Sketch Transit Modeling Based on 2000 Census Data

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Abstract: Transit planners need cost-effective ways of evaluating a wide range of alternatives relatively quickly, in order to identify potential transit systems that are likely to offer the greatest benefits for a given cost. In this paper, we describe a sketch transit planning model for the Washington DC region that is based on the Metropolitan Planning Organization’s travel demand model structure and model networks, but that is estimated from more recent 2000 Census data, better matches suburban transit ridership, is sensitive to land use effects, and is less costly to use. Similar transit sketch models could be developed and applied in other regions.

Words: 5156
Figures: 4
Tables: 4
Total: 7156
INTRODUCTION

Public transit planning has become increasingly challenging. The decentralization of people and jobs has transformed travel patterns. An increasing share of trips made is not served by transit at all. Auto availability rates have increased sharply, so that transit-dependent persons are a declining share of the population. Funding for transit capital and operating expenses is a perennial problem. Nevertheless, there is strong public interest in most regions for expanded transit services – especially for rail, and to a lesser extent Bus Rapid Transit (BRT). Many proposals for new transit services are tied into broader public policy goals including economic development and redevelopment, reducing congestion, and reducing sprawl.

Transit planners need cost-effective ways of evaluating a wide range of alternatives relatively quickly, in order to identify potential transit systems that are likely to offer the greatest benefits for a given cost. Furthermore, the tools need to address the linkages involved in the public policy debates. What are the connections between transit and economic development? What is the potential for transit in reducing future congestion? Will transit perform better if more compact and walkable development is built rather than sprawl? Scenario analysis that varies future transit networks, roadway networks and land use is needed to answer these questions. In this work, a transit sketch planning model was developed to support transit/land use scenario analyses.

REGIONAL TRANSIT MODELING ISSUES

The most complex transit models in general use are the Metropolitan Planning Organizations’ (MPOs) regional travel demand models. These models include trip generation from land use, distribution of trips based on the generalized cost of travel to different destinations, and competition with auto. In theory, the complexity of these models made them the best tools for evaluating new transit services. In practice, there are several potential problems. These include model accuracy, insensitivity to land use effects, and institutional barriers/cost of use.

Model Accuracy – In most regional models, there has been much more attention to matching traffic counts on individual roadway segments than on matching transit loadings on individual route segments. This bias is reflected in this quote from one of the standard modeling guides.

The amount of time and effort required to validate a transit assignment is directly correlated with the level of precision demanded. For highway planning purposes, it is generally sufficient to validate top the regional number of boardings, so that the appropriate number of person trips are removed from the highway network. For transit planning purposes, however, it may be necessary to validate to the mode, corridor, route, segment, or even station level of detail.1

In our experience, most regional models are only validated to the level of the regional level of boardings. Thus, the models are implicitly developed primarily for highway planning purposes and air quality conformity determinations. For example, in a peer review of the Southern Association of Governments (SCAG) model of the greater Los Angeles region, reviewers expressed concern that SCAG proposed only to match regional transit ridership within +/- 10%. They urged instead that SCAG match regional ridership by transit mode, i.e. bus, urban rail and commuter rail.2 In a large and diverse region, there is no guarantee that even this more stringent standard is sufficient for good transit planning.

Another challenge to model validation is that estimation typically is based on a relatively small household survey, which may include only a small number of transit trips in the area of interest, particularly if the area of interest is in the suburbs. In many regions, household travel surveys are more than ten years old. In rapidly-growing regions, these surveys do not reflect current suburban travel patterns.

Sensitivity to Land Use – There is a large body of research that shows that travel behavior is influenced by land use. One way to organize this research is around the “3 Ds” – “Density”, “Diversity”, and “Design” as independent variables. An extensive review of land use/transportation studies using the 3 Ds framework was done by Ewing and Cervero.3

The potential impact of more compact, mixed land use, with a walkable design has become a major planning issue in a number of regions that are trying to reduce growth in future vehicle miles of travel (VMT). The Sacramento region
is at the forefront of this movement. Director of the Sacramento Area Council of Governments, Martin Tuttle, was interviewed about this process.

