	38.88	16.35	41.39	3.04
63	34.17	15.54	43.80	6.39
64	33.89	14.74	45.53	5.41
65	11.67	25.99	42.65	17.48
66	26.70	41.48	19.17	11.80
67	24.66	44.77	20.62	9.46
68	35.03	29.43	26.66	8.41
69	43.06	14.11	30.67	12.02
70	53.88	7.93	31.14	6.94
71	35.78	37.08	23.08	3.86
72	47.18	24.51	22.79	5.29
73	41.68	28.44	18.49	10.18
74	34.29	28.63	32.11	4.54
75	37.50	13.54	37.84	10.90
76	35.13	14.50	33.20	16.89
77	57.39	6.45	31.57	4.55
78	54.05	1.67	43.18	1.02
79	25.88	3.67	69.55	0.85
80	19.80	4.26	73.95	1.95
81	8.68	29.59	59.68	1.91
82	26.68	24.88	47.46	0.95
83	15.88	43.99	37.27	2.62
84	19.54	50.80	24.88	4.71
85	9.69	66.83	21.43	1.66
86	15.03	62.34	19.47	2.55
87	14.25	49.24	26.64	4.85
88	7.41	64.10	19.71	8.53
89	11.17	51.16	30.33	6.89
90	25.95	24.09	44.80	5.16
91	28.80	26.22	37.22	7.69
92	78.37	5.18	13.16	3.28
93	67.94	3.05	28.64	0.36
94	42.43	1.45	55.40	0.62
95	24.55	2.39	72.10	0.92
96	42.73	8.28	48.65	0.34
97	56.59	10.70	29.15	3.57
98	31.05	8.72	57.44	2.79
99	20.91	7.38	69.11	2.59
100	17.32	3.45	78.76	0.42
101	29.57	0.95	68.95	0.51
102	26.96	2.00	70.35	0.69
103	15.84	3.42	79.30	1.43
104	33.19	1.61	62.79	2.41
105	28.38	7.72	60.59	3.30
106	26.09	3.06	68.89	1.90
107	22.40	1.79	74.87	0.95
108	34.62	3.23	60.72	1.45
109	34.74	2.70	61.55	0.98
110	30.78	2.56	65.53	1.12
111	28.05	7.03	62.99	1.86
112	19.17	4.29	70.00	6.34
113	33.06	2.62	63.04	1.18
114	35.69	8.31	52.11	3.57
115	60.67	4.85	32.96	1.06

Table D-2.3 (continued)

BEA area	Crops	Dairy products	Livestock and livestock products	Poultry and poultry products
116	17.27	17.13	54.87	10.47
117	56.32	4.36	10.77	28.15
118	10.23	5.80	32.24	51.24
119	10.59	7.29	33.90	48.13
120	29.86	8.37	60.18	1.57
121	37.52	3.20	58.51	0.77
122	21.47	0.68	77.77	0.05
123	57.73	0.49	39.95	1.75
124	45.15	0.34	49.35	3.13
125	30.06	3.44	63.68	2.74
126	15.17	2.18	77.75	4.45
127	21.81	23.17	49.67	5.30
128	16.66	5.27	59.97	18.10
129	20.94	9.97	56.86	12.15
130	7.89	10.49	33.61	46.69
131	12.43	5.69	32.99	48.14
132	22.36	17.85	35.49	22.04
133	68.08	5.73	15.57	9.69
134	82.86	0.94	8.73	7.10
135	19.42	2.54	19.25	57.67
136	11.00	11.38	26.93	47.50
137	44.06	7.96	31.66	11.68
138	35.19	29.12	20.77	13.18
139	81.24	7.47	9.77	1.37
140	59.17	4.16	15.98	18.70
141	50.85	7.46	36.45	4.81
142	24.98	6.45	57.00	11.47
143	42.32	5.23	49.73	2.57
144	83.36	3.14	12.97	0.57
145	27.30	4.76	64.15	3.06
146	9.16	10.37	77.65	2.52
147	26.70	2.87	68.72	1.64
148	18.22	3.83	76.02	1.86
149	25.33	4.24	69.88	0.39
150	9.83	1.61	88.24	0.34
151	16.64	16.62	56.90	9.60
152	47.77	6.50	45.08	0.67
153	13.71	5.32	77.78	1.25
154	68.11	3.62	26.15	1.30
155	24.18	39.89	15.67	19.00
156	53.61	2.61	41.89	1.68
157	56.21	12.26	20.44	9.66
158	39.23	11.55	39.76	6.56
159	38.97	9.44	50.59	0.94
160	14.19	5.25	80.23	0.02
161	21.19	18.50	53.09	7.20
162	39.14	5.03	54.91	0.94
163	40.56	2.60	49.66	7.01
164	51.00	14.00	6.55	28.40
165	41.29	12.38	34.56	11.78
166	61.27	8.08	26.26	4.37
167	45.93	15.06	18.29	20.66
168	78.30	4.32	12.90	4.36
169	38.82	4.96	54.18	0.88
170	14.15	35.58	37.86	0.90
171	61.34	9.12	23.26	5.99

Table D-3.1. Forestry and fisheries employment: regional shares and location quotients for BEA economic areas

BEA area	Regional share of national employment (%)			Location quotients (%)		
	1950	1960	1970	1950	1960	1970
1	1.91	1.20	1.51	1131	686	979
2	2.71	2.05	1.84	643	508	470
3	.39	.34	.42	142	135	162
4	5.67	5.65	3.86	158	160	109
5	.72	.52	.66	47	32	39
6	.27	.29	.32	34	40	46
7	.29	.30	.28	37	39	38
8	.03	.02	.08	6	4	14
9	.24	.17	.28	23	17	30
10	.19	.17	.21	73	71	91
11	.34	.27	.35	141	123	168
12	.12	.12	.15	26	27	38
13	.09	.11	.11	19	30	30
14	2.63	1.89	2.04	25	18	20
15	1.88	1.51	1.41	48	38	36
16	.36	.33	.38	37	34	40
17	4.21	3.61	2.56	309	257	177
18	.67	.87	.92	51	59	50
19	.18	.21	.39	84	104	186
20	.12	.22	.33	25	50	73
21	1.46	1.48	1.31	272	284	239
22	2.58	2.52	1.60	428	399	237
23	.77	1.06	.99	92	133	116
24	1.75	1.34	1.25	730	531	473
25	.05	.11	.22	7	17	34
26	.10	.24	.23	12	30	26
27	.27	.37	.60	128	194	305
28	.11	.23	.25	23	50	54
29	.22	.39	.45	75	124	137
30	.15	.32	.32	63	158	168
31	.41	.64	.55	227	322	247
32	.41	.40	.35	162	169	147
33	3.27	1.92	.86	1435	885	414
34	4.15	3.14	1.81	955	618	332
35	.83	.50	.90	419	138	192
36	1.15	1.59	1.88	204	162	146
37	1.80	2.07	2.19	397	300	266
38	1.66	1.26	1.59	1074	761	935
39	.65	.67	.42	521	390	220
40	.23	.35	.35	54	96	101
41	2.41	1.65	.59	861	663	255
42	1.39	1.24	.63	508	489	254
43	.08	.18	.25	25	67	96
44	.31	.77	.98	30	72	76
45	.29	.78	.88	30	89	105
46	.72	.66	.53	75	78	65
47	.45	.71	.27	164	249	82
48	.24	.47	.39	65	133	104
49	.37	.43	.48	49	59	63
50	.24	.40	.59	50	96	145
51	.15	.24	.57	34	68	170
52	.18	.34	.60	23	57	116
53	.09	.15	.57	23	44	166
54	.08	.11	.09	13	17	14
55	.15	.15	.17	32	39	45

Table D-3.1 (continued)

BEA area	Regional share of national employment (%)			Location quotients (%)		
	1950	1960	1970	1950	1960	1970
56	.05	.02	.01	30	18	10
57	.07	.07	.05	24	24	20
58	.01	.00	.01	2	0	5
59	.01	.00	.01	8	3	3
60	.14	.13	.16	18	15	19
61	.01	.00	.02	1	1	5
62	.08	.09	.12	8	9	12
63	.03	.05	.04	5	8	6
64	.22	.37	.42	26	43	46
65	.07	.16	.22	34	99	157
66	.27	.36	.30	12	18	17
67	.02	.00	.03	4	1	7
68	.43	.35	.28	19	15	12
69	.01	.03	.02	8	22	11
70	.26	.30	.23	48	55	42
71	.19	.28	.31	7	11	11
72	.44	.43	.23	126	121	64
73	.33	.35	.44	62	65	81
74	.09	.09	.08	19	17	14
75	.03	.03	.02	8	8	5
76	.04	.04	.04	10	8	10
77	.49	1.52	1.32	10	33	29
78	.05	.07	.01	15	19	4
79	.09	.09	.09	27	29	27
80	.01	.01	.02	3	7	13
81	.19	.18	.12	100	107	81
82	.03	.04	.06	9	13	18
83	.19	.30	.27	85	133	107
84	.32	.55	.64	28	48	57
85	1.11	.80	.56	231	179	126
86	.20	.31	.49	98	178	286
87	.73	.84	.76	271	369	386
88	.07	.07	.10	59	64	93
89	.17	.12	.08	97	82	60
90	.03	.03	.05	18	20	35
91	.43	.58	.67	29	39	42
92	.04	.02	.04	26	13	41
93	.01	.02	.02	11	22	27
94	.07	.11	.19	52	81	168
95	.09	.18	.18	67	131	147
96	.01	.01	.02	7	10	30
97	.05	.02	.04	21	9	26
98	.01	.01	.02	13	10	31
99	.03	.01	.01	11	4	7
100	.13	.22	.56	97	170	490
101	.00	.01	.04	2	10	68
102	.06	.03	.03	26	16	19
103	.03	.02	.04	9	7	15
104	.02	.03	.03	9	18	20
105	.01	.01	.01	4	6	6
106	.03	.06	.07	6	13	16
107	.06	.07	.06	12	15	14
108	.05	.03	.03	23	13	14
109	.01	.01	.01	2	3	5
110	.04	.06	.03	9	14	8
111	.10	.06	.21	8	5	17
112	.11	.12	.13	47	58	60
113	.19	.08	.16	94	48	102
114	.47	.53	.54	26	31	32

Table D-3.1 (continued)

BEA area	Regional share of national employment (%)			Location quotients (%)		
	1950	1960	1970	1950	1960	1970
115	.48	.40	.40	133	140	[illegible]
116	.22	.32	.39	43	75	[illegible]
117	.90	.76	.88	199	192	[illegible]
118	.14	.36	.33	91	301	254
119	.10	.08	.12	20	15	22
120	.06	.04	.10	9	6	16
121	.04	.03	.04	13	9	15
122	.01	.03	.03	4	11	11
123	.00	.00	.00	0	0	2
124	.01	.00	.00	6	0	0
125	.01	.01	.02	7	7	16
126	.02	.02	.01	17	23	15
127	.12	.15	.11	11	12	7
128	.01	.02	.02	5	7	10
129	.06	.09	.13	22	35	43
130	.33	.38	.42	101	140	160
131	.23	.27	.27	113	178	179
132	.31	.45	.38	132	196	186
133	.69	.91	.85	268	389	392
134	.55	.71	.69	157	265	325
135	.27	.45	.45	93	175	191
136	.31	.59	.53	126	302	304
137	2.32	2.38	1.79	715	681	533
138	4.89	4.11	3.20	524	433	334
139	1.70	1.13	1.01	595	372	309
140	.26	.33	.23	138	165	124
141	.79	.67	1.16	92	66	92
142	.25	.18	.24	45	30	39
143	.61	.64	.62	264	264	264
144	.37	.79	.87	214	438	642
145	.13	.20	.21	47	57	65
146	.22	.46	.68	114	191	266
147	.12	.16	.21	58	69	80
148	.25	.42	.60	43	60	71
149	.16	.32	.40	153	255	337
150	.06	.11	.12	48	86	100
151	.35	.81	1.06	83	167	202
152	.21	.44	.65	135	280	426
153	.58	1.20	2.28	458	1079	2102
154	.59	1.15	2.05	161	313	617
155	4.88	4.03	4.11	469	366	333
156	.22	.59	.89	96	265	449
157	2.10	3.04	3.89	264	393	463
158	.76	1.64	2.58	324	654	1003
159	.20	.44	.53	153	308	383
160	.07	.10	.24	98	100	206
161	.04	.07	.14	66	69	81
162	.26	.62	.94	83	122	145
163	.07	.07	.10	56	35	46
164	2.05	1.16	1.53	518	178	202
165	3.36	2.84	3.25	95	57	58
166	.27	.63	.76	63	130	159
167	.17	.46	.49	63	158	164
168	.39	.82	1.26	109	165	235
169	.48	1.36	1.50	578	1612	1833
170	.51	.86	1.02	915	1206	1848
171	2.02	1.99	2.33	97	81	83
172	2.62	1.25	1.28	2380	880	786
173	1.09	.67	.59	324	167	131

such data do not exist,[8] we have again proceeded with the simplistic assumption that the 1970 regional employment shares of this obviously heterogeneous industry group will prevail in the future.

D.4 MINING EMPLOYMENT

Nationally, mining employment[9] has declined substantially since 1950, but the decrease has been concentrated in the coal mining subindustry (see Table D-4.1). Regionally, mining employment shares have exhibited substantial variation over time as a consequence of the decline in coal mining and the relocation of employment in other subindustries as new resource locations have been exploited (e.g., Gulf of Mexico petroleum and natural gas deposits). These regional shifts in mining employment are evident in the summary measures of Tables D-4.2 and D-4.3. The regional variation over time in the location of mining employment along with our strong interest in the regional mining of fuels have combined to argue against a summary treatment of mining as a whole.

Separate treatment of mining subindustries, however, has been hindered by the absence of satisfactory regional data on the activity levels of each sector. In fact, we have only been able to estimate the BEA area employment shares by subindustry (metals, coal, petroleum and natural gas, and nonmetals, excluding fuels) for one year — 1970 — by combining regional earnings by subindustry data with total mining employment control totals[10] (Table D-4.4). At this point we are proceeding with the simple assumption that 1970 regional employment shares by subindustry will prevail in the future. But, we fully expect to frequently override these assumptions as some regional resources are depleted or become more expensive to extract and as new resource locations are exploited.

Table D-4.1. National mining employment: 1950, 1960, and 1970

	Employment			
	1950	1960	1970	1970/1950
All mining	945,179	674,662	630,788	.667
Metal mining	95,136	99,163	95,420	1.003
Coal mining	517,754	206,043	145,641	.281
Crude petroleum and natural gas mining	236,632	261,934	273,214	1.155
Nonmetallic, excl. fuels, mining	95,657	107,522	116,513	1.218

Source: U.S. Water Resources Council, *OBERS Projections of Economic Activity in the U.S.* (April 1974).

Table D-4.2. The range of variation of regional mining employment shares: BEA economic areas, 1950, 1960, 1970

	Low share (%)	High share (%)	Mean ($\bar{x}$)	Standard deviation (s)	Coefficients of variation ($s/\bar{x}$)
BEA share 1950	.003	11.36	.578	1.40	2.42
BEA share 1960	.005	6.80	.578	.97	1.68
BEA share 1970	.009	5.81	.578	.92	1.60

However, for the present these adjustments by necessity must come from sources outside of MULTIREGION.

D.5 COMPUTATIONAL SEQUENCE WITHIN MULTIREGION

The formal shift and share model presented in Sect. D.1 was in terms of absolute numbers of employees -

$$E^{R}_{i,75} = E^{R}_{i,70}\left[1 + r^{US}_{i,70,75} + C^{R}_{i,70,75}\right] .$$

However, for symmetry of treatment with the manufacturing and local service sectors, the computations of natural resource based employment should also be in terms of regional shares of national employment. Thus, the formal shift and share model has been reordered to

$$\text{Share}_{R,i,75} = \text{Share}_{R,i,70} + \frac{E^{R}_{i,70}}{E^{US}_{i,75}} C^{R}_{i,70,75} ,$$

where $C^{R}_{i,70,75} = \dfrac{E^{R}_{i,75}}{E^{R}_{i,70}} - \dfrac{E^{US}_{i,75}}{E^{US}_{i,70}}$ = region R's competitive or shift effect

in industry i. If $C^{R}_{i,70,75} = 0$, we have a constant share model; if $C^{R}_{i,70,75} = C^{R}_{i,65,70}$, we have a constant shift model; but if $C^{R}_{i,70,75}$ is made a function of certain fundamental interregional differences in the costs of resource exploitation, we have a variable shift model. While the computational sequence within MULTIREGION is programmed to accept any of these options, we are presently proceeding with a constant share model

Table D-4.3. Mining employment: regional shares and location quotients for BEA economic areas

BEA area	Regional shares of national employment (%)			Location quotients (%)		
	1950	1960	1970	1950	1960	1970
1	.04	.02	.04	22	8	28
2	.03	.03	.03	6	7	9
3	.20	.16	.17	74	65	72
4	.16	.20	.35	4	5	10
5	.07	.12	.20	4	7	13
6	.23	.31	.28	30	44	42
7	.20	.37	.33	26	51	49
8	.05	.07	.11	10	14	21
9	.65	.48	.33	64	50	38
10	.18	.09	.08	68	37	37
11	1.20	.71	.48	510	342	244
12	.08	.11	.11	17	27	30
13	4.81	1.45	.44	1033	396	129
14	.61	1.23	1.42	6	12	15
15	3.01	1.48	1.24	78	39	34
16	1.27	.92	.68	132	101	76
17	.12	.16	.21	9	11	15
18	.07	.12	.23	5	8	13
19	.21	.19	.22	98	99	111
20	.19	.19	.20	42	45	47
21	.10	.11	.22	19	22	42
22	.01	.02	.04	2	2	6
23	.08	.09	.21	9	12	26
24	.01	.01	.05	2	3	18
25	.11	.20	.18	19	32	29
26	.06	.10	.20	8	13	24
27	.10	.15	.10	48	80	54
28	.03	.07	.06	6	15	14
29	.04	.06	.08	14	20	24
30	.01	.01	.04	3	7	23
31	.00	.00	.01	1	2	4
32	.06	.09	.11	23	37	48
33	.00	.02	.02	2	7	12
34	.08	.17	.21	19	35	40
35	.01	.03	.06	4	9	12
36	.04	.13	.17	7	13	14
37	.40	.81	.94	90	121	122
38	.03	.03	.06	17	20	35
39	.01	.02	.05	5	13	28
40	.03	.07	.12	7	19	36
41	.04	.06	.11	13	26	49
42	.17	.30	.47	61	124	203
43	.01	.03	.04	4	12	18
44	.27	.37	.50	27	36	41
45	2.81	1.61	1.05	298	193	136
46	.06	.11	.15	6	13	20
47	.06	.07	.11	20	25	35
48	.38	.33	.28	105	99	80
49	.34	.40	.37	45	56	52
50	2.90	1.70	1.02	624	428	269
51	5.16	3.89	3.04	1210	1147	975
52	10.95	6.76	5.74	1404	1183	1187
53	1.94	1.58	1.00	491	488	312
54	.08	.16	.18	13	28	30
55	2.28	2.18	1.97	504	581	562

Table D-4.3 (continued)

BEA area	Regional shares of national employment (%)			Location quotients (%)		
	1950	1960	1970	1950	1960	1970
56	.77	.45	.25	491	349	215
57	.52	.21	.22	181	78	89
58	.09	.08	.07	42	42	32
59	.02	.03	.05	15	23	39
60	.21	.23	.24	27	28	29
61	.03	.05	.06	8	18	21
62	.08	.15	.17	8	15	19
63	.05	.12	.15	9	21	26
64	1.03	.79	.81	127	96	96
65	2.76	2.02	1.63	1335	1334	1216
66	11.31	6.14	4.98	519	327	302
67	.17	.18	.13	39	46	37
68	.72	.84	.89	33	38	42
69	.03	.04	.05	22	29	38
70	.13	.14	.33	24	27	65
71	.13	.23	.39	5	9	15
72	.30	.34	.29	86	100	86
73	.13	.13	.13	25	25	26
74	.03	.10	.20	5	20	40
75	.02	.05	.06	7	18	20
76	.02	.03	.05	4	7	13
77	.34	.43	.72	7	9	17
78	.27	.25	.21	78	76	68
79	.06	.08	.08	16	24	26
80	.03	.03	.04	20	17	24
81	.06	.09	.08	31	54	57
82	.02	.04	.06	8	13	20
83	.04	.04	.06	17	18	24
84	.09	.14	.13	8	12	12
85	.82	1.09	.83	173	256	199
86	.03	.02	.04	13	14	22
87	1.78	2.88	2.28	673	1323	1237
88	.01	.01	.02	4	10	15
89	.01	.01	.05	8	8	43
90	.01	.03	.02	9	25	13
91	.24	.27	.25	16	19	17
92	.01	.01	.01	3	10	10
93	.04	.23	.22	35	252	284
94	.15	.13	.12	115	102	117
95	.25	.44	.39	179	327	338
96	.04	.08	.06	44	105	98
97	.01	.01	.02	4	7	9
98	.02	.01	.02	22	13	29
99	.02	.03	.03	10	12	19
100	.31	.40	.41	232	321	383
101	.03	.15	.12	39	240	234
102	.02	.04	.07	9	20	41
103	.02	.03	.04	6	11	17
104	.02	.03	.04	10	18	32
105	.03	.04	.05	11	17	26
106	.20	.16	.15	41	38	36
107	.05	.09	.13	11	21	32
108	.02	.02	.04	10	12	21
109	.65	.76	.58	267	352	336
110	.57	1.08	.71	143	259	197
111	.32	.36	.45	26	30	39
112	.13	.12	.14	56	60	74
113	.05	.08	.07	25	45	48
114	3.10	2.20	2.41	178	136	156

Table D-4.3 (continued)

BEA area	Regional shares of national employment (%)			Location quotients (%)		
	1950	1960	1970	1950	1960	1970
115	.16	.20	.19	44	72	82
116	.46	.35	.30	92	85	79
117	.29	.27	.37	64	70	95
118	.28	.23	.18	185	202	149
119	1.73	2.44	2.10	351	526	443
120	1.79	2.25	2.28	288	395	403
121	1.15	1.44	1.00	420	547	437
122	.65	.96	.94	273	368	441
123	.32	.42	.44	203	235	290
124	1.52	3.12	3.17	1144	1689	2066
125	.90	.96	.63	498	592	495
126	.13	.19	.15	148	266	240
127	.88	1.67	1.79	80	138	124
128	.05	.05	.09	23	24	43
129	.16	.23	.20	61	96	74
130	.90	1.01	.88	280	389	355
131	.10	.16	.12	49	108	86
132	.66	.75	.78	283	341	407
133	.26	.37	.50	101	165	248
134	.26	.31	.30	74	118	148
135	.10	.25	.24	35	100	108
136	.09	.23	.42	37	119	258
137	.03	.09	.15	9	27	47
138	.97	2.71	3.64	105	297	407
139	.87	1.99	2.73	307	681	894
140	.25	.43	.49	132	225	280
141	1.69	3.00	4.27	201	311	362
142	.46	.77	.80	85	138	142
143	.85	1.22	1.33	372	521	605
144	.12	.21	.21	72	122	166
145	.96	1.90	1.96	349	557	668
146	.14	.66	.71	76	284	298
147	.32	.33	.31	153	150	127
148	.31	.88	1.32	54	129	168
149	.54	1.53	1.09	509	1293	994
150	.44	.78	1.13	333	622	1013
151	1.53	1.91	1.92	368	410	393
152	.08	.05	.08	50	30	55
153	.73	.66	.58	585	622	575
154	.61	.65	.62	168	183	199
155	.17	.11	.16	16	10	13
156	.10	.03	.03	43	15	15
157	.10	.09	.16	13	12	20
158	.06	.09	.07	25	37	28
159	.05	.03	.03	40	22	25
160	.24	.35	.45	325	371	405
161	.16	.18	.18	280	179	109
162	.67	1.15	1.26	216	236	207
163	.45	1.08	1.72	386	583	848
164	.03	.08	.08	7	13	11
165	1.65	2.13	3.08	47	45	59
166	.99	1.00	1.24	234	215	276
167	.09	.08	.11	33	27	40
168	.22	.18	.13	62	37	26
169	.06	.05	.02	68	60	25
170	.01	.01	.01	24	17	23
171	.19	.45	.70	9	19	26
172	.15	.14	.36	138	101	235
173	.02	.02	.05	5	5	12

Table D-4.4. 1970 Estimated regional employment shares for metals, coal, natural gas and petroleum, and nonmetal (excluding fuels) mining

BEA area	Estimated regional mining employment shares: 1970			
	Metals	Coal	Natural gas and petroleum	Nonmetals (excl. fuels)
1	.15		.03	.04
2	.02		.01	.16
3				.94
4				1.92
5				1.10
6	.71			.92
7	1.12			.89
8				.60
9			.57	.47
10		.01	.12	.13
11		1.73	.07	.25
12		.23		.30
13		1.63	.01	.32
14	1.69	.09	.90	4.20
15	1.91	1.83	.14	2.60
16	1.29	.61		1.88
17		.04	.08	.91
18		.03	.04	1.16
19		.40		.67
20	.53	.02		.62
21		.01	.03	1.09
22		.01		.19
23	.15			1.04
24				.25
25				1.00
26	.03		.01	1.02
27	.04	.02		.49
28	.01			.33
29				.41
30				.23
31				.05
32				.59
33				.13
34	.42			.76
35	.01			.29
36			.22	.40
37			.01	5.10
38			.08	.13
39			.10	.04
40	.27		.02	.37
41			.02	.52
42				2.54
43	.04			.21
44	.20		.01	2.50
45	.47	3.70	.05	.56
46			.01	.80
47	.18			.43
48	.78	.39		.40
49		.15	.04	1.70
50	1.10	3.05	.03	.78
51	.40	12.68	.01	.23
52		22.90	.87	.36
53		3.69	.19	.37
54		.01	.02	.91
55		6.44	.91	.52

Table D-4.4 (continued)

BEA area	Estimated regional mining employment shares: 1970 Metals	Coal	Natural gas and petroleum	Nonmetals (excl. fuels)
56		.72	.14	.15
57		.78	.04	.13
58		.18	.01	.10
59		.02		.25
60		.16	.07	.93
61				.31
62	.16	.09	.07	.53
63			.07	.69
64	.08	.99	1.09	.56
65		6.39	.23	.26
66		20.30	.35	.72
67		.17	.07	.35
68	.67	.88	.90	1.10
69			.05	.15
70			.03	1.72
71	.02	.01	.09	1.88
72			.25	1.01
73	.01		.11	.46
74			.27	.48
75				.34
76				.27
77	.01	.15	.49	2.60
78		.77		.20
79		.01		.41
80				.23
81	.31			.19
82				.31
83				.31
84				.72
85	4.84			.58
86				.19
87	15.13		.02	.09
88				.08
89	.18			.14
90				.09
91	.07		.03	1.26
92		.02		.03
93	.02	.10	.46	.01
94	.29		.23	.11
95	.02	.05	.83	.16
96		.13	.06	.04
97				.08
98				.09
99			.01	.17
100	1.84		.18	.32
101			.28	.01
102			.05	.25
103				.20
104				.22
105				.29
106		.11	.01	.64
107		.01		.69
108				.19
109			1.29	.18
110			1.64	.12
111		.03	.14	2.10
112		.01		.77
113		.05		.31
114	4.68	4.62	.73	1.83

Table D-4.4 (continued)

BEA area	Estimated regional mining employment shares: 1970 Metals	Coal	Natural gas and petroleum	Nonmetals (excl. fuels)
115	.02		.01	1.01
116	.12	.53	.18	.42
117	1.08	.05	.04	.96
118		.32	.21	.09
119		.03	4.87	.24
120			5.28	.31
121	.13		2.26	.16
122	.01		2.21	.05
123			1.04	.02
124	.07		7.46	.05
125			1.49	.03
126			.31	.08
127			4.04	.44
128			.05	.38
129			.27	.47
130	.01		2.05	.05
131	.22		.15	.13
132			1.81	.10
133			1.02	.40
134	.01		.63	.15
135			.53	.09
136			.98	.05
137			.30	.11
138			8.18	1.02
139			6.21	.58
140			1.00	.37
141			9.73	.90
142	.16		1.60	.57
143	.01		3.12	.05
144			.44	.13
145	3.56	.02	2.36	2.35
146	4.18	.14	.10	.06
147	.88	.86	.05	.14
148	2.62	.11	2.03	.24
149	3.08	.76	.99	.20
150	2.43	.12	1.70	.11
151	8.38	.78	.58	1.32
152	.18		.01	.26
153	3.54	.02		.28
154	3.78			.29
155	.08	.06	.02	.69
156	.02	.01		.12
157	.01			.86
158	.08			.31
159	.03		.01	.12
160	2.70		.01	.22
161	.60		.02	.45
162	8.12	.04	.03	.12
163	11.34		.02	.08
164			.02	.42
165	2.18		5.51	2.33
166	.01		2.59	.78
167	.01		.04	.53
168			.16	.35
169	.04			.08
170	.06			.01
171	.54		.54	2.10
172	.11	.03	.78	.02
173				.28

which we are prepared to override for some regions and industries by exogenously specifying $C^R_{i,70,75}$ as a nonzero value.

In its present formulation, MULTIREGION automatically assigns a zero value to C^R_i for all regions and time periods. We override this assumption by assigning nonzero values to the C^R_i of selected regions and time periods (e.g., a negative value for coal mining in BEA 52 — Huntington, West Virginia and a positive value in BEA 150 — Cheyenne, Wyoming to represent a shift from Appalachian to Western coal). However, when the C^R_i's of one or a few regions are set at nonzero values all other regions are usually affected. To minimize the amount of exogenous estimating of the C^R_i's of all regions, MULTIREGION is programmed to estimate natural resource-based employment in two steps. In the first step, the C^R_i's of some regions may be designated as nonzero and forecast shares are computed for each industry and region. However, since the C^R_i's of <u>all</u> regions have not been adjusted, the sum over all regions of the computed shares is not likely to equal one. Thus, the second and final step is to multiply the computed shares by forecast national employment to derive expected regional employment and then force the sum over all regions to equal the national total.

REFERENCES FOR APPENDIX D

1. H. S. Perloff, E. S. Dunn, Jr., E. E. Lampard, and R. F. Muth, *Regions, Resources, and Economic Growth* (Baltimore: John Hopkins Press, 1960), and Lowell D. Ashby, *Growth Patterns in Employment by County, 1940-50 and 1950-60*, (Washington, D.C., U.S. Government Printing Office, 1965).

2. J. M. Esteban-Marquillas, "A Reinterpretation of Shift-Share Analysis," *Regional and Urban Economics* 2(3): 249-261 (1972).

3. D. B. Houston, "The Shift and Share Analysis of Regional Growth: A Critique," *Southern Economic Journal* 33(4): 577-581 (1967), and H. James Brown, "Shift and Share Projections of Regional Economic Growth: An Empirical Test," *Journal of Regional Science* 9(1): 1-18 (April 1969). Ashby has responded to both in "The Shift and Share Analysis: A Reply," *Southern Economic Journal* 34(3) (January 1968) and in a paper presented to the Southern Regional Science Association meeting in April 1972.

4. Agriculture is defined to include agricultural production — crops, agricultural production — livestock, and agricultural services. This latter category includes soil preparation services; crop services; veterinary services; animal services, except veterinary; farm labor and management services, and landscape and horticultural services.

5. Corresponding values for 1949, 1954, 1959, and 1964 are available in a series of documents by R. J. Olsen and G. W. Westley, *1952, 1956, 1962, and 1967 County and City Data Books: Cumulations to OBE Areas*, ORNL-NSF-EP Nos. 31-34 (1972) available from NTIS.

6. Recent studies by the Center for Agricultural and Rural Development of Iowa State University do provide some of the necessary understanding of regional agricultural production. The work is documented in Heady, E. O., H. C. Madsen, K. J. Nicol, S. H. Hargrove, *Agricultural and Water Policies and the Environment: An Analysis of National Alternatives in Natural Resource Use, Food Supply Capacity and Environmental Quality*, Center for Agricultural and Rural Development, CARD Report 40T, Iowa State University, June 1972.

   Heady, E. O., and D. L. Thomas, *Alternative Crop Exports, Land Use, Production Capacity, and Programmed Prices of U.S. Agriculture for 1975*, Center for Agricultural and Rural Development, CARD Report 50, Iowa State University, July 1974.

   Nicol, K. J., E. O. Heady, and H. Madsen, *Models of Soil Loss, Land and Water Use, Spatial Agricultural Structure, and the Environment*, Center for Agricultural and Rural Development, CARD Report 49T, Iowa State University, July 1974.

   Most recently we have begun to realize that we need to better understand the interaction of regional energy and agricultural development over resources they have in common like water. For example, officials of the U.S. Geological Survey have been quoted (*Land and Environment* 2(7): 1974) as expecting water-intensive energy development projects to displace agriculture in many western states, encouraging increased farming in the Southeast.

7. Forestry and fisheries is defined to include timber tracts, forest nurseries and seed gathering, gathering of miscellaneous forest products (e.g., pine gum), forestry services, commercial fishing, fish hatcheries and preserves, and hunting, trapping and game propagation.

8. Even at the national level we have found the data confusing. In the 1970 Census of Population 1960 and 1970 employment in forestry and fisheries was given as:

	1960	1970
Forestry	46,803	54,072
Fisheries	45,321	37,024

But in the *U.S. Statistical Abstract,* 1971, the National Oceanic and Atmospheric Administration indicates fisheries employment as:

	1950	1960	1968
Total persons employed	263,478	224,056	217,191
Fisherman	161,463	130,431	128,449
Shore workers	102,015	93,625	88,742

With differences as large as this at the national level, regional data from the latter source are apt to be very difficult to reconcile with national Census totals.

9. Mining is broken into four major subindustries: metal mining, coal mining, crude petroleum and natural gas mining, and nonmetallic (excluding fuels) mining. Metal mining includes iron ores, copper, lead and zinc, gold and silver, bouxite and other aluminum, ferro alloys excluding vanadium, metal mining services, and miscellaneous metal ores including mercury, uranium-radium-vanadium, and metal ores not elsewhere classified. Coal mining includes antracite and bituminous coal and lignite. Crude petroleum and natural gas mining includes crude petroleum and natural gas, natural gas liquids, and oil and gas field services. Nonmetallic mining includes dimension stone; crushed and broken stone; sand and gravel; clay, ceramic and refractory minerals; chemical fertilizer minerals; nonmetallic mining services, and miscellaneous nonmetallics such as gypsum, talc, soapstone, and pyrophyllites.

10. Regional earnings by subindustry from the Water Resources Council's *OBERS Projections* were combined with relative national wage rates by subindustry to compute "adjusted" regional earnings by subindustry. For each BEA area a subindustry share of adjusted regional earnings was then computed and applied to total BEA area mining employment to estimate subindustry mining employment. These estimates were then adjusted to final values using a simple balance routine as described in C. Harris and F. Hopkins, *Locational Analysis,* Heath Lexington Books, Lexington, 1972.

