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TRANSPORTATION RESEARCH BOARD

How Accurate are Traffic Forecasts?

October 14, 2020

@NASEMTRB
#TRBwebinar

PDH Certification Information:

- 1.5 Professional Development Hour (PDH) – see follow-up email for instructions
- You must attend the entire webinar to be eligible to receive PDH credits
- Questions? Contact Reggie Gillum at RGillum@nas.edu

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RCEP

REGISTERED CONTINUING EDUCATION PROGRAM

#TRBwebinar

Learning Objectives

1. Describe the overall accuracy of traffic forecasts
2. Apply a spreadsheet to estimate uncertainty windows around traffic forecasts
3. Access and contribute to a database for monitoring forecast accuracy

#TRBwebinar

How Accurate are Traffic Forecasts?

Presented by:
Greg Erhardt, University of Kentucky
Dave Schmitt, Connetics Transportation Group
Jawad Hoque, University of Kentucky
Mei Chen, University of Kentucky

Transportation Research Board Webinar

October 14, 2020

A Broken Algorithm?

Gordon, Aaron. “The Broken Algorithm That Poisoned American Transportation.” Vice, August 24, 2020.

15%

Is a 15% difference accurate or inaccurate?

Is a 15% difference expected or unexpected?

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

“The greatest knowledge gap in US travel demand modelling is the unknown accuracy of US urban road traffic forecasts.”

- Hartgen, 2013

“The lack of availability for necessary data items is a general problem and probably the biggest limitation to advances in the field.”

Nicolaisen and Driscoll, 2014

Research Questions and Approach

How accurate are traffic forecasts?

Dave Schmitt

- 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?

Dave Schmitt

- 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?

Jawad Hoque

- Method: Estimate uncertainty in future forecasts from accuracy of past forecasts.
- Output: A range of forecasts.

How can we improve forecasting practice?

Greg Erhardt

- Method: Derive lessons from this research and review with practitioners.
- Output: Recommendations for how to learn from past traffic forecasts.

NCHRP

RESEARCH REPORT 934

Traffic Forecasting Accuracy Assessment Research

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TRANSPORTATION RESEARCH BOARD

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Traffic Forecasts: Accuracy and Sources of Error

Findings NCHRP 934 Technical Report

Dave Schmitt

Connetics Transportation Group

Transportation Research Board Webinar

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Bringing New Data

-“The lack of availability for necessary data items is a general problem and probably the biggest limitation to advances in the field.”

-Nicolaisen and Driscoll, 2014

Forecast Accuracy Database:

Project, forecast and actual traffic information.

2611 unique projects

Large-N Analysis

Case Studies:

5 projects with model runs

Deep Dives

Large-N Analysis

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

	Ohio DOT	Wisconsin DOT	Michigan DOT	Virginia DOT	Florida DOT-D4	Florida DOT-D5	Minnesota	Kentucky TC
Number of records	6,229	458	9	1,160	143	50	2,179	n/a
Number of unique projects	2,466	132	7	39	134	31	110	
Cumulative Spreadsheet or database (flat file)								

Large N Analysis- Methodology

Percent difference from forecast:

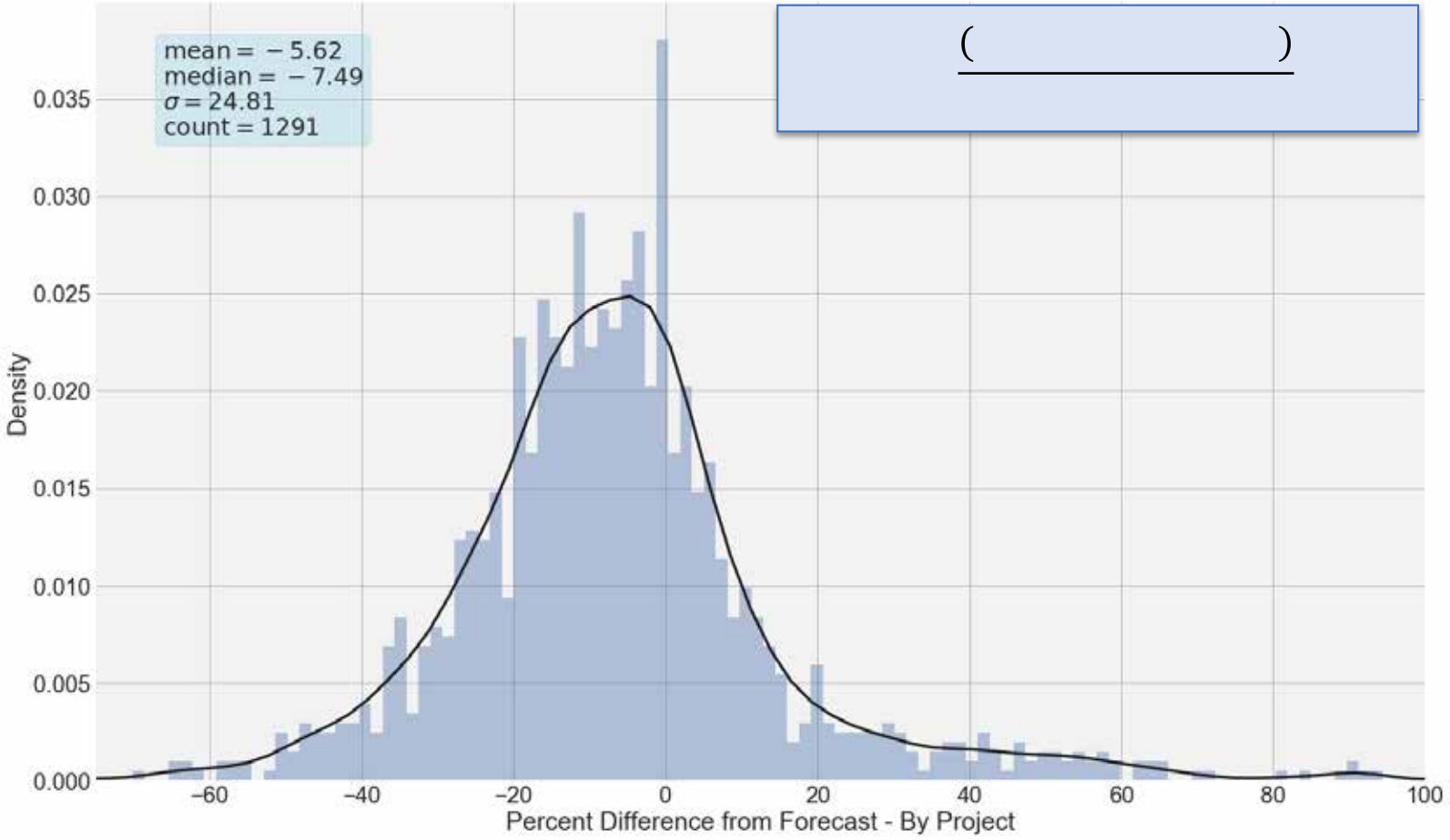
$$\frac{\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad}{\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad} \%$$

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.

