Improving Vehicle Trip Generation Estimations for Urban Contexts

A Method Using Household Travel Surveys to Adjust ITE’s *Trip Generation Handbook* Rates

Christopher D. Muhs, presenting on behalf of: Kristina M. Currans & Dr. Kelly J. Clifton

Innovations in Travel Demand Modeling

April 29th, 2014
ITE’s *Trip Generation Handbook*

Current state-of-the-practice for estimating vehicle trip generation for Traffic Impact Analysis

Includes:

- Methodology
- ~160 land uses
- ~550 locations
- ~5,000 points
Traffic Impact Analysis
Dependent predictors are only establishment size

Vehicle trips only

By time of day, day of week

Biased toward suburban, automobile-oriented locations

Not sensitive to urban contexts
Establishing the Need

• Studies show ITE lacks sensitivity to urban contexts\(^1\)

• Growing literature establishing the relationship between land use, the built environment and travel behavior\(^2\)

• Issues not yet addressed in ITE applications

\(^1\)(Bochner et al, 2011; Clifton et al, 2012; Daisa et al, 2009; Schneider et al, 2011)
\(^2\)(Cervero et al, 1997; Ewing et al, 2001; Ewing et al, 2010)
Current Methods for Urban Adjustments

- No Adjustment (ITE)
- Rule-of-Thumb Adjustment
- Travel Demand Model Based
- Local Study

Least Data Intensive
Most Transferable Between Regions

Most Data Intensive
Least Transferable Between Regions
Current Methods for Urban Adjustments

Least Data Intensive
Most Transferable Between Regions

Most Data Intensive
Least Transferable Between Regions

No Adjustment (ITE)

Rule-of-Thumb Adjustment

Travel Demand Model Based

Compiles own trip gen. data
New York City
San Francisco
San Diego
Arlington

Local Study

Introduction - 7
Current Methods for Urban Adjustments

Least Data Intensive

Most Transferable
Between Regions

Most Data Intensive

Least Transferable
Between Regions

Framework for using regional household travel data
Compiles own trip gen. data

NCHRP 758 Project
New York City
San Francisco
San Diego
Arlington

No Adjustment (ITE)
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Introduction - 8
Current Methods for Urban Adjustments

- Least Data Intensive
  - Most Transferable
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- Most Data Intensive
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- No Adjustment (ITE)
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- Pivot-based model using elasticities
- Framework for using regional household travel data
- Compiles own trip gen. data
- Fehr & Peers - MXD
- NCHRP 758 Project
- New York City
- San Francisco
- San Diego
- Arlington

Introduction - 9
Current Methods for Urban Adjustments

Least Data Intensive
Most Transferable Between Regions

No Adjustment (ITE)

Rule-of-Thumb Adjustment

Pivot-based model using elasticities
OTREC Caltrans

Framework for using regional household travel data
NCHRP 758 Project

New York City
San Francisco
San Diego
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Most Data Intensive
Least Transferable Between Regions

Travel Demand Model Based

Compiles own trip gen. data

Introduction - 10
Research Objective

Develop an “off-the-shelf” methodology to adjust ITE’s *Trip Generation Handbook* at single land use locations with sensitivity to urban contexts using readily available data, and verify it using independently-collected data.
METHODOLOGY
Typical Traffic Impact Analysis

- Development
- Vehicle Trip Estimation
- Assess Change in Value of Performance Measure
- Mitigation

Arrows indicate:
- Influences
- Direction
- Feedback
Proposed Adjustment
How does this adjustment work?

(1) Estimate vehicle trips at the establishment using ITE’s *Trip Generation Handbook*.