Appendix E

MANUFACTURING LOCATION ANALYSIS

Conceptually, MULTIREGION distinguishes among: (1) export employment — the spatially sporadic activities generally oriented toward serving persons and businesses outside of the region, (2) local service employment — the more spatially ubiquitous activities oriented toward serving the region's population and businesses, and (3) natural-resource-based employment — agriculture, forestry and fisheries, mining, and export recreation activities associated with such facilities as the Great Smoky Mountains National Park. This appendix summarizes results for manufacturing employment which may be assumed to have an export orientation that reaches across BEA economic area boundaries to provide strong interregional linkages. Manufacturing employment has been broken into fourteen industry groups and a model of relative regional attractiveness has been empirically fitted for each group using data for 171 BEA economic areas.

E.1. REVIEW OF PAST STUDIES

E.1.1 Regional attractiveness models

While a broad goal of many regional scientists is to establish quantitative (rather than qualitative) statements about industrial location, most would agree that we are not yet able to formulate a satisfactory simultaneous equations model of this very complex interactive process. Thus, researchers have frequently proceeded using simpler regional attractiveness models[1] to acquire some of the insights to regional economic development processes that are required for more complete and complex representations. Regional attractiveness models take the form:

$$\text{Relative Regional Attractiveness}_{Ri} = f(X_{R1},\ldots,X_{RM})$$

or the linear form:

$$\text{R. Reg. Attract.}_{Ri} = \alpha_{io} + \alpha_{i1} X_{R1} + \ldots + \alpha_{iM} X_{RM}$$

where the

X_{Rj} = measures or region R's characteristics

e.g., Access to Final Markets
Access to Intermediate Markets
Access to Supplies (labor, etc.)

α_{ij} = parameters which reflect the importance of each characteristic to each industry.

At one and the same time, the strengths and weaknesses of this sort of model are its ability to encompass many alternative location theories without careful discrimination among them. The model does not distinguish among locational changes that: (1) are adjustments to interregional rate of return differences, (2) create or sustain regional rate of return differences, or (3) create a perfect spatial oligopoly by minimizing risk rather than maximizing profit, to name but a few alternatives.[2]

What the model does is represent regions competing against each other in a game called "industrial location." The results of this game may be tabulated periodically by any number of indicators such as:

$$Share_{Ri} = EMP_{Ri}/EMP_{US,i}$$

where EMP_{Ri} = the _i_th industry's employment in region R,

$EMP_{US,i}$ = total U.S. employment in industry _i_, and

$\sum_R Share_{Ri} = 1.0.$

Thus, $Share_{Ri}$ is a measure of how well region R is faring in the competitive industrial location game and should correlate highly with the region's endowments or characteristics (e.g., its access to markets and raw materials, its labor force characteristics, etc.). Notable past efforts that have attempted to empirically test or fit a model of this sort include the works of Fuchs (1962), Spiegelman (1968), Burrows, _et.al_. (1971), Bergsman, _et.al_.(1972, 1975), and Harris and Hopkins (1972, 1973).

E.1.2 Five previous studies

Fuchs, Spiegelman, Burrows, Bergsman, and Harris have tried to relate changes in regional employment, output, or value added to regional socioeconomic conditions through the use of multiple regression analysis. There are significant differences between each of these studies and our own which may be seen in Table E-1.1. Where Fuchs used states, Spiegelman used State Economic Areas, Burrows and Harris used counties, and Bergsman used metropolitan areas as their basic geographic unit (observation); we have used BEA nodal economic areas.[3] The county unit is too small for meaningful analysis; the state unit is too large and not sufficiently homogeneous. While State Economic Areas come close to being meaningful geographic areas for industrial location analysis, BEA economic areas are not constrained by state and SMSA boundaries and therefore do a very good job of bounding the spheres of influence on their urbanized centers.

Table E-1.1. Regression analyses of industrial location; tabular comparison of five past studies and our research

	Fuchs (1962)	Spiegelman (1968)	Burrows, et *al*. (1971)	Harris and Hopkins (1973)	Bergsman, et *al*. (1975)	Present study
Geographic grid size	States	State economic areas	Counties	Counties	Metropolitan areas	BEA economic areas
Number of observations	48	506 (fewer in some of the regressions)	3097	311 maximum 233 average for manufactring	284	171 (unpooled) 342 (pooled 1950-1960 and 1960-1970)
Industry detail in regression analyses	Manufacturing as a whole	53 4-digit SIC manufacturing industries	18 2-digit or aggregates of 2-digit SIC industries *not* confined to manufacturing	84 industry sectors (62 within manufacturing)	40 industrial clusters (clusters defined according to similarity of location patterns in 1965)	14 2-digit or aggregates of 2-digit SIC manufacturing industries
Dependent variable(s)	4 measures of comparative growth in manufacturing adjusted for industrial structure (1) Δ Value added 1929-1954 (2) Δ Value added 1947-1954 (3) Δ Total employment 1929-1954 (4) Δ Total employment 1947-1954	(1) Δ Employment 1947-58 (2) $\Delta \frac{\text{Employment 1947-58}}{\text{Employment 1947}}$	1960 Employment	(1) $\Delta QR = \Delta \text{ Output Share}_{Ri}$ $= \text{Q.Share}^{t}_{Ri} - \text{Q.Share}^{t-1}_{Ri}$ (2) $\Delta QA = \Delta QR \times \text{Output}^{t}_{US,i}$ (rarely used) where t = 1966 t-1 = 1965	1970 Employment	Employment Share (1970) Employment Share (1960)

Table E-1.1. cont'd.

	Fuchs (1962)	Spiegelman (1968)	Burrows, et al. (1971)	Harris and Hopkins (1973)	Bergsman, et al. (1975)	Present study
Geographic grid size	States	State economic areas	Counties	Counties	Metropolitan areas	BEA economic areas
Independent variables (1) A partial listing (2) All variables not used in every regression	(1) Relative wage levels (State vs. national) (2) Δ in relative unionization, 1939-1953 (3) Population density (4) Average monthly temperature deviation from 65°F (5) Relative manufacturing employment per capita 1929	(1) % Urban, % rural, nonfarm (2) % of males in various occupations (3) Median income (males, females (4) % of farmland in various classes (5) % of farmland in product groups (6) Temperature (Jan., July) (7) Population of largest city (8) Population density (9) % change in population 1950-1960 (10) Power cost (11) Building construction cost (12) Miles of surfaced roads/1000 persons (13) Relative extent of unionization (14) Average wage rate in manufacturing (15) % distribution of employment by industry	(1) Employment by industry (2) Population growth 1940-1950 (3) % Urban, % rural nonfarm (4) % population 21-64 years old (5) Live birth/family/year (6) % of population with < 5 years school (7) % of population with <12 years school (8) % of labor force that is male (9) % of labor force unemployed (10) % distribution of employment by industry (11) Average family size (12) Median family income (13) % dwelling units built after 1940 (14) Time and savings deposits/person	(1) Transport cost of shipping the marginal unit of output from industry i out of county j in 1965 (2) Transport cost of obtaining the marginal unit of input from major supplying industry k into county j in 1965 (3) Annual wage rate in industry i in county j in 1965 (4) value of land in county j in 1964 (5) output of industry i in county j in 1965 (6) equipment investment in 1965 by the equipment purchasing sector for which industry i is a part in county j (7) number of people	(1) Localization economies — employment in some industry in 1965 (2) Urbanization economies — population in 1965 (3) Wage rates — average local wage rates, 1965 (4) Availability of labor — (a) gross — before outmigration or hiring $LG_i = (UR65_i)(P65_i) + IM_i$ (b) net — after outmigration and hiring $LN_i = [UR65_i + DUR_i]p65_i$ (5) market demand (a) local — local consumption plus interindustry demand less local production EED_{ik} = effective excess demand for	Generally variables very similar to those used by Spiegelman, Burrows and Bergman (1) Employment share (T-10) (2) Relative accessibility to market demand and supply (T-5) — a gravity potential model (see Appendix H) is used to summarize the net (after discounting for distance) effect of market supplies and demands in other regions. These measures are then expressed as shares of national total supplies and demands. Included are: (a) final demand potential and (b) intermediate supply potential

Table E-1.1. cont'd.

	Fuchs (1962)	Spiegelman (1968)	Burrows, et al. (1971)	Harris and Hopkins (1973)	Bergsman, et al. (1975)	Present study
Geographic grid size	States	State economic areas	Counties	Counties	Metropolitan areas	BEA economic areas
Independent variables (continued)		(16) Dummy variables indicating the existence of (a) river or lake with flow > 100 cubic feet/sec/day (b) Port with draft > 9 feet (c) State inducements to industrial location (d) College or university with enrollment > 5000 (17) Miscellaneous combinations of the above variables	(15) Normal maximum temp. (16) Normal precipitation (17) Distance to nearest SMSA > 250,000 persons (18) Distance to nearest SMSA > 1,000,000 persons (19) Terrain variability index (20) Relative extent of unionization (21) Number of railroad lines (22) Number of major highways serving the largest population center (maximum = 9) (23) Cost of oil/barrel (24) Cost of gas/1000 cubic feet (25) Cost of electricity (26) Water availability (existence of a seacoast or navigable waterway) (27) Median age of population	per square mile in 1965 in region j (8) a representation of major buying sector k in county j that bought goods from industry i in 1965. Measures for consumers, government, construction contractors, equipment purchases and foreigners as well other industries (9) Output of major supplying sector k in county j that sold goods to industry i in 1965 NOTE: Some of these variables may be used in ratio form, region/nation, where national total used is the sum of the region ratios.	product k at city i (b) nearby — a geographic potential is used to summarize the net (after discounting for distance) effect of EED_{jk} in other cities (6) availability of inputs (limited to a maximum of 3 per industry) (a) local — local production less local consumption and interindustry use. AVA_{ihk} = availability of input h for industry k in city i (b) nearly — a geographic potential is used to summarize the net (after discounting for distance) effect of AVA_{ihk} in other	(maximum of 4 per industry) (d) self potential (supply and demand interation within the same industry) (3) labor conditions (T-5) (a) strike activity relative to the nation (b) employment pressure index (labor market tightness) (c) dummy variable for low relative low manufacturing wage (d) dummy variable for high relative manufacturing wage (4) port activity (T-5) (5) land cost proxy

Table E-1.1. cont'd.

	Fuchs (1962)	Spiegelman (1968)	Burrows, et al. (1971)	Harris and Hopkins (1973)	Bergsman, et al. (1975)	Present study
Geographic grid size	States	State economic areas	Counties	Counties	Metropolitan areas	BEA economic areas
Independent variables (continued)			(28) Land area (29) Average number of employees per manufacturing establishment (30) Misc. state industry structure variables (31) Misc. combinations of the above variables			(T-5) — population per usable land (6) special indexes for: (a) agricultural orientation (b) forest resources (c) enplanements (T-5) (d) oil pipelines (e) mild climates (f) oil and gas reserves (g) coal and iron reserves (h) electricity cost (T-5) (7) regional dummy variables for BEA subnational regions — New England, Mideast, Southeast,

Table E-1.1. cont'd.

	Fuchs (1962)	Spiegelman (1968)	Burrows, et al. (1971)	Harris and Hopkins (1973)	Bergsman, et al. (1975)	Present study
Geographic grid size	States	State economic areas	Counties	Counties	Metropolitan areas	BEA economic areas
Independent variables (continued)						Plains, Southwest, Mountain, and Far West A more precise definition of each variable can be found at the end of this appendix.
Principal sources of employment data	Census of Manufacturers	Census of Manufacturers (Special compilation to state economic areas)	Census of Population 1940, 1950, and 1960 as cumulated in Ashby tape	County Business Patterns 1965 and 1966. Undisclosed numbers estimated from the distribution of firms by employment size. Output estimated by applying output-employment or output-payroll ratios to county employment or payroll by industry.	County Business Patterns 1965 and 1970. Undisclosed numbers estimated from the distribution of firms by employment size.	Census of Population 1940, 1950, 1960, and 1970 — a special compilation for the Regional Economic Analysis Division of BEA.

The five studies seem to span the range of possible industrial detail. Fuchs did not disaggregate manufacturing at all (in his regression analyses) while Spiegelman examined fifty-three 4-digit SIC[4] manufacturing industries. Bergsman began with 4-digit SIC detail but then clustered or aggregated 4-digit industries into groups that possessed similar locational patterns. He has most recently analyzed the locational behavior of forty industrial clusters. Harris examined eighty-four industries ranging from 2- to 4-digit SIC detail. We have analyzed the fourteen 2-digit or aggregates of 2-digit SIC manufacturing industries available from the combined 1950, 1960, and 1970 Censuses of Population;[5] greater industrial detail and internal homogeneity would be desirable but is not available at this time for BEA economic areas.[6]

The measures of regional activity used as dependent variables in the five sets of regression analyses were: the level of employment by Burrows and Bergsman; the change in employment by Fuchs and Spiegelman; the change in value added by Fuchs; and the change in output share by Harris.[7] In contrast, we have chosen to use the level of a region's share of national employment by industry as our measure of relative regional attractiveness.

The range of explanatory variables used is so broad as to preclude easy summary or comparison. Generally, most of the explanatory variables readily available for the geographic grids in question have been tried at one time or another. While we have tried to be extra careful and possibly imaginative in the selection and determination of the explanatory variables used in this study (see below), the previous studies have not been without these same ingredients.

As a consequence of their substantial differences in industry detail, dependent variables, explanatory variables, geographic units and time spans, the empirical results of these five studies are hard to appraise and compare. Two generalizations that can be made are: (1) all five studies had some success with measures of market accessibility[8] (frequently for purchased inputs), and (2) all other explanatory variables, including labor conditions, gave mixed results among the five studies.

E.2 RESEARCH METHODS USED IN THIS STUDY

E.2.1 Census data for BEA economic areas

We have already implied that our preferred indicator of relative regional attractiveness is regional employment by industry expressed as a share of national employment — $Share_{Ri}$. We prefer an employment rather than output or earnings measure because of its general availability and reliability and because the theoretical structure of MULTIREGION views each BEA area as a labor market. Regional shares are preferred because the empirical results are to be used to allocate exogenously given national totals to regions; only after improving our understanding of regional economic development processes can we expect to use unconstrained regional estimates to determine national totals. Census of Population data for 1950, 1960, and 1970 are used to ensure that the definition of employment is consistent with those for labor force, unemployment, etc., (see Appendix C.2.1 for Census definitions).

The first five columns of Table E-2.1 summarize the level and growth in employment by industry during the twenty-year period, 1950 through 1970. A quick glance shows that industries vary quite a bit in their absolute size and rate of growth. During the twenty-year period, employment in the electrical equipment sector has grown most rapidly to become one of the nation's largest industries while petroleum refining employment has actually declined. Undoubtedly these size and growth variations among industries create differential opportunities for relocation that suggest separate treatment of each industry.

The remaining columns of Table E-2.1 summarize the range of regional variation of $Share_{Ri}$ by industry for 1960 and 1970.[9] It is the regional variation within a given industry that we seek to relate to regional characteristics. The substantial variation among industries again suggests separate treatment of each.

E.2.2 The explanatory variables

The explanatory variables we have used may be grouped into seven categories along the lines of the general hypotheses being examined. These groups and hypotheses are:

1. Initial conditions — used to examine the idea that economic development is an evolutionary process — you are today, in part, because of what you were yesterday — and the fact that inertia is hard to overcome.[10] A representative variable is $Share_{Ri}(t-10)$.

2. Market accessibility — used to test the fundamental hypothesis that, given input location and prices, etc., an industry attempts to maximize its profits by choosing a site or sites that maximize market accessibility.[11] Representative variables are relative final demand potentials and relative intermediate demand potentials.

3. Market competition — while normal conditions might suggest a negative spatial association with others in the same industry,[12] the existence of substantial agglomeration economies would suggest a positive association.[13] Representative variables are relative self potentials.

4. Labor conditions — labor intensive industries are posited to be especially sensitive to local labor conditions.[14] Representative variables are local strikers relative to the U.S., labor availability, low wage rates, high wage rates (skill), and labor participation rates.

5. Natural and amenity resource availability — while natural resources in the traditional sense may have a diminishing importance, the "new" (amenity) resources of our urban age may be taking their places.[15] Representative variables are usable land, ground water

Table E-2.1. The range of variation of national employment and regional employment share, 171 BEA economic areas — 1950 to 1970.

Industry	Total employment (000)				$Share_{Ri}$ (1960 and 1970)				
	1950	1960	1970	$\frac{1970}{1950}$	High	Low	Range	Standard deviation (s)	Standardized range (Range/s)
1. Food and kindred products	1434	1900	1485	1.04	8.805	.025	8.780	.918	9.56
2. Textile mill products	1254	982	1020	.81	14.866	0.0	14.866	1.732	8.58
3. Apparel	1079	1212	1307	1.21	28.848	0.0	28.848	2.063	13.98
4. Lumber products, furniture	1207	1100	1035	.86	4.095	.003	4.092	.729	5.61
5. Paper and allied products	475	601	689	1.45	9.730	0.0	9.730	1.039	9.36
6. Chemicals and allied products	668	899	1050	1.57	15.603	.002	15.601	1.489	10.48
7. Petroleum refining	291	293	224	.77	9.488	0.0	9.488	1.539	6.17
8. Primary metals	1182	1268	1279	1.08	15.412	0.0	15.412	1.615	9.54
9. Fabricated metal and ord	852	1344	1550	1.82	8.822	.001	8.821	1.245	7.09
10. Nonelectrical machinery	1310	1628	2107	1.61	8.723	.003	8.720	1.214	7.18
11. Electrical equipment	799	1550	2018	2.53	14.213	.001	14.212	1.504	9.46
12. Motor vehicle & equipment	880	874	1072	1.22	37.214	0.0	37.214	2.851	13.05
13. Other transport equipment	488	1015	1191	2.44	18.199	0.0	18.199	1.707	10.66
14. All other manufacturing	1999	2344	2586	1.29	13.872	.004	13.868	1.356	10.23
Industry total	13,918	17,010	18,613	1.34					

availability, surface water availability, net primary forest productivity, forest cover, mild/sunny climate, and mineral resource availability.

6. Financial resources and subsidies — the status and aggressiveness of the local banking community as well as the tangible and intangible location subsidies granted by governments may be key indicators of local attitudes toward industrial development.[16] Representative variables are the cost of construction, loan to deposit ratio of commercial banks, and state subsidies.

7. Availability of intermediate inputs — Accessibility to miscellaneous support services and products, given market accessibility, has been posited to be a critical input to location decisions.[17] Representative variables are relative intermediate supply potentials, electricity costs, port activity, and airline service.

While the descriptive titles of a few variables have been mentioned for each of the seven categories, a full accounting of the variables used is found at the end of this appendix. In addition, since we have been especially careful and perhaps innovative in establishing measures of "access" to markets and inputs for categories (2), (3), and (7), we now turn to a more complete discussion of these measures.

E.2.3 Market accessibility

Since the gradual completion of the Interstate highway system may have had a substantial and differential regional impact upon the growth of market accessibility, we devoted a major effort to the development of a measurement process which emphasized the time of truck transportation between metropolitan areas while standardizing for regional differences in terrain and changing conditions of truck operating speed, roadways, and congestion. The process consisted of (1) superimposing terrain and congestion conditions upon a road map, (2) the measurement of each road-terrain-congestion segment, and (3) the conversion of these segments into elapsed times of truck transport between the metropolitan centers of nearby BEA economic areas (see Appendix H for more details).[18] These computed truck operating times between over seven hundred city pairs for each of three years, 1950, 1960, and 1970, were then used to define market demand and supply potentials for each BEA area for each of the three points in time.

Since the gravity and potential concepts of human interaction are commonly used by regional scientists, the evolution of these concepts will not be reviewed here.[19] The specific forms of the potential model used in this study were:

a. Final Demand Potentials — 1950, 1960, 1970

$$FDP_{ik} = \sum_{j=1}^{171} [(POP_j \times PCY_j)/D_{ij}^{\lambda_k}] \quad \text{for } D_{ij} \leq 8.3 \text{ hours},$$ [20]

where FDP_{ik} = final demand potential for commodity k in BEA area i; POP_j = population of the j^{th} BEA economic area; PCY_j = per capita income of the j^{th} BEA area,[21] D_{ij} = minimum truck operating time between i and j (where i = j, D_{ij} = 1/2 D_{ij} to the nearest BEA area), and λ_k = distance decay coefficient which varies with the good being shipped.[22]

b. Intermediate Demand Potentials — 1950, 1960, 1970

$$IDP_{ikm} = \sum_{j=1}^{171} (EMP_{jm}/D_{ij}^{\lambda_k}) \text{ for } D_{ij} \leq 8.3 \text{ hours},$$

where IDP_{ikm} = intermediate demand potentials in BEA area i for commodity k by industry m and EMP_{jm} = employment in industry m within BEA area j.

c. Intermediate Supply Potentials — 1950, 1960, 1970

$$ISP_{ik} = \sum_{j=1}^{171} (EMP_{jk}/D_{ij}^{\lambda_k}) \quad \text{for } D_{ij} \text{ 8.3 hours},$$

where ISP_{ik} = intermediate supply potential in BEA area i of commodity k.

d. Intermediate SELF Potential — 1950, 1960, 1970

$$I\text{-}SELF\text{-}P_{ik} = ISP_{ik} = \sum_{j=1}^{171} (EMP_{jk}/D_{ij}^{\lambda_k}) \quad \text{for } D_{ij} \leq 8.3 \text{ hours},$$

where $I\text{-}SELF\text{-}P_{ik}$ = the combined intermediate supply and demand potential in BEA area i of industry k with itself.

Since truck operating times (D_{ij}) have been decreasing over time while population (POP_j), per capita income (PCY_j), and many employment categories (EMP_{jk} and EMP_{jm}) have been increasing, the (absolute) market potentials calculated according to the above formulas tend to be increasing for each BEA economic area and collinear among areas. To more clearly distinguish among BEA areas, we have defined a relative market potential to be a region's share of the total national market. Thus relative market potentials have been defined as:

$$Rel.FDP_{ik} = FDP_{ik}/(POP_{us} \times PCY_{us}),$$

$$Rel.IDP_{ikm} = IDP_{ikm}/EMP_{us,m},$$

$$Rel.ISP_{ik} = ISP_{ik}/EMP_{us},k.$$

While these values were computed directly for 1950, 1960, and 1970, values for 1955 and 1965 were estimated by interpolation.

Emphasis has been placed upon rational measures of absolute and relative market potential because these variables constitute our means of considering and measuring interregional interindustry linkages and effects. For example, consider nearby or adjacent BEA economic areas A and B:

a. Where there are positively linked industries (x and y) or an industry with substantial agglomeration economies (y), a substantial increment in industry y employment in region B will raise region A's market potentials (as well as region B's) and thereby make region A (as well as B) more attractive as a future location for both industries x and y. Transportation improvements in region B and beyond will raise A's market potentials to make it a more attractive location for x and y. In this way positive interregional effects may be transmitted through our market potential variables.

b. Where the firms of industry z have spatially dispersed to avoid competition from others within the same industry (negative link with self), a substantial increment in industry z employment in region B will raise region A's market self potential to make region A less attractive as a future location for industry z. Transportation improvements would similarly raise the level of spatial interaction between the firms in industry z causing further spatial dispersion in the future. Negative interregional effects may in this way be transmitted through our market potential variables.

E.2.4 Two empirical models

We have distinguished two empirical models by choosing to include or exclude initial conditions — $S_{Ri}(t-10)$ — as an explanatory variable. The resulting models are:

Model A [$S_{Ri}(t)=f$(other variables)]: Since the employment in manufacturing industry i in region R is made a function of conditions in region R except the presence of industry i ten years ago (initial conditions), the results of this model may be assumed to give insight to the determinants of the historical location of industry i.

Model B [$S_{Ri}(t) = g(S_{Ri}(t-10)$, other variables)]: In a sense, the inclusion of $S_{Ri}(t-10)$ standardizes the dependent variable for initial conditions so that the coefficients of all other variables give insight to the determinants of the more recent change in industry i employment in region R.

Except for the inclusion or exclusion of $S_{Ri}(t-10)$, the same explanatory variables appear in both models A and B for each industry. In addition many common explanatory variables appear across industries. While the variables included were chosen through a long series of experiments, there remains room for further custom tailoring of the list of explanatory variables for each industry and the consideration of interaction terms and trended coefficients.

Pooled cross-section data from the 1950, 1960, and 1970 Censuses of Population have been used to statistically estimate models A and B instead of cross-section data for a single year or time-series data. Because suitable time-series data do not exist for small geographic areas, the use of pooled cross-section data may be thought of as a pseudo time-series analysis. It is an attempt to augment the variation over space contained in cross-section data with some variation over time. But, the use of pooled cross-section data has required that the two empirical models be modified to include a "pooled" variable, a shift factor which takes on the value 0 for observations during 1960 and the value 1 for observations during 1970.

E.3 POOLED CROSS-SECTION RESULTS BY INDUSTRY

Our latest empirical results are reported in Tables E-3.1 (Model A) and E-3.3 (Model B). They include as explanatory variables region R's share of employment in industry i ten years ago (S(t-10)), relative final demand potential (FDP) and relative intermediate self potential (Self P.) with a five year lag, up to four relative intermediate demand and supply potentials (IDP and ISP) selected by inspecting national interindustry tables, selected labor conditions (STRIK, EPI, LW and HW) with a five year lag, lagged port activity (PORT), a proxy measure of land costs (L.C. — defined as population/ usable land), other special regional conditions, and regional dummy variables for all subregions of the nation (except the Great Lakes) as defined in Fig. C-3.1. The regional dummy variables were included at the last stage of the analysis as measures of longer-term regional conditions (relative to the Great Lakes = 0) not captured by any of the other explanatory variables.[23] Again, except for the inclusion or exclusion of the lagged dependent variable, the same explanatory variables appear in both models A and B. The results of model A should give insight to the determinants of the historical location of the spatially sporadic manufacturing industries while those of model B should give insight to the determinants of more recent changes in relative location.[24]

E.3.1 Model A

One may observe from our empirical results that interregional market size has been a very important determinant of the historical location of manufacturing employment but such a statement will require some explanation. The statement can be made from the regression coefficients and t-values in Table E-3.1 plus the Beta coefficients in Table E-3.2 only after reviewing some of the strengths and weaknesses of the simple linear model we have postulated.

In Section E.1.1 (above) we admitted that both the strengths and weaknesses of a simple linear regional attractiveness model are its ability to encompass many alternative location theories without careful discrimination among them. Here, we can only reiterate that for the most part the hypotheses included in the model are very broadly stated and thereby exclude consideration of possible nonlinear effects, interactive variables, etc. However, in the area of access to interregional markets, the hypotheses contained in the model are very specific; access to interregional markets has been very precisely stated in terms of (1) truck operating times, (2) distance decay coefficients, (3) a time-invariant gravity model, (4) employment as a proxy for mass at points of supply and demand, and (5) a five-year adjustment period. Thus, when interpreting our empirical results, the coefficients of the interregional market variables in both models A and B should not be viewed as simply accepting or rejecting the importance of access to markets but rather may be seen to give evidence of the appropriateness of the specific terms by which market access has been measured. For example, a negative coefficient could reflect a declining spatial association over time or a period of adjustment in excess of 5 years rather than the unimportance of access to markets. In contrast to the coefficients, the t-value or standard error of each coeffient does lend itself to a fairly clear interpretation; the larger is the t-value, the more uniform has been the association across regions and time. Finally, the magnitudes of the coefficients in Table E-3.1 are not sufficient to establish the relative importance of each explanatory variable because the units of measurement vary even among the market variables. Thus, Beta coefficients[25] which indicate the percent of a "typical" variation in the dependent variable associated with a "typical" variation in the explanatory variable (typical variation is equal to one standard deviation) are reported in Table E-3.2.

Given these insights, we may repeat that interregional market size as measured by FDP, IDP, and ISP has been a very important determinant of the historic location of manufacturing employment. The average absolute values of the market Beta coefficients across the thirteen manufacturing industry groups is .516 which indicates that 51.6% of a standard deviation variation in $Share_{Ri}$ was associated with a standard deviation variation in an average measure of interregional market size; the corresponding values for the individual dimensions of market size are .508, .193, .472, and .891 for FDP, IDP, ISP, and SELF potential, respectively. The coefficients and t-values for relative SELF potential are all positive and large which may be interpreted as evidence of the historic importance of agglomeration economies, a shorter than five year period of adjustment, and rather uniform behavior across regions. The coefficients of FDP are generally negative but statistically significant which implies rather uniform behavior across regions with a period of adjustment of more than five years; note the very large Beta value for FDP in the electrical equipment sector.

Table E-3.1. Model A results for thirteen manufacturing industries
171 BEA economic areas, pooled 1960 and 1970 data.

		R^2	F (d.f.)	Intercept	FDP-5	IDP(-5) Name	IDP(-5) Coef.	ISP (-5) Name	ISP (-5) Coef.	Self P. (-5)	Labor conditions (-5) STRIK	Labor conditions (-5) EPI	Labor conditions (-5) LW	Labor conditions (-5) HW	PORT ACTIVITY	L.C.	Other Name	Other Coef.	Region (Rel. to G. Lakes = 0) 1	2	4	5	6	7	8	Pooled 1960=0 1970=1
1B	Food and kindred products	.759	56.4 (18,323)	-1.607 (-2.80)	-.195 (-3.79)	CHEM	.005 (1.21)			.0315 (8.00)	-.058 (-1.84)	3.01 (3.37)	.080 (1.20)	-.042 (-.44)	.0171 (9.56)	.0013 (10.30)	AG OR	-.088 (-.75)	-.35 (-1.86)	-.22 (-1.79)	-.05 (-.40)	.02 (.13)	.00 (.02)	.11 (.72)	.05 (.37)	-.23 (-4.25)
2	Textile mill products	.580	24.8 (18,323)	-4.394 (2.98)	-.115 (-1.75)	APP	-.001 (-.40)	CHEM	.0166 (1.64)	.0145 (10.71)	.031 (.34)	7.68 (3.24)	-.43 (-2.60)	-.38 (-1.58)	.0080 (1.67)	.0011 (3.27)			.180 (.35)	-.617 (-1.40)	-.231 (-.63)	.082 (.25)	.291 (.79)	-.048 (-.10)	.090 (.22)	-.340 (-2.41
3	Apparel	.754	58.3 (17,324)	-1.411 (-1.05)	-.211 (-3.82)			TEXT	-.0032 (-2.63)	.0328 (9.87)	-.107 (-1.30)	3.18 (1.47)	.09 (.62)	-.12 (-.57)	.0295 (8.19)	.0029 (9.51)			-2.789 (-6.32)	-2.533 (-6.58)	-.567 (-1.74)	-.276 (-.93)	-.431 (-1.32)	-.381 (-.95)	-.744 (-2.04)	-.287 (-2.26)
4	Lumber products and furniture	.698	39.1 (19,322)	-.336 (-.64)	-.207 (-5.35)			F.MET	.0057 (1.76)	.0334 (12.53)	-.041 (-1.29)	.61 (.71)	-.01 (-.20)	.13 (1.43)	.0104 (7.04)	.0006 (4,98)	CLIM FOREST	-.179 (-4.30) .55(10^{-6}) (5.11)	.370 (2.22)	.173 (1.35)	-.202 (-1.61)	.234 (2.00)	.300 (2.33)	.281 (1.81)	.843 (5.91)	-.180 (-3.63)
5	Paper and allied products	.841	89.4 (19,322)	-.611 (-1.15)	-.234 (-6.42)			CHEM	-.0067 (-1.93)	.0642 (16.29)	-.104 (-3.48)	1.10 (1.33)	.013 (.22)	-.16 (-1.79)	.0184 (10.78)	.0012 (9.29)	FOR.PULP FOR.SAW	.05(10^{-6}) (.28) 1.59(10^{-6}) (1.90)	.031 (.18)	-.026 (-.23)	.034 (.30)	.174 (1.52)	.097 (.78)	.093 (.62)	.218 (1.47)	-.258 (-5.13)
6	Chemicals and allied products	.860	93.6 (21,320)	.292 (.37)	-.370 (-5.50)	TEXT	.0023 (-1.82)	PETR	-.0114 (-5.35)	.0721 (11.30)	-.171 (-4.09)	-.516 (-.40)	-.065 (-.75)	-.187 (-1.60)	.0271 (12.38)	.0017 (9.98)	ENPLAN OIL PIPE CLIM	70.7 (.61) .039 (3.79) .185 (3.01)	-.644 (-2.74)	-.647 (-3.99)	-.229 (-1.36)	.115 (.75)	-.076 (-.42)	.037 (.18)	.084 (.43)	-.24 (-3.28)
7	Petroleum refining	.745	52.3 (18,323)	-1.540 (-1.49)	-.106 (-1.32)	CHEM	.0037 (.62)			.0191 (7.38)	-.143 (-2.39)	2.398 (1.42)	-.128 (-1.11)	.306 (1.89)	.0412 (14.47)	.0005 (2.35)	OIL+GAS	.067 (1.99)	-.553 (-1.75)	-.387 (-1.63)	.084 (.37)	.190 (.85)	.149 (.56)	.382 (1.26)	.181 (.67)	-.29 (-3.02)
8	Primary metals	.771	48.9 (22,319)	-3.92 (-3.35)		ELECT F. MET M.VEH O.TRANS	-.0074 (-1.11) .0247 (2.32) -.0049 (-4.21) -.0208 (-2.11)			.0533 (9.02)	-.156 (-2.37)	5.21 (3.01)	.295 (2.50)	.233 (1.35)	.0220 (7.97)	.00005 (.20)	CLIM COAL & IRON RES. ELECT C $	.241 (2.85) .078 (11.55) -.289 (-1.24)	1.115 (3.24)	.078 (.32)	.529 (2.14)	.800 (3.41)	.756 (2.73)	1.014 (3.37)	(	-.502 (5.15)
9	Fabricated metal and ORD	.762	48.8 (21,320)	-.882 (-1.09)		ELECT MACH M.VEH O.TRANS	-.0094 (-1.64) -.0388 (-2.75) -.0036 (-3.98) .0106 (1.24)	P.MET	-.0099 (-3.59)	.0834 (8.70)	-.019 (-.37)	.473 (.36)	.068 (.74)	.303 (2.24)	.0124 (5.63)	.00102 (5.65)	CLIM	.058 (.92)	.029 (.11)	-.356 (-1.84)	.371 (1.97)	.504 (2.80)	.441 (2.13)	.740 (3.14)	.294 (1.19)	-.355 (-4.75)
10	Nonelectric machinery	.704	40.3 (19,322)	-2.38 (-2.78)		ELECT O.TRANS M.VEH	-.0020 (-.40) .0086 (1.52) -.0018 (-2.18)	P.MET	.0086 (3.58)	.0189 (2.14)	-.150 (-2.55)	3.061 (2.27)	.110 (1.12)	.431 (2.97)	.0184 (8.13)	.00123 (6.36)			.293 (.94)	-.748 (-2.81)	.367 (1.52)	.448 (1.99)	.513 (1.95)	.667 (2.31)	.139 (.44)	-.371 (-4.38)
11	Electrical equipment	.747	40.8 (23,318)	-2.15 (-2.00)	-.348 (-5.69)	MACH M.VEH O.TRANS	-.0029 (-.07) -.0029 (-3.37) .0217 (3.28)	MACH P.MET F.MET	.0102 (.21) -.0007 (-.20) .0332 (3.39)	.0203 (3.77)	-.158 (-2.22)	2.740 (1.60)	.070 (.61)	-.018 (-.11)	.0207 (7.37)	.0018 (7.93)	ENPLAN	154.5 (.97)	-.785 (-2.13)	-.133 (-.40)	.897 (3.01)	.835 (3.11)	.774 (2.43)	.653 (1.93)	.319 (.85)	-.320 (-3.08)
12	Motor vehicles and equipment	.571	21.4 (20,321)	2.14 (.86)	-.057 (-.38)			P.MET F.MET MACH ELECT	-.0791 (-9.13) .1999 (11.40) -.0903 (-3.94) -.0151 (-1.24)	.0182 (7.84)	.737 (4.32)	.300 (.08)	-.022 (-.08)	.347 (.84)	-.0070 (-1.02)	.0004 (.64)			-.767 (-.89)	2.016 (2.55)	-2.220 (-3.13)	-1.802 (-2.75)	-2.515 (-3.40)	-2.477 (-3.03)	-3.666 (-4.39)	.101 (.42)
13	Other transportation	.666	30.3 (21,320)	-1.34 (-1.02)	-.846 (-7.41)			P.MET F.MET MACH ELECT	-.0173 (-3.75) .0366 (2.85) .0104 (.91) -.0079 (-1.70)	.2349 (16.19)	.054 (.61)	2.45 (1.18)	-.004 (-.03)	.281 (1.29)	.0160 (4.34)	.0009 (3.07)	CLIM	.036 (.36)	-.727 (-1.54)	.156 (.37)	.012 (.03)	-.020 (-.059)	-.333 (-.86)	.052 (.12)	.361 (.82)	-.28 (-2.27)