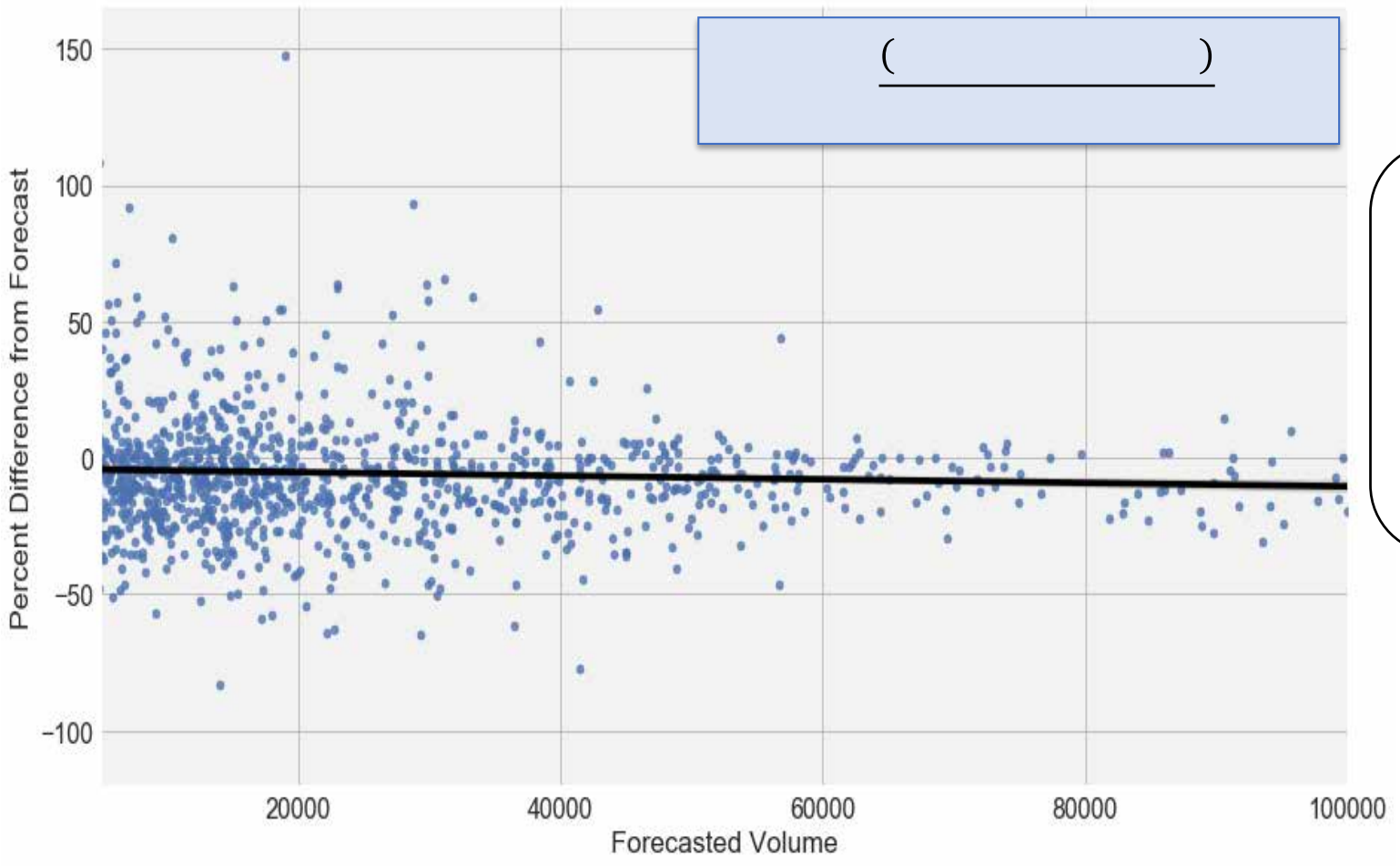
How Accurate Are Traffic Forecasts?



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

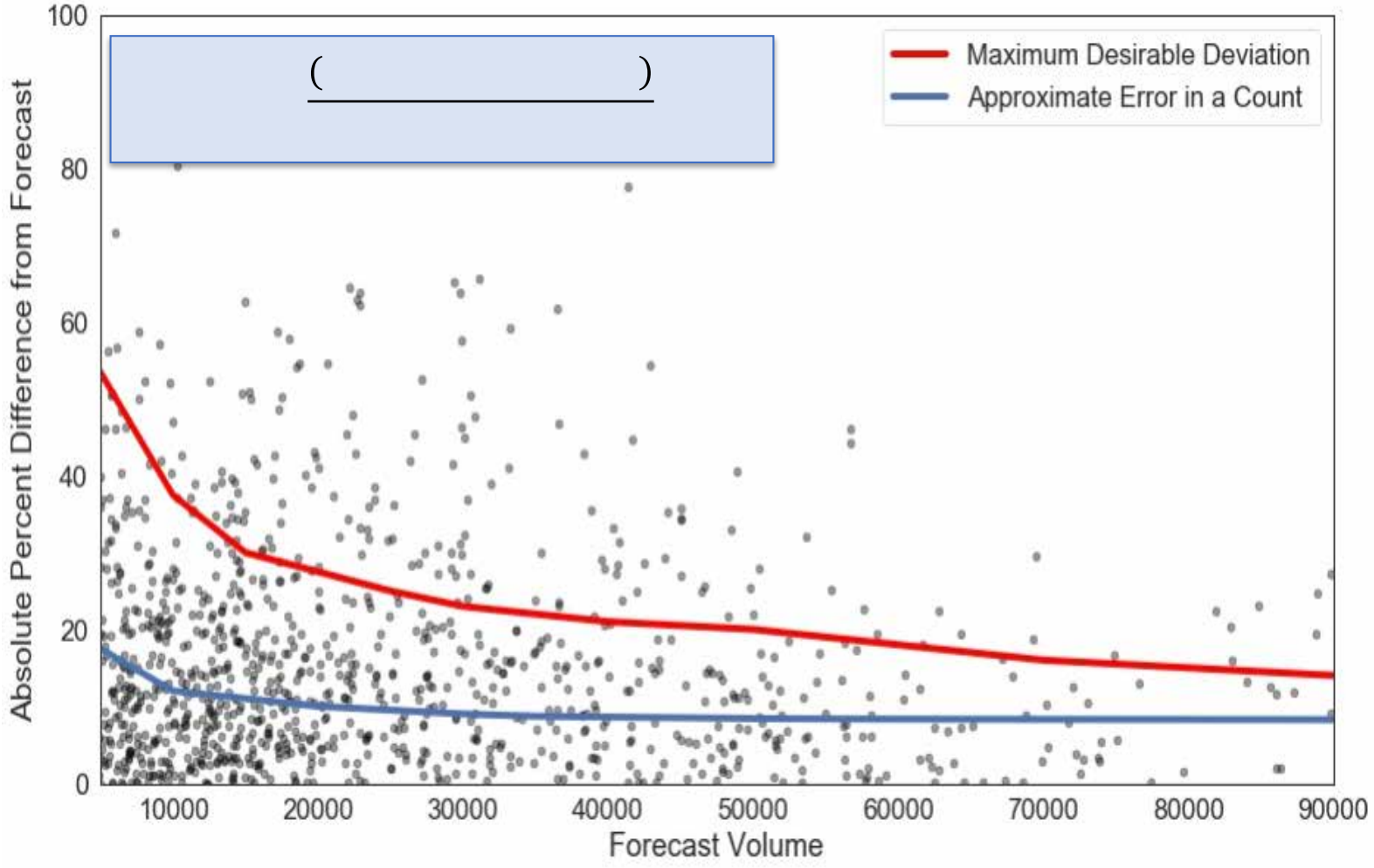
On average, the actual traffic is about 17% different from forecast.

How Accurate Are Traffic Forecasts?



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

How Accurate Are Traffic Forecasts?



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."

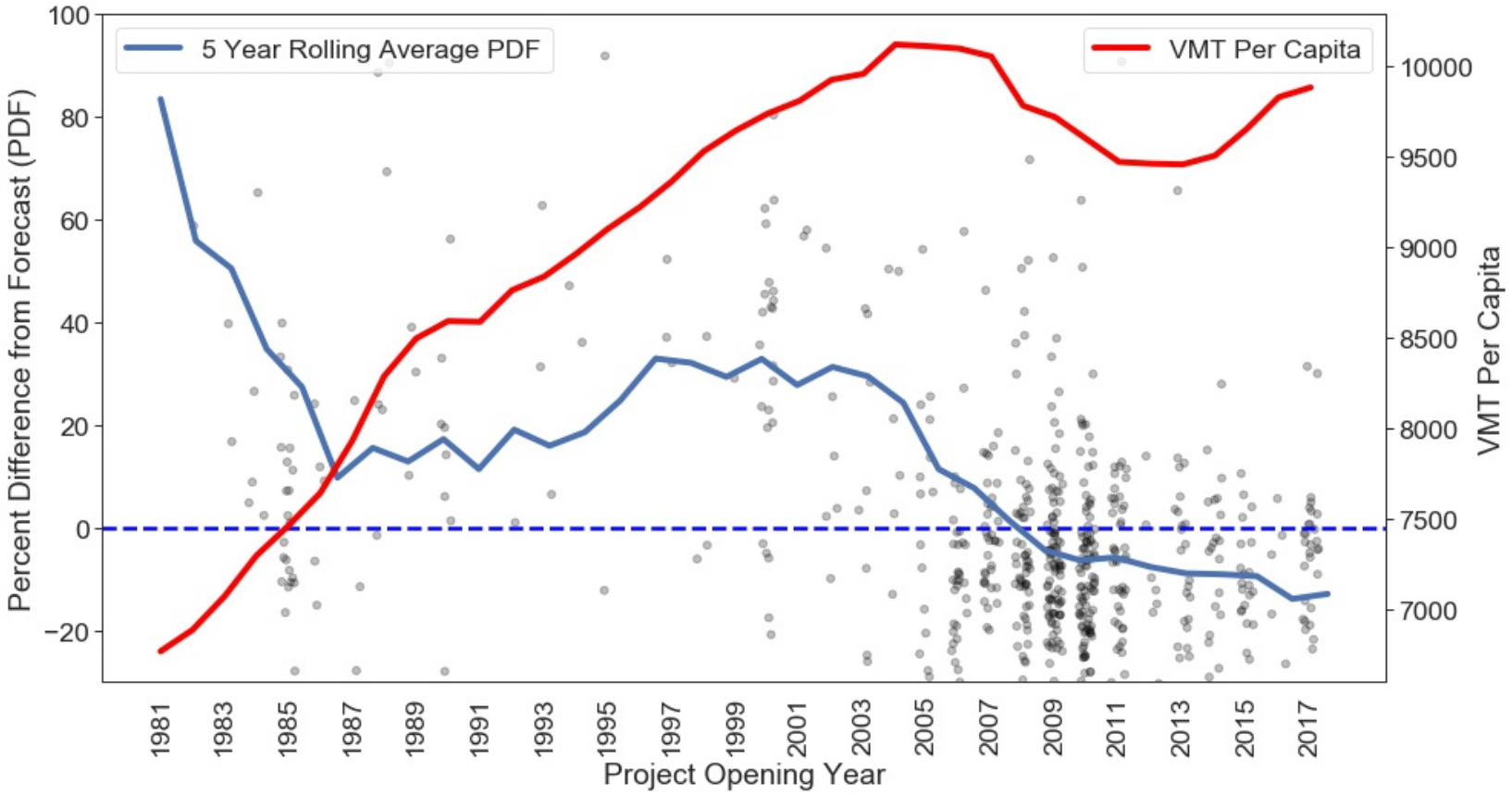
Source: Hoque, Jawad Mahmud, Gregory D. Erhardt, David Schmitt, Mei Chen, Ankita Chaudhary, Martin Wachs, and Reginald Souleyrette. "The Changing Accuracy of Traffic Forecasts." , in-review.

