State of Utah
Demographic and Economic Projection Model System

Demographic and Economic Analysis

Governor’s Office of Planning and Budget

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Introduction

Utah's population and employment projection modeling experience includes a rich history of development. For nearly three decades, during the administrations of four governors, a host of very talented and dedicated researchers have made varied and meaningful contributions to the development, production, and dissemination of population and employment projections. These projections include detailed demographic and economic information to the county level and form the data foundation upon which long term capital and social service program decisions are made by Utah state government.

The current system is housed in the Demographic and Economic Analysis Section (DEA) of the Governor's Office of Planning and Budget. DEA has prepared this document to facilitate a more comprehensive and accurate understanding of the population and employment projection modeling system. This document serves as an organizational and educational reference for the DEA staff, as well as a more formal documentation for the public. Since improvements in the projection process are on-going, this document is a work-in-progress and updates will be published as major advances occur.

The projection process, which includes development, production, and distribution, is currently undergoing a major re-engineering. This re-engineering includes cross-training and skill broadening of DEA staff; evaluation, refinement, and documentation of models; the formation of advisory groups; and public outreach. This document is part of this larger and ongoing improvement effort and will be instrumental in advancing future changes.

This document is organized so that readers can review the projection modeling system in its entirety, so far as it is documented, or, refer to separate topics of interest, as delineated by the various sections. While this approach results in a document that is a bit disjointed, it does provide, in one location, an abundance of valuable and frequently requested information about the projection modeling system.

Section I presents an overview of the projection process and links the process to the mission of the Demographic and Economic Analysis Section. Six criteria for a successful projection effort are identified.

Section II explains the structure and components of the Demographic and Economic Model System. This system currently includes a total of 59 programs and three physically separate models, commonly referred to as UPED, UCAPE, and CASA. All of these models are described in further detail in the following sections.

Section III focuses on the Utah Process Economic and Demographic Model (UPED), which is the nucleus of Utah's projection modeling effort. This section of the report includes a general discussion,definitions of variables, and the equation system.

Section IV is an overview of the Utah County Allocation of Population and Employment Model (UCAPE). UCAPE produces projections of total population and employment for 66 industries.

Section V is a presentation of the County Age and Sex Allocation Model (CASA). CASA produces county level projections for population and the components of change by sex and single year of age.

Section VI is an overview of the history of Utah's economic and demographic projection system. This history spans a period of nearly three decades, four governors, and numerous state planning coordinators. An annotated bibliography of documents relevant to the projection system is presented as well.

Section VII reviews the historical accuracy of long range projections generated by the State of Utah. This summary provides an overview of the performance of Utah's projection efforts and suggests issues for further investigation.

The appendices include a general discussion of models and modeling; a glossary of UPED variables, subscripts, variable types, and parameters; a user's guide for the UPED model; an index to the parameters and exogenous variables in UPED; a description of the parameters, files, and software used to produce the 1994 economic and demographic projections; and an index to the projection model system software. Additional documentation associated with the projection model system software is archived under separate cover.

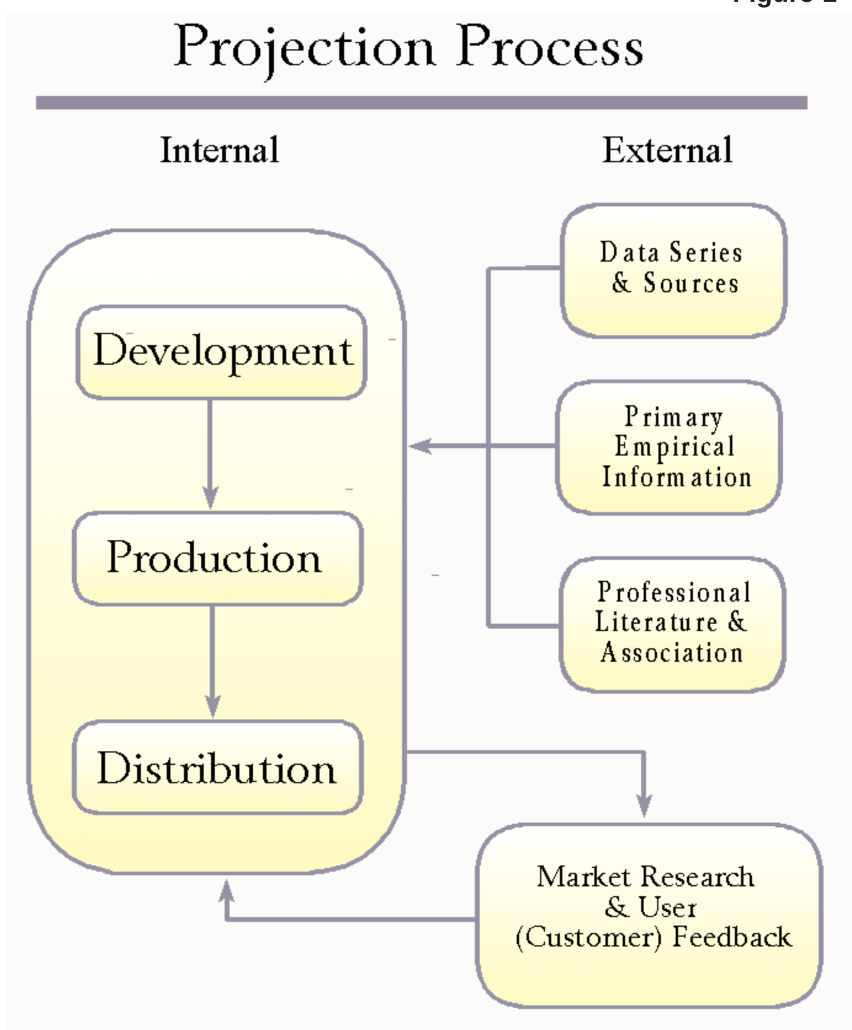
I. The Projection Process

The mission of the Demographic and Economic Section (DEA) of the Governor's Office of Planning and Budget (GOPB) is: to improve decision-making by providing economic and demographic data and analysis to the governor and to individuals from state agencies, other government entities, businesses, academia, and the public.

Economic and demographic projections for the state as well as its regions and counties constitute a significant component of this commitment. This commitment is further strengthened by Governor Leavitt's request, like those of previous governors, that all state agencies utilize the projections generated by GOPB so that state planning decisions are made from a consistent set of data.

Projections of population and labor force by sex and single year of age, employment by sixty-six industry sectors, and households by age and sex of household head to the year 2020 are produced and published bi-annually. Figure 1 gives a view of the projection process. Internal to DEA are the functions of research and development, production, and distribution, all of which are currently undergoing review and re-engineering efforts. Research and development involves reviewing the relevant literature on theory and methods, interacting with other professionals in the field, and the conceptualization, design, specification, programming, testing and validation of models. The production of projections requires acquiring and manipulating data from both primary and secondary sources, developing assumptions, estimating and projecting model parameters and exogenous variables which incorporate those assumptions, and then generating the projections by running the models. Distribution of projections to users is accomplished by both printed and electronic means. Efforts are underway to more closely involve projection users in the projection process so as to ensure that the resulting product reflects the needs and requirements of those users.

Figure 1



Identified criteria for a successful projection effort by DEA are:

1. Logical - Projections and models should be explainable and understandable and should meet all requirements for logical validity.

2. Statistically Valid - Estimates, projections and models should meet appropriate tests of significance and independence as well as be thoroughly tested and validated.

3. Collaborative - Technical experts, state and local public officials, and projection users should be allowed to participate in the process.

4. Full Disclosure - Methods, assumptions and results should be documented with limitations explicitly stated.

5. Timely - Currency of the projections should be maintained and user expectations should be met.

6. Efficient - The best use should be make of office resources, both human and capital.

II. The Demographic and Economic Model System

The flow diagram presented in Figure 2 is the Demographic and Economic Projection Model System for the State of Utah. It is currently housed in the Demographic and Economic Analysis Section (DEA) of the Governor's Office of Planning and Budget (GOPB). This system is composed of various data sets, data manipulating programs, the three models (Utah Process Economic and Demographic Model (UPED), Utah County Allocation of Population and Employment Model (UCAPE) and County Age and Sex Allocation Model (CASA), several report generating programs, graphics programs, and a number of utility programs. All programs are currently written in FORTRAN; one, however, has embedded C code.
Important data sets for the model system include:

1. U.S. Bureau of Economic Analysis 2 digit SIC employment by county from 1969.

2. Utah Department of Employment Security 2 digit SIC employment by month and ownership code from 1978.

3. U.S. Bureau of Labor Statistic and WEFA Associates projections of U.S. employment.

4. U.S. Bureau of the Census Censuses of Population, Modified Age, Race and Sex (MARS) population series, and the Public Use Micro Sample (PUMS) for population, household, labor force and migration data.

5. U.S. Bureau of the Census population projections by age and sex for the U.S.

6. Utah Population Estimates Committee for current county population estimates.

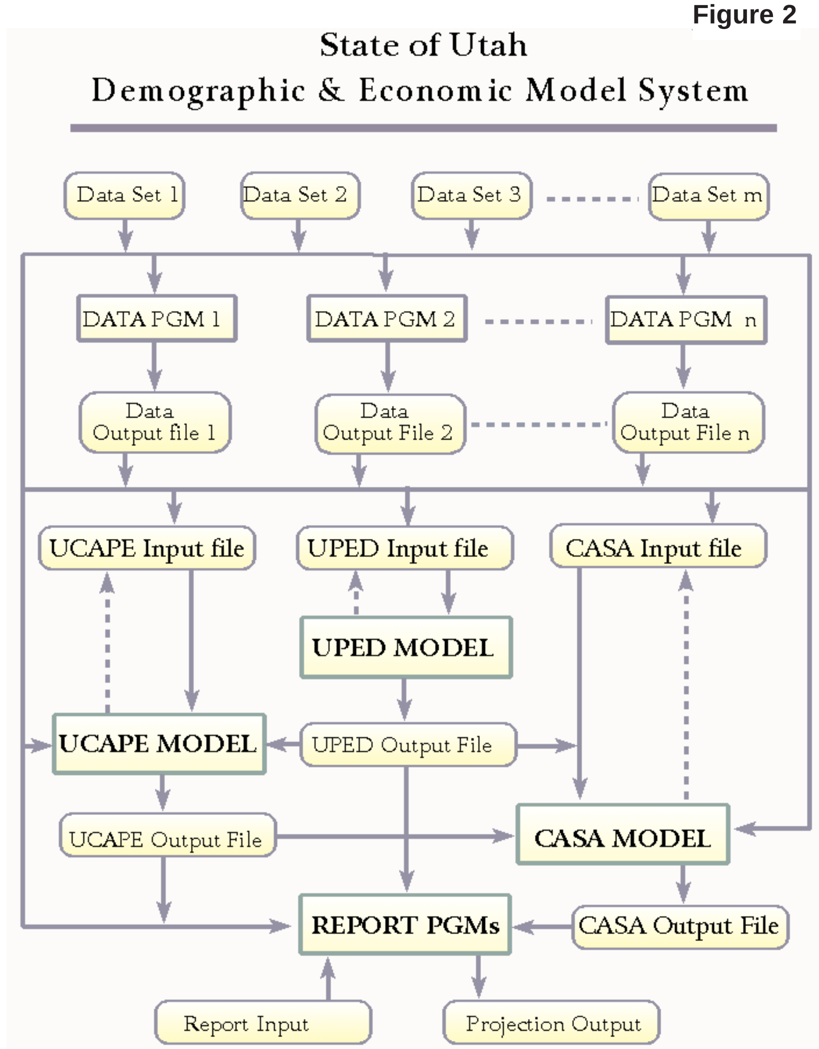
7. Utah Division of Health Statistics historical series of birth and death records.

8. Utah Board of Education school enrollments by class.

9. Utah Higher Board of Education and Brigham Young University for college enrollment data by age, sex, and residency of student.

10. Church of Latter Day Saints' missionary data by age and sex.

Figure 2



There are a total of fifty-nine programs for accessing and manipulating these data sets. These programs estimate model parameters, project model parameters and exogenous variables, and generate output in the formats required by the models' input files. Projections of model variables are produced on a regional or sub-state basis, allocated to counties, then aggregated to derive the state total. Traditionally, these regions corresponded with the multi-county districts of the seven associations of government. The data system was recently redesigned to allow the model user to aggregate counties into regions using economic criteria. In UPED, regions are conceptually labor markets bounded by limited commuting.

The model system includes three physically separate models. UPED produces projections of population, households, labor force and employment at the regional level. UCAPE allocates the total population and employment by industry as projected by UPED to the counties comprising each region. CASA, using the regional demographic parameters and projected variables from UPED, and the total population county projections from UCAPE, generates county populations by age and sex. Both UPED and CASA produce the components of population change (i.e., births, deaths and three categories of migration). Table 1 lists the variables produced by each model and specifies the level of detail at which they are available. Table 2 summarizes each model's capabilities.

The reporting component of the model system consists of twenty-two programs for accessing and manipulating model output. These include programs for aggregating model output, producing tables for publication, producing specialized tables for different users of model output, and generating ASCII comma and double quote delimited files for input into database and spreadsheet software, such as Paradox and QuattroPro. As with the data system, the reporting was redesigned to accommodate user specified aggregations of counties for reporting purposes. Thus, output of the model which is produced using one set of regions can be reported on the basis of a different set of regions. This component includes two graphics programs, one for viewing UCAPE output on the computer screen and the other produces population trees.

The model system also has twelve utility programs. These are primarily programs to check and evaluate model output during the production stage of the projection process.

Table 1
Demographic and Economic Model System
Variables Produced

	Model		
Variable	**UPED**	**UCAPE**	**CASA**
Population	a,s,mcd	cnty	a,s,cnty
Temporarily Present Non-Residents	a,s,mcd		a,s,cnty
Temporarily Absent Residents	a,s,mcd		a,s,cnty
Births	a of mother, s of child, mcd		a of mother, s of child,cnty
Deaths	a,s,mcd		a,s,cnty
Natural Increase Population	a,s,mcd		a,s,cnty
Employment Related Net In-Migration	a,s,mcd		a,s,cnty
Non-Employment Related In-Migration	a,s,mcd		a,s,cnty
Non-Employment Related Out-Migration	a,s,mcd		a,s,cnty
Households	s,a of head, mcd		s,a of head, cnty
Labor Force	a,s,mcd		
Basic Employment	k,mcd		
Residentiary Employment	k,mcd		
Total Employment	k,mcd	k,cnty	

where:
a is age, a=1,86
s is sex, s=1,2
k is industry, k=1,66
mcd is multi-county district, mcd=1,7
cnty is county, cnty=1,29

Table 2
Demographic and Economic Model System
Capabilities

	UPED	UCAPE	CASA
Baseline Projection	yes	yes *	yes
Impact Projection	yes	yes *	yes
Historical Parameter Estimates	yes *	yes *	yes *
Target or Goal Seeking	yes *	no	yes *

*added since September 1, 1990

III. Utah Process Economic and Demographic Model:

A. General Discussion

1. Introduction

The following is a discussion of the major concepts and relationships in the Utah Process Economic and Demographic Model (UPED), which is itself a component of the more comprehensive State of Utah Demographic and Economic Model System. Within this larger system, UPED provides the analytical foundation and associated theoretical underpinnings that serve to explain, and assist in evaluation of, alternative development futures for Utah.
The UPED model is a structural equation, economic-demographic model which relates changes in economic structure to demographic changes. Therefore, UPED introduces complexities beyond those generally encountered in the standard demographic accounting framework and in the conventional cohort-component population projection methodology. Further, the fundamental UPED population identity for the ending population of a given period (Equation 1, page 26) differs from the standard accounting approach. This unique specification allows for the explicit consideration of certain issues beyond those of the traditional formulation.

