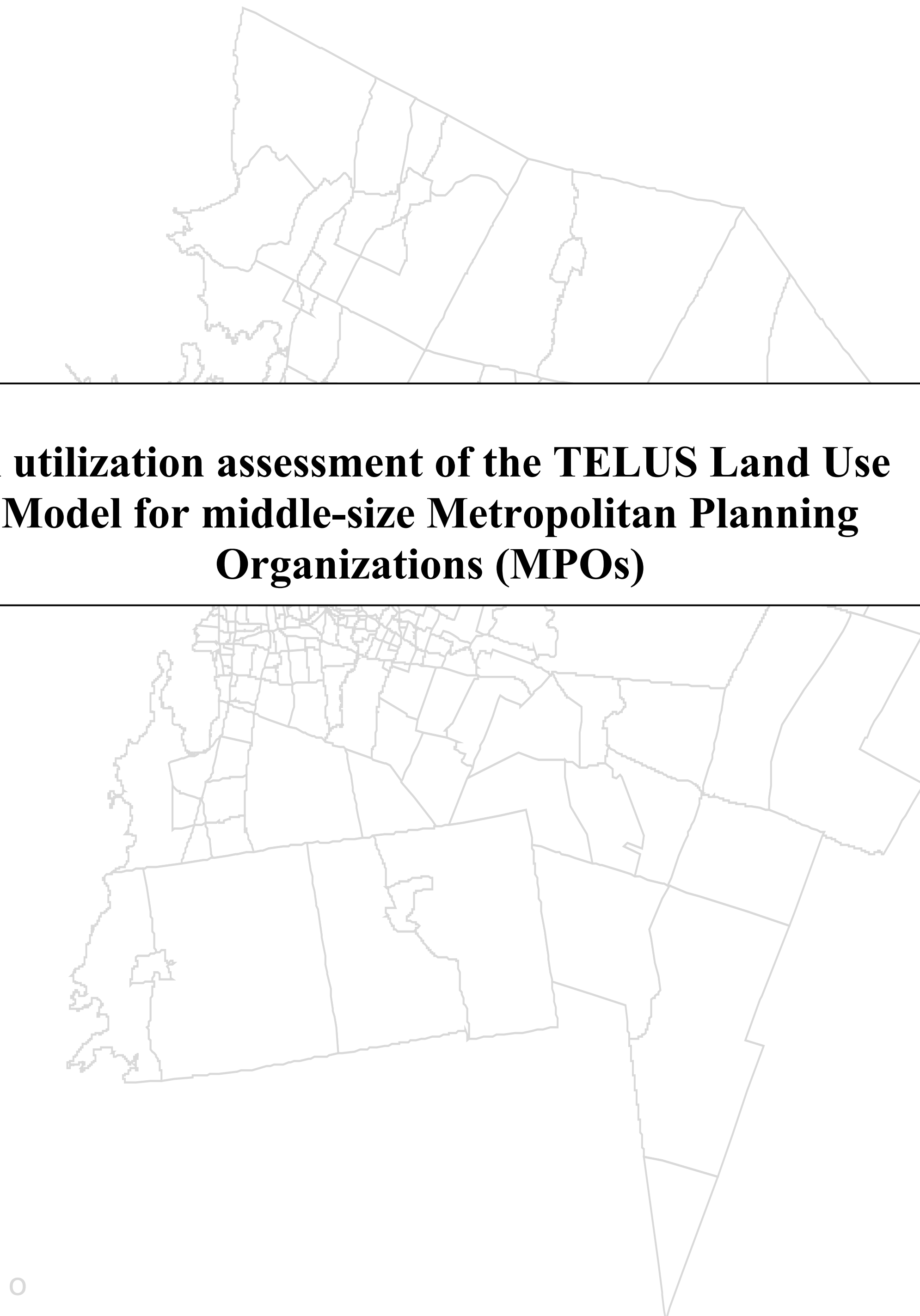

A utilization assessment of the TELUS Land Use Model for middle-size Metropolitan Planning Organizations (MPOs)

Prepared by Georgia Pozoukidou   Advisor: Dr. S.H. Putman

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Note

This report was written by Georgia Pozoukidou, a Ph.D. student in the Department of City and Regional Planning at the University of Pennsylvania. The data used in the analyses described here were obtained from the two regions under the aegis of the TELUS project. The work was guided and supervised by Prof. Stephen H. Putman, who, as part of his work on the TELUS project, also provided the software and some programming assistance in converting the data into the format necessary for its use in the analyses. Some of the early data collection, i.e. obtaining the data from the agencies and some initial processing, was done by Yunwoo Nam, Jienki Synn, and Yongmin Yan, all of whom were also Ph.D. students in the Department of City and Regional Planning at the time. They, too, were supervised by Professor Putman.

The over-riding goal for these analyses was to produce purely statistical tests of the data available from the two agencies, in order to asses the prospects for use of these data in the TELUM land use model which is being developed as a derivative of Prof. Putman's METROPILUS modeling package. The results, as can be seen, were very interesting and informative from the point of view of the sorts of data issues which will have to be dealt with in the development of the TELUM package.

All this not withstanding, it is imperative to note that **the conclusions expressed in this paper are not the official conclusions of the TELUS project or its sponsors**. They are simply the initial discussion of the results obtained.

CONTENTS

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INTRODUCTION

The purpose of this study is to examine how computer transportation and land use simulation models can be used by middle-sized Metropolitan Planning Organizations (MPOs) to address their planning responsibilities.

TELUS which is an information and decision support system is designed specifically to help metropolitan planning organizations (MPOs) prepare their annual transportation improvement programs and other planning responsibilities under the Transportation Efficiency Act for the 21st century (TEA 21). It contains different information management and decision support features such as Project Tracking, Geographical Information Systems, Planning Analysis Module etc. Among them is the Land Use Module called TELUS.

The TELUS Land Use Module is used in transportation planning to allocate future population and employment across subareas of an MPO region based on the location and capacities of various modes in the transportation network, existing and projected population and employment estimates/forecasts and other factors. TELUS Land Use Model is being developed by S.H. Putman Associates, who in the past develop the transportation and land use model called METROPILUS[1].

METROPILUS is a software package that uses household, employment, and land use data of a region to do forecasting for their future location according to the different employment, household and land use types that have been defined for the study area. Basic parts of Metropilus are the Dis-aggregated Residential Allocation Model (DRAM) and the Employment Allocation Model (EMPAL). These modules of METROPILUS will be used in order to test the ability of METROPILUS model to "work" successfully for mid-sized MPOs.

To assess the current status of land use planning at various mid sized MPOs around the country, two MPOs were selected as case studies; Community Planning Association, Boise, ID and Chittenden County MPO South Burlington, VT

The study consists of three main parts.
Chapter one is a review of METROPILUS transportation and land use simulation model with a more detail analysis of DRAM and EMPAL modules. The analysis is focused on the equations that these two modules are using and the required data inputs for the forecasting procedure. Large part of the chapter is devoted to the process of calibration, which is used to fit DRAM and EMPAL models into the real world.

[1] TELUS Land Use Model and METROPILUS are terms that will be used interchangeable in this text

Chapter two and three are focusing on two case studies, the Community Planning Association, Boise, ID and the Chittenden County MPO South Burlington, VT respectively. In each one of these chapters there is a first part, which is a detail description of the demographic and economic trends of the area and a second and most significant part, which is related to the DRAM and EMPAL calibration runs and results for these areas.

Finally the last part of this study is the conclusions.

CHAPTER I

Forecasting with Metropilus

Basic parts of Metropilus software package are DRAM and EMPAL. Following is a brief description of each one of them is provided, focusing mainly on the structure of the equations that these transportation and land use model packages are using. These equations are the final product of an extensive analysis of employment and residential location models that has been done by Dr. S.H. Putman. This analysis is described in great detail in Chapter 6 and 7 of his book *Integrated Urban Models. Policy analysis of transportation and land use, Pion Limited, London 1983.*

1.1 The Employment Location model – EMPAL

EMPAL is a modified version of the standard singly-constrained spatial interaction model. There are three modifications: 1) a multivariate, multiparametric attractiveness function is used, 2) a separate, weighted, lagged variable is included outside the spatial interaction formulation, and 3) a constraint procedure is included in the model, allowing zone and/or sector specific constraints[2].

EMPAL model normally uses for 4-8 employment sectors. Until EMPAL was released most of the work done, in the field of forecasting spatial distribution of employment, was splitting employment into two categories: Basic and non-Basic. The fact that EMPAL model uses four employment types is a significant modification. The parameters λ, α, β, a and b of the equation are estimated individually for each one of the employment types through the calibration process that will be discussed later. The equation structure used for EMPAL and for this project is as follows:

$$E^k_{j,t} = \lambda^k \sum_i P_{i,t-1} A^k_{i,t-1} W^k_{j,t-1} c^{\alpha^k}_{i,j,t} \exp(\beta^k c_{i,j,t}) + (1-\lambda^k) E^k_{j,t-1}$$

where

$$W^k_{j,t-1} = (E^k_{j,t-1})^{a^k} L_j^{b^k}$$

and

$$A^k_{i,t-1} = \left[\sum_{\ell} (E^k_{\ell,t-1})^{a^k} L_{\ell}^{b^k} c^{\alpha^k}_{i,\ell,t} \exp(\beta^k c_{i,\ell,t}) \right]^{-1}$$

$E^k_{j,t-1}$ = employment (place-of-work) of type k in zone j at time t-1

$E^k_{j,t}$ = employment (place-of-work) of type k in zone j at time t

L_j = total area of zone j

$c_{i,j,t}$ = impedance (travel time or cost) between zones i and j at time t

$P_{i,t-1}$ = total number of households in zone i at time t-1

λ^k, α^k, β^k, a^k, b^k = empirically derived parameters

[2] Metropolis Manual Chapter 6 and S. H. Putman, Integrated Urban Models (Chapter 6). Pion Limited, London, 1983

1.2 The Residential Location model - DRAM

DRAM is also a modified version of a singly – constrained spatial interaction model. There are two major modifications: 1) a multivariate, multiparametric attractiveness function is used, 2) a consistent balanced constraint procedure is included in the model, allowing zone and/or sector specific constraints[3].

The model is normally used for 3-5 (the current maximum is 8) household categories whose parameters are individually estimated. Again the model is described in great detail in chapter 7 of Dr .Putman's book *Integrated urban models*.

The equation structure currently in use is given here.

$$N_i^n = \sum_j Q_j^n B_j^n W_i^n c_{i,j}^{\alpha^n}$$

where

$$Q_j^n = \sum_k a_{k,n} E_j^k$$

and

$$B_j^n = \left[\sum_j W_i^n c_{i,j}^{\alpha^n} \right]^{-1}$$

and

$$W_i^n = \left(L_i\right)^{q^n} \left(x_i\right)^{r^n} \left(L_i^r\right)^{s^n} \prod_{n'} \left(1 + \frac{N_i^{n'}}{\sum_n N_i^n} \right)^{b_{n'}^n}$$

where

E_j^k = employment of type k (place of work) in zone j

N_i^n = households of type n residing in zone i

L_i^v = vacant developable land in zone i

x_i = 1.0 plus the percentage of developable land already developed in zone i

L_i^r = residential land in zone i

$a_{k,n}$ = regional coefficient of type n households per type k employee

[3] Metropolis Manual Chapter 6 and S. H. Putman, Integrated Urban Models (Chapter 7). Pion Limited, London, 1983

$c_{i,j}$ = impedance (travel time or cost) between zones i and j

α^n, q^n, r^n, s^n, $b^n_{n'}$ = empirically derived parameters

1.3 Required data inputs for the forecasting procedure

The forecasting procedure starts with EMPAL. The model usually uses four to eight employment types/sectors. For each one of employment type a parameter will be estimated. In order to proceed with the forecasting procedure EMPAL needs the following input data:

- Employment by type in all zones
- Population by income in all zones
- Total area for all zones per zone
- Zone to zone travel cost or travel time between all zones

After the employment location forecasting performed by EMPAL, residential location forecasts will be performed using the DRAM module of Metropilus. The model usually uses four to six household types, which represent different income groups i.e. high income, low income etc. and whose parameters will be individually estimated. To forecast the location of residents DRAM need the following input data:

- Residents of all types in all zones at time t
- Land use of r residential purposes in each zone at time t
- The percentage of developable land that has already been developed in each zone at time t
- The vacant developable land in each zone at time t
- Zone to zone travel cost
- Employment of all types in all zones at time t+1

The residential location forecast produced by DRAM are then used as inputs to generate and distribute trips, split trips by mode and then assign vehicle trips to the transportation network.

1.4 Calibration

Calibration is the process of fitting the DRAM and EMPAL models into the real world by estimating the parameters for each locator type (i.e. high income households, manufacturing etc), which will be used in the models' equation. These parameters will be the ones that best fit in the general model structure of the dataset and will minimize the discrepancies between the model results and the real data. The calibration process used by the CALIB module of ITLUP is based on the maximization of the likelihood function and employs a gradient search method.

Using CALIB we calculate partial derivatives (or estimate parameters) for each one of the locator types. Each locator type (government employment, low-income household etc) in each of EMPAL and DRAM models will have different locating behavior in a particular region. At the same time a particular locator type may also exhibit different locating behavior in different regions. Because of this, it is necessary to estimate the equation coefficients of the model equations separately for each locator type in each region. The process of estimating these equation coefficients is called model calibration. For each locator type runs of CALIB are performed. It may take one or several CALIB runs for each locator type's full calibration.

The user should examine the results of the calibration process in order to evaluate if the estimated partial derivative values are reasonable and acceptable as inputs in DRAM and EMPAL models. In order to do this one or more indicators of goodness of fit are used. The appropriate goodness of fit measure for calibration of DRAM and EMPAL is the likelihood function, derived from the notion of maximum likelihood as used in econometrics. More details about the likelihood function and how is used are provided in chapter 4 the Metropilus manual.

Other measures of goodness of fit that the user can use to evaluate the calibration results are the following:

R-Square: R-square value is an indicator of how well the model fits the data. The smaller the variability of the residual values around the regression line relatively to the overall variability the better is our prediction. The value of R-square can range from 0 to 1, where 1 indicates that we have accounted for almost all of the variability with the variables specified for the model. Despite the fact that R-square is a very common and reliable measure of goodness of fit the fact that DRAM and EMPAL incorporate non-linear equations limits the reliability if this indicator. For that Best Worst likelihood Ratio which is presented below is considered to be as most appropriate measure of fit.

Best-Worst likelihood Ratio: The "best fit" of a model is when the difference between the model's estimate of the deepened variable and the observed values in the calibration dataset is as small as possible. The "perfect fit" would be if for each locator type and zone the estimated number of employees or households were the same as the observed. The "worst fit" would be when all values, in each one of the zones, of the depended variable are estimated by the mean of that variable.

From these two extreme likelihood variables a measure of relative goodness of fit is derived called likelihood ratio and it is the ratio of the difference of the computed likelihood minus the worst fit likelihood, divided by the difference of the best minus the worst likelihood. The value of this ratio range from 1 to 0, were 1 is the best/perfect fit and 0 is the worst fit. The B/W likelihood ratio takes the following equation form:

$$\varphi = \frac{L - L_w}{L_b - L_w}$$

Mean Absolute Percent of Error (MAPE): Of the several statistics, which are often used to test the results of forecasting models the Mean Absolute Percent of Error is one of the most appropriate measure of goodness of fit. MAPE examines the distribution of the residuals (or errors) between the observed data and the models current best-fit estimates. More specificdally it is the average of the absolute values of percent of error between the observed and the estimated by the model values.

When we are using MAPE as a measure of goodness of fit we should be aware that its does not take into account the size of the zones (population and employment wise). This can create some distortions especially when we have large percentages of errors in small zones. For example a 10% percent error in a small zone that has population of 100 people has a different gravity in the total observations than a 10% error in a larger zone which has a population of 2000 people.

In order to avoid such misinterpretations it is wise to examine MAPE indicator for the biggest 25% and the smallest 25% of the zones and explore if we are likely to get mistakes because of the size of zones. If that is the case then another indicator is used for the same purpose, which is presented next.

MARMO. MARMO is very similar to MAPE. It also express the average of the absolute values of percent of errors between the observed set of data and the data estimated by the model (DRAM, EMPAL), but it is weighted by the size of the observation (actual count of population or employment). A 20% to 30% percent usually represents a good MARMO.

Regional Location Elasticities. Location elasticities measure the sensitivity of household and employment location to changes in the attractiveness variables of the DRAM and EMPAL models.

The location elasticities are defined for each one of the employment and residential zones. For instance for a 1% increase in an attractiveness variable in a specific zone, the location elasticity measures the resulting percentage of change in the number of households and employees in that zone.

Location elasticities are static measures of model sensitivity, which means that location elasticity for a specific attractiveness variable is calculated assuming that the values of all other attractiveness variables are remain the same or fixed. Because of that the location elasticities will change as the values of the DRAM and EMPAL attractiveness values change.

In more detail the value of the location elasticity for a specific attractiveness variable and zone is a function of:

- The value of the calibrated parameter for the attractiveness variable
- The number of the households or employees in the zone
- The magnitude of the attractiveness variable
- The relative attractiveness of the other zones in the region

Location elasticities will be larger when the calibrated parameter for the attractiveness variable is large (in absolute value), the number of households or employees is small (in comparison to the rest of the zones in the region), or the value of the attractiveness variable is small (in comparison to the other zones in the region).

A more detail explanation of DRAM and EMPAL Location Elasticities functions is provided in Chapter 4 of Metropolis Manual.

CHAPTER II

Case Study I: Community Planning Association, Boise, ID

The Community Planning Association of Southwest Idaho is a regional planning organization. Their mission is to provide a forum to address and prioritize region-wide issues, to serve as a catalyst and ensure local government involvement in building region-wide consensus, to develop and support policies to achieve region-wide solutions and to maintain resources to support efficient region-wide planning and development.

In this context Community Planning Association performs reviews of land use plans via local comprehensive plans as part of the review process and track building permits throughout Ada County and Canyon County. Activities in the transportation field includes developing reviews for the twenty-year long range plans and creating a vision for the future transportation system in Ada and Canyon Counties.