For years, Tuttle says, Sacramento’s COG failed to exercise regional vision in deciding where to spend transportation dollars. Instead, the organization “chased development with transportation projects” requested by individual governments.

“It became obvious to everyone that whether we built our region out with roads or transit, congestion would still get worse, says Tuttle, executive director of the council, which directs state and federal transportation in the six-county capital region. “The consensus of the group was that we had to look at land use,” he says.4

The importance of land use/transportation interactions has been shown in research. It is an increasingly important issue at the regional level. It is being promoted at the national level.5 However, regional models generally are insensitive to land use, which is one of the underlying causes of model inaccuracy.

**Institutional Barriers/Cost of Use** – The regional models are developed by MPO staff or by consultants to MPO staff. The MPO is most focused on the Transportation Improvement Program (TIP), long-range transportation plan, and conformity determination. Transit providers often are disconnected from the modeling process. For example, the following concerns were expressed in the Atlanta Regional Commission (ARC) model peer review process by the Metropolitan Atlanta Rapid Transit Authority (MARTA):

MARTA requested that ARC provide more explanation of and training in how the model treats transit and the associated assumptions within model runs. New technologies in the future should be implemented at times when partnering agency staff has time to learn alongside ARC staff, ensuring that the entire process and quality control elements are understood. The greater the involvement of collaborating agencies throughout the model development process, the easier buy-in becomes later on.6

Related to the institutional barriers and training issues, is cost. The more sophisticated MPO models can be so cumbersome and expensive to use that they are rarely applied in initial planning stages – being reserved primarily for evaluation of entire TIPs, long-range plans, conformity determinations, and in major Environmental Impact Studies (EIS) for major roadway and transit projects. At the EIS stage, the range of alternatives that are evaluated generally is narrow.

**TRANSIT MODELING ALTERNATIVES**

There are less complex alternatives to regional modeling. The simplest level is “pivot point” analysis using elasticities. “Direct demand” models offer an intermediate level of complexity. “Reference class forecasting” has also been recommended as an alternative to conventional modeling.

**Pivot Point/Elasticity Analysis** – For short-term service changes such as frequency and fare changes, current ridership will be the best foundation for estimating future ridership. Data from similar service changes has been tabulated, and provide estimates of service elasticities.7 The elasticities are applied to estimate future ridership. Similar methods can be applied to estimate the incremental change in ridership that will result from an expanded service area for the introduction of express service.8 In our project, we are focused on new service type, BRT, in rapidly-growing areas that have little transit service today. Therefore, pivot point analysis is infeasible.

**Direct Demand Models** – Direct demand models have an intermediate level of complexity. Like the regional models, they have statistically estimated parameters. However, the models are based only on the population and land use characteristics at the ends of possible trips. There is no trip table with origin-destination interchanges between all areas. A good example of this type of model is Thompson’s analysis of ridership potential in the Sacramento region.9

Walters and Cevero applied a direct demand model from BART ridership data in the San Francisco region. Their motivations were very similar to ours. They write:
When facing the challenge of coming up with ridership forecasts for a planned transit corridor, the natural instinct of planners is to turn to regional four-step travel forecasting models. Besides the lengthy time commitments this often entails, the direct ridership modeling approach was preferred for several key reasons. First and foremost, traditional four-step models are not calibrated at a resolution or with the kinds of variables necessary to conduct a fine-grained analysis of station boardings based on characteristics of surrounding neighborhoods. The mode-choice component of most four-step models, moreover, rarely includes the kinds of land-use variables needed to study the impacts of compact, mixed-use transit-oriented development (TOD).\textsuperscript{10}

There are limitations to the direct demand approach. Direct demand models generally have been developed based on existing radial transit trips to CBDs. It is unclear how to transfer the direct demand models to the case of suburban-to-suburban trips. In one comparative analysis of potential suburban TOD to suburban TOD trips, a direct demand model forecast low ridership, but a regional model enhanced with land use variables forecast much higher transit usage.\textsuperscript{11} The direct demand model’s estimation data did not include any cases with suburban TOD, so may not have been applicable to this case.

