studies, urban development analysis, and planning and evaluation of public services. However, the analysis of UTPP data indicates a few programming, statistical, and bias problems. Most of these problems were resolved before DVRPC used the UTPP as a data base for trend analysis, information purposes, traffic simulation, highway and transit project studies, strategic planning, and economic development. The errors in the 1980 data are generally smaller than those found in the 1970 UTPP.

Unlike the 1970 trips, the 1980 trip destinations were assigned or coded to block groups and tracts, and no effort by DVRPC was needed to develop or apply a procedure to allocate the uncoded trips. However, employment or trip information should be adjusted before it is used in transportation planning studies because it does not include all workers or jobs.

Most of the 1980 UTPP problems and errors can be avoided in the 1990 census by quality control edits and a careful review of the census questionnaire, sample size, and the computer programs required for processing the information. Specifically, the journey-to-work questions should be simplified to prevent any confusion on the part of respondents on such questions as mode of travel and industry classification. Many confused the access mode to subway-elevated or railroad lines with the principal mode of travel. The questionnaire should be redesigned to capture multimodal trip information from the place of residence to the place of work. It should also simplify the SIC categories to avoid any error or misunderstanding in the employment sectors.

The sample size (8.3 percent) for coding work-trip destinations should be increased 100 percent, as originally planned, to improve the quality of the trip matrix used to calibrate trip distribution models for travel forecasting and projection.

The format of the 1980 UTPP tapes is quite complex, and the print program is not operational for the Delaware Valley region. This caused extensive delays in extracting the UTPP data. Finally, DVRPC received the UTPP almost 4 years after the data had been collected; a more timely release of data is obviously important to all census data users.

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The author is responsible for the findings and conclusions in this paper, which may not represent the official view or policies of the funding agencies.

Uses of the Urban Transportation Planning Package from the 1980 Census in the Denver-Boulder Region

DAVID L. KURTH

ABSTRACT

The initial uses of the Urban Transportation Planning Package in the Denver-Boulder region are described. The five main purposes for which the data have been used are presented. The processes used to analyze the data, the results obtained, difficulties encountered with using the data, and solutions to those difficulties are discussed. Where possible, comparisons with results of the 1970 census or previous travel surveys are presented. Finally, some comments are made about the quality of the data and their usefulness in the Denver-Boulder region.

The Urban Transportation Planning Package (UTPP) from the 1980 census is a valuable source of detailed information for transportation planners. There are many possible uses of the data including, for example, recalibration and validation of various portions of regional transportation models, carpool planning, bus service planning, high-occupancy-vehicle (HOV) lane planning, and bicycle planning.

The initial uses of the UTPP data in the Denver metropolitan area are presented. As of June 1984, the data had been available to transportation planners in the Denver area for 8 months and had been used for five main purposes:

1. Adjustment of socioeconomic distributions used in the regional trip generation model,
2. Validation of the work-trip distribution model for the Denver urbanized area,
3. Calibration of a subarea model outside of the Denver urbanized area,
4. Special transit studies, and
5. Sales to developers and market research firms.

In addition, several of the tabulations were printed and have been used to answer basic questions about commuting in the Denver region [e.g., What percentage of the workers in the Denver central business district (CBD) live within the city of Denver?] Each of the five main purposes will be discussed in greater detail in order to present how the data have been used, the processes used to analyze the data, difficulties encountered with the data, and solutions to those difficulties. Some final comments will be made about the quality of the data and their usefulness in Denver.

The Denver Regional Council of Governments (DRCOG) made the decision to purchase the UTPP data in early 1983. The decision was based in part on the need to recalibrate the regional travel model. The UTPP data will be supplemented by a small-scale travel survey taken in the fall of 1984.

The area covered by the regional travel model for the Denver-Boulder Standard Metropolitan Statistical Area (SMSA) is shown in Figure 1. Separate travel models are now maintained for the other urbanized areas, Boulder and Longmont, in the Denver-Boulder SMSA. Because the Bureau of the Census required that UTPP data be acquired for the entire SMSA, the 589 traffic zones included in the Denver travel modeling area had to be augmented to include Boulder, Longmont, some nonurbanized parts of Adams, Arapahoe, and Boulder counties, Douglas County, and Gilpin County. A total of 794 traffic zones were defined for the entire SMSA.

