Accuracy Assessment of Traffic Forecasts

Presentation to the NCMUG
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Speakers

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Special Thanks

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  - Dr. Mei Chen
  - Dr. Reginald Souleyrette

- Marty Wachs, UCLA

- Florida Department of Transportation, District 4

- H.W. Lochner
Agenda

Highlights from NCHRP 934: Traffic Forecasting Accuracy Assessment Research

Application for FDOT, District 4
Traffic Forecasting
Accuracy
Assessment
Research
(NCHRP 934)
Accuracy

- Closeness of observation and measurement or estimate
- Retrospective evaluation of forecast quality
- Comparison of actual traffic and forecasted traffic

Uncertainty

- Estimate of the accuracy. Range in which the real value lies
- Prospective modification of forecasts to ensure quality and reliability
- Range of values possible for actual traffic
Research Questions and Approach

How accurate are traffic forecasts?
- **Method:** Statistical analysis of actual vs forecast traffic for a large sample of projects after they open.
- **Output:** Distribution of expected traffic volume as a function of forecast volume.

What are the sources of forecast error?
- **Method:** "Deep dives" into forecasts of six substantial projects after they open.
- **Output:** Estimated effect of known errors, and remaining unknown error.

How can we generate an expected range of outcomes?
- **Method:** Estimate uncertainty in future forecasts from accuracy of past forecasts.
- **Output:** A range of forecasts.

How can we improve forecasting practice?
- **Method:** Derive lessons from this research and review with practitioners.
- **Output:** Recommendations for how to learn from past traffic forecasts.

Dave Schmitt

Jawad Hoque

Greg Erhardt
Large-N Analysis

Question: How accurate are traffic forecasts?

- **Method:** Statistical analysis of actual vs forecast traffic for a large sample of projects after they open.
- **Output:** Distribution of expected traffic volume as a function of forecast volume.
## Forecast Accuracy Database

6 states: FL, MA, MI, MN, OH, WI + 4 European nations: DK, NO, SE, UK
Total: 2,600 projects, 16,000 segments
Open with Counts: 1,300 projects, 3,900 segments

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Large N Analysis- Methodology

Compared the earliest **post-opening** traffic counts with forecast volume

Percent difference from forecast:

\[
\frac{\text{Actual Count} - \text{Forecast Volume}}{\text{Forecast Volume}} \times 100 \%
\]

Level of Analysis
- Segment Level
- Project Level

Expressing the percent difference relative to the forecast is forward-looking, and a useful measure of uncertainty before a project opens.
How Accurate Are Traffic Forecasts?

On average, the actual traffic volume is about 6% lower than forecast.

On average, the actual traffic is about 17% different from forecast. (absolute value of differences)

$PDFF_i = \frac{(Actual - Forecast)}{Forecast} \times 100$
How Accurate Are Traffic Forecasts?

Traffic forecasts are more accurate, in percentage terms, for higher volume roads.

\[ PDFF_i = \frac{(Actual - Forecast)}{Forecast} \times 100 \]
How Accurate Are Traffic Forecasts?

\[
APDFF_i = \left(\frac{|Actual - Forecast|}{Forecast}\right) \times 100
\]

NCHRP Report 255: maximum desirable deviation of a traffic assignment model from base year traffic counts.

84% of forecasts fell within the maximum desirable deviation, and 47% of forecasts had less deviation than expected of traffic counts.

95% of forecasts reviewed are “accurate to within half of a lane.”

What Factors Affect Forecast Accuracy?

Traffic forecasts are more accurate for:

- Higher volume roads
- Higher functional classes
- Shorter time horizons
- Travel models over traffic count trends
- Opening years with unemployment rates close to the forecast year
- More recent opening & forecast years
Deep Dives- Methodology

- Collect data:
  - Public Documents
  - Project Specific Documents
  - Model Runs

- Investigate sources of errors as cited in previous research:
  - Employment, Population projections etc.

- Adjust forecasts by elasticity analysis

- Run the model with updated information
Deep Dive Conclusions

- The reasons for forecast inaccuracy are diverse.
- Employment, population and fuel price forecasts often contribute to forecast inaccuracy.
- External traffic and travel speed assumptions also affect traffic forecasts.
- Better archiving of models, better forecast documentation, and better validation are needed.
What are the Limitations?

