Verification and Re-estimation of the Smart Growth Trip Generation Model with Portland Data

University of California, Davis for the California Department of Transportation
December 2013

Authors

Andrew McFadden

Robert Schneider

Kevan Shafizadeh

Susan Handy

FUNDING

This project was funded by the California Department of Transportation (Caltrans) with Federal Highway Administration (FHWA) State Planning & Research Program (SPR) and State Public Transportation Account (PTA) funds provided by the Caltrans Headquarters Divisions of Transportation Planning, and Research & Innovation. Ms. Terry Parker, Senior Planner in the Transportation Planning Division's Office of Community Planning, provided overall coordination of this project and Final Report preparation.

Contents

1. Introduction

The Institute of Transportation Engineers' *Trip Generation Manual* provides estimates of the number of trips per unit size that a new development is likely to generate. Most of the data on which ITE bases its trip-generation rates is obtained at suburban locations. As a result, these rates may not accurately reflect the trip generation patterns at smart growth sites where close proximity to other destinations as well as transit and bike facilities make non-vehicular forms of travel more prevalent than at the suburban locations used by ITE.

To address this bias, Schneider et al. (2013a) developed a methodology for producing more accurate trip-generation rates for smart growth sites across California. The project produced a data collection methodology, a smart growth factor incorporating 8 variables representing the degree to which a site reflects smart growth characteristics, trip generation adjustment models for both AM and PM peak hours, and a spreadsheet tool for use by practitioners. The trip-generation models were based on data from more than 50 sites in California. Validation of these models was conducted using data from several sites left out of the estimation process. Table 1 lists the appendices included in the original study that provide further information on specific components of the project.

Table 1. Appendices to Original Report

Appendix A. Definition of "smart growth"
Appendix B. Annotated review of land use & transportation literature
Appendix C. Summary & comparison of existing tools worldwide
Appendix D. Evaluation of the operation & accuracy of available methodologies
Appendix E. UCD's Data Collection Methodology and Results
Appendix F. Method for Adjusting ITE Trip Generation Estimates for Smart Growth Projects Smart Growth Trip-Generation Adjustment Tool

This report outlines follow-up work done to test and improve the PM model developed in the original study, as described in Appendix F and Schneider et al. (2013b). The follow-up work supplements the original trip generation data collected in California with data collected at 78 sites in the Portland region by Kelly Clifton and others (2012) at Portland State University. These new sites were located across the Portland area in both smart growth and non-smart growth developments. The following sections describe the work done to verify the original model, re-estimate a new PM model based on the combined dataset, and conduct validation on the re-estimated model.

2. Verification of Original Model

The section describes the results of our application of the original PM peak-hour smart growth trip generation model (Schneider et al., 2013b) to the78 sites in the Portland metro area. The model was used to estimate vehicle trips for these sites taking into account their smart growth characteristics (or lack thereof) and the resulting estimates were compared to observed vehicle trips. This verification process was performed to test both the predictive power and applicability of the original model for an independent data set.

The 78 sites from Portland consisted of three different land uses: sit down restaurants, convenience stores, and drinking places (see Clifton et al. 2012 for an explanation of the rationale for the choice of these land uses).The numbers of sites in the dataset for each of these land uses are shown in Table 2. For each of these sites, we assembled data on the smart growth characteristics used in the original SGTG model.

Table 2. Land Uses of Portland Data

ITE Land Use Code	Land Use Name	Frequency	Percent of Sample
932	High-Turnover (Sit-Down) Restaurant	39	50%
851	Convenience Market	26	33%
925	Drinking Place	13	17%
Total		78	100%

The original study (Schneider et al., 2013a) outlined several key criteria that a site must meet for the model to be applicable. These criteria, established through consultation with a Practitioners Panel, are shown in Table 3. Each of the 78 Portland sites was checked for consistency with the criteria for applying the model. Note that two of the Portland land uses (ITE Land Use Codes 932 and 851) are different from those used in the original study and specified in the criteria (as shown in Table 3).

Table 3. Criteria for Applying Original Smart Growth Trip Generation Model (Schneider et al., 2013a)

Land Uses	ITE Trip Generation Land Use Codes: Residential (220, 222, 223, 230, 232), office (710), restaurant (925, 931), and coffee/donut shop (936); potentially applicable to retail land use codes.
Development Intensity	▪ The area within a 0.5-mile radius of the site is mostly developed, and ▪ There is a mix of land uses within a 0.25-mile radius of the site, and ▪ J>4,000 and R>(6,900-0.1J), where J is the number of jobs within a 0.5-mile radius of the site and R is the number of residents within a 0.5-mile radius of the site, and ▪ There are no special attractors within a 0.25-mile radius of the site (e.g., stadiums, military bases, commercial airports, etc).
Transit Service	During a typical weekday PM peak hour, there are at least 10 bus stop locations on all bus lines that pass within any part of a 0.25-mile radius around the study site, or 5 individual train stop locations on all train lines that pass within any part of a 0.5-mile radius around the study site during a typical weekday PM peak hour.
Pedestrian or Bicycle Infrastructure	There is at least one designated bicycle facility within two blocks of the edge of the site (designated bicycle facilities include multi-use trails, cycle tracks, and bicycle lanes), or there is >50% sidewalk coverage on streets within a 0.25-mile radius of the site.

Based on these criteria, the Portland sites were grouped into the following three categories:

- *Most Appropriate:* 4 sites met all criteria, and 16 met all but the land use requirement (20 sites total).
- *Nearly Appropriate:* 23 met nearly all criteria.
- *Least Appropriate:* 35 did not meet the criteria to be evaluated in the model.