The extra work required to define traffic zones outside of the Denver modeling area has already been beneficial. Three of the main uses of the data covered in this paper have required the extra data.

ADJUSTMENT OF SOCIOECONOMIC INPUTS TO TRIP GENERATION

Once preliminary checks indicated that the UTPP data were consistent and reasonable, they were used to recalibrate portions of the regional trip generation model. The DRCOG trip generation model is a household-based cross-classification model stratified by income group and household size. Population and households by income category are exogenously forecast for each traffic zone, and two submodels are used to convert these exogenously forecast data to a joint distribution of households stratified by income group and household size.

The first submodel uses the average household size of a zone to estimate the percentage of households by size in the zone (1,2). The model was originally calibrated using 1970 census data [see Figure 2 (3,Table H-1)]. In order to update the model, data from UTPP tabulation I-9, size of household, were used to develop a scatterplot of percentage of total households versus average household size. The Statistical Analysis System (SAS) was used to simplify this work. The only intermediate processing required was the aggregation of households of five, six, and seven and more persons into households of five and more persons and the conversion of absolute households by size to percentage of total households by size.

The raw results of this submodel recalibration for one-person households are shown in Figure 3. Curves were hand fit through each of scatterplots and adjusted to satisfy two criteria:

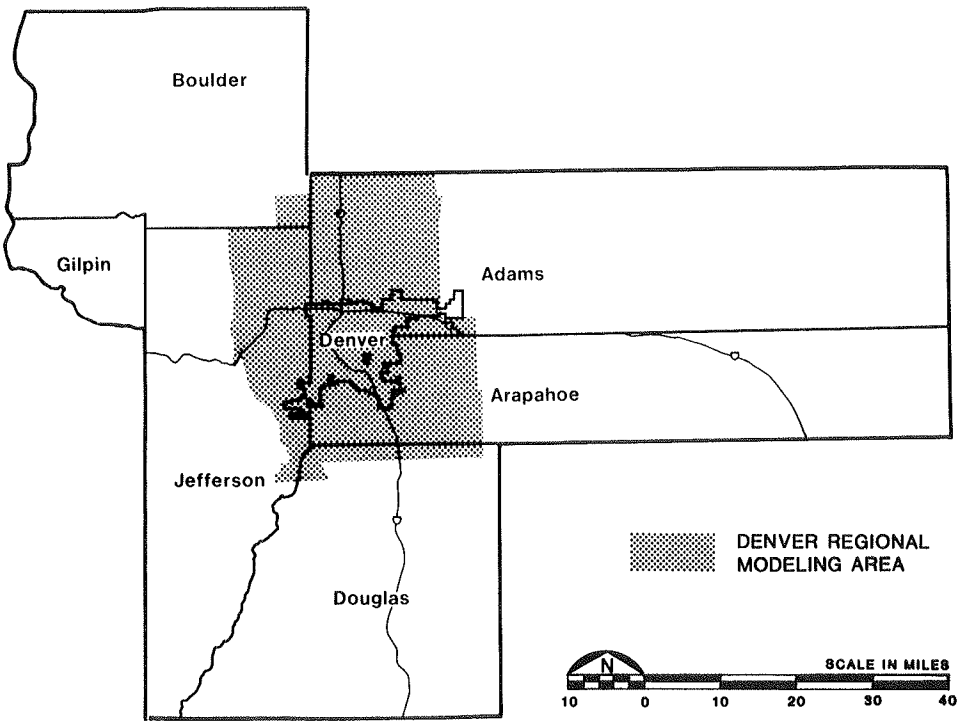

FIGURE 1 Denver-Boulder SMSA.

