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Executive Summary Report

Sensitivity of Four-Step Versus Tour-Based Models to Transportation System Changes

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Project Background

The potential benefits of the tour-based approach, combined with the increasing levels of demands placed by legislations on the abilities of travel demand models, has led several planning agencies in the United States to shift (or consider the shift) to the tour-based approach. The Mid-Ohio Regional Planning Commission (MORPC) utilizes a fully operational tour-based model for the Columbus region. For the purposes of this study, the Ohio Department of Transportation (ODOT) developed a traditional trip-based model from the same data. This presence of both a trip-based and fully operational tour-based model allows the testing and comparison of the two models in terms of forecasting ability, especially at a time when several planning agencies (including Northeast Ohio Areawide Coordinating Agency (NOACA) and Ohio Kentucky Indiana Council of Governments (OKI)) are considering the move toward the activity-based/tour-based modeling approach for operational purposes.

Study Objectives

The main objective of this study was to examine the performance of the MORPC trip-based and tour-based frameworks in the context of three specific projects started and completed within the past 15 years in the Columbus metropolitan area. The three specific projects included (1) Polaris project, (2) Hilliard-Rome project, and (3) Spring-Sandusky interchange project. The Polaris project included a combination of substantial retail and employment growth, combined with a new Polaris Parkway and interchange with interstate highway I-71 (completed in 1993), Polaris Parkway widening (completed in early 2000), and additional split interchanges with Polaris Parkway and Gemini Parkway (completed in 2007). The Hilliard-Rome project refers to the large land-use related developmental changes in the Hilliard-Rome area

(Hilliard-Rome is the name of the first exit on I-70 west of I-270 in the Columbus region) in the late 1990s and early 2000s. The Spring-Sandusky interchange project, also undertaken in the late 1990s and early 2000s, involved reconstruction of SR 315 between I-670 and I-70/71, and the new construction of the portion of I-670 between I-70 and SR 315 to allow easier access/egress into downtown area and help avoid traffic delays on I-70/I-71. To have a control region for the analysis, where large land use and network changes did not occur to promote significant changes in travel pattern between 1990-2005, the area in the vicinity of I-71 and Harrisburg Pike (SR3) in Southern Franklin County was chosen.

Description of Work

A study area was established for each of the three projects (and the control area) to reflect the geographic location within which roadway link volumes would most substantially be impacted directly from the planned developments. For each study area, a detailed review of the roadways was undertaken which included verifying the accuracy of the roadway connectivity, lane configuration, and traffic counts. ODOT and MORPC staff, with the help of the research team, generated demographic data and created transportation networks for three analysis years used in the study -- 1990, 2000, and 2005 -- incorporating the appropriate status of the study projects for the corresponding analysis year. In total, six model runs were developed -- one for each analysis year and model. Both the trip-based and tour-based models used the identical equilibrium highway assignment closure criteria during the initial and final highway assignments.

The performance evaluation of the trip-based and tour-based models was pursued at two levels. The first level corresponded to a region-level analysis (independent of specific projects) that compared selected model outputs from each of the trip-based and tour-based model systems with corresponding region-level observed data. The second level corresponded to a local-level analysis (specific to each of the three projects identified earlier) that compared the trip volume outputs on selected roadway links in and around the project region with corresponding link counts. For both the region-level and local-level analysis, the research team considered three years for analysis, as identified earlier:

- Model year 1990: This is the base year/ no-build case; construction of the selected study projects did not begin prior to this year.
- Model year 2000: The Hilliard-Rome project was complete and the Polaris Interchange (Phases 1 and 2 of 3) was complete, while the Spring-Sandusky interchange was under construction.
- Model year 2005: The Hilliard-Rome project, the Spring-Sandusky interchange, and Phase 2 of the Polaris project were all complete, while Phase 3 of the Polaris project was not yet constructed.

The year 1990 represents the “before project” case for all the three study projects (*i.e.*, Polaris, Hilliard-Rome and Spring-Sandusky), while the year 2005 represents the “after project” case for the Hilliard-Rome and Spring-Sandusky projects. The year 2000 was included in the “before-after” project analysis because of the availability of the 2000 Census data, as well as the 1999 Household Interview Survey (HIS), that contributed toward our regional-level analysis comparison of the trip-based and tour-based model system outputs. Further, the year 2000 represented the completion of the Polaris Parkway widening (even though the I-71 split interchanges were not completed by then). Thus, we undertook a local-level analysis comparison on roadway links in and around the project areas for the Hilliard-Rome project (the year 2000 represents the immediate “after” situation for the Hilliard-Rome project) and for the Polaris project (the year 2000 marked the end of a clear phase of the project, as just discussed). The roadway network was appropriately coded to represent the completion of the Polaris Parkway widening in 2000 during the analysis. However, no local-level analysis was undertaken for the year 2000 for the Spring-Sandusky project since this project was still ongoing at that time.

For the region-level analysis, four travel dimensions (vehicle ownership, work flows, work trip start time distribution, and work trip travel time) were identified for which near-compatible observed data were available. The observed data included the Census Summary Files 3 (SF3) and the Census Journey to Work data (for the years 1990 and 2000), the 1999 Household Interview Survey (HIS) (for the year 2000), and the American Community Survey (ACS) (for the year 2005). The analysis then entailed a comparison of the model-generated outputs for each travel dimension with the corresponding observed data. For the local-level analysis, a number of roadway links with available volume count data were selected, and the model-generated link volume predictions were compared with the observed link count volumes. This local-level analysis was conducted by roadway functional class.