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

Has Forecast Accuracy Changed?



While VMT per capita was increasing, counted traffic volumes were higher than forecast, but after VMT per capita peaks, the opposite is true.

Traffic forecasts may not have fully captured the factors driving aggregate VMT trends.

Source: Hoque, Jawad Mahmud, Gregory D. Erhardt, David Schmidt, Mei Chen, Ankita Chaudhary, Martin Wachs, and Reginald Souleyrette. “The Changing Accuracy of Traffic Forecasts.” , in-review.

What are the Limitations?

The data were assembled based on availability—they are not necessarily a random or representative sample

The recorded data were often missing desired attributes—and this varied based on the agency

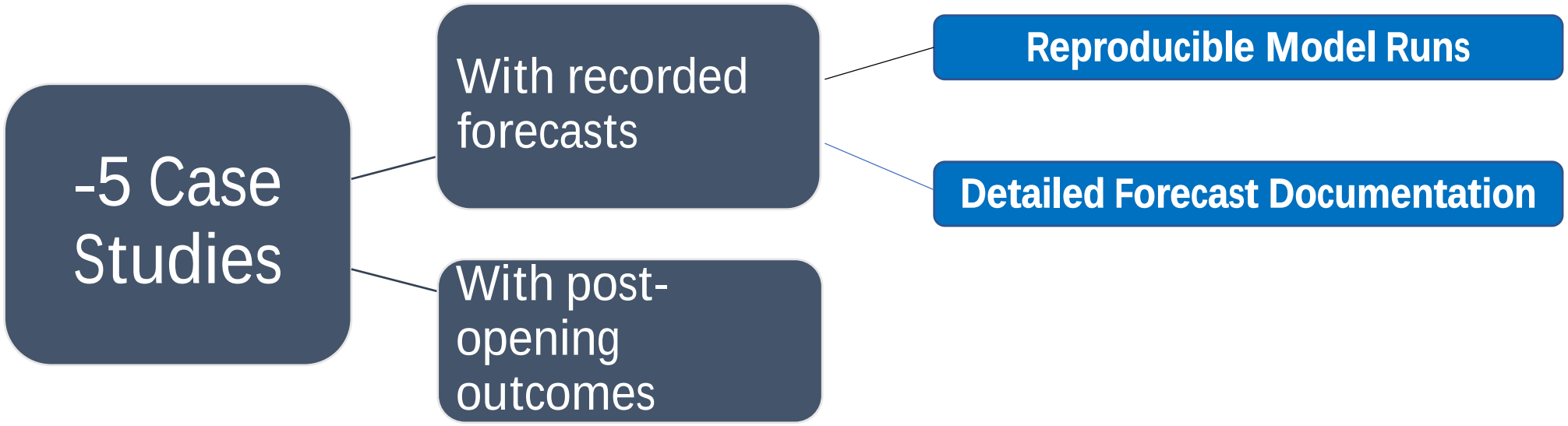
Continued and consistent data collection is needed to overcome these limitations.

Deep Dives

Deep Dives

Question: 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.



Deep Dives- Methodology

Collect data:

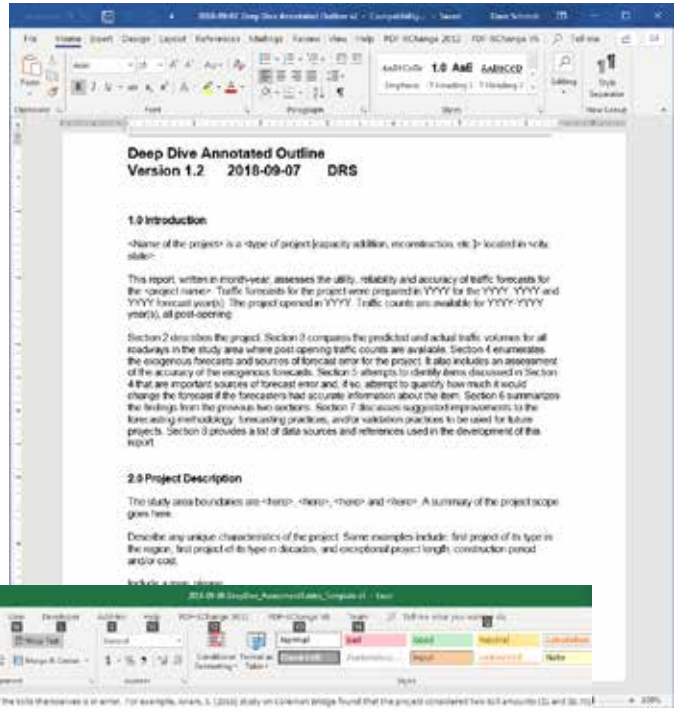
- Public Documents
- Project Specific Documents
- Model Runs

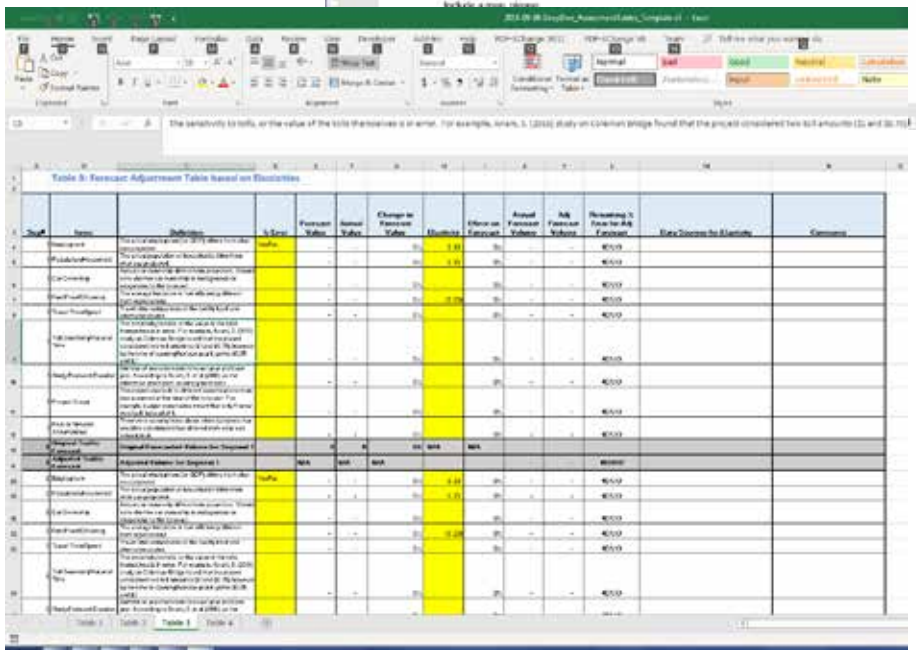
Investigate sources of errors as cited in previous research:

- Employment, Population projections etc.

Adjust forecasts by elasticity analysis

Run the model with updated information





What are the sources of forecast error?

Project	Original Percent Difference from Forecast	Remaining percent difference from forecast after adjusting for errors in:		Remaining percent difference from forecast after all adjustments
Eastown Road Extension Project, Lima, Ohio	-43%	Employment	-39%	-28%
		Population/Household	-38%	
		Car Ownership	-37%	
		Fuel Price/Efficiency	-34%	
		Travel Time/Speed	-28%	

Widened a 2.5-mile segment of the arterial from 2 lanes to 5 lanes and extended the arterial an additional

What are the sources of forecast error?

Project	Original Percent Difference from Forecast	Remaining percent difference from forecast after adjusting for errors in:		Remaining percent difference from forecast after all adjustments
Indian River Bridge, Palm City, Florida	-60%	Employment	-59%	-56%
		Population	-61%	
		Fuel Price	-56%	

This 0.6 mile long bridge with four travel lanes in total. runs along CR 714 (Martin Highway), connecting with the Indian River Street and goes across the St. Lucie River.