In order to understand the general context that this study is taken place, following is a brief presentation of demographic and economic facts for the study area, which includes **Ada County and Canyon County**,

2.1 Brief History

It was French Canadian fur trappers that gave Boise its name in the very early 1800's. Traveling through the high desert terrain, they came upon the valley, "Les Boise! (The Trees!)" they exclaimed[4]. **Ada County** was established as part of the Idaho Territory in 1864 with **Boise** as its county seat. In 1890, Idaho was admitted as the 43rd state, and the City of Boise was chosen as its capital. Boise became the premier city in the state leading in population, manufacturing, retailing and quality of life. Ada County prospers through Boise's strengths, as does the other cities in the Boise Metropolitan Statistical Area (MSA) [5]: Eagle, Garden City, Kuna, Meridian and the adjoining counties of Canyon and Elmore.

Men with a vision made Ada County a corporate landmark. Men like C.W. Moore whose general store has evolved into US Bancorp. W.H. Moorison, and M.H. Knudsen, founders of the Morrison-Knudsen Corporation, now the global engineering and construction company

[4] Source www.boiseid.anc.net

[5] Boise Metropolitan Statistical Area consists of two counties and several cities. The two counties are Ada and Canyon Counties. All the data that will be provided in the text and referred as Boise MSA will include the territory of these two counties.

Washington Group International; J.R. Simplot who started the Simplot Corporation and made Idaho famous for its potatoes; and Joe Albertson, who dream of food distributing netted one of American's largest and fastest growing chains of supermarkets. The list is long, Micron Technology, Inc. Hewlett-Packard, Boise Cascade Corporation, T.J. International, PRECO, Inc., and SCP Global Technologies.

Canyon County was established in 1891, and is the second county included in Boise MSA. Its two major cities are **Nampa** and **Caldwell**, the latter being its county seat. The Hudson's Bay Company established the original Fort Boise in 1834 near the town of Parma, but abandoned it in 1855. Emigrants also traveled through the county on Oregon Trail.

Today, Canyon County is the second largest county in the state and is a very important part of the strong Boise metropolitan area economy, sharing in the area's high-tech sector. The county contains rich agricultural land and boasts several food processing facilities, as well as two vineyards.

2.2 Geographic and Demographic Facts

Boise MSA lies in an area of 1,645 Sq. Miles. It is located on an elevation of 2,842 Ft and has a mean temperature of 50.9F Degrees. The annual precipitation is 12.11 inches and the number of sunny days is 234[6]. Boise is the state capital, and the Boise area is the largest metropolitan community in Idaho.

Approximately 432,000 people live in the Boise Metropolitan Statistical Area (MSA). Boise and Meridian are the major cities in Ada County and Nampa and Caldwell are the major cities in Canyon County[7]. Following is the population data for the two counties and MSA.

[6] Source for the geographical data- www.boiseid.acn.net
[7] Affirmative Action Statistics 1999, Idaho Department of Labor, released May 2000

Table 1: Case Study I-Population number and percent of change				
Area	**2000**	**1990**	**Change('90-'00)**	**Percent of Change('90-'00)**
Idaho	1.293,953	1,006,749	287,204	28.5%
Boise MSA	432,345	295,851	136,494	46.1%
Ada County	300,904	205,775	95,129	46.2%
Canyon County	131,441	90,076	41,365	45.9%

Source: 2000 Census

With a national 13.2 percent and a state 28.5 percent population growth rate for the decade 1990-2000 Boise MSA growth rate is way above the average (table 1). This fact indicates that the study area is experiencing a rapid population growth, which subsequently will influence the form of the city. According to the census data Ada county population increased by 95,129 which is translated to a 46.2% percent increase. At the same time Canyon county experienced also a great increase in population numbers, which is almost 46 percent.

Table 2 shows the age structure composition of the population. The distribution of the population among the different age group seems to be "healthy", meaning that no age group is over or underrepresented in the population pyramid. This information is especially significant for this study since it gives us an idea of the size of future employment based of the current population at the age groups of under 18 years old and 18 to 24 years old. The median age for Boise MSA is 31.6 year old which indicates a very young population.

Table 2: Case Study I - Population Age Structure									
		Percent of total Population/age group						**Males/100females**	
Geographic Area	Total Population	0- 18 years	18-24 years	25-44 years	45-64 years	65+ years	Median Age	All ages	18 +
Idaho	1,293,953	28.5	10.7	28.0	21.5	11.3	33.2	100.5	98.5
Boise MSA	432,345	29.1	10.5	30.4	19.9	10.0	31.6	99.6	97.6
Ada County	300,904	27.3	10.3	32.5	20.8	9.1	32.8	100.6	98.9
Canyon County	131,441	30.9	10.7	28.3	19.1	11.0	30.5	98.7	96.3

Source: 2000 Census

In terms of racial composition the area is pretty homogeneous with the white representing almost 90 percent of the total population in Boise MSA (table 3). The "other" category as presented in table 2 includes Black or African American, Asian, Native or Hawaiian and other races. It should be noted that in the category white, Hispanic race is included. More detail information about the racial composition of the study area is provided by the General Demographic Profile Characteristics tables (data tables for United States, Idaho state, Boise MSA and the two counties) are included in the appendix.

Table 3: Case Study I - Population Racial Composition			
Geographic Area	Total Population	%White	%Other
Idaho	1,293,953	91	9
Boise MSA	432,345	89.9	10.1
Ada County	300,904	92.9	7.1
Canyon County	131,441	83.1	16.9

Source: 2000 Census

Table 3.1 shows the housing occupancy rates in the study area. This information is valuable for because it indicates the available housing stock, which will partly determine if the city will further expand or if it is more likely to use the existing housing stock. The median home price for Ada and Canyon County are $126, 000 and $90,000 respectively and the rent for a two-bedroom apartment in Canyon County is $710. More information on housing and households generally are provided in the appendix by the General Demographic Characteristics tables.

Table 3.1: Case Study I - Housing Occupancy			
Geographic Area	Total Housing Units	% Occupied housing units	%Vacant
Idaho	527,824	89.0	11
Boise MSA	166,481	95.2	4.8
Ada County	118,516	95.7	4.3
Canyon County	47,965	93.9	6.1

Source: 2000 Census

Income Data

Table 4 shows the median household income (1997 model based estimate) for the study area, Idaho state and US. The numbers reveal that the state of Idaho is below the U.S.A. average. In contrast Ada county has a relative high median household income compared to Boise MSA and to Canyon county.

Table 4: Case Study I - Income	
Geographic Area	**Median Household Income**
National	37,005
Idaho	33,612
Boise MSA	37,439
Ada County	43,321
Canyon County	31,558

Source: US Department of Commerce - Bureau of Economic Analysis; Market Statistics 2000

Employment

According to the Idaho Department of Labor the total employment number for Boise MSA is 232,000 (2000). The total civilian labor force is 239,600 and the unemployment rate is 3.1% [8]. The employment growth for the last decade is shown in the following table:

Table 5: Case Study I Non-Ag Employment Growth	
1992-1993	7.61%
1993-1994	6.51%
1994-1995	4.62%
1995-1996	4.07%
1996-1997	4.13%
1997-1998	3.27%
1998-1999	4.63%
1999-2000	4.1%

Source: Idaho Department of Labor

The area is characterized by moderate educated workforce - of persons over 25 years of age, 82 percent have attained a high school graduation or higher, and 21 percent have attained a bachelors degree or higher.

The major industries and the largest employers, which indicate the nature of the economic base of the study area, are shown in table six.

Table 6: Case Study I - Major Industries

Agriculture/Food Processing
Corporate Headquarters
Education
Financial Services
Government
High Technology
Manufacturing
Military
Healthcare
Trade, Retail & Wholesale
Transportation
Utilities

Number of Businesses in MSA - 14,000

Source: Idaho Department of Labor

Case Study I - Largest Employers

Ada/Canyon School Districts
State of Idaho
Micron Technology, Inc.
Albertson's Inc.
Hewlett-Packard
J.R. Simplot Company
Micronpc.com
Boise State UniversityCity/County Government
Saint Alphonsus RMC
St. Luke's RMC
DIRECTV
U.S. Bank
MCMS
Manpower Technical
Sears Boise Regional Credit Center
First Security Bank/Wells Fargo
Idaho Power Company
Jabil Circuit
Boise Cascade Corporation

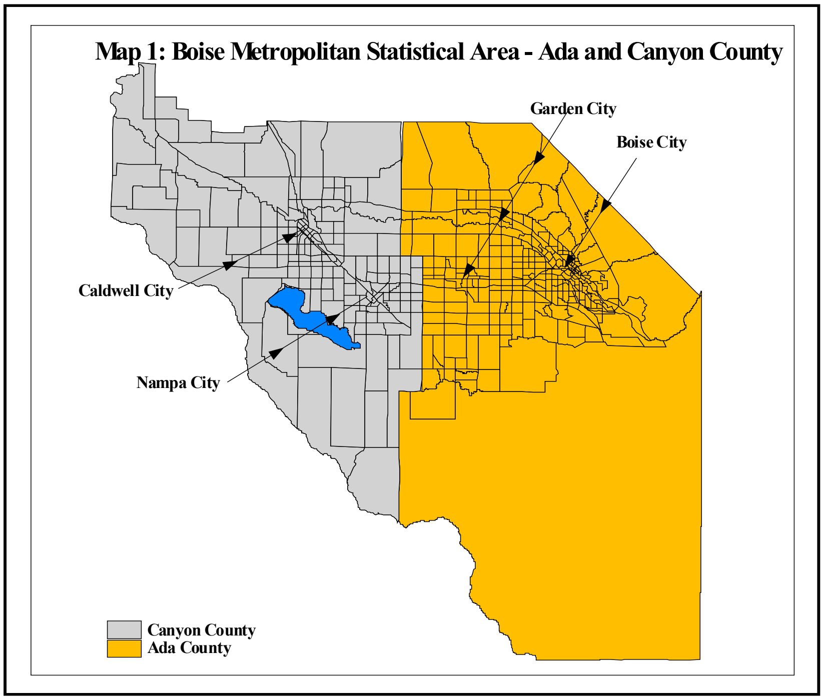
Source: Idaho Department of Labor

[8] All the number are averages, and seasonally adjusted. The data was provided by the Idaho Department of Labor.

2.3 Calibration and Available Data

Following is a description of the data provided by the Community Planning Association of Southwest Idaho. This data was used to run calibration for DRAM and EMPAL.

a. Zones



Map 1 shows the study area and the Transportation Analysis Zones (TAZ) that the area is divided. TAZ is the most commonly used spatial level to generate land used forecasting.

As mentioned above the study area consists of two counties, Ada County and Boise County. The total number of TAZs for both counties is 471 zones (the zone that represents the lake is not included). For the purposes of this project we had to assign new TAZ identification numbers for the 471 zones due to discrepancies in the original data. Ada County has 285 Zones, with a range of identification numbers from 1 to 285 and Canyon County has 187 Zones with a range of identification numbers from 286 to 471 (the lake is not included in the numbering).

The total study land area is 1,651 sq. miles.

b. Population

The total population for all zones according to the census data for 1997 was 378,722 people. The total population for the year 2001 was projected to be 416,919, which indicates an increase of 10% within 5 years. This averages an increase of 2% per year. The rate of change among the 470 zones ranges from 0% to 625%.

Map 2 shows the distribution of the population in the two counties for 1997. It is obvious that there is a pattern or concentration of population within the study area mainly around the three major cities of Boise, Garden City, Nampa and Caldwell. Mapping population density (map 4) this pattern becomes clearer; population is concentrated to certain areas (Boise city, Garden City, Nampa and Caldwell). It should be noted that the population concentration patterns remain the same for the 2001-projected population.

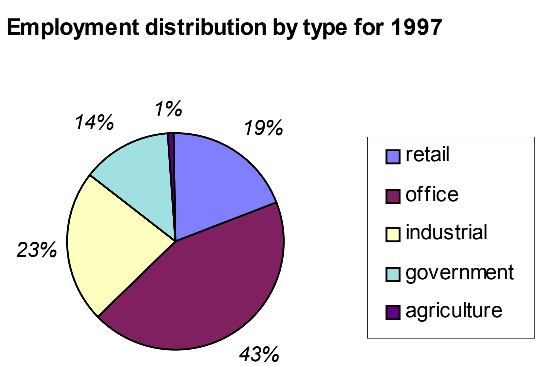
Map 3 shows the population percent of change for each zone. The orange colors indicate positive rate of change and gray colors indicate negative rate of change or decrease of population numbers in the zone. It is obvious that the immediate zones to Boise city are experiencing a decrease in their population numbers. The trend is opposite in TAZs close to Garden city and northeast boundaries of Ada county.

c. Households

The related maps (maps 5 and 6) shows that households have the same distribution patterns as population, something that was expected because household distribution is directly related to population distribution.

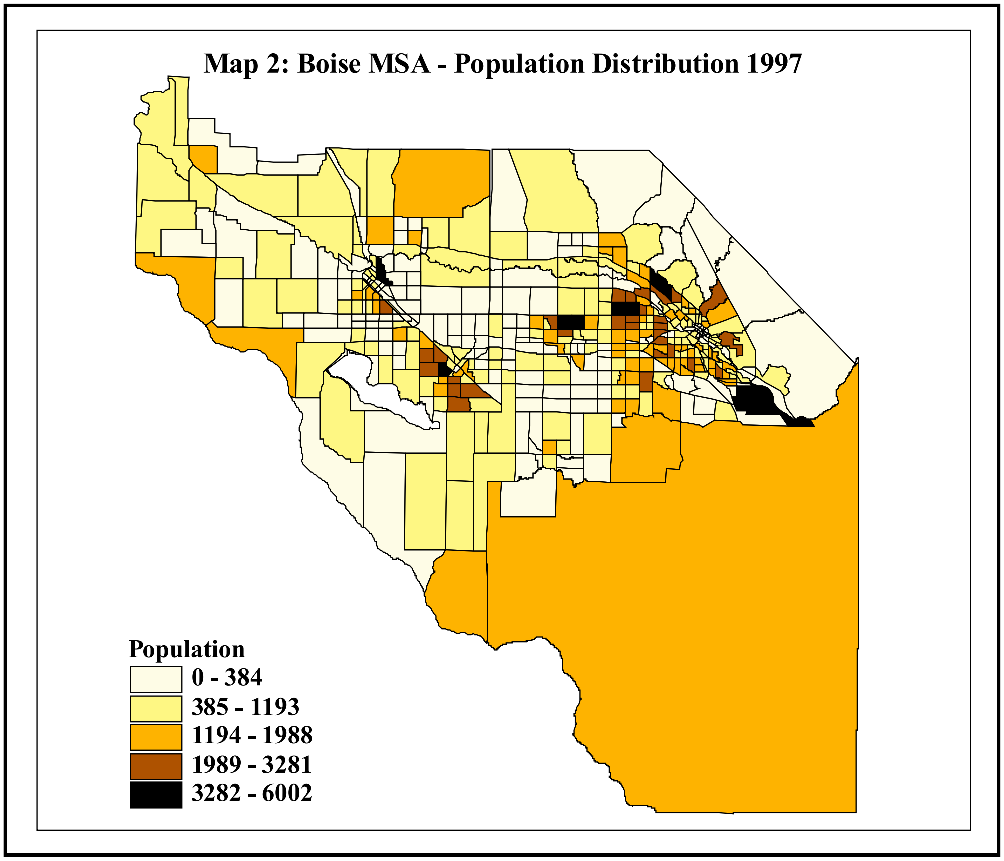
It should be noted that the available household data is limited to the total number of households per zone. That means that necessary information to execute calibration runs is missing. In order to overcome this problem we made the assumption that the total number of households is equally divided between four types of households income groups. These are:

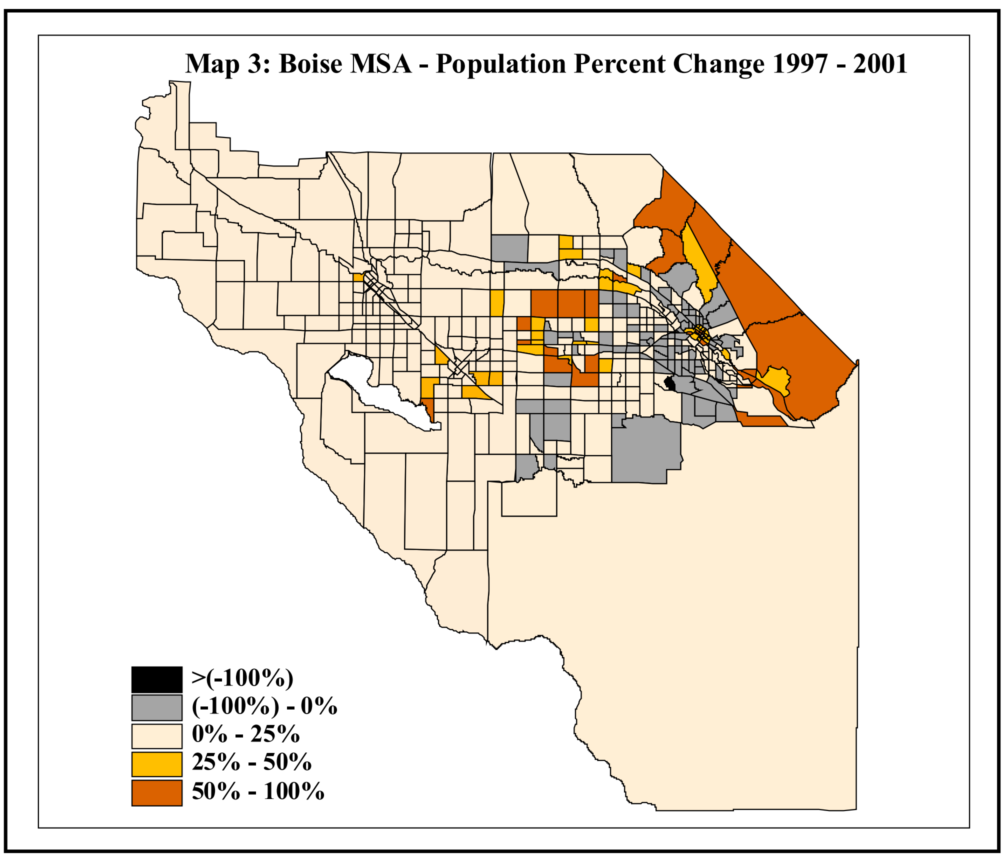
- High Income Households
- High-Middle Income Households
- Low-Middle Income Households
- Low Income Households