- Project documentation often does not record relevant information—those projects where we had reproducible model runs were more successful.
- These are only a few examples. Can they be generalized?

Continued and consistent data collection is needed to overcome these limitations.
How to Generate Uncertainty Envelopes

The other option of producing better forecasts is employing what (Ascher, 1979) calls “outsider’s approach” and Kahneman and Tversky (1977) calls “reference class forecasts”.

Using the base-rate and distribution results from similar situations in the past to adjust forecasts.
Quantile Regression
A method to both measure accuracy & estimate uncertainty envelopes

Draw line through the middle of the cloud: regression.

Draw a line along the edge of the cloud: quantile regression.

Quantifying uncertainty is as simple as inputting values in a spreadsheet and drawing lines.
Measuring accuracy and estimating uncertainty windows using Quantile Regression

Model Form

\[ y_i = \alpha + \beta \hat{y}_i + \gamma X_i \hat{y}_i + \epsilon_i \]

- Multiplicative effect instead of additive
- Estimate separate \( \alpha \), \( \beta \) and \( \gamma \) for different percentile values (95\(^{th}\), 80\(^{th}\), 50\(^{th}\), 20\(^{th}\), 5\(^{th}\)).
- Coefficients signify the effect of the explanatory variables on different percentile values of actual observation (traffic or transit ridership).
- Example, coefficient of -0.25 on unemployment rate on the 95\(^{th}\) percentile model means with each unit increase in unemployment rate, the 95\(^{th}\) percentile actual traffic value decreases by 0.25 units.
Quantile Regression Models

Simple Model
- Actual Traffic Count as a function of Forecast Traffic
- Detects bias

Inference Model
- Actual Traffic Count as a function of forecast traffic as well as other statistically significant explanatory variables
- Performance Metric

Forecasting Model
- Actual Traffic Count as a function of forecast traffic as well as other statistically significant explanatory variables *that are known at the time of forecast.*
- Uncertainty envelope
Simple Model

\[ A_{95th} = 2940 + 1.42F + \varepsilon \]

\[ A_{50th} = 37 + 0.94F + \varepsilon \]

\[ A_{5th} = -826 + 0.62F + \varepsilon \]

A= Actual Traffic
F= Forecasted Traffic
## Results - Factors Affecting Forecast Uncertainty

<table>
<thead>
<tr>
<th></th>
<th>5th Percentile</th>
<th>50th Percentile</th>
<th>95th Percentile</th>
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</thead>
<tbody>
<tr>
<td>Pseudo R-Squared</td>
<td>0.475</td>
<td>0.739</td>
<td>0.830</td>
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<tr>
<td>(Intercept)</td>
<td>-182.267</td>
<td>255.551</td>
<td>976.786</td>
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<tr>
<td>Adjusted Forecast</td>
<td>0.705</td>
<td>0.891</td>
<td>1.254</td>
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<td>Control for forecasts values over 30,000 ADT</td>
<td>0.024</td>
<td>-0.004</td>
<td>-0.413</td>
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<tr>
<td>Unemployment Rate in the Year Forecast was Produced</td>
<td>-0.006</td>
<td>0.002</td>
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<tr>
<td>Control variable for Forecasts Produced Before 2010</td>
<td>-0.007</td>
<td>0.0002</td>
<td>0.003</td>
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<tr>
<td>Forecast Horizon</td>
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<td>Control Variable for Project on a New Road</td>
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<td>-0.008</td>
<td>-0.090</td>
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<td>Control Variable for Forecasts done using Travel Demand Model</td>
<td>0.068</td>
<td>-0.008</td>
<td>-0.101</td>
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<tr>
<td>Control Variable for Project on Higher Functional Class</td>
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<td>-0.062</td>
<td>-0.116</td>
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<tr>
<td>Control Variable for Project on Collector or Local Roadway</td>
<td>-0.212</td>
<td>-0.126</td>
<td>-0.321</td>
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</table>
Forecast produced in the year 2018

Unemployment rate at State level in 2018 is 4%

Forecasting the traffic for 2028 i.e. forecast horizon of 10 years

The project is a new construction project on a Minor Arterial

Forecast is done using a travel demand model.
Resources & Publications

- Guidance Document & Research Report
  - [https://www.nap.edu/catalog/25637/traffic-forecasting-accuracy-assessment-research](https://www.nap.edu/catalog/25637/traffic-forecasting-accuracy-assessment-research)