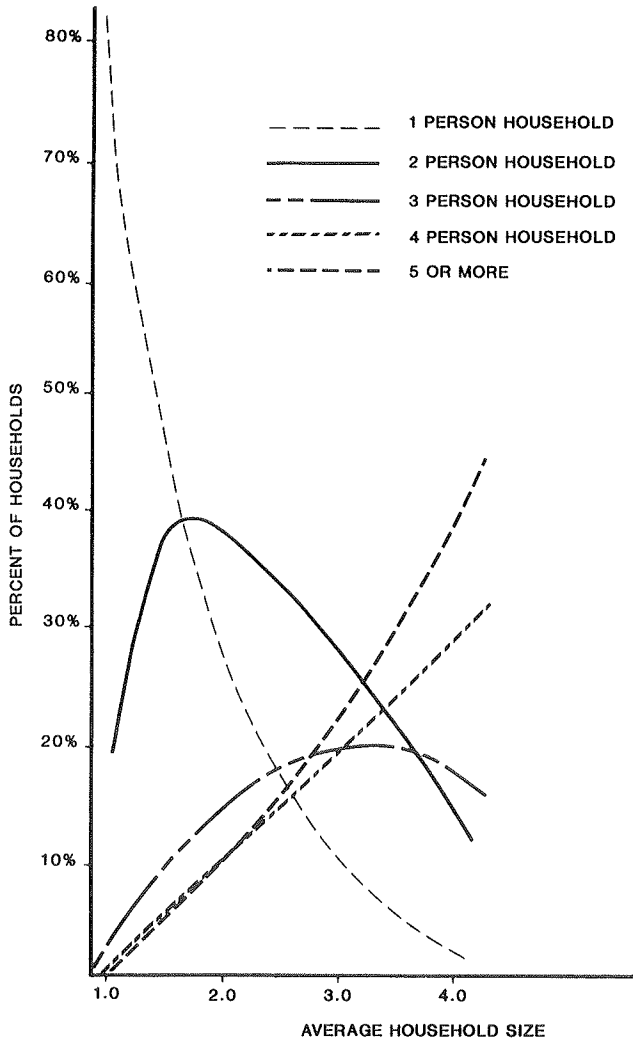

FIGURE 2 Distribution of households by average household size (*3*, Table H-1).

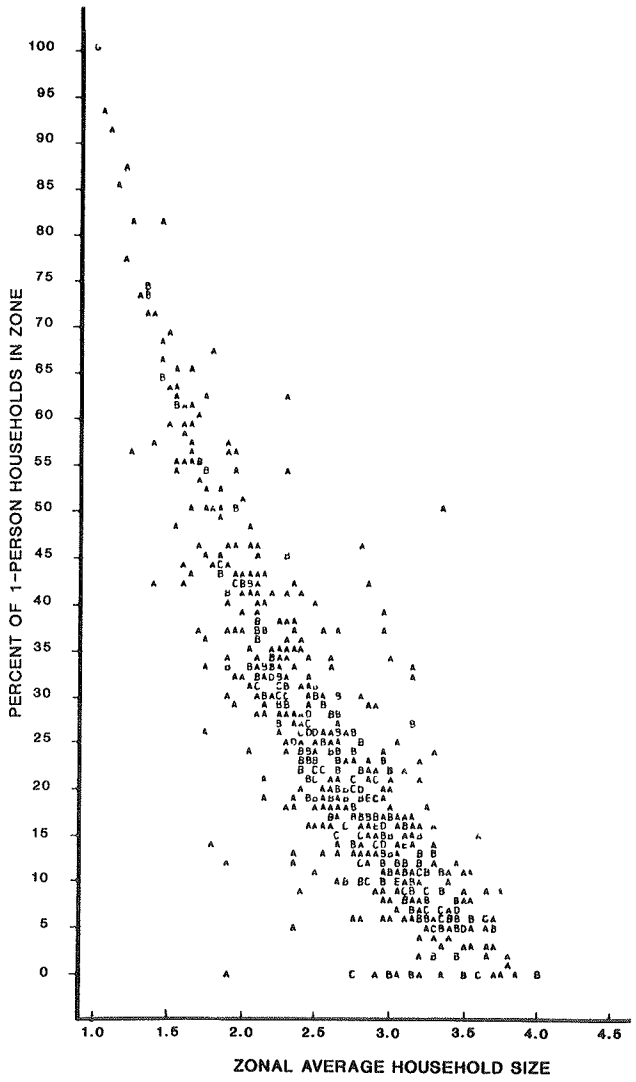

FIGURE 3 Percentage of one-person households versus average household size.