Out of the 78 sites, only four met all criteria. Nevertheless, as many of the restaurant and convenience store land-use types closely matched uses at the site on which the original model was based, 16 additional sites that met all but the land use requirement were added to these four to define the Primary Analysis Set (N = 20). Twenty-three sites were identified that nearly met all the criteria of the original model, where "nearly" was defined as meeting all criteria at half their original threshold (i.e., 5 train stops instead of 10). Although 50% is an arbitrary threshold, we concluded that these sites displayed adequate smart growth qualities to be tested with the model. These 23 sites were added to the Primary Analysis Set to create the Secondary Analysis Set (N = 43). The last 35 sites did not meet the original criteria or the relaxed criteria for the Secondary Analysis Set, but they were still analyzed as a part of the Full Analysis Set (N = 78).

The original model used site attributes to predict the adjustment to ITE-based trip estimates (equation 1).

$$\boldsymbol{ln}\frac{\textbf{\textit{Actual Peak Vehicle Trips}}}{\textbf{\textit{ITE Estimated Peak Vehicle Trips}}} \tag{1}$$

For the verification analysis, we used the exponent of this expression (e^x), that is, the ratio of actual trips to the ITE estimate (equation 2).

$$Actual\ Peak\ Vehicle\ Trips \big/ ITE\ Estimated\ Peak\ Vehicle\ Trips \tag{2}$$

This ratio is used in the verification analysis in two different ways:

1) to compare the observed vehicle trips at a site to the ITE-based estimate, and
2) to compare the model-predicted vehicle trips at a site to the ITE-based estimate.

The figures below compare (1) on the y-axis and (2) on the x-axis. A perfect model would trend along the diagonal line shown in each figure (i.e. model-predicted trips would equal observed trips). Figure 1 shows this comparison for only the most appropriate Primary Analysis Set, while Figure 2 and Figure 3 present this comparison for the Secondary Analysis Set and Full Analysis Set, respectively (with the 23 nearly appropriate sites shown in red, and the 35 least appropriate sites shown in purple). Figures 1 through 3 show the complete results of each subsample, including all outliers. To obtain the predicted number of peak-vehicle trips, we multiplied the ratio shown in equation 2, above, by the ITE estimate. Figure 4 shows the ITE-estimated and model-predicted vehicle trips plotted against actual trips for the Primary Analysis Set (most appropriate sites only) in order of increasing vehicle trips.

Some sites had vehicle trip counts far higher than the ITE-based estimates. For example, the Hot Lips Pizza site at 721 NW 9th Avenue was identified as an outlier in the Primary Analysis Set with actual trips more than twice the number of trips estimated by ITE despite having smart-growth characteristics (Figure 1). As discussed below, restaurants displayed higher variability in actual trips than other land uses, and further work is needed to understand these variations.

The goodness of fit of the model is shown by how closely the estimates correspond with the perfect linear fit line provided in Figures 1, 2, and 3. As expected, the model was less accurate at predicting trip generation at sites that did not meet the smart-growth criteria specified for the model. In general, the model provided a more accurate prediction of the observed PM peak-hour vehicle trips at smart growth sites with 75% of the most appropriate sites predicted closer to the actual estimate than the ITE prediction (Figure 4). Note that for the most appropriate sites, the model tends to over-estimate trips rather than under-estimate trips, thereby producing conservative estimates of the benefits of smart growth characteristics in reducing vehicle trips. The fact that the model performs better for the most appropriate sites than the nearly appropriate sites reinforces the importance of applying the model only to sites that meet the specified smart-growth criteria.

The results of this follow-up study verify the previously estimated model on a new dataset and validate the initial criteria placed on potential sites for use with the model. Yet, as only a few of the Portland sites met the criteria for applying the model, further work is needed to make the model more robust across a wider range of site characteristics. As a first step, we re-estimated the model with the combined data from the Portland and original California sites.