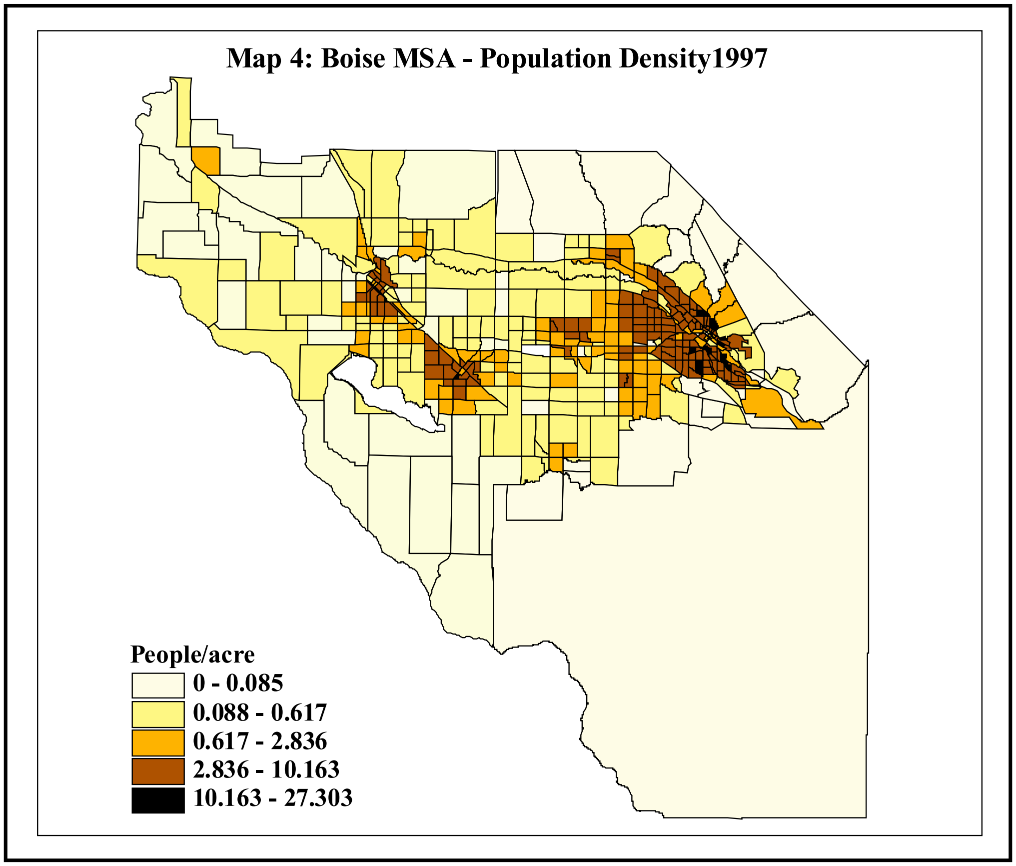


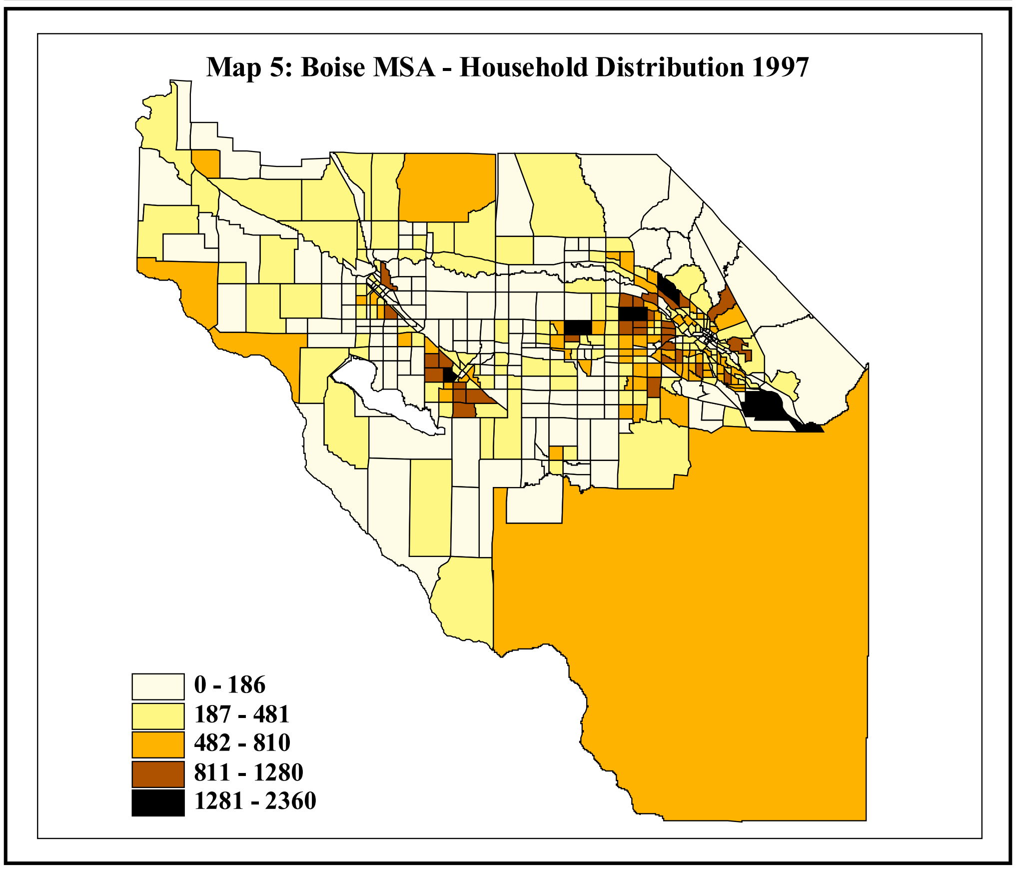
d. Employment

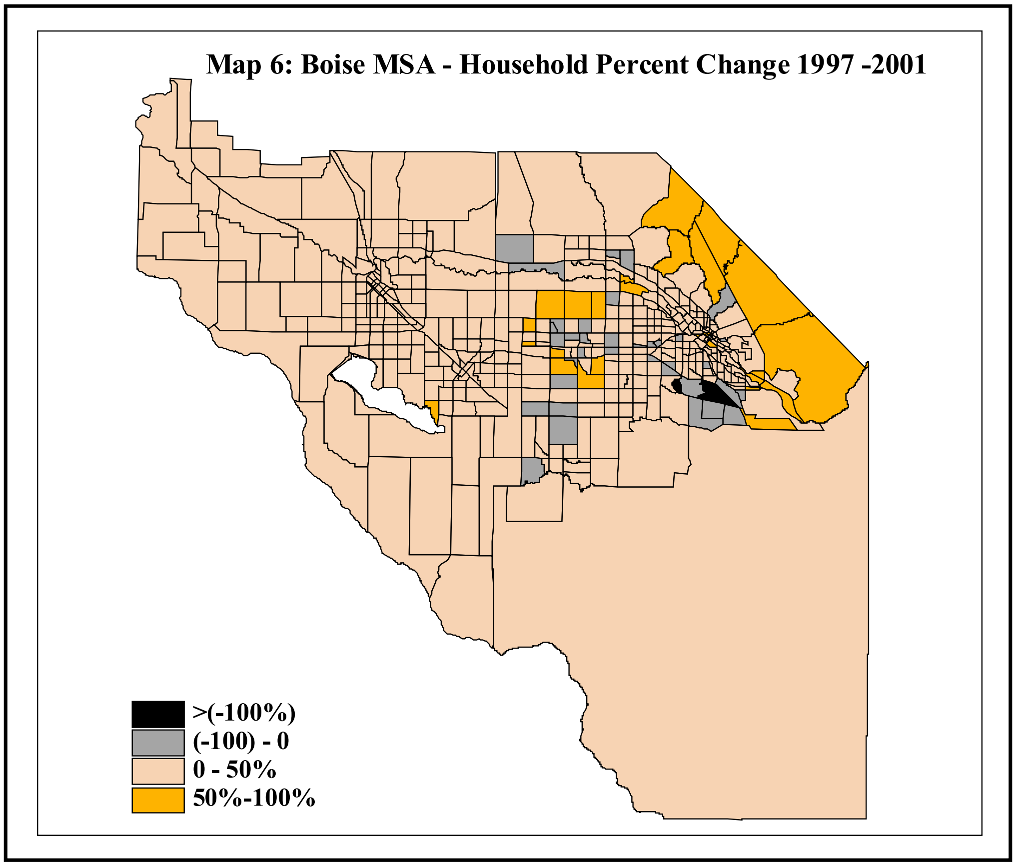
Total employment and employment by type is available, for each zone and for both 1997 and 2001. Total employment number for 1997 is 223,296. These employees are distributed among the following five employment types: **Retail, Office, Government, Industry and Agriculture.**


Map 2: Boise MSA - Population Distribution 1997
Population
0 - 384
385 - 1193
1194 - 1988
1989 - 3281
3282 - 6002

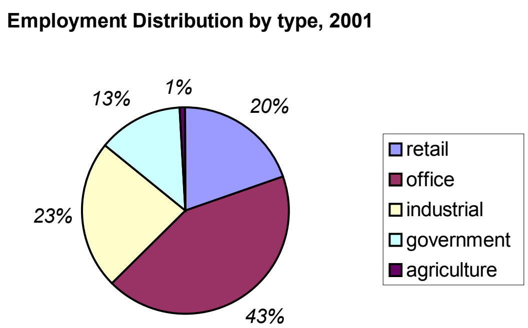

Map 3: Boise MSA - Population Percent Change 1997 - 2001
>(-100%)
(-100%) - 0%
0% - 25%
25% - 50%
50% - 100%


Map 4: Boise MSA - Population Density1997
People/acre
0 - 0.085
0.088 - 0.617
0.617 - 2.836
2.836 - 10.163
10.163 - 27.303


Map 5: Boise MSA - Household Distribution 1997
0 - 186
187 - 481
482 - 810
811 - 1280
1281 - 2360


Map 6: Boise MSA - Household Percent Change 1997 -2001
>(-100%)
(-100) - 0
0 - 50%
50%-100%

The first diagram shows the distribution of employment among these five sectors for 1997. It is obvious that employment is heavily concentrated on the office sector with 43 percent Another big part of employment is distributed among government and retail, for that we can say that in Boise MSA employment is heavily concentrated on the third sector. A comparison between the total employment for 1997 and the projected employment for 2001 shows that there is an increase of 12.4 percent.



As shown in the above diagram, the distribution of employment between the different employment types remains the same.

Map 7 and 8 shows the employment distribution for 1997 and the percent of change for the five-year interval of 1997 to 2001, respectively. Again there is a concentration of employment near the four major cities of the area. The following maps (9,10,11 and 12), shows the distribution of each employment sector in the study area. Agriculture employment sector is omitted due to the insignificant percentage of employees that this sector occupies.

e. Land Use Data

Land Use data is not available for the study area.

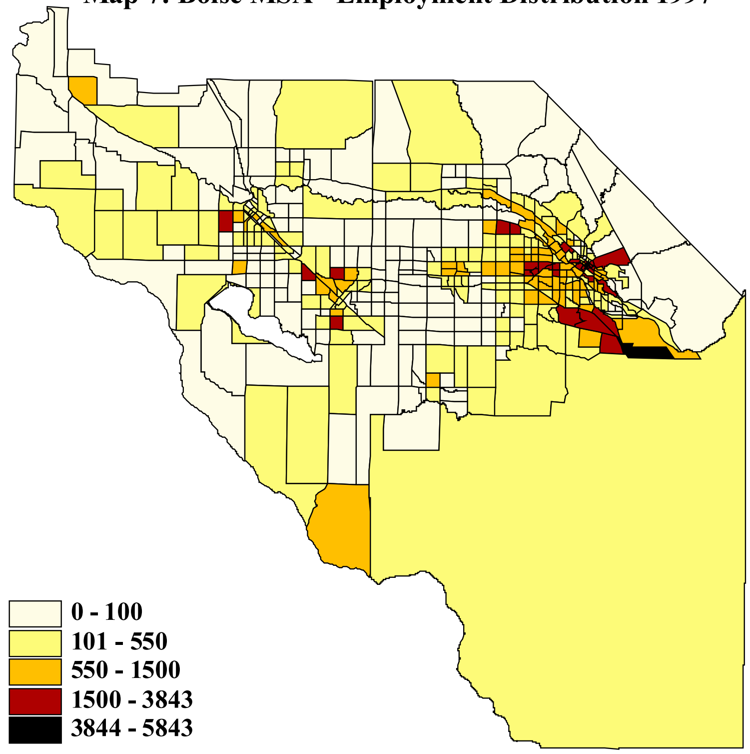
f. Zone to Zone Travel Time

Travel time data is available. The travel time matrix contains zone to zone travel time (in minutes). The Community Planning Association of Southwest Idaho made this data available for the purposes of this research.

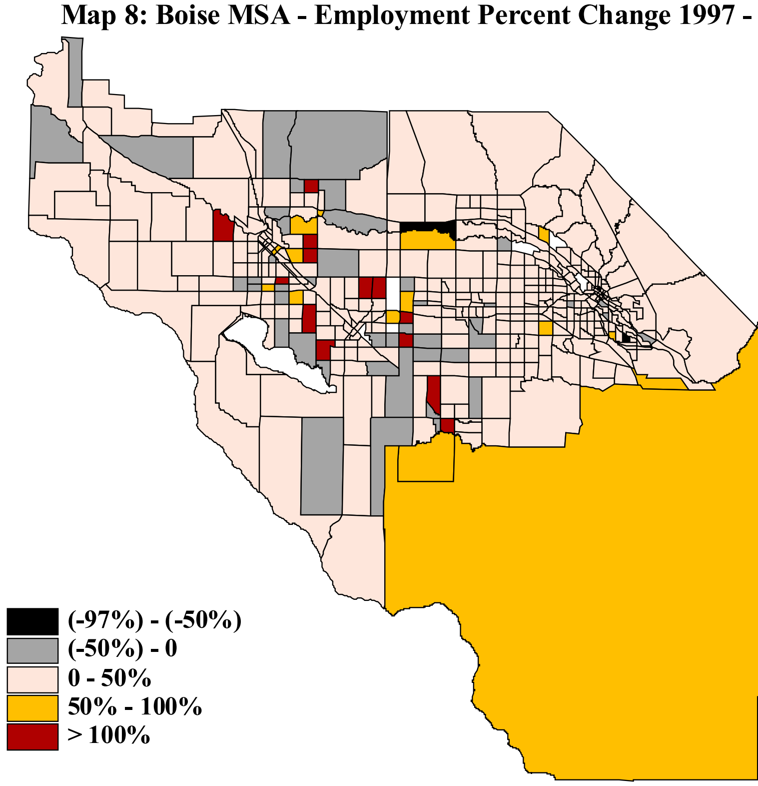
2.4 Calibration Runs and Results

For calibration with EMPAL it is necessary to have employment data by employment type and by zone for two time points five years apart. In our case the current time is taken to be year 2001 and the lagged time is taken to be 1997. The employment data is the only one that is required in two time points in the calibration of EMPAL.