Table E-3.2 Beta coefficients for Model A - thirteen manufacturing industries
171 BEA economic areas
pooled 1960 and 1970 data

				IDP		ISP			Labor cond.						Other		Region (Relative to GL=0)							
		S(T-10)	FDP	Name	Coef.	Name	Coef.	Self p.	STRIK	EPI	LW	HW	PORT	L.C.	Name	Coef.	1	2	4	5	6	7	8	Pooled
1B	Food & kindred prod.	—	-.343	CHEM	.099			.529	-.084	.120	.040	-.017	.413	.441	AG. OR	-.030	-.064	-.065	-.022	.006	.001	.028	.017	-.124
2	Textile mill prod.	—	-.300	APP	-.046	CHEM	.223	.713	.024	.162	-.113	-.079	.102	.189		—	.017	-.098	-.059	.017	.057	-.006	.015	-.098
3	Apparel	—	-.365		—	TEXT	-.130	.841	-.069	.056	.020	-.022	.317	.423		—	-.228	-.337	-.122	-.047	-.071	-.043	-.102	-.070
4	Lumber prod. & furn.	—	-.745		— —	F.MET.	.196 —	.852	-.074	.030	-.007	.062	.316	.252	CLIM FOREST	-.201 .202	.086	.065	-.123	.111	.141	.090	.328	-.123
5A	Paper & allied prod.	—	-.365			CHEM	-.151	.927	-.132	.039	.006	-.055	.392	.341	FOR. P. FOR. S.	.009 .049	.005	-.007	.015	.058	.032	.021	.059	-.124
6	Chemicals & allied prod.	—	-.491	TEXT	-.060	PETR.	-.263	1.128	-.153	-.013	-.020	-.045	.404	.345	ENPLAN OIL PIPE CLIM	.016 .121 .102	-.073	-.119	-.068	.027	-.017	.006	.016	-.080
7	Petroleum refining	—	-.241	CHEM	.100			.427	-.124	.057	-.038	.072	.594	.107	OIL & G. RES.	.074	-.061	-.069	.024	.043	.033	.058	.033	-.095
8	Primary metals	—	—	ELECT F. MET. M. VEH. O. TRAN.	-.147 .440 -.241 -.126			.792	-.128	.118	.083	.052	.302	.009	CLIM COAL & IN RES. ELECT $	.122 .435 -.048	.116	.013	.146	.172	.160	.148	.160	-.156
9	Fabricated M & ORD	—	—	ELECT MACH M. VEH. O. TRAN.	-.207 -.492 -.227 .074	P.MET.	-.305	1.669	-.020	.014	.025	.088	.220	.248	CLIM	.038	.004	-.078	.132	.141	.121	.140	.067	-.143
10	Nonelect. mach.	—	—	ELECT O. TRAN. M. VEH.	-.115 .137 -.201	P.MET.	.273	.622	-.165	.092	.041	.129	.336	.309			.041	-.169	.134	.129	.144	.129	.032	-.153
11	Electrical equip.	—	-1.320	MACH M. VEH. O. TRAN.	-.097 -.313 .347	MACH P.MET. F.MET.	.270 -.019 .551	1.176	-.139	.067	.021	-.004	.305	.360	ENPLAN	.034	-.088	-.024	.265	.193	.176	.102	.060	-.106
12	Motor veh. & equip.	—	-.092			P.MET. F.MET. MACH ELECT	-1.065 1.748 -1.267 -.460	.867	.344	.004	-.004	.044	-.054	.037			-.045	.194	-.346	-.220	-.301	-.204	-.364	.018
13	Other transport	—	-.819			P.MET. F.MET. MACH ELECT	-.389 .535 .243 -.402	1.040	.042	.052	-.001	.060	.207	.160	CLIM	.017	-.072	.025	.003	-.004	-.067	.007	.060	-.083

The coefficients of the IDP and ISP variables appear with a greater mixture of signs and generally lower t-values giving evidence of more variable response times and greater behavioral diversity across regions. Note especially, the very substantial coefficients for primary metals (-1.065), fabricated metals (1.748), and machinery (-1.267) as suppliers of the motor vehicle and equipment industry which suggests that there have been changing associations among these industries as well as an adjustment period of other than five years. In summary, our results give evidence that interregional market size has been an important historic determinant of manufacturing location with access to others in the same industry being most important followed by access to final demand, intermediate suppliers and intermediate demanders in that order with some exceptions in particular industries (e.g., motor vehicles and equipment).

Moving on to other explanatory variables, regional labor market conditions appear to have made only a small contribution to the total explanation of historic manufacturing location; only 6 to 7 percent of a standard deviation variation in Share_{Ri} was associated with a one standard deviation variation in general labor conditions. Within the labor conditions category, most industries have tended to avoid regions with above average strike activity (except motor vehicles), have been attracted to regions with tight labor markets (high EPI), and have been rather indifferent to the especially low wage or high wage (high skill) nature of a region's labor force.

Historically, port activity and population density (L.C. — a proxy measure of land cost measured by population/usable land) have exhibited substantial positive influences on location. Port activity (or availability), while important to most industries, has been most important to the petroleum refining (Beta coefficient equals .594), food and kindred products (.413), chemicals and allied products (.404), and paper and allied products (.392) industries. Population density has been most important to the food (.441), apparel (.423), electrical equipment (.360), chemicals (.345), and paper products (.341) industries. While these two variables do seem to have captured different concepts in different industries, there is a high enough simple correlation between them (.62) to make one suspect that both variables may have frequently represented local market conditions; ports are generally densely populated points of product and resource trans-shipment which by their nature have created trade and manufacturing opportunities.

The remaining explanatory variables center about natural resource availability, long-term regional conditions and a time trend. Of the "other" variables included, greatest historic importance can be assigned to the availability of coal and iron resources (Beta coefficient = .435) for the primary metals industry and forest resources for the lumber products and furniture sector. Regional dummy variables included as measures of long-term regional conditions (relative to the Great Lakes = 0) not captured by any of the previously included explanatory variables do not appear to have had much impact on historic manufacturing location; exceptions were: (1) the disadvantage of all other regions relative to the Great Lakes for the motor vehicle industry and (2) the substantial advantage of the West for the lumber products and furniture industry. Finally, the coefficients of the pooled variable are generally negative and statistically significant but this trend factor has not contributed a great deal to the explanation of manufacturing location. It does, however, introduce the idea of shifting location relationships over time that will be more thoroughly considered in Section E.3.4 (below).

E.3.2 Model B

Past employment location has been the most important determinant of present employment location (see Tables E-3.3 and E-3.4). The inclusion of the S(T-10) variable almost invariably results in coefficients of determination of .95 or more. The average Beta coefficient across the thirteen industries for S(T-10) is .957 indicating almost a one-to-one correspondence between typical variations in S(T) and S(T-10). In addition to reinforcing the idea that inertia is a very powerful force, the coefficient of the S(T-10) variable, especially where it may be significantly different from 1.0, sheds light on the trends toward spatial diffusion or concentration within an industry. All but one of the industries considered have coefficients significantly less than 1.0 giving evidence of past trends toward spatial dispersion; the coefficient for "lumber products and furniture" is not significantly different from 1.0.

After adjusting for initial conditions, the importance of most other explanatory variables is substantially less than in Model A. Interregional market size remains as the most important determinant of locational change (average absolute Beta coefficient = .074) followed by port activity/population density (.023), long-term regional conditions (.018), and labor conditions (.015) in that order. The average Beta values for the individual dimensions of market size are .056, .099, .067,and .076 for FDP, IDP, ISP, and self potential, respectively. Obviously, some of the importance of relative SELF potential exhibited in the results for Model A has been drawn off through the inclusion of S(T-10) but the coefficients of self potential generally remain positive and statistically significant giving evidence of the continued importance of agglomeration economies in recent locational change (especially for textiles and fabricated metals). An important exception is primary metals where the coefficient is negative and significant suggesting some recent economies to spatial dispersion. The coefficients of FDP are generally negative but only occasionally statistically significant which implies a period of adjustment of more than five years with quite a bit of diversity of behavior across regions. The coefficients of the IDP and ISP variables again appear with a great mixture of signs and generally low t-values giving evidence of more variable response times or changing interindustry linkages and substantial behavioral diversity across regions. In summary, our empirical results for Model B reinforce the idea that after adjusting for initial conditions, interregional market size has been an important determinant of recent changes in manufacturing location.

Regional labor market conditions have made only a small contribution to the explanation of locational change; only 1.5 percent of a typical variation in Share_{Ri} was associated with a typical variation in general labor conditions. Within the labor conditions category, the most substantial and

Table E-3.3 Model B results for thirteen manufacturing industries
171 BEA economic areas
pooled 1960 and 1970 data

		R^2	F (d.f.)	Inter-cept	S(T-10)	FDP(-5)	IDP(-5) Name	IDP(-5) (Coef.)	ISP(-5) Name	ISP(-5) (Coef.)	Self.p. (-5)	Labor cond.(-5) STRIK	EPI	LW	HW	Port activity	L.C.	Other Name	Other (Coef.)	Region (rel. to GL=0) 1	2	4	5	6	7	8	Pooled	H_0: BS(T-10)=1 (t value)
1B	Food & kindred prod.	.979	787.4 (19,322)	-.369 (-2.15)	.889 (58.81)	-.032 (-2.09)	CHEM	-.0011 (-.85)			.0047 (3.76)	.012 (1.26)	.563 (2.10)	.014 (.71)	-.007 (-.24)	.001 (1.84)	-.000003 (-.07)	AG. OR	.027 (.78)	.03 (.53)	.05 (1.36)	.10 (3.03)	-.02 (-.45)	.07 (1.94)	.08 (1.81)	.11 (2.59)	-.01 (-.82)	(-7.24)
2	Textile mill prod.	.956	365.4 (19,322)	.036 (.07)	.928 (52.22)	.025 (1.15)	APP	-.004 (-4.42)	CHEM	-.001 (-.43)	.0034 (6.98)	-.044 (-1.47)	.077 (.10)	-.106 (-1.95)	.054 (.69)	-.002 (-1.35)	.00001 (.106)			-.921 (-5.55)	.145 (1.00)	.053 (.45)	-.005 (-.05)	.026 (.22)	-.065 (-.44)	-.055 (-.41)	-.021 (-.46)	(-4.08)
3	Apparel	.987	1382.7 (18,323)	-.687 (-2.23)	.742 (76.71)	-.038 (-2.97)			TEX	.0008 (2.78)	.0032 (3.73)	.087 (4.60)	1.055 (2.13)	.007 (.19)	-.074 (-1.48)	.0014 (1.53)	-.0001 (-1.80)			.073 (.67)	-.041 (-.43)	.209 (2.78)	.037 (.54)	.152 (2.03)	.088 (.96)	.243 (2.88)	-.012 (-.42)	(-26.68)
4	Lumber prod. & furn.	.952	316.9 (20,321)	-.370 (-1.77)	1.012 (41.14)	-.003 (-.17)			F.MET.	.0003 (.20)	.0071 (1.28)	.015 (1.18)	.458 (1.35)	-.029 (-1.20)	-.001 (-.02)	-.0009 (-1.45)	.00005 (.98)	CLIM FOREST	.015 (.85) $-.08(10^{-6})$ (-1.77)	-.013 (-.19)	.014 (.28)	.038 (.75)	.090 (1.93)	.092 (1.78)	.128 (2.06)	.056 (.93)	-.020 (-.97)	(.47)
5A	Paper & allied prod.	.972	560.4 (20,321)	-.296 (-1.33)	.858 (38.94)	.004 (.02)			CHEM	-.001 (-.74)	.0039 (1.71)	.009 (.70)	.419 (1.20)		-.017 (-.47)	.0005 (.62)	.00007 (1.09)	FOREST PULP FOR-SAW	$.30(10^{-6})$ (4.20) $.29(10^{-6})$ (.83)	-.086 (-1.19)	-.034 (-.69)	.065 (1.35)	.086 (1.79)	.091 (1.75)	.064 (1.02)	.165 (2.66)	-.021 (-.95)	(-6.44)
6B	Chemicals & allied prod.	.986	1018.6 (22,319)	-.227 (-.89)	.895 (53.5)	-.065 (-2.95)	TEXT	.0012 (2.80)	PETR.	.00076 (1.06)	.0017 (2.99)	-.002 (-.17)	.296 (.72)	-.019 (-.68)	.006 (.17)	.0039 (4.73)	-.00003 (-.42)	ENPLAN OIL PIPE CLIM	31.5 (.86) .0021 (.62) .049 (2.49)	-.009 (-.12)	-.137 (-2.63)	-.034 (-.63)	.027 (.56)	-.041 (-.72)	.055 (.86)	.034 (.56)	-.04 (-1.80)	(-6.29)
7	Petroleum refining	.950	320.2 (19,322)	-.011 (-.02)	.910 (36.25)	-.03 (-.89)	CHEM	.004 (1.34)			.0024 (1.94)	-.029 (-1.09)	-.009 (-.01)	-.047 (-.93)	.097 (1.35)	.0023 (1.39)	-.0002 (-1.71)	OIL & G.RES.	.003 (.19)	-.051 (-.36)	-.184 (-1.75)	.036 (.36)	.083 (.84)	.095 (.80)	.062 (.46)	.059 (.49)	-.043 (-.99)	(-3.60)
8	Primary metals	.990	1328.0 (23,318)	.298 (1.17)	.927 (82.13)		ELECT F.MET. MOT.V. O.TRAN.	.0005 (.34) .0079 (3.47) -.0002 (-.96) .0014 (.67)			-.0055 (-5.97)	.0003 (.02)	-.468 (-1.25)	-.004 (-.17)	.040 (1.08)	.0016 (2.52)	-.00015 (-2.87)	CLIM COAL & IRON RES. ELECT. C.$	-.036 (-1.99) -.004 (-2.23) -.014 (-.29)	-.136 (-1.82)	-.031 (-.60)	.085 (1.61)	.013 (.25)	.080 (1.35)	.031 (.47)	.052 (.74)	-.003 (-.12)	(-6.48)
9	Fabricated M & ORD	.929	190.6 (22,319)	-.344 (-.77)	.812 (27.47)		ELECT MACH M.VEH. O.TRAN.	-.0071 (-2.27) -.0018 (-.23) -.0002 (-.40) .0160 (3.43)	P.MET.	-.0009 (-.60)	.0067 (1.12)	.058 (2.12)	.404 (.57)	-.025 (-.50)	.008 (.11)	.0011 (.84)	-.00002 (-.22)	CLIM	.057 (1.65)	-.055 (-.37)	-.095 (-.90)	.080 (.77)	.055 (.55)	.018 (.16)	.136 (1.04)	.202 (1.49)	-.040 (-.95)	(-6.36)
10	Nonelect. mach.	.972	551.1 (20,321)	-.337 (-1.26)	.900 (55.11)		ELECT O.TRAN. M.VEH.	-.0033 (-2.14) .0071 (4.03) .0003 (1.10)	P.MET.	.0009 (-1.17)	.0014 (.50)	.020 (1.06)	.644 (1.54)	-.030 (-1.00)	.066 (1.45)	.0007 (.94)	.00006 (.94)			-.097 (-1.01)	.013 (.15)	-.010 (-.13)	0.013 (-.18)	-.038 (-.46)	-.012 (-.14)	-.089 (-.91)	-.034 (-1.25)	(-6.15)
11	Electrical equip.	.937	194.9 (24,317)	-.544 (-1.00)	.758 (30.78)	-.022 (-.68)	MACH M.VEH. O.TRAN.	-.0146 (-.75) .00003 (.060) .0102 (3.04)	MACH P.MET F.MET	.0188 (.76) -.0029 (-1.54) -.0004 (-.08)	-.00004 (-.01)	.0090 (.25)	1.079 (1.25)	-.042 (-.72)	.037 (-.44)	.0029 (1.90)	.0004 (2.95)	ENPLAN	89.5 (1.12)	-.341 (-1.84)	-.340 (-2.06)	-.038 (-.25)	-.043 (-.31)	-.072 (-.44)	-.055 (-.32)	-.077 (-.41)	-.100 (-1.90)	(-9.82)
12	Motor veh. & equip.	.986	1110.6 (21,320)	-.082 (-.19)	.825 (99.07)	-.045 (-1.69)			P.MET F.MET MACH ELECT	.0011 (.62) .0114 (3.12) -.0113 (-2.72) .0042 (1.93)	.0006 (1.42)	.0133 (.43)	.452 (.64)	-.018 (-.37)	.040 (.55)	.0006 (.52)	-.00002 (-.18)			-.280 (-1.82)	-.211 (-1.48)	-.073 (-.57)	-.037 (-.32)	-.083 (-.62)	-.163 (-1.10)	-.154 (-1.01)	-.046 (-1.07)	(-20.99)
13	Other transport	.949	271.2 (22,319)	-.380 (-.74)	.963 (42.22)	-.051 (-1.06)			P.MET F.MET MACH ELECT	.0004 (.19) -.0008 (-.16) -.0006 (-.13) -.0005 (-.26)	.0118 (1.53)	.0844 (2.45)	.693 (.85)	-.089 (-1.53)	.035 (.41)	-.0050 (-3.31)	-.00048 (-4.01)	CLIM	.009 (.22)	.428 (2.30)	-.083 (-.51)	.150 (1.09)	-.025 (-.19)	.078 (.52)	.030 (.18)	.111 (.65)	.027 (.54)	(-1.64)
	Mean ($\bar{X}$)											1.28	.61	.29	.15	8.29	173.6			.029	.082	.269	.140	.135	.058	.088	.50	
	Standard deviation(s)											1.33	.04	.46	.36	22.16	304.0			.169	.275	.444	.348	.342	.235	.283	.50	

Table E-3.4 Beta coefficients for Model B - thirteen manufacturing industries
171 BEA economic areas
pooled 1960 and 1970 data

	S(T-10)	FDP	IDP		ISP		Self p.	Labor cond.				Port	L.C.	Other		Region (Relative to GL=0)							Pooled
			Name	Coef.	Name	Coef.		STRIK	EPI	LW	HW			Name	Coef.	1	2	4	5	6	7	8	
1B Food & kindred prod.	.975	-.057	CHEM	-.020		—	.079	.017	.022	.007	-.003	.027	-.001	AG. OR	.009	.005	.015	.050	-.006	.027	.021	.035	-.007
2 Textile mill prod.	.946	.064	APP	-.166	CHEM	-.020	.168	-.034	.002	-.028	.011	-.027	.002		—	-.090	.023	.014	-.001	.005	-.009	-.009	-.006
3 Apparel	.969	-.066		—	TEXT	.032	.081	.056	.019	.001	-.013	.015	-.021		—	.006	-.005	.045	.006	.025	.010	.033	-.003
4 Lumber prod. & furn.	.983	-.010		—	F.MET.	.009	.043	.027	.023	-.018	-.000	-.029	.021	CLIM FOREST	.017 -.030	-.003	.005	.023	.043	.043	.041	.022	-.013
5A Paper & allied prod.	.950	.001		— —	CHEM	-.024 —	.056	.011	.015	-.010	-.006	.011	.019	FOR. P. FOR. S.	.058 .009	-.014	-.009	.028	.029	.030	.014	.045	-.010
6B Chemicals & allied	.924	-.086	TEXT	.030 — —	PETR	.017 — —	.110	-.002	.007	-.006	.002	.058	-.005	ENPLAN OIL PIPE CLIM	.007 .006 .027	-.001	-.025	-.010	.006	-.009	.009	.007	-.014
7 Petroleum refining	.925	-.072	CHEM	.096		—	.054	-.025	-.000	-.014	.023	.033	-.035	OIL & GAS RES.	.003	-.006	-.033	.010	.019	.021	.009	.011	-.014
8 Primary metals	1.018	—	ELECT F. MET. M. VEH. O. TRAN.	.010 .140 -.012 .009			-.130	+.000	-.011	-.001	.009	.022	-.028	CLIM COAL & IRON RES. ELECT $	-.018 -.022 -.002	-.014	-.005	.023	.003	.017	.004	.009	-.001
9 Fabricated M & ORD	.921	—	ELECT MACH M. VEH. O. TRAN.	-.157 -.023 -.013 .111	P.MET.	-.028	.134	.062	.012	-.009	.002	.019	-.006	CLIM	.037	-.007	-.021	.028	.015	.005	.026	.046	-.016
10 Nonelect mach.	.969	—	ELECT O. TRAN. M. VEH.	-.190 .113 .032	P.MET.	-.028	.045	.022	.019	-.011	.020	.013	.015			-.014	.003	-.004	-.004	-.011	-.002	-.021	-.014
11 Electrical equip.	.875	-.084	MACH M. VEH. O. TRAN.	-.493 .003 .162	MACH P.MET. F.MET.	.501 -.074 -.008	-.002	.008	.026	-.013	-.009	.043	.072	ENPLAN	.020	-.038	-.062	-.011	-.010	-.016	-.009	-.014	-.033
12 Motor veh. & equip.	.955	-.073			P.MET. F.MET. MACH ELECT	.015 .100 -.158 .128	.031	.006	.006	-.003	.005	.005	-.002			-.017	-.020	-.011	-.005	-.010	-.013	-.015	-.008
13 Other transport	1.026	-.050			P.MET. F.MET. MACH ELECT	.008 -.012 -.014 -.024	.052	.066	.015	-.024	.007	-.065	-.085	CLIM	.004	.042	-.013	.039	-.005	.016	.004	.018	.008

statistically significant associations are positive coefficients for the STRIK variable within the apparel, fabricated metals, and other transport equipment industry groups which might imply that these industries have found it difficult to leave highly unionized and strike prone regions. Other subcategories of labor conditions do not yield substantial, significant, or intuitively meaningful associations.

Our empirical results suggest that port activity and population density (L.C.) are not generally important influences on locational change. In contrast to the results of Model A where port activity had a positive influence on the historic location of most industries, it appears to have had a significant positive influence on recent locational change in the chemicals, primary metals, food, and electrical equipment industries and a significant negative influence in the other transport equipment industry. Population density appears to have had a significant negative influence on recent locational change in the primary metals and other transport equipment industries and a positive influence in the electrical equipment industry. In the case of electrical equipment, it is likely the attraction to ports and population density has been dictated by the trade and manufacturing opportunities created at major trans-shipment points.

Of the remaining explanatory variables which encompass natural resource availability, long-term regional conditions and trends, only a few natural conditions are of much consequence to locational change. The presence of pulping wood has been important to the paper and allied products industry, mild climates have attracted the fabricated metals and chemicals industries, and the historically important forest resources and coal and iron resources have repelled the lumber products and furniture and primary metals industries, respectively.

E.3.3 "All other" manufacturing

We have termed the fourteenth industry group "All Other" manufacturing and treated it somewhat differently than the previous thirteen because of the diversity of its components. With each industry's 1970 employment level and 1958-1970 rate of growth in parentheses, the components of "all other" manufacturing are tobacco products (71,000; -15%), rubber and plastic products (548,000; +57%), leather and leather products (296,000; -15%), stone, clay and glass products (595,000; +8%), instruments and related products (404,000; +41%), and miscellaneous manufacturers (754,000; + 35%). Because of this diversity we found it impossible to think in terms of interregional market potentials (FDP, IDP, ISP, and Self P.) for "all other" manufacturing; it seemed foolish to assume the underlying composition of "all other" manufacturing equal or approximately equal in all BEA economic areas. Thus, we have chosen to use a rather general measure of FDP where $\lambda = 1.0$ and the local employment shares of three industries — petroleum refining, chemicals, and textiles — as four measures of market size which have been combined with our usual measures of labor conditions, port activity, population density, region, and time trend to estimate Models A and B. These results, along with 1970 cross-section estimates are compiled with the appropriate Beta coefficients in Table E-3.5.

Table E-3.5. Empirical results for "All Other" manufacturing — Models A and B for 171 BEA economic areas using pooled 1960 and 1970 data and separately for 1970 data

	Pooled Model A			Pooled Model B			1970 Model A			1970 Model B		
	Coefficient	t-value	β	Coefficient	t-value	β	Coefficient	t-value	β	Coefficient	t-value	β
R^2	.847			.984			.828			.986		
F value (d.f)	99.0	(18,323)		1035.6	(19,322)		43.4	(17,153)		581.6	(18,152)	
Intercept	-1.313	(-1.83)		-.461	(-1.98)		-1.764	(-1.73)		-.685	(-.232)	
S(T-10)				.875	(52.41)	.977				-.838	(40.90)	.997
FDP(-5)	.073	(2.45)	.142	.0079	(.81)	.015	.097	(2.30)	.230	.014	(1.14)	.033
<u>Proxy supply potentials</u>												
SHARE-PETROL	.108	(2.86)	.124	.090	(7.35)	.104	.82	(1.52)	.100	.087	(5.56)	.106
SHARE-CHEM	.532	(11.36)	.603	-.018	(-.99)	-.021	.477	(7.12)	.577	-.059	(-2.50)	-.071
SHARE-TEXTILE	.143	(6.33)	.187	.003	(.40)	.004	.095	(2.97)	.134	-.000	(-.01)	-.000
<u>Labor conditions</u>												
STRIK	.037	(.91)	.036	.018	(1.35)	.017	.031	(.45)	.031	.036	(1.83)	.036
EPI	1.736	(1.51)	.047	.689	(1.85	.019	2.106	(1.31)	.063	.988	(2.12)	.030
L.W	.201	(2.56)	.068	.008	(.30)	.003	.171	(1.56)	.064	.017	(.53)	.006
H.W.	.327	(2.93)	.087	.064	(1.76)	.017	.348	(2.33)	.103	.088	(2.01)	.026
Port activity	-.005	(-1.89)	-.082	-.003	(-3.64)	-.051	-.003	(-1.03)	-.067	-.002	(-2.25)	-.042
L.C.	.0003	(1.84)	.075	-.000	(-1.85)	-.025	.0003	(1.44)	.089	-.0001	(-1.36)	-.025
<u>Region</u> (relative to Great Lakes = 0)												
1. New England	1.38	(6.04)	.171	.075	(.97)	.009	1.39	(4.41)	.190	.10	(1.08)	.014
2. Mideast	-.07	(-.49)	-.014	.039	(.83)	.008	-.08	(-.37)	-.017	.06	(.99)	.013
4. Southeast	-.06	(-.39)	-.019	.143	(2.97)	.047	.16	(.77)	.057	.19	(3.23)	.070
5. Plains	.15	(.98)	.037	.039	(.81)	.010	.24	(1.16)	.069	.03	(.46)	.008
6. Southwest	.03	(.18)	.008	.024	(.45)	.006	.21	(.88)	.057	.04	(.66)	.012
7. Mountain	.27	(1.36)	.047	.054	(.84)	.009	.40	(1.42)	.077	.08	(.97)	.015
8. Farwest	.05	(.28)	.011	.121	(2.05)	.025	.19	(.74)	.044	.10	(1.38)	.024
Pooled (1960 = 0, 1970 = 1)	-.104	(-1.56)	-.038	-.011	(-.49)	-.004						
H_o: β S(T-10) = 1 (t value)					(-7.47)						(-7.90)	

Once again one can note the historic importance of market size in Model A albeit somewhat diminished because of our inability to include the preferred interregional market potential concepts. Regional labor market conditions appear to have made but a modest contribution to the historic location of this industry; the statistical significance of both high wage (skill) and low wage regions may simply confirm the problem of heterogeneous subindustries. Unlike most other industries, "all other" manufacturing has not shown a very strong positive association with port activity and population density; in fact, it has exhibited a weak negative association with ports and a weak positive association with population density. Regional dummy variables included as measures of long-term regional conditions (relative to the Great Lakes = 0) do not appear to have had much impact on the historic location of "all other" manufacturing with the especially important exception of New England which appears to have had a very strong historic advantage.

From the empirical results for Model B, past location remains the most important determinant of present employment location. Market size has had some effect, but this only shows up through the local employment share of petroleum refining because of our inability to include the preferred interregional market potential concepts. Labor conditions remain as weak determinants with market tightness (EPI) and high wage (skill) conditions having some positive influence. High port activity and population density appear to have discouraged the more recent location of "all other" manufacturing. Longer-term regional conditions embodied in the regional dummy variables seemed to have favored the Southeast and Far West as new locations.

E.3.4 <u>A simple Chow test: Is pooling appropriate</u>?

While it does not completely resolve the issue, we have performed a simple Chow test[26] to determine if the two subsets (cross-section estimates) could have been drawn from the same population. Thus, the null hypothesis is that the coefficients from the two cross-sections are not significantly different

$$H_o: \; \beta_i^{60} = \beta_i^{70}$$

and the alternative hypothesis is that <u>at least one</u> of the coefficients is significantly different

$$H_1: \; \beta_i^{60} \neq \beta_i^{70}$$

The test does not resolve the issue of the appropriateness of pooling cross-sections because a slightly revised model including selected slope interactive dummy variables would reverse the results in the case where only a few coefficients were significantly different between the subsets (cross-sections).

The results of these simple Chow tests applied to the above described manufacturing location equations are found in Table E.3.6. The results simply suggest that pooling may not be appropriate — that at least one of the coefficients is significantly different. Since we have been unable to test this hypothesis more completely by experimenting with interactive dummy variables attached to particular coefficients, we have tabulated the results of the

Table E-3.6. Chow test for equality of subsets of coefficients: manufacturing location analysis

Equation	Model*	F	Prob. F/H_0
Food and kindred products	A	2.4982	.0013
Food and kindred products	B	7.3745	.0000
Textiles	A	0.8886	.5884**
Textiles	B	1.2400	.2272**
Apparel	A	2.8741	.0004
Apparel	B	4.3249	.0000
Lumber products and furniture	A	0.5573	.9212**
Lumber products and furniture	B	2.8360	.0003
Paper and allied products	A	4.2880	.0000
Paper and allied products	B	3.2076	.0001
Chemicals	A	2.4740	.0008
Chemicals	B	3.0214	.0001
Petroleum	A	0.4224	.9796**
Petroleum	B	7.0864	.0000
Primary metals	A	3.2885	.0000
Primary metals	B	6.2166	.0000
Fabricated metals	A	1.8017	.0198
Fabricated metals	B	3.0369	.0001
Nonelectrical machinery	A	1.3687	.1452**
Nonelectrical machinery	B	2.0943	.0055
Electrical equipment	A	1.4749	.0805**
Electrical equipment	B	2.3999	.0006
Motor vehicles	A	0.6310	.8820**
Motor vehicles	B	11.7533	.0000
Other transportation	A	1.7306	.0278
Other transportation	B	5.2292	.0000
Miscellaneous	A	0.8863	.5912**
Miscellaneous	B	5.1263	.0000

*Model A = Lag out.
Model B = Lag in.

**Cannot reject the null hypothesis that the slope coefficients in the two regressions are the same (at the 5% level).

most recent 1970 cross-section estimates (Table E-3.7) which could be considered as a first (although not a preferred) alternative to the pooled results in their present form. As time permits, we will reappraise the appropriateness of the pooled model through tests of interactive dummy variables.

E.4 COMPUTATIONAL SEQUENCE: MANUFACTURING EMPLOYMENT

In MULTIREGION we assume that manufacturing employment adjusts to regional socioeconomic conditions with a five-year lag. This assumption is not unrealistic when we realize we are attempting to capture secular trends rather than cyclical behavior and simplifies the computations process within the model. The most cumbersome part of the manufacturing employment computations is the computation of the market potentials during each time step of MULTIREGION: we prefer to compute these values at the end of each time step because they may be used to summarize regional economic conditions. All required computations for manufacturing employment may be divided into four phases.

Phase I — Preliminary data manupulation. Necessary information is prepared from national/regional data estimates, and projections including (1) employment share (last period), (2) relative market potentials (last period values of FDP, IDP, ISP), (3) labor market conditions (last period values of STRIK, EPI, LW and HW), (4) trended values of PORT ACTIVITY and some "other" conditions, (5) trended regional dummies, and (6) national manufacturing employment by industry in Census of Population terms. Adjust S(T-10) coefficients and intercepts for use with a five-year lag.

Phase II _ Compute trial manufacturing employment shares. Regional manufacturing employment shares by industry are computed from Phase I data. 1970 residuals are retained but decay over time. Because experimental trackings of historic regional growth and development (1960 to 1970) indicate that the unconstrained model allows employment relocation to occur too quickly, an industry-specific control is placed on the rate of adjustment toward equilibrium (see Chapter 8).

Phase III — Compute manufacturing employment by industry. Regional employment shares are applied to forecasted national employment by industry to derive expected regional employment.

Phase IV — Compute revised relative market potential. At the conclusion of each time step, relative market potentials (FDP, IDP, ISP, Self P) are computed using forecast regional employment by industry and truck operating times. These revised market potentials may be used as added summary measures of regional economic change.

E.5 DEFINITIONS AND SOURCES OF EXPLANATORY VARIABLES

During the course of our analysis numerous explanatory variables were compiled and tested. Only some of these variables remain in the empirical results reported above. In this section we provide a listing of all explanatory variables considered during the analysis.

Table E-3.7. Model B results for thirteen manufacturing industries: 171 BEA economic areas, 1970 data.