1. The sum of the percentage of households for all household sizes had to equal 100 for each average household size and
2. The average household size that results at each point has to be accurate.

The second criterion is not necessarily obvious (and, in fact, was violated in the submodel based on 1970 census data). For example, suppose that the average household size for a zone was 2.6 and that there are 100 households in the zone. From Figure 2, the following households and persons by household size might result (the average household size for households of five and more is 5.56):

Household Size	Percentage of Households	No. of Households	No. of People
1	19	19	19
2	32	32	64
3	18	18	54
4	15	15	60
5+	16	16	89
		100	286

Obviously, the resulting average household size is 2.86, not 2.6 as was originally input. The results of this submodel recalibration are shown in Figure 4. It is interesting to note the similarity in the shapes of the curves based on 1970 and 1980 data. Although the curves are not identical, their similarity implies a high degree of stability in this submodel over the past 10 years.

The only problems encountered with the UTPP data in this work were occasional illogical average household sizes. As a check of the data, the average household size of five-plus persons was computed from the reported total households, the reported average household size, and the reported one-, two-, three-, and four-persons households. This test showed that about 17 percent of the households with five-plus persons had an average household size of less than five. Although this is an illogical result, the effect on the submodel calibration was minimal because substantial smoothing of the curves was required to satisfy the second criterion listed earlier.

The second submodel is a Fratar or marginal weighting (4) procedure to adjust the regional joint distribution of households by income group and household size to match the marginal distributions of household by income group and households by household size for each zone. As with the first

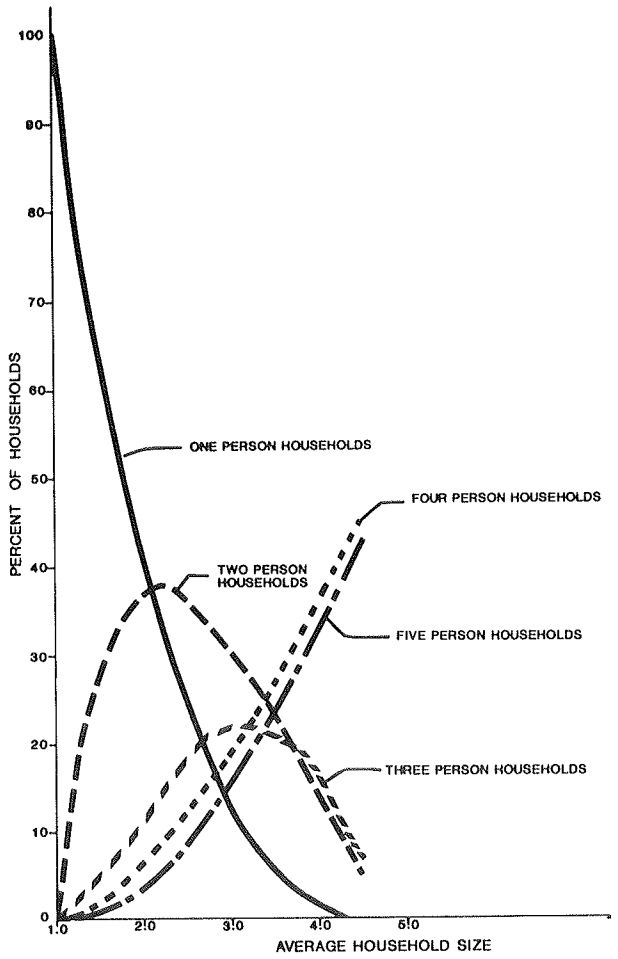

FIGURE 4 Percentage of households by average household size: 1980 UTPP data.

submodel, the input regional joint distribution was based on 1970 census data. Data from UTPP tabulation I-11, household income, were summarized for the region directly from the standard UTPP report. Some interpolation of the standard income ranges used in the UTPP was required to obtain the desired marginal distribution of percentage of households by income group.

The joint distribution from the 1980 UTPP can be compared with the original joint distribution from the 1970 census (Table 1). Through comparison of these two distributions, it is possible to see some of the socioeconomic changes that occurred in the Denver region between 1970 and 1980, especially the increase in one- and two-person households and decrease in larger households. The data appear to be reasonable and confirm the trend in decreasing household size thought to have occurred in Denver in the 1970s.