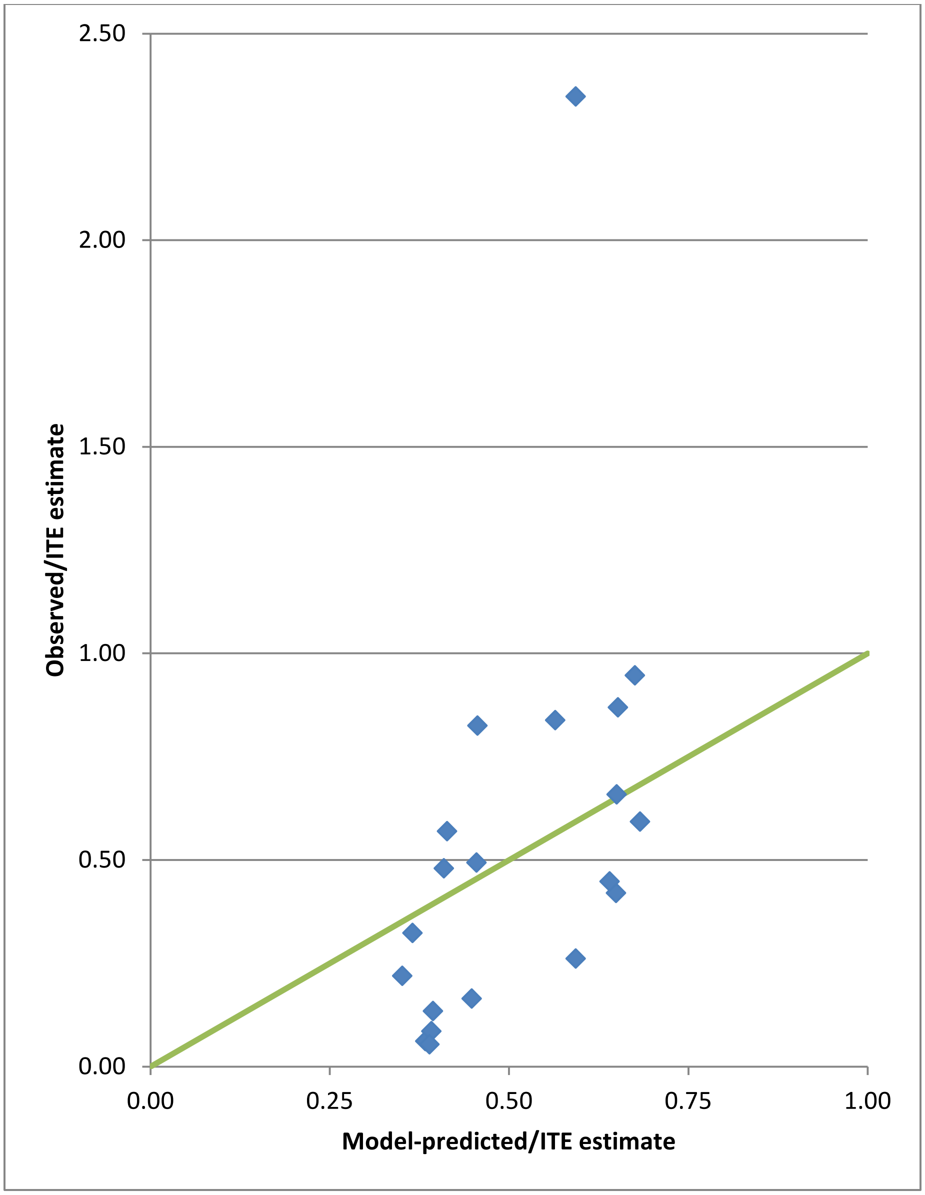

Figure 1. Observed versus Predicted Ratios to ITE Estimates: Most Appropriate Sites

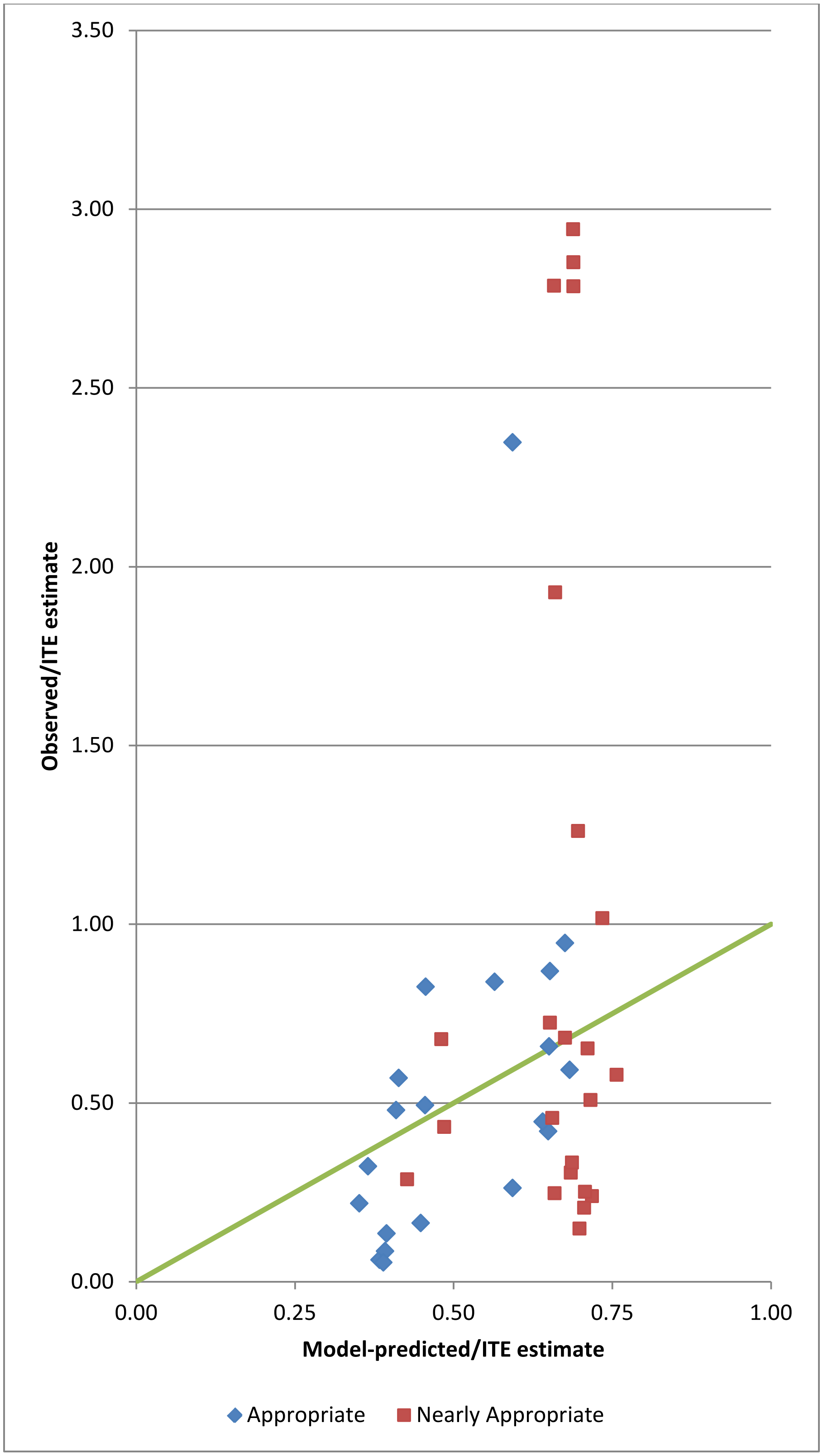

Figure 2. Observed versus Predicted Ratios to ITE Estimates: Most Appropriate and Nearly Appropriate Sites