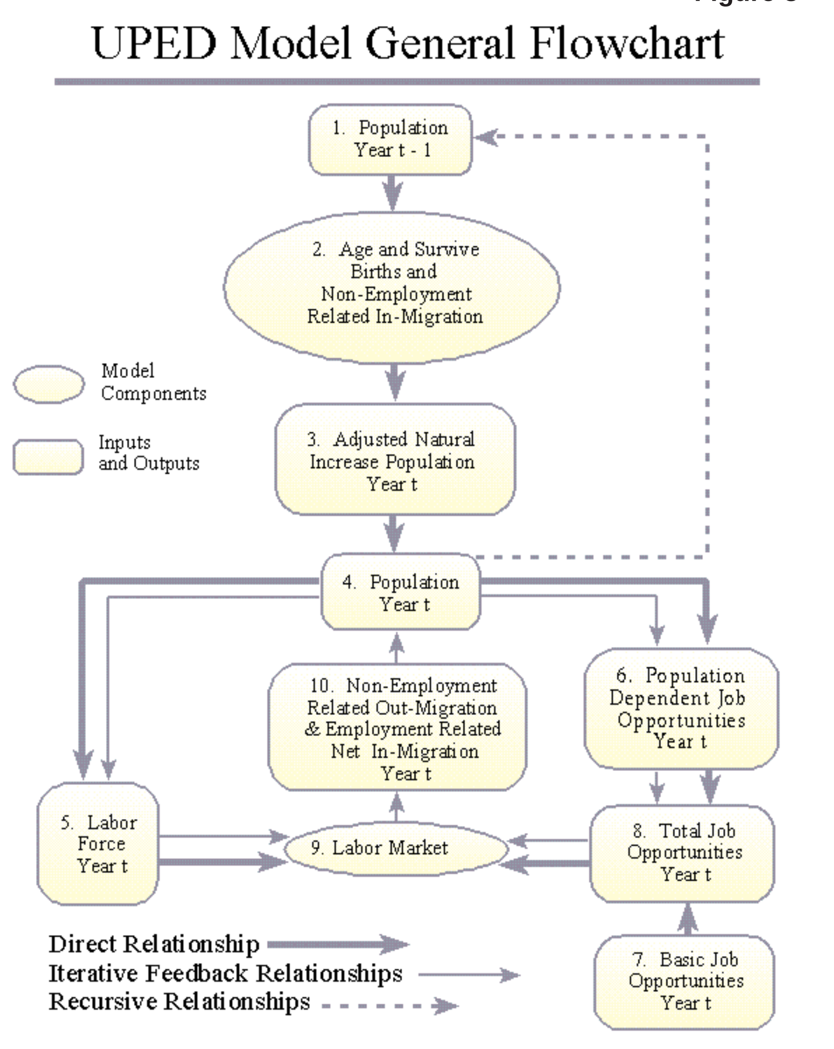
2. Projecting Changes in Population: Some General Concepts

Change in a population's size, composition (i.e., age and sex) and location over time may be described by applying vital rates (fertility and mortality) and migration rates to a given base population along with accounting for the ageing process. These rates correspond to and provide summary measures of the influence on the population of underlying social and economic structures and dynamics. Population change is summarized by the associated accounting identity that adds the number of births, subtracts the number of deaths, and adds the number of net in-migrants (which may be positive or negative) to a beginning base population in arriving at an end of period population. Of these components of population change, migration poses the greatest challenge to population projection practitioners; small open regions are particularly difficult in this regard.

While it is undoubtedly true that fertility, mortality and geographic mobility are affected by, as well as influence the "non-demographic," these vital and mobility rates are generally treated (analytically) as purely demographic phenomenon. Migration, on the other hand, may clearly be driven by non-demographic forces and motivations. People may relocate for economic reasons (e.g., in search of employment) or non-economic reasons (e.g., relocation for retirement or quality of life). And, still others may relocate because they are connected in some way (e.g., partners, dependents, etc.) to a person or persons who are migrating for whatever reason.

When population change is presented within the standard accounting framework by applying demographic rates (fertility, mortality, and migration) to the population, demographic processes have been described but not explained. Such projections are largely true by definition. Structural equation, economic-demographic models, such as UPED, have the advantage of making explicit the relationships and causal linkages that underlay demographic rates and/or population dynamics. Such models, while being more complex and requiring more data, contain more information and provide more understandable explanations (in terms of assumptions and

Figure 3



relationships) of population change than do the traditional approaches. These structural models, designed to reflect economic and demographic linkages, are especially valuable for addressing issues relating to possible future alternatives when decision-makers are faced with choices, or to potential future courses given uncontrollable and uncertain, external events.

3. The Analytical Structure of UPED

UPED integrates a cohort-component demographic model with an economic base employment model. It generates long term demographic (population) and economic (employment) forecasts. The demographic component of UPED produces projections of births, deaths, and non-employment related in- and out-migration, while the economic component generates projections of employment and employment related net in-migration. The single most important driver of growth or decline in this model is the growth rate of employment associated with a region's economic base (BEDPGRk, t).(1)

Demographic Component of UPED

The demographic portion of UPED follows this general logic: an initial value for the population (POP1a,s;, Box 1 of Figure 3) is given as an initial condition or generated as the projected population of the previous period. This estimate (Census definition) is adjusted to derive the permanent resident population at the beginning of the period (RESPOP a,s). This population is survived, aged, (SURPOPa,s) and adjusted for births to determine the natural increase population (NIPOPa,s). Non-employment related in-migrants (NEIM a,s) are added and non-employment out-migrants (NEOM a,s) are subtracted such that the result is a first approximation of the end of period population (POP3 a,s), that is, the expected end of period population in the absence of employment related migration (Boxes 2 and 3 of Figure 3). This value becomes input to the economic side of the model (Box 4 of Figure 3).

Economic Component of UPED

The economic component of UPED is an economic base employment model with the organizing concept of a labor market which in disequilibrium controls net in- or out- employment related migration. The central premise of this model is that external demand for a region's exports is the primary driving force behind the region's economic and demographic growth or decline. This demand is registered in the model as basic employment (BED k, Box 7 of Figure 3). Basic employment is that which is used to produce goods and services for export, either directly or indirectly. Indirect basic employment refers to that used to produce goods and services for direct exporters or other indirect exporters. Estimates and projections of basic employment by sixty-six industry sectors are made independently of the model for each of the state's seven regions for up to fifty years.

The population in the region also demands goods and services. Local production of goods and services for local consumption requires labor input. This demand for labor is represented in the model as residentiary or population dependent employment (RED k). As the population of the region changes, this residentiary employment will change in a like direction. In the model, factors determining the level and industrial composition of this category of employment are 1) the population size and age structure, 2) trends in national per capita employment by industry reflecting changes in national consumption patterns and productivity, and 3) the local structure of production relative to the nation reflecting regional differences, as compared with the U.S., in consumption patterns and the regions import structure (Box 6). The total demand for labor, measured in jobs, is the sum of basic and residentiary employment (TED k, Box 8).

The population of the region, besides contributing to the demand for labor, also supplies labor (LFa,s, Box 5). Population size, its age and sex composition, labor force participation rates and multiple job holding rates determine the supply of labor, again measured in terms of the number of jobs. Given the population from the demographic component of the model, if the supply of labor exceeds the demand for labor in sufficient numbers to yield an unemployment rate which exceeds the equilibrium rate (Box 9), employment related net out-migration (ERLMIGa,s) occurs. On the other hand, if the unemployment rate is less than the equilibrium rate, employment related net in-migration results (Box 10). If the labor market is in equilibrium, i.e., the unemployment rate is sufficiently close to the equilibrium rate, no migration occurs and the model proceeds to the next projection year. Age and sex characteristics of the migrating labor force and their dependents are determined by the age and sex composition of the source population (the region's population with out-migration and the U.S. population with in-migration), labor force participation rates and a set of migration propensities (relative probabilities of migrating by age and sex). Nonemployment related out-migration (NEOM a,s) is also projected in this section of the model, since the population base for this category of migration is the natural increase population plus employment related net in-migration (Box 10).

In the event of migration, the size and composition of the population changes (Box 4) which, in turn, affects the residentiary demand for labor (Box 6), thus inducing further migration. This simultaneity is solved iteratively. The system is stable with equilibrium in the labor market typically achieved in four or five iterations. With equilibrium, the model proceeds to the next projection year. The ending population (POP3 a,s) of the current year becomes the beginning population (POP1 a,s) of the following year (Box 1).

4. Organizing Concepts

Regions: The UPED model operates on a regional basis. Conceptually, a UPED region is defined as a single labor market bounded by limited commutation. Among other implications, this means that migration and residency apply to regions within the state. This means, for example, that out-migration from a given region within the state may refer to migration either to another region within the state or to another state or nation.

Dimensions: Population variables and parameters are generally dimensioned by single year of age and sex, as denoted by the subscripts a and s. These must be aggregated across age and sex to yield totals. The form of aggregation will vary according to the concept being measured.

Time: The analytical basis of the model posits a sequence of calculations. This means a time subscript (t) is implicit in many of the variables with a beginning of the period value (which is the prior period ending value) and the end-of-the period value (which becomes the beginning value for the next period). UPED uses time periods of one year.

Age: UPED uses single-year-of-age information which is centered on July 1. Age groups are offset from age by one year. Thus, age group one refers to all persons aged 0 with an average age of 0.5 years. The last age group is open ended and refers to the 85 year and older population.

Industries: There are 66 industries designated most often by the subscript k, but at times also by the subscript l. This is essentially the 2-digit Standard Industrial Classification (SIC).

III. UPED Variables

B. Definitions and Relationships

What follows is a listing of the definitions associated with selected variables and parameters used in Utah Process Economic and Demographic Model (UPED). Relationships among the most fundamental of these variables are explained. Explicit reference to the relevant equations in Section III C is included as well. The variables discussion is divided into two parts that correspond to the demographic and economic components of the model.

1. Demographic Component of UPED

POP1a,s: Population at the beginning of the period

Characteristics:
Point in time (beginning of the period) measurement of a stock (number of persons). Endogenous variable that is recursively computed. Initial values are required.

Definition/Discussion:
This is a Census type count of the population at the beginning of the period. In effect it is a "body count" with the fundamental identifier being "usually lives here." Therefore, it differs from the concept of "legal residence" or "permanent residence." POP1 includes people out of the region on vacation or business trips but excludes people who consider themselves permanent residents of the region but who are currently living out-of-region attending college or on a mission. It also includes people who are from other regions but living here while attending college. POP1a,s for any given period is given by the ending population (POP3a,s) of the prior period (Equation 7).

POP3a,s: Population at the end of the period

Characteristics:
Point in time (end of the period) measurement of a stock (number of persons). Endogenous variable. Values are computed internally.

Definition/Discussion:
This is a Census type count (as is POP1a,s) of the population at the end of the period. The calculation of POP3a,s for each time period is the resultant of the fundamental UPED identity (Equations 1 and 2).

TAR a,s: Temporarily absent permanent residents

Characteristics:
Point in time (beginning of the period) measurement of a stock (number of persons). Endogenous variable. Values are computed internally.

Definition/Discussion:
These are permanent residents who are temporarily absent from the area, primarily those away from the region attending college or on missions. Temporarily absent residents (TAR a,s) for any given year are some portion (NOMTR a,s) of non-employment related out-migrants from last year (i.e., NEOM1a,s) (Equation 11).

NOMTR a,s: Proportion of last year's nonemployment related out-migrants that become this year's temporarily absent residents

Characteristics:
Period of time (year) measurement of a rate (proportion of last year's non-employment related out-migrants). Parameter, time dependent.

Definition/Discussion:
This is the proportion of last year's nonemployment related out-migrants (NEOM1 a,s) that become this year's temporarily absent residents (TAR a,s) (Equation 11).

TPNR a,s: Temporarily present non-residents

Characteristics:
Point in time (beginning of the period) measurement of a stock (number of persons). Endogenous variable. Values are computed internally.

Definition/Discussion:
These are persons who are permanent residents of another region but who are living in this region temporarily, primarily younger people attending universities and colleges. Temporarily present non-residents (TPNR a,s) for this year are some portion (NIMTR a,s) of non-employment related in-migrants from last year (NEIM1 a,s) (Equation 12).

NIMTR a,s: Proportion of last year's non-employment related in-migrants that become this year's temporarily present non-residents

Characteristics:
Period of time (year) measurement of a rate (proportion of last year's non-employment related in-migrants). Parameter, time dependent.

Definition/Discussion:
This is the proportion of last year's nonemployment related in-migrants (NEIM1a,s) that become this year's temporarily present non-residents (TPNRa,s) (Equation 12).

RESPOP a,s: Permanent resident population

Characteristics:
Point in time (beginning of the period) measurement of a stock (number of persons). Endogenous variable. Values are computed internally.

Definition/Discussion:
This is computed by summing the census type count of the population at the beginning of the period (POP1a,s) and temporarily absent residents (TAR a,s), then subtracting temporarily present non-residents (Equation 3). This population is survived by applying age and sex specific one-year survival rates and then aged one year.

BIRTHS a,s: Number of births that occur to permanent residents this year

Characteristics:
Interval of time (a year) measurement of a flow (number of persons). Endogenous variable. Values are computed internally.

Definition/Discussion:
These are calculated from the middle of the period female portion of the resident population. This is the average of the female portion of the beginning of the year population (RESPOPa,s) and the surviving female portion of the population aged to the end of the period (SURPOPa,s) (Equation 20). Age specific birth rates (BRTHRAa) are applied to this average female population to compute births. The variable (BIRTHS a,s) is dimensioned by the age group of the mother (FMLPOPa) and the sex of the baby (SXPROPs) (Equation 21).

FMLPOPa: Mean permanent resident female population before migration

Characteristics:
Point in time (middle of the period) measurement of a stock (number of persons). Endogenous variable. Values are computed internally.

Definition/Discussion:
This is the base female population for the calculation of births and therefore the relevant sub-population is the 15 to 44 year old group. It is the average of the female portion of the beginning of the period resident population (RESPOPa,s) and the female portion of the population survived and aged to the end of the period (SURPOPa,s) (Equation 20).

SXPROPs: Proportions of male and female births

Characteristics:
Timeless measurement of a ratio (male births and female births as proportions of total births). Parameter.

Definition/Discussion:
This indicates the proportions of newborns expected to be male and female.

BRTHRAa: Births per woman

Characteristics:
Period of time (year) measurement of a rate (expected number of live births per woman per year). Parameter, time dependent.

Definition/Discussion:
These are the age-specific birth rates that are applied to FMLPOPa to calculate the number of births to resident Utah females during a given year.

DEATHS a,s: Number of deaths that occur to the permanent resident population

Characteristics:
Interval of time (a year) measurement of a flow (number of persons). Endogenous variable. Values are computed internally.