	R^2	F (d.f)	Intercept	S(T-10)	FDP(-5)	IDP(-5) Name	IDP(-5) Coef.	ISP(-5) Name	ISP(-5) Coef.	Self P. (-5)	Labor conditions (-5) STRIK	Labor conditions (-5) EPI	Labor conditions (-5) LW	Labor conditions (-5) HW	PORT	L.C.	Other Name	Other Coef.	Region (Rel. to G.L.=0) 1 NE	2 ME	4 SE	5	6	7	8	H_o: β S(T-10)=1 (t value)
1. Food and kindred products	.985	560.6 (18,152)	-.154 (-.78)	.938 (48.98)	-.047 (-3.34)	CHEM	.0006 (.51)			.0065 (4.76)	.0016 (.13)	.305 (1.02)	.019 (.81)	.020 (.65)	-.0011 (-1.73)	-.0002 (-4.22)	AG OR	-.018 (-.45)	-.03 (-.54)	.01 (.36)	.05 (1.36)	-.04 (-.89)	.03 (.60)	.04 (.84)	.07 (1.39)	(-3.25)
2. Textile mill products	.974	319.2 (18,152)	.322 (.59)	.966 (48.05)	.027 (1.16)	APP	-.0047 (-3.86)	CHEM	-.0012 (-.37)	.0028 (5.40)	-.017 (-.40)	-.505 (-.58)	-.071 (-1.19)	.008 (.10)	-.0027 (-1.70)	-.00014 (-1.26)			-.50 (-2.57)	.35 (2.00)	.10 (.71)	.04 (.31)	.08 (.59)	.00 (.03)	.06 (.37)	(-1.68)
3. Apparel	.982	504.5 (17,153)	-1.058 (-2.41)	.676 (43.40)	-.046 (-2.39)			TEXT	.0004 (.96)	.0045 (3.48)	.103 (3.09)	1.661 (2.40)	.013 (.26)	-.083 (-1.22)	.0022 (1.94)	-.00003 (-.26)			-.16 (-1.00)	-.14 (-.95)	.22 (1.93)	.01 (.11)	.15 (1.39)	.08 (.63)	.24 (1.92)	(-20.80)
4. Lumber products & furniture	.964	213.6 (19,151)	-.538 (-2.02)	1.027 (33.89)	-.015 (-.78)			F. MET	.0010 (.68)	.0028 (1.80)	.32 (1.65)	.62 (1.46)	-.032 (-1.08)	-.050 (-1.16)	-.0011 (-1.52)	-.00004 (-.61)	CLIM FOREST	.023 (1.04) -.06(10^{-6}) (-1.05)	.06 (.75)	.04 (.65)	.06 (1.01)	.13 (2.19)	.15 (2.37)	.18 (2.30)	.00 (.00)	(.90)
5. Paper and allied products	.962	203.3 (19,151)	-.384 (-1.08)	.850 (22.16)	.007 (.32)			CHEM	-.0020 (-.97)	.0074 (2.27)	.014 (.56)	.44 (.81)	-.050 (-1.24)	.008 (.13)	-.0005 (-.43)	-.0001 (-1.10)	F.PULP F.SAW	.32(10^{-6}) (2.75) .51(10^{-6}) (.89)	-.06 (-.54)	.04 (.49)	.13 (1.61)	.16 (2.13)	.18 (2.13)	.14 (1.34)	.20 (2.04)	(-3.92)
6. Chemicals and allied products	.991	757.0 (21,149)	-.522 (-1.73)	.960 (44.35)	-.002 (-.08)	TEXT	.0014 (3.11)	PETR	.0015 (1.83)	-.0014 (-.53)	-.019 (-.96)	.796 (1.66)	-.017 (-.52)	.053 (1.25)	.0029 (3.30)	.000008 (.11)	ENPLAN OIL PIPE CLIM	-12.66 (-.37) -.0043 (-1.06) .028 (1.20)	-.04 (-.40)	-.12 (-1.83)	-.00 (-.08)	.02 (.40)	-.01 (-.07)	.01 (.15)	-.06 (-.88)	(-1.84)
7. Petroleum refining	.963	222.4 (18,152)	-.009 (-.02)	.966 (29.69)	-.082 (-1.92)	CHEM	.0037 (1.19)			.0018 (1.25)	.024 (.57)	.180 (.19)	-.008 (-.12)	.200 (2.27)	.0011 (.56)	.00034 (2.81)	OIL-GAS	-.0005 (-.02)	-.16 (-.87)	-.04 (-.27)	-.13 (-1.00)	-.01 (-.11)	-.12 (-.77)	-.16 (-.90)	-.32 (-2.06)	(-1.04)
8. Primary metals	.990	686.3 (22,148)	.458 (1.32)	.946 (54.17)		ELECT F. MET M.VEH O.TRANS	.0013 (.70) .0157 (5.38) -.0006 (-1.77) -.0047 (-1.87)			-.0094 (-7.39)	-.024 (-1.02)	-.530 (-1.08)	.004 (.13)	.037 (.77)	.0004 (.55)	-.00025 (-3.93)	CLIM COAL & IRON RES ELECT	-.086 (-3.38) -.006 (-2.61) -.070 (-1.02)	-.16 (-1.60)	-.08 (-1.16)	.12 (1.73)	.01 (.16)	.15 (1.89)	-.01 (-.09)	.06 (.61)	(-3.08)
9. Fabricated metal and ORD	.954	147.6 (21,149)	-.058 (-.12)	.900 (24.11)		ELECT MACH M.VEH O. TRANS	-.0094 (-2.92) .0137 (1.58) -.0011 (-2.13) .0169 (3.74)	P.MET	.0017 (.98)	-.0055 (-.86)	.048 (1.28)	.276 (.36)	.012 (.22)	.023 (.28)	.0015 (1.20)	-.00025 (-2.25)	CLIM	-.034 (-.87)	-.18 (-1.09)	-.16 (-1.35)	.01 (.06)	-.10 (-.86)	-.06 (-.47)	-.16 (-1.08)	-.11 (-.73)	(-2.67)
10. Nonelectrical machinery	.979	372.7 (19,151)	-.400 (-1.24)	.893 (43.46)		ELECT O. TRANS M.VEH	-.0014 (-.78) .0032 (1.64) -.0002 (-.45)	P.MET	.0006 (.70)	.0001 (.03)	.0165 (.60)	.745 (1.51)	-.055 (-1.51)	.079 (1.53)	-.0007 (-.79)	.00002 (.30)			-.17 (-1.50)	-.06 (-.61)	.02 (.25)	.03 (.41)	-.01 (-.06)	-.03 (-.27)	-.06 (-.53)	(-5.23)
11. Electrical equipment	.979	297.4 (23,147)	-.815 (-1.95)	.775 (39.04)	-.012 (-.38)	MACH M.VEH O.TRANS	.0077 (.53) .0003 (.87) .0016 (.66)	MACH P.MET F.MET	-.014 (-.79) -.003 (-2.32) .007 (1.91)	.0012 (.49)	.032 (.92)	1.394 (2.11)	-.06 (-1.36)	-.08 (-1.33)	-.0004 (-.40)	.0002 (2.67)	ENPLAN	93.68 (1.93)	-.12 (-.79)	-.03 (-.19)	.06 (.52)	-.00 (-.02)	.11 (.86)	-.03 (-.19)	.01 (.09)	(-11.36)
12. Motor vehicles & equipment	.995	1484.4 (20,150)	-.200 (-.52)	.914 (109.1)	.093 (3.38)			P.MET F.MET MACH ELECT	-.0006 (-.40) -.0039 (-1.27) -.0131 (-3.35) -.0016 (-.74)	.0015 (3.64)	.103 (3.09)	.605 (1.01)	-.025 (-.58)	-.0003 (-.01)	.0005 (.49)	-.00003 (-.40)			-.05 (-.36)	-.39 (-2.98)	-.32 (-2.81)	-.18 (-1.81)	-.26 (-2.21)	-.19 (-1.41)	-.29 (-2.08)	(-10.26)
13. Other transport	.970	226.7 (21,149)	-1.285 (-2.35)	.820 (34.32)	-.140 (-3.22)			P.MET F.MET MACH ELECT	-.0012 (-.62) .0073 (1.42) .0005 (.11) -.0024 (-1.28)	.0284 (3.95)	.092 (2.02)	2.206 (2.61)	-.094 (-1.53)	-.002 (-.03)	.000006 (.00)	-.00031 (-2.68)	CLIM	-.0010 (-.02)	.36 (1.77)	.16 (.89)	.22 (1.50)	-.05 (-.34)	.11 (.65)	.01 (.04)	.09 (.48)	(-7.52)

E-5.1. Definitions and sources of explanatory variables.

Variable	Description	Source
1. Initial conditions	The lagged value of the dependent variable; $SHARE_{Ri}(t-10)$	
2. Market accessibility		
2.1 Final demand potentials — 1950, 1960, 1970	Final demand potentials are given by the following formula: $FDP_{ik} = \sum_{j=1}^{171} \frac{Pop_j \times PCY_j}{D_{ij}^{\lambda_k}}$ for $D_{ij} \leq 8.3$ hours. where Pop_j = Population of the j^{th} BEA economic area PCY_j = Per capita income of the j^{th} BEA area D_{ij} = Truck operating time between i and j (where i = j, D_{ij} = 1/2 D_{ij} to the nearest BEA area) λ_k = Distance decay coefficient which varies with the good being shipped. Food and kindred products λ = 2.197 Textile mill products λ = .469 Apparel λ = .672 Lumber products and furniture λ = .976 Paper and allied products λ = 1.965 Chemicals and allied products λ = 1.360 Petroleum refining λ = .688 Primary metals λ = 1.221 Fabricated metals and ordnance λ = 1.445 Nonelectrical machinery λ = .469 Electrical equipment λ = .290 Motor vehicles and equipment λ = .450 Other transport equipment λ - 1.838	Distance decay coefficients derived from William R. Black, "Interregional Commodity Flows: Some Experiments with the Gravity Model," *Journal of Regional Science*, Vol. 12, No. 1, 1972.

Variable	Description	Source
2.2 Intermediate demand potentials - 1950, 1960 1970	The intermediate demand potentials are given by the following formula: $IDP_{ikm} = \sum_{j=1}^{171} \frac{EMP_{jm}}{D_{ij}^{\lambda_k}}$ for $D_{ij} \leq 8.3$ hours where EMP_{jm} = Employment in industry m within BEA area j D_{ij} = as in 2.1 λ_k = as in 2.1.	Same as 2.1.
2.3 Relative final demand potentials - 1950, 1960 1970	The relative final demand potentials are given by the following formula: $Rel\ FDP_{ik} = FDP_{ik}/(POP_{us} \times PCY_{us})$	
2.4 Relative intermediate demand potentials - 1950, 1960, 1970	The relative intermediate demand potentials are given by the following formula: $Rel\ IDP_{ikm} = IDP_{ikm}/EMP_{us,m}$	

Variable	Description	Source
3. Market competition		
3.1 Intermediate self potentials - 1950, 1960, 1970	The intermediate self potentials are given by the following formula: $$I\text{-}SELF\text{-}P_{ik} = \sum_{j=1}^{171} \frac{EMP_{jk}}{D_{ij}^{\lambda_k}} \quad \text{for } D_{ij} \leq 8.3 \text{ hours}$$ where EMP_{jk} = Employment in industry k within BEA area j D_{ij} = as in 2.1 λ_k = as in 2.1.	
3.2 Relative intermediate self potentials - 1950, 1960, 1970	The relative intermediate self potentials are given by the following formula: $$Rel\ I\text{-}SELF\text{-}P_{ik} = ISP_{ik}/EMP_{us,k}$$	
4. Labor conditions		
4.1 Population - 1950, 1960, 1970	County Population data cumulated to 171 Bureau of Economic Analysis (BEA) defined areas.	Richard J. Olsen and G. W. Westley, <u>1952 County and City Data Book Cumulations to OBE Areas</u>, ORNL-NSF-EP-31 (January 1973); Richard J. Olsen and G. W. Westley, <u>1962 County and City Data Book Cumulations to OBE Areas</u>, ORNL-NSF-EP-33 (January 1973); ORNL-NSF unpublished cumulations to BEA areas of the 1960 and 1970 Census of Population.

	Variable	Description	Source
4.2	Relative manufacturing wage - 1950, 1960, 1970	Given the industrial composition of local employment, an actual and expected wage rate exist. The relative manufacturing wage rate is the ratio of the actual to the expected wage rate, as shown in the following formula: $RMW_j = \frac{\sum_i (\text{local wage rate}_{ij})(\text{employment}_{ij})}{\sum_i (\text{national wage rate}_i)(\text{employment}_{ij})}$ where j = BEA area and i = industry. Note that the actual wage rate in each area is the sum of the products of the local wage rate in each industrial classification and the corresponding local employment in each classification. The expected wage rate in each area is the sum of the products of the <u>national</u> wage rate in each industrial classification and the corresponding local employment in each classification. To gain three data points corresponding to those in the <u>Census of Population</u>, an average of 1947 and 1954 was used for 1950, an average of 1958 and 1963 for 1960, and 1967 is used for 1970.	Department of Commerce, Bureau of the Census, <u>Census of Manufactures: 1947</u>, <u>1954</u>, <u>1958</u>, <u>1963</u>, and <u>1967</u>.
4.3	Male unemployment rate (persons 14+) - 1950, 1960, 1970	For each BEA area this variable is the percentage of the male labor force (persons 14+) that is unemployed.	Same as in 4.1.
4.4	Female unemployment rate (persons 14+) - 1950, 1960, 1970	For each BEA area this variable is the percentage of the female labor force (persons 14+) that is unemployed.	Same as in 4.1.
4.5	Unemployment rate (persons 14+) - 1950, 1960, 1970	For each BEA area this variable is the percentage of the total labor force (persons 14+) that is unemployed.	Same as in 4.1.

Variable	Description	Source
4.6 Male labor force participation rate - 1950, 1960, 1970	For each BEA area this variable is the percentage of the male population (persons 14+) that is in the male labor force.	Same as in 4.1.
4.7 Female labor force participation rate - 1950, 1960, 1970	For each BEA area this variable is the percentage of the female population (persons 14+) that is in the female labor force.	Same as in 4.1.
4.8 Strikers relative to the U.S. - 1950, 1960, 1970	Because of annual fluctuations in strike activity, three year averages of state strike activity form the basis of the index of strike activity: 1950-1952, 1958-1960, and 1968-1970. The Bureau of Labor Statistics reports strike activity by industry for those states having 25 or more strikes per year; however, only 25 states consistently had the required number of strikes to permit publication of strike data for the nine time periods in question. The number of strikers in each state were averaged by industry for the years 1950-1952, 1958-1960, and 1968-1970; and strike rates by industry were determined for 1950, 1960 and 1970 by calculating the average number of strikers/total employment. Given the state strike rates by industry, we found the number of strikers in each county in 25 states by applying the state strike rates to county employment. The county strike activity was then aggregated to the BEA level; and strike rates were determined for the periods 1950, 1960 and 1970 for 171 BEA areas. Finally, all BEA area strike rates were divided by the corresponding national rate.	Bureau of Labor Statistics, Analysis of Work Stoppages, Federal Bulletins #1035 (1950), #1090 (1951), #1136 (1952), #1258 (1958), #1278 (1959), #1302 (1960), #1646 (1968), #1687 (1969), and #1727 (1970). Washington: U.S. Government Printing Office; Employment data is the same as in 4.1.
4.9 Percent of manufacturing employees that are production workers - 1950, 1960, 1970	This variable is calculated for three points in time: the average of 1947 and 1954 represents 1950, the average of 1958 and 1963 represents 1960, and 1967 represents 1970.	Same as 4.2.

Variable	Description	Source
4.10 "Potential" MLPR - 1950, 1960, 1970	For each BEA area this variable is calculated via a multiple regression equation estimated using pooled 1950, 1960, and 1970 data for 171 BEA areas. MLPR = 61.964 - .581 MUnR + 1.612 MedSch (13.814) (-7.473) (11.298) + .229 Mix-M - .242 Med Age - 4.537 Pool (4.353) (-4.644) (-11.145) To estimate "potential" MLPR for each BEA area, the explanatory variables were assigned values as follows: Male Unemployment rate (MUnR) = 2.5 Median School (MedSch) = actual BEA value % of the labor force that is male (Mix-M) = national average Median age (Med Age) = actual BEA value Pool = year (0, 1, 2)	
4.11 "Potential" FLPR - 1950, 1960, 1970	For each BEA area this variable is calculated via a multiple regression equation estimated using pooled 1950, 1960, and 1970 data for 171 BEA areas. FLPR = -2.729 - .454 MUnR + 1.161 Med Sch (-1.599) (-6.627) (9.231) +.935 Mix-F -.035 Med Age -1.221 Pool (20.133) (-.764) (-3.404) To estimate "potential" FLPR for each BEA area, the explanatory variables were assigned values as follows: Male Unemployment rate (MUnR) = 2.5 Median School (Med Sch) = actual BEA value % of labor force that is female (Mix-F) = national average Median age (Med Age) = actual BEA value Pool = year (0, 1, 2)	

Variable	Description	Source
4.12 Median Schooling of persons 25+ - 1950, 1960, 1970	For each BEA area this variable is the approximate mean of county median school years completed of those persons 25 years old or older.	Richard J. Olsen and G. W. Westley, 1956 County and City Data Book Cumulations to OBE Areas, ORNL-NSF-EP-32 (January, 1973); Richard J. Olsen and G. W. Westley, 1967 County and City Data Book Cumulations to OBE Areas, ORNL-NSF-EP-34 (January, 1973); and ORNL-NSF unpublished cumulations to BEA areas of selected items in the 1960 and 1970 Census of Population.
4.13 Industry Mix - Female - 1950, 1960, 1970	For each BEA area this variable is the percentage of employment that is female.	Same as 4.12.
4.14 Population Median Age - 1950, 1960, 1970	For each BEA area this variable is the mean of county median age.	Same as 4.12.
4.15 Relative Low Wage Dummy	The relative manufacturing wage rate (4.2) forms the basis for this variable. If the BEA area has a value greater than 85, it is assigned a zero; otherwise, it is assigned a one.	Same as in 4.2.
4.16 Relative High Wage Dummy	If in a particular BEA area the relative manufacturing wage rate is greater than 105, it is assigned a one; otherwise, it is assigned a zero.	Same as in 4.2.
4.17 Employment Pressure Index	The employment pressure index for each BEA area is given by TOT employment/population aged 15-65.	Unpublished cumulations of the 1950, 1960, and 1970 Census of Population.
5. Natural and Amenity Resources		
5.1 Area in square miles	County data are cumulated to the BEA level.	R. J. Olsen and G. W. Westley, 1967 County and City Data Book Cumulations to OBE Areas, ORNL-NSF-EP-34 (January, 1973).
5.2 Terrain - % level, % rolling, % mountain	The National Atlas of the United States of America contains a map entitled "Classes of Land-Surface Form" which distinguishes among thirty-one classes of land-surface form. These classes were consolidated into level, rolling and mountainous.	U.S. Department of Interior, Geological Survey, The National Atlas of the United States of America (Washington: U.S. Government Printing Office, 1970).

Variable	Description	Source
5.3 Usable land in square miles	Usable land is defined as the product of (% level + 1/2% rolling + 1/10% mountain) (area).	
5.4 Land Cost: 1950, 1960, 1970	The land cost of a particular BEA area is defined as population/ usable land.	Same as in 4.1.
5.5 Ground water - % of area covered	Two grades of ground water quality are considered. With a BEA area overlay map a visual judgment was made as to the presence of good and best ground water. The scores were as follows: no ground water (0), good (1), and best (2).	Same as in 5.2.
5.6 Surface water	The surface water variable is a compound dummy variable. First scores are given for the presence (or lack of) precipitation equal to or greater than 48 inches per year. Second, scores are given for the presence (or lack of) a port. These two dummy variables are then summed.	Same as in 5.2.
5.7 Net primary forest productivity	This variable is the potential forest biomass productivity.	Dave Sharpe, ORNL-NSF-IBP, "Net Primary Production: C. W. Thronthwait Memorial Model," 1972.
5.8 Forest type and extent	With a BEA area overlay map a visual judgment was made as to the percentage of each BEA area that is made up of furniture wood, pulp wood and saw timber.	Same as in 5.2.
5.9 Climate - mild winter and especially frequent sunshine	The climate variable is a compound dummy variable. First for mild winters, a zero was assigned to BEA areas with more than 3000 heating degree days per year, a one was assigned to BEA's with more than 1000 and up to 3000 heating degree days, and a two was assigned for 1000 or fewer degree days. Second, for frequent sunshine BEA areas with less than 120 days with precipitation greater than .01 inches are given a one, zero otherwise. These two variables are then summed.	Same as in 5.2.
5.10 Mineral resource availability, coking coal, copper, zinc, lead iron, oil, gas	With a BEA area overlay map a visual approximation was made as to the presence of the various minerals.	Same as in 5.2.

Variable	Description	Source
5.11 Education expenditures per capita	1962 county education expenditures and 1960 population are cumulated to BEA areas and expenditures/capita are calculated.	Same as in 5.1.
5.12 Educational Effort Index	For each BEA area this variable is, in 1960, (per capita expenditures/per capita income) x 100.	Same as in 5.1.
5.13 Index of agricultural orientation	For each BEA area the index of agricultural orientation is the per capita value of farm products (in $1000).	Same as in 5.1.
6. Financial Resources and Subsidies		
6.1 Loan to Deposit Ratio - 1950, 1960, 1970	The loan to deposit ratio of the three largest banks in each BEA area, i.e., total average loans/total average deposits is used as an index of the true loan to deposit ratio.	Rand McNally and Company, Rand McNally Banker's Directory (Chicago: 1950, 1960 and 1970).
6.2 Cost of Construction - 1950, 1960, 1970	The series used attempts to compare the cost of local construction with the cost of New York City; thus, for each BEA area there was an index number reflecting the relative cost of construction in this area. Since some BEA areas have many observations, while others have none, for the former we averaged all values in a particular BEA area, and for the latter the index(es) of adjacent BEA areas are used.	Dodge Building Cost Services, United States Construction Costs (New York: McGraw-Hill Information Systems Company, October 1972).
6.3 Deposits per Capita - 1950, 1960	County deposits cumulated to BEA areas.	Richard J. Olsen and G. W. Westley, 1952 County and City Data Book Cumulations to OBE Areas, ORNL-NSF-EP-31 (January, 1973) and Richard J. Olsen and G. W. Westley, 1962 County and City Data Book Cumulations to OBE Areas, ORNL-NSF-EP-33 (January, 1973).
6.4 State Subsidies - Four Possible Types - 1961, 1969	Here, a particular BEA area is given a "1" if 3 or 4 subsidies are given by the state in which it is located. It is given a zero otherwise. For those particular BEA's located in two or more states, the score for the state with the most incentives is given. The subsidies were (1) property tax exemption, (2) bonds, (3) state financial assistance, and (4) private development agency.	"States - What They Give to Get Industry and What They Get in Return," Business Management, 36 (August 1969), pp. 26-29; "Hotter Bidding for New Plants," Business Week (December 16, 1961) pp. 126-130.

Variable	Description	Source
7. Intermediate Inputs		
7.1 Enplanements (000's) - 1950, 1960, 1970	Enplanements of each individual airport cumulated to BEA areas.	U.S. Department of Commerce, Air Commerce Traffic Patterns: 1952 (Washington: U.S. Government Printing Office, 1953); Federal Aviation Agency, Bureau of Facilities and Material Airports Division, Air Commerce Traffic Pattern: 1960 (Washington: U.S. Government Printing Office, 1961); and Civil Aeronautics Board and Federal Aviation Agency, Airport Activity Statistics of Certificated Route Air Carriers: 1970 (Washington: U.S. Government Printing Office, 1971).
7.2 Natural Gas Pipeline Crossings - 1950, 1960 1970	The number of natural gas pipeline crossings of BEA boundaries in the years 1950, 1956 and 1967 are used as proxy variables for the regional availability of natural gas during the periods 1950, 1960 and 1970. Included in the 1956 data are pipelines under construction.	James J. Parsons, "Natural Gas," Scientific American, Vol. 185 (November 5, 1950), pp. 18-19; Federal Power Commission, "Major Natural Gas Pipelines" (Washington: U.S. Government Printing Office, 1956); and United States Department of Interior, Geological Survey, The National Atlas of the United States of America (Washington: U.S. Government Printing Office, 1970).
7.3 Enplanements/ Originations - 1970	For each BEA area this variable is a ratio of the number of revenue passengers boarding scheduled flights at points of initial enplanements (and including originating, stopover and transfer passengers) to the number of revenue passengers boarding scheduled flights at points of origination.	Civil Aeronautics Board and Federal Aviation Agency, Airport Activity Statistics of Certificated Route Air Carriers: 1970 (Washington: U.S. Government Printing Office, 1971).
7.4 Number of Rail Crossings - 1967	Rail line crossings of each BEA area boundary serves as an index of rail availability.	United States Department of Interior, Geological Survey, The National Atlas of the United States of America (Washington: U.S. Government Printing Office, 1970).

Variable	Description	Source
7.5 Number of Limited Access Highway Crossings when System is Complete	The total number of limited access highway crossings of BEA area boundaries when the Interstate system is complete.	Same as in 7.4.
7.6 Number of Products and Crude Oil Pipeline Crossings	The total number of 1967 crude oil and products pipeline crossings of BEA area boundaries.	Same as in 7.4.
7.7 Average Industrial Cost of Electricity (¢/kWhr) during January for 1950, 1960 and 1970	The average cost of electricity in the 1000 kilowatt billings demand category in the reporting cities of a particular BEA area. Areas with no reporting cities are given the rates of adjacent BEA areas. The cost of power is the average of the cost per kWhr in the 200 thousand and 400 thousand kWhr monthly consumption groups. That is, the cost per kWhr in both consumption groups is calculated and averaged.	Federal Power Commission, Bureau of Power, <u>Typical Electric Bills</u> (Washington: U.S. Government Printing Office, January 1951, January 1960, January 1970).
7.8 Port Activity - 1954, 1960, 1970	The index of port activity, for those BEA areas having ports, is the total foreign and domestic commerce of all ports in each BEA area.	U.S. Army Corps of Engineers, <u>Water-Borne Commerce of the United States</u> (Washington: U.S. Government Printing Office, 1954, 1960, 1970).
7.9 Intermediate Supply Potentials - 1950, 1960, 1970	Defined as $ISP_{ik} = \sum_{j=1}^{171} \frac{EMP_{jk}}{D_{ij}^{\lambda_k}}$ for $D_{ij} \leq 8.3$ hours where EMP_{jk} = employment in industry k within BEA_j D_{ij} and λ_k = as in 2.1.	
7.10 Relative Intermediate Supply Potentials - 1950, 1960, 1970	Defined as $Rel\ ISP_{ik} = ISP_{ik}/EMP_{us,k}$	

REFERENCES FOR APPENDIX E

1. Victor R. Fuchs, Changes in the Location of Manufacturing in the United States Since 1929, Yale University Press, New Haven, 1962. J. C. Burrows, C. E. Metcalf, and J. B. Kaler, Industrial Location in the United States, Heath Lexington Books, Lexington, 1971. R. G. Spiegelman, A Study of Industry Location Using Multiple Regression Techniques, Agricultural Economics Report 140, Economic Research Service, U.S. Department of Agriculture, 1968. Joel Bergsman, P. Greenston, and R. Healy, Research on Urban Economic Development and Growth Policy, Urban Institute Paper 200-5 (Washington, D.C.: The Urban Institute, 1972) and "Determinants of Metropolitan Growth: 1965-70," paper presented at the Regional Science Association, Philadelphia, November 1972. G. Alperovich, J. Bergsman, and C. Ehemann, "An Econometric Model of Employment Growth in U.S. Metropolitan Areas," Urban Institute (Washington, D.C.: The Urban Institute, 1975) Working paper #0974-5. Curtis C. Harris, Jr., and F. E. Hopkins, Locational Analysis; An Interregional Econometric Model of Agriculture, Mining, Manufacturing, and Services, Heath Lexington Books, Lexington, 1972. C. C. Harris, Jr., The Urban Economies, 1985, Heath Lexington Books, Lexington, 1973.

2. Harry W. Richardson, Regional Growth Theory (London: The Macmillan Press, Ltd., 1973, Chapter 2, "The Current State of Regional Growth Theory."

3. BEA economic areas are mutually exclusive functional economic areas that include the total land area and population of the United States. They were defined by the Office of Business Economics (now the Bureau of Economic Analysis) of the U.S. Department of Commerce in 1969.

4. Standard Industrial Classification code. See Office of Management and Budget, Executive Office of the President, Standard Industrial Classification Manual, 1972. U.S. Government Printing Office, Washington, D.C.

5. This industry detail was possible only after the 1970 employment by industry was recompiled for the Bureau of Economic Analysis by the Bureau of the Census to be consistent with the contents of Lowell D. Ashby, Growth Patterns in Employment by County 1940-1950 and 1950-1960: Volumes 1 through 8. U.S. Government Printing Office, 1965. The combined county employment files are available in Lowell D. Ashby and David W. Cartwright, Regional Employment by Industry, 1940-1970, Department of Commerce, U.S. Government Printing Office (no date).

6. We are presently preparing employment files with greater industrial detail from County Business Patterns data for 1967 and 1972.

7. Curtis Harris has reestimated his industrial location equations using regional share of output as the dependent variables. See Curtis C. Harris, Jr., The Urban Economies, 1985, Heath Lexington Books, Lexington, 1973, p. 72.

8. Representative measures of market accessibility used in previous studies include the region's population and its rate of growth, the region's or nearby regions' level of employment or output in linked industries or their respective rates of growth, personal consumption expenditures in the region, and distance to larger SMSAs.

9. Alaska (BEA area #172) and Hawaii (BEA area #173) have been excluded from our analysis.

10. An interesting perspective to regional growth as an evolutionary process is provided by Edgar S. Dunn, Jr., in Economic and Social Development: A Process of Social Learning, Baltimore: J. Hopkins Press for Recources for the Future, 1970.

11. Location theory frequently begins with minimization of transport costs as the objective of location choice. See G. J. Karaska, "The Partial Equilibrium Approach to Location Theory: Graphic Solutions," in G. J. Karaska and D. F. Bramhall (eds.), Location Analysis for Manufacturing: A Selection of Readings, Cambridge: M.I.T. Press, 1969.

12. M. L. Greenhut has frequently argued that the market protection provided by space has contributed significantly to the formation of the effective oligopolistic market economy we now enjoy. See his Microeconomics and the Space Economy, Chicago: Scott Foresman and Co., 1963, for example.

13. The concept of agglomeration economies is thoroughly discussed in all regional economics textbooks and may be used as the primary rationale for the existence of nodes of economic activity (i.e., cities). See H. W. Richardson, Elements of Regional Economics, Baltimore: Penguin Books, 1969, Chapter 3, "Location and Agglomeration."

14. Frank T. de Vyver, "Labor Factors in the Industrial Development of the South," in Karaska and Bramhall (eds.), Location Analysis for Manufacturing: A Selection of Readings, pp. 108-124.

15. Brian J. L. Berry and Elaine Neils, "Location, Size, and Shape of Cities as Influenced by Environmental Factors: The Urban Environment Writ Large," in H. S. Perloff (ed.), The Quality of the Urban Environment: Essays on "New Resources" in an Urban Age, Baltimore: J. Hopkins Press for Resources for the Future, 1969.

16. We are following Spiegelman's attempt to measure these location subsidies.

17. The importance of these interindustry links is assumed to be growing as the stages of production become more differentiated.

18. These truck operating times between over 700 city pairs for three points in time are available to others in R. J. Olsen and G. W. Westley, Synthetic Measures of Truck Operating Times Between the Metropolitan Centers of BEA Economic Areas: 1950, 1960, and 1970 with Projections for 1980, ORNL-NSF-EP-78, January 1975.

19. The interested reader may consult Gerald A. P. Carrothers, "An Historical Review of the Gravity and Potential Concepts of Human Interaction," Journal of the American Institute of Planners, Spring, 1965, pp. 94-102: and Walter Isard, et al., Methods of Regional Analysis: An Introduction to Region Science, Cambridge, M.I.T. Press, 1960, pp. 493-568.

20. The 8.3 hour criterion represents a slight adjustment of a subjectively chosen 8.0 hour criterion; other critical values could have been used. The assumption here is that truck transport generally is of less importance beyond what may be termed an overnight transport distance stated in hours.

21. U.S. Department of Commerce and Natural Resource Division, Economic Research Service, U.S. Department of Agriculture, 1972 OBERS Projections: Economic Activity in the U.S. by Water Resources Regions and Subareas: Historical and Projected, 1929-2020, U.S. Water Resources Council, Washington, D.C. The latest personal income estimates for BEA areas at the time this study was begun were for 1950, 1959, and 1968. The latter two estimates were used in lieu of 1960 and 1970 data that have since become available.

22. While the literature on the gravity model does include reference to how λ varies inversely with the value of the good being shipped (e.g., D. L. Huff, Determination of Intra-Urban Retail Trade Areas, Real Estate Research Program, University of California, Los Angeles, 1962, pp. 19 and 31), the "value of product" and alternative hypotheses are only now being subjected to systematic testing. A recent paper by William R. Black, "Interregional Commodity Flows: Some Experiments with the Gravity Model," Journal of Regional Science, Vol. 12, No. 1 (April 1972), pp. 107-118, describes some systematic tests of these alternative hypotheses. The distance decay coefficients used in this study were derived from values found in the Black article by computing a weighted average of the values for component commodities of each industry group using 1970 national employment by industry as the weights.

1.	Food and kindred products	λ = 2.197
2.	Textile mill products	λ = .469
3.	Apparel	λ = .672
4.	Lumber products and furniture	λ = .976
5.	Paper and allied products	λ = 1.965
6.	Chemicals and allied products	λ = 1.360
7.	Petroleum refining	λ = .688
8.	Primary metals	λ = 1.221
9.	Fabricated metals and ordnance	λ = 1.445
10.	Nonelectrical machinery	λ = .469
11.	Electrical equipment	λ = .290
12.	Motor vehicles and equipment	λ = .450
13.	Other transport equipment	λ = 1.838

23. The simple correlation coefficients between pairs of explanatory variables are tabulated below for pooled 1960 and 1970 data.

	STRIK	EPI	LW	HW	PORT	L.C.	Region 1	Region 2	Region 4	Region 5	Region 6	Region 7	Region 8	Pooled
STRIKE	1.00													
EPI	-.03	1.00												
LW	-.33	-.19	1.00											
HW	.18	.08	-.28	1.00										
PORT	.17	.01	-.17	.35	1.00									
L.C.	.27	.02	-.22	.33	.62	1.00								
1	-.10	.08	-.07	-.07	.04	.20	1.00							
2	.22	.05	-.15	.08	.26	.43	-.05	1.00						
4	-.23	-.33	.32	-.24	-.06	-.07	-.11	-.18	1.00					
5	-.12	.25	.11	-.15	-.10	-.19	-.07	-.12	-.25	1.00				
6	-.22	-.17	.18	-.05	-.02	-.16	-.07	-.12	-.24	-.16	1.00			
7	-.24	.05	-.08	-.07	-.09	-.12	-.04	-.07	-.15	-.10	-.10	1.00		
8	-.11	-.01	-.20	.52	.03	.11	-.05	-.09	-.19	-.13	-.12	-.08	1.00	
Pooled	-.05	.24	.03	.01	.03	.04	.00	.00	.00	.00	.00	.00	.00	1.00

Most simple correlation coefficients between the dependent and independent variables are shown below for pooled 1960 and 1970 data.