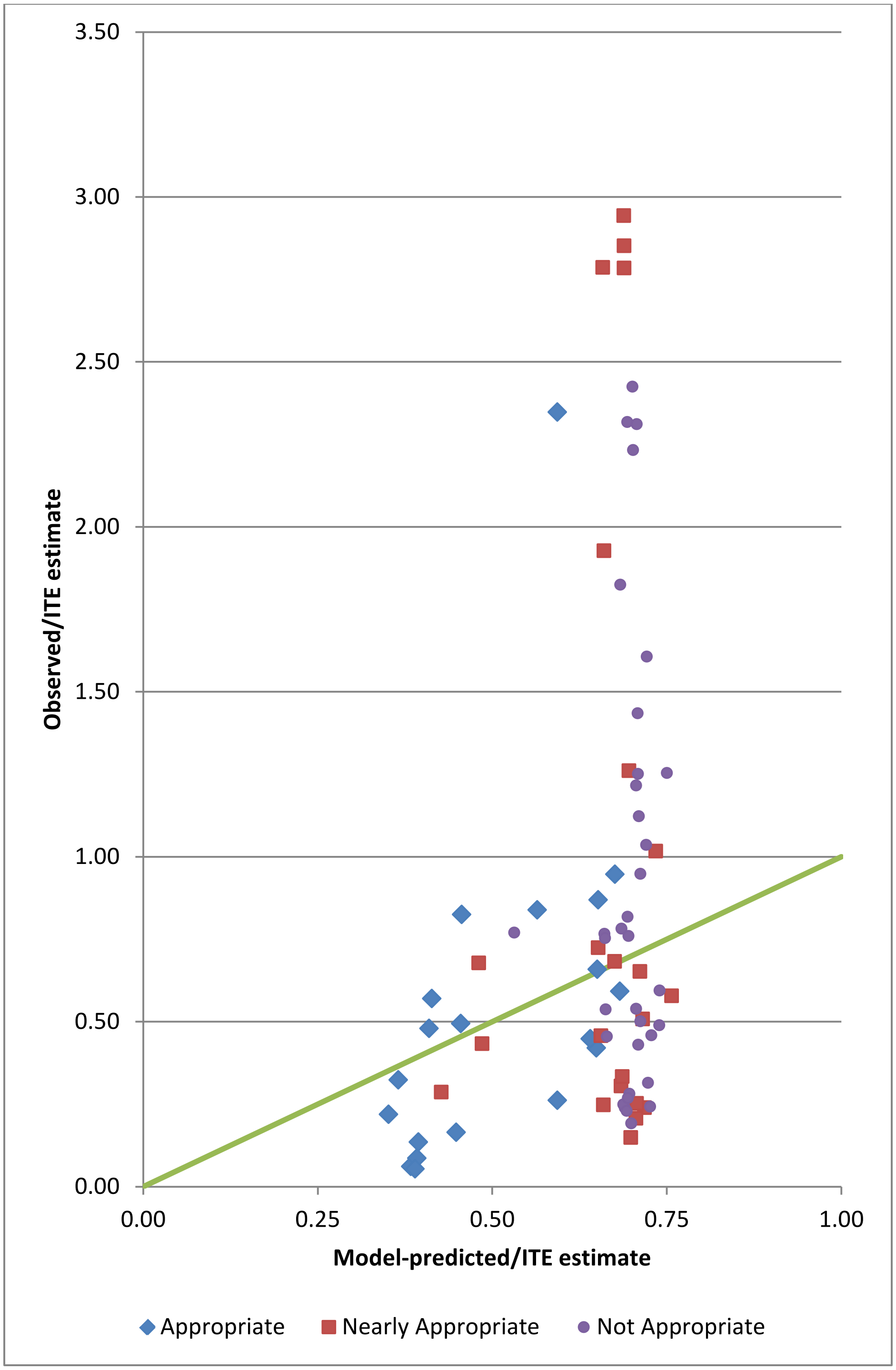

Figure 3. Observed versus Predicted Ratios to ITE Estimates: All Sites

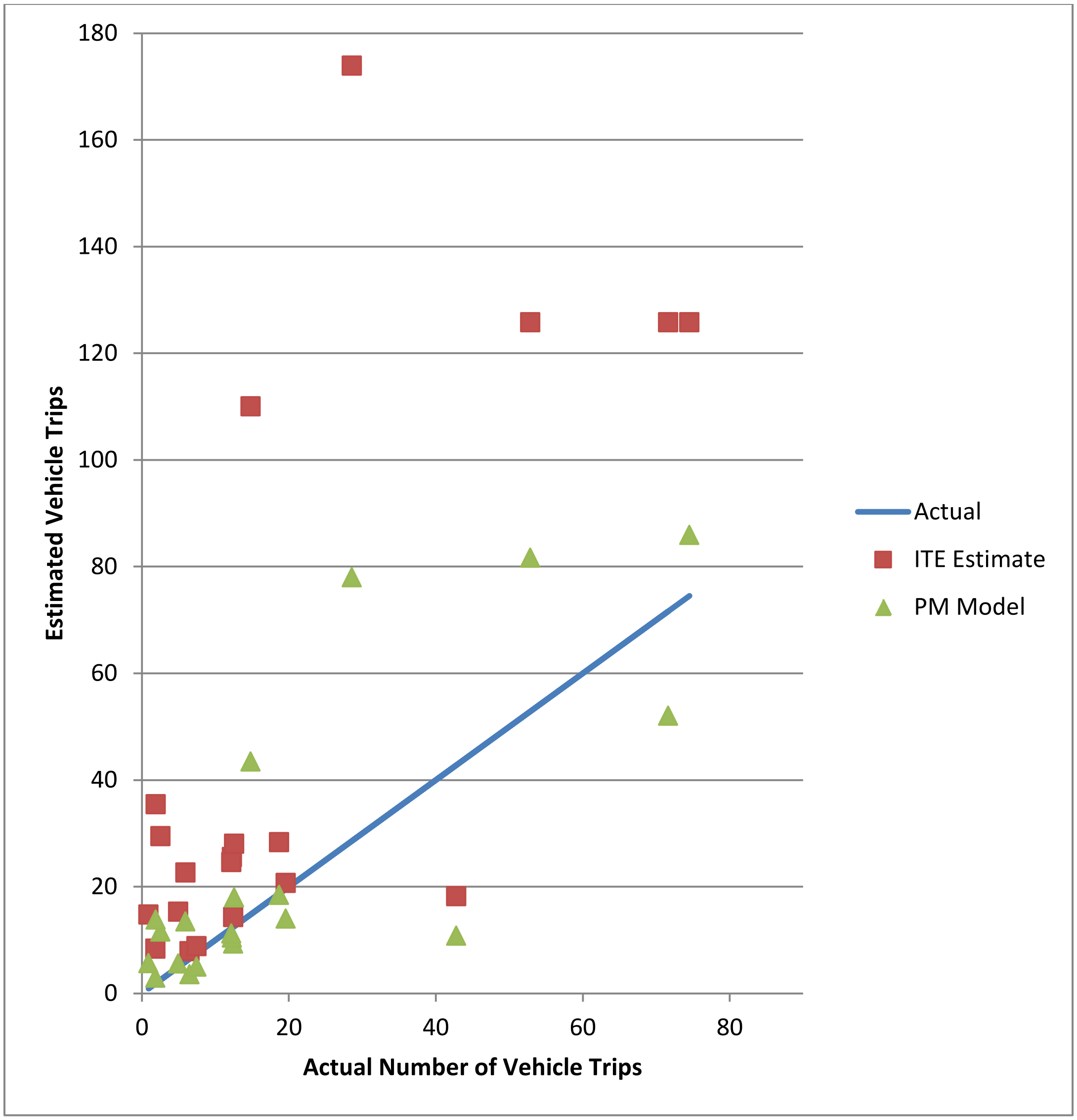

Figure 4. ITE- and Model- Estimated Trips vs. Actual Trips: Most Appropriate Sites

3. Re-estimating Original Model with New Portland Data

The following section describes the process of re-estimating the California SGTG model using the Portland data combined with the California data. The process involved 1) selecting sites for analysis and validation, 2) re-estimating the Smart-Growth Factor, and 3) re-estimating the linear regression model predicting the value shown in equation 1 above. The primary purpose of this exercise is to test the robustness of the original California model by examining the consistency between the California model and the new model estimated with the combined dataset.

Although relatively few of the potential Portland sites met the criteria for application of the smart growth model, as described above, all Portland sites (N=78) were used to either re-estimate the model (N=64) or validate the new model (N=14). This new combined data set thus represents more diverse land use contexts than the sites used to estimate the California SGTG model. Figure 8 below shows the validation and estimation sites with an inset map to magnify sites clustered in Downtown Portland. The validation sites were selected using a similar process as in the original analysis: when two sites were within a quarter of a mile of each other, one was randomly selected for the validation subset. This helps to ensure that sites in the estimation set are not correlated with each other based upon location. The 14 Portland sites selected in this way (shown in blue below in Figure 5) were combined with the 13 original California validation sites for the validation of the new model, described below. The SGTG model was re-estimated using 114 sites, 64 from Portland and 50 from California.