**Reference Class Forecasting** – Flyvbjerg et. al. have researched errors in model forecasts, and have recommended “reference class forecasting” as an alternative to synthetic modeling. They describe this as a process of three steps:

1) Identifying a relevant reference class of past projects. The class must be broad enough to be statistically meaningful but narrow enough to be truly comparable with the specific project.

2) Establishing a probability distribution for the selected reference class. This requires access to credible, empirical data for a sufficient number of projects within the reference class to make statistically meaningful conclusions.

3) Comparing the specific project with the reference class distribution in order to establish the most likely outcome for the specific project.\textsuperscript{12}

They stress that their recommendations are particularly relevant for the first large project of a particular type in a region, e.g. rail transit or a new tunnel. The focus for our project is on relatively inexpensive BRT. Nevertheless, it is good advice to check any forecast results comparable projects in the same region and/or in different regions.

**SKETCH MODEL**

In previous work, we have enhanced four-step regional travel demand models with land use variables.\textsuperscript{13} 14 These projects addressed the land use issue discussed above. However, only the MPO is in a position to modify an MPO model, and MPOs typically are more focused on other issues such as air quality conformity analysis. The motivation for this work was to develop a sketch model outside an MPO that kept many of the strengths of a regional model, but was also more accurate for transit ridership and also simpler to use. This work was done for nongovernmental agencies, but similar models could be developed for transit agencies.

The sketch transit planning model was developed for the Washington DC region. It was based on the Metropolitan Planning Organization’s model structure and model networks. It uses the Transportation Analysis Zones (TAZs) used in the Metropolitan Washington Council of Governments (MWCOG) Transportation Policy Board (TPB) model. Given that the focus is on transit, the far outlying areas with little transit ridership were eliminated from the model. The model includes the District of Columbia, Montgomery and Prince Georges Counties in Maryland, and Arlington, Fairfax, Loudoun and Prince William Counties in Virginia, as well as the Cities of Alexandria, Fairfax, Manassas and Manassas Park.

**Census Data**

The sketch model is estimated from 2000 Census data. These data were chosen because they are considerably newer than the household travel survey data (1994), represent a much larger sample, and are available in consistent form throughout the U.S. The major limitation is that only work trips are included. Census Transportation Planning
Package (CTPP) data are tabulated from the Census long form which was completed by approximately one sixth of all households. It includes three parts:

1) tabulations by place of residence
2) tabulations by workplace
3) flows from residence to workplace

All three parts have been used in this work. Part 1 includes the same population and household data that are in Summary File 3 (SF3) data, except that the data are provided at a TAZ level that matches the MPO model structure. Part 2 has the same layout as Part 1 but is different from other Census data in that it is summarized by the workplace TAZ. Part 3 is the critical component for this work as it includes TAZ-to-TAZ commuting data. Initially, we also used the Part 3 data to estimate mode shares at the home TAZ and work TAZ. However, some data in Part 1 and Part 2 is suppressed from Part 3. Therefore, Part 3 was relied on for estimation (the majority of TAZ-TAZ pairs), but Parts 1 and 2 were also important in validation (all TAZ-TAZ pairs).

Initial work was done with a Part 3 table that included residence-workplace flow by mode and by income group, with the aim of developing separate models for the different income groups. Unfortunately, large amounts of data are suppressed from these income tables for confidentiality. Therefore, income was introduced into the model using aggregate data. An INC1 variable was developed that represents the proportion of households in the home TAZ with incomes under $40,000 (2000 $).

**Mode-Specific Service Data**

Auto and transit networks and base-year morning peak traffic volumes were imported from the TPB Volume-to-delay functions were developed that match travel times reported in the Census data. Walk access times are calculated along roadway links.

The transit service parameters used in the sketch model include:

- Single occupancy vehicle (SOV) auto time,
- High-occupancy vehicle with 3 or more persons (HOV 3+) auto time
- Transit walk access time
- Transit drive access time
- Transit wait time (including transfer time)
- Transit in-vehicle time

In addition, some tests were done with other variables, including the number of transfers, which were not found to be statistically significant.