Employment Share

	FOOD 1	TEXT 2	APP 3	LWF 4	PAPER 5	CHEM 6	PETR 7	P. MET 8	F. MET 9	MACH 10	ELECT 11	M.V. 12	O. TRAN 13	All other 14
ISP: 1	.58													
ISP: 2		.68	.27											
ISP: 3			.63											
ISP: 4				.51										
ISP: 5					.72									
ISP: 6		.28			.60	.69								
ISP: 7						.43	.55							
ISP: 8								.65	.47	.54	.39	.48	.12	
ISP: 9				.18					.63		.55		.25	
ISP: 10										.51	.37	.32	.09	
ISP: 11											.44	.25	.16	
ISP: 12												.48		
ISP: 13													.63	
ISP: 14														
FDP	.60	.14	.38	.21	.55	.58	.27				.45	.27	.30	.58
STRIK	.19	-.11	.07	.00	.17	.20	.09	.42	.31	.36	.23	.38	.08	.22
EPI	.20	.18	.08	.00	.13	.04	.02	.00	.17	.23	.19	.03	.15	.16
LW	-.22	-.08	-.07	-.14	-.20	-.16	-.19	-.20	-.24	-.26	-.21	-.12	-.16	-.19
HW	.30	-.04	.16	.34	.26	.26	.35	.29	.39	+.37	.31	.26	.28	.28
PORT	.74	.25	.69	.46	.71	.81	.79	.48	.66	.64	.68	.27	.47	.69
L.C.	.70	.35	.72	.42	.69	.74	.49	.51	.68	.66	.72	.23	.46	.75
REGION: 1	.05	.15	.05	.09	.27	.02	-.04	.02	.13	.16	.13	-.03	.15	.24
REGION: 2	.31	.12	.37	.09	.32	.35	.19	.34	.23	.25	.32	.03	.12	.34
REGION: 4	-.14	.29	.01	.19	-.07	-.04	-.14	-.14	-.17	-.22	-.16	-.11	-.10	-.12
REGION: 5	-.06	-.13	-.09	-.25	-.15	-.13	-.11	-.13	-.13	-.11	-.12	-.07	-.10	-.12
REGION: 6	-.12	-.12	-.07	-.19	-.18	-.08	.15	-.10	-.12	-.12	-.11	-.07	-.05	-.12
REGION: 7	-.09	-.08	-.07	-.15	-.13	-.08	-.05	-.06	-.09	-.10	-.09	-.05	-.07	-.09
REGION: 8	.07	-.09	-.03	.31	.01	-.03	.06	-.03	.09	-.02	.03	-.03	.25	-.02
Pooled	.00	-.00	.00	-.00	-.00	-.00	-.00	-.00	-.00	-.00	-.00	-.00	-.00	-.00

24. Before examining the empirical results by industry group, additional insights to the composition of each industry may be helpful. The employment numbers provided are based upon Bureau of Labor Statistics estimates as published in Table 370, U.S. Bureau of the Census, Statistical Abstract of the U.S.: 1973, (9th edition), Washington, D.C., 1973. The wage information is from U.S. Bureau of the Census, Annual Survey of Manufacturers: 1970, General Statistics for Industry Groups and Industries, M70(AS)-1, U.S. Government Printing Office, Washington, D.C., 1972.

Food and kindred products. In 1970, this industry (SIC #20) employed 8.5 percent of total manufacturing employment at an annual wage ten percent below the national manufacturing average. Total employment in the industry has been declining, but employment in the beverage and canned, cured, and frozen food subindustries has been increasing. The food industry is quite heterogeneous and its changing pattern of location is the result of different forces in different subindustries. The dairy products industry has undergone a productivity revolution as it has converted to large automated facilities with the result that employment has dropped precipitously. Improvements in refrigerated transport and the economies of large-scale slaughtering operations have caused the meat packing industry to relocate out of cities to the more rural areas where cattle are raised. Increased consumer demands for processed foods have caused the growth of canned, cured, and frozen foods employment in areas nearest their suppliers, i.e., farms and ports. Both bakery and beverage products are final demand oriented because their manufacturers are, respectively, bulk and weight adding processes.

Textile mill products. In 1970, this industry (SIC #22) employed 4.8 percent of total manufacturing employment at an annual wage 30 percent below the national average. Changes in the technology of the industry and subsequent changes in consumer demand are reflected in the tremendous growth of the weaving mills, synthetics employment (SIC #222) and the decline of the weaving mills, cotton (SIC #221) and weaving finishing mills, wool (SIC #223) employment. Also, during the period 1958-1970, knitting mills (SIC #225), floor covering mills (SIC #227) and yarn and thread mills (SIC #228) had increases in employment.

Apparel and related products. In 1970, this industry (SIC #23) employed 6.9 percent of total manufacturing employment at an annual wage 40 percent below the national average. The major employment increases during the period 1958-1970 occurred in men's and boy's furnishings (SIC #231), women's and misses' outerwear (SIC#233) and miscellaneous fabricated textile products (SIC #239). Employment declined in hats, caps and millinery (SIC #235) and children's outerwear (SIC #236).

Lumber, wood, and furniture. In 1970, the combined lumber and wood products (SIC #24) and furniture and fixtures (SIC #25) industries employed 5 percent of total manufacturing employment at an annual wage 24 percent below the national manufacturing average. Employment in the lumber and wood products industry has been declining in all regions except the Mountain states with the greatest decline in the South Atlantic region where many small inefficient plants have been replaced with more efficient and less labor intensive facilities. While employment in the dominant sawmills and planning mills subindustry has been declining dramatically (27% from 1958 to 1970), employment in most other subindustries including millwork, plywood and related products has been growing.

Employment in the furniture and fixtures industry has been growing. The household furniture subindustry accounted for 69 percent of the industry's total employment in 1970. The furniture industry has been growing most rapidly in the South (i.e., South Atlantic, East South Central, and West South Central) and the Far West and appears to be oriented toward supplies of hardwood sawtimber and low-cost labor. Recent trends toward mechanized production methods have reduced the historical importance to the industry of skilled craftsmen.

Paper and allied products. In 1970, this industry (SIC #26) employed 3.4 percent of total manufacturing employment at an annual wage slightly above the national average. Employment in the industry consists primarily of paperboard containers and boxes (SIC #264) and paper mills, except building paper (SIC #262). While employment in the industry increased 19.2 percent during the period 1958-1970, the largest increases were in miscellaneous converted paper products (32.4%) and paperboard containers and boxes (23.8%).

Chemicals and allied products. In 1970, this industry (SIC #28) employed 4.6 percent of total manufacturing employment at an annual wage 14 percent above the national manufacturing average. In terms of employment, its principal subindustries are industrial chemicals (28.7%), plastic materials and synthetics (21.3%), drugs (14.9%), and soaps, cleaners, and toilet goods (12.4%). The largest subindustry, industrial chemicals, has been growing most slowly and the second largest, plastic materials and synthetics, has been growing most rapidly (53% between 1958 and 1970).

Petroleum and coal products. The industry (SIC #29) is composed primarily of petroleum refining (SIC #291) and to a lesser extent, of paving and roofing materials (SIC #295) and miscellaneous petroleum and coal products (SIC #299). In 1970, employment in the industry was small and wages were high, more than 25 percent above the national average. Employment in SIC #29 declined about 18 percent during the period 1958-1970.

Primary metals. In 1970, this industry (SIC #33) used 6.6 percent of total manufacturing employment at an annual wage 12 percent above the national average. Employment in the industry is primarily in ferrous metals and secondarily in nonferrous metals. Ferrous metals employment is composed of blast furnace and basic steel products (SIC #331) and iron and steel foundaries (SIC #332). In 1970 these two industries accounted for 65.8 percent of total employment in SIC #33. Nonferrous employment is concentrated in nonferrous rolling and drawing (SIC #335), nonferrous foundaries (SIC #336) and primary nonferrous metals (SIC #333) in descending order of importance.

Fabricated metals. In 1970, the industry (SIC #34) used 7 percent of the manufacturing labor force at an annual wage equal to the national average. Over 70 percent of the employment in SIC #34 is accounted for by fabricated metal products (14.6%) and cutlery, hand tools and hardware (11.6%). During the period 1958-1970, the industry as a whole grew by 26 percent with the largest increase (73%) in metal stampings (SIC #346).

Nonelectrical machinery. In 1970, the industry (SIC #35) emplyed 9.8 percent of total manufacturing employment at an annual wage ten percent above the national average. All the subindustries of nonelectrical machinery are large and have been growing but the most rapidly growing have been office and computing machinery (SIC #357), service industry machines (SIC #358) and miscellaneous machinery, except electrical (SIC #359).

Electrical equipment and supplies. The electrical equipment and supplies industry (SIC #36) employs 9.6 percent of total manufacturing employment at an annual wage equal to the national manufacturing average. Its major subindustries are communications equipment (29.6%) and electronic components and accessories (19.3%) with other subindustries being electric test and distribution equipment, electrical industrial apparatus, hosuehold appliances, electric lighting and wiring, radio and TV receiving equipment, and miscellaneous electrical equipment and supplies. Unlike many of the other industries we have examined, the largest subindustries of the electrical equipment industry are also the most rapidly growing (i.e., communications equipment and electronic components).

Transportation equipment. In 1970, the transportation equipment industry (SIC #37) used 8.8 percent of total manufacturing employment at an annual wage 26 percent greater than the national average. In 1970, the industry's employment was dominated by three subindustries, motor vehicles and equipment (SIC #371, 42.7%), aircraft and parts (SIC #372, 38.3%), and ship and boat building and reparing (SIC #373, 14.7%). During the period 1958-1970, employment in transportation equipment increased 7.9 percent, while motor vehicles increased 23.7 percent and "all other" transportation equipment decreased 1.4 percent.

25. A. S. Goldberger, Econometric Theory, New York: John Wiley and Sons, Inc., 1964, pp. 197-200.

26. Chow, Gregory C.: "Tests of Equality between Subsets of Coefficients in Two Linear Regressions," Econometrica 28 (1960), pp. 591-605. See also Franklin M. Fisher, "Tests of Equality between Sets of Coefficients in Two Linear Regressions: An Expository Note," Econometrica 38 (1970) pp. 361-366, and James L. Murphy, Introductory Econometrics, Homewood, Ill.; Richard D. Irwin, Inc., 1973, pp. 232-245. The present test was prepared by David Vogt of ORNL.

Appendix F

LOCAL SERVICE EMPLOYMENT

This appendix summarizes results on the subject of locally oriented employment and how it may relate to changing socioeconomic conditions. In keeping with the format of our manufacturing location analysis (Appendix E), we once more resort to a model of the general form:

$$\text{Relative Regional Attractiveness}_{Rk} = f(X_{R1}, \ldots, X_{RN}) \quad .$$

However, in this instance, because of the postulated local orientation of the industries involved, only one explanatory variable reaches across BEA economic area boundaries to test for interregional linkages. Local service employment has been broken into sixteen industry groups and separate equations have been empirically fitted for each group using data for 171 BEA economic areas.

F.1 REVIEW OF PAST STUDIES

F.1.1 Regional multiplier models

Regional multiplier (or export-base) models argue that so much of the economic activity within small regions is oriented toward serving markets outside the region that, in a very real sense, the activities of these export-oriented industries form the basis or foundation for the remaining local service industries.[1] In its crudest form, regional multiplier analysis establishes a ratio between local service activity (L) and export activity (E). Any change in export activity may be multiplied by this ratio (L/E) to estimate the change in service activity. The total impact of an autonomous change in export activity is then the sum of the changes in export and service activity.

Symbolically,

$$T = E + L = \text{total regional economic activity}$$

$$L/E = b = \text{the } \underline{\text{average}} \text{ base-service ratio}$$

$$\Delta T = \Delta E + \Delta L$$

$$= \Delta E + b\Delta E$$

$$= (1 + b)\Delta E$$

$$\frac{\Delta T}{\Delta E} = 1 + b = k = \text{the regional multiplier.}$$

In this simple formulation, a regional multiplier model can be seen to resemble the simplest Keynesian national multiplier model; both models are demand oriented and intended to shed light upon short-term cyclical fluctuations. Just as Keynesian models have evolved over time to include more realistic conditions and results, regional multiplier models may be expanded to include: (1) autonomous services activity, (2) service industry differentiation, (3) variable base service ratios, (4) induced export activity which depends in part upon the region's services base, (5) lagged response patterns, and (6) capacity or supply constraints and conditions. As regional multiplier models evolve they tend to become supply and demand oriented models of regional economic growth.[2] But just as Keynesian models build from a fundamental distinction between consumption and investment, regional multiplier models build from a distinction between local (L) and export (E) activities.

F.1.2 Distinguishing between local and export activities

While regional multiplier models are conceptually simple, their empirical implementation has been something less than the routine application of a few generally accepted procedures. At least three questions must be answered during the implementation of a multiplier model:

(1) In what units should or can we measure regional economic activities for multiplier analyses?

(2) How can we distinguish between local and export activities?

(3) Given measures, how should local activity be related to export activity?

The most frequent response to the first question has been that regional activity should be measured in dollars of output or income similar to the units used in our Gross National Product and National Income accounting systems.[3] But in the absence of an acceptable regional product and income accounting system, employment has and will likely continue to serve as a proxy measure for output by industrial sector. Thus, perhaps 25% of the regional multiplier studies done in the past have been stated in income or output terms while the remaining 75% have been in employment terms.

The second question is very important, because given an industry-specific measure of regional activity, be it income, output, or employment, most industries contain an element of both local and export orientation; distinguishing between the two remains a very real problem. The techniques that have been used have ranged from a priori all-or-nothing allocations at one extreme to very careful allocations based upon expensive surveys of a region's consumers and industries at the other. Between these extremes lie the most frequently used indirect methods — the average (or location quotient) and minimum requirements approaches.

Both of these approaches require industry-specific activity measures for comparably defined regions over space and time which may be compared to similar measures for some "home" or base region; for example, retail trade employment per capita for region R as a percent of retail trade employment per capita for the nation. Having calculated location quotients (LOs) of this type, the average requirements approach assumes that regions with above-average presences (LQs > 1.0) of a particular activity are net exporters of the excess while regions with below-average presences (LQs < 1.0) are net importers of the deficit. Thus, under the average requirements approach, regional exports sum to regional imports across regions. In addition, there is an implicit assumption that national consumption and productivity patterns hold locally.

On the other hand, the minimum requirements approach[4] arrays the ratios or location quotients from low to high and then assumes the lowest, or one of the lowest, represents the minimum industry presence required for a viable regional economy. Thus, any activity up to the minimum requirement is assumed to be locally oriented and any excess is export oriented. While one can criticize the minimum requirements approach on a number of grounds including the implied assumption that everyone exports but no one imports, the procedure has arisen for a reason — field checks have shown that the average requirements approach frequently understates the export orientation of particular regional industries.[5] Some of these criticisms have been reduced by allowing the minimum requirement to vary positively with city size in more refined applications of the approach.[6]

F.1.3 How does local service activity relate to exports?

Given measures of local and export activities by industry and region, there have been a number of approaches to regional multipliers. Under one set of approaches, the local/export ratios, or the "base ratios," may be computed for historical periods, and an analysis of possible trends may be used to project the "base ratio" for future periods. For short-term cyclical applications a constant base ratio may be used (which assumes that marginal equals average), especially when activity is measured in terms of income rather than employment. But for longer term secular growth applications, a trended base ratio is most frequently used which acknowledges the temporal variability of the ratio (average effects do not equal marginal ones).[7]

The remaining approaches to the development of regional multipliers generally attempt to understand and guage the variability of base ratios over space and time through the use of regression analyses. The remainder of our discussion of past studies will concentrate on a review of the statistical results of Hildebrand and Mace (1950), Ullman and Dacey (1960), Weiss and Gooding (1968), Moody and Puffer (1970), and Polzin (1974).[8]

Using monthly data for Los Angeles County, Hildebrand and Mace prepared a regression of localized employment (L) upon nonlocalized employment (E) for short-run applications:

$$L = \alpha_o + \alpha_1 E$$

$$L = 222{,}000 + 1.248E.$$

This functional form explicitly allows the marginal ratio (α_1) to differ from the average (L/E), but the absence of standard errors in the published report does not permit a statistical test for this difference.[9]

In a substantial 1960 effort, Ullman and Dacey applied the model

$$Y_{ij} = a_i + b_i \log P_j ,$$

where

Y_{ij} = minimum requirement of industry i (i = 1, ..., 14) in city j, and

P_j = population of city or metropolitan area j,

to a cross section of 1950 data for 204 cities and metropolitan areas divided into six size classes.[10] Two of their findings are of importance. First, the larger the city, the higher is the minimum requirement (stated as a percent of total employment) suggesting that larger cities "take in their own wash" to a greater extent than do smaller cities. Second, for individual industries retail trade has the largest minimum requirement while professional services increases most with city size (i.e., has the largest b_i).

Weiss and Gooding estimated differential employment multipliers. Using annual employment data (1955-1964) for the Portsmouth, New Hampshire area, they regressed total service or local employment (L) upon employment in their distinct export sectors. Their model and results were:

$$L = -12{,}905 + \underset{(2.5)}{.78E_1} + \underset{(2.4)}{.55E_2} + \underset{(2.5)}{35E_3} \qquad R^2 = .78$$

where

E_1 = private export employment,

E_2 = civilian employment at Portsmouth Naval Shipyard, and

E_3 = total (military and civilian) employment at Pease Air Force Base.

It should be noted than an artificial one-half year lag was imposed upon the explanatory variables. The interpretations of Weiss and Gooding's results are that the multiplier effect was largest for private export employment ($k_1 = \Delta T/\Delta E_1 = 1.8$) and smallest for employment at the air base ($k_3 = \Delta T/\Delta E_3 = 1.4$). The authors reason that military bases have low regional multiplier effects because (1) they procure most of their materials and equipment from national markets via established Defense Department supply channels and (2) they offer a wide variety of on-base shopping, recreation, and other facilities for military personnel.[11]

Using monthly employment data for the San Diego economy, Moody and Puffer have estimated an asymmetric adjustment base model[12] of the form:

$$T = L + E$$

$$L^* = bE$$

$$= k_i(L^*_{t-1} - L_{t-1})$$

where

L^* = equilibrium L and

$i = 1$ when $(L^* - L) > 0$

$i = 2$ when $(L^* - L) < 0$.

The estimated parameters were $b = 5.45$, $k_1 = .0033$, and $k_2 = 0.0$. Thus a surprisingly large multiplier ($\Delta T/\Delta E = 6.45$) was coupled to a very slow reaction time on the upside (with no reaction in declines) so the full multiplier effect would not be felt for several decades. "During this adjustment period, of course, many other factors important to the urban economy would change making it highly unlikely that equilibrium would ever be reached."[13]

Most recently Polzin used 1968 employment data for a cross section of 79 Standard Metropolitan Statistical Areas (SMSAs) to estimate the model:

$$L_i = f(P_i, Y_i, C_i),$$

where

P_i = population in area i,

Y_i = per capita personal income in area i, and

C_i = relative isolation of city i measured by the road miles to the nearest SMSA of at least double its population (New York, Chicago, and Los Angeles were thus excluded from the sample).

The model was estimated in log-log form so the coefficients could be interpreted as elasticities and separately for four city sizes.[14] The empirical results suggest three observations. First, localized employment may be proportional to population when per capita income and a city's relative isolation (i.e., its position in an urban hierarchy) are held constant. Second, "the income elasticity of localized employment may be greater for cities with larger populations."[15] Finally, distance to a larger city seems to have less effect for larger cities.

In addition to suggesting the extent to which regional scientists have used employment as <u>the</u> measure of regional activity in multiplier models, our brief survey of previous studies[16] should suggest a number of hypotheses. First, the base ratio seems to be positively associated with city size. Second, different sectors of local activity have different multipliers. Third, there are lagged adjustments of local activity to changes in export activity. Fourth, there are high income elasticities of demand for the outputs of the local sector. Finally, all other things being equal, high accessibility to a much larger city acts to retard the development of the local sector.

F.2 RESEARCH METHODS USED IN THIS STUDY

F. 2.1 Census data for BEA economic areas

We have confined our analysis to cross-section data[17] for each of 171 BEA economic areas because they contain a functional wholeness with respect to local service activities that is not present for other spatial grids such as SMSA and State Economic Areas. Furthermore, rather than spending much time and energy trying to distinguish between the local and export components of a given industry's activities, we have initially categorized industries as locally oriented on an all-or-nothing basis. But, as our regression analysis has proceeded for each industry, we have, in fact, developed region- and time-specific "average requirements" for local service employment; our regression results are for a "representative region" which is a standard for across region distinctions among net import, export, and local components by industry.[18]

Table F-2.1 summarizes national trends in service or non-basic employment. One should note that employment in the service or non-basic sector as we have defined it has been growing more rapidly than total employment with the result that seven out of every ten employed persons in 1970 were in services in contrast to six of every ten in 1960. However, there has been quite a bit of variation in growth rates among the service sectors ranging from the absolute decline in employment within the railroad and private household industries to the skyrocketing growth within professional services. Also note the variation in size among the industries with the combination of retail trade and professional services accounting for thirty percent of the total.

Table F-2.2 summarizes the regional variability in local service employment per capita. One should note the great range of variation among BEA areas for any given industry and year as well as the slow but general convergence toward national norms evidenced by declining coefficients of variation over time.[19] Countering this last trend, there is some evidence that four industries are becoming more geographically concentrated over time; they are railroad, lodgings and personal services, business and repair services, and amusement and recreation services. It is the variability among BEA areas as well as the trends towards geographic dispersion and concentration that we have sought to relate to changing regional conditions.

Table F-2.1 National trends in service* employment census of population data

	Total in thousands			GROWTH	RANK	
	1950	1960	1970	1970/1950	1970 SIZE	1950-70 GROWTH
Total Population	150,216.1	179,325.7	203,211.9	1.35		
Total Employment	57,474.9	66,372.6	79,307.9	1.38		
Total Service* Employment	34,384.5	42,391.5	55,140.3	1.60		
Construction	3,509.1	3,968.6	4,491.4	1.28	3	12
Printing and Publishing	867.2	1,194.9	1,404.8	1.62	9	5 (tie)
Railroad	1,408.4	979.6	677.7	.48	15	16
Truck and Warehouse	713.1	949.8	1,155.7	1.62	12	5 (tie)
Other Transportation Services	875.8	930.8	1,192.3	1.36	11	10
Communications	719.8	855.5	1,148.5	1.60	13	7
Public Utilities	796.6	935.3	1,062.7	1.33	14	11
Wholesale Trade	2,010.3	2,311.5	3,189.2	1.59	6	8
Retail Trade	8,729.6	9,977.3	12,383.8	1.42	2	9
Finance Insurance and R. E.	1,948.0	2,820.7	3,907.2	2.01	5	2
Lodging and Personal Services	1,888.9	2,026.6	2,233.0	1.18	8	14
Business and Repair Services	1,332.8	1,683.1	2,409.0	1.81	7	3
Amusement and Recreation Services	501.7	525.6	631.8	1.26	16	13
Private Household	1,664.0	1,992.8	1,284.4	.77	10	15
Professional Services	4,868.2	7,896.8	13,629.4	2.80	1	1
Public Administration	2,551.0	3,342.6	4,339.4	1.70	4	4

* This definition of "service" is peculiar to our present discussion and should not be confused with the Standard Industrial Classification category.

Table F-2.2 Variability of local service employment per population (in thousand)

171 BEA areas: 1950, 1960, and 1970 Census data

	1950			1960			1970			Coefficient of Variation 50 → 70
	Mean	Range high/low	Coefficient of Variation*	Mean	Range high/low	Coefficient of Variation	Mean	Range high/low	Coefficient of Variation	
Total Employment	366.6	445.8/294.8	.08	357.3	417.8/268.0	.07	378.9	439.6/286.8	.07	
Construction	23.5	43.8/ 14.3	.24	22.9	38.4/ 14.9	.21	23.3	37.4/ 14.9	.17	↓
Printing and Publishing	3.9	14.3/ .8	.58	4.8	13.0/ 1.2	.49	5.2	14.0/ 1.3	.47	↓
Railroad	9.8	30.8/ 1.4	.54	5.8	17.6/ .6	.55	3.8	11.5/ .2	.61	(↑)
Truck and Warehouse	4.5	9.6/ 1.4	.33	5.1	9.4/ 2.0	.30	3.4	11.0/ 2.3	.29	↓
Other Transportation	4.0	18.3/ 1.2	.66	3.5	17.5/ 1.1	.67	3.9	17.2/ 1.2	.63	↓
Communications	3.9	7.7/ 1.4	.31	4.1	9.0/ 1.9	.27	4.8	10.1/ 2.5	.26	↓
Public Utilities	4.9	8.6/ 2.0	.26	5.1	10.0/ 2.5	.25	5.4	10.2/ 3.2	.22	↓
Wholesale	11.4	26.1/ 4.8	.31	11.2	22.6/ 6.3	.26	13.5	23.5/ 8.0	.24	↓
Retail	54.6	87.7/ 34.0	.16	55.2	73.4/ 42.7	.11	61.0	80.5/ 47.0	.11	↓
Finance, Insurance, and R. E.	9.2	27.0/ 3.4	.42	11.9	28.8/ 5.2	.34	14.7	32.9/ 7.5	.31	↓
Lodging and Personal Services	12.0	33.0/ 7.1	.30	11.7	73.5/ 6.9	.48	11.9	83.8/ 7.5	.51	(↑)
Business and Repair Services	8.4	12.1/ 4.1	.22	7.9	23.6/ 3.9	.30	9.5	24.4/ 5.3	.33	(↑)
Amusement and Recreation Services	3.0	25.2/ 1.2	.75	2.7	31.6/ 1.3	1.09	2.9	41.9/ 1.1	1.15	(↑)
Private Household	11.1	32.0/ 3.6	.54	12.5	33.1/ 4.9	.48	7.7	19.7/ 2.9	.46	↓
Professional Services	30.2	51.7/ 16.8	.21	42.3	69.9/ 25.3	.20	65.3	108.8/ 42.9	.18	↓
Public Administration	15.3	118.4/ 5.3	.68	17.0	101.5/ 7.0	.57	19.3	101.5/ 8.3	.52	↓

* Coefficient of variation = Standard deviation/Mean

F.2.2 The basic model

In implementing the model of relative regional attractiveness,

$$\text{Relative Regional Attractiveness}_{Rk} = f(X_{R1}, \ldots, X_{RN})$$

or in linear form

$$RRA_{Rk} = \beta_{ok} + \beta_{1k} X_{R1} + \ldots + \beta_{Nk} X_{RN},$$

we have again chosen to use the share of industry k's employment in region R as our dependent variable.

$$\text{Share}_{Rk} = S_{Rk} = EMP_{Rk}/EMP_{US,k},$$

where EMP_{Rk} = the kth industry's employment in region R,

$EMP_{US,k}$ = total U.S. employment in industry k, and

$$\sum_{R=1}^{173} S_{Rk} = 1$$

Estimates of the β_{ik}'s permit the computation of an $\hat{S}_{Rk}$ for a BEA area at a point in time which may be interpreted as its "average requirements" share of employment in service industry k, an average requirement that varies over time and space with the characteristics of the region being considered.

The explanatory variables, X_{Ri}, used can be grouped into categories along the lines of the hypotheses being examined. They are:

1. Initial conditions — used to examine the idea that economic development is an evolutionary process — you are today, in part, because of what you were yesterday — and the fact that inertia is hard to overcome. A representative variable is S_{Rk} (t - 10).

2. Market size — used to test the fundamental hypothesis that local service activity varies positively but not necessarily linearly with market size. Representative variables are total employment growth and relative population potential.

3. Local market quality — used to test the hypothesis that over and above market size, mitigating economic conditions may influence the level of locally-oriented employment.[20] Representative variables are labor market tightness, educational achievement, and land costs (or population density).

4. Special regional circumstances — used to test the hypothesis that regional cultural or historical influences may affect local service employment. Representative variables could measure the presence of state capitols, regional Federal Reserve Banks, etc.[21]

F.2.3 Two empirical models

We have distinguished two empirical models by choosing to include or exclude initial conditions — S_{Rk} (T-10) — as an explanatory variable. The resulting models are:

Model A. [$S_{Rk}(t) = f$ (other variables)]: Since the employment in local service industry k in region R is made a function of conditions in region R except the presence of industry k ten years ago (initial conditions), the results of this model may be assumed to give insight to the determinants of the historical location of industry k.

Model B. [$S_{Rk}(t) = g(S_{Rk}(t - 10)$, other variables)]: In a sense, the inclusion of S_{Rk} (t - 10) standardizes the dependent variable for initial conditions so that the coefficients of all other variables give insights to the determinants of the more recent change in industry k employment in region R.

Except for the inclusion or exclusion of S_{Rk} (t - 10), the same explanatory variables appear in both models A and B. Should the analysis be pursued further some custom tailoring of the list of explanatory variables for each industry might be desirable.

Pooled cross-section data from the 1950, 1960, and 1970 Censuses of Population have been used to statistically estimate models A and B instead of cross-section data for a single year or time-series data. Because suitable time-series data are not available for small geographic areas, the use of pooled cross-section data may be thought of as a pseudo-time-series analysis. It is an attempt to augment the variation over space contained in cross-section data with some variation over time. But, the use of pooled cross-section data has required that the two empirical models be modified to include a "pooled" variable, a shift factor which takes on the value 0 for observations during 1960, and the value 1 for observations during 1970.

F.3 POOLED CROSS-SECTION RESULTS BY INDUSTRY

Our latest empirical results are reported in Tables F-3.1 (Model A) and F-3.3 (Model B). They include as explanatory variables region R's share of employment in industry k ten years ago (S(t - 10)), the five-year rate of growth of total employment in region R (TEG(5)), relative population potential (R.POT — a gravity model measure of potential interregional interaction and accessibility), median years of school completed by persons 25 years old and over (MS), the employment pressure index (EPI), a proxy measure of land costs (L.C. — defined as population/usable land), and regional dummy variables for all subregions of the nation (except the Great Lakes) as defined in Figure C-3.1. The regional dummy variables were included at the last stage of the analysis as measures of longer-term regional conditions (relative to the Great Lakes = 0) not captured by any of the other explanatory variables.[22] Again, except for the inclusion or exclusion of the lagged dependent variable, the same explanatory variables appear in both models A and B. The results of model A should give insight to the determinants of the historical location of the spatially ubiquitous local service industries while those of model B should give insight to the determinants of more recent changes in relative location.[23]

F.3.1 Model A

Historically, interregional market size as measured by R.POT has been a most important determinant of the location of local service employment. It has been most important for "printing and publishing," important for most other industries, and least important for "other transportation services" (air transport, local and interurban passenger transit, pipeline transportation, and other). Total employment growth, another dimension of market size, has been a much less important determinat of the historical location of service employment; its coefficients are significant for only half the industry groups and even then its contribution to the overall explanation of location is small.

Median schooling usually serves as a good proxy for a region's long-term earning ability or permanent income level, but it does not appear to have been a significant determinant of service employment location. This suggests that a substantial portion of higher real per capita incomes may be expanded for higher quality goods and services offered by a relatively constant number of vendors per capita. Two other measures of local market quality, labor tightness (EPI) and a refined measure of population density (L.C.), give evidence of having been important determinants of historic service employment location. High market quality seems to have been especially important for "other transport services," "printing and publishing," and "finance insurance and real estate," and least important for "railroads," and "public utilities."

Regional dummy variables included as measures of long-term regional condition influencing location suggest very few differences among the Great Lakes, New England and Mideast regions. However, relative to the Great Lakes region, BEA areas in all other regions except New England and the Mideast have experienced a greater presence of local service employment. It would appear that this could be due to the absence of a highly differentiated urban hierarchy within these regions (i.e., the BEA areas are of more equal size without dominant cities like Boston in New England, New York in the Mideast and Chicago in the Great Lakes) which means that each BEA area has tended to take care of more of its own local service employment needs.