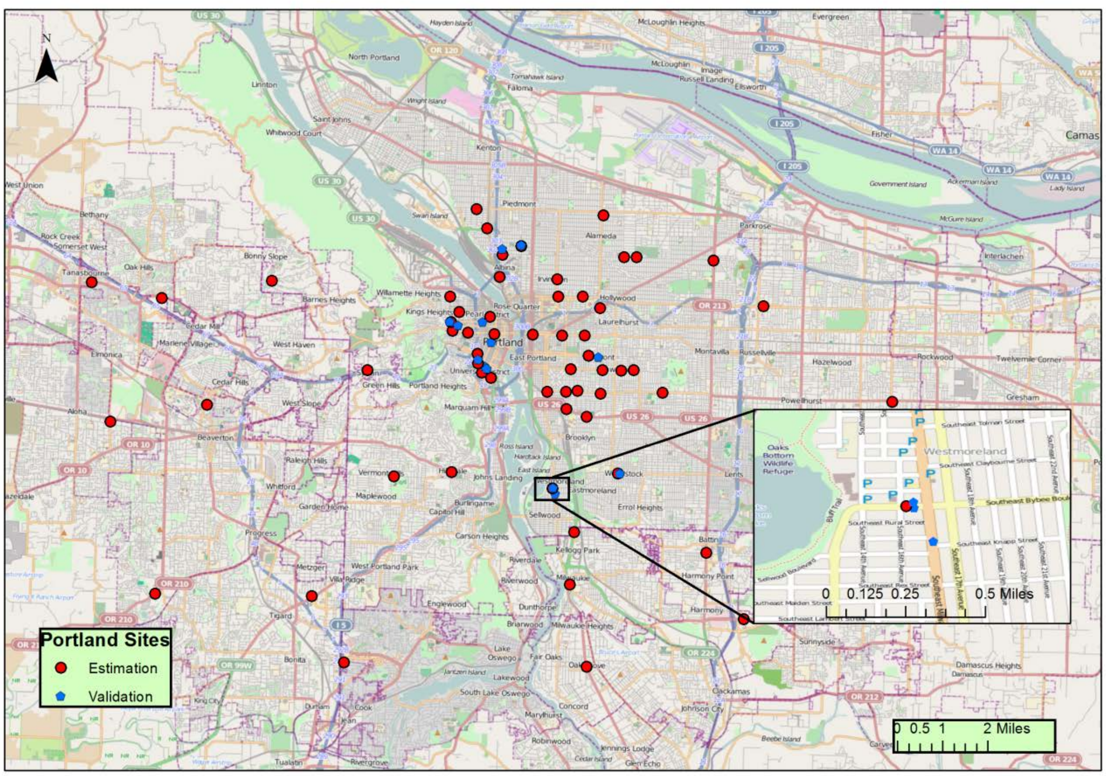

Figure 5. Validation and Estimation Sites from Portland Data

The next step was to re-estimate the Smart-Growth Factor using the expanded data set. The Smart-Growth Factor is a measure of the degree to which a site reflects the combination of selected smart-growth characteristics and was estimated using factor analysis (see Appendix F and Schneider et al., 2013b) Table 4 compares the factor loadings for the original and new factor analyses for the Smart-Growth Factor. Although the loadings on both straight-line distance to CBD and building setback decrease substantially (highlighted), they are both conceptually relevant to retain in the Smart-Growth Factor. Their retention is supported by guidance from Costello and Osbourne (2005), who suggest that variables with factor loadings greater than an absolute value of 0.32 may be relevant to include. We also analyzed specifications with more than one factor but found the single-factor solution preferable, as in the original study. Table 5 shows the original and updated factor scores for the 8 variables making up the Smart-Growth Factor.

Table 4. Original and New Factor Loadings for Smart-Growth Factor

Variable	Original Loading	New Loading	Change in Magnitude
Residential population within an 804m (0.5-mile), straight-line radius (000s)	0.538	0.617	0.079
Jobs within an 804m (0.5-mile), straight-line radius (000s)	0.781	0.830	0.049
Straight-line distance to center of central business district (CBD) (miles)	-0.632	-0.397	**-0.235**
Average building setback distance from sidewalk (feet)	-0.636	-0.372	**-0.264**
Metered on-street parking within a 161m (0.1-mile), straight-line radius (1=yes, 0=no)	0.707	0.791	0.084
Individual PM peak-hour bus line stops passing within a 402m (0.25-mile), straight-line radius	0.745	0.789	0.044
Individual PM peak-hour train line stops passing within a 804m (0.5-mile), straight-line radius	0.661	0.678	0.017
Proportion of site area covered by surface parking lots (0.00 to 1.00)	-0.467	-0.508	0.041

Table 5. Original and New Factor Scores for Smart-Growth Factor

Variable	Original Scores	New Scores
Residential population within an 804m (0.5-mile), straight-line radius (000s)	0.099	0.129
Jobs within an 804m (0.5-mile), straight-line radius (000s)	0.324	0.317
Straight-line distance to center of central business district (CBD) (miles)	-0.138	-0.064
Average building setback distance from sidewalk (feet)	-0.167	-0.075
Metered on-street parking within a 161m (0.1-mile), straight-line radius (1=yes, 0=no)	0.184	0.282
Individual PM peak-hour bus line stops passing within a 402m (0.25-mile), straight-line radius	0.227	0.221
Individual PM peak-hour train line stops passing within a 804m (0.5-mile), straight-line radius	0.053	0.111
Proportion of site area covered by surface parking lots (0.00 to 1.00)	-0.080	-0.049

To calculate the Smart-Growth Factor for each of the 114 sites, the new factors scores for each variable were multiplied by the standardized values for each of the variables and the products were summed.[1] Table 6 shows the updated descriptive statistics with the Portland sites included.

Table 6. Smart-Growth Factor Variable Descriptive Statistics base on 114 PM Peak Hour Study Sites

Variable	N	Minimum	Maximum	Mean	Std. Dev.
Residential population within an 804m (0.5-mile), straight-line radius (000s)	114	0.41	42.11	7.84	5.43
Jobs within an 804m (0.5-mile), straight-line radius (000s)	114	0.17	136.40	14.49	22.99
Straight-line distance to center of central business district (CBD) (miles)	114	0.03	40.10	5.78	7.14
Average building setback distance from sidewalk (feet)	114	0.00	524.00	56.68	85.86
Metered on-street parking within a 161m (0.1-mile), straight-line radius (1=yes, 0=no)	114	0.00	1.00	0.35	0.48
Individual PM peak-hour bus line stops passing within a 402m (0.25-mile), straight-line radius	114	0.00	255.00	27.39	39.43
Individual PM peak-hour train line stops passing within a 804m (0.5-mile), straight-line radius	114	0.00	64.00	6.67	13.71
Proportion of site area covered by surface parking lots (0.00 to 1.00)	114	0.00	0.75	0.25	0.25

The third step was to use the calculated Smart-Growth Factor for each estimation site as an explanatory variable in re-estimating the SGTG model that predicts the adjustment to ITE-based estimates of vehicle trips (equation 1) for the PM peak hour. The first model tested (shown below in Table 7) included the same variables as in the original model: the Smart-Growth Factor, three land-use indicator variables, and a dummy variable for proximity to a university. All coefficient signs in the new model match those of the original model, but the new model has a much lower adjusted R^2 than the original model. The Smart-Growth Factor and University indicator variables both became larger in absolute magnitude and more significant statistically, while the opposite was true for the land-use indicator variables.

Table 7. Original Model Re-Estimated with Expanded Dataset

Dependent Variable = Natural Logarithm of Ratio of Actual Peak Hour Vehicle Trips to ITE-Estimated Peak Hour Vehicle Trips						
	Original PM Model			**New PM Model**		
Model Variables	**Coefficient**	**t-statistic**	**p-value**	**Coefficient**	**t-statistic**	**p-value**
Smart-Growth Factor (SGF)	-0.155	-1.491	0.143	-0.174	-1.929	0.056
Office land use (1 = yes, 0 = no)	-0.529	-2.558	0.014	-0.452	-1.754	0.082
Coffee shop land use (1 = yes, 0 = no)	-0.744	-2.339	0.024	-0.693	-1.733	0.086
Multi-use development (1 = yes, 0 = no)	-0.079	-0.381	0.705	-0.078	-0.359	0.721
Within 1 mi. of a university (1 = yes, 0 = no)	-0.311	-1.099	0.278	-0.359	-1.629	0.106
Constant	-0.491	-4.469	0.000	-0.460	-5.651	0.000
Overall Model						
Sample Size (N)	50			114		
Adjusted R^2-Value	0.290			0.158		
F-Value (Test value)	4.99 (p = 0.001)			5.23 (p =0.0002)		

[1] $SGFn = \sum_i Score_i \times \left(\frac{x_{in}-\mu_i}{s_i}\right)$ where *x* is variable *i*'s value for site *n*, μ is the sample mean, and *s* is variable *i*'s sample standard deviation.