The Census data do not support estimation of cost variables. There are few tolls currently operational in the region. Most auto commuters do not pay for parking. Therefore, most auto drivers have the same costs. Transit costs are set according to system wide policies. Therefore, the data do not include a range of auto and transit costs that would clearly show the tradeoffs made between time and costs.

To some extent, cost effects are incorporated in the estimated coefficients. The mode specific constants for transit are negative, and this partly reflects the disutility of paying for transit out of pocket, even for short trips. Transit mode share is positively related to employment density, and this may be partly due to the increased costs of providing parking in dense employment areas.

Although it was not possible to estimate cost coefficients from the Census data, a change in cost (tolls, transit fare changes) can be incorporated in the sketch model by assuming a value of time, and then transforming the cost into an equivalent time. This situation is common also with the MPO models. It is similarly impossible to estimate cost coefficients from household travel survey (“revealed preference”) data. Instead, “stated preference” data are needed that ask respondents to make tradeoffs involving time and cost. Otherwise, values of time are assumed. Federal guidance for studying proposed projects is to base the “value of time” or willingness to pay to save time on the real income of the users.
Land Use Data

Land use variables were applied at the Transportation Analysis Zone (TAZ) level using data obtained from MWCOG. The sizes of the TAZs were calculated from the TAZ shapefile. A household density variable was calculated as the square root of households per square mile. The employment density variable similarly is the square root of employees per square mile. Across several projects, this square root density transformation has fit the data better than either of the most common alternatives, linear and logarithmic. In work in the Chicago region, it was found that a linear relationship was too strong as the effect of 100,000 jobs per square mile was not 100 times the effect of 1,000 jobs per square mile. On the other hand, a logarithmic relationship was too weak. The square root relationship provides a good model fit.

The attractiveness of transit depends on the local urban form. Some regions have collected detailed local data on factors such as sidewalks and computed Pedestrian Environment Factors. Lacking such data, we have approximated the urban form by counting the number of intersections per square mile. The number of intersections was computed from the U.S. Census Bureau’s TIGER 2000 road coverage by creating a nodes layer and counting all nodes that were connected to at least three roads. The proportion of the TAZ within ½ mile of a Metro rail stop was also calculated. This variable was found to be highly significant. Cevero has found that including density variables but not transit service variables can overestimate the importance of density because there is generally a correlation between density and transit service.

Model Structure

The sketch model estimates TAZ-to-TAZ mode shares. The base year TAZ-to-TAZ trip table is taken directly from the Census data. As this is based on a 1/6 sample of the entire population, it should be much more accurate than a synthetic regional model. Trip tables for any other analysis years are developed through an iterative adjustment process based on the forecast growth in work trip origins and destinations. Such “Fratar” processes are standard tools in transportation modeling software. This process is a major simplification over a full regional travel demand model where the trip tables are developed synthetically.

It is assumed that walk access to transit must be available on the employment end for either walk-access or drive-access trips. Transit shares will generally be higher where walk access also is available on the home end. However, the CTPP data do not distinguish between walk access and drive access. We segmented the market by using the networks to tell us which TAZ-TAZ pairs have walk access on both ends. These pairs were used in the walk access model estimation, and are also used in the walk access model application. TAZ-TAZ pairs with walk access available only on the employment side were used in the drive access model estimation and in the drive access model application. It is important to note that the walk access model covers all transit trips where walk access is possible, even those where drive access was used. The resulting aggregate transit share is unbiased, but the two components will not be identical with observed walk-access and drive-access shares.

The primary focus of the sketch model is on transit. However, HOV also was included to provide a platform for testing policies that include High-Occupancy Toll (HOT). The dataset was set up to evaluate HOV2 vs. HOV3+. However, there are limited cases where there are shorter travel times for HOV3 than HOV2 and relatively few HOV3 trips in the CTPP data. Therefore, it was impossible to estimate a multinomial model with SOV, HOV2 and HOV3+, so all HOV was grouped together.