Definition/Discussion:
This is the number of deaths that occur to the permanent resident population in the current year. It is computed as one minus the survival rate applied to the beginning of the period permanent resident population (RESPOP a,s), with adjustments made for infant deaths and for the 86 and over age group (Equation 22).

SURPOP a,s: Survived resident population

Characteristics:
Point in time (end of the period) measurement of a stock (number of persons). Endogenous variable. Values are computed internally.

Definition/Discussion:
The survived resident population is determined by applying survival rates (SURATEa,s) to the beginning of the period resident population (RESPOPa,s) and aging the survivors by one year. This leaves the first age group in SURPOPa,s empty.

BSURATs: Birth survival rate

Characteristics:
Period of time (year) measurement of a rate (probability of surviving the first one-half year of life). Parameter, time dependent.

Definition/Discussion:
This is the proportion of newborns for a given time period (a year) expected to survive to the end of the year. Because births are calculated in the model as occurring half-way through the year, this results in a six month survival rate. This rate is applied to the calculated number of births to derive the number of persons in age group number one (average age is 0.5 years) in the natural increase population (NIPOPa,s) (Equation 19)
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NIPOP a,s: Natural increase population

Characteristics:
Point in time (end of the period) measurement of a stock (number of persons). Endogenous variable. Values are computed internally.

Definition/Discussion:
This is the natural increase population of the resident population. Resident population at the beginning of the period has been aged and survived (SURPOPa,s). To this population, births, adjusted for survival, are added. In the survival process, deaths for the year are, in effect, subtracted. (Equation 19)

NEOM a,s: Non-employment related out-migration

Characteristics:
Interval of time (a year) measurement of a flow (number of persons). Endogenous variable. Values are computed internally.

Definition/Discussion:
This is the number of permanent residents plus employment related net in-migrants who migrate from the region during the period for reasons other than employment. It includes the stock of those who were non-employment related out-migrants (NEOMa,s) last year and who are still temporarily absent (TAR a,s) this year plus the flow of incremental non-employment related out-migrants (NEOMa,s) for this year.

Example: If a Utah resident leaves for an out-of-state university in 1994 and does not return until 1996, s/he would be considered a non-employment related out-migrant (NEOMa,s) in 1994, a temporarily absent resident (TARa,s) and a non-employment related out-migrant (NEOMa,s) in 1995, and a temporarily absent resident (TAR a,s) in 1996. This individual would be subtracted from the beginning population in 1994 (and thus have a net effect of minus one on the ending population (POP3 a,s). In 1995 s/he will have a zero effect on the ending population (POP3 a,s). In 1996 the individual will be added back into the final population (POP3 a,s).

The number of non-employment related out-migrants (NEOM a,s) for the current year are given by the sum of an autonomous component (AOUT) and an endogenous component. The latter is produced by applying a migration rate (NOMRAT a,s) to the sum of the natural increase population (NIPOPa,s) and net employment related in-migration (NEIM a,s minus NEOM a,s). This is equivalent to POP3 a,s less NEIM a,s plus NEOM a,s. (Equation 14).

NEOM1 a,s: Non-employment out-migration from the previous period

Characteristics:
Interval of time (a year) measurement of a flow (number of persons). Endogenous variable. Values are computed internally.

Definition/Discussion:
This is the number of non-employment related out-migrants from the previous period (Equation 9). This is multiplied by a rate (NOMTR a,s) to calculate temporarily absent residents (TAR a,s) (Equation 11).

NOMRAT a,s: Non-employment related out-migration rate

Characteristics:
Period of time (year) measurement of a rate (probability of migrating). Parameter, time dependent.

Definition/Discussion:
This is the probability of migrating from a region for non-employment purposes and is applied to the natural increase population (NIPOPa,s) plus net employment related in-migration. This is equivalent to multiplying the probability of being a non-employment related out-migrant to the ending population (POP3 a,s) minus non-employment in-migration (NEIM a,s) plus non-employment out-migration (NEOM a,s) (i.e., the permanent resident population present at the end of the period) (Equation 14).

NEIM a,s: Non-employment related in-migration

Characteristics:
Interval of time (a year) measurement of a flow (number of persons). Endogenous variable. Values are computed internally.

Definition/Discussion:
This is the number of persons migrating into a region for reasons other than employment during a given period. It includes those who were non-employment related in-migrants (NEIM a,s) last year and who are still temporarily present non-residents (TPNR a,s) plus the flow of incremental non-employment related in-migrants for this year. A growth rate (NIMGR a,s) is applied to the previous period non-employment related in-migration, to which is added an autonomous component (AIN a,s) to calculate this period's value (Equation 13).

NEIM1 a,s: Non-employment related in-migration from the previous period

Characteristics:
Interval of time (a year) measurement of a flow (number of persons). Endogenous variable. Values are computed internally.

Definition/Discussion:
This is the number of non-employment related in-migrants from the previous year (Equation 8). A growth rate (NIMGR a,s) is applied to this value and an autonomous component (AIN a,s) is added in order to compute the current period's non-employment related in-migration (NEIM a,s) (Equation 13).

NIMGR a,s: Growth rate of non-employment related in-migration

Characteristics:
Period of time (year) measurement of a rate (growth rate of non-employment related in-migration). Parameter, time dependent.

Definition/Discussion:
This growth rate is applied to the non-employment related in-migration from last period (NEIM1 a,s). This value is added to the total non-employment related in-migration from last period (NEIM1 a,s) and to an autonomous component (AIN a,s). The result is non-employment related in-migration (NEIM a,s) for the current period (Equation 13). This category of migrants includes college students and retirees.

ERLMIG a,s: Employment related net in-migration

Characteristics:
Period of time (year) measurement of a flow (number of persons). Endogenous variable. Values computed internally and iteratively.

Definition/Discussion:
Employment related net in-migration is computed in the economic component of the model.

2. Economic Component of UPED

TLF: Total labor force

Characteristics:
Point in time (end of the period) measurement of a stock (number of persons). Endogenous variable. Values are computed internally.

Definition/Discussion:
The total labor force is a person count of the number of persons who are employed or are seeking work. It is calculated by applying labor force participation rates (LFPR a,s) to the population (POP3 a,s). (Equation 30). When the multiple job holding rate (DBJOBR) is applied to the total labor force, the result is the demand for jobs, a jobs count.

LFPR a,s: Labor force participation rates

Characteristics:
Point in time measurement of a ratio (persons in labor force to the population). Endogenous variable. Values are computed internally.

Definition/Discussion:
The labor force participation rate indicates the proportion of persons in a particular group that are in the labor force. Participation in the labor force indicates that a person is either employed (full or part time) or actively seeking employment. This may also be viewed in probablistic terms. For example, a labor force participation rate of 50% for 25 year old females means that the probability of any given 25 year old female being in the labor force is 50%.

The labor force participation rate is calculated using a modified Gompertz curve (Equation 31). UPED specifies that the labor force participation rate moves over time from an initial level (FO a,s,t at time =0) to a final or target level (FOT a,s,t) along a secular trend line (FO a,s,t as given by Equation 32) over the forecast period. The model also incorporates a cyclical element such that the labor force participation rate oscillates around the trend line. This cyclicality is driven by the difference between value of the economic opportunity index for a given period (E, as given in Equation 36) and the normal or equilibrium value of the same index (EO) bounded by upper (FU a,s as given by Equation 34) and lower (FL a,s as given by Equation 33) limits. The function also incorporates the labor force elasticity with respect to the economic opportunity index(, as given by Equation 35). This captures the direct relationship between economic opportunity and the size of the labor force.

BED k: Basic employment

Characteristics:
Point in time measurement of a stock (number of jobs). Endogenous non-recursive variable. Values are computed internally.

Definition/Discussion:
Basic employment (BED k) in a regional economy is the total number of jobs required to produce that region's exports to buyers which are outside of the region. In the model, this includes both direct and indirect basic employment. The latter refers to employment located in the region used to produce products that are purchased by firms which directly sell their products to out-of-region residents or entities. Basic employment (BED k) is part of total employment (TED k). Both represent demands for labor, measured in jobs or, alternatively, the supply of jobs.
Total basic employment (BED k) is composed of permanent basic employment (BEDPk) and temporary basic employment (BEDT k) (Equations 4 and 15). The latter is generally associated with one-time projects or events, such as the construction of a power plant. Only the permanent basic employment is subject to a growth rate (BEDPGR k, t=n) in the model (Equation 18).

BEDP k, t=n: Permanent basic employment

Characteristics:
Point in time measurement of a stock. This is measured as a number of jobs. Exogenous or endogenous variable at user's option.

Definition/Discussion:
Permanent basic employment (BEDP k) are those jobs that are considered to be part of the on-going economic base. In UPED this includes both direct and indirect basic employment.

BEDPGR k, t=n Permanent Basic Employment Growth Rate

Characteristics:
Period of time measurement of a rate of growth. Optional variable and is further optionally exogenous or recursively endogenous.

Definition/Discussion:
This is the growth rate that is applied to permanent basic employment. The computation of this growth rate (Equation 18) includes an escalator (BEDPES k), which expresses the rate of change of the growth rate over time. The model also allows an option of either applying or not applying basic employment growth rates (BEDPGR k, t=n) to absolute changes in basic employment (BEDPAC k and/or to accumulated changes in these (BEDCAC k, t=n)) (Equations 16 and 17). Thus, any portion of permanent basic employment (BEDP k) may be treated in the same way that temporary basic employment (BEDT k) is treated with respect to the application of growth rates.

RED k: Residentiary employment

Characteristics:
Point in time measurement of a stock. This is measured as a number of jobs. Endogenous non-recursive variable. Values are computed internally.

Definition/Discussion:
Residentiary employment is the direct and indirect employment associated with local production for local consumption. Alternatively, it is local production that is not for export, either directly or indirectly. Equivalent terms are population dependent or non-basic employment. It is a component of total employment and, consequently, a component of the total demand for labor as measured in job units. In the model, the initial value for residentiary employment in a given period (RED1 k, t) is the final computed value of residentiary employment from the prior period (RED k, t-1) (Equation 10).

Residentiary employment is determined by the composition of effective demand in the local economy and the ability and willingness of local producers to accommodate this demand. Residentiary employment is determined by a series of relationships (Equations 23 through 26) that relate the following factors to the residentiary employment in a region's industries:

a) BDRPRP k is a weighting factor which attempts to capture the relative effect of temporary jobs and incomes versus permanent jobs and incomes on residentiary employment. A value of one indicates full effect while a value less than one indicates partial effect. This is accomplished through a factor (F k,l) which relates the proportionate effect of temporary basic activity (e.g., large construction projects) in one industry to the residentiary response in other industries (Equations 23 and 24).

b) RSEREL k is a residentiary employment relative that is essentially a residentiary employment location quotient with a population base. It is a measure of the per capita residentiary employment of the region to that of the nation after adjustment for the relative effects of age structure on residentiary demand across industries. This parameter is important because a region's industrial distribution of employment may differ from that of the nation for any number of reasons, including comparative advantage and the structure of exports and imports, differing age distributions, unique culture, different standards of living and disposable income, etc. (Equations 23 and 25).

c) REPROP k is per capita residentiary employment for the nation adjusted for the effects of the population's age distribution on residentiary demand by industry. By incorporating this variable in the residentiary demand equation, the population of the region is assumed to participate in projected changes in national consumption and productivity patterns (Equations 23 and 26).

TED k: Total employment

Characteristics:
Point in time measurement of a stock. This is measured as a number of jobs. Endogenous non-recursive variable. Values are computed internally.

Definition/Discussion:
The supply of jobs or the demand of labor measured in job units, i.e., total employment (TEDa,s), is composed of residentiary jobs (REDa,s)and basic jobs (BEDa,s) (Equation 5).

ERLMIG a,s: Employment related net in-migration

Characteristics:
Period of time measurement of a flow of migrants. Non-recursive variable that is computed internally.

Definition/Discussion:
Disequilibrium in the labor market (i.e., a mismatch between the demand for jobs (supply of labor) and the supply of jobs (demand for labor) determines economic-induced migration (Equations 27 and 28). Employment related migration has the added effect of changing the level and the structure of residentiary employment.

IM a,s: Employment related net in-migration, current iteration

Characteristics:
Period of time flow of net in-migrants. Endogenous, non-recursive variable that is computed internally.

Definition/Discussion:
A non-zero value of employment related net in-migration is a labor market disequilibrium phenomenon. It means that there are either insufficient jobs to support the current population, in which case net out-migration results, or that there is an inadequate labor pool to fill job openings, in which case in-migration occurs. The equilibrium condition for the labor market is expressed as a range of unemployment rates. The upper bound (OUTRAT) of this range is the out-migration triggering rate while the lower bound (INRAT) is the in-migration triggering rate. The net in-migration equation also incorporates age and sex specific migration propensities and labor force participation rates as well as the source population of migrants by age and sex in order to project the age and sex characteristics of labor force migrants and their dependents. In the case of net out-migration the population at risk is the region's population. In the case of net in-migration the projected national population is considered to be the population at risk of migrating (Equations 27 and 28).

UNRATE: Unemployment rate

Characteristics:
Point in time measure of a ratio (i.e., the number of unemployed persons relative to the number of persons in the labor force). Endogenous, non-recursive variable. Values are computed internally.

Definition/Discussion:
The unemployment rate is the fraction of the labor force that is not employed. The definitional calculation in the model specifies the unemployment rate as the compliment of the employment rate measured in jobs (Equation 29). The unemployment rate is compared to an equilibrium range (bounded by INRAT and OUTRAT). Disequilibrium in the labor market leads to employment related migration adjustments, net out-migration when the calculated unemployment rate exceeds the out-migration triggering rate and net in-migration when the unemployment rate is exceeded by the in-migration triggering rate (Equation 27). Equilibrium and the end of the model run for the current year occurs when UNRATE is within the equilibrium range (Equation 6).