To test the statistical significance of the changes in the coefficients, we calculated t-statistics using Equation 3, with degrees of freedom calculated using Equation 4. The results of this test are presented in Table 8.

$$\frac{\bar{X}_1-\bar{X}_2}{\sqrt{\frac{s_1{}^2}{n_1}+\frac{s_2{}^2}{n_2}}} \qquad (3)$$

$$\frac{\left({s_1{}^2}/{n_1}+{s_2{}^2}/{n_2}\right)^2}{\left[\left({s_1{}^2}/{n_1}\right)^2/(n_1-1)\right]+\left[\left({s_2{}^2}/{n_2}\right)^2/(n_2-1)\right]} \qquad (4)$$

Table 8. T-tests Performed on Original and New Model Coefficient Differences

	Original PM Model		New PM Model		Test of Difference			
Model Variables	**Coefficient**	**Std. error**	**Coefficient**	**Std. error**	**Coefficient Difference**	**t-statistic**	**d.f.**	**p value**
Smart-Growth Factor (SGF)	-0.155	0.104	-0.174	0.090	-0.019	-1.146	82.944	0.255
Office land use	-0.529	0.207	-0.452	0.257	0.077	2.043	115.195	0.043
Coffee shop land use	-0.744	0.318	-0.693	0.400	0.051	0.863	116.301	0.390
Multi-use development	-0.079	0.207	-0.078	0.218	0.001	0.018	98.222	0.986
Within 1 mi. of a university	-0.311	0.283	-0.359	0.220	-0.048	-1.058	76.149	0.293
Constant	-0.491	0.110	-0.460	0.081	0.031	1.763	73.636	0.082

The results of this t-test indicate that the new coefficient of the multi-use development indicator variable remained nearly the same as in the former model, and that the Smart-Growth Factor, coffee shop indicator, and university indicator did not change significantly. The office land-use indicator and the constant were the only variables to change significantly with a 90% confidence interval. These results suggest that the original model is relatively robust.

However, the lower goodness-of-fit of the original model re-estimated with the expanded data set prompted us to explore new model specifications. Indicator variables were created for each of the new land uses in the expanded data set to reflect the wider range of land uses in the Portland data. All of these indicator variables were then introduced into the model using a backwards stepping process (shown in Table 9). (It should be noted that one restaurant site from the original analysis had not formerly been assigned as a restaurant, but instead was assigned to an “other” group as there were too few restaurant sites to warrant a specific indicator. A restaurant indicator variable was created in the new specification, and that one site from the original analysis was added to the restaurant group.)

The new model has an improved adjusted R^2 value compared to previous models, and all variables are significant with at least a 95% confidence threshold. This model excludes the university indicator variable, which was not significant at any reasonable level of confidence. However, this variable was included in the original model to provide accurate and unbiased parameter estimates and so was added to this model to produce the final model, shown in Table 10. This model explains a very similar amount of variation (adjusted R^2 = 0.486) as the above models, and all variables aside from the university indicator and the intercept are significant at a 95% confidence level.

Table 9. Backwards Regression Model

Dependent Variable = Natural Logarithm of Ratio of Actual Peak Hour Vehicle Trips to ITE-Estimated Peak Hour Vehicle Trips			
	New PM Model		
Model Variables	**Coefficient**	**t-statistic**	**p-value**
Smart-Growth Factor (SGF)	-0.28	-4.171	6.23E-05
Office land use (1 = yes, 0 = no)	-0.77	-3.747	2.92E-04
Coffee shop land use (1 = yes, 0 = no)	-1.21	-3.758	2.80E-04
Residential land use (1 = yes, 0 = no)	-0.47	-3.093	2.53E-03
Multi-use development (1 = yes, 0 = no)	-0.61	-3.313	1.26E-03
Convenience Store land use (1 = yes, 0 = no)	-1.14	-8.117	9.18E-13
Drinking Place (1 = yes, 0 = no)	-1.01	-5.340	5.33E-07
Constant	0.00	0.033	0.97
Overall Model			
Sample Size (N)	114		
Adjusted R^2-Value	0.485		
F-Value (Test value)	16.231 ($p \approx 0$)		

Table 10. Backwards Stepwise Model with added University Indicator Variable

Dependent Variable = Natural Logarithm of Ratio of Actual Peak Hour Vehicle Trips to ITE-Estimated Peak Hour Vehicle Trips			
	New PM Model		
Model Variables	**Coefficient**	**t-statistic**	**p-value**
Smart-Growth Factor (SGF)	-0.24	-3.299	0.001
Office land use (1 = yes, 0 = no)	-0.85	-3.900	1.70E-04
Coffee shop land use (1 = yes, 0 = no)	-1.20	-3.727	3.14E-04
Residential land use (1 = yes, 0 = no)	-0.48	-3.197	0.002
Multi-use development (1 = yes, 0 = no)	-0.62	-3.357	0.001
Convenience Store land use (1 = yes, 0 = no)	-1.12	-7.975	1.99E-12
Drinking Place (1 = yes, 0 = no)	-0.99	-5.249	8.03E-07
Within 1 mi. of a university (1 = yes, 0 = no)	-0.19	-1.089	0.278
Constant	0.03	0.35	0.727
Overall Model			
Sample Size (N)	114		
Adjusted R^2-Value	0.486		
F-Value (Test value)	14.375 ($p \approx 0$)		

4. Validation of New Model

The 27 sites that were excluded from the data set used to estimate the above models were used to validate the final model shown in Table 10. The results of this validation can be seen in Figure 6.