What are the sources of forecast error?

Project	Original Percent Difference from Forecast	Remaining percent difference from forecast after adjusting for errors in:		Remaining percent difference from forecast after all adjustments
Central Artery Tunnel, Boston, Massachusetts	-16%	Employment	-10%	-10%
		Population	-14%	
		Fuel Price	-10%	

Reconstruction of Interstate Highway 93 (I-93) in downtown Boston, the extension of I-90 to Logan International Airport, the construction of two new bridges over the Charles River, six interchanges and the Rose Kennedy Greenway in the space vacated by the previous elevated I-93 Central Artery in Boston, Massachusetts.

What are the sources of forecast error?

Project	Original Percent Difference from Forecast	Remaining percent difference from forecast after adjusting for errors in:		Remaining percent difference from forecast after all adjustments
Cynthiana Bypass, Cynthiana, Kentucky	-27%	Employment	-25%	-8%
		Population	-25%	
		External Trips Only	7%	

A 2-lane, state highway bypass project, to the west of the City from the southern terminus where US 62S and US27S meet.

What are the sources of forecast error?

Project	Original Percent Difference from Forecast	Remaining percent difference from forecast after adjusting for errors in:		Remaining percent difference from forecast after all adjustments
US 41 (later renamed as I-41), Brown County, Wisconsin	-5%	Population	-4%	-6%
		Fuel Price	-6%	

A project of capacity addition, reconstruction of nine interchanges, constructing 24 roundabouts, adding collector-distributer lanes, and building two system interchanges located in Brown County, Wisconsin.

Deep 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.

Quantifying Uncertainty in Traffic Forecasts

A Retrospective Approach

Jawad Mahmud Hoque

University of Kentucky

Transportation Research Board Webinar

October 14, 2020

Accuracy and Uncertainty

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

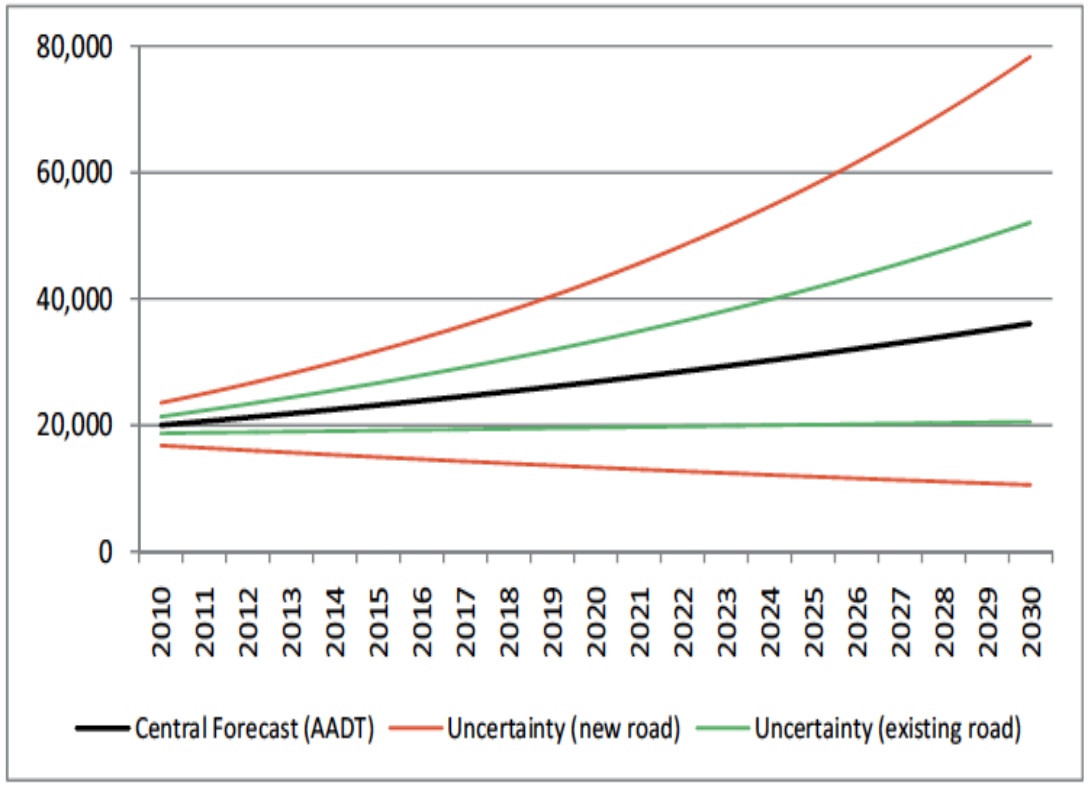
Range of values possible for actual traffic

Uncertainty Envelope

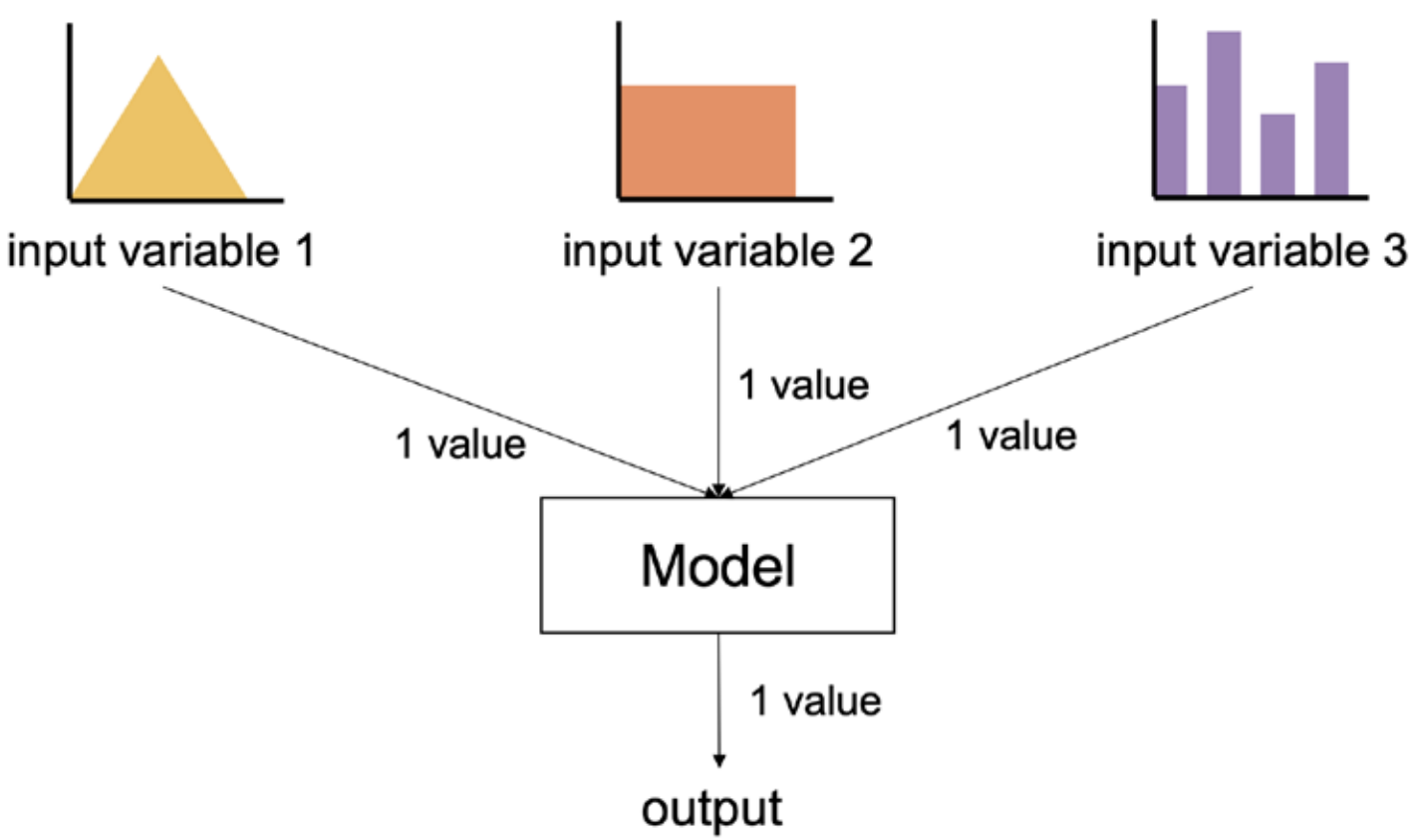
Proposed by Bain, 2011

Constructed using survey results

Forecast Horizon	Existing Road	New Road
Next Day	+/- 7.5%	N/A
1 Year	+/- 10%	+/- 15%
5 Years	+/- 15%	+/- 25%
20 Years	+/- 32.5%	+/- 42.5%



Sensitivity Testing / Scenario Analysis



Repeat with extremities in input

Slide Courtesy: Dr. Byrne

Limitations

Assumptions about the range of inputs.