VALIDATION OF THE WORK-TRIP DISTRIBUTION MODEL

The work-trip distribution model was calibrated in 1975 based on 1971 travel survey data. Recently, some questions as to the accuracy and applicability of the work-trip distribution model have been raised by local decision makers. Some of the questions arose because of a misunderstanding of the basic travel forecasting process: Observed trip tables are required for travel forecasting. Other questions

TABLE 1 Distribution of Households by Household Size and Income Group

Income Category	Percentage of Households by Household Size					Total
	1	2	3	4	5+	
1980 Census Data						
1	9	3	1	1	1	15
2	10	8	3	2	2	25
3	6	16	9	9	6	45
4	1	5	3	3	3	15
Total	25	32	17	15	11	
1970 Census Data						
1	7	4	2	1	1	15
2	6	8	4	3	4	25
3	5	12	7	10	11	45
4	1	4	3	3	4	15
Total	19	28	16	17	20	

were raised for valid reasons, for example, The area has been through two major fuel shortages since 1971, so how do we know that 1971 travel-making characteristics still hold in 1984?

In order to test the validity of the work-trip distribution model, a trip-length frequency distribution comparison was made of the trip table from UTPP tabulation IV-1 and the regionally modeled trip table for 1980. Also direct comparison was made between the two trip tables squeezed to 38 districts. These comparisons were facilitated through the conversion of the UTPP data to the Urban Transportation Planning System (UTPS) J-tape or matrix format. In addition, work trips by bicycle, walk only, and other means were removed from the UTPP trip table during the reformatting process. This work was done to make the UTPP data compatible with and accessible to UTPS programs. A simple FORTRAN program was written to perform the conversion of the UTPP trip tables; the UTPS program MBUILD could have been used to convert the data, but the special form of the UTPP data made it easier to use a simple FORTRAN program to do this work.

Once the UTPP data had been converted to UTPS matrix format, it was necessary to factor the UTPP trip tables and the modeled work-trip tables for 1980 to a common total. The work trips, as reported in the UTPP data, were used as the control total. This was done in order to compare observed work trips.

The choice of the UTPP trip total has no effect on the results, because trip patterns, not trip generation, are being compared. However, it is interesting to note the factor by which the modeled trip tables were multipled. Each interchange in the modeled trip table was multiplied by 0.59, so that the total productions modeled were equal to the total UTPP productions. Assuming that about 15 percent of the workers in the region do not make a work trip on a given day, either because of sickness or because they work on weekends, and assuming a factor of 1.92 to convert journey-to-work data to production-attraction data normally used in transportation models, the 0.59 factor implies that the trip generation is very reasonable (5). This is because the UTPP data summarize only one-way trips made by the average worker, whereas the regional model summarizes two-way trips made on the average work day.

Figure 5 shows the trip-length frequency distribution comparison. All home-based trips made by automobile or transit are represented in the trip-length frequency distributions even though modeled

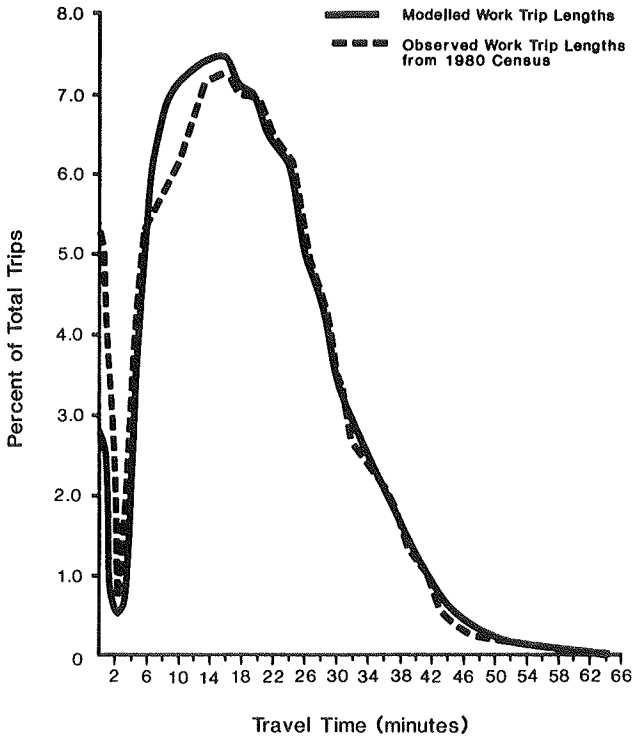

FIGURE 5 Comparison of observed and modeled work-trip lengths for 1980.

highway travel times were chosen as a measure of separation. This plot shows that the DRCOG work-trip distribution model is working quite well and needs little, if any, adjustment.