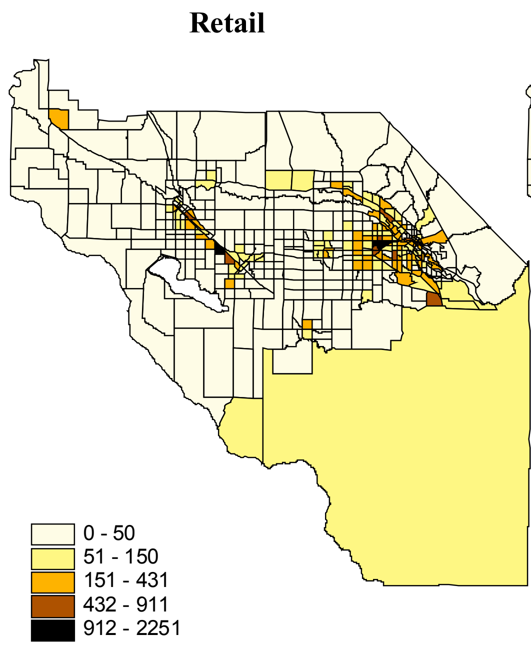
Map 7: Boise MSA - Employment Distribution 1997



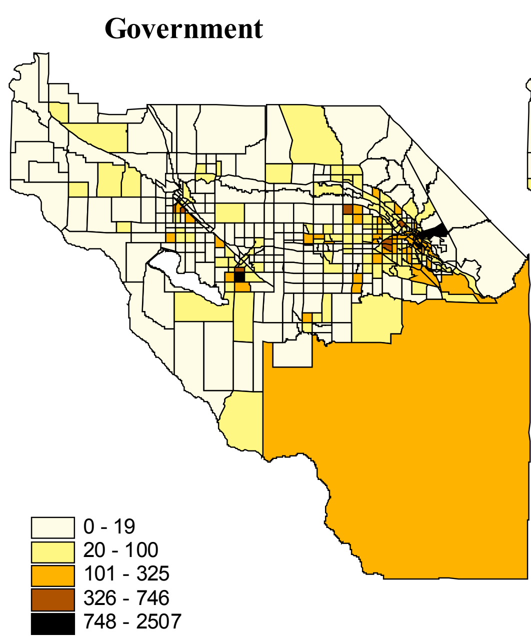
Map 8: Boise MSA - Employment Percent Change 1997 - 2001



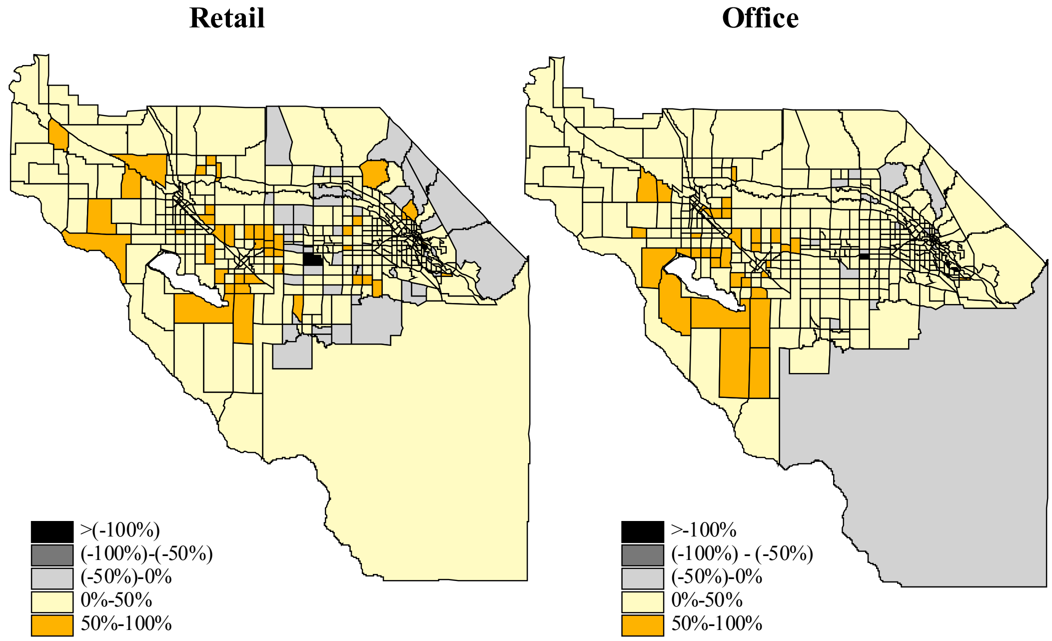
Map 9: Boise MSA - Employment Distribution by Sector, 1997



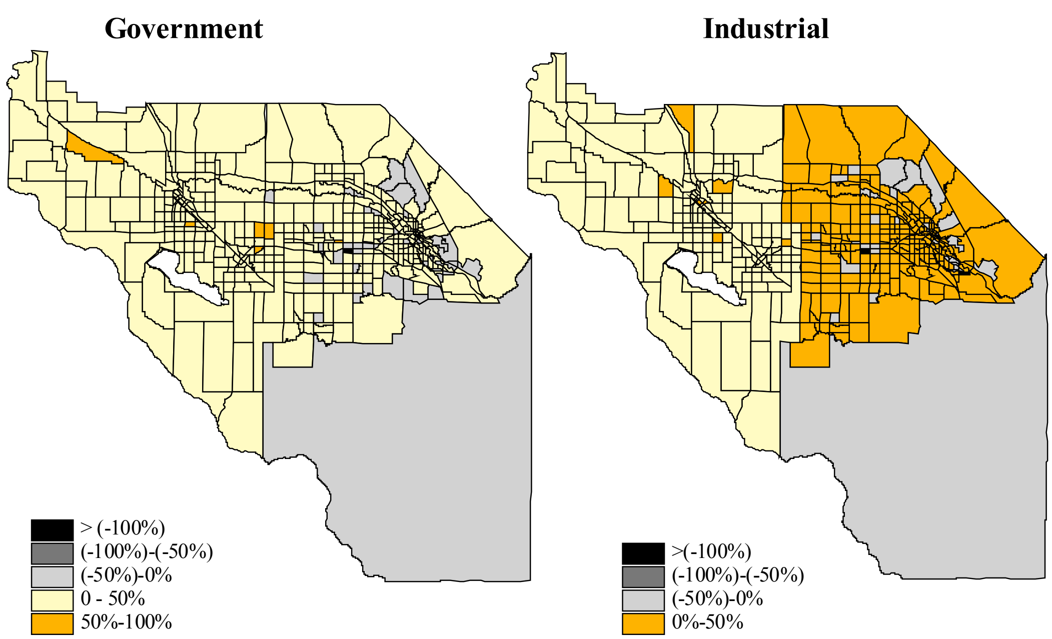
Map 10: Boise MSA - Employment Distribution by Sector, 1997



Map 11: Boise MSA - Employment Percent Change by Sector (1997 -2001)



Map 12: Boise MSA - Employment Percent Change by Sector (1997-2001)



For calibration with DRAM it is necessary to have employment data by employment type and by zone, for the current time point. EMPAL current year matches the DRAM current year, which in our case is the year 2001. It is also necessary to have population data in the form of households for one time point that will match the current employment year. DRAM also can use lagged household data in the form of total number of households per zone normally five years earlier. The household data is divided by type and zones. Usually we have 4 to 8 categories of household types. As referred above this case study is peculiar, due to the fact that we do not have a breakdown of households in different income categories but the total number of households in each zone. In order to be able to run calibration we divided the total number of households into four different categories by equally distribute households in each one of them.

So the four different household types included in the calibration runs are:

- High Income Households
- High-Middle Income Households
- Low-Middle Income Households
- Low Income Households

and the five different employment types are:

- Retail
- Office
- Government
- Industry
- Agriculture

a. Employment Calibration Results

The measures of goodness of fit achieved seem to be very good. Following is the table showing a summary of the calibration results. The four indicators as described above are presented with their values.

Table 7: Case Study I-Goodness of Fit

	Retail	Office	Industry	Government
R-Square	.9926	.9932	.9938	.9998
B/W LR	.9841	.9764	.9834	.9994
MAPE	17.873%	22.865%	11.133%	4.040%
MARMO	6.930%	6.412%	7.457%	1.334%

R-Square and **B/W LR** are really high and indicate that employment data almost perfectly fit the EMPAL model. MAPE values are also indicating that the estimated parameters for DRAM an EMPAL models equation are very close to the best fit model since the percentage of error between the observed and the models current best fit estimates for each one of the locator types are within the acceptance range.

For reasons explained in chapter I, a more detail examination of Mean Absolute Percent of Error (MAPE) for the dataset was made. Following is values of MAPE for the smallest 25% and the largest 25% for each one of the employment types.

Table 8: Case Study I-Mean Absolute Percent Error (MAPE)				
	Retail	**Office**	**Industry**	**Government**
Min Observed Value	1	1	1	1
Max Observed Value	2322	4498	5313	2607
MAPE for Smallest 25% of Zones	.000%	500%	21.212%	.000%
% of smallest zones of region total	.24%	.12%	.25%	.35%
MAPE for Largest 25% of Zones	5.898%	6.297%	6.203%	7.971%
% of largest zones of region total	81.50%	84.22%	85.97%	84.98%

In conclusion, in most of the employment types MAPE has values within an acceptable range for the 25% smallest zones. Exception is the case of office employment sector were MAPE for the 25% smallest zones is 500%, which actually inflates the value of MAPE for the dataset. For that MARMO is a more secure indicator for our purposes. MARMO values as shown in table 7 is within an acceptable range.

Examination of lambda values is another way to evaluate calibration results. Lambda is a weighting factor or a parameter related to the extent to which a specific employment type is oriented to past locational determinants or to current intra-urban location of the population[9]. Locational determinants are related to parameters like the value of the land, the accessibility patterns (i.e. proximity to a major rail line), or even to the agglomeration effects of some economic activities.

In this case the value of lambda for the retail, as shown in table 9, indicates the high importance of the prior retail location and spatial interaction. The low λ values for the rest of the employment types suggest that these employment groups are rather static and is most likely to be found in zones were they were previously concentrated.

Table 9: Case Study I-EMPAL Estimated Parameter Values							
	α	β	**EMP**	**LAND**	λ	**1-λ**	R^2
Retail	.0178	-.1136	.9681	.0048	.0380	0.962	.9926
Office	3.685497	-1.72591	1.0000	.0000	.0000	1.000	.9932
Industry	3.6855	-1.7259	.9901	.0885	.0100	0.99	.9896
Government	3.6855	-1.7259	.9997	.0026	.0003	0.997	.9938

[9] S.H.Putman, Integrated Urban Models. Policy analysis of transportation and land use. London, 1983 (p.164)

The **regional location elasticities** is a measure of sensitivity of employment location of a specific employment type to the changes in the attractiveness variables. Among other table 9 shows the regional location elasticities for the employment type I-Retail. What these results tell us is that a 1 percent increase in land will have a subsequent increase in employment by 0.96 percent. Results are similar for the rest of the employment types.

b. Household Calibration Results

Because of the peculiarity of the household data we had to run calibration for DRAM equation just for one of the four income categories. The results are shown below.

Table 10: Case Study I-Goodness of Fit

	Households
R-Square	.9640
B/W LR	.9488
MAPE	25.596%
MARMO	10.732%

Table 11: Case Study I- Mean Absolute Percent Error MAPE

	Households
Min Observed Value	0
Max Observed Value	613
MAPE for Smallest 25% of Zones	61.362%
% of smallest zones of region total	2.27%
MAPE for Largest 25% of Zones	9.546%
% of largest zones of region total	61.56%

Table 12: Case Study I-DRAM Estimated Parameter Values

	α	β	**VACDEV**	**PERDEV**	**LIHH***	**LAGHH**
Households	.8797	-1.2754	.1952	.3680	1.0027	.0786

*the parameter values are the same for all HH types that is why the rest of them are omitted from the table.

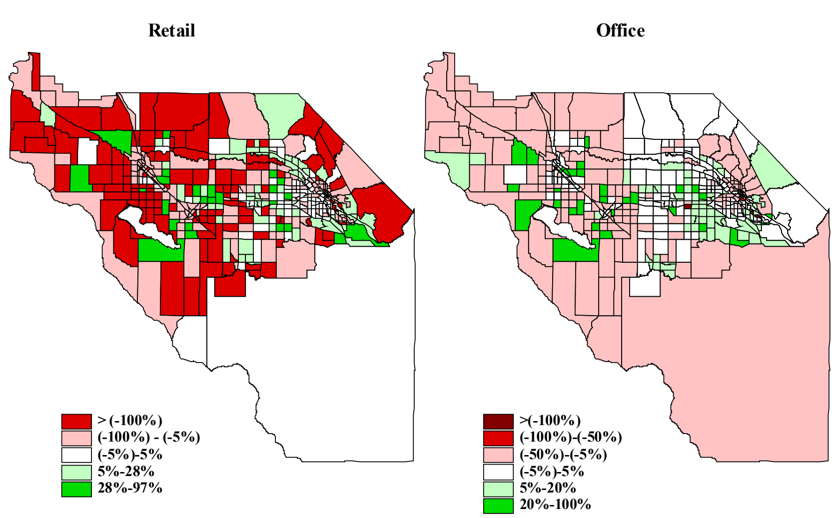
All the measures of goodness of fit shows that household data almost perfectly fits DRAM equations. MAPE though has a relative high value that is why further analysis needed. Further analysis of MAPE showed that it has low values for the 25% of the largest zones of the study area and high values for the 25% of the smallest zones, which inflates the overall MAPE value. In conclusion we can say that household data almost perfectly fits DRAM equations.

c. Calibration Residuals

A more detail examination of the distribution of the residuals will give us a better idea about our data and the validity of the results. Also an examination of their locational distribution might show interesting spatial patterns.

Calibration residuals represent the unobserved factors that influence the relative attractiveness of employment. The calibration process through DRAM and EMPAL creates a set of residuals. These residuals indicate how accurate is the calibration and consequently how accurate is the forecasted population or employment values for each zone. The residuals are proportions and are calculated by dividing the difference of the observed and predicted value by the observed. In other words residuals are the difference between the actual/observed number of employees/households and predicted number of employees/ households in each zone divided by the observed values of employees in the same zone.

Map 13: Boise Caribration Residuals

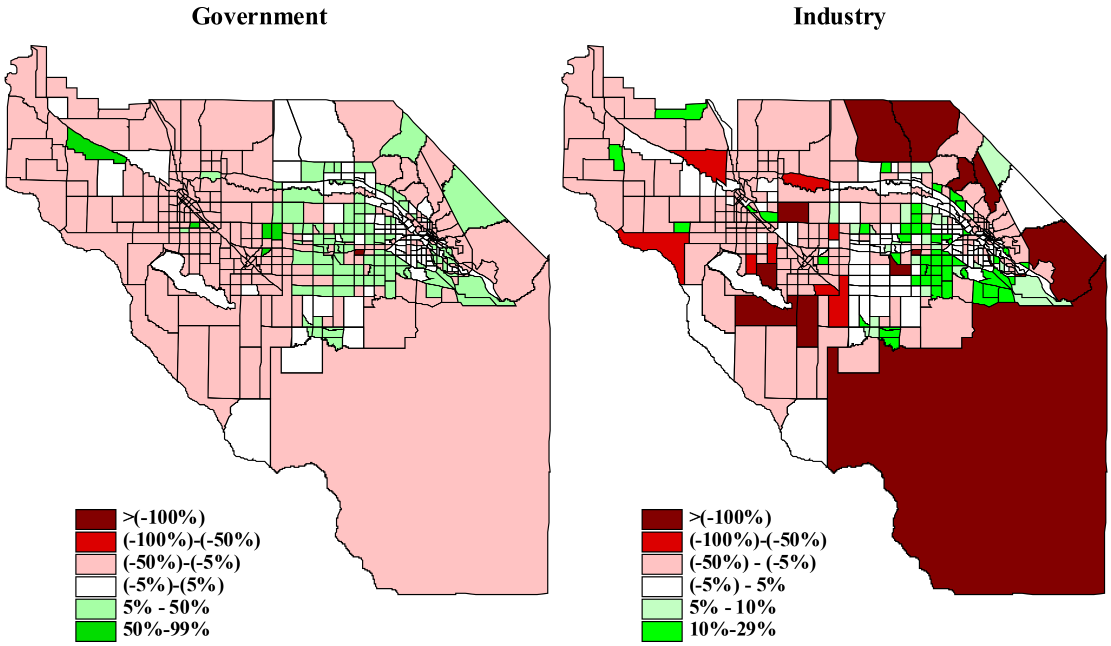


Map 13, 14 and 15 shows the distribution of residuals for each one of the employment sectors and for households. In map 13 and for Retail the dark green color indicates that these zones have been underestimated by 28 percent to 97 percent. Under the same notion the red colored zones have been overestimated by the indicating percentage. Zones that they do not have any color are within the range of plus/minus five percent error.

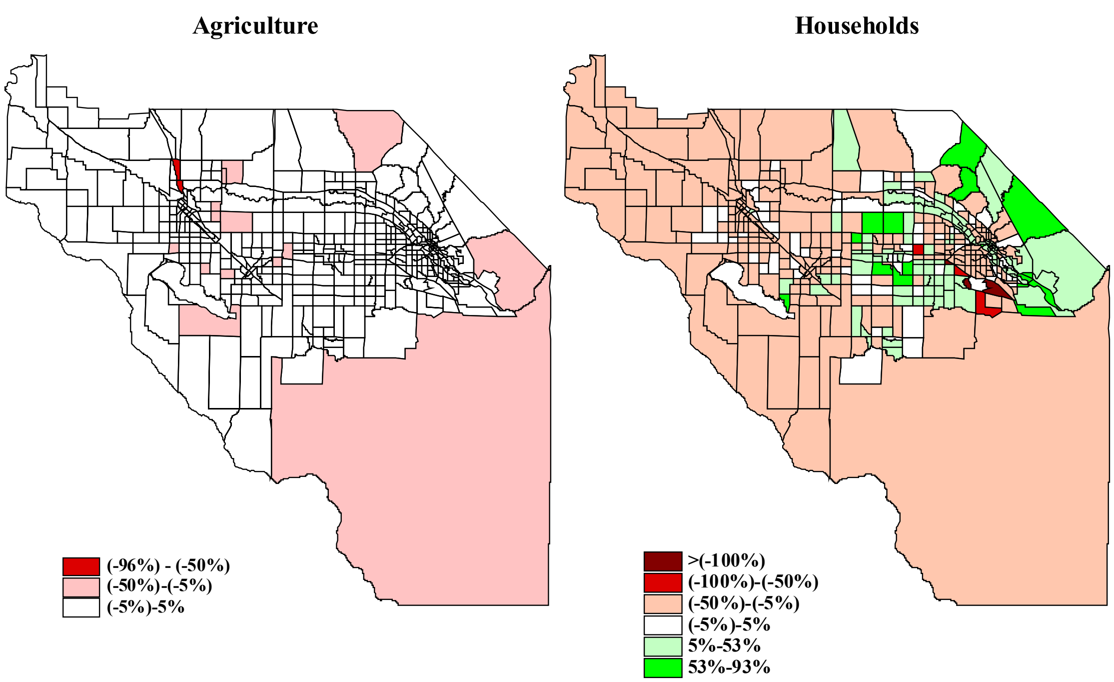
d. Validity of Household and Employment Projections

Despite the fact that the measures of goodness of fit seem to be very satisfactory and indicate that the estimated parameters for EMPAL and DRAM model equations are very close to the best fit

Map 14: Boise Caribration Residuals



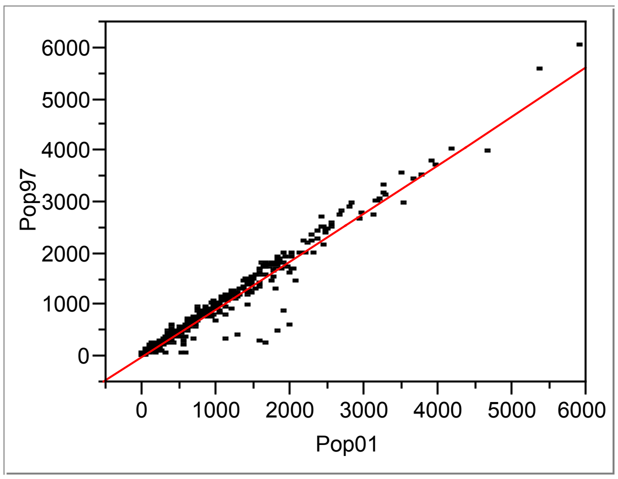
Map 15: Boise Caribration Residuals



model there is a suspicion that the data provided for 2001 is just a linear extrapolation of the 1997 data. If this is the case then the calibration results presented above are unreliable.