Uncertainty in the input data propagates through the model (Zhao and Kockleman, 2002)

Much higher run time on an already time-intensive process.

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.

How to Generate Uncertainty Envelopes

Create uncertainty envelopes around forecasts using empirical evidence of past accuracy

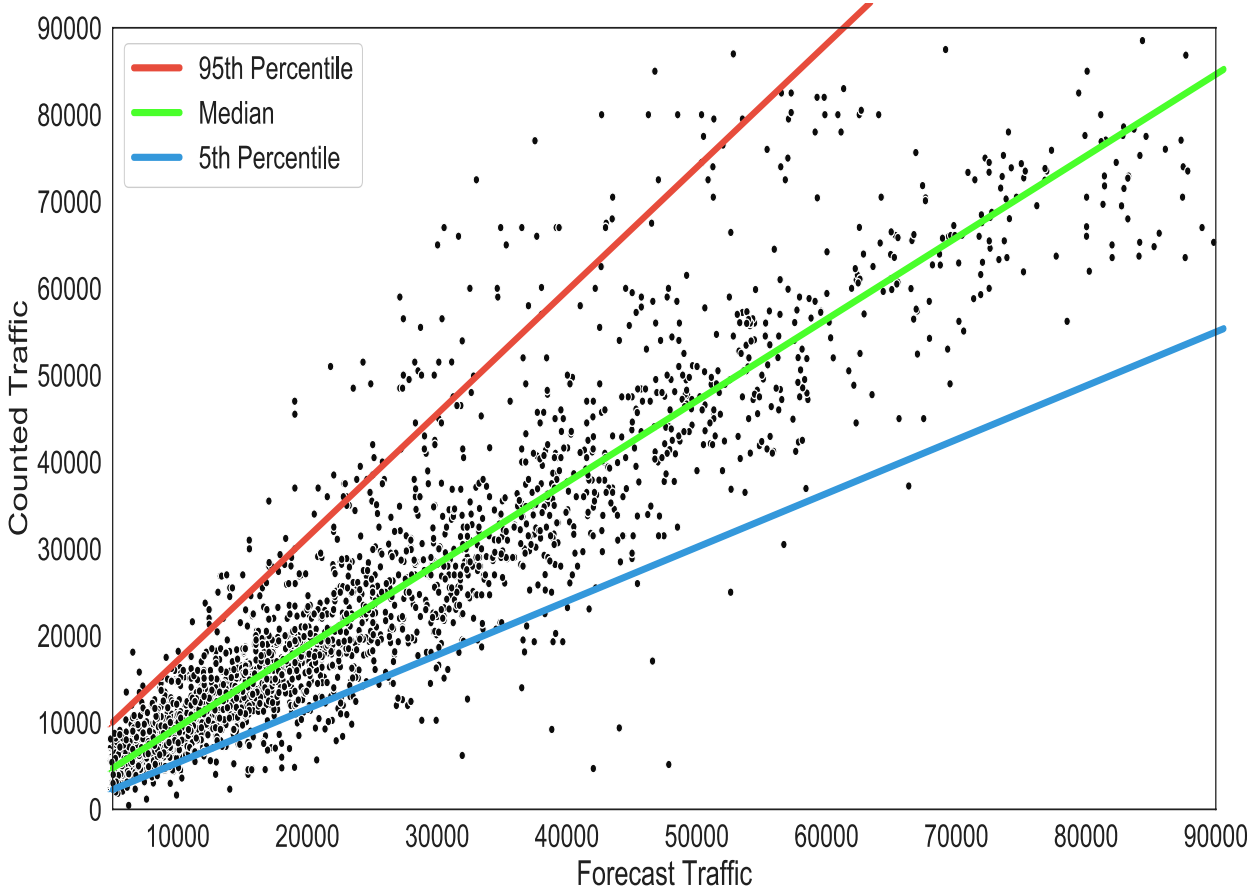
- Inspired by the principle of Reference Class
- Will consider the spread of the variables inducing bias
  - Traffic forecasts by roadway functional class or project type (new construction, existing roadway)
  - Transit ridership forecasts by locality type (transit or auto oriented, high or low population density) or project type (rail or bus route development) etc.

Quantile Regression – A method to both measure accuracy and 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 Bias

- Odeck and Welde (2017) propose an econometric method to measure bias:

$$y_i = \alpha + \beta \hat{y}_i + \varepsilon_i$$

Where, y_i is the actual demand on project i,
$\hat{y}_i$ is the forecasted demand on project i,
α and β are estimated terms in the regression.

- We can extend this to identify factors related to bias:

$$y_i = \alpha + \beta \hat{y}_i + \gamma X_i \hat{y}_i + \varepsilon_i$$

Where γ are estimated terms in the regression.
X_i is a vector of descriptive variables that may be related to bias.

Measuring accuracy and estimating uncertainty windows using Quantile Regression

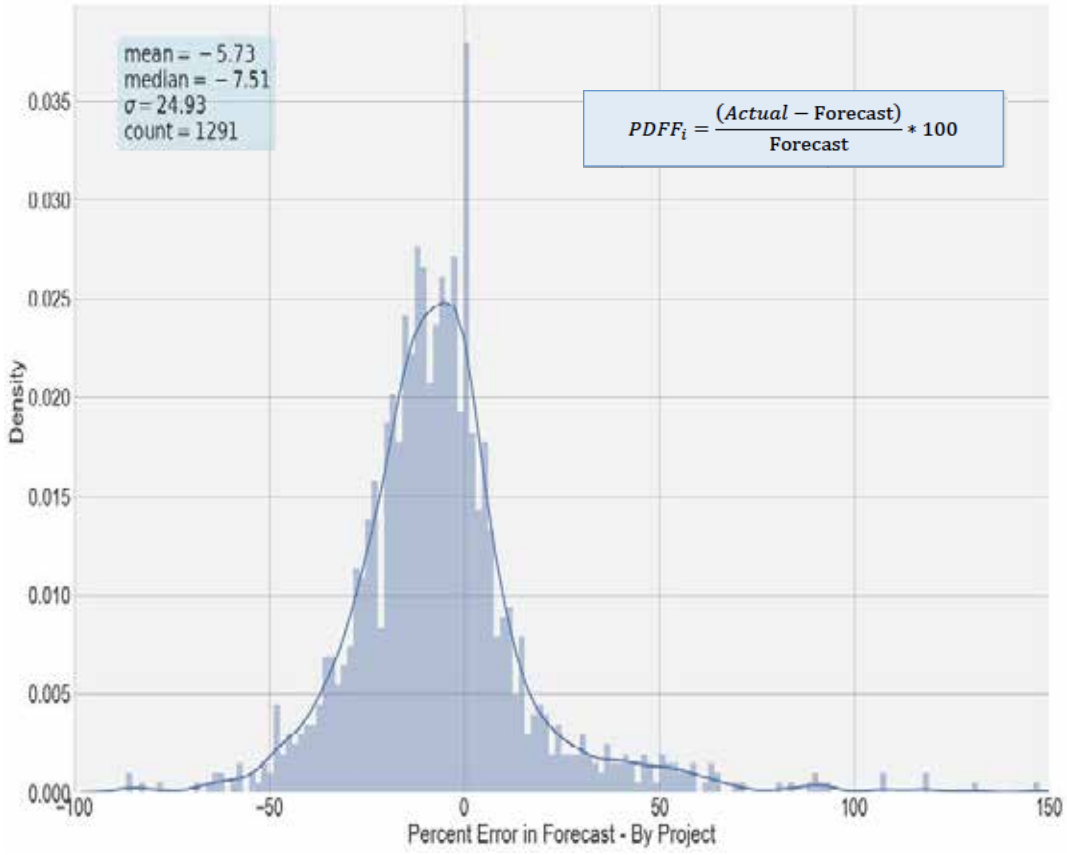
Model Form

$$y_i = \alpha + \beta \hat{y}_i + \gamma X_i \hat{y}_i + \varepsilon_i$$

- Multiplicative effect instead of additive
- Estimate separate α, β and γ 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.