This conclusion is further supported by the direct comparison of trip interchanges after both trip tables had been aggregated to 32 districts. The high correlation coefficient, 0.93, showed that the trip tables were highly similar. However, there were some district interchanges that were significantly different when the UTPP data and the modeled work-trip tables were compared. An investigation of some of the major district interchange discrepancies showed difficulties with both the UTPP and the modeled trip tables. In the UTPP data, one zone with a large manufacturing plant showed no trip attractions. On the other hand, the UTPP data revealed that a major employer was inadvertently omitted from 1980 DRCOG employment files. These difficulties underscore the problems of comparing large urban data sets: Some differences are bound to exist due to random errors or differences in summarization processes. Although the differences noted previously could cause localized problems with traffic assignments, they do not by themselves significantly affect average trip lengths or length frequency distributions in Denver. The regional employment files have been corrected where differences with the UTPP data indicated such correction was necessary. Census Bureau officials have stated that they are willing to investigate problems reported with the UTPP data and correct any errors found. However, this action has not yet been deemed necessary by DRCOG staff.

CALIBRATION OF A SUBAREA TRAVEL MODEL

The third major use of the UTPP data in the Denver region was for calibration of a subarea model covering three communities just northwest of the Denver modeling area. These rural communities are now developing into major bedroom communities and employment centers.

A subarea focusing model was developed to analyze the effects of alternative transportation investments in these three communities. Figure 6 shows the areas covered by the primary, secondary, and tertiary study areas. Most of the primary and secondary study areas are outside the area normally included in the regional travel model for the Denver area. As a result, UTPP data from Tables I-11, household income, and III-2, sex by industry, were used to provide initial estimates of base-year socioeconomic data. The UTPP data were summarized with a simple SAS program in order to format the data into easily readable tables. Standard UTPP summary reports could have been used, but these are somewhat unwieldly and difficult to understand.

The second major use of the UTPP data in the subarea model calibration was for the home-based work-trip distribution model. Trip interchanges for the entire region were aggregated (and disaggregated where necessary) to match the zone structure used in the subarea model. The resulting trip table was factored through a Fratar process to match trip ends projected by the trip generation model. The resulting trip table was directly input into UTPS program AGM in order to calibrate the home-based work-trip distribution model. It would have been possible, and probably more appropriate, to calibrate the work-trip distribution model on the UTPP trip table that was not factored to match the modeled trip ends to ensure that the factoring process did not bias the results of the calibration.

The final use of the UTPP data in the subarea model calibration was in the calibration of nonwork-trip distribution models. A methodology developed by FHWA and presented in a course on urban transportation planning using the 1980 census was used in this calibration process. Basically, the process was as follows:

1. F-factors for the home-based work-trip distribution model were estimated using UTPP data;
2. The newly calibrated F-factors were compared to original home-based work F-factors for the Denver model, and proration factors were developed for each impedance range;
3. The proration factors were applied to F-factors for the nonwork purposes from the Denver model for each impedance range; and
4. The resulting F-factor estimates for the nonwork purposes were then adjusted to develop smooth F-factor curves.

The F-factors for the original home-based work-trip distribution model for the Denver region agreed quite closely with the new home-based work F-factors developed from the UTPP data. As a result, little adjustment was required to the nonwork F-factors. Unfortunately, the results of this calibration process were not very satisfying. The traffic volumes in the primary study area that resulted from the trip tables based on the F-factor estimates were about twice those observed. The slopes of the nonwork F-factor curves had to be increased substantially in order to decrease traffic volume to reasonable levels. The final nonwork F-factors used in the calibrated subarea model were substantially different from the initial estimates based on UTPP data.