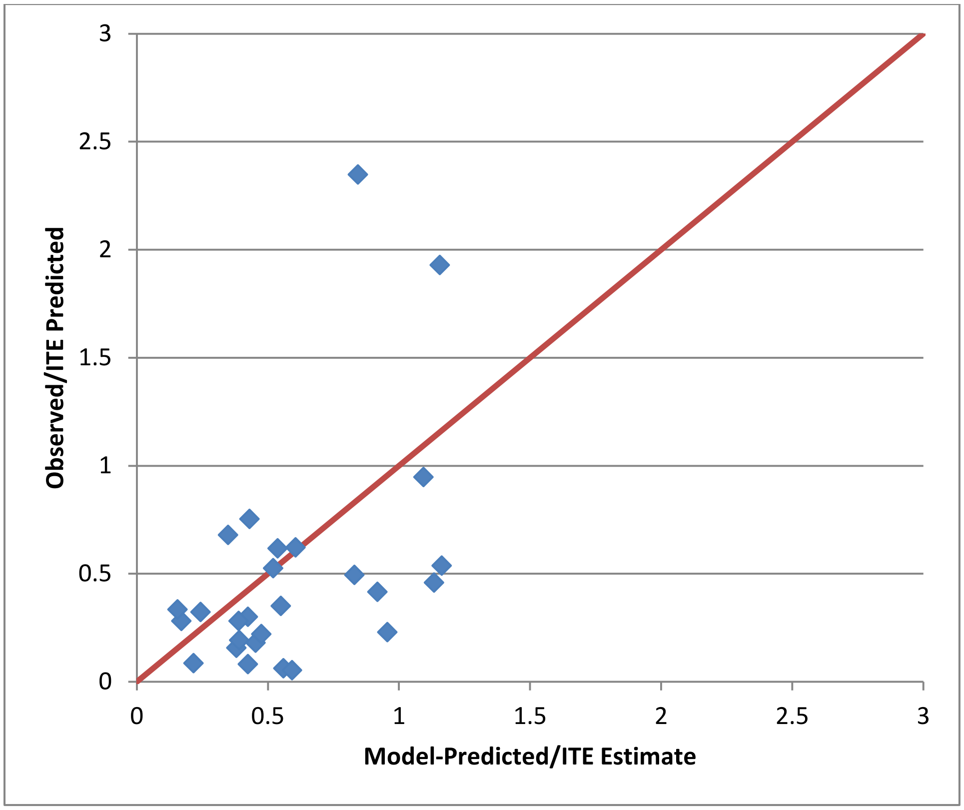

Figure 6. Observed versus Predicted Ratios to ITE Estimates: Validation Sites

The model performs well in general, though the model tends to over-predict trips (as indicated by points below the diagonal line in Figure 6). Two notable outliers are in the restaurant category (a Laughing Planet Cafe and a Hot Lips Pizza in the Ecotrust Building). A possible explanation for these outliers is that the ratio of actual to ITE-estimated trips does not vary as strongly with smart growth characteristics for this land use. This limitation was also seen in Clifton et al. (2012) where only 58% of restaurant validation sites were closer to the actual trip rate than are the ITE estimate. Here 88% of the model estimates for restaurant sites are closer to the actual than are the ITE estimates, whereas overall 96% of the model estimates are closer than the ITE estimates.

There are a number of important considerations in this analysis, including the appropriateness of combining sites from Portland and California. Additionally, certain land uses varied more drastically than others. In some intermediate models that included the restaurant land-use indicator variable, this variable had a positive coefficient, which stems from the fact that restaurants included in the sample had vehicle trip rates higher than the ITE estimates on average. Further work to account for unmeasured variables is needed to address this problem. This work and further efforts will better quantify the effects of smart growth characteristics on trip rates, and in doing so inform practitioners of how to better estimate potential vehicle trip rates from smart growth sites.

5. Conclusions

This report chronicles follow-up work done on the original California-based Smart Growth Trip Generation (SGTG) model developed by Schneider et al. (2013b). It combines the original data set with one collected in the Portland Metro Area by Clifton et al. (2012) to verify the original model, re-estimate a new model, and validate the new model based on a set aside subset of data. Verification results showed that the original model successfully predicted the number of vehicle trips better than the ITE estimate in 75% of Portland sites that most closely met the criteria for applying the original model. The model re-estimation effort increased the goodness of fit while incorporating more sites to create a more robust model that is a applicable over a wider range of site characteristics. Finally, the validation section showed that the new model performed well for a diverse set of 27 sites in California and Oregon.

References

Clifton, Kelly, Kristina Currans, and Christopher Muhs (2012) Contextual Influences on Trip Generation. Oregon Transportation Research and Education Consortium. Available online: http://otrec.us/project/407 on 11/8/2013

Costello, A. B. & Osborne, J. W., 2005. Best Practices in Exploratory Factor Analysis: Four Recommendations for Getting the Most from Your Analysis. *Practical Assessment, Research and Evaluation*, 10(7). Available online: http://pareonline.net/pdf/v10n7.pdf.

Schneider, R., K. Shafizadeh, and S. Handy (2013a) *California Smart Growth Trip Generation Rates Study, Final Report.* University of California, Davis for the California Department of Transportation, Available online: http://ultrans.its.ucdavis.edu/projects/smart-growth-trip-generation

Schneider, R., K. Shafizadeh, and S. Handy (2013b) *California Smart Growth Trip Generation Rates Study, Appendix F: Methodology for Adjusting ITE Trip Generation Estimates for Smart Growth Projects*, University of California, Davis for the California Department of Transportation, Available online: http://ultrans.its.ucdavis.edu/projects/smart-growth-trip-generation