(2) Convert ITE’s *Handbook* vehicle trip estimates into person trips based on assumptions on ITE’s data:

\[
\frac{(Vehicle\ Trips_{ITE} \times Vehicle\ Occupancy_{ITE})}{Automobile\ Mode\ Share_{ITE}} = Person\ Trips_{ITE}
\]

(3) Re-distribution ITE’s person trip estimates into all modes based on the urban context’s modes share/vehicle occupancy:

\[
\frac{Person\ Trips_{ITE} \times Automobile\ Mode\ Share_{Urban\ Context}}{Vehicle\ Occupancy_{Urban\ Context}} = Vehicle\ Trips_{Urban\ Context}
\]
Proposed Adjustment
Proposed Adjustment

Research
- Compile and Organize Household Travel Surveys
- Collect Built Environment Information
- Mode Share/Vehicle Occupancy Equation Development

Applied by Practitioner
- Urban Area-Type Development
  - Vehicle Trip Estimation
  - Adjustment for Urban Context
    - Assess Change in Value of Performance Measure
      - Mitigation

Influences → Direction → Feedback
Proposed Adjustment

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Influences
Direction
Feedback
HOUSEHOLD TRAVEL SURVEYS
Traffic Impact Analysis
Household Travel Surveys (HTS)
• Three HTS are used in this analysis:
  – Portland, Oregon (2011)
  – Baltimore, Maryland (2001)
Household Travel Surveys (HTS)

- Organized similar to ITE’s *Trip Generation Handbook* to support compatibility
  - Each trip provides two trip end observations
    - Origins = exiting trip ends
    - Destinations = entering trip ends
  - Classified by:
    - time of day (AM Peak, Midday, PM Peak)
    - day of week (Weekday, Friday, Weekend)
  - Relate purposes/activities to land use types
Trip Purposes versus Land Use

• Develop schema crosswalk of relationships
• Example relationships:
  – “eating outside of home” = restaurant
  – “work” activities = primary workplace industry
  – “home” activities = home place structure
• Uncertain relationships. Examples:
  – “school” activity: do homework at café
  – “eating outside of home” at café
  – “work-related” meeting at café
• Different assumptions → different crosswalk
# Trip End Data Sets

<table>
<thead>
<tr>
<th>Trip End Type</th>
<th>Trip Ends (Sample Size)</th>
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</thead>
<tbody>
<tr>
<td>All Trip Ends (pooled)</td>
<td>243,671</td>
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<tr>
<td>Retail</td>
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<td>Residential</td>
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<td>Restaurant</td>
<td>17,622</td>
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<tr>
<td>Office</td>
<td>10,924</td>
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</table>
Proposed Adjustment

Research

Compile and Organize Household Travel Surveys

Collect Built Environment Information

Mode Share/Vehicle Occupancy Equation Development

Adjustment for Urban Context

Assess Change in Value of Performance Measure

Mitigation

Applied by Practitioner

Urban Area-Type Development

Vehicle Trip Estimation

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BUILT ENVIRONMENT
Built Environment Measures of Urban Context

Collected a range of built environment metrics
- At the ½-mile buffer for each trip-end
- Using Census, LEHD, Tiger files

Strongest relationship with travel:
- Intersection density
- Population density
- Activity density (population + employment)

Controlled for:
- Distance to the Central Business District
- Within ½ mile to a transit-oriented development
Proposed Adjustment

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Influences
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ADJUSTMENT DEVELOPMENT
Resulting Adjustments

Adjustment A: Simple mode share table
Resulting Adjustments

Adjustment A: Simple mode share table

Adjustment B: Regression with the best model performance (pseudo $R^2=0.29$)
Resulting Adjustments

Adjustment A: Simple mode share table

Adjustment B: Regression with the best model performance (pseudo $R^2=0.29$)

Adjustment C: Regression that is sensitive to land use policies (pseudo $R^2=0.26$)
# Resulting Adjustments

## All Trip Ends (pooled)

<table>
<thead>
<tr>
<th>Category</th>
<th>Veh Occ</th>
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<tbody>
<tr>
<td>Retail</td>
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<td>Residential</td>
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<tr>
<td>Single-Family</td>
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<td>Multifamily</td>
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<tr>
<td>Entertainment/Recreational</td>
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<tr>
<td>Service (non-restaurant)</td>
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## Mode Share

<table>
<thead>
<tr>
<th>Mode Share</th>
<th>A</th>
<th>B</th>
<th>C</th>
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Equation Development - 36
# Resulting Adjustments

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<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Service (non-restaurant)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Restaurant</td>
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<td>Office</td>
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</tbody>
</table>
## Resulting Adjustments