III. UPED

C. Equation System

1. Identities

$$\sum_a \sum_s POP3_{a,s} = \sum_a \sum_s (POP1_{a,s} + TAR_{a,s} - TPNR_{a,s} + BIRTHS_{a,s} - DEATHS_{a,s} + NEIM_{a,s} - NEOM_{a,s} + ERLMIG_{a,s}) \quad \textbf{(1)}$$

$$POP3_{a,s} = NIPOP_{a,s} + NEIM_{a,s} - NEOM_{a,s} + ERLMIG_{a,s} \quad \textbf{(2)}$$

$$RESPOP_{a,s} = POP1_{a,s} + TAR_{a,s} - TPNR_{a,s} \quad \textbf{(3)}$$

$$BED_k = BEDP_k + BEDT_k \quad \textbf{(4)}$$

$$TED_k = BED_k + RED_k \quad \textbf{(5)}$$

2. Equilibrium Condition

$$INRAT \leq UNRATE \leq OUTRAT \quad \textbf{(6)}$$

3. Recursive Relations

$$POP1_{a,s,t} = POP3_{a,s,t-1} \quad \textbf{(7)}$$

$$NEIM1_{a,s,t} = \begin{cases} NEIM_{a,s,t-1} & \text{when } RUNOPT(6) = 0 \\ NEIM_{a,s,t-1} - AIN_{a,s,t-1} & \text{when } RUNOPT(6) \neq 0 \end{cases} \quad \textbf{(8)}$$

$$NEOM1_{a,s,t} = \begin{cases} NEOM_{a,s,t-1} & \text{when } RUNOPT(7) = 0 \\ NEOM_{a,s,t-1} - AOUT_{a,s,t-1} & \text{when } RUNOPT(7) \neq 0 \end{cases} \quad \textbf{(9)}$$

$$RED1_{k,t} = RED_{k,t-1} \quad \textbf{(10)}$$

$$TAR_{a,s} = NOMTR_{a,s} \cdot NEOM1_{a,s} \quad \textbf{(11)}$$

$$TPNR_{a,s} = NIMTR_{a,s} \cdot NEIM1_{a,s} \quad \textbf{(12)}$$

5. Non-Employment Related Migration

$$NEIM_{a,s} = AIN_{a,s} + (1 + NIMGR_{a,s}) \cdot NEIM1_{a,s} \quad \textbf{(13)}$$

$$NEOM_{a,s} = \left[\frac{AOUT_{a,s} + (NOMRAT_{a,s}) \cdot (POP3_{a,s} - NEIM_{a,s})}{(1 - NOMRAT_{a,s})} \right] \quad \textbf{(14)}$$

$$BED_k = BEDP_k + BEDT_k \quad \textbf{(15)}$$

$$BEDP_{k,t=n} = \begin{cases} (BEDP_{k,t=n-1} - BEDCAC_k)(1 + BEDPGR_k) + BEDCAC_k + BEDPAC_k & when\ RUNOPT(4) = 0 \\ BEDP_{k,t=n-1}(1 + BEDPGR_k) + BEDPAC_k & when RUNOPT(4) \neq 0 \end{cases} \quad \textbf{(16)}$$

where:

$$BECCAC_{k,t=n} = \sum_{t=1}^{n-1} BEDPAC_{k,t} \quad \textbf{(17)}$$

7. Natural Increase

$$BEDPGR_{k,t=n} = e^{[(1 + \ln(1 + BEDPGR_{k,t=n-1}))e^{BEDPES_{k,t=n}} - 1]} - 1 \quad \textbf{(18)}$$

$$NIPOP_{a,s} = \begin{cases} [SURATE_{a,s} \cdot RESPOP_{a,s}] + [SURATE_{a-1,s} \cdot RESPOP_{a-1,s}] & when\ a = 86 \\ SURATE_{a-1,s} \cdot RESPOP_{a-1,s} & when\ 1 < a < 86 \\ BSURAT_s \sum_a [SXPROP_s \cdot FMLPOP_a \cdot BRTHRA_a] & when\ a = 1 \end{cases} \quad \textbf{(19)}$$

where:

$$FMLPOP_a = [(1 + SURATE_{a,s=2})/2] \cdot RESPOP_{a,s=2} \quad \textbf{(20)}$$

$$BIRTHS_{a,s} = SEXPROP_s \cdot FMLPOP_a \cdot BRTHRA_a \quad \textbf{(21)}$$

where:

a is the age of the mother

s is the sex of the child

$$DEATHS_{a,s} = \begin{cases} [(1 - SURATE_{a,s})RESPOP_{a,s}) + (1 - SURATE_{a-1,s})RESPOP_{a-1,s})] & when\ a = 86 \\ (1 - SURATE_{a-1,s})RESPOP_{a-1,s} & when\ 1 < a < 86 \\ (1 - BSURAT_s) \sum_a [SXPROP_s \cdot FMLPOP_a \cdot BRTHRA_a] & when\ a = 1 \end{cases} \quad \textbf{(22)}$$

8. Residentiary Employment

$$RED_k = BDRPRP_k \cdot RSEREL_k \cdot REPROP_k \cdot \sum_a \sum_s (POP3_{a,s} \cdot DMPROP_{a,k}) \quad \textbf{(23)}$$

where:

$$BDRPRP_k = 1 - [\sum_l (1 - F_{k,l}) \cdot BEDT_l] \;/\; \sum_a \sum_s POP3_{a,s} \quad \textbf{(24)}$$

$$RSEREL_k =$$

$$\left[\frac{RED_k}{\sum_a \sum_s \sum_k (DMPROP_{a,k} \cdot POP3_{a,s})}\right] \Bigg/ \left[\frac{NATRE_k}{\sum_a \sum_s \sum_k (DMPROP_{a,k} \cdot NATPOP_{a,s})}\right]\Bigg|_{t=0} \quad \textbf{(25)}$$

$$REPROP_k = \left[\frac{NATRE_k}{\sum_a \sum_s (DMPROP_{a,k} \cdot NATPOP_{a,s})}\right] \quad \textbf{(26)}$$

9. Employment Related Migration

$$IM_{a,s} = \begin{cases} \dfrac{(INRATE - UNRATE)(TLF/(1-INRAT)) \cdot MIGPR_{a,s} \cdot NATPOP_{a,s}}{\sum_a \sum_s LFPR_{a,s} \cdot MIGPR_{a,s} \cdot NATPOP_{a,s}} & when\ UNRATE < INRAT \\[2ex] \dfrac{(OUTRAT - UNRATE)(TLF/(1-OUTRAT)) \cdot MIGPR_{a,s} \cdot POP3_{a,s}}{\sum_a \sum_s LFPR_{a,s} \cdot MIGPR_{a,s} \cdot NATPOP_{a,s}} & when\ UNRATE < OUTRAT \end{cases} \quad \textbf{(27)}$$

$$ERLMIG_{a,s} = \sum_i IM_{a,s} \quad \textbf{(28)}$$

where:

$$UNRATE = 1 - \frac{\sum_k TED_k}{(1-DBJOBR) \cdot TLF} \quad \textbf{(29)}$$

$$TLF = \sum_a \sum_s LFPR_{a,s} \cdot POP3_{a,s} \quad \textbf{(30)}$$

i represents an iteration.

10. Labor Force Participation

$$LFPR_{a,s} = \left[(FU_{a,s} - FL_{a,s}) \cdot \left(\frac{FO_{a,s} - FL_{a,s}}{FU_{a,s} - FL_{a,s}} \right)^{e^{\left(\frac{\varepsilon_{a,s} \cdot FO_{a,s} \cdot (E - EO)}{(EO \cdot (FO_{a,s} - FL_{a,s}) \cdot \ln\left(\frac{FO_{a,s} - FL_{a,s}}{FU_{a,s} - FL_{a,s}} \right)} \right)}} \right] + FL_{a,s} \quad \mathbf{(31)}$$

$$FO_{a,s,t} = FOT_{a,s} - \left[FOP_{a,s}^{\left(\frac{\sum_{i=1}^{t} t_i}{FON} \right)} \right] \cdot (FOT_{a,s} - FO_{a,s,t-0}) \quad \mathbf{(32)}$$

$$FL_{a,s,t} = FLT_{a,s} - \left[FLP_{a,s}^{\left(\frac{\sum_{i=1}^{t} t_i}{FLN} \right)} \right] \cdot (FLT_{a,s} - FL_{a,s,t-0}) \quad \mathbf{(33)}$$

$$FU_{a,s,t} = FUT_{a,s} - \left[FUP_{a,s}^{\left(\frac{\sum_{i=1}^{t} t_i}{FUN} \right)} \right] \cdot (FUT_{a,s} - FU_{a,s,t-0}) \quad \mathbf{(34)}$$

$$\varepsilon = AE - BE \cdot (FO_{a,s}) \quad \mathbf{(35)}$$

$$E = \frac{\sum_{k} TED_k}{\sum_{s,\, a=16}^{64} POP3_{a,s}} \quad \mathbf{(36)}$$

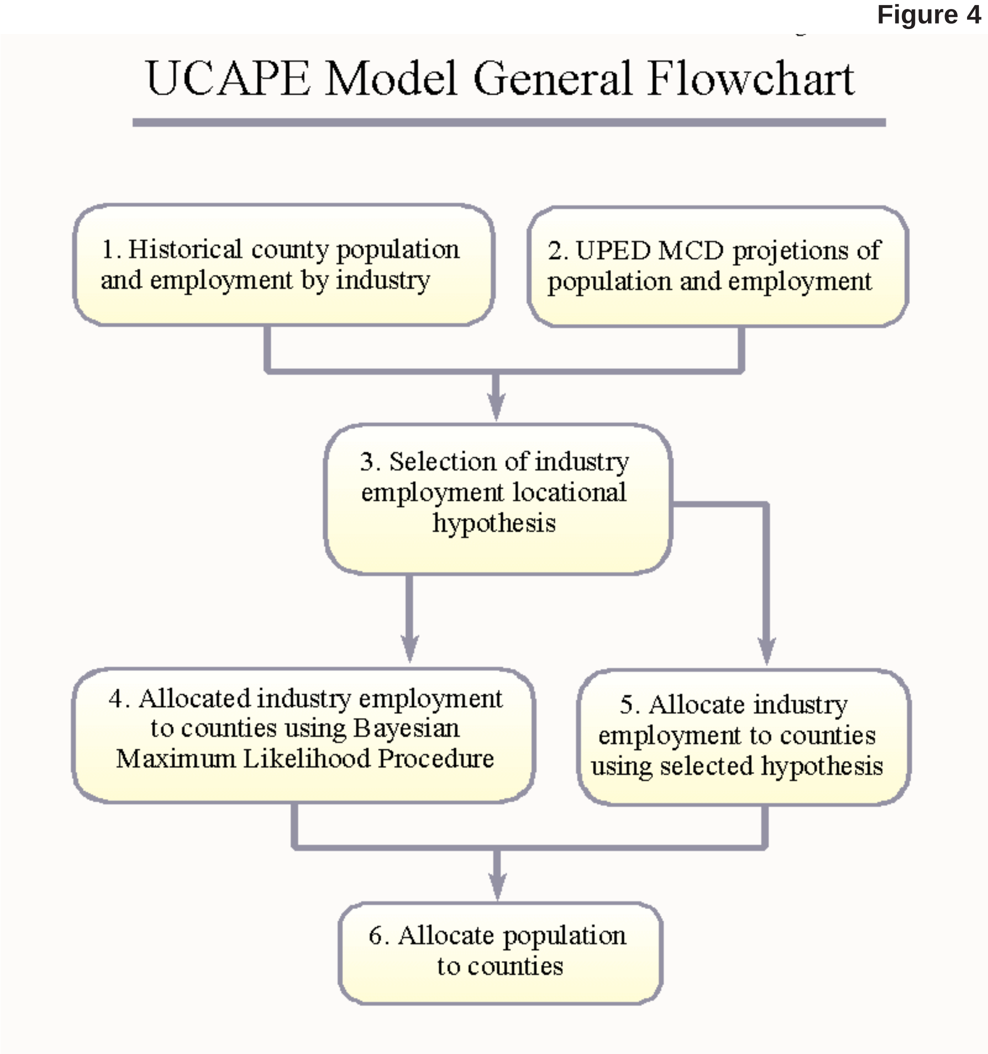
IV. Utah County Allocation of Population and Employment Model:

UCAPE

The Utah County Allocation of Population and Employment Model (UCAPE) allocates the Utah Process Economic and Demographic Model (UPED) regional level projections of total population and employment (Box 2 in Figure 4) by industry to sub-regional areas. This model is currently implemented at the county level and produces projections of total population and employment for sixty-six industries (essentially the 2-digit SIC industries) for each county in the region. These employment by detailed industry projections are aggregated to and reported by major industry in order to assure confidentiality and to avoid disclosure problems.

Historical series of total population and employment by industry for each county (Box 1) serve as the basis for the parameter and probability estimates used in the UCAPE model. They also define the initial conditions upon which the model operates. These series are entered directly into the model which incorporates the necessary statistical and estimating methods and procedures. Each industry is potentially associated with a locational hypothesis or rule by which changes in employment in that industry are allocated to sub-regional areas (Boxes 3 and 5). These may be resource oriented, market oriented, or central place, or other hypotheses, or they may be rules incorporating user knowledge and judgement. (As of yet, the complete set is not fully implemented and tested.

Figure 4



For those industries having no associated hypothesis or rule, allocation of employment to sub-areas is accomplished jointly using a Bayesian maximum likelihood estimating procedure (Box 4). The first step here is an ordinary least squares (OLS) extrapolation of this category of employment to sub-areas which is constrained to the total regional unallocated employment. Secondly, industry specific allocations are produced from a) the unallocated regional employment by industry (from the UPED model), b) the unallocated employment by sub-area (from the above OLS procedure), (both of which are reduced to the form of marginal probability distributions), and c) a prior joint probability distribution of employment with dimensions industry and county (from the input historical series of employment by industry and county).

Total population is distributed to sub-areas on the basis of the employment allocations and a set of sub-area specific population to employment relative (relative to the region) weights (Box 6). These weights preserve relative differences between counties in population composition, labor force participation, and commutation patterns.

V. County Age and Sex Allocation Model:

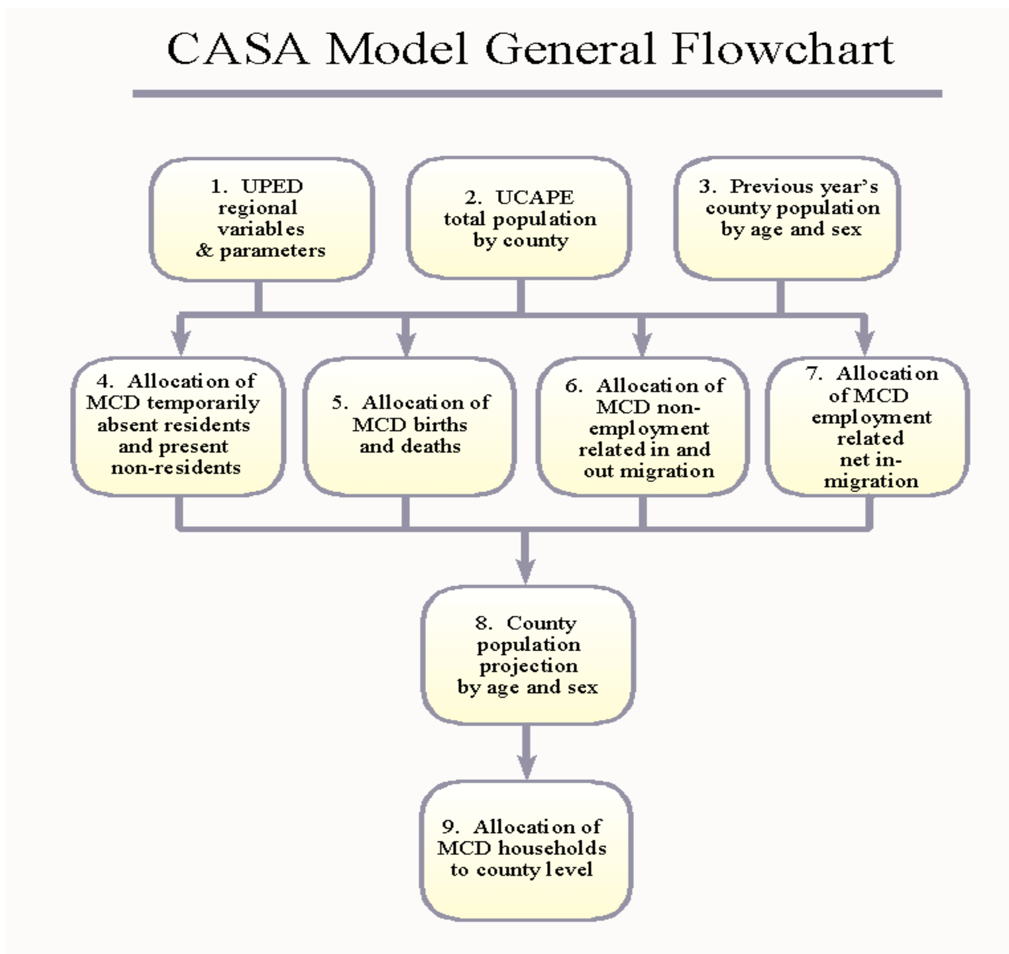
CASA

The County Age and Sex Allocation Model (CASA) produces county level projections of population and the components of population change by sex and single year of age (Box 8 of Figure 5). Households by sex and age of household head are also produced (Box 9). Components of change variables are temporarily absent residents, temporarily present non-residents, births, deaths, non-employment related in-migration, non-employment related out-migration, and employment related net in-migration. From the UPED regional level output (Box 1), CASA retrieves the projected variable values of the beginning of the period population, temporarily absent residents, temporarily present non-residents, natural increase population, employment related net in-migration, non-employment related in-migration, non-employment related out-migration, and the end of period population, as well as the values of the parameters: birth rates, survival rates and employment related migration propensities. From UCAPE (Box 2), CASA uses the projected values of total population by county. Initial conditions (Box 3) are specified by county beginning populations and by the previous period's non-employment related in and out migration.