A simple regression between population for 1997 and population for 2001 confirms that the projected 2001 data is a linear projection of the 1997 data. The chart below shows the relationship between the two datasets. The same analysis was done for employment and showed a linear relationship between the actual (1997) and projected (2001) data. These results confirm our suspicions and verify that the data is inadequate and cannot be used for the purposes of our research purposes.

Population- Bivariate Fit of Households 1997 By Households 2001



Linear Fit

Pop97 = -26.93701 + 0.9388139 Pop01

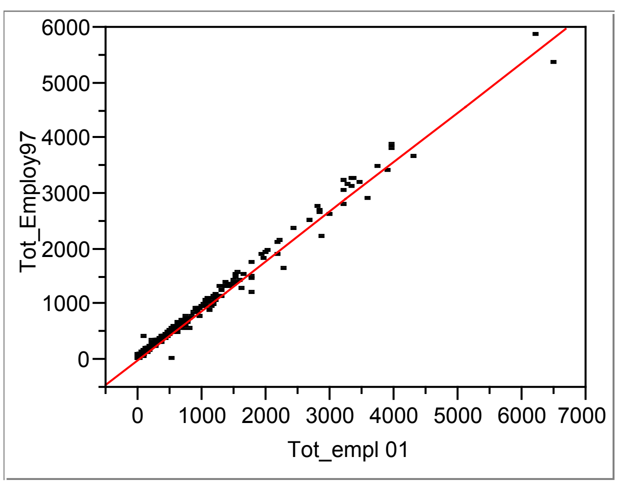
Summary of Fit

RSquare	0.960297
RSquare Adj	0.960213
Root Mean Square Error	173.4101
Mean of Response	804.0807
Observations (or Sum Wgts)	471

Parameter Estimates

Term	Estimate	t Ratio	Prob>|t|
Intercept	-26.93701	-2.41	0.0162
Pop01	0.9388139	106.51	0.0000

Employment- Bivariate Fit of Tot_Employ97 By Tot_empl 01



Linear Fit

Tot_Employ97 = -3.306822 + 0.8962959 Tot_empl 01

Summary of Fit

RSquare	0.991452
RSquare Adj	0.991433
Root Mean Square Error	72.09517
Mean of Response	474.1125
Observations (or Sum Wgts)	471

Parameter Estimates

Term	Estimate	t Ratio	Prob>|t|
Intercept	-3.306822	-0.85	0.3972
Tot_empl 01	0.8962959	233.23	0.0000

CHAPTER III

Case Study II: Chittenden County MPO South Burlington, VT

3.1 Brief History

Chittenden County Metropolitan Planning Organization (CCMPO), is the transportation planning agency for the greater Burlington, Vermont, region and its 18 municipalities[10].

The CCMPO region encompasses about 145,000 people in the 18 municipalities of Chittenden County: Bolton, Burlington, Charlotte, Colchester, Essex, Essex Junction, Hinesburg, Huntington, Jericho, Milton, Richmond, St. George, Shelburne, South Burlington, Underhill, Westford, Williston, and Winooski. The region is home to about 25 percent of the state's population.

Each year, the CCMPO oversees about $30 million in transportation investments. It evaluates and approves proposed transportation improvement projects and provides a forum for interagency cooperation and public input into funding decisions. It also sponsors and conducts studies, assists local municipalities with planning activities, and develops and updates the County's long range transportation plan (known as the Metropolitan Transportation Plan). CCMPO is Vermont's only MPO.

Most important and larger municipality of CCMPO, is Burlington. Burlington municipality started as an important port in the 19th century and boasts a wealth of historic resources. It has long been commonly held that the town was named for the Earl of Burlington, though nobody could identify which of several Earls that might have been.

Incorporated as a city by act of the Legislature in 1864, the original town was split into what is now the City of Burlington and a new town of South Burlington. A portion of the original acreage had already been drawn off to form Williston city.

Two major state highways enter South Burlington (US 7 from the south and US 2 from the east), historically and still primarily carrying traffic into and out of Burlington. Because of the high traffic volume, both have been highly susceptible to major strip development. As a result, the city has two distinct and widely separated business districts, but nothing that can be identified as a

[10] Source: http://www.ccmpo.org/index.htm

"downtown" city center. What is considered the busiest intersection in the state is at the corner of Williston Road (Route 2) and Dorset Street.

In the late Seventies, several blocks of the main business district were converted to a pedestrian mall. Despite the development of malls and shopping parks elsewhere in the county, the Church Street Marketplace remains a thriving shopping and social center with numerous sidewalk cafes, specialty shops and reach cultural heritage[11].

Battery Street, near the waterfront and site of a ferry landing since the early 1800s, is known for its historic commercial and industrial buildings. More than 200 housing units in the King Street Neighborhood Historic District have been rehabilitated in recent years.

3.2 Geographic and Demographic Facts

Chittenden County is home of 146,571 residents (table 13), which represents 24.1 percent of the population of Vermont. In 1990, the county's resident population totaled 131,761 indicating an increase of 11.2 percent in a 10-year period and a 1.1 percent annual increase.

Table 13: Case Study II-Population number and percent of change

Area	2000	1990	Change('90-'00)	Percent of Change('90-'00)
Vermont	608,827	562,758	46,069	8.2%
Chittenden County	146,571	131,761	14,810	11.2%

Source: 2000 Census

Of the 146, 571 total county population in 2000, 23.5 percent were 18 year of age or younger (table 14). The age distribution of the county reflects the age distribution of the United States as a whole. The median age for 2000 for Chittenden County was 34.2 years compared to 37.7 years for Vermont and 35.5 for US population. Of the entire county population in 2000, persons

[11] www.virtualvermont.com

between the ages of 35 and 54 account for 32.1 percent, which is the group that encompasses the "baby boom" cohort. The 2000 count also indicates that 9.4 percent of the population is above 65 years old.

Table 14: Case Study II-Population Age Structure							
		Percent of total Population/age group					
Geographic Area	Total Population	0- 18 years	18-24 years	25-44 years	45-64 years	65+ years	Median Age
Vermont	608,827	24.2	9.3	29	24.8	12.7	37.7
Chittenden County	146,571	23.5	13.17	32.03	21.9	9.4	34.2

Source: 2000 Census

In terms of racial composition the area is predominately white and represent 96.3 percent of the total population. The "other" category as shown in table 13 includes Black or African American, Asian, Native or Hawaiian and other races. More detail information about the racial composition of the study area is provided by the General Demographic Profile Characteristics tables which are included in the appendix.

Table 15: Case Study II-Population Racial Composition			
Geographic Area	Total Population	%White	%Other
Vermont	608,827	96.8	3.2
Chittenden County	146,571	95.1	4.9

Source: 2000 Census

Table 16: Case Study II-Housing Occupancy			
Geographic Area	Total Housing Units	% Occupied housing units	%Vacant
Vermont	294,382	81.7	18.3
Chittenden County	58,846	95.9	4.1

Source: 2000 Census

Income Data

Table 17 shows the median household income (1997 model based estimate). Chittenden County median household income is way above the national and state average which indicates a wealthy economy and consequently a wealthy population.

Table 17: Case Study II-Income	
Geographic Area	Median Household Income
National	$37,005
Vermont	$35,210
Chittenden County	$46,747

Source: US Department of Commerce - Bureau of Economic Analysis; Market Statistics 2000

Employment

Chittenden County has become the nucleus of the economic activity of the state. In 1960's, 1970's and 1980's the area experienced great economic development and attracted companies from Switzerland, Germany and Toronto. Today there are over 101,000 Vermonters employed in the Burligthon labor market area and over 300 manufacturers located in business and industrial parks throughout Chittenden County. Following is a table showing the number of firms in the main economic sectors, which gives us an idea about the employment structure of study area.

Table 18: Case Study II-Chittenden County Employment Profile

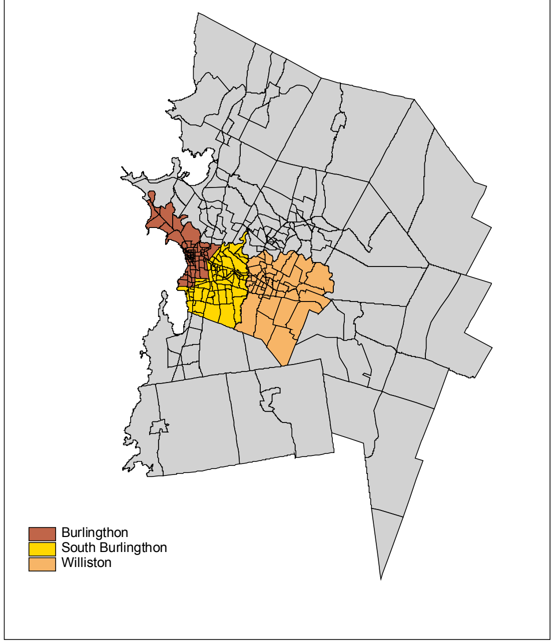
Sector employed	# of Firms	% Percentage
Agriculture, Forestry, Fishing	114	.5
Construction	612	4.5
Manufacturing	302	18.2
Transportation, Utilities	243	4.7
Trade	1776	22.6
Finance, Insurance, Real Estate	501	5
Services	2403	29.7
Government	278	14.4
Total	**6,229**	

Source: 2001 Chittenden County Plan

3.3 Calibration and Available Data

Following is description of the data provided by the Chittenden County Regional Planning Commission. This data was used to run calibration for DRAM and EMPAL.

Map16: Chittenden County Study Area



a. Zones

The study area of Chittenden County has 325 Transportation Analysis Zones and these zones will be the level of analysis from now on. Again for the purposes of the calibration process we had to assign new identification number for the 325 zones. Map 16 shows the study area and Transportation Analysis Zones (TAZ) that the area is divided. As mentioned above the most significant cities within the study area are Burlington, South Burlington and Williston which are shown also in map 16.

b. Households

The available household data is limited to the total number of households per zone. Map 17 and 19 shows the household distribution and household density respectively. The TAZs that belong to Burlington, South Burlington and Williston are the most densely populated. For the five-year period of 1993-1998, there is an increase of households by 17.1 percent. Map 18 shows the percent of change for each TAZ.

For calibration purposes the households were equally divided to four types or income groups. These groups are:

High Income Households

High Middle Income Households

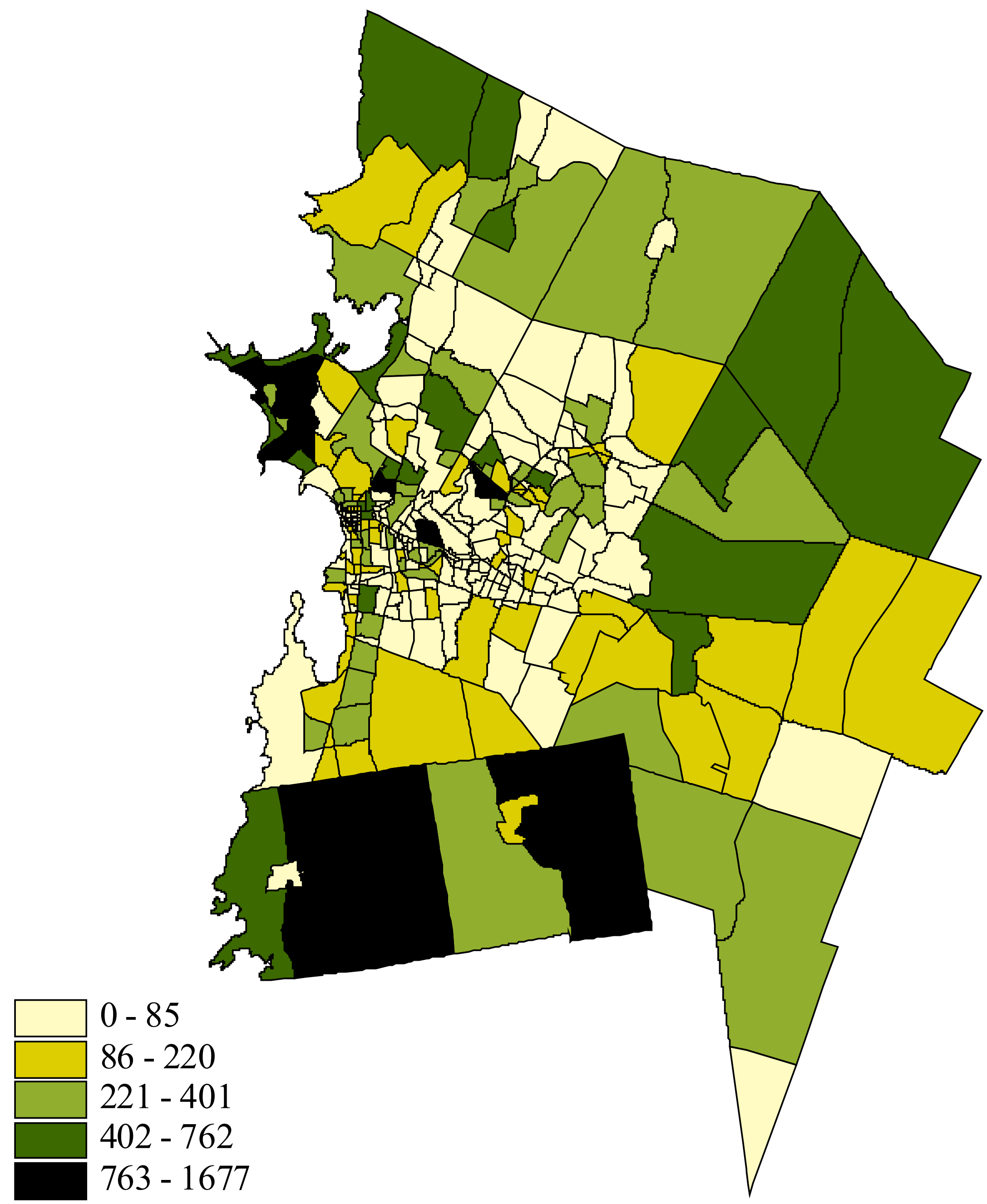
Low Middle Income Households

Low Income Households

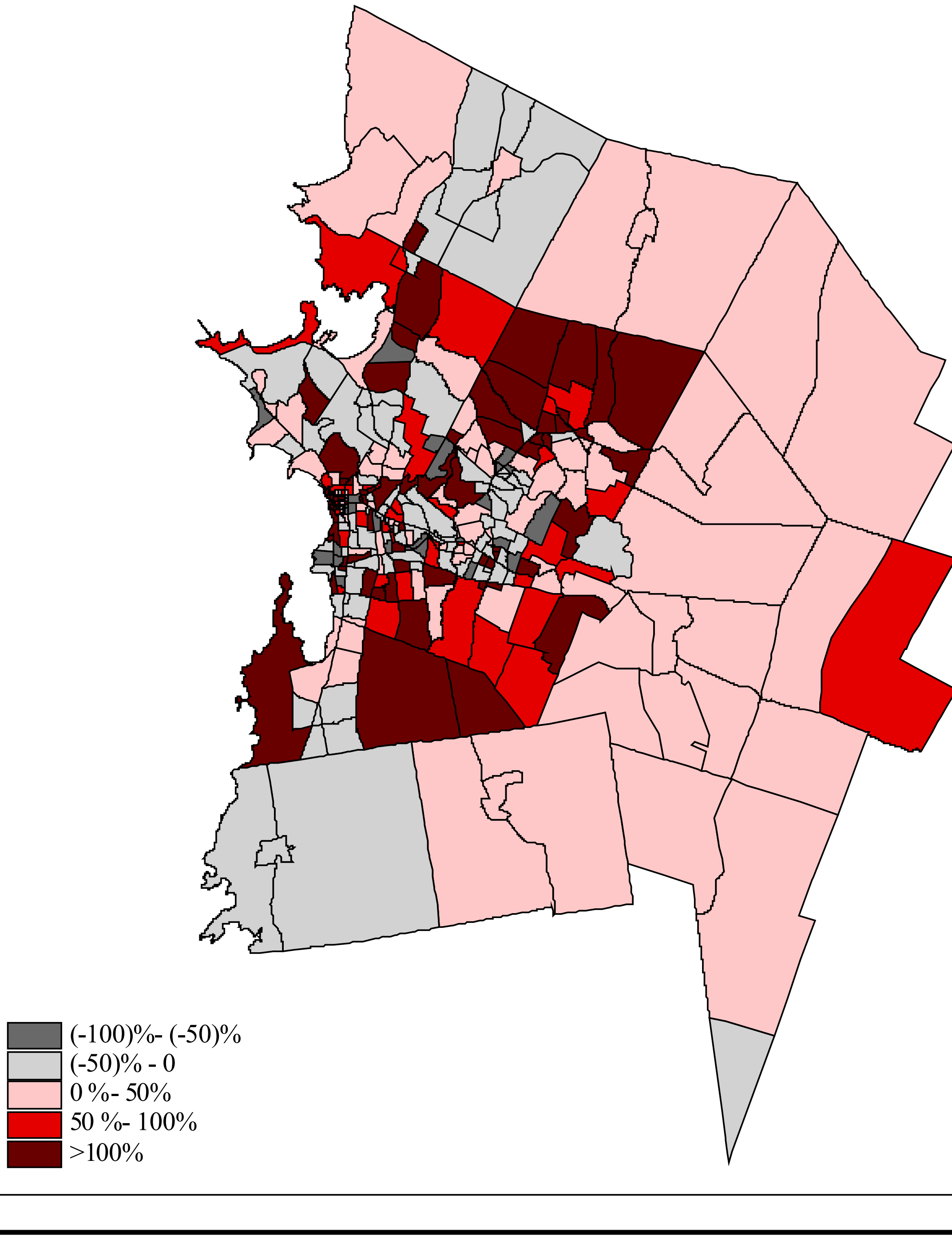
c. Employment

Total employment and employment by type is available, for each zone and for both 1993 and 1998. Total employment number for 1993 is 80,099. This number is distributed among the following six employment types: **Low, Medium Low, Medium High, High, School and Hotel**.