### Mode Share

<table>
<thead>
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<td>✓</td>
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</tbody>
</table>

- **All Trip Ends (pooled)**
- **Retail**
- **Residential**
  - Single-Family
  - Multifamily
- **Entertainment/Recreational**
- **Service (non-restaurant)**
- **Restaurant**
- **Office**

- 9 tables
- 27 models
### Resulting Adjustments

#### Mode Share

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Veh Occ</th>
</tr>
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<tbody>
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<td>✔️</td>
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<tr>
<td>Residential</td>
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<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>

3 methods of adjustment were tested
Proposed Adjustment

Research

Compile and Organize Household Travel Surveys
Collect Built Environment Information
Mode Share/Vehicle Occupancy Equation Development

Applied by Practitioner

Urban Area-Type Development
Vehicle Trip Estimation
Adjustment for Urban Context
Assess Change in Value of Performance Measure
Mitigation

Influences
Direction
Feedback
Proposed Adjustment

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Direction

Feedback
Verification of Methodologies

• Test three adjustments for the nine general land use categories

• Independently-collected data
  – Traffic Impact Analysis data (*Handbook*)
  – 195 points
  – 13 different types of establishments
  – Portland, Oregon; San Diego, Oakland, LA, California; Washington, D.C area; Vermont
  – OTREC\(^1\), Caltrans/Kimley-Horn\(^2\) and ITE

\(^1\)(Clifton et al, 2012), \(^2\)(Daisa et al, 2009)
Verification of Methodologies

Ex: Retail - Convenience Markets

Estimated minus Observed
Vehicle Trip Ends per 1,000 Sq. Ft.

Activity Density
[residents and employment per acre]
Verification of Methodologies

Ex: Retail - Convenience Markets

Estimated minus Observed

[Vehicle Trip Ends per 1,000 Sq. Ft]

ITE's Handbook

Urban Adjustments

Activity Density

[residents and employment per acre]
## Verification Results

<table>
<thead>
<tr>
<th>ITE’s Handbook</th>
<th>Similar Results</th>
<th>Urban Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Residential condominiums/townhouses</td>
<td>• Mid-rise apartments</td>
<td>• High-rise apartments</td>
</tr>
<tr>
<td>• Supermarkets</td>
<td></td>
<td>• High-rise residential condominiums/townhouses</td>
</tr>
<tr>
<td>• Quality (sit-down) restaurants</td>
<td>• High-turnover (sit-down) restaurants</td>
<td>• Convenience markets</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Shopping centers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Coffee/donut shops</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Bread/donut/bagel shops</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Drinking places</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Office buildings</td>
</tr>
</tbody>
</table>
Simple adjustment A (mode share table) had comparable results to models B & C.

Similar results for pooled models and models segmented by land use category.

Shows benefit of simple adjustment method based on urban context.
Discussion and Implications

• Objective was achieved
  – an “off-the-shelf” adjustment method was developed that is sensitive to urban contexts, applicable nationally and ready to apply

• Results punctuate the need for considering the urban environment in evaluating the traffic impacts of new development

• Short term: Simple adjustments may benefit estimations as much as complex ones
Discussion and Implications

- Application of an HTS urban context adjustment is a band-aid for the traffic impact estimation
- If ITE’s *Handbook* should remain relevant to wide-spread application, this adjustment is not going to be sufficient in the long run
- More detailed requirements for ITE or Traffic Impact Analysis data collections
  - Captures urban context
  - Person trips, mode share distribution, vehicle occupancy
  - Location information
Acknowledgements

Data:
• Institute of Transportation Engineers
• Kimley-Horn/Caltrans
• OTREC
• Oregon Department of Transportation
• Puget Sound Regional Council
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Questions?

Kristina M Currans
Civil Engineering
Portland State University
kcurrans@pdx.edu


Schneider, R. J., Shafizadeh, K., & Handy, S. L. (2013). California Smart-Growth Trip Generation Rates Study. Davis, California: University of California, Davis for the California Department of Transportation.

Maps by Stamen: http://maps.stamen.com