Table F-3.1. Model A results for sixteen local service industries: BEA economic areas, pooled 1960 and 1970 data

	R^{-2}	F Value (d.f.)	Intercept	S(T-10)	TEG (S)	R.POT (T-5)	M.S. (T)	EPI (T)	L.C. (T)	Pooled (60=0, 70=1)	1 NE	Region (Relative to Great Lakes = 0) 2 ME	4 SE	5 PL	6 SW	7 MTN	8 FW
Construction	.650	46.8	-1.42	—	.012	15.07	-.026	1.88	1.76	-.180	.02	-.04	.48	.55	.70	.70	.53
		(13,328)	(-2.09)		(2.78)	(5.47)	(-.49)	(1.96)	(14.95)	(-2.13)	(.11)	(-.35)	(3.72)	(4.07)	(4.92)	(3.80)	(3.19)
Printing and Publishing	.667	50.5	-2.67	—	.003	22.68	-.041	3.58	3.30	-2.73	-.52	-.34	.35	.78	.83	1.05	.41
			(-2.34)		(.49)	(4.89)	(-.45)	(2.22)	(16.62)	(-1.92)	(-1.63)	(-1.59)	(1.59)	(3.41)	(3.50)	(3.35)	(1.47)
Railroad	.457	21.3	.08	—	.002	17.92	-.003	-.55	1.31	-.186	-.51	-.09	.17	.54	.36	.68	.35
			(.10)		(.44)	(5.12)	(-.04)	(-.45)	(8.72)	(-1.73)	(-2.13)	(-.53)	(1.00)	(3.10)	(2.01)	(2.90)	(1.64)
Trucking and Warehousing	.634	43.6	-1.47	—	.004	19.80	-.062	2.52	2.00	-.183	-.32	-.32	.33	.59	.68	.84	.53
			(-1.83)		(.79)	(6.10)	(-.99)	(2.23)	(14.41)	(-1.84)	(-1.42)	(-2.17)	(2.14)	(3.65)	(4.09)	(3.86)	(2.74)
Other Transportation	.642	45.2	-3.34	—	.006	7.43	-.001	4.19	4.53	-.215	-1.22	-.28	.54	.70	.89	.81	.23
			(-2.37)		(.69)	(1.30)	(-.01)	(2.11)	(18.51)	(-1.23)	(-3.10)	(-1.05)	(2.00)	(2.48)	(3.03)	(2.11)	(.67)
Communications	.668	50.7	-2.42	—	.006	15.44	-.014	3.02	2.98	-.230	-.35	-.24	.44	.67	.78	.88	.58
			(-2.47)		(.99)	(3.89)	(-.18)	(2.18)	(17.50)	(-1.89)	(-1.29)	(-1.29)	(2.36)	(3.39)	(3.81)	(3.29)	(2.45)
Public Utilities	.662	49.4	-.93	—	.007	15.88	-.015	.92	2.05	-.190	-.18	-.13	.38	.57	.68	.73	.47
			(-1.27)		(1.53)	(5.34)	(-.27)	(.89)	(16.10)	(-2.08)	(-.90)	(-.93)	(2.69)	(3.83)	(4.46)	(3.66)	(2.64)
Wholesale Trade	.628	42.6	-2.06	—	.006	16.47	-.040	2.93	2.65	-.200	-.35	-.32	.43	.69	.80	.88	.58
			(-2.15)		(1.06)	(4.22)	(-.53)	(2.16)	(15.85)	(-1.67)	(-1.30)	(-1.77)	(2.32)	(3.55)	(4.02)	(3.34)	(2.46)
Retail Trade	.656	48.1	-1.43	—	.007	16.61	-.021	1.82	2.04	-.200	-.13	-.20	.37	.57	.65	.73	.51
			(-1.90)		(1.56)	(5.46)	(-.37)	(1.72)	(15.64)	(-2.14)	(-.63)	(-1.44)	(2.55)	(3.78)	(4.18)	(3.55)	(2.79)
Mean					7.72	.027	10.93	.62	.18	.50							
Standard Deviation					8.86	.022	1.11	.04	.33	.50							

Table F-3.1 (continued)

	$\bar{R}^2$	F Value (d.f.)	Intercept	S(T-10)	TEG (5)	R.POT (T-5)	M.S. (T)	EPI (T)	L.C. (T)	Pooled (60=0, 70=1)	1 NE	Region (Relative to Great Lakes = 0) 2 ME	4 SE	5 PL	6 SW	7 MTN	8 FW
Finance, Insurance, and Real Estate	.669	51.1 (13,328)	-2.93 (-2.65)	—	.006 (.95)	16.14 (3.59)	-.027 (-.31)	3.84 (2.46)	3.47 (18.04)	-.240 (-1.74)	-.44 (-1.43)	-.33 (-1.60)	.48 (2.29)	.77 (3.47)	.91 (3.96)	.99 (3.27)	.52 (1.92)
Lodging and Personal Services	.638	44.4	-1.75 (-2.24)	—	.013 (2.73)	12.72 (4.02)	-.014 (-.23)	2.30 (2.08)	2.13 (15.73)	-.188 (-1.94)	-.27 (-1.25)	-.15 (-1.02)	.40 (2.68)	.50 (3.20)	.63 (3.84)	.63 (2.96)	.44 (2.30)
Business and Repair Services	.642	45.3	-2.36 (-2.17)	—	.009 (1.36)	16.46 (3.75)	-.018 (-.22)	2.82 (1.85)	3.13 (16.64)	-.238 (-1.76)	-.56 (-1.84)	-.29 (-1.42)	.46 (2.21)	.74 (3.40)	.89 (3.96)	.94 (3.19)	.63 (2.40)
Amusement and Recreation Services	.537	29.3	-2.15 (-1.74)	—	.016 (2.08)	14.06 (2.81)	-.033 (-.35)	2.90 (1.67)	2.76 (12.90)	-.199 (-1.30)	-.57 (-1.66)	-.23 (-.99)	.38 (1.63)	.67 (2.70)	.71 (2.75)	.83 (2.48)	.96 (3.20)
Private Household	.603	38.3	-1.69 (-2.57)	—	.006 (1.57)	12.27 (4.60)	-.036 (-.70)	2.63 (2.83)	1.57 (13.72)	-.139 (-1.70)	-.20 (-1.09)	.01 (.05)	.76 (6.06)	.47 (3.58)	.70 (5.13)	.59 (3.28)	.52 (3.25)
Professional Services	.690	56.2	-1.64 (-2.16)	—	.005 (1.12)	16.50 (5.37)	-.010 (-.16)	1.89 (1.76)	2.26 (17.16)	-.215 (-2.28)	-.02 (-.08)	-.14 (-.98)	.38 (2.63)	.62 (4.07)	.68 (4.31)	.79 (3.82)	.55 (2.95)
Public Administration	.622	41.5	-2.59 (-2.94)	—	.011 (2.01)	18.60 (5.21)	-.002 (-.03)	2.95 (2.37)	1.94 (12.68)	-.256 (-2.33)	.01 (.04)	.42 (2.55)	.59 (3.52)	.71 (3.98)	.89 (4.86)	1.01 (4.19)	.83 (3.88)

Table F-3.2. Beta coefficients for Model A results:
BEA economic areas, pooled 1960 and 1970 data

	TEG (5)	R.POT	M.S. (T)	EPI (T)	L.C. (T)	Pooled	Region (relative to Great Lakes = 0) 1 N.E.	2 ME	4 SE	5 PL	6 SW	7 MTN	8 FW
Construction	.120	.391	-.033	.085	.664	-.104		-.014	.247	.224	.275	.191	.173
Printing and Publishing	.020	.341	-.030	.094	.720	-.091	-.059	-.062	.103	.182	.190	.164	.078
Railroad	.024	.455		-.024	.482	-.105	-.098	-.027	.083	.212	.140	.181	.111
Trucking and Warehousing	.035	.445	-.069	.099	.654	-.092	-.054	-.089	.146	.205	.233	.198	.151
Other Transportation Services	.030	.094		.092	.831	-.061	-.116	-.043	.134	.138	.171	.107	.037
Communications	.041	.270	-.012	.092	.757	-.090	-.046	-.050	.153	.181	.207	.161	.129
Public Utilities	.065	.375	-.018	.038	.702	-.100	-.033	-.037	.176	.207	.245	.181	.140
Wholesale Trade	.047	.311	-.037	.096	.725	-.084	-.049	-.074	.159	.201	.231	.173	.137
Retail Trade	.067	.386	-.025	.074	.688	-.103	-.023	-.058	.168	.206	.231	.177	.150
Finance, Insurance, and Real Estate	.040	.249	-.020	.103	.778	-.083	-.051	-.062	.148	.185	.215	.159	.101
Lodging and Personal Services	.119	.292	-.016	.092	.710	-.096	-.047	-.042	.181	.178	.218	.151	.126
Business and Repair Services	.059	.271	-.015	.081	.747	-.087	-.069	-.058	.148	.189	.223	.162	.131
Amusement and Recreation Services	.103	.231	-.027	.083	.658	-.073	-.071	-.046	.125	.171	.176	.143	.199
Private Household	.072	.349	-.050	.130	.648	-.088	-.043		.428	.209	.305	.175	.187
Professional Services	.045	.361	-.010	.072	.717	-.105	-.003	-.037	.165	.210	.226	.180	.150
Public Administration	.090	.387		.107	.585	-.118		.106	.243	.227	.282	.218	.218

Note: values less than .01 deleted

Since the units of measurement vary among the explanatory variables, the coefficients reported in Table F-3.1 are not sufficient to establish the relative importance of each explanatory variable. To get closer to a measure of relative importance, "Beta coefficients" are reported in Table F-3.2. They indicate the percent of a "typical" variation in the dependent variable associated with a "typical" variation in the explanatory variable where a "typical" variation is equal to one standard deviation.[24] Combining the insights of Table F-3.1 and F-3.2, one may conclude that the most important explanatory variables of historic service employment location have been population density (L.C.), interregional market potential (R.POT), long-term regional conditions, and labor market tightness (EPI) in that order.

F.3.2 Model B

Past employment location is the most important determinant of present employment location. The inclusion of the S(T-10) variable almost invariably results in coefficients of determination equal to .99. But, in addition to reinforcing the idea that inertia is a very powerful force, the coefficient of the S(T-10) variable, especially where it may be significantly different from 1.0, sheds light on the trends toward spatial diffusion or concentration within an industry. While local service industries are supposed to be spatially diffused by definition, most industries considered have a coefficient significantly less than 1.0 indicating a further trend towards spatial dispersion; only two industries, "railroad" and "business and repair services," have coefficients significantly greater than 1.0 indicating a trend toward spatial concentration.

After adjusting for initial conditions, total employment growth (TEG) seems to be the most important determinant of locational change; its coefficients are positive and statistically significant for all local service industries. Interregional market size (R.POT) is significant for only half of the industry groups. Because this measure ties regional economies together, the implication is that employment in wholesale trade, printing and publishing, finance insurance and real estate, public administration, trucking and warehousing and retail trade would grow in regional centers such as Denver in response to growth in nearby areas such as Grand Junction and Cheyenne. While these interregional linkages are weaker than expected a priori, they are there and bear further investigation. The negative associations for other transport services and amusement and recreation services probably represent recent market access growth in regions at some distance from those in which these fairly stagnant industries have been located.

Market quality is conspicuous by its apparent lack of importance as a determinant of locational change, median schooling (MS) is not significant, there are some positive associations with labor market tightness (EPI), and population density (L.C.) has a negative association with about half of the industry groups (except printing and publishing) reinforcing the idea of spatial dispersion to less density populated BEA's.

Table F-3.3. Model B results for sixteen local service industries: BEA economic areas, pooled 1960 and 1970 data

	MEAN $\bar{X}$	R^2	F Value (d.f.)	Intercept	S(T-10)	TEG (5)	R.POT (T-5)	M.S. (T)	EPI (T)	L.C. (T)	Pooled (60=0, 70=1)	Region (Relative to Great Lakes = 0): 1 NE	2 ME	4 SE	5 PL	6 SW	7 MTN	8 FW	H_o: β S(T-10) = 1 (t value)
Construction	.581	.990	2238.2	.07	.956	.008	.50	-.010	-.00	-.07	-.000	.07	-.01	.03	.01	-.02	-.02	-.03	
			(14,327)	(.60)	(103.7)	(10.43)	(1.01)	(-1.07)	(-.03)	(-2.65)	(-.01)	(2.22)	(-.42)	(1.27)	(.35)	(-.71)	(-.48)	(-.87)	(-4.8)
Printing and Publishing	.583	.996	5314.8	-.15	.912	.004	1.58	-.007	.25	.06	-.014	.07	.00	.05	.07	.06	.07	.10	
				(-1.13)	(156.7)	(4.69)	(2.87)	(-.68)	(1.34)	(2.01)	(-.87)	(1.94)	(.18)	(1.83)	(2.54)	(2.17)	(1.90)	(3.09)	(-15.1)
Railroad	.584	.986	1684.7	-.01	1.017	.002	-.27	.004	-.03	-.09	-.002	-.08	-.10	-.00	-.01	-.02	-.02	.04	
				(-.05)	(112.5)	(2.21)	(-.47)	(.34)	(-.16)	(-3.51)	(-.11)	(-2.02)	(-3.72)	(-.08)	(-.52)	(-.70)	(-.56)	(1.17)	(1.9)
Trucking and Warehousing	.583	.989	2114.3	-.28	.975	.004	1.01	-.001	.35	-.03	-.015	-.02	-.00	.10	.03	.07	.06	.12	
				(-2.01)	(103.1)	(4.27)	(1.71)	(-.14)	(1.76)	(-1.05)	(-.86)	(-.50)	(-.14)	(3.85)	(.96)	(2.38)	(1.61)	(3.47)	(-2.7)
Other Transportation Services	.577	.990	2392.8	-.47	.9996	.006	-2.60	.012	.59	.05	-.004	-.11	-.04	.03	-.02	-.03	-.08	.03	
				(-2.03)	(108.6)	(3.84)	(-2.75)	(.68)	(1.80)	(.83)	(-.13)	(-1.72)	(-.92)	(.63)	(-.52)	(-.64)	(-1.18)	(.45)	(-.0)
Communications	.582	.989	2191.1	-.20	.948	.006	-.11	.001	.24	.06	-.011	.01	.00	.08	.03	.02	.02	.10	
				(-1.12)	(99.9)	(5.85)	(-.15)	(-.05)	(.95)	(1.34)	(-.48)	(.21)	(.10)	(2.43)	(.82)	(.41)	(.32)	(2.26)	(-5.4)
Public Utilities	.582	.991	2706.6	-.09	.917	.005	.51	-.002	.14	-.03	-.009	-.03	-.01	.08	.02	.03	.02	.07	
				(-.80)	(112.2)	(6.52)	(1.03)	(-.19)	(.84)	(-.94)	(-.65)	(-.82)	(-.36)	(3.37)	(1.01)	(1.34)	(.69)	(2.50)	(-10.2)
Wholesale Trade	.582	.986	1678.2	-.24	.924	.004	2.20	.001	.25	-.12	-.027	.11	-.01	.09	.03	.08	.07	.15	
				(-1.29)	(92.4)	(3.87)	(2.87)	(.10)	(.93)	(-2.72)	(-1.17)	(2.08)	(-.41)	(2.44)	(.85)	(1.91)	(1.37)	(3.27)	(-7.6)
Retail Trade	.582	.992	2952.6	-.11	.963	.005	.68	.000	.10	-.07	-.013	.04	-.03	.03	.02	.02	.02	.08	
				(-.93)	(118.4)	(7.20)	(1.41)	(.05)	(.62)	(-2.62)	(-.90)	(1.14)	(-1.21)	(1.46)	(1.00)	(.82)	(.75)	(2.93)	(-4.6)
Mean					.58	7.72	.027	10.93	.62	.18	.50	.029	.082	.269	.140	.135	.058	.088	
Standard Deviation					1.18	8.86	.022	1.11	.04	.33	.50	.168	.274	.443	.347	.341	.235	.283	

Table F-3.3 (continued)

	MEAN	R^2	F Value (d.f.)	Intercept	S(T-10)	TEG (5)	R.POT (T-5)	M.S. (T)	EPI (T)	L.C. (T)	Pooled (60=0, 70=1)	Region (Relative to Great Lakes = 0) 1 NE	2 ME	4 SE	5 PL	6 SW	7 MTN	8 FW	H_o: β S(T-10) = 1
Finance, Insurance, and Real Estate	.582	.994	3662.3 (14,327)	-.21 (-1.37)	.899 (129.3)	.006 (6.36)	1.42 (2.23)	.002 (.14)	.20 (.91)	.03 (.78)	-.025 (-1.30)	.03 (.74)	-.03 (-.97)	.08 (2.57)	.06 (1.78)	.07 (2.19)	.06 (1.40)	.13 (3.39)	(-14.5)
Lodging and Personal Services	.581	.989	2032.8	.03 (.21)	.926 (100.5)	.009 (9.96)	-.16 (-.28)	-.005 (-.42)	.03 (.17)	-.10 (-3.16)	-.003 (-.16)	.01 (.13)	-.01 (-.54)	.00 (.10)	.01 (.18)	-.03 (-.92)	-.03 (-.71)	.06 (1.83)	(-8.0)
Business and Repair Services	.582	.980	1173.7	-.36 (-1.42)	1.073 (75.3)	.008 (5.03)	-1.34 (-1.27)	.011 (.57)	.25 (.69)	.01 (.21)	-.013 (-.42)	-.07 (-.98)	.03 (.73)	.05 (1.04)	-.00 (-.05)	.03 (.64)	-.02 (-.23)	.04 (.71)	(5.1)
Amusement and Recreation Services	.581	.992	3032.9	-.21 (-1.31)	1.001 (139.5)	.008 (7.98)	-1.91 (-2.93)	-.003 (-.25)	.39 (1.75)	-.07 (-2.11)	.009 (.44)	.00 (.02)	.05 (1.77)	-.00 (-.12)	-.02 (-.59)	-.04 (-1.20)	-.05 (-1.15)	.07 (1.73)	(.1)
Private Household	.583	.981	1236.8	-.10 (-.71)	.875 (81.7)	.004 (4.06)	.40 (.66)	.015 (1.31)	-.06 (-.30)	-.03 (-.91)	-.023 (-1.29)	-.02 (-.60)	-.04 (-1.58)	.07 (2.59)	.03 (1.16)	.03 (.89)	-.01 (-.21)	.10 (2.91)	(-11.7)
Professional Services	.582	.995	4360.1	-.12 (-1.18)	.967 (136.7)	.004 (7.22)	.28 (.67)	.005 (.59)	.07 (.52)	-.03 (-1.15)	-.014 (-1.09)	.01 (.26)	-.02 (-1.02)	.02 (.94)	.01 (.26)	.01 (.63)	.00 (.17)	.06 (2.52)	(-4.7)
Public Administration	.579	.991	2621.1	.13 (.98)	.974 (116.9)	.006 (6.83)	1.21 (2.14)	-.017 (-1.65)	-.06 (-.32)	-.08 (-2.63)	.004 (.26)	.01 (.21)	.03 (1.30)	.04 (1.54)	.06 (2.00)	.06 (1.99)	.09 (2.35)	.10 (3.11)	(-3.2)

Table F-3.4. Beta coefficients for Model B results:
BEA economic areas, pooled 1960 and 1970 data

								Region (relative to Great Lakes = 0)						
	S(T-10)	TEG (5)	R.POT (T-5)	M.S. (T)	EPI (T)	L.C. (T)	Pooled	1 N.E.	2 ME	4 SE	5 PL	6 SW	7 MTN	8 FW
Construction	1.000	.007	.013	-.012		-.027		.014		.015				-.008
Printing and Publishing	.977	.023	.024			.014				.014	.016	.014	.011	.019
Railroad	1.025	.019				-.035		-.015	-.030					.013
Trucking and Warehousing	.995	.032	.023		.014	-.011				.045	.010	.024	.015	.033
Other Transportation Services	.997	.027	-.033		.013			-.011					-.010	
Communications	.981	.044				.014				.028				.021
Public Utilities	.998	.044	.012							.035		.012		.021
Wholesale Trade	.999	.033	.041			-.033	-.011	.015		.032		.022	.014	.035
Retail Trade	1.004	.046	.016			-.024				.015				
Finance, Insurance, and Real Estate	.982	.037	.022							.023	.013	.017	.010	.025
Lodging and Personal Services	1.009	.077				-.034								.018
Business and Repair Services	.990	.051	-.022							.016				
Amusement and Recreation Services	1.003	.051	-.031		.011	-.017			.011			-.010		.014
Private Household	.991	.040	.011	.020		-.012	-.015		-.015	.041	.015	.012		.037
Professional Services	.999	.038												.017
Public Administration	.997	.047	.025	-.018		-.023				.017	.018	.018	.019	.027

Note: values less than .01 deleted

Longer-term regional conditions captured by regional dummy variables (relative to the Great Lakes = 0) are generally not important across most industries except for the Southeast and Far West. BEA areas in these two regions can continue to expect an above average presence of most local service industries.

Beta coefficients for model B are reported in Table F-3.4. The most important explanatory variables of service employment locational change (i.e., location standardized for intitial conditions) are total employment growth (TEG) followed about equally by interregional market potential (R.POT), population density (L.C.), and long-term regional conditions.

F.3.3 A simple Chow test: Is pooling appropriate?

While it does not completely resolve the issue, we have performed a simple Chow test[25] to determine if the two subsets (cross-section estimates) could have been drawn from the same population. Thus, the null hypothesis is that the coefficients from the two cross-sections are not significantly different

$$H_o: \ \beta_i^{60} = \beta_i^{70} ,$$

and the alternative hypothesis is that at least one of the coefficients is significantly different

$$H_1: \ \beta_i^{60} \neq \beta_i^{70} .$$

The test does not resolve the issue of the appropriateness of pooling cross-sections because a slightly revised model including selected slope interactive dummy variables would reverse the results in the case where only a few coefficients were significantly different between the subsets (cross-sections). The results of these simple Chow tests applied to the local service employment equations are found in Table F-3.5. The results simply suggest that pooling may not be appropriate for Model B — that at least one of the coefficients is significantly different. Since we have been unable to test this hypothesis more completely by experimenting with interactive dummy variables attached to particular coefficients, we have tabulated the results of the most recent 1970 cross-section estimates (Table F-3.6) which would be considered as a first (although not a preferred) alternative to the pooled results in their present form. As time permits, we will reappraise the appropriateness of the pooled model through tests of interactive dummy variables.

Table F-3.5. Chow test for equality of subsets of coefficients: local service employment

Equation	Model*	F	Prob. F/H_o
Construction	A	1.4899	.1260**
Construction	B	2.4258	.0042
Printing and publishing	A	1.5293	.1118**
Printing and publishing	B	1.9731	.0223
Railroad	A	0.9627	.5149**
Railroad	B	10.1859	.0000
Trucking and warehousing	A	1.0355	.4159**
Trucking and warehousing	B	3.3711	.0002
Other transportation service	A	0.7763	.6761**
Other transportation service	B	6.1537	.0000
Communications	A	.9633	.5155**
Communications	B	2.4938	.0032
Utilities	A	1.4765	.1311**
Utilities	B	3.7157	.0001
Wholesale trade	A	1.6678	.0724**
Wholesale trade	B	5.1141	.0000
Retail trade	A	1.2202	.2671**
Retail trade	B	4.4908	.0000
Finance, insurance, and real estate	A	1.2926	.2207**
Finance, insurance, and real estate	B	4.4074	.0000
Lodging and personal services	A	1.9538	.0277
Lodging and personal services	B	3.2546	.0002
Business and repair service	A	0.8520	.6256**
Business and repair service	B	17.2927	.0000
Amusement and recreation	A	.7715	.6810**
Amusement and recreation	B	11.4436	.0000
Private households	A	1.6182	.0849**
Private households	B	4.5160	.0000
Professional services	A	1.2844	.2257**
Professional services	B	1.0356	.4167**
Public administration	A	.9857	.5372**
Public administration	B	3.5860	.0001

* Model A = Lag out.
  Model B = Lag in.

**Cannot reject the null hypothesis that the slope coefficients in the two regressions are the same (at the 5% level).

Table F-3.6. Model B (lag in) results for sixteen local service industries: BEA economic areas, 1970 data

	$\bar{R}^2$	F value (d.f.)	Intercept	S(T-10)	TEG (5)	R. POT. (T-5)	M.S. (T)	EPI (T)	L.C. (T)	Region (relative to Great Lakes = 0) 1 NE	2 ME	4 SE	5 PL	6 SW	7 MTN	8 FW
Construction	.989	1064.7	.10	.921	.008	1.43	-.021	.08	-.06	.15	.02	.05	.06	.04	.04	.02
			(.52)	(68.43)	(6.22)	(2.13)	(-1.42)	(.31)	(-1.66)	(3.23)	(.65)	(1.45)	(1.53)	(1.07)	(.77)	(.46)
Printing & publishing	.997	3661.1	-.22	.928	.006	1.58	-.008	.33	-.05	.12	.03	.05	.08	.07	.09	.12
			(-1.20)	(125.66)	(4.57)	(2.54)	(-.57)	(1.49)	(-1.42)	(2.61)	(.89)	(1.65)	(2.35)	(2.08)	(1.96)	(2.93)
Railroad	.989	1048.0	.19	.956	.002	.76	-.005	-.21	-.12	-.03	-.09	.03	.01	-.00	.03	.09
			(.95)	(86.43)	(1.28)	(1.09)	(-.34)	(-.84)	(-3.75)	(-.68)	(-2.73)	(.78)	(.30)	(-.06)	(.53)	(1.99)
Truck & warehousing	.994	2045.7	-.36	1.001	.004	-.26	-.009	.63	.01	.03	.05	.08	.03	.05	.03	.09
			(-2.16)	(98.63)	(3.79)	(-.44)	(-.71)	(3.04)	(.21)	(.63)	(1.64)	(2.69)	(.89)	(1.51)	(.63)	(2.51)
Other transportation serv.	.994	1875.9	-.76	.945	.007	-1.32	.021	.79	.14	-.08	-.07	.03	.00	.01	-.03	.09
			(-2.47)	(92.73)	(3.12)	(-1.30)	(.91)	(2.11)	(2.26)	(-1.03)	(-1.34)	(.58)	(.03)	(.13)	(-.37)	(1.28)
Communications	.991	1292.3	-.41	.973	.008	-1.05	.007	.43	.10	-.03	-.01	.08	.00	.01	-.02	.07
			(-1.52)	(74.13)	(4.16)	(-1.14)	(.33)	(1.30)	(1.84)	(-.43)	(-.16)	(1.63)	(.00)	(.26)	(-.34)	(1.11)
Public utilities	.995	2304.2	-.10	.938	.005	-.50	-.018	.48	.01	-.04	.01	.05	-.01	-.02	-.01	.07
			(-.69)	(99.75)	(5.42)	(-.99)	(-1.61)	(2.66)	(.41)	(-1.05)	(.54)	(1.81)	(-.24)	(-.73)	(-.14)	(2.21)
Wholesale trade	.980	603.0	-.39	.873	.007	3.13	-.00	.47	-.10	.19	-.05	.10	.07	.09	.11	.20
			(-1.13)	(53.14)	(3.10)	(2.69)	(-.14)	(1.11)	(-1.58)	(2.24)	(-.91)	(1.57)	(1.03)	(1.30)	(1.29)	(2.68)
Retail trade	.994	2043.4	-.29	.997	.006	.04	.007	.25	-.07	+.08	-.02	.02	.02	.02	.01	.08
			(-1.82)	(95.88)	(5.27)	(.07)	(.59)	(1.28)	(-2.32)	(1.91)	(-.66)	(.51)	(.67)	(.50)	(.26)	(2.35)
Finance, insurance & real estate	.997	357.02	-.29	.940	.006	.69	.005	.24	-.01	.04	-.01	.05	.04	.07	.04	.11
			(-1.59)	(123.78)	(4.91)	(1.13)	(.38)	(1.08)	(-.20)	(1.02)	(-.50	(1.64)	(1.13)	(1.85)	(.83)	(2.90)
Lodging & personal services	.988	977.8	-.09	.891	.012	.48	-.006	.19	-.09	.05	-.03	-.01	.02	-.01	.00	.12
			(-.40)	(66.97)	(7.47)	(.63)	(-.37)	(.70)	(-2.15)	(.89)	(-.93)	(-.14)	(.58)	(-.12)	(.04)	(2.47)
Business & repair services	.995	2314.6	-.37	.992	.009	.70	-.000	.37	-.05	.05	.06	.06	.07	.08	.08	.13
			(-1.72)	(103.87)	(5.74)	(.96)	(-.00)	(1.41)	(-1.14)	(.92)	(1.66)	(1.55)	(1.81)	(1.97)	(1.48)	(2.72)
Amusement & recreation services	.996	3425.0	-.39	.946	.009	-.735	.0046	.486	-.040	.061	-.005	.016	.010	.012	.002	.111
			(2.26)	(143.37)	(7.85)	(-1.27)	(.35)	(2.28)	(-1.31)	(1.44)	(-.16)	(.52)	(.31)	(.35)	(.04)	(2.91)
Private household	.986	843.8	-.10	.924	.005	-.68	.013	-.06	-.02	.01	.01	.02	.03	.02	-.04	.07
			(-.53	(65.29)	(3.66)	(-1.01)	(.88)	(-.24)	(-.44)	(.31)	(.23)	(.46)	(.81)	(.45)	(-.87)	(1.63)
Professional services	.996	3429.0	-.15	.981	.005	-.19	.000	.18	-.03	.04	.01	.02	.00	.02	.00	.06
			(-1.17)	(117.22)	(5.83)	(-.41)	(.04)	(1.14)	(-1.29)	(1.11)	(.25)	(.69)	(.15)	(.72)	(.13)	(1.98)
Public administration	.995	2245.9	.16	1.019	.006	-.04	-.016	-.06	-.09	.01	.03	-.00	.01	.01	.03	.04
			(.94)	(104.40)	(5.12)	(-.06)	(-1.17)	(-.30)	(-2.91)	(.30)	(1.16)	(-.01)	(.46)	(.35)	(.68)	(.92)

F.4 COMPUTATION SEQUENCE: SERVICE EMPLOYMENT

In MULTIREGION we assume that service employment adjusts to many (but not all) regional socioeconomic conditions contemporaneously (i.e., without a lag). This is not a bad assumption when the time step is five years as it is in MULTIREGION, but it does mean a multi-stage computation process must be used. Trial (last period) values of some explanatory variables must be used to produce first-stage estimates of local service employment, regional labor demand and supply, and labor market tightness (EPI). Then these estimates of regional labor market conditions are used to compute revised estimates of regional service employment. The computation process continues in this fashion through a user specificed number of stages. At all stages across region sums of service employment by industry are forced to predetermined national totals by industry. These computations may be divided into five phases.

Phase I - Preliminary data manipulation. Necessary information is prepared from national/regional data, estimates, and projections including (1) employment share (last period), (2) MS (as per migration subroutine), (3) TEG, R.POT, L.C. and EPI (last period), (4) trended regional dummies, and (5) national service employment by industry in Census of Population terms. Adjust S(T-10) coefficients and intercepts for use with a five-year lag.

Phase II - Compute trial service employment shares. Regional service employment shares by industry are computed from Phase I data. 1970 residuals are retained but decay over time. Because experimental trackings of historic regional growth and development (1960 to 1970) indicate that the unconstrained model allows employment relocation to occur too quickly, an industry-specific control is placed on the rate of adjustment toward equilibrium (see Chapter 8).

Phase III - Trial service employment by industry. Trial regional employment shares are applied to forecasted national employment by industry. Across region sums are forced to national totals.

Phase IV - Trial labor market conditions. Trial labor supply is brought together with the sum of trial service employment and other employment to establish trial labor market conditions including EPI and P.DEN. Floors and ceilings are applied to some of these variables.

Phase V - Final service employment and labor market conditions. Final values are computed by reiterating Phases II through IV a user specified number of times. Simulation experiments have shown that this number should be kept small (e.g, two or three rather than ten). Across region sums of employment, population, and labor supply are forced to predetermined national totals and regional ceilings and floors (boundary conditions) are imposed during each interation.

REFERENCES FOR APPENDIX F

1. For a simple but eloquent discussion of export-base analysis, see Charles M. Tiebout, *The Community Economic Base Study*, Supplementary Paper No. 16, New York: Committee for Economic Development, 1962. Some thoughts critical of export-base analysis have been assembled in Ralph W. Pfouts (ed.), *The Techniques of Urban Economic Analysis*, Chandler-Davis Publishing Co., West Trenton, N.J., 1960. Additional suggestions are contained in George H. Borts and Jerome L. Stein, *Economic Growth in a Free Market*, Columbia University Press, New York, 1964; and Richard F. Muth, "Differential Growth Among Large U.S. Cities," in *Papers in Quantitative Economics*, James P. Quirk and Arvid M. Zarley (eds.), University Press of Kansas, Lawrence, 1968, pp. 311-355, and "Migration: Chicken or Egg?" *Southern Economic Journal*, 37(3), 295-306 (January 1971).

2. Discussions between D. C. North and C. M. Tiebout in the form of a series of journal articles have been reprinted in S. Friedmann and W. Alonso (eds.), *Regional Development and Planning*, Cambridge: The M.I.T. Press, 1964, pp. 240-265. A more mathematical elaboration of the evolution of base theory toward an integrated theory of regional growth may be found in Horst Siebert, *Regional Economic Growth: Theory and Policy*, Scranton, Pennsylvania: International Textbook Co., 1969.

3. C. M. Tiebout, *op. cit.*, "Measuring the Local Economy," Chap. 5.

4. Gunnar Alexanderson, *The Industrial Structure of American Cities: A Geographic Study of Urban Economy in the U.S.*, Lincoln: University of Nebraska Press, 1956. E. Ullman and M. F. Dacey, "The Minimum Requirements Approach to the Urban Economic Base," *Papers and Proceedings of the Regional Science Association*, vol. 6 (1960), pp. 175-194.

5. Roger Leigh, "The Use of Location Quotients in Urban Economic Base Studies," *Land Economics*, vol. 46(2) (1970), pp. 202-205. Leigh concludes that —

> In short, high location quotients seem to successfully identify industries with large proportions of sales made outside the urban area that undoubtedly are important components of the urban economic base. But the majority of industries have low to medium location quotients, while their out-of-town sales proportions cluster in the 30 percent to 60 percent range in a manner unrelated to the magnitude of the location quotient; and this does not permit clear identification of the basic-nonbasic status of the industry from the location quotient above. Even where the location quotients are below 1, out-of-town sales proportions can be significant and industries can claim to be part of the urban economic base.

See also Theodore Lane, "The Urban Base Multiplier: An Evaluation of the State of the Art," *Land Economics*, vol. 42 (1966), pp. 339-

347; S. H. Park, "The Economic Base Identification: An Appraisal," *Land Economics*, vol. 41 (1965), pp. 382-386; R. T. Pratt, "An Appraisal of the Minimum Requirements Technique," *Economic Geography*, vol. 44 (1968), pp. 117-124; and D. Greytak, "A Statistical Analysis of Regional Export Estimating Techniques," *Journal of Regional Science*, vol. 9 (1969), pp. 387-395.

6. Ullman and Dacey, *op. cit.*

7. Tiebout, *op. cit.*, "Structural Interrelations in the Local Economy," Chap. 6.

8. G. H. Hildebrand and A. Mace, Jr., "The Employment Multiplier in an Expanding Industrial Market: Los Angeles County, 1940-47," *Review of Economics and Statistics*, August 1950, pp. 241-49; Ullman and Dacey, *op. cit.;* S. J. Weiss and E. C. Gooding, "Estimation of Differential Employment Multipliers in a Small Regional Economy," *Land Economics*, vol. 44 (1968), pp. 235-243; H. Moody and F. Puffer, "The Empirical Verification of the Urban Base Multiplier; Traditional and Adjustment Process Models," *Land Economics*, vol. 46 (1970), pp. 91-98; and P. E. Polzin, "Aggregate Intersectoral Relationships in Urban Areas: A Study of Localized Employment for SMSA," *Annals of Regional Science*, vol. 8 (1974), pp. 70-78.

9. G. Thompson, "An Investigation of the Local Employment Multiplier," *Review of Economics and Statistics*, February 1959, pp. 66-67 is an application of Hildebrand's and Mace's procedures to the Lincoln, Nebraska metropolitan area.

10. The population size classes and the number of observations within each class were —

Over 1,000,000 (14)	Metropolitan areas
300,000-800,000 (38)	
100,000-150,000 (38)	
25,000-40,000 (38)	Cities
10,000-12,500 (38)	
2,500-3,000 (38)	

11. Weiss and Gooding, *op. cit.*, p. 243. These comments can be taken to mean that they measured local and export incorrectly.

12. Their work begins by reviewing and extending the efforts of K. Sasaki, "Military Expenditures and the Employment Multiplier in Hawaii," *Review of Economics and Statistics*, August 1963, pp. 298-304.

13. Moody and Puffer, *op. cit.*, p. 97.

14. The population size classes of SMSA's and the number of observations within each were:

Over 1,000,000 (16)
300,000-1,000,000 (25)
125,000-300,000 (27)
Under 125,000 (11)

15. Polzin, *op. cit.*, p. 75.

16. The interested reader may also want to review R. J. Anderson, Jr., "A Note on Economic Base Studies and Regional Econometric Forecasting Models," *Journal of Regional Science*, vol. 10 (1970) pp. 325-333; D. H. Garnick, "Disaggregated Base-Service Models and Regional Input-Output Models in Multiregional Projections," *Journal of Regional Science*, vol. 9 (1969), pp. 87-100 and "Differential Regional Multiplier Models," *Journal of Regional Science*, vol. 10 (1970), pp. 35-47; and A. S. Harvey, "A Dualistic Model of Urban Growth," *Annals of Regional Science*, vol. 8, (1974), pp. 58-69.