Data

- National Cooperative Highway Research Program (NCHRP) Project 934 Database on Traffic Forecast Accuracy
  - Almost 2600 unique projects with 16,000 segments/links.
  - Mean Percent Deviation from Forecast of -5.73%%
  - Mean Absolute Percent Deviation from Forecast of 17.29%
  - Project Information, Forecast information, Actual Traffic Count



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

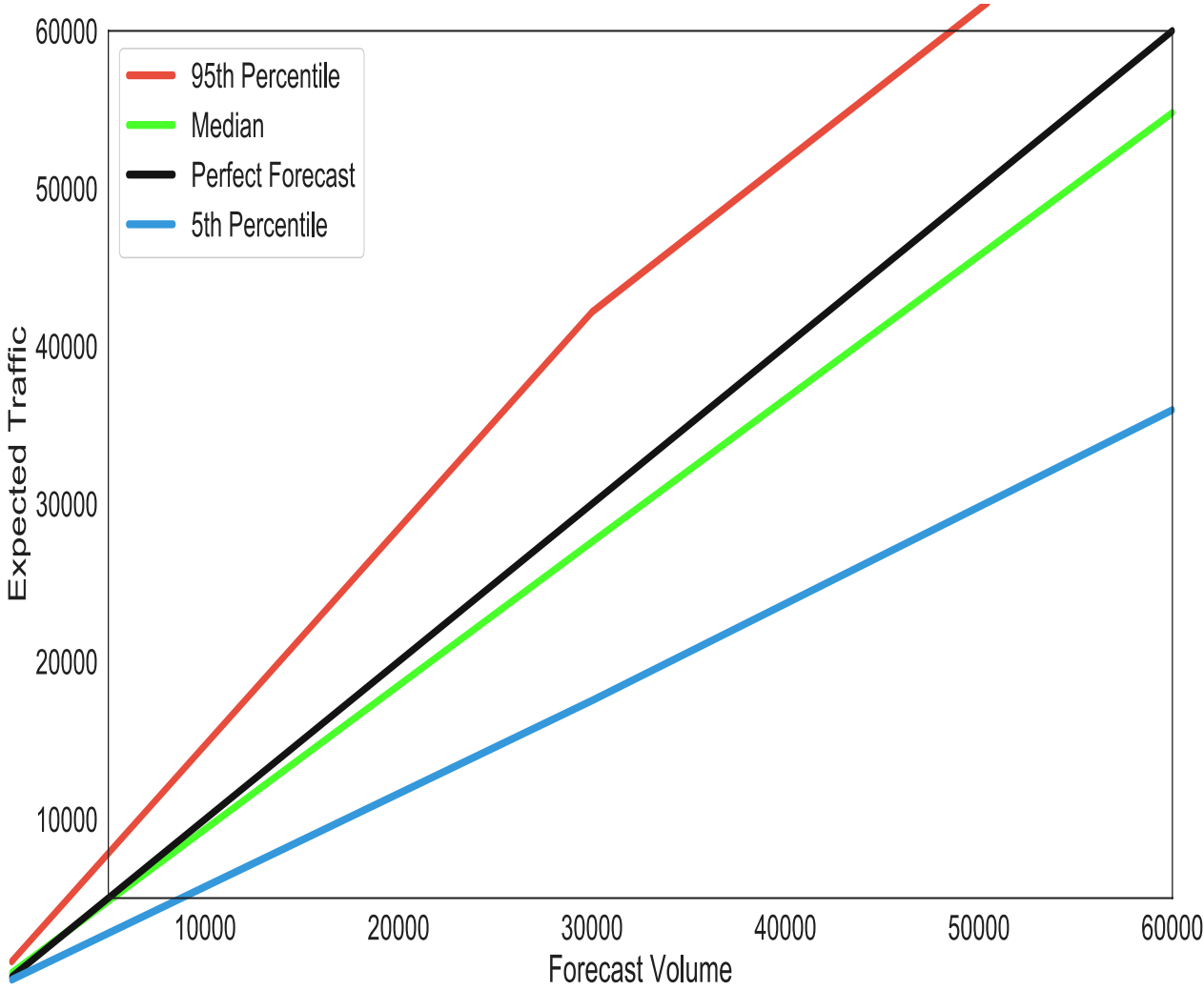
$A_{5th} =$

Results- Factors Affecting Forecast Uncertainty

	5th Percentile	50th Percentile	95th Percentile
Pseudo R-Squared	0.475	0.739	0.830
	Coef.	Coef.	Coef.
(Intercept)	-182.267	255.551	976.786
Adjusted Forecast	0.705	0.891	1.254
Control for forecasts values over 30,000 ADT	0.024	-0.004	-0.413
Unemployment Rate in the Year Forecast was Produced	-0.006	0.002	0.010
Control variable for Forecasts Produced Before 2010	-0.007	0.0002	0.003
Forecast Horizon	0.006	0.008	0.020
Control Variable for Project on a New Road	0.093	-0.008	-0.090
Control Variable for Forecasts done using Travel Demand Model	0.068	-0.008	-0.101
Control Variable for Project on Higher Functional Class	-0.150	-0.062	-0.116
Control Variable for Project on Collector or Local	-0.212	-0.126	-0.321