Using a modified component-cohort procedure, CASA then allocates the regional level projections of population and the components of population change by sex and single year of age to counties (Boxes 4-7), such that consistency is maintained between the CASA county allocated values and the regional UPED projected values, the UCAPE county total projections and the values represented by the initial conditions.

The most complex component of CASA is the procedure for allocating regional level projections of employment related net in-migration (Box 7). Some counties may experience net migration flows in a direction opposite to that of the region as a whole, i.e. a county may experience net out-migration while the region of which it is a part may be experiencing net in-migration. The result of this is a tendency for the age and sex distributions of the 'counter-flow' counties to increasingly diverge from the distributions of the other counties in the region. Thus, CASA is able to account for growing counties in a stagnating or declining region and for declining counties in growing regions. This feature, together with the differences in initial age and sex distributions between counties, allows for both convergent and divergent movements in population characteristics between areas composing a single region.

Figure 5



VI. Projection System History

Utah's population and employment projection modeling experience includes a rich history of development. For nearly three decades, during the administrations of four governors, a host of very talented and dedicated researchers have made varied and meaningful contributions to the development, production, and dissemination of population and employment projections. These projections include detailed demographic and economic information to the county level and form the data foundation upon which long term capital and social service program decisions are made by Utah state government.

The continued development of the projection system has been possible largely because of the generous financial support of federal agencies, especially the Departments of Housing and Urban Development and Commerce. In particular, the Economic Development Administration, within the Department of Commerce, has provided funding at critical stages in the development of Utah's demographic and economic modeling system. The Bureau of Economic and Business Research, in the College of Business at the University of Utah, has also made significant contributions to the modeling system used today. Finally, the foresight and support of Utah governors and state planning coordinators over the years have been essential.

The Governor's Office of Planning and Budget maintains the current projection modeling system and is committed to further improvements. The following annotated bibliography provides a chronology of the people and published documents that have provided the State of Utah with this projection model system. Clearly, the tasks of collecting the documents, identifying and acknowledging the individuals who have contributed, and reconstructing the thirty year history of the UPED model is a major project. This bibliography is a work in progress towards this end. We invite comment and additions to this history.

Annotated Bibliography

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Program Outline for the Utah State Development Plan. Office of the State Planning Coordinator, Robert P. Huefner, Office of the Governor Calvin L. Rampton; 1965.

Financially Aided through a grant from the Urban Renewal Administration of the Housing and Home Finance Agency, under the Urban Planning Assistance Program authorized by Section 701 of the Housing Act of 1954 as amended.

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Financially aided through a grant from the Urban Renewal Administration of the Housing and Home Finance Agency, under the Urban Planning Assistance Program Section 701 of the Housing Act of 1954, as amended. State Advisory Planning Committee recommends multi-county planning regions for planning and administrative purposes. Region designation is based on common interest, geographic unity, socio-economic data, and natural resources, among other factors.

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Population Projections: Utah and Utah's Counties. Therel R. Black, Jewell J. Rasmussen, and Frank C. Hachman, Bureau of Economic and Business Research College of Business, Center for Economic and Community Development, University of Utah; 1967.

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Impact of Defense Spending on the Economy of Utah. George Jensen, Leonard J. Arrington, Department of Economics Utah State University, Logan, Utah; 1967.

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Utah Interindustry Study: An Application of Input-Output Analysis. Iver E. Bradley, James P. Gander, Utah Economic and Business Review, Bureau of Economic and Business Research, College of Business, University of Utah; 1968.

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Produced by a professional staff under contract with the Four Corners Regional Commission. Report of work completed pursuant to requirements of contract. Includes development of standards for the designation of subregional planning districts and the establishment of standard mapping techniques in cooperation with the four corners region.

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State Planning in Utah. Robert P. Huefner; 1970.

Manuscript written by Utah's first state planning coordinator. Reflections of the first four years of the Utah state planning program; explains the circumstances of its birth, recounts strategy and experiences, and draws conclusions about appropriate role, functions, and organization of a state planning program.

Directory of State of Utah Statistics. Frank C. Hachman, Barbara Stubblefield, Bruce L. Heath, Utah State Planning Coordinator's Office; 1971.

Financially aided by federal grants from the Four Corners Regional Commission and the U. S. Department of Housing and Urban Development, under provision of section 701 of the Housing Act of 1954, as amended.

Directory of core primary sources of Utah data.

Demographic Patterns and Characteristics of Utah. Lawrence Nabers and I. E. Bradley; 1971.

Summary and discussion of demographic trends in Utah, including projections based on fertility assumptions.

The Implementation of Composite Computer Mapping for the Four Corners Regional Commission. Frank C. Hachman, Craig Bigler, Rodger L. Weaver, Bureau of Economic and Business Research Center for Economic and Community Development, University of Utah, Salt Lake City, Utah; 1972.

Documents the application of composite computer mapping to the Four Corners Project. Objectives were to indicate geographic allocation of industry growth, economic growth and decline, and integrating governmental planning. A mapping tool was developed that provides subregional estimates of the economic base, allocates geographically the patterns of economic growth

or decline which can indicate the areas more likely to need public investment.

An Analysis of Utah Labor Force Participation, Statistical Analysis of Employment Opportunities and Labor Force Participation Rates. Larry M. Blair; 1972.

Part I Identifies the labor force participation rates by sex, age and ethnic group for the various geographic and political regions within the state using the 1970 Census. Part II describes the factors that could be affecting labor force participation for various labor groups in Utah.

Report on the Development of the Utah Process: A Procedure for Planning Coordination Through Forecasting and Evaluating Alternative State Futures and Summary Report and Recommendations. Craig Bigler, Rhead S. Bowman, Douglas W. Kirk, and Rodger L. Weaver, Office of the Utah State Planning Coordinator, Office of the Governor Calvin L. Rampton; 1972.

Funded jointly by the Four Corners Regional Commission and the Office of Regional Economic Coordination, Department of Commerce. Describes assumptions of research program and the Alternative Futures approach. Documents the development and implementation of a planning coordination process for state agencies.

Planning, Programming, Budgeting System and Alternative Futures Contingency Budgets: A Comparative Theoretical Analysis. Rodger Lee Weaver, Dissertation 1973.

Comparative theoretical analysis of two alternative approaches to comprehensive public- sector program budgeting at the state level. Analysis is focused on decision-making mechanisms and treatment of uncertainty.

Report on the Development and Implementation of the Utah Process Alternative Futures. 1975 - 1990, Vols. I and II. T. Ross Reeve and Rodger L. Weaver, Office of the Utah State Planning Coordinator, Office of the Governor Calvin L. Rampton; 1974.

Report on the Development and Implementation of the Utah Process Land Use and Tax Base Model (UPLAND). T. Ross Reeve and Rodger L. Weaver, Office of the State Planning Coordinator, Office of the Governor Calvin L. Rampton; 1974.

Financially Aided through a Federal Grant from the Department of Housing and Urban Development, under the Comprehensive Planning Assistance Program authorized by Section 701 of the Housing Act of 1954, as amended. Discusses UPLAND Model as it was originally designed and specified for urban areas.

The Navajo Economic-Demographic Model: NED: A Method for Forecasting and Evaluating Alternative Navajo Economic Futures, Volume 1. Office of the State Planning Coordinator, Office of the Governor Calvin L. Rampton, and Office of Program Development, The Navajo Nation, Window Rock, Arizona; 1975

Financially aided through federal grants from the Four Corners Regional Commission and the Economic Development Administration. Technical description of the Navajo Economic-Demographic Model that was developed as a method of forecasting and evaluating employment and population effects of planning decisions.

Intergovernmental Planning Coordination: The Utah Experience. Office of the Utah State Planning Coordinator, Office of the Governor Calvin L. Rampton, and the Department of Community Affairs; 1975.

Funded by a federal grant by the Department of Housing and Urban Development under the Urban Planning Assistance Program authorized by Section 701 of the Housing Act of 1954, as amended. Describes Utah's approach and process to provide for intergovernmental planning coordination by defining roles of federal, state, and local government entities in the administration of federal programs and funds as well as in planning and the decision-making process. The Utah Process of planning coordination through Alternative Futures generated by the UPED model is incorporated into intergovernmental planning policy.

The Utah Process Alternative Futures (1975 - 1990) Volume I, II, and Summary. Office of the State Planning Coordinator, Office of the Governor Calvin L. Rampton; 1975.

Financially aided by the Four Corners Regional Commission and the Office of Regional Economics Coordination, Department of Commerce. Contains ten alternative future economic and demographic conditions produced for the State of Utah and its Multi-County Planning Districts. Includes discussion of the assumptions, data and projections.

Modeling Requirements in Government Decision Making Processes—A Concept Paper. T. Ross Reeve, Rodger L. Weaver, Utah State Planning Coordinator's Office; 1976

Introduces and discusses the advances in government contingency planning and decision making with the advance of economic modeling systems. Discusses the projective models developed to date, in context of the information required and the type of planning and budgeting scheme being developed.

UPED and UPLAND Models Report. T. Ross Reeve, Rodger L. Weaver, The Rho Corporation, Salt Lake City Utah; 1977.

The Utah Process Small Area Economy & Demographic Information Projection System. Kent Briggs State Planning Coordinator, Office of the Governor Calvin L. Rampton and the Rho Corporation; 1979.

Financially aided through a grant from the Economic Development Administration under Section 301A of the Economic Development Act of 1964. Contains a discussion of the UPED and UPLAND models, including a users guide for the models, technical description of equations, report programs, and outcomes.

UPED79 Report on Revisions of the Utah Process Economic and Demographic Impact Model (UPED). Rodger L. Weaver, Frank C. Hachman, Anthony S. Wilcox, and T. Ross Reeve, Bureau of Economic and Business Research, College of Business, University of Utah and Utah State Planning Coordinator, Office of the Governor Scott M. Matheson; 1980.

Documentation of UPED model revision.

Basic-Nonbasic Allocation Error and Least Squares Bias in Regional Export Base Models. Boyd L. Fjeldsted, Bureau of Economic and Business Research, College of Business, University of Utah; 1980.

Refinement of Broad Area Impacts of MX Missile Deployment on Nevada and Utah and Preliminary Allocation of Impacts to Community Group Level. Rodger L. Weaver, T. Ross Reeve, University of Utah, Salt Lake City, Utah; 1980.

Utah 2000: A High Development Scenario. Office of the State Planning Coordinator, Martha Dyner, Office of the Governor Scott M. Matheson; 1980.

Develops context for long-range comprehensive planning and growth management strategies for Utah using UPED to provide a frame of reference for thought about the future and for policy considerations.

UPED Index to Parameters and Exogenous Variables Data Sources and Calibration Procedures. Office of the State Planning Coordinator, Martha Dyner, Office of the Governor Scott M. Matheson; 1981.

1984 Baseline Projections and Executive Summary. Office of Planning and Budget, Ralph Becker, State Planning Coordinator, Office of the Governor Scott M. Matheson; 1984.

1986 Baseline Projections. Data Resources Section, Utah Office of Planning and Budget, Mike Christensen State Planning Coordinator, Office of the Governor Norman H. Bangerter; 1986.

1987 Baseline Projections. Utah Office of Planning and Budget, Mike Christensen State Planning Coordinator, Office of the Governor Norman H. Bangerter; 1987

CASA: County Age and Sex Allocation Model Technical Description. Rodger L. Weaver T. Ross Reeve, Utah Office of Planning and Budget Technical Services Division, Office of the Governor Norman H. Bangerter; 1988.

State of Utah Economic & Demographic Projections 1988. Data Resources Section, Utah Office of Planning and Budget, Mike Christensen State Planning Coordinator, Office of the Governor Norman H. Bangerter; 1988.

State of Utah Economic & Demographic Projections 1990. Demographic and Economic Analysis, Utah Office of Planning and Budget, Mike Christensen State Planning Coordinator, Office of the Governor Norman H. Bangerter; 1990.

State of Utah Economic & Demographic Projections 1992. Demographic and Economic Analysis, Utah Office of Planning and Budget, Brad T. Barber State Planning Coordinator, Office of the Governor Norman H. Bangerter; 1992.

State of Utah Economic & Demographic Projections 1994. Demographic and Economic Analysis, Governor's Office of Planning and Budget, Brad T. Barber State Planning Coordinator, Office of the Governor Michael O. Leavitt; 1994.

State of Utah Economic & Demographic Projections 1994: Highlights. Demographic and Economic Analysis, Governor's Office of Planning and Budget, Brad T. Barber State Planning Coordinator, Office of the Governor Michael O. Leavitt; 1994.

State of Utah Demographic and Economic Projection Modeling System. T. Ross Reeve and Pam Perlich, Demographic and Economic Analysis, Governor's Office of Planning and Budget, Brad T. Barber State Planning Coordinator, Office of the Governor Michael O. Leavitt; 1995.

VII. HISTORICAL PROJECTION ACCURACY

Over the past three decades, the Utah Process Economic and Demographic (UPED) model has been used to make twelve series of baseline projections. These series differ in the number of years projected; the frequency in number of years (i.e., annual or five year increments); the institutions, persons, and resources involved in making the projections; and the source and quality of input data. The ex post accuracy of each series has been determined by changing economic conditions and trends over the projection interval relative to the assumptions made about the future at the time of the projections. The resulting collection of projections embody differing degrees of projection accuracy. The accuracy of these twelve baseline projections is described here.

A. Methodology

In order to determine the accuracy of past population projections, the following steps were taken:

1. Projection series were identified that began in each of the following years:

   1967 1975 1986 1990
   1969 1980 1987 1992
   1972 1984 1988 1994

2. Given that projections for years preceding 1975 were not figured on the MCD level or were figured using different MCDs than those used presently, county level results were combined to form comparable data.