17. The Census of Population data used in this study is more complete than that from alternative sources such as the Census of Business or County Business Patterns.

18. The regression results permit the computation of expected values for each region which may be interpreted as average (or local) requirements. The difference between actual and expected values may be used to determine if the region is a net exporter (actual > expected) or net importer (actual < expected) of the service in question.

19. The same general convergence was found by Garnick, *op. cit.*, (1969).

20. Tiebout, *op. cit.*, argued for a distinction between change due to population growth and that due to higher incomes of a given population. The effects are apt to be different.

21. In an earlier study of local service employment in the Southeast, R. J. Olsen, "Locally Oriented Employment: An Average Requirements Approach Using Regression Analysis," we successfully used dummy variables to represent the presence of state capitols and/or Federal Reserve banks in BEA areas. These characteristics proved to be important determinants of the historic location of service employment but less important for locational change.

22. The simple correlation coefficients between pairs of explanatory variables are tabulated below.

	S(T-10)	TEG	R.POT	MS	EPI	L.C.	Pooled
S(T-10)	1.00						
TEG	.16	1.00					
R.POT	.46	-.01	1.00				
MS	.11	.36	.24	1.00			
EPI	.15	.22	.30	.49	1.00		
L.C.	.77	.07	.50	.11	.05	1.00	
Pooled	-.00	.07	.28	.54	.14	.03	1.00
Region 1	.10	-.02	.09	.09	.11	.20	0
2	.33	-.06	.47	.08	.06	.42	0
4	-.10	.02	-.17	-.53	-.35	-.08	0
5	-.11	-.26	-.20	.11	.25	-.19	0
6	-.10	.09	-.25	-.06	-.13	-.16	0
7	-.09	.04	-.26	.23	.05	-.12	0
8	.06	.29	-.19	.27	-.04	.13	0

23. Before examing the empirical results by industry group, additional insights to the composition of each industry may be helpful. The numbers provided are based upon Bureau of Labor Statistics estimates as published in Table 370, U.S. Bureau of the Census, *Statistical Abstract of the U.S.: 1973*, (9th edition), Washington, D.C., 1973.

Contract construction. In 1970, employment in this industry was composed of general building contractors (30%), heavy construction contractors (21%), and special trade contractors (plumbers, carpenters, electricians, painters, etc. — 49%).

Printing and publishing. In 1970, approximately 84% of total employment was in activities that have an orientation to the local business community — newspapers, commercial printing, business forms, and bookbinding. The remaining 16% was engaged in publishing periodicals, books, and greeting cards; products that may be assumed to be exported from the region.

Other transportation services. In 1970, employment in this industry was composed of local and interurban passenger transit (buses, taxis, etc. — 29%), transportation by air (36%), pipeline transportation (2%), and other transport and services (33%).

Communications. In 1970, employment in this industry was made up of telephone communications (84%), telegraph (3%), and radio and television broadcasting (12%).

Public utilities. In 1970, industry employment was composed of electric companies (42%), gas companies (23%), combination companies (27%), and water, steam, and sanitary systems (8%).

Retail trade. In 1970, employment in this group was composed of retail general merchandise (21%), food stores (16%), apparel and accessory stores (7%), furniture and home furnishings stores (4%), eating and drinking places (22%), and other (30%).

Finance, insurance, and real estate. Within this industry, finance (including commodity and security brokerage) has been growing more rapidly than insurance (carriers and agents) or real estate; in 1970 the employment breakdown was finance, 44%, insurance, 36%, real estate, 18%, and other, 2%.

Lodging and personal services. Employment within the personal services component (laundry, cleaning, other garment services, beauty shops, barber shops, photographic studios, shoe repair, funeral service, and miscellaneous) represented 56% of the total in 1970.

Business and repair services. In 1967, business and repair services employment was composed of miscellaneous business services (64.8%), automobile repair and service (20.6%), and miscellaneous repair services (14.6%). Of these subindustries, miscellaneous business services, which include advertising, consumer credit reporting and collection agencies, mailing reproduction and stenographic services, services to buildings and dwellings, personnel supply services, computer and data processing services, research, development and testing laboratories, and management consulting firms, have been growing most rapidly (92.7% from 1958 to 1967). Miscellaneous repair services, which include electrical appliances, watch, and furniture repair, have been growing most slowly (9.0%).

Amusement and recreation services. Within the industry, the motion picture sector (includes their production and movie theaters) has experienced a decline in number of employees while the "other amusement and recreation services" sector (orchestras, entertainers, bowling alleys, billiard parlors, dance halls, commercial sports, rinks, concessions, etc.) has experienced increased employment. In 1967, "other amusement and recreation services" accounted for 68% of total employment.

Professional services. The industry in 1970 was composed of employment in hospitals (19.9%), other health services (11.5%), education (45.5%), welfare, religious and nonprofit membership organizations (8.6%), and legal, engineering, and miscellaneous professional services (14.5%). In general, these component shares had not changed much since 1960.

Public administration. In 1972, government employment was composed of Federal (20.5%), state (21.6%), and local (57.9%) government employees. These component shares have changed over time due to above average growth in state and local government employment; Federal employment has increased most slowly.

24. A. S. Goldberger, *Econometric Theory*, New York: John Wiley & Sons, Inc., 1964, pp. 197-200.

25. Chow, Gregory C., "Tests of Equality between Subsets of Coefficients in Two Linear Regressions," Econometrica 28 (1960), pp. 591-605. See also Franklin M. Fisher, "Tests of Equality between Sets of Coefficients in Two Linear Regressions: An Expository Note, Econometrica 38 (1970) pp. 361-366, and James L. Murphy, Introductory Econometrics, Homewood, Ill.; Richard D. Irwin, Inc., 1973, pp. 232-245. The present test was prepared by David Vogt of ORNL.

Appendix G

EXPORT RECREATION: BEA 50 AS AN EXAMPLE

Conceptually, MULTIREGION distinguishes among export, local service, and natural resource-based employment. But, the absence of data for a formal "outdoor recreation" industry and the frequently seasonal nature of the activity has prevented an adequate treatment of export recreation within any of these three categories. This appendix presents a two-step procedure that has been used to estimate and project the export recreation employment associated with the Great Smoky Mountains National Park in BEA economic area 50; similar procedures should be applicable to other centers of export recreation.

G.1 EVIDENCE OF EXPORT RECREATION ACTIVITY

Because the analysis of export recreation activity is hindered by the absence of a formal "recreation" industry for statistical reporting purposes and the frequently seasonal nature of the activity, one must look to annual data on the more standard industry groups such as retail trade, lodging and personal services, and amusement and recreation services for evidence of the industry. For example, Table G.1.1 contains the highest BEA area employment location quotients in these industries defined in terms of the highly seasonal (April) Census of Population data for 1970. While only those BEA areas having two or more location quotients ranking in the top ten are shown, one can easily relate BEA areas 35 (Orlando), 36 (Miami), 37 (Tampa), and 173 (Honolulu) with mild winter climates and ocean-oriented recreation, BEAs 160 (Reno) and 161 (Las Vegas) with legal gambling and nightclub entertainment, and BEA 149 (Grand Junction) with ski resorts and mountain recreation. If we had looked at annual data instead of the seasonal (April) data reported in the Census of Population, it would have been even more clear that there is a rather widespread presence of export recreation activity quite independent of the urban hierarchy and city size that deserves comprehensive analysis.

A simple framework for measuring and projecting the direct regional impacts of recreation activity associated with a national park will now be presented. The analysis includes a gravity-potential model of visitor interaction and a regression model for relating retail-service activity to population and income growth in a multiregional market area.[1]

Table G-1.1. Selected BEA economic area employment location quotients: Census of Population data for April 1970.

BEA economic area	1970 employment location quotient in percent (rank)					
	Retail Trade		Lodging and personal services		Amusement and recreation services	
# 35 — Orlando, FL	115	(17)	136	(10)	137	(9)
36 — Miami, FL	121	(6)	208	(3)	192	(4)
37 — Tampa, FL	127	(2)	158	(6)	156	(6)
122 — Amarillo, TX	117	(9)	142	(8)	84	(74)
149 — Grand Junction, CO	116	(13)	180	(5)	144	(7)
160 — Reno, NV	105	(71)	241	(2)	1183	(1)
161 — Las Vegas, NV	102	(87)	684	(1)	610	(2)
173 — Honolulu, HI	94	(136)	182	(4)	139	(8)

G.2 ESTIMATING RECREATION MARKET POTENTIAL

The use of interaction models in the analysis of retail trade and manufacturing market areas is well documented in the regional economics literature.[2] The gravity-potential model expresses the interaction between two places as a function of their respective densities or mass (e.g., population, income, retail sales, etc.) weighted by the intervening distance between the two. The resulting distance decay function describes the rate at which interaction diminishes as distance increases or mass declines.

Data on the state of origin of visitors to Knoxville and the Great Smoky Mountains National Park (GSMNP) are available for 1970.[3] These state data were first allocated to the BEAs that cover each state according to their population and income. Then, these BEA area visitor origin estimates were combined with measures of truck operating times between the metropolitan centers of BEA areas[4] (see Appendix H) to estimate the parameters of a simple gravity-potential model as described by Isard.[5] The estimated model for 1970 visits to the Great Smoky Mountains National Park is:

$$\text{BEA 50 } V_{1970} = .1608 \sum_{j=1}^{171} \frac{POP_j}{D_{ij}^{0.70}} ,$$

where

BEA 50 V_{1970} = Recreation market potential (visits per capita) in BEA 50,

POP_j = Population in BEA_j, j=1, ---, 171 ,

D_{ij} = Motor vehicle access time between BEA 50 (i) and all other BEAs (j), D_{ii} = 1.0 hours.

The estimated model suggests a time distance exponent of 0.70 which seems theoretically appropriate for visits to a national park. In a hierarchical ordering of consumer goods and services, a distance exponent would be expected to be large (e.g., 2, 3, or 4) for lower order goods and services that are available at a large number of places (e.g., clothing, food items) but small for higher order goods and specialized services (e.g., national park vacations). Similarly, the distance exponents for recreation facilities oriented to local and BEA area markets should be large relative to those for facilities oriented to national markets.

It is important to note that the estimated parameters in the above model apply only to visits to the Great Smoky Mountains National Park; thus, no attempt was made to plot equipotential contours around all national parks. As an alternative, a truncated ($D_{ij} \leq 16$ hours) market potential for the GSMNP was calculated for each of the years 1950, 1960, 1970, and 1980. Since estimates of the distribution of visitors by origins for 1950, 1960, and 1980 are not available, we have assumed the parameters of the gravity-potential model remain constant over time; this is an assumption which needs further testing. Population and access times, however, were allowed to change over time.

The 16-hour accessibility areas around BEA 50 in 1950, 1960, 1970, and projected 1980 are illustrated in Fig. G-1. The gradual expansions of the 16-hour area between 1950 and 1980 are due to decreasing travel time associated with Interstate highway completions and higher operating speeds. By 1980 the Interstate system is expected to be complete but enforcement of lower speed limits and higher fuel costs may offset some of the expected accessibility gains.

In Table G-2.1, the recreation market potential, population, and total personal income within 16 hours of the park are enumerated. Between 1960 and 1970, population increased 103 percent and total personal income increased 219 percent. Between 1970 and 1980, as the expansion of the 16-hour accessibility area subsides, growth will come primarily from within the 1970 16-hours area. The population and income increases are projected to be 24 and 70 percent, respectively. Similar socioeconomic changes are occurring around other national parks in the U.S.

G.3 REGRESSION MODELS RELATING RETAIL-SERVICE ACTIVITY TO RECREATION MARKET POTENTIAL

The primary impact of export recreation on the economy of BEA 50 is assumed to be in the retail-trade and services sectors. Since the direct income

ORNL-DWG 75-543

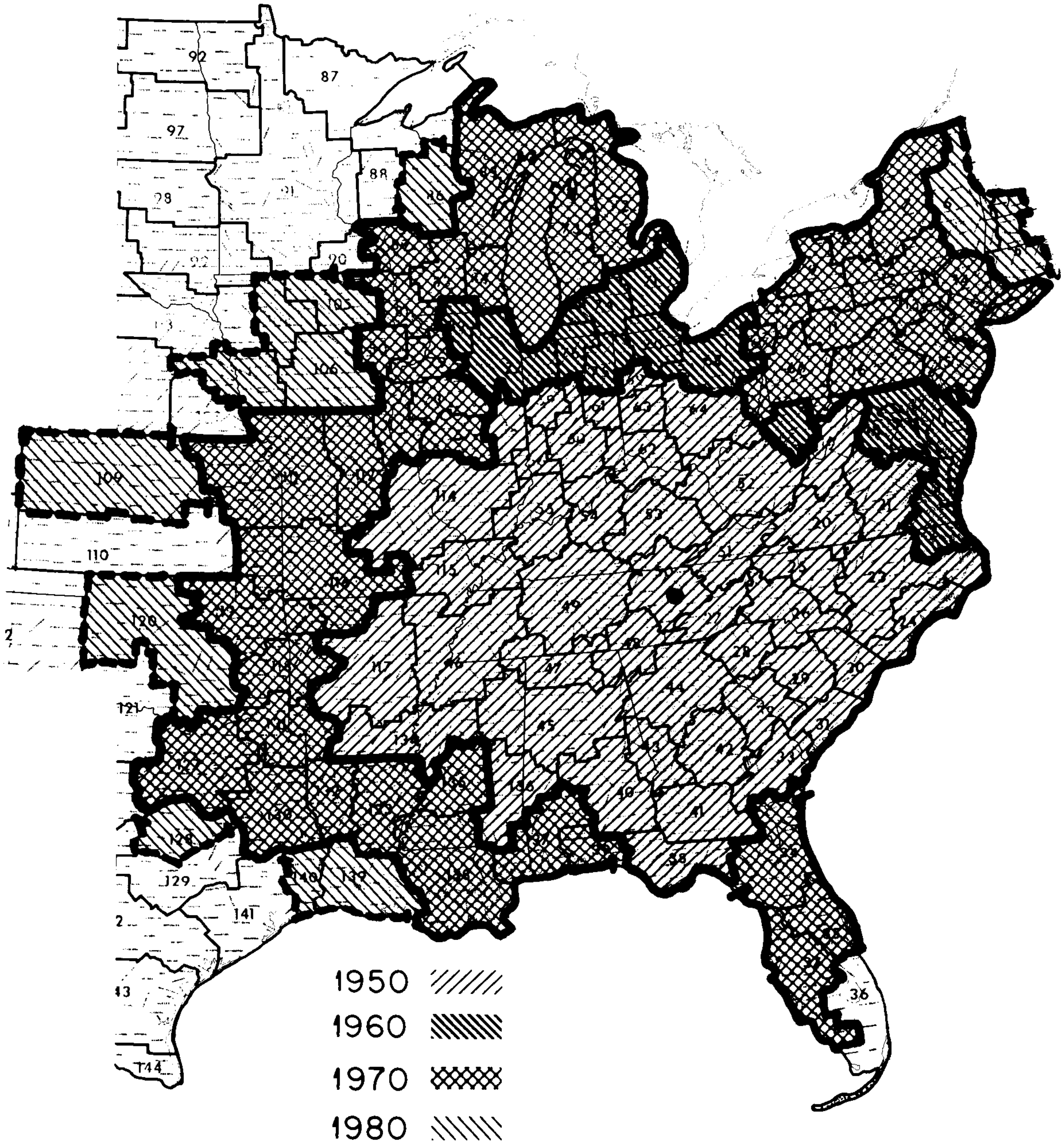


Fig. G-1. BEA areas within 16 hours travel time of the Great Smoky Mountains National Park: 1950, 1960, 1970, and projected 1980.

Table G-2.1. Recreation market potential, population, and income within 16 hours of the Great Smoky Mountains National Park: 1950, 1960, 1970, and projected 1980.

	1950	1960	% Δ	1970	% Δ	1980	% Δ
Recreation potential	.5077	1.6742	230	4.2331	153	*6.5000*	54
Population	33,976,037	66,120,822	95	134,280,766	103	(a) *166,310,200*	24
Total personal income (Mil. 1967 $)	52,158	142,142	173	453,694	219	(a) *769,988*	70

[a] Population and personal income projections for BEA areas taken from U.S. Department of Commerce and Natural Resource Division, Economic Research Service, U.S. Department of Agriculture, *Economic Activity in the U.S. by Water Resoruces Regions and Subareas Historical and Projected*, 1920-2020, U.S. Water Resources Council, Washington, D.C. (1974).

and employment associated with the Great Smoky Mountains National Park is concentrated in one or two counties, a county regression model was considered most appropriate for analyzing retail-service receipts.[6] The study sample includes 95 counties in Tennessee and observations in 1950, 1960, and 1970. The set of counties selected includes parts of seven BEA areas that vary with respect to population and income levels, urban orientation, and attractiveness. The five general classes of variables included in the regression analyses were: *(1) Retail-Service Receipts, (2) Income, (3) Population Characteristics, (4) Recreation Activity, and (5) Dummy Variables.* The latter were used to measure the influence of more locally-oriented Wildlife Management Areas, Tennessee Valley Authority reservoirs, state parks and forests on county retail-service receipts.[7] Dummy variables were also used in pooled cross-section equations to check for slope and intercept shifts in 1950, 1960, and 1970. Neither type of dummy variable was significant.

The regression equations selected for estimating and projecting retail-services receipts are shown in Table G-3.1. Only the pooled cross-section equation estimated by ordinary least squares (OLS) techniques was used to project 1980 retail-service receipts; the individual cross-section results and the pooled cross-section results estimated by generalized least squares (GLS) techniques are presented for purposes of comparison and discussion.

In the individual cross-section results for 1950, 1960, and 1970, the coefficients of median family income decrease in size and significance over time. Since the size and significance of the other coefficients (URB and POT) are faily stable, the decline in $\bar{R}^2$ from 0.84 in 1950, to 0.67 in 1960, and 0.61 in 1970 may be attributed to the decreasing importance of income as an explanatory variable which, in turn, may be due to the increasing centralization of retail-service activities in large cities.

The 16-hour recreation market potential calculated earlier was a significant explanatory variable. However, it was only slightly better than "total visits" which was used as an explanatory variable in other equations not reported here. But, since the value of the recreation potential variable may be estimated for 1980, there is an obvious forecasting advantage in choosing it for inclusion in the model.

The variable — percent urban — was used as a proxy variable to measure the central place tendency (i.e., retail center size) of counties.[8] The coefficient of the variable was significant in all models and indicates the level of retail-service receipts is positively and directly related to the percent of population urban.

The pooled cross-section model was estimated by a GLS procedure to assess the impact of violations of the assumptions of the ordinary least squares model arising out of (1) the retail trade interdependence of counties within a functional economic area and (2) the pooling of data from successive cross sections. Little difference exists between the results of the two estimating procedures. However, the t values are generally lower in the GLS model due to more efficient estimates of the variances of the regression coefficients. Thus, because earlier fears of substantial estimation errors now seem more imagined than real, the OLS estimate appears to be quite satisfactory for further discussions and applications.

Table G-3.1. Regression results for cross-section and pooled cross-section models using ordinary least-squares (OLS) and generalized least-squares (GLS) estimating techniques: dependent variable is adjusted retail-services receipts per capita.

Explanatory variables[a]	Cross section (OLS)			Pooled cross section and time series	
	1950	1960	1970	OLS	GLS[b]
A (constant)	0.306	0.513	0.665	0.4252	0.280
(t value)	(5.3)***	(6.3)***	(5.2)***	(16.4)***	(14.53)***
MFI	0.101	0.053	0.020	0.0680	0.0797
(t value)	(2.7)***	(1.8)*	(0.7)	(8.4)***	(13.67)***
URB	0.0110	0.0110	0.0100	0.0100	0.0071
(t value)	(8.6)***	(7.3)***	(7.6)***	(16.6)***	(7.7)***
POT	0.576	0.231	0.203	0.2089	0.1640
(t value)	(2.4)***	(2.0)*	(4.0)***	(5.2)***	(4.08)***
$\bar{R}^2$	0.84	0.67	0.61	0.7351	0.6538
Se	0.1226	0.1895	0.2111	0.1833	0.2508
F(df)	163.70 (3,91)	65.93 (3,91)	49.72 (3,91)	263.67 (3,281)	105.95 (3,281)
DW	1.85	1.44	2.04	1.72	

***, **, * = significant at 0.01, 0.05, and 0.10 levels respectively.

[a]MFI = Adjusted median family income.
URB = The percent of county population that is urban.
POT = Recreation potential within 16 hours of the Great Smoky Mountains National Park.

[b]The GLS model was estimated with a variance component model described in Nerlove and programmed by Freiden.

Estimates of regional population and income for 1980 based on the OBERS projections have been combined with the results of the pooled cross-section (OLS) model to estimate that 38 million dollars in 1980 can be attributed to the presence of the GSMNP in the Sevier County area of BEA 50. In employment terms[9] this means about 2700 jobs in 1970 and 4300 in 1980 are directly related to the presence of the national park.

G.4 POST SCRIPT

For the purposes of MULTIREGION, we would like to have analyses similar to this one for all major export recreation facilities in the U.S. Such analyses could provide a useful supplement to or even be directly incorporated into our understanding of local service industry groups (see Appendix F). At present the greatest impediment to a broader application of the two-step procedure described in this appendix is the absence of readily accessible information on the origins of visitors to major export recreation facilities.[10] Such information is necessary to calibrate the gravity-potential model for different classes of recreation facilities; for example, not only should important parameters vary between facilities like Disneyworld and the Great Smoky Mountains National Park but also between the latter and Yellowstone National Park.

REFERENCES FOR APPENDIX G

1. The discussion that follows draws very heavily from the work of Charles R. Kerley as reported in "Estimating Direct Regional Employment in Export Base Recreation: The Great Smoky Mountains National Park in BEA 50" presented at the annual meetings of the Western Regional Science Association, February 1975 (reprinted as ORNL-RUS-6, 1975) and with G. W. Westley, *Projecting County-Level Retail-Service Receipts in a Region with Export-Base Recreation: The Knoxville Economic Region (BEA 50)*, ORNL-RUS-7 (October 1975).

2. For example, see W. Isard, *Methods of Regional Analysis: An Introduction to Regional Science*, and G. A. P. Carrothers, "An Historical Review of the Gravity and Potential Concepts of Human Interaction," *Journal of the American Institute of Planners*, Vol. 22, Spring 1956.

3. L. Copeland and Leona Copeland, *The Four Knoxville Tourist Seasons Pay*, 23rd Annual Travel Survey, College of Business Administration, The University of Tennessee, Knoxville, 1972, and National Park Service annual releases, "Summary — Monthly Public Use Report: Great Smoky Mountains National Park," Park Headquarters, Gatlinburg, Tennessee.

4. Because of the high correlation between car and truck operating times, we have used the intercity operating times reported in R. J. Olsen and G. W. Westley, *Synthetic Measures of Truck Operating Times between the Metropolitan Centers of BEA Economic Areas: 1950, 1960, 1970, with Projections to 1980*, ORNL-NSF-EP-78, January 1975.

5. W. Isard, *Methods of Regional Analysis*, pp. 494-499.

6. Had we been looking at the direct impacts of a system of parks in different BEA areas, the BEA area grid might have been more appropriate than counties.

7. Any region under study is apt to have some unique characteristics that must be considered in the estimation of the regression model. In the present study area, there were a number of recreation facilities in addition to the national park that were generally expected to influence local income and employment through increased retail-service trade.

However, the estimated coefficients of the dummy variables representing these additional facilities were not significantly different from zero. Although some benefits accrue to the counties containing these facilities, the amount must be so small that county level analysis disguises the impacts.

8. Central place tendency refers to the fact that more urban counties in a regional hierarchy tend to be net exporters of retail-service goods to less urban counties.

9. Estimated retail-service receipts were converted to employees by applying a constant of 0.07 employees per thousand dollars of retail-service receipts. Historical data show this rate has been relatively constant over the past 15 years.

10. As an example of data that are available but not accessible, consider the visitor logs maintained at most national parks. These logs are most frequently filed away and never summarized or analyzed.

APPENDIX H

MARKET ACCESSIBILITY

Economists generally feel that transportation has an important role in regional economic development. Traditionally, it has been argued that transportation improvements have improved accessibility to markets and raw materials, with the result that transport costs have declined and market areas have expanded to promote the economies of (1) large-scale production, (2) regional competition, and (3) regional integration. More recently, an opposing viewpoint has claimed that the transport system is increasingly a result rather than a cause of economic development; that the transportation network of advanced industrialized countries is so extensive that "any addition is now insignificant to the whole system and has little effect in shaping regional specialization."[1] Which of these or other alternative hypotheses is correct is really an empirical question whose resolution requires consistent measurements of changes in accessibility over time.

To begin to test the relationship of transportation changes to industrial location, we developed synthetic measures of truck operating times (nonstop) between the metropolitan centers of BEA economic areas for 1950, 1960, and 1970. Truck operating times were emphasized because (1) the trend within manufacturing toward goods with high value-to-weight ratios makes the sometimes higher cost of truck transportation relatively less important than its flexibility and speed, and (2) the gradual completion of the Interstate highway system has been the most noticeable change in our goods transport network during the past 20 years. A synthetic measurement process was undertaken because (1) we wanted the capability to change road conditions to measure the impact of a new highway on transport time and (2) we were pessimistic about the possibility of quickly compiling actual truck operating times between all major cities in the U.S., going back 20 or more years.

This appendix includes discussions of the measurement process used, the assumptions made, and a few applications of the results. A tabulation of synthetically measured truck operating times between over 700 city pairs for 1950, 1960, and 1970, with projections for 1980 is available separately.[2] Thus, this appendix is essentially an explanation of our measurements of intercity accessibility. Earlier technical appendixes (B, E, F, and G) have disclosed the usefulness of these measurements in determining the importance of transportation changes to economic development.

H.1 THE MEASUREMENT PROCESS

Since historical data on actual truck operating times for all regions of the country were not readily available, we developed a measurement process which emphasized the <u>time</u> of truck transport while standardizing for regional differences in terrain and changing conditions of truck speed, roadways, and congestion. The process consisted of (1) superimposing terrain and congestion conditions upon a road map, (2) measuring each road-terrain-congestion segment, and (3) converting these segments into elapsed times of truck transport between metropolitan centers. The four principal ingredients of the process were as follows:

a. Truck operating speeds. The Highway Capacity Manual, 1965,[3] a design manual intended for highway engineers, reports highway design rules that have evolved from controlled experiments where each of the numerous roadway and traffic factors that affect highway capacity and speed has been allowed to vary independently of all others. Using these highway design rules plus many compromises and assumptions, we developed truck "operating speeds" for three time points (1950, 1960, and 1970), three classes of terrain (level, rolling, and mountainous), three classes of highway (limited access, four-lane unlimited access, and two-lane unlimited access), and two traffic conditions (relatively free flow and relatively congested). "Operating speed" is defined as "the maximum safe speed for given traffic conditions that an individual vehicle can travel if the driver so desires, without exceeding the design speed at any point."[4]

b. Road conditions. Interstate route maps prepared for a major oil company[5] provided reasonably consistent information about changing road conditions for 1950-1970. These maps distinguished between limited-access highways (including Interstates and toll roads), multilane highways, and two-lane roads. In addition, they provided approximate mileages between most town centers and road junctions.

c. Terrain. The National Atlas of the United States of America[6] contains a map entitled "Classes of Land-Surface Form," which distinguishes among 31 classes of land-surface form defined from combined information on slope, local relief, and profile type. Since the most detailed classification permitted by our estimated truck operating speeds was level, rolling, or mountainous, the much greater variety of terrain conditions mapped in the atlas was consolidated into these three gross categories.

d. Traffic conditions. With the belief that congestion is principally an urban phenomenon, we assumed that Standard Metropolitan Statistical Areas (SMSAs) were relatively congested and non-SMSAs were not. Thus, as SMSA definitions changed over time, the extent of assumed congestion was changed.

Given these ingredients, an overlay of terrain-congestion conditions was superimposed upon each road map (Fig. H-1), and a map measurer was used to record the extent of various road conditions between the metropolitan centers of pairs of BEA economic areas. The length of each road segment was recorded at every change of road, terrain, or congestion condition (Table H-2.1, Step 1). These segments were converted to distances in miles and then into elapsed times for the appropriate truck operating speeds (Table H-2.1, Step 2). To minimize measurement errors, the resulting elapsed times between cities

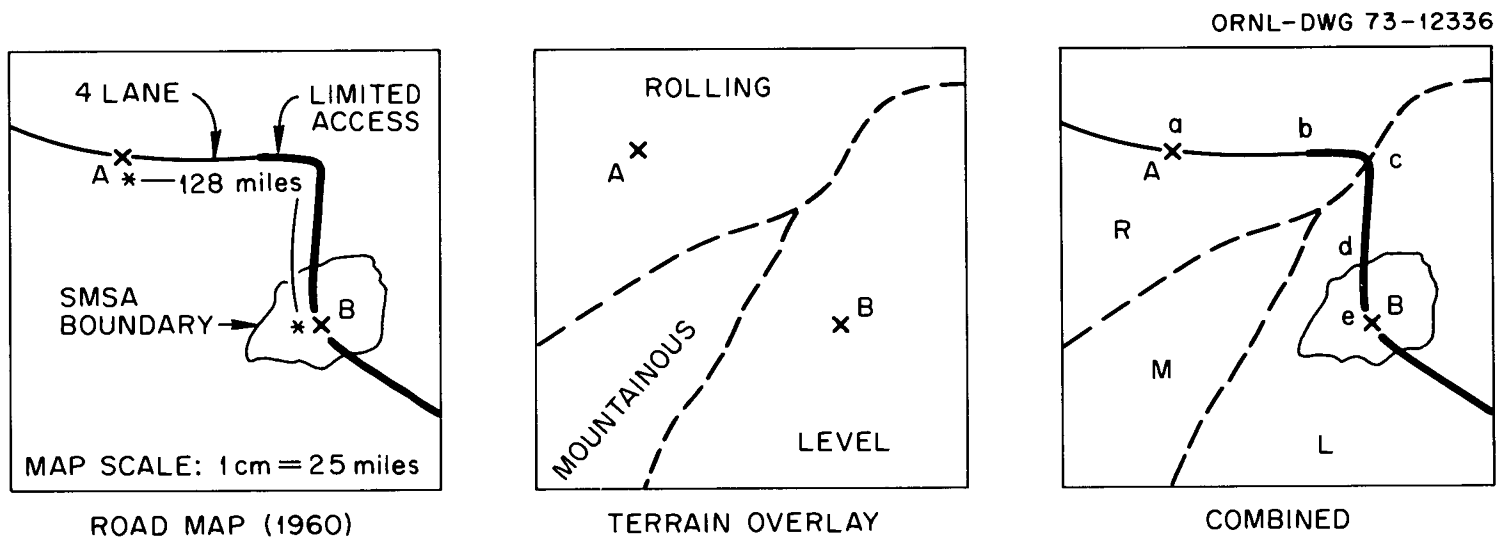


Fig. H-1. The measurement process combining a road map and terrain overlay for hypothetical cities A and B (1960).

Table H-2.1. The measurement process — measurement, conversion, and normalization for hypothetical cities A and B (1960)

Step 1 - Measurement					Step 2 - Conversion		
Segment	Road	Terrain	Congestion?	Length (cm.)	Length (miles)	Assumed speed	Elapsed time (hours)
ab	4 lane	R	No	2	50	43.8	1.14155
bc	L.A.	R	No	1	25	47.8	.52301
cd	L.A.	L	No	1.5	37.5	56.2	.66726
de	L.A.	L	Yes	1	25	37.1	.67385
Total elapsed distance and time					137.5		3.00567

Step 3 - Normalization:

$$\text{Normalization factor (N.F.)} = \frac{\text{Approximate miles}^*}{\text{Calculated miles}} = \frac{128}{137.5} = .9309$$

Normalized time = Computed time x N.F.

= 3.00567 x .9309 = 2.798 hours

*Approximate mileages are those found on interstate route maps.

were normalized by the ratio of approximate (from Interstate route maps) to calculated mileages between cities (Table H-2.1, Step 3). These computed truck operating times between over 700 city pairs for each of the three years 1950, 1960, and 1970 are tabulated in a separate report.[2] The two ingredients used in the measurement process — truck operating speeds and terrain conditions — warrant further discussion.

H.2 TRUCK OPERATING SPEEDS

We have attempted to determine how the speeds of typical semi-trailer trucks have varied over time and under changing conditions of terrain, traffic, and highway design.

H.2.1 Previous studies

Average truck speeds have not been routinely and thoroughly investigated in the past. The Federal Highway Administration of the U.S. Department of Transportation does publish annual Traffic Speed Trends,[7] but the data included are derived from speed studies voluntarily conducted by a varying number of states. While the information is supposed to be collected on level, straight sections of main rural roads and represent the "desired" speeds of drivers, the interpretation of the results is difficult and generally left up to the reader.

Perhaps the most useful past study is a design manual intended for highway engineers, Highway Capacity Manual, 1965. This manual usefully argues that highway capacity and, therefore, speed are functions of numerous (1) roadway and (2) traffic factors. The manual reports the results of controlled experiments where each factor has been allowed to vary independently of all others. The results are then converted into specific rules for highway design engineering. We have relied almost completely on the data available in the design manual to develop estimates of truck "operating speeds," defined as "the maximum safe speed for given traffic conditions that an individual vehicle can travel if the driver so desires, without exceeding the design speed at any point.[4]

H.2.2 Baseline (1965) operating speeds and the effects of congestion

Baseline operating speeds for different road and traffic conditions for level terrain were used as a starting point. For 1965 these were as follows:

Level of service	Freeway	Multilane highway	Two-lane highway
B	60 mph	55 mph	50 mph
D	40 mph	35 mph	30 mph

"Level of Service" is a continous measure of traffic conditions (congestion) and ranges from A (free-flow operation, with operating speeds at or greater than 60 mph) to F (forced-flow condition in which the expressway acts as storage for vehicles backing up from a downstream bottleneck).[8] We selected levels of service B (in the higher speed range of stable flow) and D (in the lower speed range of stable flow) for this study because of our inability to discriminate between five categories of traffic conditions from highway road maps. We assumed level of service D in metropolitan areas and B elsewhere.