One of the reasons that this process may not have worked is that although the communities are becoming urbanized, they still retain rural characteristics. It is quite possible that home-based work trip making is similar to that noted in the Denver urban

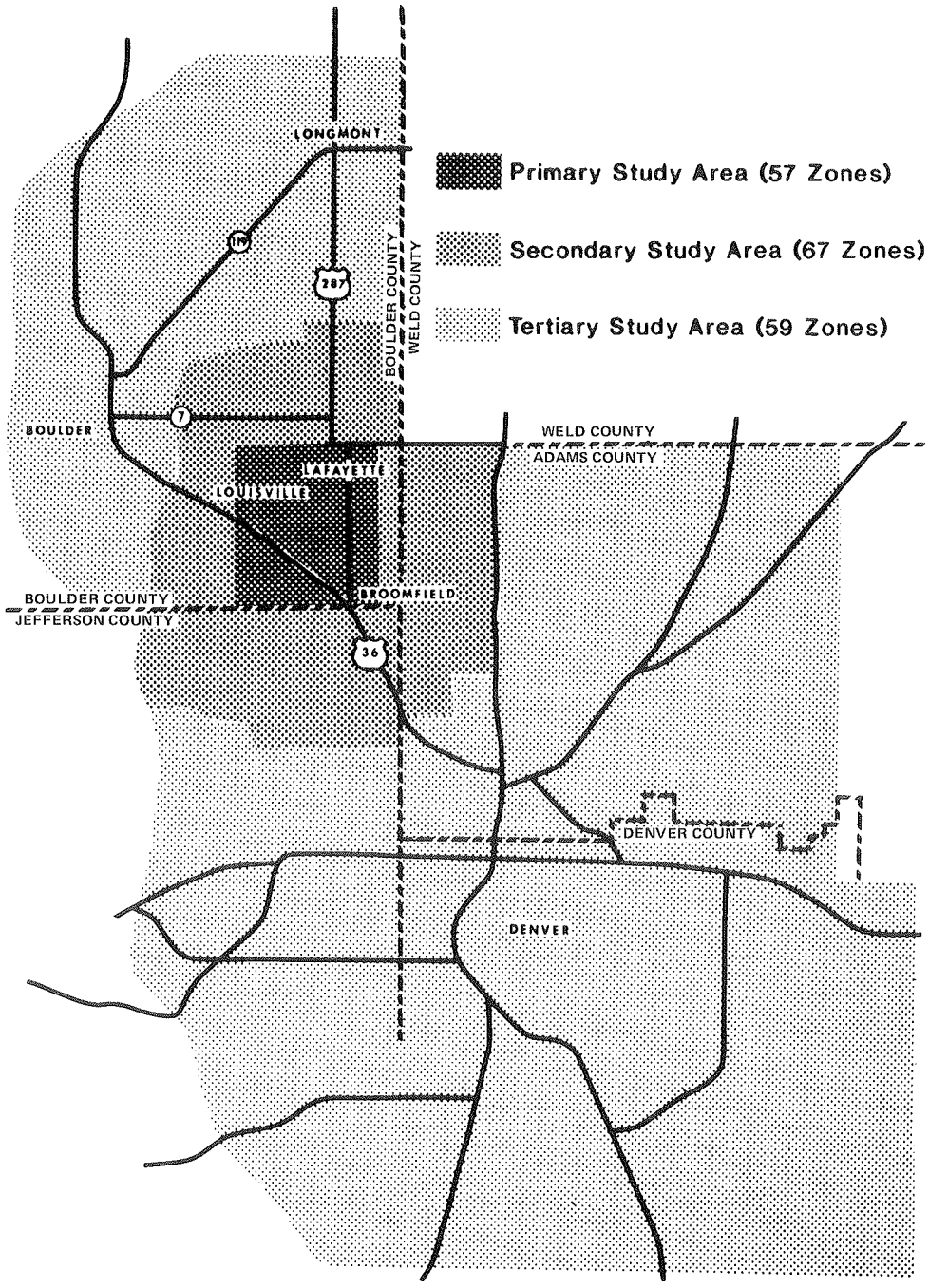

FIGURE 6 Tri-city subarea.

area (at least in terms of trip length), whereas nonwork trip making for shopping and other purposes might be much more community oriented. Another test of this process in an urban subarea is warranted to determine whether the process is valid and where it can be used.