The large size of the CTPP dataset (over 100,000 observations) made it very challenging to estimate nested logit models with the full dataset. Rather than resorting to using only a sample of the data in estimation, the model was estimated and implemented stepwise. First, motorized trips are segmented into transit and auto trips using a binomial logit model. Then the auto trips are segmented into SOV and HOV trips using a second binomial model. There are separate branches for walk access and drive access, so there are a total of four binomial models in all.

The estimated binomial models are:

1) transit share for those making motorized work trips and with transit walk access on home and work trip ends,
2) HOV share for those making auto work trips with transit walk access on home and work trip ends,
3) transit share for those making motorized work trips and without transit walk access on home end (but with transit walk access on work end), and
4) HOV share for those making auto work trips without transit walk access on home end.

The sketch model application similarly goes through these steps.

The model form is similar to the TPB model but there are some differences. Both the TPB model and the sketch model include a transit constant and transit in-vehicle-time variables. The sketch model separates out-of-vehicle time into two components – walk access time and wait time – whereas the TPB model groups them into a single factor. The TPB includes an explicit cost variable, but (as discussed above) cost is treated only implicitly in the sketch model. The sketch model only includes a distance variable.

The biggest differences are in the treatment of land use. As discussed above, the sketch model includes household density, job density, intersection density, and the presence of Metro service. The MWCOG model includes a jobs/housing balance variable, but otherwise only treats land use implicitly through auto availability. Its auto availability model includes a DC dummy variable, area type, and employment within 40 minutes by transit – all land use variables although not as precise as the ones in the sketch model. The TPB auto availability model also includes income and household size.19

**Sketch Model Estimation Results**

The estimated coefficients are shown in Tables 1 through 4. Table 1 shows the coefficients for the walk access transit model. The coefficients are all for the transit alternative. In the binomial model, the utility of auto is 0, and the transit coefficients are relative to auto. All coefficients in the model are statistically significant at very high levels. The transit constant is negative, indicating that transit is less attractive (on average) than auto. However, the magnitude of the INC1 coefficient is almost as large, suggesting that transit and auto are of similar attractiveness for those with household incomes of $40,000 per year or less.

The three transit time coefficients are all negative as would be expected. The auto time coefficient is positive as would be expected (remembering that this is applied to the transit utility – longer auto times mean higher transit utility). The magnitude of the transit wait and auto time coefficients are almost identical. The walk access and in-vehicle time coefficients are considerably smaller. These results are somewhat different than the common practice of forcing the transit in-vehicle and auto time coefficients to be identical, and then forcing the transit out-of-vehicle time to be higher than the in-vehicle time. These differences could result from interactions with the land use and transit service variables that are in this model, but that have not been typically included in other models. Given the level of significance of the coefficients, and the limited experience with models of this type, no a priori relationships between the variables were forced, and the coefficients are used as estimated.
Table 1: Walk Access Transit Model Estimation Results

<table>
<thead>
<tr>
<th>variable</th>
<th>coefficient</th>
<th>standard error</th>
<th>t stat</th>
<th>probability</th>
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<td>0.08710</td>
<td>33.50</td>
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</tr>
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</table>

IVT – in vehicle time (minutes)
WAIT – wait time plus transfer time (minutes)
WALK – access walk time plus egress walk time (minutes)
DRIVE – access drive time plus egress drive time (minutes)
SOVTIME – time from home to work by single-occupancy vehicle (minutes)
SOVDIST – distance from home to work by auto (miles)
SQRHSM – square root of households per square mile at home end
HI – road intersections per square mile at home end
SQRESM – square root of employment per square mile at work end
EI – road intersections per square mile at work end
HMETRO – proportion of home TAZ within ½ mile radius of Metro rail station
INC1 – fraction of households in residential TAZ with incomes <= $40,000
EMETRO – proportion of work TAZ within ½ mile radius of Metro rail station
TIMEDIF3 – time savings for HOV3+ over SOV (minutes)

The distance coefficient is negative. (Again, it is important to remember that this applies to transit relative to auto, i.e. longer distance equals transit is less attractive.) This could indicate that lack of information concerning transit service increases with distance from home. It could also indicate a lack of comfort with being far from home and having to rely on transit. It could be a combination of both factors.