3. Some projection series (1967 through 1986) featured data only in five-year increments, rather than in single-year increments. To compensate for this discrepancy, a linear interpolation was used to "fill in" the years between the five-year increments.

4. In some cases the initial entry in a given projection series (the "launch" year) did not agree with the actual population figure. This may be because estimates provided at the time of projection were later revised by the Utah Population Estimates Committee. To offset this disparity, the launch year number was changed to match the actual number.

5. The absolute value percentage error (APE) was then calculated for each entry in each projection series, being derived by the following formula:

$$| AT - PT | / AT$$

where A is the actual population, P is the projected population, and T is the amount of time between the launch year (L) and the projection year (Y), also referred to as the forecast interval.

B. Results

Figures 6-A through 6-H provide visual comparisons between the actual population and projected population in each series for the state and seven MCDs. It is interesting to note some of the trends that have taken place (especially in the smaller MCDs) and the effects that they have had on forecasting.

Tables 3-A through 3-H provide APE data for each interval in the twelve projection series. The figures that accompany these tables (Figures 7 and 8) supply mean APE data by launch year and forecast interval, respectively. From Figure 7 one can infer that the 1975 series was one of the most accurate, with a mean APE of 2.6% for the state level and a high of only 13.2% (in the Southwest MCD). The 1987 and 1988 series also appear to be quite accurate, but the fact that they contain roughly half the number of intervals found in the 1975 series makes them less tenable. This is because the mean APE generally increases as the number of forecast intervals increases (see Figure 8); in some cases, however, it actually begins to decrease between the fifth and tenth interval because the overall number of observations has begun to decrease as well (only three of the twelve series extend beyond ten intervals). The fact that the 1975 series contains the most intervals and still has a low mean APE makes it truly remarkable.

Figures 9 and 10 contain APE and mean APE data by forecast interval for all 744 observations shown in Tables 3-A through 3-H. Once again, the mean APE generally increases as the number of intervals increases, though there are several "outliers" visible in Figure 9 that may affect the mean.

Figure 11 shows how APE is affected by population size. It is apparent that the APE is much higher where population is the smallest:

1. All observations where the APE is over 30% fall below 50,000.

2. All observations where the APE is over 25% fall below 175,000.

3. All observations where the APE is over 20% fall below 250,000.

4. All observations where the APE is over 15% fall below 1,100,000.

It is also worth mentioning that all observations for which the APE was above 24% correspond to the four smallest MCDs, and all observations for which the APE was above 37% correspond to the two smallest MCDs. For the largest population area (the state), no single observation had an APE greater than 14% and there was no mean APE greater than 8%.

C. Observations

While a thorough understanding of the value and meaning of these measurements of projection accuracy is still a topic for further research and discussion, this structured and simple treatment of error illuminates several important points about projections.

1. Utah's projection history includes periods of both over and under projecting population.

2. Projections in any given period are significantly impacted by the most recent trends.

3. Generally, smaller relative projection errors occur in regions with larger populations and visa versa.

4. Utah's projection effort has consistently over-projected population in the Bear River MCD, had large errors in the boom-bust regions of Uintah Basin, Southeast, and Central MCDs, and under-projected population in the rapidly growing Southwest MCD.

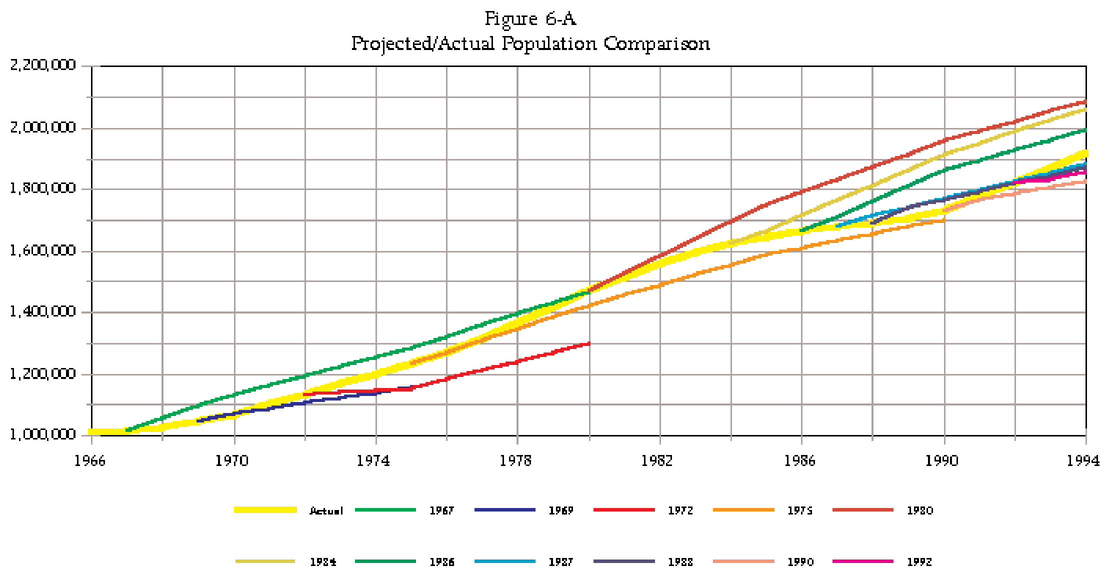
5. While the accuracy of these projections is important, no measure of accuracy can indicate the importance of these projections in the planning and planning coordination process. Among others, the projection process provides an organizing framework for discussions concerning long term resource commitments.

D. Implications for the Future

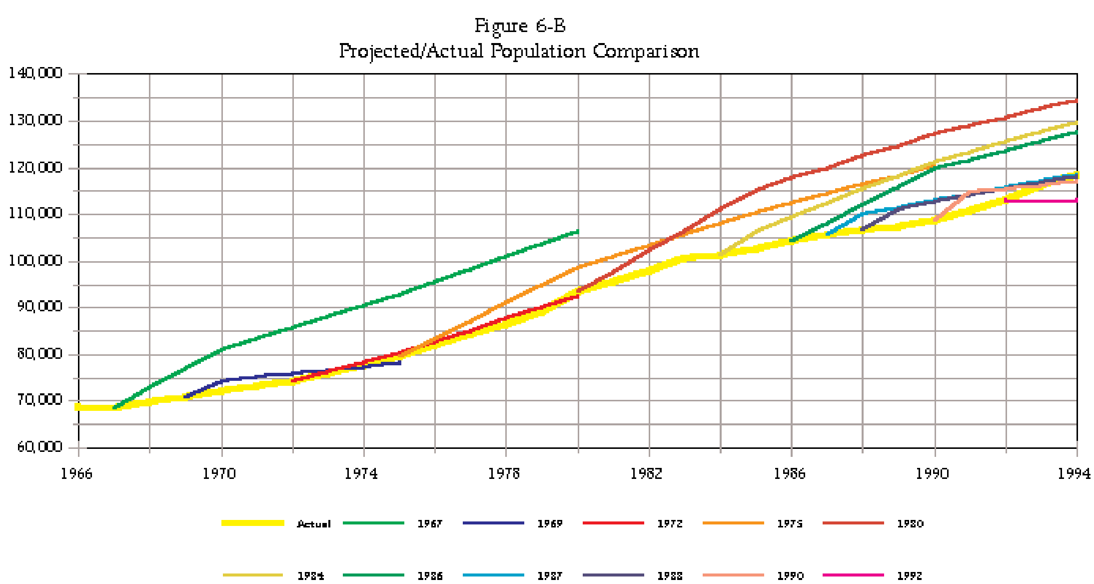
The Governor's Office of Planning and Budget is committed to continued improvements in its population and employment projection effort. This description of the past projection accuracy is intended to contribute to these efforts. Current demographic and economic projection research is focused on measuring and reducing forecast error. Anticipated improvements in Utah's demographic and economic projection models are incorporation of stochastic processes (i.e., formally including statistical concepts such as probability, uncertainty, and bias) and inclusion of additional variables. Anticipated improvements in the projection production and dissemination processes include increased involvement of technical and local experts as well as continuous improvement in the format and content of the data products. The object of these planned innovations is to make the resulting projections more useful to decision makers.

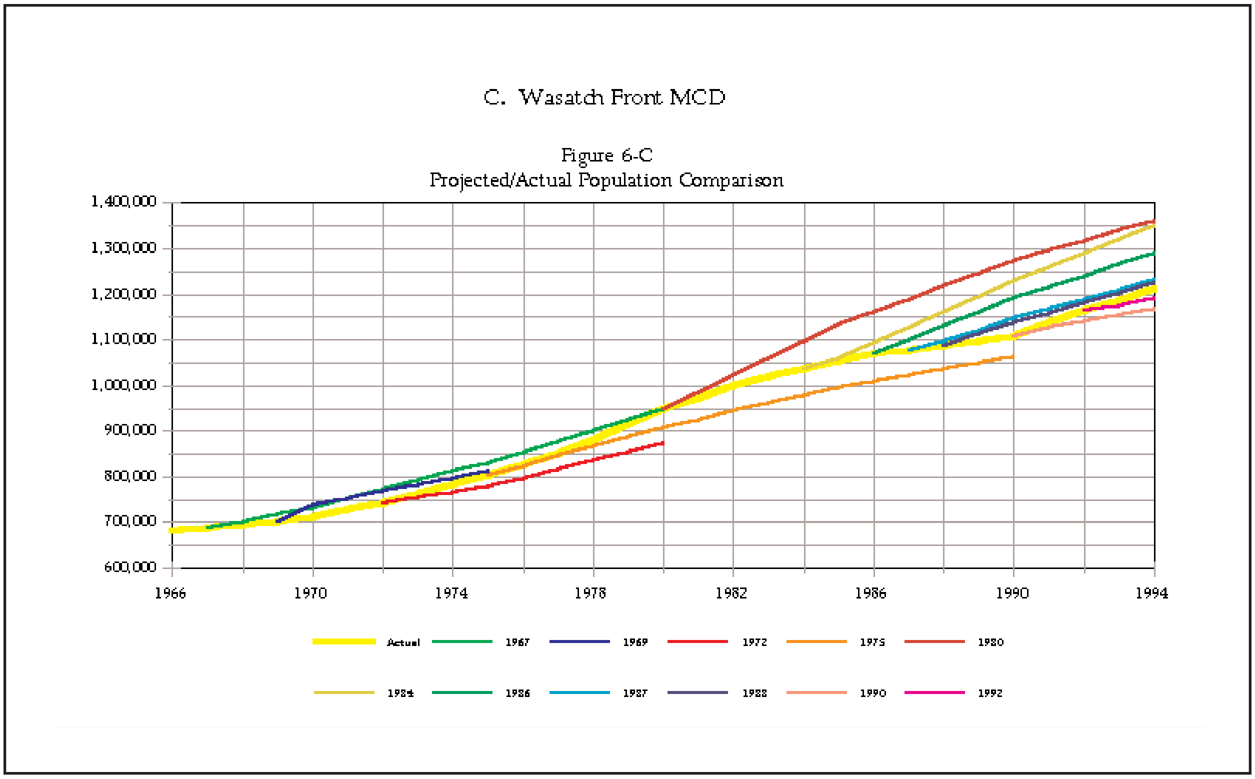
Projected/Actual Population Comparison

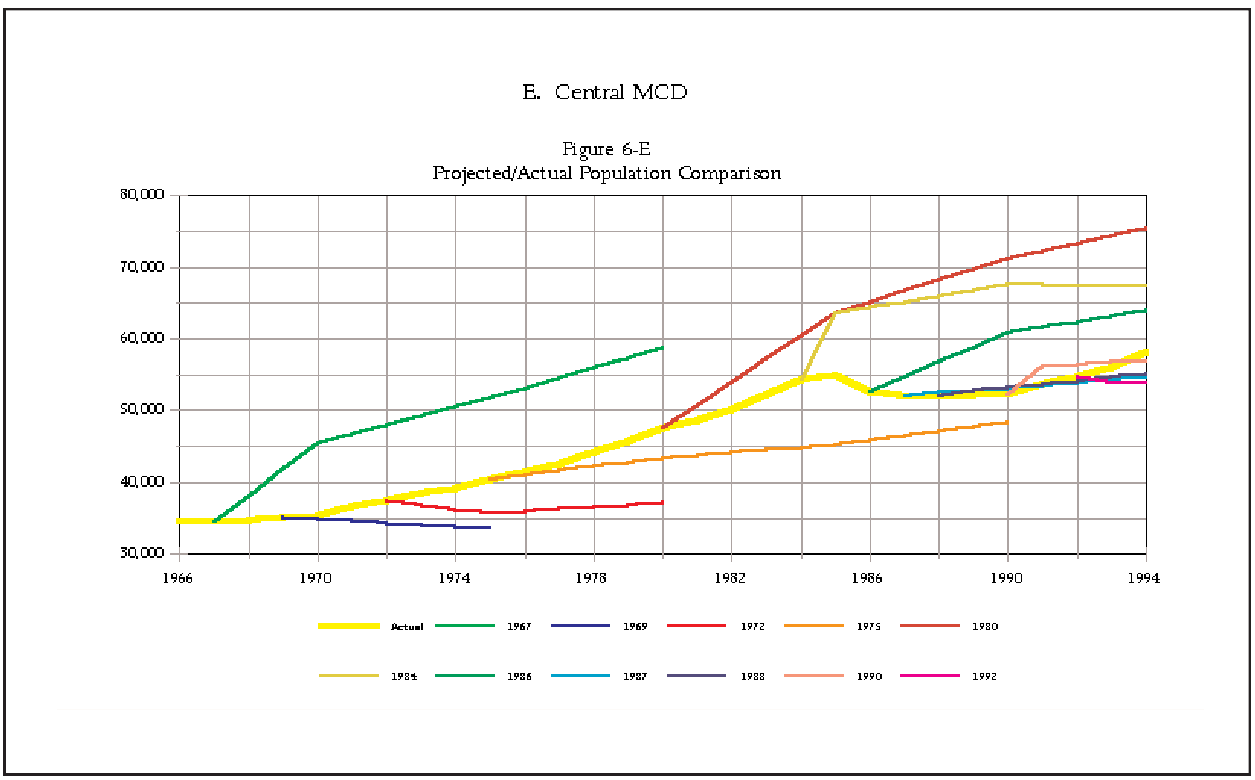
A. State of Utah



B. Bear River MCD

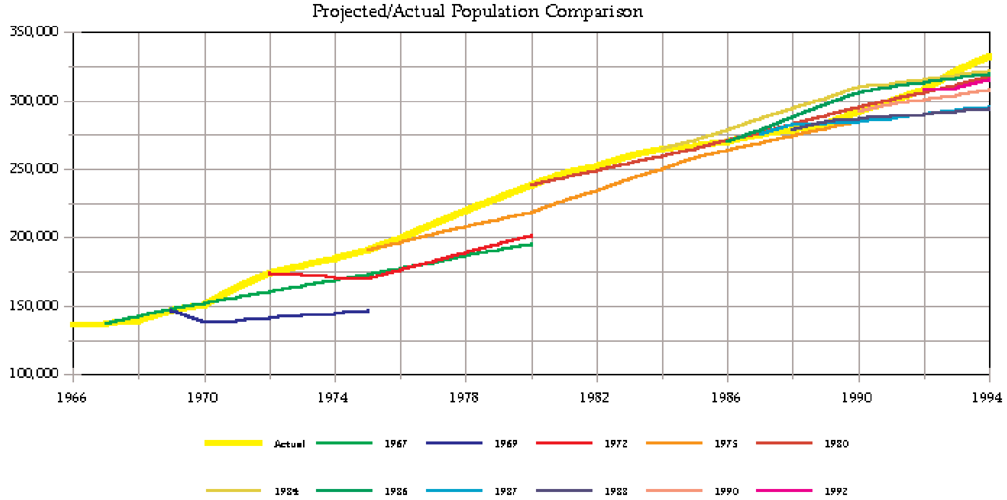



C. Wasatch Front MCD
Figure 6-C
Projected/Actual Population Comparison
1,400,000
1,300,000
1,200,000
1,100,000
1,000,000
900,000
800,000
700,000
600,000
1966
1970
1974
1978
1982
1986
1990
1994
Actual
1967
1969
1972
1975
1980
1984
1986
1987
1988
1990
1992