SPECIAL TRANSIT STUDIES AND MARKETING OF DATA

One of the first uses of the UTPP data was to provide the Regional Transportation District (RTD) with data useful in determining potential markets for transit services. Because a number of major suburban employment centers have been built in the Denver region, the RTD wanted to determine whether there were any latent transit markets that were not being served. More recently, the city of Aurora, a major suburb of Denver, wanted to determine the same sort of information--that is, whether major employment centers in their city were being well served by transit.

UTPP Table IV-1 was used to provide data for both of these requests. In both cases, the trip interchange table that had been converted to UTPS matrix format was used. For the RTD, some interesting processing was done to present the data in a format easily usable for this analysis. Because two or more traffic zones were normally specified as an employment center, the regional trip interchange table was

squeezed in one direction only; that is, the columns, or destinations, of the table were aggregated to form districts that were equivalent to the employment centers. The rows of the table, or the origins, were not aggregated. The UTPS program UFMTR was used to produce a trip interchange report in column format, that is, where trip interchanges are listed with each origin zone and destination district on a single line. The resulting rectangular matrices were output to disk rather than to the printer by the program UFMTR, and the interchanges were sorted by increasing magnitude of interchange. In this way, the RTD could easily map and determine the largest potential transit markets that were not already served by transit for these employment centers.

This innovative processing was not done for the city of Aurora. Rather, the trip table was simply aggregated to districts as specified by the city of Aurora and printed in matrix form. This simplified processing was done for Aurora because the need was different: City staff wanted to be able to quickly look up trip interchanges to and from the city of Aurora.

The trip interchange data have also proved valuable to developers in the Denver region. Residential and commercial developers offer a potential source of revenue to help recover the cost of the UTPP data. Just after the RTD request had been completed, a residential developer with several homesites in the region requested data on trip lengths in Denver in order to help design a marketing campaign. The developer was quite willing to purchase special reports of the UTPP data after he understood what was available. The UTPP trip interchange data were processed in a manner similar to that used for the RTD request, except that the origins were aggregated into districts rather than destinations. The origin districts included traffic zones comprising and surrounding the developer's homesites in the region. From these data, the developer was able to target his marketing campaign to specific groups in their work locations.

FUTURE USES OF THE UTPP DATA

The principal future uses of the UTPP data will be in the recalibration of the regional home-based work-trip distribution model and the calibration of subarea travel models. An attempt will be made to calibrate a work-trip generation model for the city of Boulder from the UTPP data. Boulder is an urbanized area northwest of Denver that has some special characteristics. Specifically, the bicycle mode share percentage is seven times greater than that observed in the Denver region and the walk-to-work mode share percentage is three times greater. As a result, home-based work-trip generation rates used in normal travel models might be expected to be substantially lower than those observed in Denver. At present, it is envisioned that the UTPP data will be used to develop work-trip generation models for both Denver and Boulder. Because the trip generation rates from these models will be somewhat higher than that observed in a travel model, the differences, or possibly percentages of difference, will be applied to the regional model to calibrate a usable model for the Boulder area.

SUMMARY

UTPP data have proved useful in the Denver region. Two of the most important uses have been recalibration and validation of various portions of the regional travel model. Because of the way in which the journey-to-work questions were asked in the 1980 census, validations of the work-trip generation model and the mode-split model have been possible only at a gross level and were not reported in this paper. The UTPP has also provided a primary source of data on areas that were not surveyed at the time of the last large travel survey. The UTPP data were successfully used to calibrate portions of travel models for these newly urbanized areas.

Although some problems with the UTPP data have been discovered, they have not been insurmountable. In general, the data have been of high quality and, in fact, have helped the discovery of problems with some of DRCOG's regional data sets.

One enhancement to the UTPP that would make it more useful to transportation planners would be the provision of the trip interchange information in UTPS matrix format. This would eliminate the irritating task of converting the trip interchange information to a form usable by most readily available analysis programs. In addition, it would allow for easy customizing of reports in terms of data and zones reported.

ACKNOWLEDGMENT

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