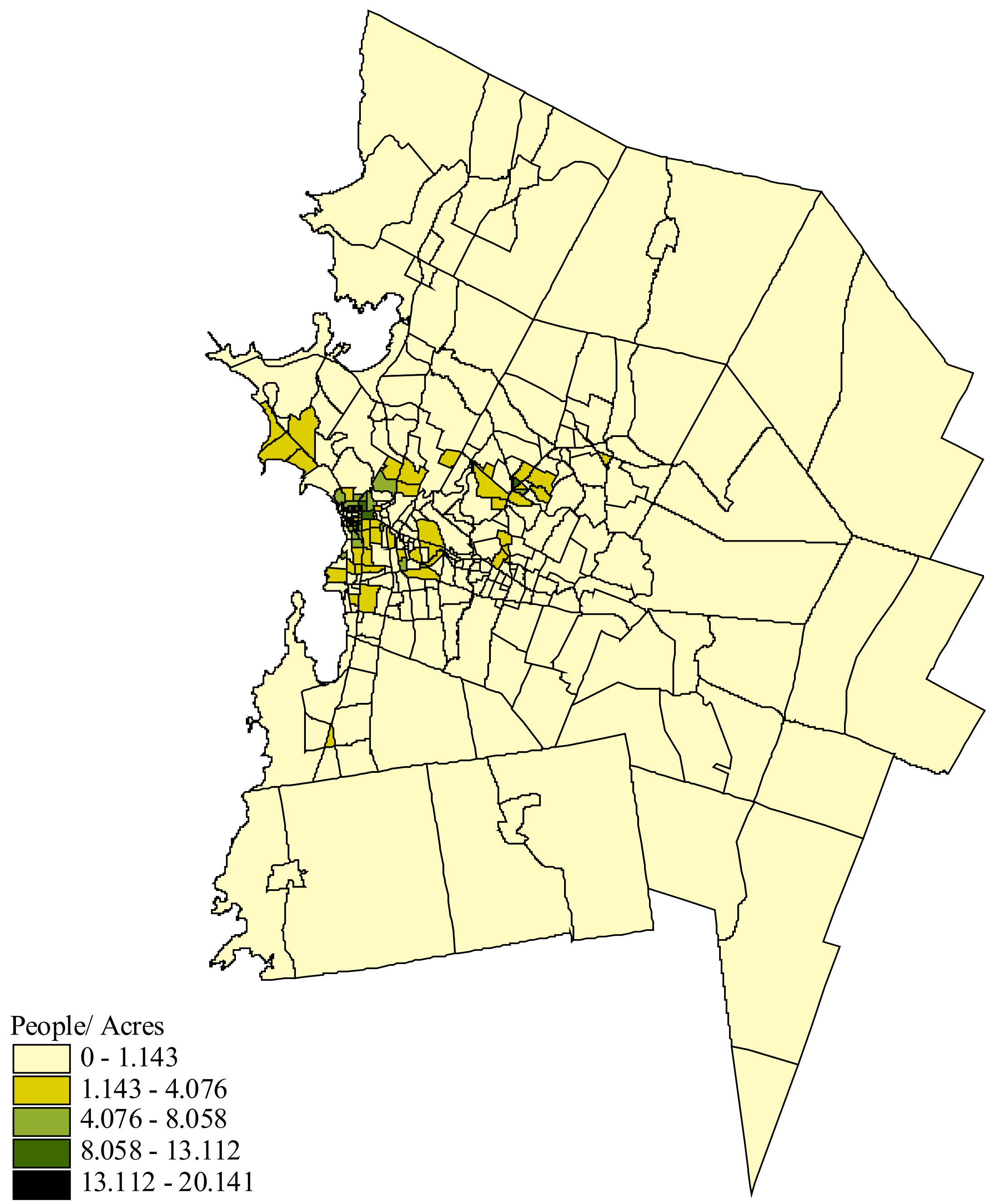
Map 17: Chittenden County-Household Distribution,1993



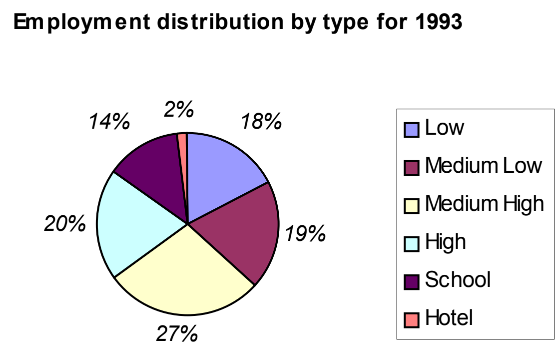
Map 18: Chittenden County-Household Percent Change,1993-1998



Map 19: Chittenden County-Household Density 1993

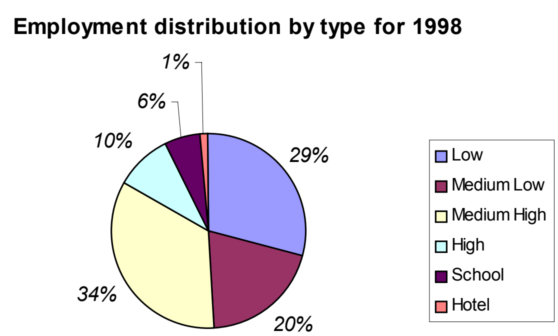


Each one of these categories was especially formulated for use in the Chittenden County Travel Demand Model and represents or includes certain SIC codes. The categorization of the SIC codes into the six employment types mentioned above was made in accordance to the trips that each SIC code generates. Table A in the appendix shows the exact SIC codes that each employment category represents.



The diagram shows the distribution of employment among the six sectors for 1993. Employment is mainly concentrated to the Medium High sector with 27 percent. Another big part of employment is distributed between the High and the Medium Low category, with 20 and 19 percent respectively. Map 20 shows the distribution of total employment among the TAZs. A comparison between the total employment for 1993 and the projected employment for 1998 shows that there is an increase of 11.5 percent within the five year period (89,288 employees). Map 21 shows the percent of change in total employment that each zone experienced. A series of maps (22,23,24) shows the distribution of each employment type in the study area for 1993.

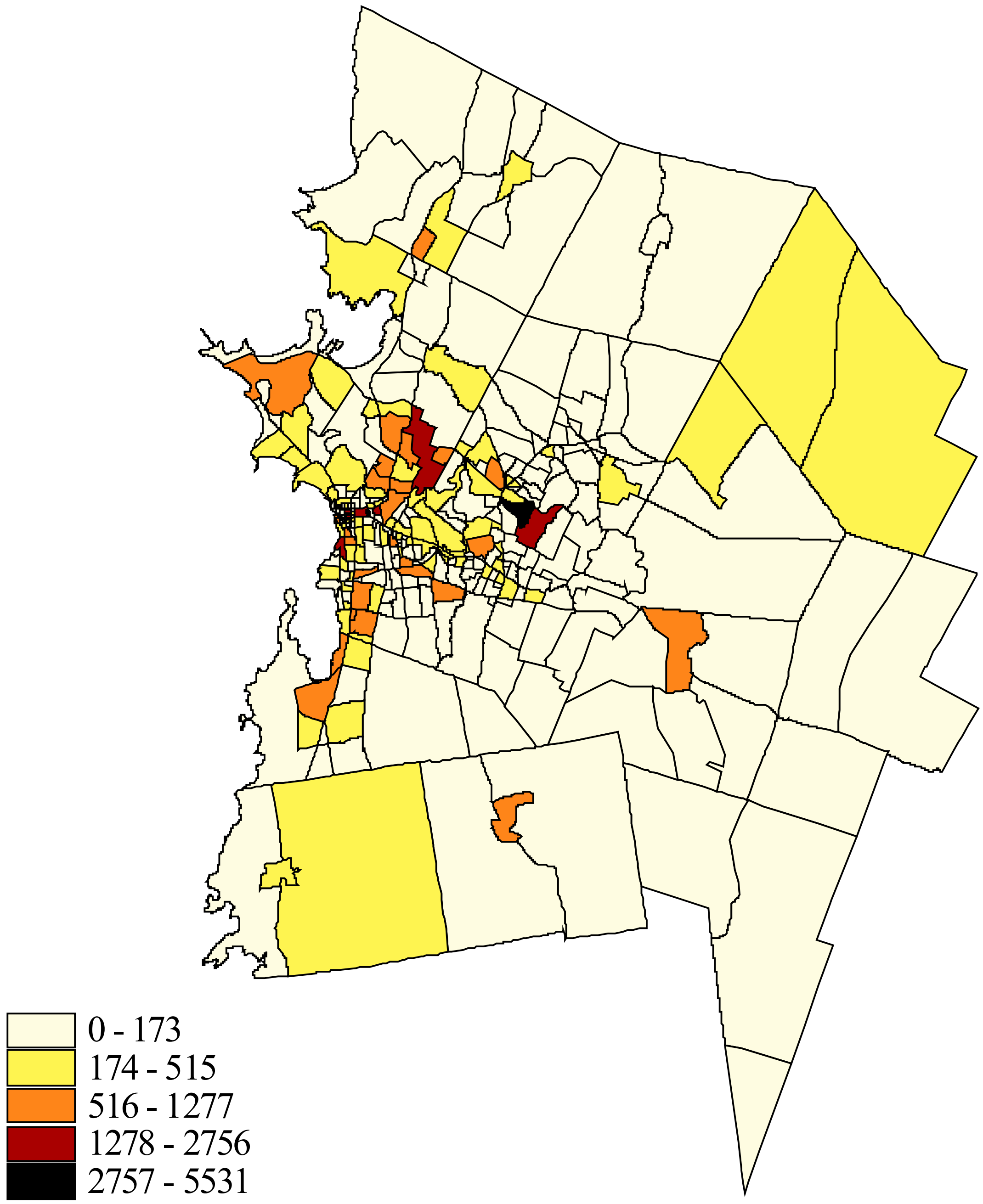
The distribution of employment between the different types changes dramatically in 1998. Low, Medium Low, and Medium High employment increase their share in contrast with High, School and Hotel which are loosing employees. Medium High employment sector is still the one that occupies the highest amount of employees. Map 25, 26, and 27 shows the changes in employment type that each zone experienced.



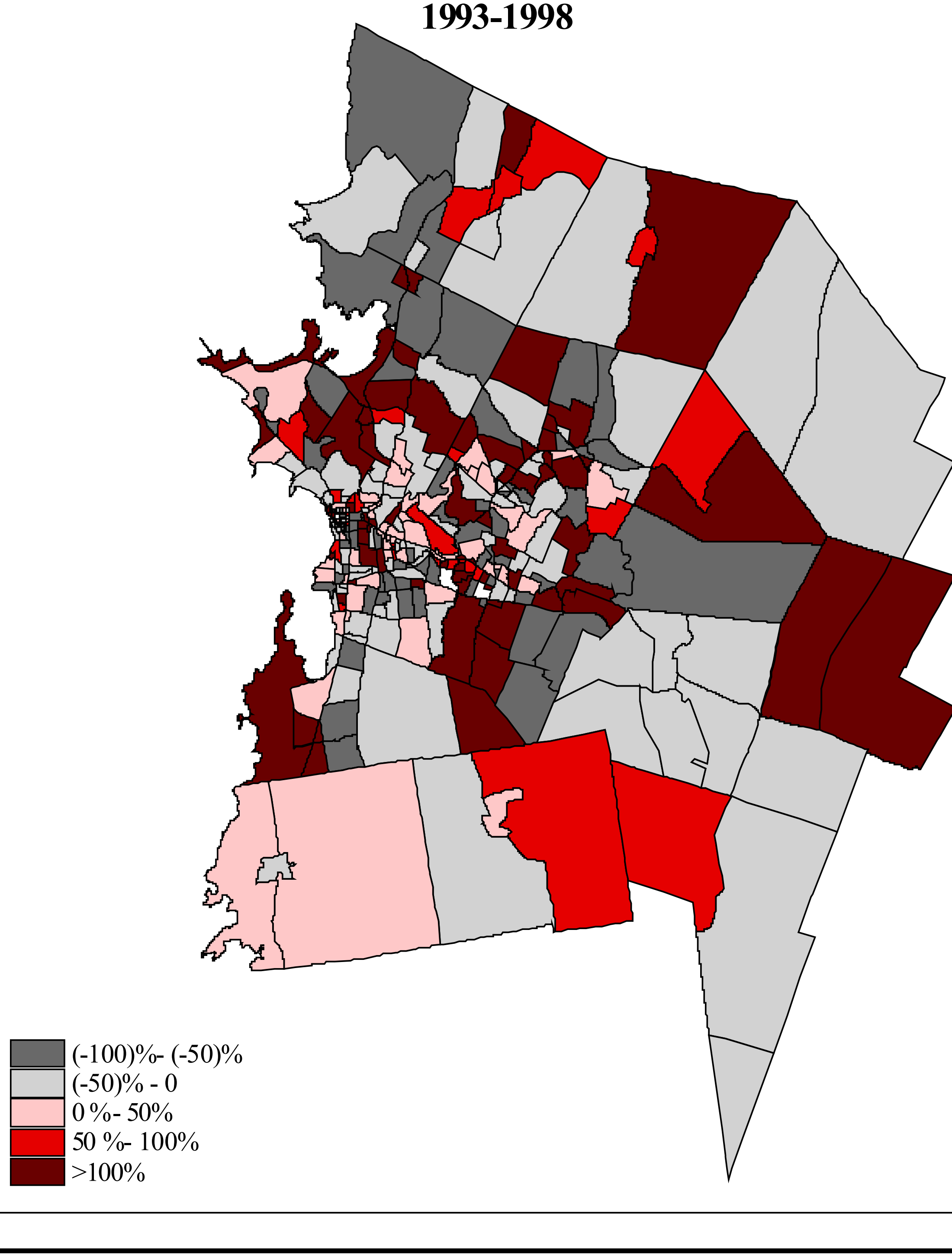
d. Land Use Data

Land Use data is not available for the study area.

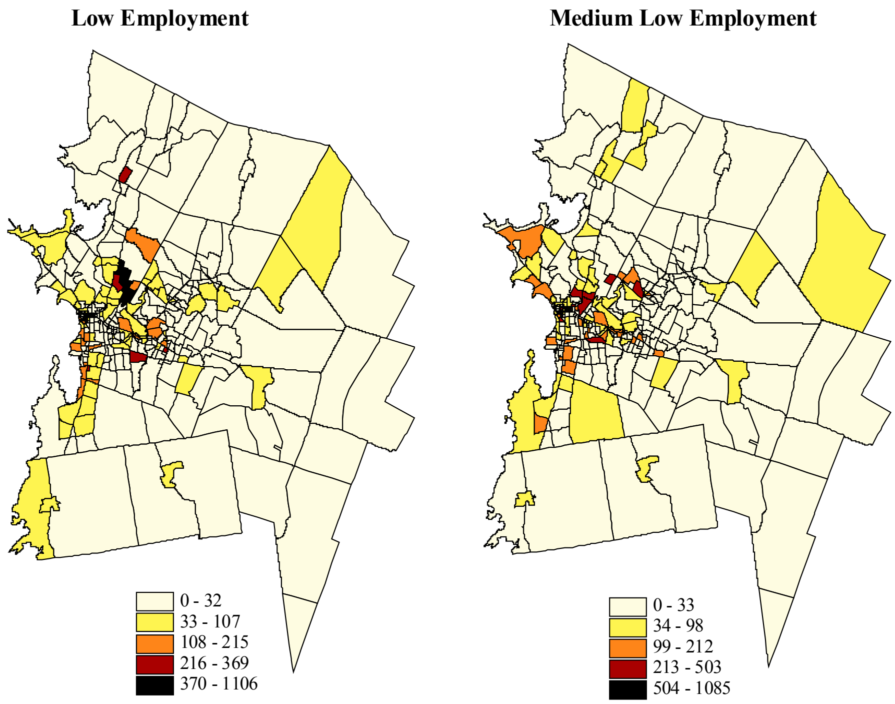
Map 20: Chittenden County-Employment Distribution,1993



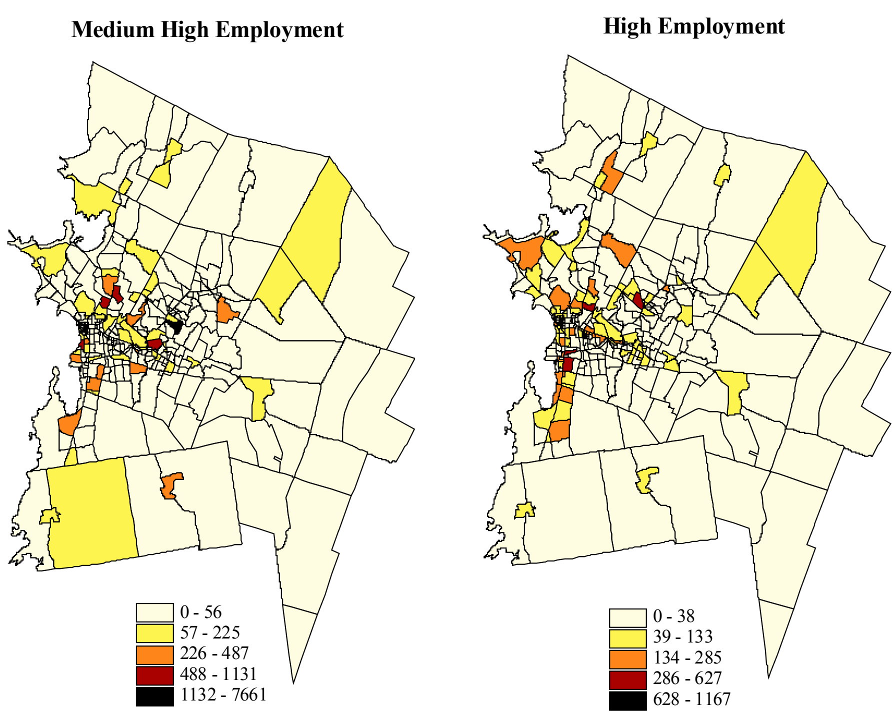
Map 21: Chittenden County- Total Employment Percent Change 1993-1998