E. Central MCD
Figure 6-E
Projected/Actual Population Comparison
80,000
70,000
60,000
50,000
40,000
30,000
1966
1970
1974
1978
1982
1986
1990
1994
Actual
1967
1969
1972
1975
1980
1984
1986
1987
1988
1990
1992

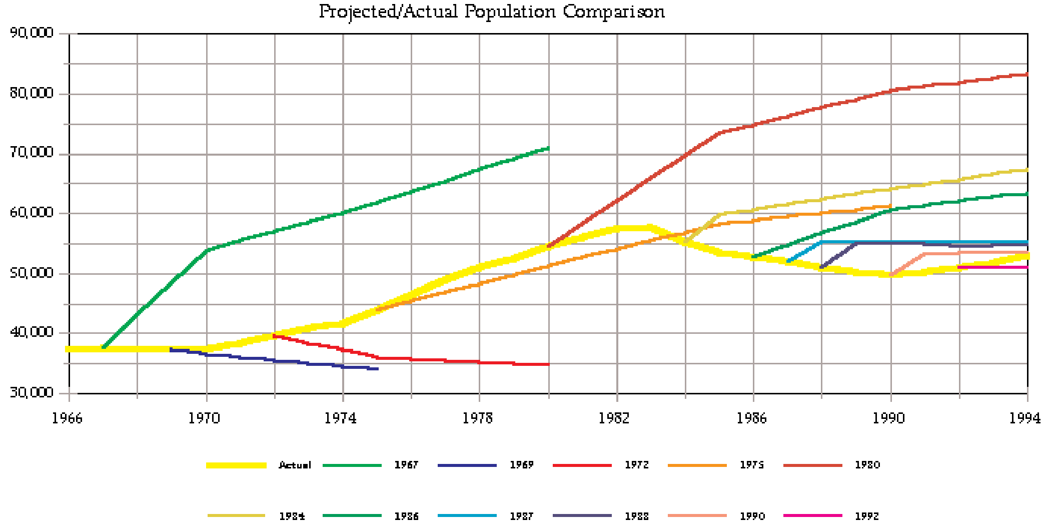
D. Mountainland MCD

Figure 6-D
Projected/Actual Population Comparison



H. Southeast MCD

Figure 6-H
Projected/Actual Population Comparison



Appendix A

Models and Modeling

Models are experimental laboratories for answering questions and generating information for various applications. These questions and applications define the purpose of the model. Model design should reflect and be subordinate to this purpose.

Models are representations of how we view the world to work. As representations or approximations of that part of the real world in which we are interested, models should be based upon our best theoretical and empirical understanding of the structure, behavior and constraints of that world.

Models consist of relationships between dependent and independent variables, often expressed in equation form through a set of parameters and mathematical operators. These expressions may be linear or non-linear. Model specification is the process of developing these equations. Complex models are composed of a set of interdependent equations. Dynamic (as opposed to static) models involve time, either directly or indirectly, as an element in the equations. Solutions to complex systems can be simultaneous or dynamic. Solutions (equilibrium) can be stable or unstable. Model behavior can be stable, explosive, oscillatory or damped.

The logical validity of a system requires coherency (all endogenous variables be related to at least one other endogenous variable), consistency (the number of endogenous variables must equal the number of equations), and the satisfaction of total and boundary conditions. Questions of uniqueness and existence also arise. Values for endogenous variables are calculated within the system. Exogenous variables affect but are not affected by other variables. Their values require an independent estimate which may replace an equation in the system. Interdependence between exogenous variables is often a serious source of error in extrapolative applications.

The empirical validity of a model requires that certain statistical tests for significance of and independence between the variables, observations, parameters and residuals be met in the specification of relationships and the estimation of parameter values. For all purposes (estimation and extrapolation), the model should be well behaved within the sample interval, i.e., be internally robust. For forecasting purposes it should also be well behaved outside the sample interval (externally robust). Backcasting, a procedure for reproducing history outside the sample interval on the basis of realized values for exogenous variables, provides such a, though partial, test and is useful for discovering specification errors. Such validation procedures increase our confidence in forecasts of future values.

An estimate of the requirements which a model should satisfy includes 1) the choice of output variables, 2) the questions it should address, and relatedly, 3) the variables to which it should be responsive.

Appendix B

GLOSSARY: UPED MODEL, VERSION V. 1995

SUBSCRIPTS
:
t is year index (t=1,2...,NYEAR; NYEAR=50)

t=0 is base year

t=1 is first model year

a is age group (a=1,2,...,AGE; AGE=86)

a= 1 is age 0; average age is 0.5 years

a= 2 is age 1; average age is 1.5 years.

a=85 is age 84; average age is 84.5 years

a=86 is 85 years and over

o is school age group (o=1,2,...,SCH; SCH=6)

o=1 is ages 5 to 11

o=2 is ages 12 to 14

o=3 is ages 15 to 17

o=4 is ages 18 to 21

o=5 is ages 22 to 24

o=6 is ages 5 to 17

s is sex (s=1, SEX; SEX=2)

s=1 is male

s=2 is female

k is industry sector (k=1,2,...,IND; IND=66)

l is industry sector (l=1,2,...,IND; IND=66)

k.l	Industry Sector Name	SIC	k.l	Industry Sector Name	SIC
1	Agriculture	1,2	34	General Merchandise Retail	53
2	Agricultural Services	7,8,9	35	Food Stores	54
3	Coal Mining	12	36	Auto Dealers & Service Stations	55
4	Petroleum & Natural Gas Mining	13	37	Apparel & Accessory Stores	56
5	Metal Mining 10		38	Furniture & Home Furnishings	57
6	Non-Metal/Non-Fuel Mining	14	39	Misc. Retail Stores	59
7	General Construction	15	40	Banking	60,61
8	Heavy Construction	16	41	Insurance	63,64
9	Special Trade Construction	17	42	Securities & Investments	62,67
10	Food Manufacturing	20	43	Real Estate	65,66
11	Textile & Apparel Mfg.	22,23	44	Hotels & Lodging Places	70
12	Printing & Publishing 27		45	Personal Services	72
13	Chemical Manufacturing	28	46	Misc. Business Services	73
14	Lumber & Furniture Mfg.	24,25	47	Auto Repair Services	75
15	Machinery excl. Electrical Mfg.	35	48	Misc. Repair Services	76
16	Electrical Machinery Mfg.	36	49	Amusement & Recreation	78,79
17	Transportation Equipment Mfg.	37	50	Private Households	88
18	Petroleum & Coal Products Mfg.	29	51	Medical & Health Services	80
19	Primary Metals Manufacturing	33	52	Private Education	82
20	Fabricated Metals Mfg.	34	53	Legal Services	81
21	Stone/Clay/Glass Manufacturing	32	54	Social Services	83
22	Misc. & Other Manufacturing	21,26,30,313,38,39	55	Museums/Galleries,etc.	84
23	Railroad Transportation	40	56	Membership Organizations	86
24	Trucking & Warehousing	42	57	Engineering/Accounting/etc.	87
25	Local & Interurban Transit	41	58	Misc. Professional Services	89
26	Air Transportation	45	59	Federal Public Administration	
27	Pipeline & Water Transport	44,46	60	Federal Military (excl. active duty)	
28	Transportation Services	47	61	Federal Post Office	43
29	Communications	48	62	State Public Administration	
30	Electric, Gas & Sanitary Services	49	63	State School	
31	Wholesale Trade	50,51	64	Local Public Administration	
32	Eating & Drinking Places	58	65	Local School	
33	Building Materials & Farm Equip	52	66	Non-Farm Proprietors	

VARIABLE TYPES:

Six types of variables are used in the model:

Endogenous Recursive variables [denoted as '(r)' below] are variables which require initial year or base period values (entered as data) with subsequent year values determined by the model. The base period values define initial conditions for the model run, while future year values define initial conditions for the following year.

Endogenous Non-recursive variables [denoted as '(n)'] are those variables with values solely determined by the model. There are no data input requirements for these variables.

Exogenous variables ['(x)'] are variables which are entered as data and whose values affect, but are unaffected by, the values of other variables or parameters. By and large, these variables have real world referents and enter into relationships additively. They contain externally determined assumptions about the future.

Parameters ['(p)'] are used as data by the model, but are not altered by the model. These may be constants or they may have time dependent values. Typically, these define the relationships between model variables. Assumptions about the future for a particular model run are embedded in these values.

Historical/Target variables ['(h)'] are entered as data. They override the computed values of their corresponding endogenous variable and are used in estimating the associated parameters for the relationships involved in the calculation of these endogenous variables.

Program variables ['(c)'] are those which define the model run, allocate computer space, address data, and serve to direct the computational sequence. These include run and report options and parameters, subscript indices, model switches, model run description variables, and variable dimension parameters.

MODEL DIMENSION PARAMETERS

Name Value Description

AGE 86 no. of single year of age, age groups
SEX 2 no. of sex categories
IND 66 no. of industry sectors
SCH 6 no. of school age, age groups
ND1VAR 41 no. of variables in array D1 with AGE, SEX dimensions
ND2VAR 3 no. of variables in array D2 with AGE dimension
ND3VAR 3 no. of variables in array D3 with SEX dimension
ND4VAR 1 no. of variables in array D4 with SCH, SEX dimensions
NE1VAR 20 no. of variables in array E1 with IND dimension
NE2VAR 1 no. of variables in array E2 with IND, AGE dimensions
NE3VAR 1 no. of variables in array E3 with IND, IND dimensions
NRSVAR 26 no. of real scalar variables in array RSC
NISVAR 2 no. of integer scalar variables in array ISC
NCD1VR 7 no. of historical/target variables in array CD1 with AGE, SEX dimensions
NCD2VR 1 no. of historical/target variables in array CD2 with SEX dimension
NCE1VR 1 no. of historical/target variables in array CE1 with IND dimension
NCRSVR 8 no. of historical/target real scalar variables in array CRSC
NARRAY 13 no. of arrays with variable names in array VN. These include arrays D1, D2, D3, D4, E1, E2, E3, RSC, ISC, CD1, CD2, CE1, and CRSC.
NYEAR 50 maximum no. of years for model runs
NROOUT 24 maximum no. of variables with names in array VN which can be output to the PRJ file or to the DMP file
NRUNOP 10 maximum no. of model run options
NRPTOP 10 maximum no. of model report options
NRUNPR 10 maximum no. of model run parameters

MAJOR MODEL VARIABLES (THOSE IN ARRAYS 1 TO NARRAY):

Name Type Description

ABIRTH (n) total births

AE (p) estimated 'intercept' in the EPSILN - FO relationship.

AIN(a,s) (x) autonomous non-employment related in-migration; estimated 'intercept' in the NEIM - NIMGR relationship.

ALF (n) total labor force

AOUT(a,s) (x) autonomous non-employment related out-migration; estimated 'intercept' in the NEOM - POP3 relationship.

BDRPRP(k) (n) weight applied to the residentiary demand for labor for the purpose of limiting the residentiary response to temporary basic events as opposed to permanent basic events

BE (p) estimated 'slope coefficient' in the EPSILN - FO relationship.

BED(k) (n) basic employment (supply of jobs; demand for labor in job units)

BEDCAC(k) (n) accumulated BEDPAC over time

BEDP(k) (x) permanent basic employment (demand for labor in job units)

BEDPAC(k) (x) absolute change in permanent basic employment (residual or basic event value)

BEDPES(k) (p) permanent basic employment growth rate escalator (annual, continuous rate)

BEDPGR(k) (p) permanent basic employment growth rate (annual, discrete rate)

BEDT(k) (x) temporary basic employment (demand for labor in job units)

BIRTHS(a,s) (n) number of births to resident females (FMLPOP) by sex of child and age of mother

BRTHRA(a) (p) birth rate - the probability that a female in a given age group will give birth during the interval of a year.

BRTRGR(a) (p) birth rate growth rate (annual, discrete rate)

BSURAT(s) (p) probability of surviving the first one-half year of life

BYPROP (p) proportion of male to total births

CBDTH3(s) (h) historical or targeted number of deaths for those born during the year

CBIR (h) historical or targeted total births

CBIR3(a,s) (h) historical or targeted number of births by sex of child and age of mother

CCCF (h) target total fertility rate (cross sectional completed cohort fertility rate

CDTH (h) historical or targeted total deaths

CDTH3(a,s) (h) historical or targeted number of deaths

CHSH (h) historical or targeted total households

CHSH3(a,s) (h) historical or targeted number of households heads

CLF (h) historical or targeted total labor force

CLF3(a,s) (h) historical or targeted labor force

CNEOM (h) historical or targeted total non-employment related out-migration

CNEOM3(a,s) (h) historical or targeted non-employment related out-migration

CPOP (h) historical or targeted total population

CPOP3(a,s) (h) historical or targeted population

CTED (h) historical or targeted total employment

CTED3(k) (h) historical or targeted employment by industry

DBJADJ (p) absolute change in multiple job holding rate (DBJOBR)

DBJOBR (p) multiple job holding rate; number of jobs desired per employed worker minus 1.0

DEATHS(a,s) (n) number of deaths to resident population

DECPOP(k) (n) weighted (by DMPROP) population exerting demand for residentiary output (employment) of industry (k)

DMPROP(a,s) (p) relative proportion of population in subgroup (a) exerting demand for the output (employment) in sector (k) (relative to highest proportion)

E (n) economic opportunity index

EO (p) 'normal' economic opportunity index

EPSILN(a,s) (n) elasticity of the labor force participation rate (LFPR) with respect to the economic opportunity index (E)

ERLMIG(a,s) (n) employment related net in-migration

ES (n) total demand for jobs including multiple jobs (supply of labor)

F(l,k) (p) proportion of 'normal' residentiary response expected in response to temporary basic employment. The 'l' subscript identifies the industry sector in which 'BEDT' occurs and 'k' is the sector whose 'RED' is affected by the 'F - BEDT' adjustment.