The four land use variables, land use density at both home and work ends and intersection density at both the home and work ends, have very significant coefficients. The transit mode share increases with land use density and employment density. The coefficients for Metro rail service are strongly positive at both the home and work ends.

Table 2 shows the coefficients for the Walk Access HOV Model (i.e. the share of auto that is HOV where walk access transit is available). In general, the variables in the HOV model are a subset of the variables in the transit model, where the omitted variables were tested and found not to be significant. The one new variable is “TIMEDIF3” which is the time savings in minutes for the HOV3+ network relative to the SOV network.
Table 2: Walk Access HOV Model Estimation Results

<table>
<thead>
<tr>
<th>variable</th>
<th>coefficient</th>
<th>error</th>
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<td>0.0000</td>
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</table>

As with transit, there is a large negative constant for HOV. Again, the INC1 variable is of similar magnitude, suggesting that households with incomes below $40,000 are relatively indifferent between SOV and HOV.

There are two auto time coefficients in the HOV model – the SOVTIME variable and the TIMEDIF3 variable. The SOVTIME coefficient is positive, suggesting HOV is more attractive for longer trips. This makes intuitive sense, given that carpool formation takes time, but which is not included in the estimation. The TIMEDIF3 coefficient is strongly positive, suggesting that time savings from HOV lanes are critically important in encouraging HOV behavior.

As with transit, the SOV distance coefficient is negative, which implies that carpooling share declines with distance. It probably is more difficult to form long distance carpools due both to less likelihood of a match and less information. Relying on a carpool also may seem less secure with increased distance.

The two land use variables at the employment end are significant and positively related to HOV share.

Tables 3 and 4 show the estimated coefficients for the Drive Access Transit and Drive Access HOV models, respectively. The coefficients generally are similar to the coefficients in the walk access models. The coefficients generally are highly significant statistically, but the level of significance is somewhat lower than for the walk access models because the sample sizes are much smaller. The great majority of commuting trips in the core of the Washington D.C. region have a walk access transit option, although the option is not always very attractive.

Table 3: Drive Access Transit Model Estimation Results

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</tr>
<tr>
<td>EI</td>
<td>0.00325</td>
<td>0.00072</td>
<td>4.53</td>
<td>0.0000</td>
</tr>
<tr>
<td>EMETRO</td>
<td>1.02043</td>
<td>0.17223</td>
<td>5.93</td>
<td>0.0000</td>
</tr>
<tr>
<td>INC1</td>
<td>4.32318</td>
<td>0.42086</td>
<td>10.27</td>
<td>0.0000</td>
</tr>
</tbody>
</table>
Table 4: Drive Access HOV Model Estimation Results

<table>
<thead>
<tr>
<th>variable</th>
<th>coefficient</th>
<th>error</th>
<th>t stat</th>
<th>probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-2.44897</td>
<td>0.06494</td>
<td>-37.71</td>
<td>0.0000</td>
</tr>
<tr>
<td>SOVTIME</td>
<td>0.00120</td>
<td>0.00439</td>
<td>0.27</td>
<td>0.7838</td>
</tr>
<tr>
<td>SOVDIST</td>
<td>-0.00320</td>
<td>0.00887</td>
<td>-0.36</td>
<td>0.7183</td>
</tr>
<tr>
<td>TIMEDIF3</td>
<td>0.03547</td>
<td>0.00364</td>
<td>9.74</td>
<td>0.0000</td>
</tr>
<tr>
<td>SQRESM</td>
<td>0.001046</td>
<td>0.00030</td>
<td>3.50</td>
<td>0.0005</td>
</tr>
<tr>
<td>EI</td>
<td>0.000504</td>
<td>0.00046</td>
<td>1.10</td>
<td>0.2713</td>
</tr>
<tr>
<td>INC1</td>
<td>2.80865</td>
<td>0.23377</td>
<td>12.02</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

A DRIVE variable has been added for the drive-to-transit access time (minutes). As expected, this coefficient is negative and is similar in magnitude to the SOVTIME coefficient. The WALK variable is omitted because it produced a coefficient that was not statistically significant. Many of the drive access TAZ pairs involve suburb-to-suburb commutes. It appears that walk access times are not modeled very accurately for large suburban TAZs. The METRO variable is only significant at the work end in the drive access transit model.