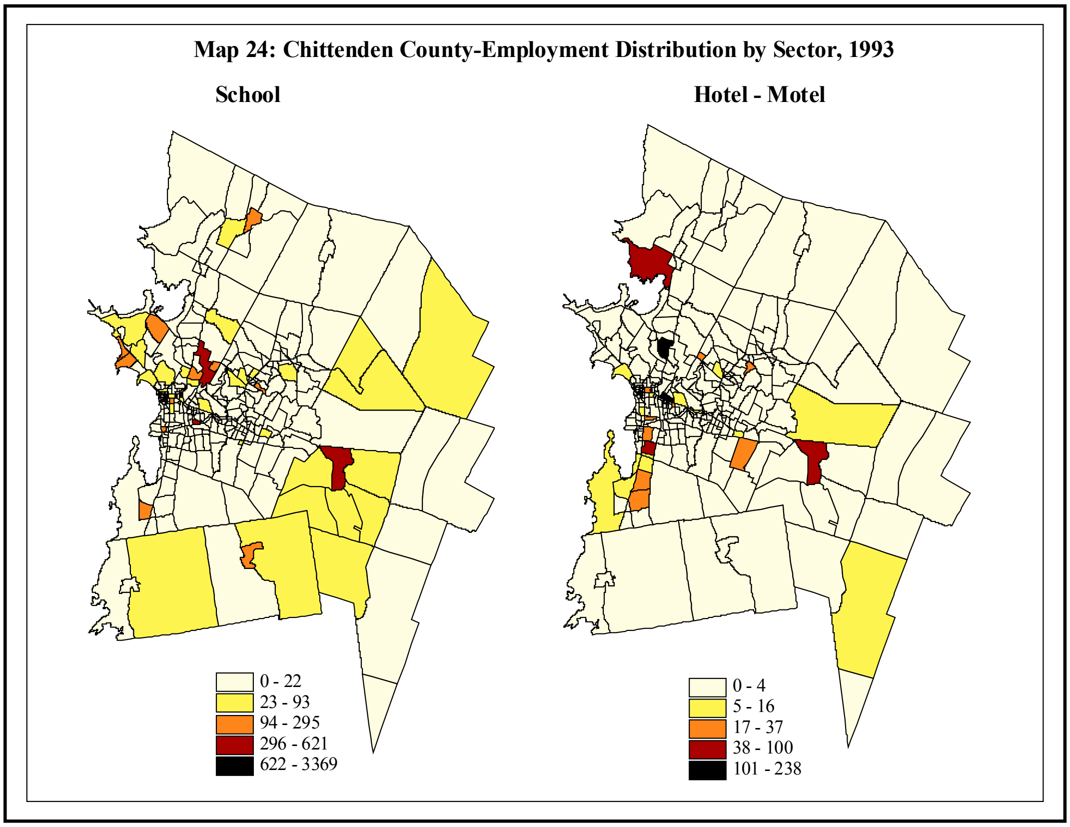


Map 22: Chittenden County-Employment Distribution by Sector, 1993

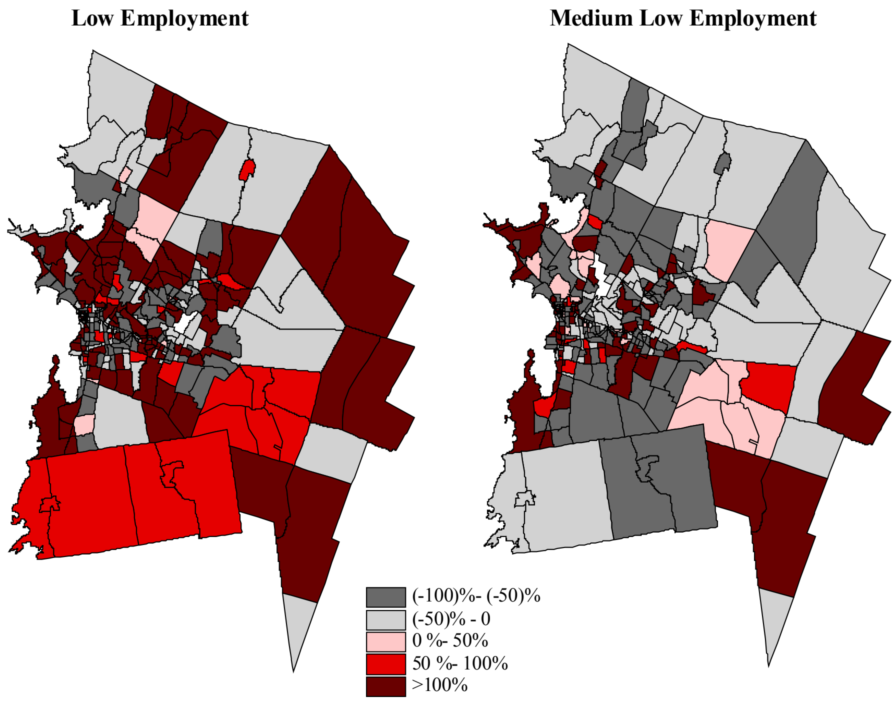


Map 23: Chittenden County-Employment Distribution by Sector, 1993

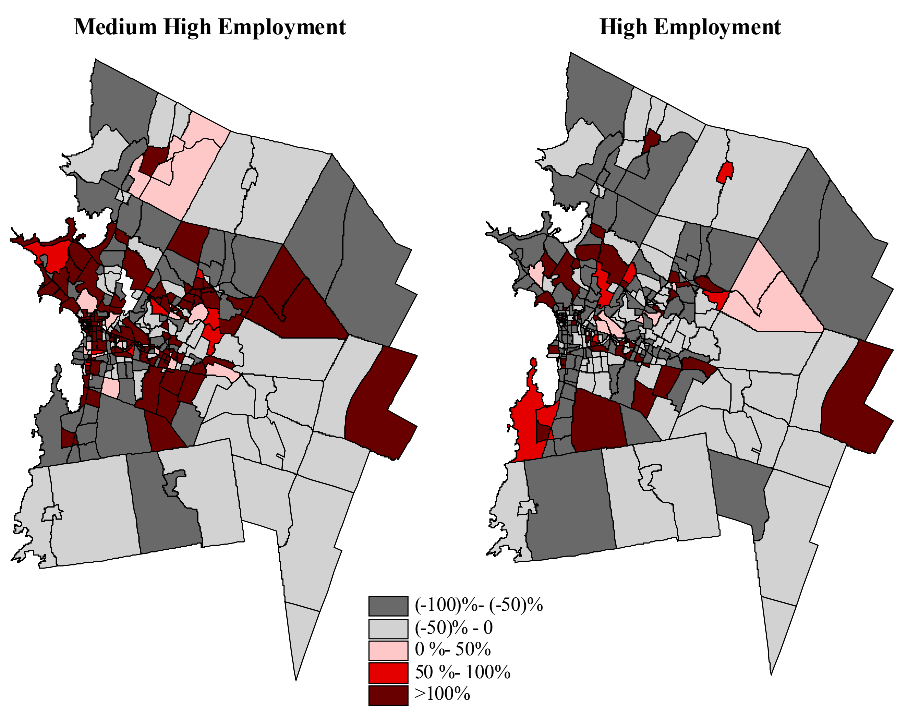



Map 24: Chittenden County-Employment Distribution by Sector, 1993
School
Hotel - Motel
0 - 22
23 - 93
94 - 295
296 - 621
622 - 3369
0 - 4
5 - 16
17 - 37
38 - 100
101 - 238

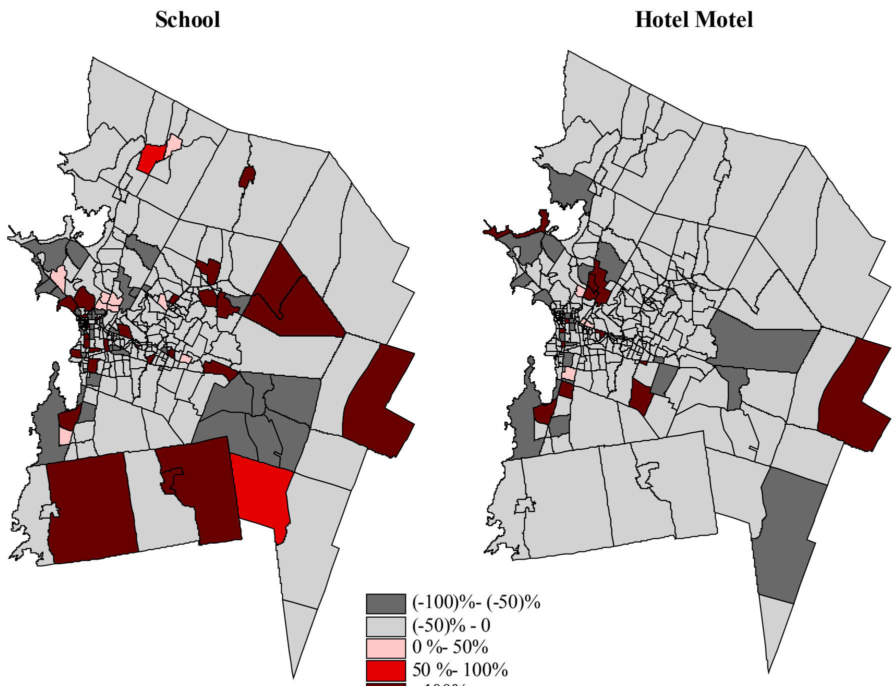
Map 25: Chittenden County-Employment Percent Change by Sector, 1993-1998



Map 26: Chittenden County-Employment Percent Change by Sector, 1993-1998



Map 27: Chittenden County-Employment Percent Change by Sector, 1993-1998



e. Zone to Zone Travel Time Cost

Travel time data is available. The travel time matrix contains zone to zone travel time (in minutes). Chittenden County Regional Planning Commission made this data available for the purposes of this research.

3.4 Calibration Runs and Results

For calibration of EMPAL it is necessary to have employment data by employment type and by zone for two time points five years apart. In this case the current time is taken to be year 1998 and the lagged time is taken to be 1993. The employment data is the only one that is required in two time points in the calibration of EMPAL.

For calibration of DRAM it is necessary to have employment data by employment type and by zone, for the current time point. EMPAL current year matches the DRAM current year, which in this case is the year 1998. It is also necessary to have household data for one time point that will match the current employment year. Household data is divided by type and zones. Usually we have 4 to 8 categories of household types. As in the previous case study we do not have a breakdown of households in different income categories but only total number of households in each zone. In order to be able to run calibration we divided the total number of households into four different categories by equally distribute households in each one of them. So the four different household types used in the calibration runs are:

- High Income Households
- High-Middle Income Households
- Low-Middle Income Households
- Low Income Households

And the five different employment types are:

- Low
- Medium Low
- Medium High
- High
- School
- Hotel

a. Employment Calibration Results

The measures of goodness of fit achieved from the calibration are not satisfactory. Following is the table showing a summary of the calibration results. The four indicators as described in chapter one of this report, are presented with their values.

Table 19: Case Study II-Goodness of Fit						
	Low	**Med_Low**	**Med_High**	**High**	**School**	**Hotel-Motel**
R-Square	.0167	.0610	.1010	.4100	.1570	.4264
B/W LR	.1049	.1955	.1707	.4291	.4376	.4684
MAPE	574.524%	417.750%	476.062%	153.495%	96.904%	56.717%
MARMO	99.897%	92.087%	83.682%	73.615%	65.306%	51.805%

R-Square and **B/W LR** are very low indicating that the employment data poorly fits EMPAL model. At the same time MAPE values are very high indicating that the estimated parameters for DRAM an EMPAL models equation does not represent the best-fit model. This is because the percentage of error between the observed and the models current best fit estimates for each one of the locator types are not within the acceptance range.

For the reasons explained in the previous case study a more detail examination of MAPE for the dataset was made. Following is values of MAPE for the smallest 25% and the largest 25% for each one of the employment types.

Table 20: Case Study II-Mean Absolute Percent Error (MAPE)						
	Low	**Med_Low**	**Med_High**	**High**	**School**	**Hotel-Motel**
Min Observed Value	1	1	1	1	1	1
Max Observed Value	5625	3072	1354	1244	572	312
MAPE for Smallest 25% of Zones	.000%	.000%	3670%	.000%	.000%	.000%
% of smallest zones of region total	.31%	.45%	.28%	.92%	1.52%	5.02%
MAPE for Largest 25% of Zones	62.73%	62.48%	50.47%	62.172%	196.84%	106.66%
% of largest zones of region total	92.42%	89.86%	81.46%	87.88%	95.41%	84.88%

Table 20 shows that in most of the employment types MAPE has values within the acceptance range at least for the 25% smallest zones. Exception is the case of Medium High employment sector were MAPE for the 25% smallest zones is 3,670%. To avoid misinterpretations MARMO was used as a more secure indicator. MARMO values, shown in table 19 are also very high indicating that the estimated parameters for DRAM and EMPAL models equation is not even close to the best fit model. The following table shows the estimated parameters for EMPAL equations.

Table 21: Case Study II- EMPAL Calibration results							
	α	β	**EMP**	**LAND**	λ	**1-λ**	**R^2**
Low	.0934	-.0541	.3040	.1778	1.0000	0	.0167
Med_Low	-.9996	.0202	.3538	-.0799	.9373	0.062	.0610
Med_High	-.2564	.0170	.1385	-.3214	.9740	0.026	.1010
High	.181839	-.210053	-.331482	-.251132	.2424	0.757	.4100
School	-.2712	.0164	.4925	.1333	1.0000	0	.1570
Hotel-Motel	-1.3166	-.0120	-.3855	-.2202	.3814	0.618	.4264

b. Household Calibration results

Because of the peculiarity of the household data we had to run calibration for DRAM just for one of the four income categories. The results are shown below.

Table 22: Case Study II- Goodness of Fit	
	Households
R-Square	.7497
B/W LR	.6990
MAPE	149.172%
MARMO	39.336%

Table 23: Case Study II- Mean Absolute Percent Error (MAPE)	
	Households
Min Observed Value	0
Max Observed Value	352
MAPE for Smallest 25% of Zones	614.583%
% of smallest zones of region total	.56%
MAPE for Largest 25% of Zones	30.792%
% of largest zones of region total	71.95%

Table 24: Case Study II- DRAM Estimated Parameter Values							
	α	β	**VACDEV**	**PERDEV**	**RESLND**	**LIHH***	**LAGHH**
Households	.9417	-1.2649	.6031	1.0075	.3680	.3680	.2510

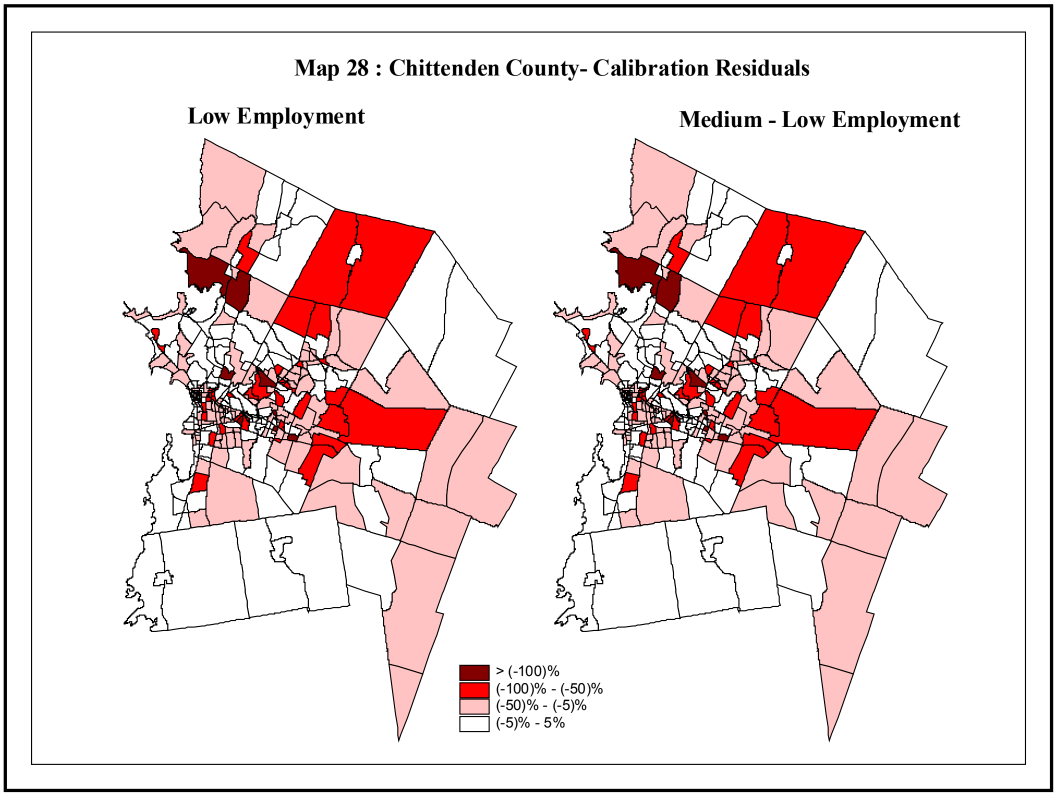
*the value is the same for all HH types that is why the rest of them are omitted from the table.

R-square and B/W LR shows that household data fits almost perfectly DRAM equations. MAPE on the other hand has a relative high value that is why a further analysis was needed. Analysis showed that MAPE value is inflated by the MAPE value of the 25 percent of the smallest zones, which is 614 percent as shown in table 23.