- Quantile Regression Spreadsheet

- Archiving Software

- Data

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“The Changing Accuracy of Traffic Forecasts”


“Estimating the Uncertainty of Traffic Forecasts from their Historical Accuracy”

Application for FDOT, District 4
Motivation & Objectives

- D4 develops dozens of traffic forecasts every year
  - Forecast reports are archived on a regular basis
  - Accuracy of the forecasts are accessed from time to time, using actual/realized traffic counts (previous assessments done in 2010 and 2014)
- Opportunity to utilize the archived data to enhance D4’s forecasting process

- Assess the accuracy of recent forecasts
  - Identify areas of improvements
- Apply lessons learned from the rich data set of forecasts
  - Quantify uncertainty in the forecasts and assist district reviewer estimate potential error range in project forecasts
Methodology

- Adopt guidance from the NCHRP 934 report (developed with D4 contributions)
- Utilize rich archived data and professional experience of seasoned D4 staff
- More emphasis on products that are easily reproducible and applicable
- Opening year forecasts assessed for accuracy
Key Tasks

Data Gathering
- Gather forecast reports developed since 1999 and develop a database of D4 traffic forecast

Data Analysis
- Analyze data and develop an automated routine to create an interactive report that can be easily updated by FDOT staff when including future projects

Uncertainty Analysis
- Develop a process to define potential uncertainty in a forecast
Forecast Database

- Forecasts stored in Excel
- Includes forecasts developed after 1999

### Summary of All D4 Traffic Projections

<table>
<thead>
<tr>
<th>General Roadway Information</th>
<th>Roadway #</th>
<th>County</th>
<th>Roadway Segment</th>
<th>Type of Study</th>
<th>Date of Report</th>
<th>Year Forecasted (Opening Year)</th>
<th>Future Forecasted AMT (Opening Year)</th>
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<td>41</td>
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</table>

#### 597 Total Records!
Interactive Report in RMarkDown HTML

- Reads the forecast Excel database
- Analyzes the data – develops interactive tables and maps in a HTML report
  - D4 staff can easily monitor the accuracy in house on a more frequent basis (e.g., every year)
- Provides recommendations to further improve the forecasting process
Districtwide Observations

- Evidence of over-estimation in opening the year forecast
- Forecasts ~15% off the actual counts

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<tr>
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<tr>
<td>Mean of PDFF (MPDFF)</td>
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<tr>
<td>Median of PDFF</td>
<td>-6.2%</td>
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<tr>
<td>MAPDFF</td>
<td>15.4%</td>
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<tr>
<td>Standard Deviation of PDFF</td>
<td>19.7%</td>
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</table>
Additional Observations

• On an average, the D4 forecasts are within ~15% (MAPDFF) of the actual traffic volumes
• Greater accuracy for the urban areas, high volume and short-term forecasts
• Improved accuracy for the most recent set of forecast data (2020 dataset)
• Slightly better accuracy of D4 forecasts compared to the database developed for NCHRP 934 report
• Regional models are very relevant to the D4 forecasting decision making process
Uncertainty Assessment: Web Application

- Developed a process to quantify uncertainty in a forecast to assist D4 in traffic forecast reviews
  - Process based on NCHRP 934 Traffic Forecasting Accuracy Assessment
  - Uncertainty range desirable if a “lane call” is involved
  - Requires house-training of the methodology

FDOT reviewer defines characteristics of the project here

Application bounds the uncertainty based on prior project experience

Results: Uncertainty Analysis of the Project Forecast
1. Based on 279 records, 90% of all projects had actual AADT between 38,380 and 58,369 and 60% of all projects had actual AADT between 43,094 and 52,710, when the forecasted AADT was 90,000.
2. Based on 279 records, 79.9% of all projects had actual AADT between the 125% and 80% of the forecasted AADT.
Next Steps

• Utilize the findings from this assessment to enhance D4’s forecasting / modeling process
• Train the uncertainty methodology for D4 project application
• Enhance this assessment based on continued application and inputs from other D4 departments
• Develop process to understand potential impacts of uncertainty on traffic operations analysis of future studies
Questions?
Thank you!