In the drive access HOV model, several of the variables that were statistically significant in the walk access model are not significant. However, as each coefficient has the expected sign, all variables were maintained for consistency in form with the walk access model.

The strong significance of the land use variables is striking given that these variables are not included in the TPB model or most other regional travel demand models in the U.S. The Metro variables that are highly significant are not included in the TPB model either. The rationale for excluding a Metro preference is that people should care only about travel time and cost – and not whether the vehicle is a train or a bus. However, Metro is more than just a mode – it is a major brand that has much higher brand recognition than the rest of the regional transit system. It also is possible that the Metro variables are picking up additional land use effects because Metro stations often are in areas with good pedestrian infrastructure and transit-oriented land uses.

Model Fit With Data

The sketch model results were compared with the Census data and also with the TPB modeled work trips. Figures 1-4 compare model vs. Census for both models for the work end at the Transportation Analysis District (TAD) level – i.e. groupings of TAZs. At the work end, the correlation between observed and modeled trips for the TPB model at the TAD level is 0.969; for the sketch model it is 0.990. At the home end, the correlations are 0.899 and 0.974 for the TPB and sketch models, respectively.
Figure 1

Figure 2

Sketch Model vs. CTPP Part 2 - Work TAD (r=.990)
The sketch model outperforms the TPB model overall but especially in suburban areas such as those studied in this BRT planning analysis. The red dots in Figures 1 and 2 represent Tysons Corner, a large “edge city” employment area in the region. The TPB model greatly overestimates transit ridership there by approximately a factor of four. The sketch model also overestimates ridership there, but by a much lesser amount.
Factoring to Daily Trips

The Census only includes work trips and only includes them in the home-to-work direction. On average, there are 1.8 daily one-way work trips for each Census work trip (not every worker commutes every weekday). In the Washington region, total transit trips are about 1.7 times total work transit trips. Multiplying the two factors together (1.8 * 1.7) results in 3.1. We use a multiplier of 3.0 in order to be conservative.

Initial Model Application

Virginia is considering private proposals to widen I-95 and I-495 (the Capital Beltway) in Northern Virginia to create new High Occupancy Toll (HOT) lanes. An initial BRT network was tested in the model. A report that describes this work is available online.20

RECOMMENDATIONS FOR FUTURE WORK

We would like to see additional work in this area proceed along three paths. First, a similar model should be estimated in one or more other regions in order to see how transferable the model structure and model parameters are. Model transferability is getting considerable attention in the transportation modeling field due to the expense of custom models. In this case, relying on the same data source, Census data, eliminates one level of incompatibility and may aid in model transference.

Second, the model needs to be checked against data other than the estimation data. The Census data set could be divided into two parts, with one part reserved for validation. However, it would be more useful to use independent data. Transit origin-destination data would be ideal.

Third, it would be useful to determine the extent to which this type of model could be integrated within a transit agency’s operations. Many transit agencies have made large investments in Geographic Information Systems (GIS). The coding of the transit system in the sketch model is its most complicated aspect. If this was being done within the transit agency anyway, it might not be that great a step to add a sketch model. This implementation could also include other estimation capabilities, such as the ability to do pivot point/elasticity forecasts where appropriate.

REFERENCES

8 Pratt et. al, Chapter 10.


14 Marshall, N. and B. Grady, “Travel Demand Modeling for Regional Visioning and Scenario Analysis”. Presented at the Annual Meeting of the Transportation Research Board, Washington DC, January 2005; and accepted for publication in the *Transportation Research Record*.

15 For example, the Denver Regional Council of Governments assumes $4 - $16 per hour depending on income and trip type. *Integrated Regional Model – Model Refresh Project*, Chapter 5, Mode Choice Model Documentation, p. 10-11, December 2004.