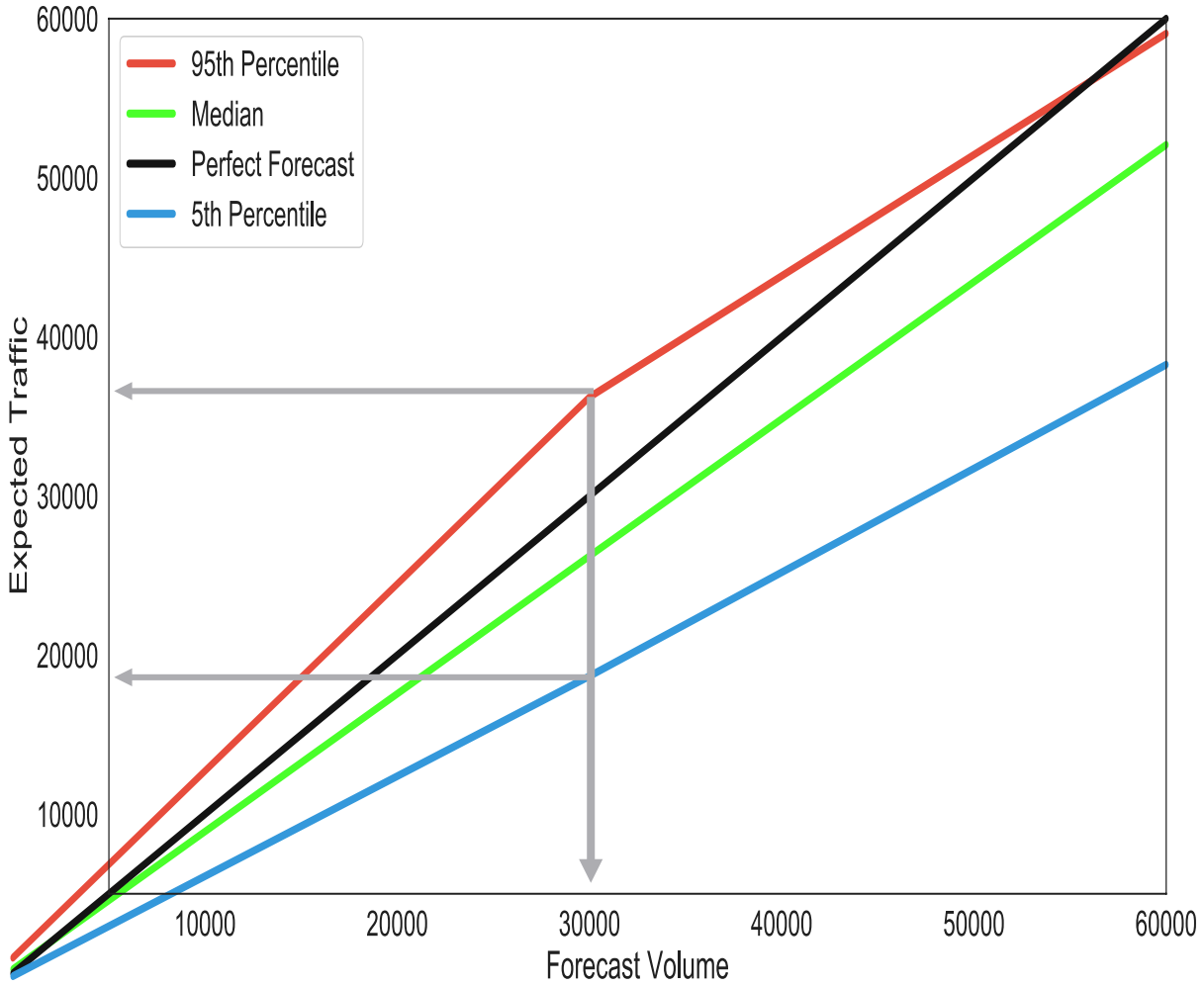
Uncertainty Envelope

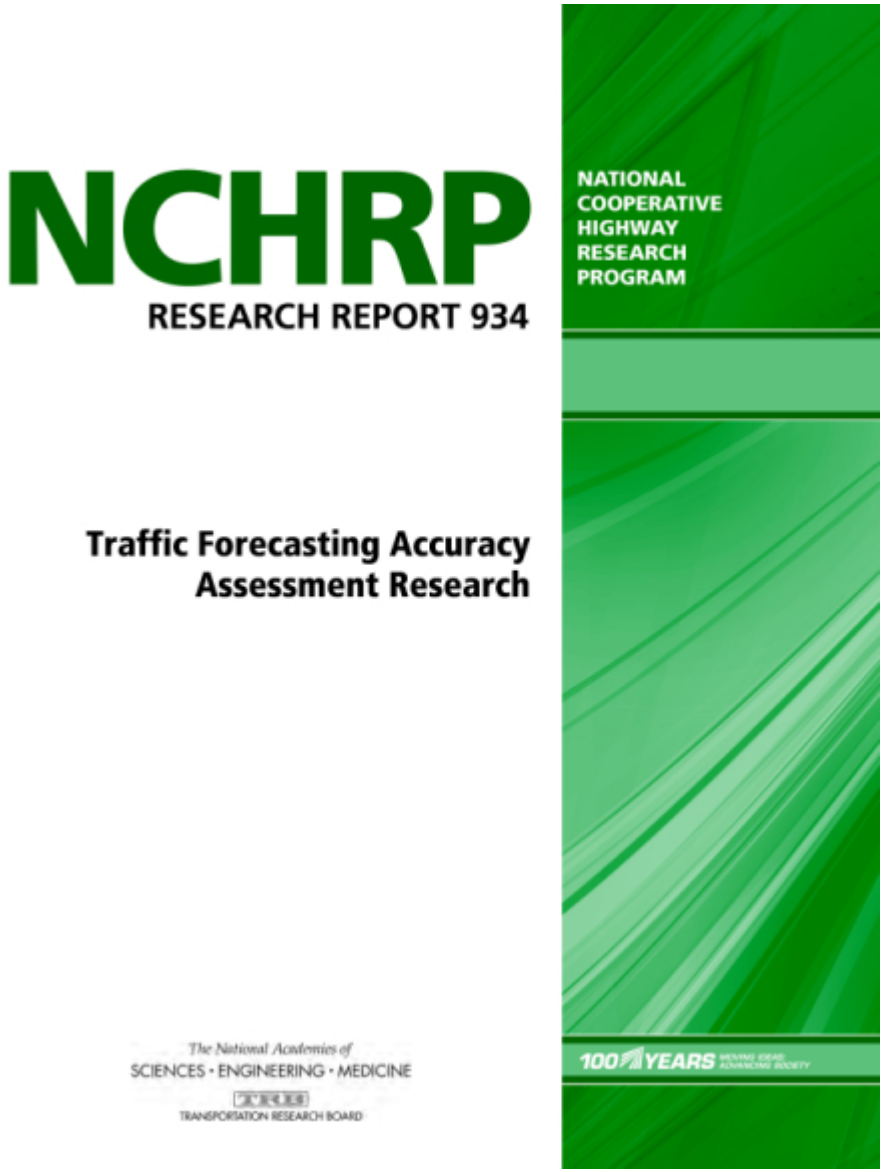
- Forecast produced in the year 2018
- Unemployment rate at State level in 2018 is 4%
- Forecasting the traffic for 2028 i.e. forecast horizon of 10 years
- The project is a new construction project on a Minor Arterial
- Forecast is done using a travel demand model.



Uncertainty Envelope

- Forecast made in 2019
- Unemployment rate at State level in 2018 is 4%
- Forecasting the traffic for 2024 i.e. forecast horizon of 5 years
- For an existing arterial
- Forecast is done using a travel demand model.





You can download a spreadsheet that implements these models from the NCHRP 934 website:

https://www.nap.edu/catalog/25637/traffic-forecasting-accuracy-assessment-research

Give it a try!

Improving Traffic Forecasting Practice

Recommendations from NCHRP 934 Guidance Document

Greg Erhardt

University of Kentucky

Transportation Research Board Webinar

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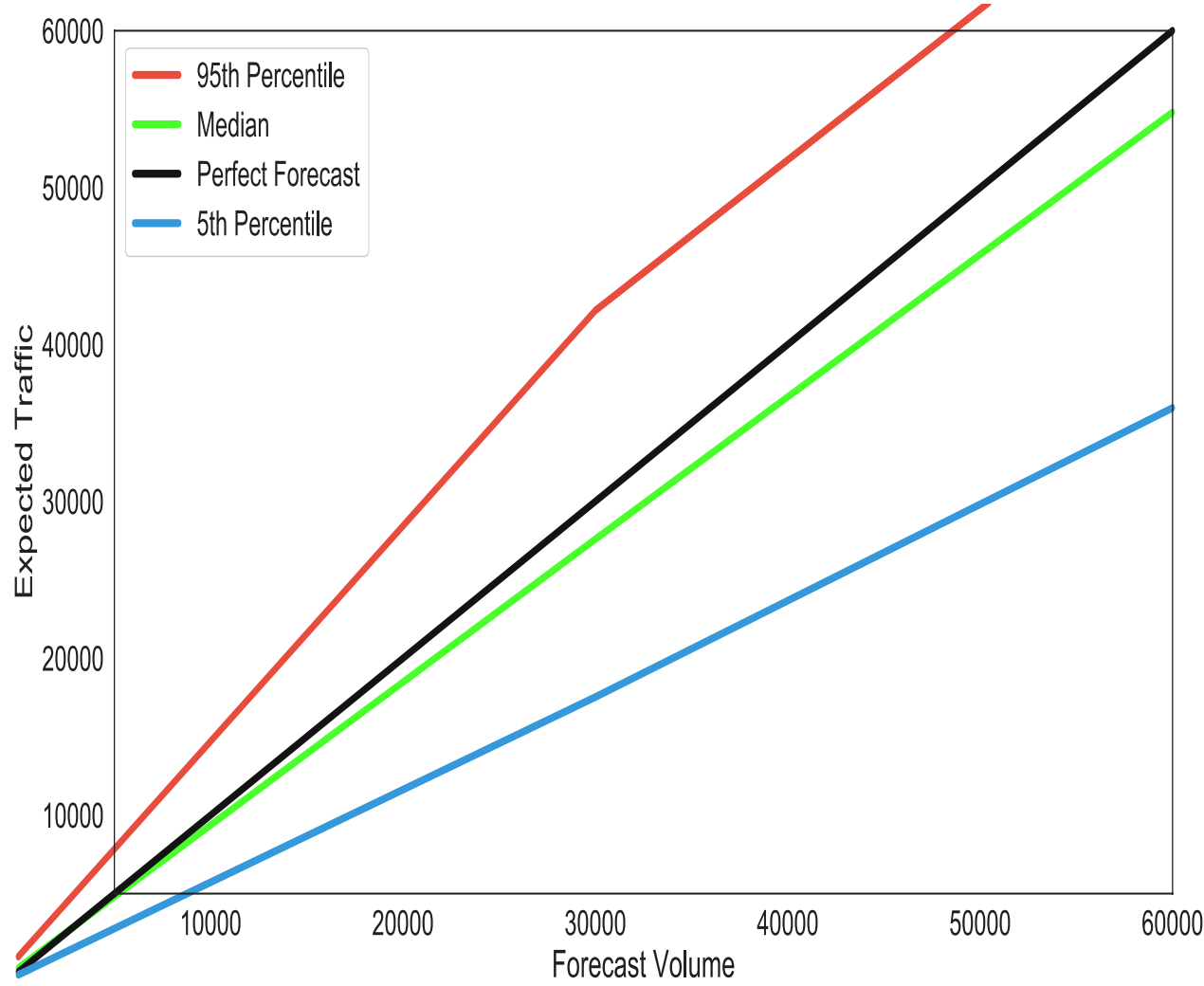
1. Communicate Uncertainty through a Range

- Report a range of forecasts.
- Quantile regression
- If the project were at the low/high end of the forecast range, would it change the decision?



2. Systematically archive traffic forecasts and collect observed data before and after the project opens.

1. Bronze: Record basic forecast and actual traffic information in a database

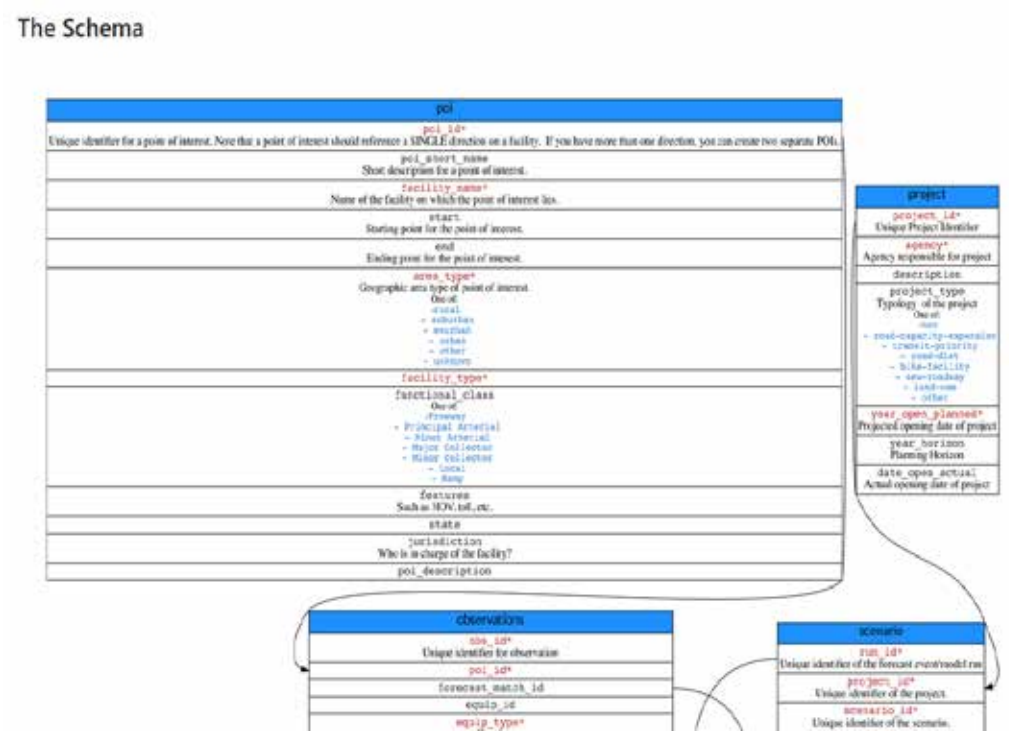
2. Silver: Bronze + document forecast in a semi-standardized report