Taking the B level of service as a base (i.e., 1.00), the relative effects of congestion (congestion adjustment relatives), assumed to remain constant over time, are as follows:

Level of service	Freeway	Multilane highway	Two-lane highway
B	1.00	1.00	1.00
D	0.67	0.63	0.60

H.2.3 Trends in baseline operating speeds

Trends in the horsepower-weight ratio of trucks have been used as a guide to changing truck speeds:

> Although engine horsepower has more than tripled during the past 25 years (since 1940), the overall vehicle performance [speed] has not improved as radically. Because increases in horsepower have been offset to a large extent by increases in gross weights, the average weight-horsepower ratio remains about two-thirds of its value 15 years age (1950).[9]

Using 1950 as a base (i.e., 1.00), the changes have been plotted in Fig. H-2 for clarification. Assuming a linear trend, the implication is that the horsepower-weight ratio (the reciprocal of the weight-horsepower ratio) had grown by 0.33 in 1960 and by 0.67 in 1970. Could or should one assume, therefore, that the sustainable operating speed of trucks changed in the same proportions between those years? Since the horsepower-weight ratio does not appear to be the only determinant of operating speed, we have arbitrarily reduced the trend apparent in the horsepower-weight ratio and used this slower trend to create baseline, level-terrain operating speeds for 1950, 1960, and 1970. We have further reduced the trend in estimating 1980 speeds in recognition of the facts (1) that additional increments in speed are more expensive to attain and (2) that rapidly increasing fuel prices will make further increments in speed especially expensive. The resulting trend of baseline operating speeds is as follows:

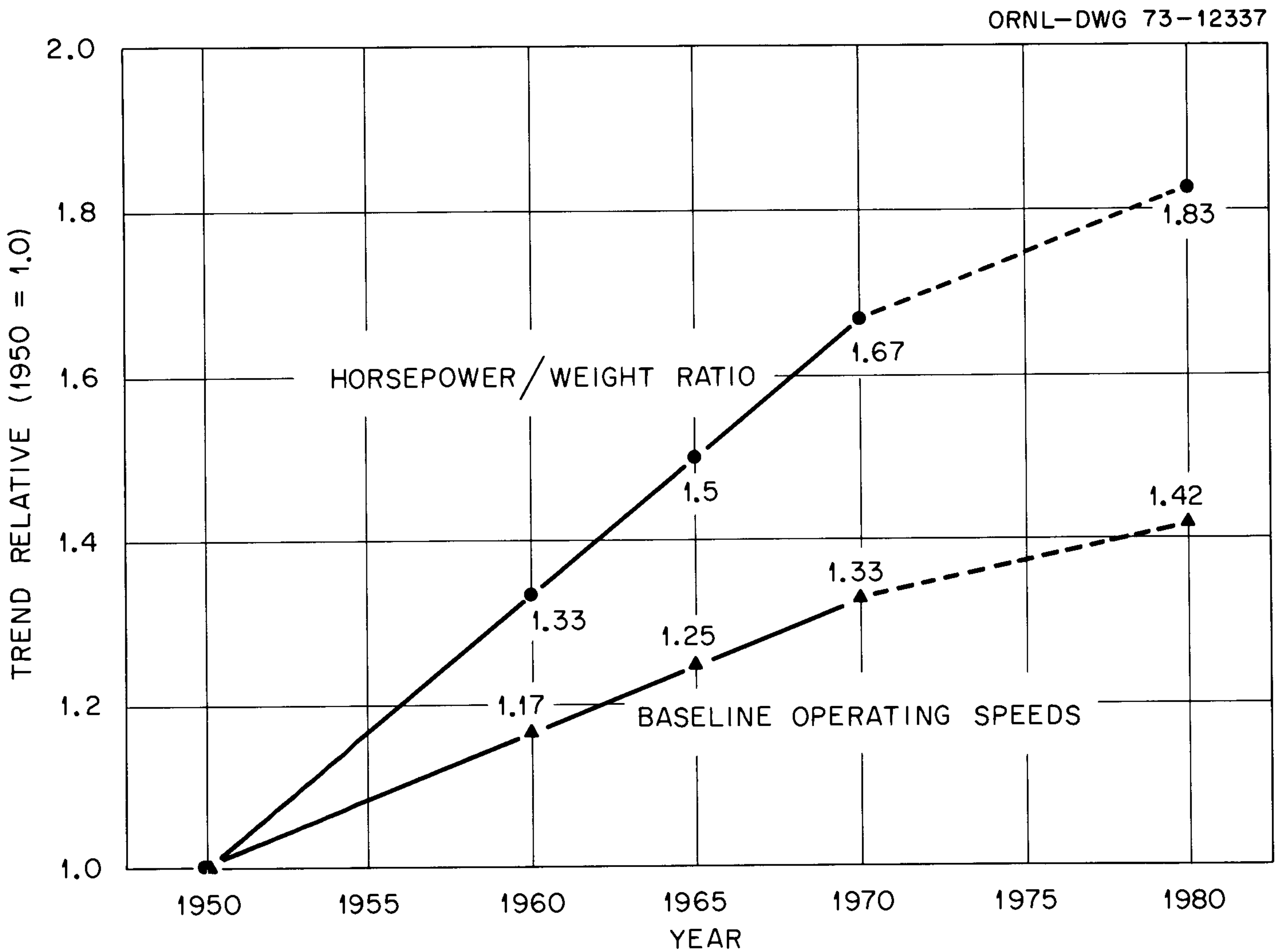


Fig. H-2. Trends in the horsepower/weight ratio and assumed baseline operating speeds.

Year	Freeway	Multilane highway	Two-lane highway
1950	48.0	44.0	40.0
1960	56.2	51.5	46.8
1970	63.8[10]	58.5	53.2
(1980)	(68.0)	(62.3)	(56.7)

H.2.4 The effects of terrain

The Highway Capacity Manual distinguishes three types of terrain:

a. Level terrain. Any combination of gradients, length of grade, or horizontal or vertical alignment that permits trucks to maintain speeds that equal or approach the speeds of passenger cars.

b. Rolling terrain. Any combination of gradients, length of grade, or horizontal or vertical alignment that causes trucks to reduce their speeds substantially below that of passenger cars on some section of the highway, but which does not involve sustained crawl speed by trucks for any substantial distance.

c. Mountainous terrain. Any combination of gradients, length of grade, or horizontal or vertical alignment that will cause trucks to operate at crawl speed for considerable distances or at frequent intervals.[11]

The effects of grade (i.e., terrain) upon highway capacity and speed are caused principally by the effects of grade upon trucks. Trucks simply travel slower on grades than on the level, while the effects of grade up to 7% on passenger cars is generally negligible.[12] The highway engineers' method of measuring this effect is to convert trucks into "passenger car equivalents" — a truck on an upgrade is set equal to a large number of passenger car equivalents, whereas a truck on the level may be equated with only a small number of cars. Furthermore, because of the queuing effect (one truck behind another), the "passenger car equivalent" of a truck tends to be higher where there is a greater concentration of trucks. To use the data in the Highway Capacity Manual, we had to assume a truck mix. We have assumed that trucks make up 10% of the vehicles on intermetropolitan routes.

For our purposes we have assumed that operating speed would be reduced in the same proportion as capacity, and we have converted truck adjustment factors[13] (multipliers used to reduce "ideal" highway capacity to "actual" capacity when 10% trucks are present) to the following terrain adjustment relatives for levels of service B and D:

Terrain	Freeways and multilane highways	Two-lane highways
Level	1.00	1.00
Rolling	0.85	0.80
Mountainous	0.65	0.57

H.2.5 Truck operating speed matrices

Starting with the trends of baseline operating speeds, we have used the terrain adjustment relatives and congestion adjustment relatives to develop Tables H-2.2 through H-2.5 for 1950, 1960, 1970, and 1980 respectively, according to the formula

$$(\text{baseline speed})_t \times (\text{terrain adjustment relative}) \times (\text{congestion adjustment relative}) = (\text{speed matrix})_t \ .$$

The results for all four time points seem reasonable and are generally in line with those in the Federal Highway Administration's *Traffic Speed Trends*.[14]

Table H-2.2. Truck operating speeds - 1950

Terrain	Level of service	Freeway	Multilane highway	Two-lane highway
Level	B	48	44	40
	D	31.7	27.7	24.0
Rolling	B	40.8	37.4	32
	D	26.9	23.6	19.2
Mountainous	B	31.2	28.6	22.8
	D	20.6	18.0	13.7

Table H-2.3. Truck operating speeds — 1960

Terrain	Level of service	Freeway	Multilane highway	Two-lane highway
Level	B	56.2	51.5	46.8
	D	37.1	32.4	28.1
Rolling	B	47.8	43.8	37.4
	D	31.5	27.6	22.4
Mountainous	B	36.5	33.5	26.7
	D	24.1	21.1	16.0

Table H-2.4. Truck operating speeds — 1970

Terrain	Level of service	Freeway	Multilane highway	Two-lane highway
Level	B	63.8	58.5	53.2
	D	42.1	36.9	31.9
Rolling	B	54.2	49.7	42.6
	D	35.8	31.3	25.6
Mountainous	B	41.5	38.0	30.3
	D	27.4	23.9	18.2

Table H-2.5. Projected truck operating speeds — 1980

Terrain	Level of service	Freeway	Multilane highway	Two-lane highway
Level	B	68.0	62.3	56.7
	D	45.6	39.2	34.0
Rolling	B	57.8	53.0	45.4
	D	38.7	33.4	27.2
Mountainous	B	44.2	40.5	32.3
	D	29.6	25.5	19.4

H.3. TERRAIN

As mentioned above, the Highway Capacity Manual distinguishes three types of terrain — level, rolling, and mountainous. Our search for suitable terrain maps led to the land-surface form maps prepared by Edwin H. Hammond. These maps "combine, for any given area, five bits of information: (1) percentage of the area which has a gentle slope of less than 8%, (2) local relief, (3) generalized profile, (4) distinctive surface materials, and (5) major lineaments such as streams, crests, scarps, and valley sides"[15] in such a way as to accentuate the classification of land forms for human use.

Ultimately, the 31 classes of land-surface form found in a map entitled "Classes of Land-Surface Form"[16] in the National Atlas of the United States of America were consolidated into three gross categories — based principally upon differences in local relief. Where local relief is defined as the maximum difference in elevation within a local area (6 miles across), local relief of 0' to 300' was considered to be level, relief of 300' to 1000' was termed rolling, and relief of 1000' and over was termed mountainous.[17] As with all classification processes, however, questions did arise at the class boundaries. In our case, a road running with the grain of mountainous terrain might have been more correctly classified as rolling than as mountainuous. The result of these consolidations of land-surface form categories is mapped in Fig. H-3.

H.4. ASSUMPTIONS FOR 1980

The projected 1980 truck operating times between metropolitan centers reported in this study were based upon the assumption that designated Interstate highways planned or under construction in 1971 would be completed by 1980 and were prepared before the oil embargo brought the "energy crisis" to everyone's attention. Thus, no attempt was made to exclude segments of the planned interstate system that may have been abandoned since 1971 or to include segments that may have been added since 1971. In addition, no attempt was made to impose ceilings on 1980 operating speeds in those few instances where they were projected to exceed the nationwide limit of 55 mph or to alter the already decelerating upward trend in baseline operating speeds in anticipation of extraordinarily high fuel prices. We believe our projected truck operating

times for 1980 remain valid, in part, because (1) many if not most states are not strictly enforcing the nationwide 55-mph speed limit, (2) the oil embargo has been lifted, with the result that gasoline and diesel fuel prices have stabilized at higher but not outrageous (e.g., European) prices, and (3) fuel and oil expenditures represent no more than five percent of the total operating costs of intercity motor carriers.[18]

Fig. H-3. Terrain.

H.5 SOME APPLICATIONS

There would appear to be an almost unlimited number of applications for the truck operating times reported in this study to regional economic analysis. A few examples may be worth mentioning.

H.5.1 Travel time between any two cities

Using a network analysis program which minimizes the resistance (time) between any two points, one can link together the city pairs reported in this study to calculate an optimum nonstop truck travel time and path between any pair of cities. Between very distant cities, more realistic elapsed times could be obtained by including mandatory rest periods in the final calculations.[19] Similarly, changes in truck travel time between four time points can be compared. For example, we estimate that a truck trip from Knoxville, Tennessee, to Cincinnati, Ohio, via Lexington, Kentucky, took 11.3 hours in 1950, 8.5 hours in 1960, and 6.5 hours in 1970. The same trip should take 5.9 hours in 1980.

H.5.2 Markets or resources within a definite transport time proximity of cities

We have used these computed truck operating times to estimate the level and rate of growth of markets accessible by overnight truck transport.[20] First, an overnight market area was defined to be that cluster of BEA areas whose metropolitan centers were within 8.3 hours[21] of the city in question. Second, population and per capita income estimates for each BEA area for 1950, 1960, and 1970 were used to convert each market area to income and population equivalents.

As an example, the income and population equivalents of the Knoxville, Tennessee (BEA #50), overnight market area are presented in Table H-5.1. In addition to the 1950, 1960, and 1970 population and income equivalents, the 1960 and 1970 equivalents for the 1950 market area and the 1970 equivalents for the 1960 market area have been compiled.

Table H-5.1. Population and income equivalents for the Knoxville overnight truck transport market — 1950, 1960, and 1970

	Aggregate personal income (millions of 1967 $)			Population (000's)		
	1950	1960	1970	1950	1960	1970
1950 market area	$11,238	$15,701	$26,455	8,389	9,035	10,232
1960 market area		23,265	38,108		13,122	14,620
1970 market area			79,353			29,776

Table H-5.2 summarizes the information of Table H-5.1 in terms of a number of rates of market growth. The overall growth rate has been partitioned into (1) the rate of growth within the market area for the base year

Table H-5.2. Rates of market growth for the Knoxville overnight truck transport market — 1950-60, 1960-70, 1950-70

	Aggregate personal income			Population		
	1950-60	1960-70	1950-70	1950-60	1960-70	1950-70
Overall growth	107.0	241.1	606.1	56.4	126.9	254.9
Internal growth	39.7	63.8	135.4	7.7	11.4	22.0
Residual growth	67.3	177.3	470.7	48.7	115.5	232.9

(internal growth) and (2) the residual growth due to the physical expansion of the market area as a consequence of improved roads and increased truck operating speeds. One may note from Table H-5.2 that the Knoxville overnight market grew a remarkable 600% in terms of income and 250% in terms of population during the 1950-1970 period. This growth was most rapid during the decade of the sixties. The internal growth rates indicate that there would have been much less dramatic change in the absence of road and truck speed improvements. The residual growth rates imply that the largest portion of Knoxville's overall market growth has been the result of improved roads and truck speeds. The contribution of improved roads was especially noticeable during the decade of the sixties.[22]

H.5.3 Supply or demand potential

A further application of the truck operating times reported in this study has been the computation of final demand potentials,[23] intermediate demand potentials, and intermediate supply potentials, using the gravity and potential concepts of human interaction commonly used by regional scientists.[24] The specific form of the potential model used was

$$\text{Potential}_i = \sum_{j=1}^{171} \frac{M_j}{D_{ij}^{\lambda_k}} ,$$

where:

D_{ij} = optimum time of truck transport in hours between the metropolitan centers of each pair of BEA areas; D_{ii} = 1/2 the access time to the nearest BEA center.

λ_k = a distance decay coefficient which is assigned a dimensionless value which varies inversely with the value of the commodity being shipped (k).[25] In those cases where the value one is assigned, the indexes that result may be interpreted as "general" market potentials.

M_j = the mass of BEA area j. For final demand potentials we have used aggregate income of BEA area j as the measure of mass. For intermediate supply potentials we have used employment in the supplying industry of BEA area j. For intermediate demand potentials we have used employment in the purchasing industry of BEA area j as the measure of mass.

As an example, the "general" income and population potentials of Knoxville, Tennessee (BEA #50), are illustrated in Table H-5.3. In addition to the 1950, 1960, and 1970 population and income potentials, the 1960 and 1970 potentials using 1950 access times and the 1970 potentials using 1960 access times have been computed.

Table H-5.3. Market potentials for Knoxville, Tennessee — 1950, 1960, and 1970

	Income potential (millions of 1967 $)			Population potential (000's)		
	1950	1960	1970	1950	1960	1970
1950 access times	$16,657	$19,846	$28,109	9,337	10,493	11,598
1960 access times		24,112	34,128		12,806	14,151
1970 access times			43,749			18,319

Table H-5.4 summarizes the information of Table H-5.3 in terms of a number of rates of growth of market potential. The overall growth rate has been partitioned into (1) the rate of growth given the base year's accessibility (income/population growth) and (2) the rate of growth due to improved access time as a consequence of improved roads and increased truck operating speeds (accessibility growth). One may note from Table H-5.4 that the Knoxville market potential grew 163% in terms of income and 96% in terms of population during the 1950-1970 period. This growth was most rapid during the decade of the sixties. The income/population growth rates indicate the change would have been much less dramatic in the absence of road and truck speed improvements. The accessibility growth rates imply that a large portion of the overall growth of Knoxville's market potential has been the result of improved roads and truck speeds.[22] As with the overnight market area estimates, the contribution of improved roads was especially noticeable during the decade of the sixties. Thus, the results of the two approaches for Knoxville are complementary and reinforcing.

Table H-5.4. Rates of growth of market potentials for Knoxville, Tennessee — 1950-60, 1960-70, and 1950-70

	Income potential			Population potential		
	1950-60	1960-70	1950-70	1950-60	1960-70	1950-70
Overall growth	44.8	81.4	162.6	37.2	43.1	96.2
Income/population growth	19.1	41.5	68.8	12.4	10.5	24.2
Accessibility growth	25.6	39.9	93.9	24.8	32.5	72.0

H.5.4 Truncated market potentials

All market and population potentials used in MULTIREGION and referred to in other sections of this volume are truncated. That is, they are basically market potentials as described in section H 5 3, but regions beyond 8.3 hours (D_{ij} > 8.3) are not included in the computations. Truncated potentials are used because the mass of regions at substantial distances from the reference region are heavily discounted over space and have the effect of masking functionally more important nearby changes in market potential. Additionally, with truncation the computations within MULTIREGION are simplified to permit greater experimentation with the potential concept within simulation and projections runs.

To continue our Knoxville example, truncated income and population potentials are presented in Table H-5.5. For simplicity, only the 1950, 1960, and 1970 potentials are shown. The overall growth rates are shown in Table H-5.6 and may be compared to those in Tables H-5.2 and H-5.4. The growth rates of truncated potentials most closely approximate those of overnight market areas; nearby changes in market potential are highlighted.

Table H-5.5. Truncated market potentials for Knoxville, Tennessee — 1950, 1960, and 1970

	Income potential (millions of 1967 $s)			Population Potential (000's)		
	1950	1960	1970	1950	1960	1970
1950 access times	$2,186			1,694		
1960 access times		$4,520			2,667	
1970 access times			$16,152			5,792

Table H-5.6. Rates of growth of truncated market potentials for Knoxville, Tennessee — 1950-60, 1960-70, and 1950-70

	Income potential (millions of 1967 $s)			Population potential (000's)		
	1950-60	1960-70	1950-70	1950-60	1960-70	1950-70
Overall growth	106.8	257.3	639.0	57.5	117.2	242.0

H.6 CONSIDERING SOME ALTERNATIVE ASSUMPTIONS

So far, we have reviewed the measurement process, the assumptions and a few applications of a synthetic but dynamic measure of intercity accessibility by truck transport. The synthetic approach used has many advantages and probably some disadvantages; the user will have to strike his own balance between these advantages and disadvantages.[26] One of the advantages is the ability to consider alternative assumptions about operating speeds, road conditions, etc., to which we now turn.

H.6.1 Road improvements

On occasion, we would like to alter road conditions to examine the impact of a new or improved highway on transport time and thereafter on regional economic activity. For example, when the original Interstate highway system was planned some natural linkages were left out. How would interregional accessibility be altered if these omitted natural linkages were completed?

As an example, we have visualized a new limited access highway from Memphis, Tennessee through northern Alabama to I-75 just northwest of Atlanta, Georgia. We drew a likely route on a road map from Memphis (BEA 46) to Huntsville (BEA 47) to Atlanta (BEA 44), superimposed terrain and congestion conditions and made the measurements as outlined in Section H.1 above. The measurements were then converted into elapsed times and normalized. These computations are summarized in Table H-6.1. They suggest that the new road would cut 1980 travel time between Memphis, Huntsville, and Atlanta by 20%.

H.6.2 Higher fuel costs

Representing the effects of higher fuel costs by altering the truck operating speed matrix for 1980, recomputing the elapsed time of each and every road segment, would be technically correct but too time-comsuming and expensive. Thus, an approximation is necessary. Because relative changes in motor fuel prices may be expected to be fairly uniform across regions, the following steps should prove satisfactory:

Table H-6.1. 1980 Truck operating times with a new limited access highway between Memphis, Tennessee, Huntsville, Alabama, and Atlanta, Georgia

Segment	Type of road	Terrain	Congestion	Length (cm)	Length (miles)	Assumed speed	Elapsed time (hours)
BEA 46 to BEA 47							
1	L.A.	L	Yes	.5	8.1965	45.6	.1797
2	L.A.	L	No	5.8	95.0794	68	1.3982
3	L.A.	R	No	1.1	18.0323	57.8	.3120
4	L.A.	L	Yes	.3	4.9179	45.6	.1078
5	L.A.	L	No	3.7	60.6541	68	.8920
6	L.A.	L	Yes	.25	4.0983	45.6	.0899
					190.9785		2.9796

Normalization:

$$NF = \frac{\text{Approximate miles}}{\text{Calculated miles}} = \frac{212}{190.98} = 1.10995$$

Normalized time = computed time x N.F.
= 2.9796 x 1.10995 = 3.3072 hours

Segment	Type of road	Terrain	Congestion	Length (cm)	Length (miles)	Assumed speed	Elapsed time (hours)
BEA 47 to BEA 44							
1	L.A.	L	Yes	.25	4.0983	45.6	.0899
2	L.A.	L	No	.5	8.1965	68	.1205
3	L.A.	R	No	8.0	131.1440	57.8	2.2689
4	L.A.	R	Yes	.5	8.1965	38.7	.2118
					151.6353		2.6911

Normalization:

$$N.F. = \frac{\text{Approximate miles}}{\text{Calculated miles}} = \frac{178}{151.6353} = 1.174$$

Normalized time = computed time x N.F.
= 2.6911 x 1.174 = 3.1594 hours

(a) determine the fraction motor fuel costs are of total truck transportation costs[18] — the fuel fraction (FF). For illustration purposes assume FF = 1/20.

(b) determine the motor fuel price in real terms for the target year relative to that in the base year (1970) — the fuel price relative (FPR). For example, assume FPR(1980) = $^{2(1980)}/_{1(1970)}$= 2.

(c) define a fuel adjustment factor (FAF) to be equal to the product of fuel's importance (FF) and its relative price change (FPR). In our example,

$$\begin{aligned} FAF &= FF \times FPR \\ &= 1/20 \times 2 = 1/10. \end{aligned}$$

(d) to conclude, adjust baseline access times for new fuel price conditions by multiplying by one plus the fuel adjustment factor. For example,

$$\text{New } D_{ij}(T) = (1.0 + FAF) \text{ old } D_{ij}(T)$$

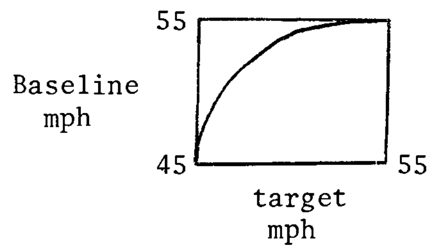
$$\begin{aligned} \text{New } D_{49,50}(80) &= (1.0 + .1)\ 3.6319 \\ &= 3.9951 \text{ hours} \end{aligned}$$

H.6.3 Lower speed limits

The national legislation creating the new uniform motor vehicle speed limit of 55 miles per hour (mph) contained staged implementation; first, states had to post the new speed limits and second, they will have to give evidence of enforcement of the new limits. While it is clear that most states did not immediately enforce the new limits, the time may be rapidly approaching when they will. Thus, how might access times be altered to reflect this eventuality?

Conceptually lower speed limits may be expected to have their greatest impact in areas of level terrain and very little congestion — areas of high average speed. To operationalize this concept, we have computed average speeds for city pairs for 1980 and assumed (1) that average speeds below 45 mph will be unaffected by the speed limit, (2) that average speeds above 55 mph will not be allowed, and (3) that average speeds between 45 and 55 mph will be partially affected. The adjustment of baseline average speeds is summarized in Table H-6.2.

Table H-6.2. The adjustment of D_{ij} for lower speed limits

If baseline average speed is	new D_{ij} is
< 45 mph	same as baseline D_{ij}
> 55 mph	$\frac{\text{Distance ij}}{55}$
≥ 45 mph but ≤ 55 mph	a) target mph is found from a graph  b) Distance ij/target mph

H.6.4 A commodity's ability to absorb transport costs

Changes in a commodity's or industry group's ability to absorb transport costs can come from at least two sources; a shift in mix of product within an industry group (e.g., more cummunications equipment and less household appliances within the electrical equipment industry group) and a shift in material composition of a product (e.g., more plastic and aluminum and less steel). Since a commodity's ability to absorb transport costs is represented by the distance decay coefficient, λ_k, within the truncated market potential model, the most likely treatment of such changes would be to alter this coefficient. Many of the insights needed to make the modifications to λ_k may be expected to come from the national interindustry tables.

H.7 COMPUTATION SEQUENCE: MARKET POTENTIALS

In MULTIREGION truncated population and market potentials are important determinants of migration, manufacturing location, and local service employment. However, the computations required to estimate these potentials are too complex for direct inclusion as variables subject to iteration within a time step of MULTIREGION. Thus, potentials are computed at the end of each time step for use as (1) summary measures of the spatial distribution of end period activities and (2) explanatory variables for the next time step of MULTIREGION. The POTENTIALS computations may be divided into three phases.

Phase I - Preliminary Data Manipulation. Necessary information is read and stored including (1) 1950, 1960, 1970, and 1980 synthetic measures of truck operating times, (2) distance decay coefficients and (3) road distance in miles between major city pairs. At this time 1965 and 1975 access times may be computed by interpolation and stored. These form the inputs to the computer program NETWORK which produces matrices of travel time to BEA areas within 8.3 hours of each BEA area for 1970, 1975, and 1980. These matrices are produced once at the beginning of a run of the model

Phase II - Compute Potentials. The results of Phase I (matrices of travel times) are combined with historic and forecast values of regional employment, population and per capita income to form final and intermediate demand and supply potentials. These are computed at the end of each five-year time step.

Phase III - Store and Transfer Potentials. Since market potentials are used both as summary measures of historical time paths of regional development and explanatory variables within MULTIREGION, historic and current values must be stored for possible display and use as explanatory variables in the next five-year time step.

REFERENCES FOR APPENDIX H

1. Gerald Kraft, J. R. Meyers, and I. P. Vallette, The Role of Transportation in Regional Economic Development, Lexington, Massachusetts; D. C. Heath and Co., 1970, p. 33.

2. R. J. Olsen and G. W. Westley, Synthetic Measures of Truck Operating Times Between the Metropolitan Centers of BEA Economic Areas: 1950, 1960, and 1970, with Projections to 1980, ORNL-NSF-EP-78, January 1975 (available from N.T.I.S).

3. Highway Research Board, Highway Capacity Manual, 1965, Special Report #87 of the Division of Engineering and Industrial Reseach, National Academy of Sciences-National Research Council, Washington, D.C., 1965.

4. Ibid., p. 246.

5. Maps prepared for the Humble Oil Company by the General Drafting Co., Inc. of Convent Station, N. J. The specific map sets used were: Northeast United States, 1950; Southeast United States, 1950; Central and Western United States, 1950; Eastern United States, 1960; Central and Western United States, 1960; Eastern United States, 1971; and Western United States, 1971.

6. U.S. Department of Interior, Geological Survey, The National Atlas of the United States of America, Washington, D.C., 1970.

7. U.S. Department of Transportation, Federal Highway Administration, Traffic Speed Trends, November, 1971. The 1950 and 1960 editions of Traffic Speed Trends were prepared by the U.S. Department of Commerce, Bureau of Public Roads.

8. Ibid., Chapter Nine.

9. Ibid., p. 99.

10. Until the fuel shortage of 1973, the fleets of a major Interstate carrier were designed for most efficient operation at 63.0 miles per hour on flat Interstate highways.

11. Ibid., p. 14.

12. Ibid., pp. 96-97.

13. Ibid., Table 9.3b, p. 257 for limited access highways, Table 10.3b, p. 287 for four-lane highways, and Table 10.9b, p. 304 for two-lane highways.

14. Traffic Speed Trends suggest that average truck speeds were 43.0 mph in 1950, 47.3 mph in 1960, and 54.7 mph in 1970 when the type of road is ignored. If one considers only Rural Interstates, the average truck speeds were 49.7 mph for 1960 and 58.1 for 1970.

15. The National Atlas of the United States, p. 55.

16. Ibid., pp. 62-63.

17. Two exceptions were category B5, which was classified as rolling in spite of relief exceeding 1000', and category D4, which was classified as mountainous in spite of relief less than 1000'.

18. Interstate Commerce Commission, Transport Statistics, Part 7, "Motor Carriers," December 31, 1972, p. 24 as cited in U.S. Department of Transportation, Energy Statistics: A Supplement to the Summary of National Transportation Statistics, Report No. DOT-TSC-OST-74-12 August 1974) p. 77.

19. At this time, U.S. Department of Transportation regulations require (1) a break (15-30 minutes) every 100 miles or 2 hours, (2) a lunch period (1 hour) every 200 miles, and (3) a statutory 8 hour break after 15 hours on duty of which up to 12 hours is driving.

20. Richard J. Olsen and G. W. Westley, "Regional Differences in the Growth of Overnight Truck Transport Markets, 1950-1970," The Review of Regional Studies.

21. The 8.3 hour criterion represents a slight adjustment of a subjectively chosen 8.0 hour criterion; other critical values could have been used.

22. Computations of this sort for all 171 BEA economic areas are available from the authors.

23. Richard J. Olsen and G. W. Westley, "Regional Differences in the Growth of Market Potentials, 1950-1970," Regional Science Perspectives, Vol. 4, pp. 99-111 (1974).

24. The interested reader may consult Gerald A. P. Carrothers, "An Historical Review of the Gravity and Potential Concepts of Human Interaction," Journal of the American Institute of Planners, Spring 1965, pp. 94-102; and Walter Isard, et al., Methods of Regional Analysis: An Introduction to Regional Science, Cambridge, MIT Press, 1960, pp. 493-568.

25. While the literature on the gravity model does include reference to how λ varies inversely with the value of the good being shipped (e.g., D. L. Huff, Determination of Intra-Urban Retail Trade Areas, Real Estate Research Program, University of California, Los Angeles, 1962, pp. 19 and 31), the "value of product" and alternative hypotheses are only now being subjected to systematic testing. A recent paper by William R. Black, "Interregional Commodity Flows: Some Experiments with the Gravity Model," Journal of Regional Science, Vol. 12, No. 1 (April 1972), pp. 107-118, describes some systematic tests of these alternative hypotheses.

26. An attempt has been made to compare a sample of our truck operating times for 1970 with corresponding automobile driving times for 1973 as published by Rand McNally. The automobile driving times were taken from "Mileage and Driving Time Map," p. 5 of Rand McNally Road Atlas: United States/Canada/Mexico, 49th Annual Edition, 1973. Of the 206 city pairs (observations) selected for comparison, 90 city pairs involved noticeable amounts of mountainous terrain, while the remaining 116 pairs involved no mountainous terrain. The 1973 auto driving times (Y) were then regressed upon the 1970 truck operating times (X) separately for the nonmountainous and mountainous data subsets. The results were:

(1) for nonmountainous routes

$r_{xy} = 0.96$

$$Y = \underset{(1.397)}{12.82} + \underset{(37.408)}{0.990}\,X \qquad R^2 = 0.924,\ F = 1399.4\ (1,\ 114)$$

and (2) for mountainous routes

$r_{xy} = 0.81$

$$Y = \underset{(1.957)}{63.84} + \underset{(13,137)}{0.742}\,X \qquad R^2 = 0.658,\ F = 172.6\ (1,\ 88)$$

These regression results tend to give credibility to our synthetic measures by confirming the high correlation of our truck operating times with actual automobile driving times in general and for nonmountainous routes in particular. For mountainous routes, the regression results confirm the noticeable delaying effect rough terrain has upon trucks.

In a less formal way our synthetic measures were compared to the terminal to terminal operating times of a major Interstate carrier. The result was that our measures were deemed to be quite accurate for major portions of the Great Lakes and Southeast regions.

APPENDIX I

COMPUTER PROGRAMS

The program MULTIREGION is written in FORTRAN IV for the IBM/360 model 91. The program is currently being run on the H compiler at level 21.6; system requirements (excluding graphics) include 550k of core, five scratch disk areas, and three 9-track tape units. Although the current version has no graphics output, a call is available to Routine RUTCIP in which the graphic calls can be placed. The machine time to begin in 1970 and provide forecasts for 1975 through 1985 (in five-year increments) is approximately 4.5 minutes of IBM/360 model 91 c.p.u. time (excluding any graphics).

Input to the program is provided via two input tape units and one card input deck. The two tape files contain, first, the base-year information (e.g., 1970) for each region and, second, the network distance matrix information for potential calculations. The first file is documented at the call to Routine UTILITY in the main program while the second file is documented in Routine POTENT. Card input contains national control values for items such as population and employment — these requirements are documented in Routine CARDRD. Additional card input is required to set base-year values in the main program.

Output from the program is provided via a print routine, PPRINT, that provides, for each five-year iteration, information for BEA economic areas specified in the input deck. Output to a 9-track tape is also provided; the form and extent of this output can be modified to suit user needs. References to this output tape are found at two locations within the main program.

The program tape is available through the Regional and Urban Studies Information Center (RUSTIC), Energy Division, ORNL. This tape (9-track, 800 BPI, SL) includes the following:

File	Contents
1	1960 base-year data for Routine UTILITY
2	1970 base-year data for Routine UTILITY
3	distance matrices for Routine POTENT
4	card images of the source code
5	card images of the card input deck

Persons requesting this information may obtain these tape files along with sample output at nominal cost. Requests should be sent to:

Dr. A. S. Loebl
RUSTIC
Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, Tennessee 37830

INTERNAL DISTRIBUTION

1. S. I. Auerbach
2. L. G. Berry
3. B. H. Bronfman
4. R. S. Carlsmith
5. W. S. Chern
6. F. L. Culler
7. R. M. Davis
8. R. C. DeVault
9. J. E. Dobson
10. W. Fulkerson
11. H. H. Herzog
12. E. A. Hirst
13. R. B. Honea
14. D. J. Jacobs
15. D. L. Kaserman
16. C. R. Kerley
17. A. S. Loebl
18. D. C. Parzyck
19. E. B. Peelle
20. H. Postma
21. B. J. Purdy
22. P. L. Rice
23. C. R. Richmond
24. M. W. Rosenthal
25. R. H. Row
26. R. M. Rush
27. R. L. Spore
28. R. I. Van Hook
29. A. H. Voelker
30. D. P. Vogt

31-32. Central Research Library
33. Document Reference Section
34-35. Laboratory Records
36. Laboratory Records - RC
37. ORNL Patent Office
38-119. Regional Economic Analysis Group
Economic Analysis Section
Energy Division

EXTERNAL DISTRIBUTION

120. Director, Research and Technical Support Division, ERDA-ORO.
121-147. Technical Information Center, ERDA-ORO.
148-300. Economic Analysis Section Distribution, Energy Division.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1977-748-189/238