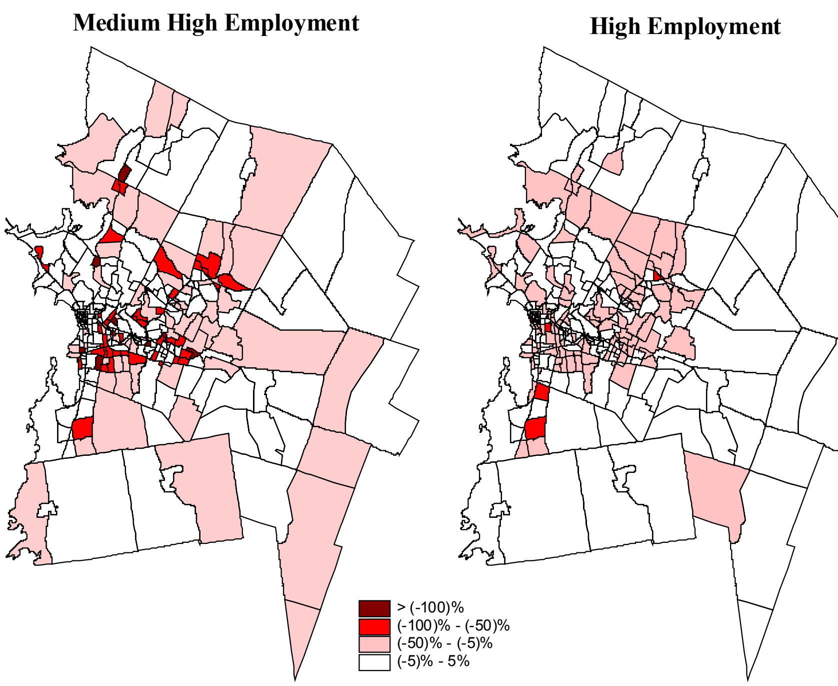
c. Calibration Residuals

As explained in the first case study, a more detail examination of the distribution of the residuals might give us a better idea about our data and the validity of the results. Map 28, 29, 30 and 31 shows the distribution of residuals for each one of the employment sectors and for households. As in the first case study the red color indicates that these zones have been overestimated by the indicating percentage. It is interesting to note that for all employment types and for households, all zones are overestimated and none of them is underestimated which indicates that in the calibration procedure there is a systematic pattern.

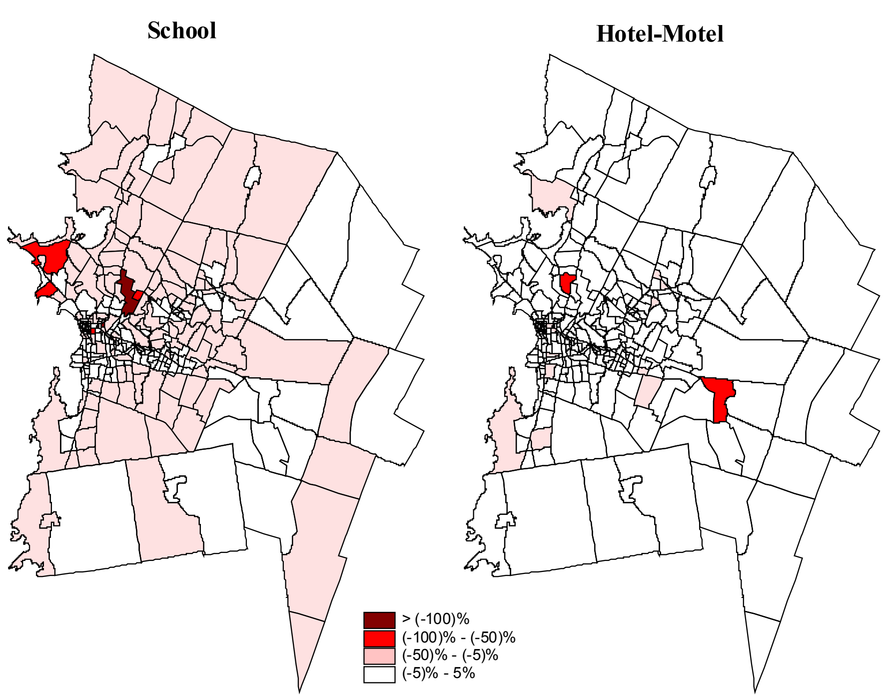
As explained before residuals indicate how accurate is the calibration and consequently how accurate is the forecasted population or employment values for each zone. The systematic pattern of overestimation employment and household values creates a lot of questions about the validity of our results. Also the fact that employment calibration results were really disappointing creates suspicions about the data used. For that a further examination of the household and employment distribution was necessary.



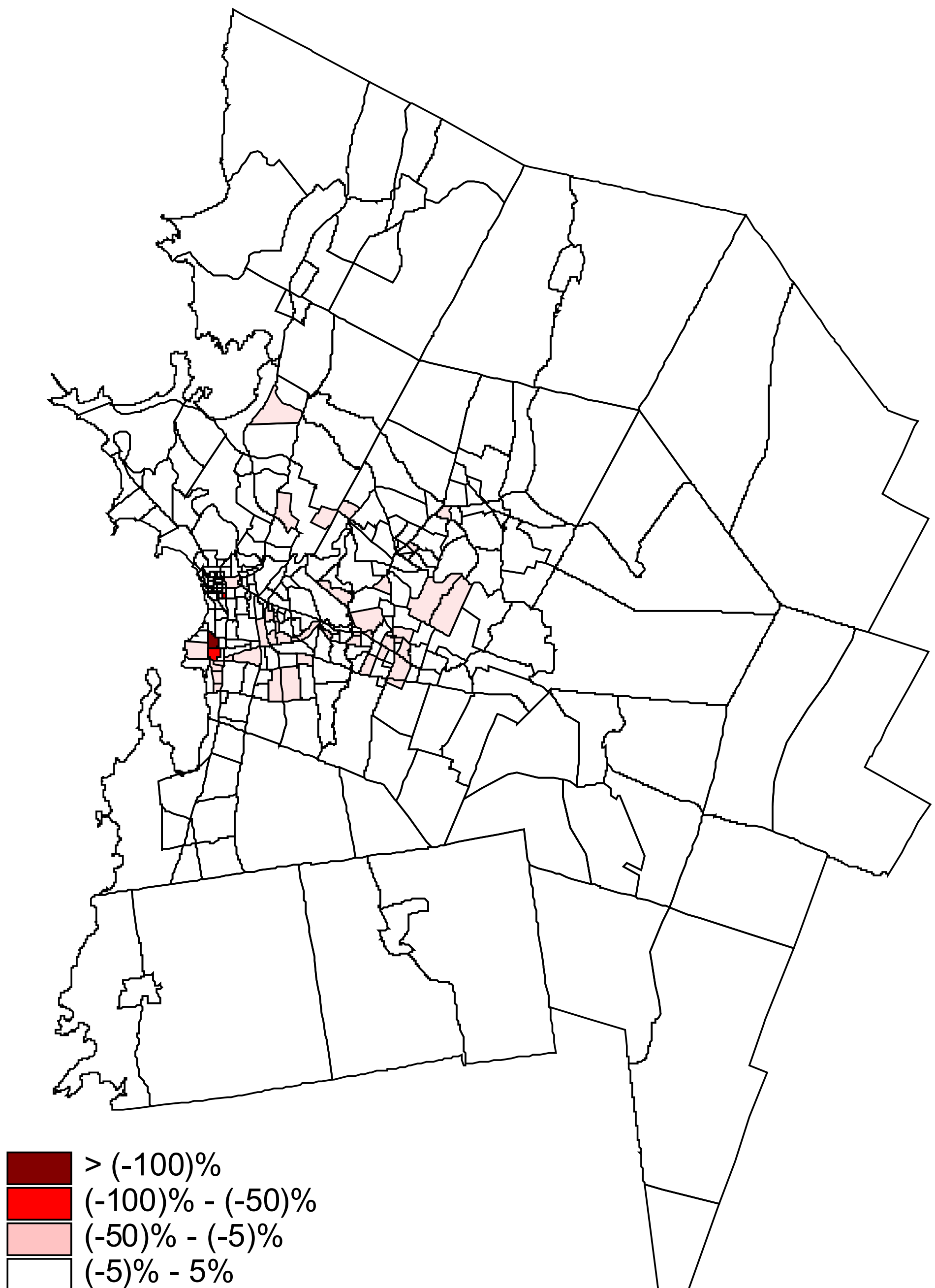
Map 29 : Chittenden County- Calibration Residuals



Map 30 : Chittenden County- Calibration Residuals



Map 31 : Chittenden County- Household Calibration Residuals



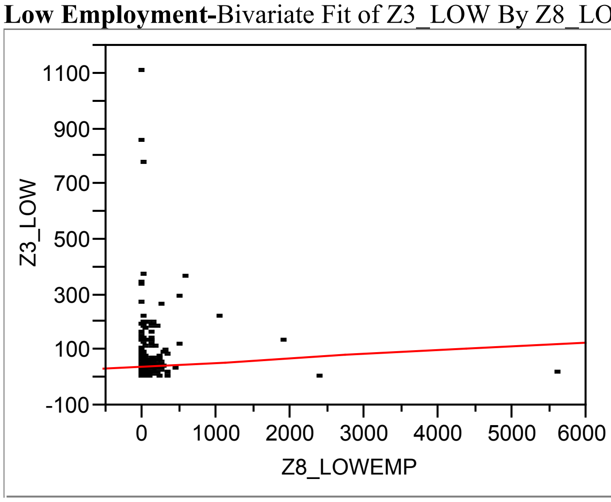
d. Validity of Household and Employment Projections

Following is a graph showing the relationship of Low Employment 1993 and Low employment 1998. In the five-year period 1993 to 1998 low employment sector experiences an increase of 84 percent. In many cases TAZs with zero low-employment in 1993 had very high numbers in 1998. This peculiarity creates the abnormal distribution that we see in the graph.

Similar to the low employment situation, is the situation with all six-employment sectors. A first evaluation might be that the projected 1998 employment numbers are not accurate. The accuracy of the number depends on the initial numbers (1993 numbers) and the projection method used. In this case it is most possible that the number for each employment type was created just by breaking down the total employment number for 1998, which also explains the much better calibration results for total employment and households.

For all these reasons the data is inadequate and cannot be used for the purposes of this research.

Low Employment-Bivariate Fit of Z3_LOW By Z8_LOWEMP



Linear Fit

Z3_LOW = 42.010277 + 0.0142605 Z8_LOWEMP

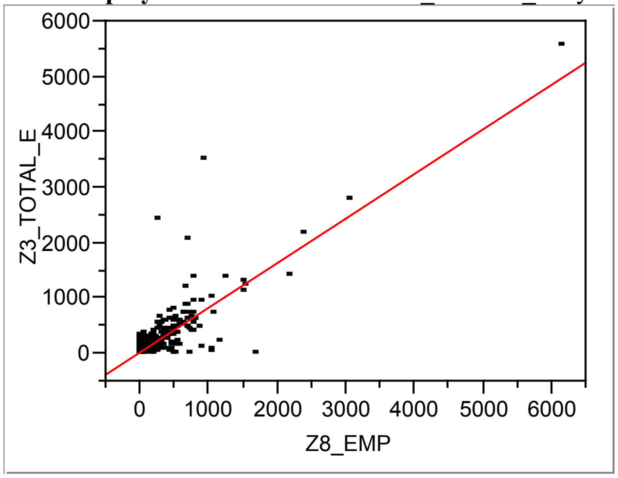
Summary of Fit

RSquare	0.002487
RSquare Adj	-0.0006
Root Mean Square Error	104.8422
Mean of Response	43.14769
Observations (or Sum Wgts)	325

Parameter Estimates

Term	Estimate	t Ratio	Prob>|t|
Intercept	42.010277	7.06	<.0001
Z8_LOWEMP	0.0142605	0.90	0.3702

Total employment-Bivariate Fit of Z3_TOTAL_E By Z8_EMP



Linear Fit

Z3_TOTAL_E = 25.202303 + 0.8053518 Z8_EMP

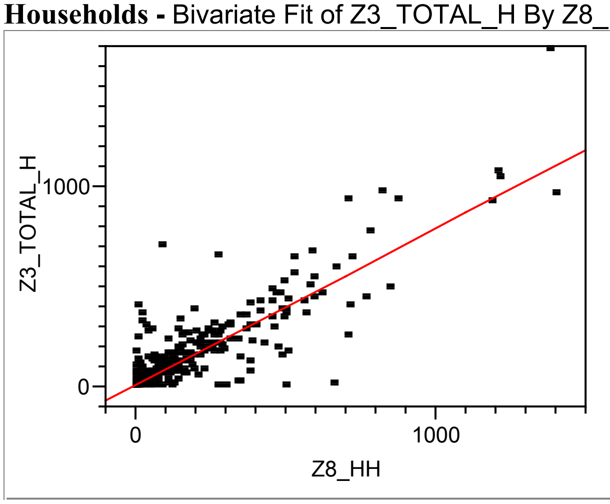
Summary of Fit

RSquare	0.672925
RSquare Adj	0.671912
Root Mean Square Error	281.9599
Mean of Response	246.4585
Observations (or Sum Wgts)	325

Parameter Estimates

Term	Estimate	t Ratio	Prob>|t|
Intercept	25.202303	1.41	0.1587
Z8_EMP	0.8053518	25.78	<.0001

Households - Bivariate Fit of Z3_TOTAL_H By Z8_HH



Linear Fit

Z3_TOTAL_H = 12.837621 + 0.779657 Z8_HH

Summary of Fit

RSquare	0.740282
RSquare Adj	0.739478
Root Mean Square Error	108.7235
Mean of Response	147.44
Observations (or Sum Wgts)	325

Parameter Estimates

Term	Estimate	t Ratio	Prob>|t|
Intercept	12.837621	1.71	0.0874
Z8_HH	0.779657	30.34	<.0001

CHAPTER IV

Conclusions

As mentioned in the introduction, the purpose of this research paper is to examine how computer transportation and land use simulation models can be used by middle-sized Metropolitan Planning Organizations (MPOs) to address their planning responsibilities.

In order to evaluate the current status of land use planning at various mid sized MPOs around the country, two MPOs were selected as case studies; Community Planning Association, Boise, ID and Chittenden County MPO South Burlington, VT.

TELUS Land Use Model (and METROPILUS model system) was used in order to evaluate and determine the ability of the selected MPOs to use such models in their land use planning procedures.

First step in forecasting future population and employment distribution with METROPILUS model system, is to fit DRAM and EMPAL models into the real world by estimating parameters for model's equation. These parameters are the ones that best fit the model and minimize the discrepancies between the model results and the real data. In this procedure (calibration process) the quality of the input data (household and employment) is extremely significant.

The data that this study used in both cases was collected and provided by the individual MPOs. Also both of MPOs did the socioeconomic forecasts. In more detail the Community Planning Association of Boise receives its socioeconomic forecasts from a local utility company which owns a land use model. Chittenden County MPO of South Burlington, utilizes a land use component of a Travel Demand Model-TDM to acquire population and employment forecasts.

It is understandable that there is no universal data i/o interface and that the data provided in both cases was customized to interact with TELUS land use model. Calibration results for both case studies showed that the quality of the data provided for analysis was **inappropriate** and **insufficient** to use with TELUS Land Use Model for future population and employment allocation.

It is obvious that the tested MPOs does not have the appropriate resources to meet the data requirements of TELUS Land Use model. The size of these organizations does not permit them to employee people with the expertise and knowledge to prepare and manage such complicated datasets and the related land use model systems.

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Web Sources

http://www.boisechamber.org

http://www.downtownboise.org

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APPENDIX

Table A: Chittenden County Travel Demand Model
Trip Generation Categories

by SIC

SIC Range		93 Land Use Category	98 Land Use Category	Description
1	999	commercial low	low	*agricultural*
1000	1499	industrial	low	*mining*
1500	1999	industrial	low	*construction*
2000	3999	industrial	low	*manufacturing*
4000	4099	industrial	low	*railroads*
4100 To	4299	industrial	Low	*buses, trucking, warehousing*
4300 To	4399	< 25 emps, retail >= 25 emps, commercial low	Medium High	US Postal Service
4400	4799	industrial	low	*non-highway transportation*
4800	4899	commercial low	low	*communications*
4900 To	4999	industrial	Low	*utilities*
5000 To	5199	commercial low	Medium Low	wholesale trade
5200 To	5249	retail	Medium High	building materials
5250 To	5269	retail	High	hardware stores, retail nurseries, garden supply
5270 To	5299	retail	Medium Low	mobile home dealers
5300 To	5329	retail	High	Department stores, big box retail
5330 To	5339	retail	Medium High	variety stores
5340 To	5419	retail	High	general merchandise
5420 To	5539	retail	Medium High	market, specialty food stores
5540 To	5549	retail	High	Gas service stations
5550 To	5599	retail	Medium Low	vehicle dealers
5600 To	5729	retail	Medium High	apparel stores, home stores
5730 To	5929	retail	High	music, electronics, computers, restaurants, drug stores, liquor
5930 To	5939	retail	Medium High	used merchandise
5940 To	5942	retail	High	sporting goods, bookshops
5943 To	5944	retail	Medium High	stationary, jewelery
5945 To	5946	retail	High	hobby, toy, game, camera stores

5947 To	5959	retail	Medium High	gift, novelties, luggage, sewing
5961 To	5989	retail	Medium Low	non-store retailers, fuel dealers
5990 To	5999	retail	Medium High	other retail, not elsewhere classified
6000	6199	<25 emps, retail >=25 emps, commercial low	Medium Low	*banking and credit agencies*
6200	6999	<25 emps, comm. high >=25 emps, commercial low	Medium Low	*other financial, insurance, & real estate*
7000 To	7011	hotel/motel	Medium High	*hotels and motels*
7012	7199	hotel/motel	Medium Low	*hotels and motels*
7200 To	7999	commercial high	Medium Low	*other lodging places, misc business services*
8000	8049	commercial high	medium high	*medical offices*
8050	8069	institutional	medium high	*hospitals, nursing homes*
8070	8079	commercial low	medium high	*medical labs*
8080	8099	commercial high	medium high	*outpatient facilities*
8100 To	8199	commercial low	Medium High	health services
8200	8219	institutional	high	elementary schools
8220 To	8229	institutional	High	Elem & Sec schools / College & University
8230	8239	retail	medium high	libraries
8240 To	8299	institutional	Medium High	other educational
8330 To	8349	commercial high	Medium High	social services
8350 To	8359	retail	High	day care
8360	8389	institutional	medium high	*residential day care facilities*
8390 To	8399	commercial high	Medium High	social services
8400	8599	commercial high	medium low	*museums and galleries*
8600	8799	commercial low	medium low	*membership organizations*
8800	8899	commercial low	medium low	*private households*
8900	8999	commercial low	medium low	*misc. services*
9000	9899	commercial high	medium low	*government*
9900 To	9999	non-classified	Medium Low	*non-classified*