F1 (n) temporary sum in 'BDRPRP' calculation

FL(a,s) (r) lower bound in the 'LFPR - EPSILN,E' relationship

FLN (p) lower bound proportion-life years in 'LFPR - EPSILN,E' relationship

FLP(a,s) (p) lower bound proportion-life proportion in 'LFPR - EPSILN,E' relationship

FLT(a,s) (p) lower bound proportion-life target in 'LFPR - EPSILN,E' relationship

FMLPOP(a) (n) mean permanent resident population female population before migration (mean of 'RESPOP(a,s=2)' & 'NIPOP(a,s=2)')

FO(a,s) (r) 'normal' labor force participation rate in the 'LFPR - EPSILN,E' relationship

FON (p) 'normal' labor force participation rate proportion-life years in 'LFPR - EPSILN,E' relationship

FOP(a,s) (p) 'normal' labor force participation rate proportion-life proportion in ' LFPR - EPSILN,E' relationship

FOT(a,s) (p) 'normal' labor force participation rate proportion-life target in 'LFPR - EPSILN,E' relationship

FRSTYR (c) beginning calendar year of model run

FU(a,s) (r) upper bound in the 'LFPR - EPSILN,E' relationship

FUN (p) upper bound proportion-life years in 'LFPR - EPSILN,E' relationship

FUP(a,s) (p) upper bound proportion-life proportion in 'LFPR -EPSILN,E' relationship

FUT(a,s) (p) upper bound proportion-life target in 'LFPR - EPSILN,E'

HHRAT(a,s) (p) household headship rate

HSHLD(a,s) (n) households

IM(a,s) (n) current model iteration value of employment related net in-migration

IMACUM(a,s) (n) accumulated model iteration values of employment related net in-migration;'IM' accumulated over iterations

IMLIM (n) maximum constraint to employment related net in-migration

INFANT(s) (n) survived population of those born during the year

INRAT (p) in-migration triggering rate

INRT1 (n) 1.0 - INRAT

INTH (n) in-migration triggering rate including iterative solution tolerance value

JOBWKR (n) number of jobs desired per employed worker (1.0 + DBJOBR)

LASTYR 8 ending calendar year of model run

LF(a,s) (n) labor force

LFPR(a,s) (n) labor force participation rates

MABLIM(a,s) (p) minimum limit of in-migration capacity

MIGPR(a,s) (p) migration propensities; relative migration probabilities (relative to highest migration rate)

MRTLIM(a,s) (p) proportionality to indigenous population in-migration capacity limitation parameter

NATPOP(a,s) (x) national population estimates and projections over model run interval

NATRE(a,s) (x) national residentiary employment estimates and projections over model run interval

NEIM(a,s) (n) non-employment related gross in-migration, current period

NEIM1(a,s) (r) non-employment related gross in-migration, previous period

NEOM(a,s) (n) non-employment related gross out-migration, current period

NEOM1(a,s) (r) non-employment related gross out-migration, previous period

NIMGR(a,s) (p) non-employment related gross in-migration (NEIM) growth rate (annual, discrete)

NIMTR(a,s) (p) Proportion of the previous period's non-employment related in-migrants (NEIM) which becomes the current period's temporarily present non-residents (TPNR).

NIPOP(a,s) (n) natural increase population of permanent resident population

NOMRAT(a,s) (p) Proportion of ending population (POP3) which becomes non- employment related out-migrants

NOMTR(a,s) (p) Proportion of the previous period's non-employment related out-migrants (NEOM) which becomes the current period's temporarily absent non-residents (TAR).

OUTRAT (p) out-migration triggering rate

OUTRT1 (n) 1.0 - OUTRAT

OUTTH (n) out-migration triggering rate including iterative solution tolerance value

POP1(a,s) (r) beginning-of-period population

POP2(a,s) (n) temporary, intermediate value of 'POP3'

POP3(a,s) (n) end-of-period population

POPERM(a,s) (n) population excluding non-employment related migration

RABLIM(k) (p) autonomous component of residentiary employment increase constraint

RED(k) (n) residentiary (population dependent, non-basic employment) employment (component of demand for labor in job units)

RED1(k) (r) residentiary employment, previous period

REDLIM(k) (n) maximum residentiary employment increase in period 't'

REPROP(k) (n) national weighted per capita residentiary employment (with the U.S. population weighted by 'DMPROP')

RESPOP(a,s) (n) permanent resident population

RRTLIM(k) (p) Proportion of 'RED1' component of residentiary employment increase constraint

RSEREL(k) (p) residentiary employment relative

SAGPOP(o,s) (n) school age population

SURATE(a,s) (p) survival rate - the probability of surviving from the beginning to the end of year.

SURPOP(a,s) (n) survived resident population

T (n) number of years remaining in model run

TAR(a,s) (n) temporarily absent permanent residents

TED(k) (n) total employment

TEDBM(k) (n) total employment before migration

THRESH (c) iterative convergence tolerance about INRAT-OUTRAT range

TPNR(a,s) (n) temporarily present non-residents

UNRATE (n) unemployment rate

OTHER HISTORICAL/TARGET VARIABLES & PARAMETERS

Name Dimensions Description

TDTH total deaths of variable DEATHS (array D1(6,a,s))

TBIR total births of variable BIRTHS (array D1(5,a,s))

CDTH3T total deaths of variable CDTH3 (array CD1(2,a,s))

CTEMP1 temporary variable

CTEMP2 temporary variable

AVBASE 2 base value of adjusted parameter in Newton-Raphson solution method by parameter

AV 2,20 adjusted parameter value in Newton-Raphson method by parameter and iteration

VV 2,20 adjusted variable value in Newton-Raphson method by variable and iteration

CTOT 2 total adjusted parameter value in Newton-Raphson method by parameter

AVBAS2 base value of adjusted parameter for zero non-employment related migration option (RUNOPT(2)=1)

AV2 20 adjusted parameter value for zero non-employment related migration option (RUNOPT(2)=1)

VV2 20 calculated variable value for zero non-employment related migration option (RUNOPT(2)=1)

CTOT2 total adjusted parameter value

TGTPOP target population for zero non-employment related migration option (RUNOPT(2)=1)

TEST1 test for convergence variable, zero non-employment related migration case

IR1 iteration counter and iteration subscript index for Newton-Raphson simultaneous equation solution method

IR2 iteration counter for zero non-employment related migration option (RUNOPT(2)=1); iteration subscript index for variables AV2 and VV2

IR3 iteration counter and iteration subscript index for non-employment related migration propensities

CTEDSW switch indicating whether (1) or not (0) BEDP and BEDT have been adjusted, given CTED3

TMIG total required non-employment related migration

TEMIG total non-employment related migration, current iteration

TEMIG1 total non-employment related migration, lagged one iteration

MBASE total calculated non-employment related migration

MAXM maximum MIGPR

TEMPORARY VARIABLES

Name Dimensions

ITMP1 scalar

ITMP2 scalar

ITMP3 scalar

TMPD1 AGE,SEX

TMPD2 AGE

TMPD3 SEX

TMPD4 SCH,SEX

TMPE1 IND

PROGRAM VARIABLES

SUBSCRIPT INDICES

Name Description

a age

s sex

k industry

RUN DESCRIPTION VARIABLES

Name Length Description

CASE 40 model run name; ex. 'Baseline 1995'

DATE 8 date (day/month/year)

REGION 20 projection area name; ex. 'Wasatch Front MCD'

INPUT/OUTPUT PARAMETERS

Name Dimensions Description

C 6 temporary character variable

FMT1 internal format statement variable

FMT2 internal format statement variable

FMT3 internal format statement variable

FNAME file prefix name for input and output files; (ex. 'WF95C1' where 'WF' is area, '95' is year and 'C1' is case)

FNLEN length of FNAME excluding trailing blanks

IARRAY NARRAY no. of variables in array for arrays:D1, D2, D3, D4, E1, E2, E3, RSC, ISC, CD1, CD2, CE1, & CRSC

IEOF 3 end of file indicator for input files, units 1-3

INPSW1 switch indicating whether (1) or not (0) model run options and parameters have been read

IUNIT 3 unit no. index

IVN 2, index map between variable name, array in which

ND1VAR+ND2VAR the variable values are stored, and the

+ND3VAR+ND4VA4 position of the variable in that array. The

+NE1VAR+NE2VAR first subscript refers to the array number;

+NE3VAR+NRSVAR the second subscript refers to the position in

+NISVAR+NCD1VR that array.(see also IARRAY and VNLEN)

+NCD2VR+NCE1VR

+NCRSVR

ROOUT NROOUT,2 variable names to be written to the output files:the PRJ file if the second subscript value is 1; the DMP file, if 2.

RODEC NROOUT,2 no. of decimal places by variable and output file (PRJ & DMP)

RORND NROOUT,2 rounding switch by variable and file: 0 is do not round,1 is round

SCHAGE SCH,2 school age group to single year age group index map:the first subscript is school age group; the second to beginning and ending single year age group indices.

VN ND1VAR+ND2VAR variable names of variables in arrays D1, D2,

+ND3VAR+ND4VA4 D3, D4, E1, E2, E3, RSC, ISC, CD1, CD2, CE1,

+NE1VAR+NE2VAR and CRSC

+NE3VAR+NRSVAR

+NISVAR+NCD1VR

+NCD2VR+NCE1VR

+NCRSVR

VNLEN length of VN array (no. of variable names)

RUN CONTROL OPTIONS AND PARAMETERS

Name Dimensions Description

CIPAR 5 historical/target integer run control parameters

COPT 6 historical/target variable option switches

CRPAR 5 historical/target real run control parameters

CYR NYEAR calendar years, t=1 to NYEAR

ITER iteration counter for labor market

IYR current projection year index

MLIMSW switch indicating whether (1) or not (0) the employment related migration constraint has been encountered PROJYRcurrent projection calendar year

RLIMSW switch indicating whether (1) or not (0) the residentiary employment constraint has been imposed

RUNOPT NRUNOP run options (1 to 7 are active)

RPTOPT NRPTOP report options (1 to 5 and 10 are active)

RUNPAR NRUNPR run parameters ()

APPENDIX C

OPERATING INSTRUCTIONS: UPED MODEL, VERSION V.1995

UPED MODEL EXECUTION:

At the DOS prompt, enter:

UPEDDR<return>

To which the model will respond:

ENTER FILE NAME:

Then enter the value of FNAME (the prefix of file names for the current model run; ex. 'WF95C1'):

WF95C1<return>

UPED MODEL FILES:

Input Files

File Name: Unit No. Contents

1. <FNAME>.IN1 1 model run descriptions, run options and parameters, report options and parameters, historical and target options and data

2. <FNAME>.IN2 2 parameter data which varies with respect to area

3. UPNATL.IN 3 parameter data which is invariant with respect to area

Output Files

File Name: Unit No. Contents

1. <FNAME>.PAR 7 parameter summary, contents are fixed in source code

2. <FNAME>.PRJ 8 projection file, contents are fixed in blockdata program file

3. <FNAME>.DMP 9 User specified output file, contents are set in <FNAME>.IN1 input file

Program Files

File Name: Contents

1. UPEDDM.FOR variable dimension parameters

2. UPEDDRN.FOR variable declarations

3. UPEDBDN.FOR block data variable declarations

4. UPEDBD.FOR block data

5. UPEDDR.FOR main program, subroutines and functions

6. UPEDDR.EXE executable program

UPED MODEL RUN AND REPORT OPTIONS AND PARAMETERS:

Run Options

RUNOPT(option=1,2,...,10) Run Options
(1)= 0: LFPR is projected using both the 'proportion-life' (secular) method and the 'elasticity -economic opportunity index' (cyclical) method.

1: LFPR is projected using only the 'proportion-life' (secular), such that LFPR='FO'.

Note: To assume constant labor force participation rates, set FO equal to FOT in the input file <FNAME>.IN2.

(2)= 0: Normal Model Run

1: Zero employment related net in-migration case;BEDP and BEDP are adjusted such that, given the values of the other parameters the final population value yields and ERLMIG value of zero.

Note: See also RUNPAR(1), CIPAR(1) & CRPAR(1)

(3)= 0: Normal Model Run

1: Impose residentiary employment growth constraints

(4)= 0: Do not apply permanent basic employment growth rates (BEDPGR) to permanent basic employment absolute change (events or residuals) (BEDPAC)

1: Do apply permanent basic employment growth rates (BEDPGR) to permanent basic employment absolute change (events or residuals) (BEDPAC)

(5)= 0: Do not adjust DBJOBR

1: Adjust DBJOBR (via CPOP)

(6)= 0: Add 'AIN' to 'TPNR' in following year

1: Do not add 'AIN' to 'TPNR' in following year

(7)= 0: Add 'AOUT' to 'TAR' in following year

1: Do not add 'AOUT' to 'TAR' in following year

(8-10) not used

COPT (option=1,2,...,6) Historical/Target Options (0=No; 1=Yes)

(1) Target: Total births (CBIR) &/or detailed births (CBIR3) and total deaths (CDTH) &/or detailed deaths (CDTH3, CBDTH3)

Solve for: BRTHRA, SURATE, BSURAT, BYPROP

(2) Target: Total non-employment related migration (CNEOM) &/or detailed non-employment related migration (CNEOM3)

Solve for: NOMRAT

(3) Target: Total labor force (CLF) &/or detailed labor force (CLF3)

Solve for: LFPR

(4) Target: Total population (CPOP) &.or detailed population (CPOP3)

Solve for: MIGPR, (DBJOBR in combination with others)

(5) Target: Total households (CHSH) &/or detailed households (CHSH3)

Solve for: HHRAT

(6) Target: Total employment (CTED) &/or detailed employment (CTED3)

Solve for: BEDP, BEDT, RSEREL

Run Parameters

RUNPAR (parameter=1,2,...,10) Run Parameters of Integer Type

(1) Beginning year for zero employment related net in-migration

Note: see also RUNOPT(2), CIPAR(1) & CRPAR(1)

(2) Beginning year for 'DBJOBR' adjustment

Note: see also RUNOPT(5)

(3-10) not used

CIPAR(parameter=1,2,...,5) Historical/Target Parameters of Type INTEGER

(1) Maximum no. of iterations for zero employment related net in-migration case

Note: see also RUNOPT(2), RUNPAR(1) & CRPAR(1)

(2-5) not used

CRPAR(parameter=1,2,...,5) Historical/Target Parameters of Type REAL

(1) Iterative tolerance value for zero employment related net in -migration case.

Note: see also RUNOPT(2), RUNPAR(1) & CIPAR(1)

(2) Iterative tolerance value for historical/target option 1 (births & deaths)

Note: see also COPT(1)

(3-5) not used

Report Options

RPTOPT(option=1,2,...,10) Report Output Options (0 is No; 1 is Yes, except No. 4)

(1) Projection file output to file: '<FNAME>.PRJ'

(2) Parameter or variable output to file '<FNAME>.DMP'

(3) Debug SUBROUTINE 'OUT3' output to file: '<FNAME>.DMP'

(4)= 0: Print demographic variables to screen

1: Print demographic & economic variables to screen

(5) Parameter summary output to file: '<FNAME>.PAR'

(6-9) not used

(10) Do not use (model development output)

Report Parameters

ROOUT (1-24,1) Variable list for 'PRJ' file output

RODEC (1-24,1) No. of decimal places for 'PRJ' file variables

RORND (1-24,1) Rounding options (0=No; 1=Yes) for 'PRJ' file variables

ROOUT (1-24,2) Variable list for 'DMP' file output

RODEC (1-24,2) No. of decimal places for 'DMP' file variables

RORND (1-24,2) Rounding options (0=No; 1=Yes) for 'DMP' file variables