The evaluations of the trip-based and tour-based model systems were undertaken in this project in the context of comparisons of predicted travel dimensions from the two systems with compatible observed travel data at each of three cross-sectional points in time (these three cross-sectional points refer to the years 1990, 2000, and 2005). While the original intent of the project was to undertake before-after project analysis in terms of comparing the predicted changes (from each model system) in the travel dimensions from before to after each project with the predicted changes in corresponding observed travel data, we did not pursue such a rigorous "before-after" model sensitivity evaluation effort because of differences in region-level and project-level data collected in the three years. For instance, the Census data from 1990 and 2000 are independent cross-sectional data sets and not elements of a larger systematic panel data collection effort. As such, there were several differences in the design and data collection efforts between these two cross-sectional data sets. Further, for the year 2005, the survey design of the ACS data, which constitutes the observed data for 2005 in our analysis, is quite different from the Census data design. Due to these and other technical considerations, the team decided to retain the benchmark data as cross-sectional "before-after" points of reference with which to compare the corresponding cross-sectional predictions from the trip- and tour-based model systems.

Research Findings & Conclusions

Regional- and project-level comparisons of the performance of the trip-based and tour-based models were made for three scenario years: 1990, 2000 and 2005. The regional-level analysis was undertaken in the context of four travel dimensions based on data availability and observed data to model output compatibility. These four dimensions were vehicle ownership, work flow distributions, work flow distribution by time-of-day, and average work trip travel times. The tour-based model performed better overall than the trip-based model for all these four dimensions, though the trip-based model predictions of vehicle ownership for non-Franklin counties and of some intra-county work flows were better than the tour-based model predictions. A further disaggregate analysis of work flows within Franklin County indicated that both the trip-based and the tour-based models under-predicted the work trip flow from the CBD district to other districts, though the relative magnitude of the work flow from the CBD district is also low (only 0.63% of work flow within Franklin county is from the CBD district). For the work trip flow into the CBD district from other Franklin County districts, which accounts for about 15% of the total works flow within Franklin County, the tour-based models predicts substantially better than the trip-based model. In terms of the work flow distribution by time of day forecasting ability and the average work trip travel time predictive ability, the tour-based model again has an edge over the trip based model.

The project-level comparative assessment of the predicted link volumes from the trip-based and the tour-based models was undertaken with respect to the observed link counts and by roadway functional class. The observed link counts were available only at an annual average daily traffic (AADT) level. The results did not show any clear trends in terms of performance of the models by functional class or year. For the Polaris project, the tour-based model consistently provided better prediction for freeway links across all the years, though it also consistently provided worse predictions for major arterial links. For the Hilliard-Rome project, the tour-based model provided much better results (relative to the trip-based model) for the freeway functional class in 1990 and marginally better results for this class in 2005, but worse results in 2000. The tour-based model also provided better results for the major arterial class in 2000 and 2005. For the Spring-Sandusky project, the tour-based model provided worse results for the freeway and expressway functional class, though the predictive power of the tour-based model was marginally better than the trip-based model for the major arterial functional class. Finally, for the control area, while the tour-based model provided better predictive ability for the freeway functional class in 1990, the trip-based model provided better predictive ability for the major arterial class in 1990. The overall relative performance of the tour-based and trip-based models were about the same for the after-project years (2000 and 2005). In the overall, the results from the trip-based and tour-based models indicate about equal predictive abilities for both the before-project and after-project situations at the level of link predictions. It is difficult to make a strong case for one of the MORPC models being superior to the other from this standpoint. However, the results do provide validation that the tour-based model, being a more recent entrant to the travel demand practitioner's toolbox, is producing reasonable results at the link level.

Implementation Recommendations

Through this analysis, the project team has learned firsthand the difficulties of making disaggregate model comparisons when the models have different units of travel. A major challenge is that translating the results to a common unit of travel generally causes inconsistencies except when performed at an aggregate level, because one must apply off-model rules to convert one model's data set to the other model's unit of travel. Given this challenge, definitive statements about the superiority of one model over the other are not easily made. Generally, the performance of the tour-based model provides evidence of the ability of these types of models to provide decision makers with better information on travel behavior. However, the MORPC tour-based model's vehicle ownership procedures appear to need further investigation, as they underperformed in all counties except for Franklin County. The performance of the tour-based model in the project situations was also somewhat disappointing, even though it performed about as well as the trip-based model. The results suggest that the MORPC tour-based model will not forecast better than traditional methods without additional behavioral resolution, network resolution, validation procedures or some combination thereof. It should, however, also be pointed out that the study projects selected in this analysis corresponded to land-use developments and roadway supply enhancements, not to demand-management actions. There is a need in the future to examine the performance of the trip- and tour-based models in the context of demand-management strategies.

This project is a significant first step toward a better understanding of the tangible benefits of disaggregate tour-based modeling methods. But it would be imprudent to judge all model systems strictly on the results of this one project, since the transportation planning community has accumulated four decades of learning and experience on trip-based models while this particular tour-based model represents only one attempt, and one of the earliest, at implementing the tour-based or activity-based approach for practical use. Regardless, this project should serve as an important reference in the assessment of the potential practical benefits of disaggregate tour-based modeling approaches vis-à-vis aggregate trip-based methods.