3. Gold: Silver + make the forecast reproducible

Archive & Information System

Desired features:

- Stable, long-term archiving
- Ability to add reports or model files
- Enable multiple users and data sharing
- Private/local option
- Mainstream and low-cost software



Standard data fields!

https://github.com/uky-transport-data-science/forecastcards

Forecast Documentation Template

- Includes the information necessary for evaluation:
  - Project description & map
  - Forecast details
  - Methods
  - Assumptions
  - Post-opening data collection plan
- Standard template of only a few pages

Forecast Archive Annotated Outline (Silver Standard)

1 Introduction

This report, written in <month-year>, documents the traffic forecasts and supporting assumptions for the <project name>. The information in this report will be the primary source of information used to record the accuracy of the traffic forecast(s) and determine whether the assumptions used as a basis for the forecast also were generally accurate.

Section 2 describes the project. Section 3 summarizes the project traffic forecasts. Section 4 describes the forecasting method used to develop the traffic forecasts in Section 3. Section 5 enumerates the common and project-specific assumptions. Section 6 describes the data collection plan that will be executed prior to the post-construction forecast analysis. Section 7 provides a list of data sources and references used to develop the forecast.

2 Project Description

<Name of the project> is a <type of project [capacity addition, reconstruction, etc.]> located in <city, state>. Traffic forecasts for the project were prepared in <YYYY> for the <YYYY>, <YYYY>, and <YYYY> forecast year(s) for <agency name>. The project is currently planned to open in <YYYY>. The internal agency tracking number(s) for planning, design and construction phases is <NNNNNNNNN>.

<Include a 1–2 sentence description of the purpose of the project and the need for the traffic forecast>.

The study area boundaries are <here>, <here>, <here>, and <here>. A summary of the project scope goes here.

Describe any unique characteristics of the project. Some examples include: first project of its type in the region, first project of its type in decades, and exceptional project length, construction period and/or cost.

Describe the travel markets that are expected to comprise the majority of demand on the project. Travel markets are significant quantities of trips that traverse from one geographic area to another. They are typically further characterized by common trip purposes, time periods, line-haul or circulation/distribution movements, or socioeconomic variables. Examples of travel markets include: suburb-to-CBD work trips, external-external trips, game day traffic, and local shopping trips.

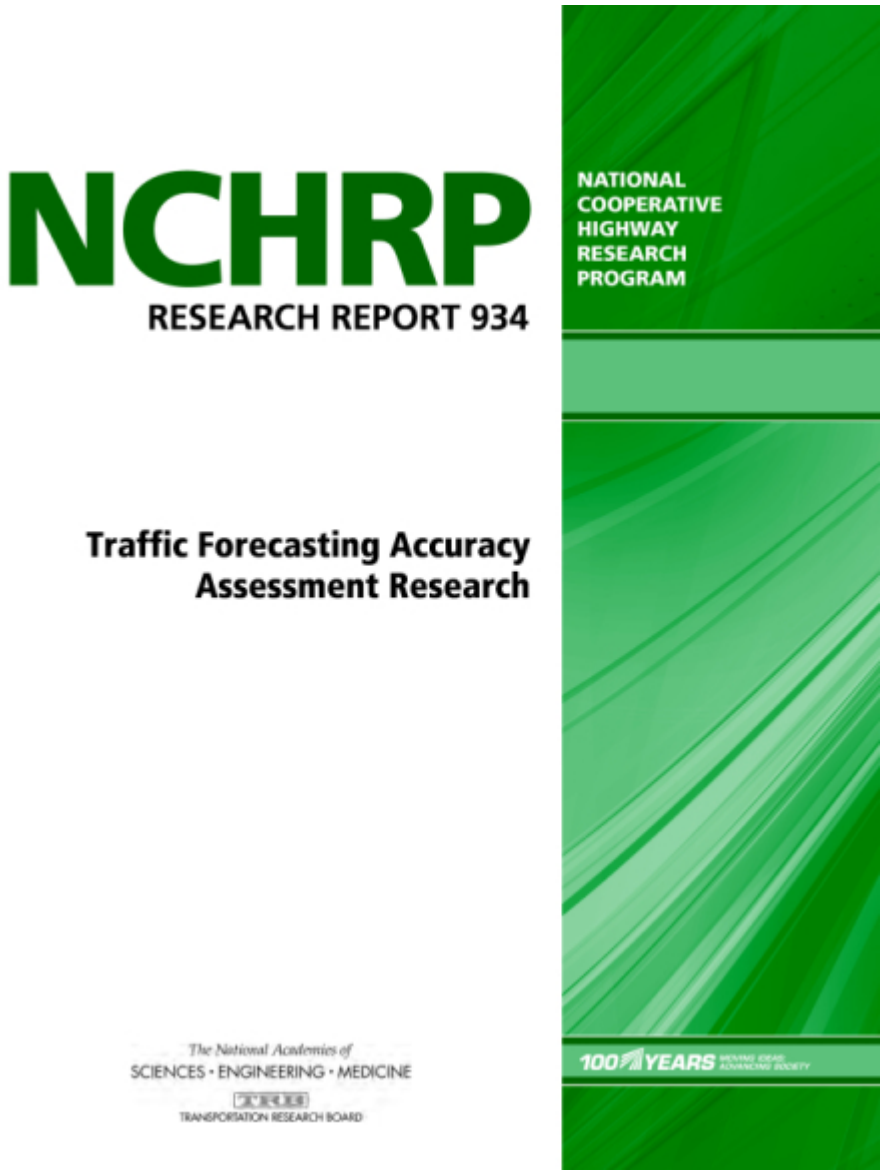
<Include a map.>

3. Periodically report the accuracy of forecasts relative to observed data.

- A short summary report updating the overall distribution of forecast error.
- Quantile regression models estimated from local data.
- Deep dives aimed at understanding the sources of error for either typical or important projects.

4. Consider the results of past accuracy assessments in improving traffic forecasting methods.

- Deep dives to reveal weaknesses in existing forecasts
  - Identify priority areas for improvements
- Validate a model's ability to predict project-level changes
  - Less time matching traffic counts, more time evaluating a model's response to change
- Large N analysis for method selection
  - Do models with more advanced features produce more accurate forecasts?



Resources

Guidance Document & Research Report

https://www.nap.edu/catalog/25637/traffic-forecasting-accuracy-assessment-research

Quantile Regression Spreadsheet

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_934_QuantileRegressionModels.xlsx

Archiving Software

https://github.com/uky-transport-data-science/forecastcards

Data

https://github.com/uky-transport-data-science/forecastcarddata

Why Should Transportation Agencies Implement These Recommendations?

To Build Trust

The agencies that shared data for this study are a model of transparency and should be celebrated for their efforts to learn from past forecasts and engage in a process of continued improvement.

1. A track record of accurate forecasts establishes the credibility of future forecasts.

2. Reporting inaccurate forecasts demonstrates a willingness to learn and improve.

3. Acknowledging the uncertainty inherent in forecasting by providing a range of outcomes means the post-opening outcome is more likely to be viewed as accurate.

A Broken Algorithm?

“At their best they (travel models) are ‘a check on wishful thinking.’ But other experts I spoke to, especially urban planners, tend to view the models as aiding and abetting the wishful thinking that more highways and wider roads will reduce traffic.”

-- Gordon, Aaron. “The Broken Algorithm That Poisoned American Transportation.” Vice, August 24, 2020.

The solution is not fewer checks on our thinking, but more!

We need your help to implement these recommendations!

Please let us know if you are interested or have questions.

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Dave Schmitt | dschmitt@ctgconsult.com

Jawad Hoque | jawadmhoque@uky.edu

Mei Chen | mei.chen@uky.edu

Today's Panelists

#TRBWebinar

Moderator: Mei Chen,
University of Kentucky

Dave Schmitt, *Connetics Transportation Group*

Greg Erhardt,
University of Kentucky

Jawad Hoque,
University of Kentucky

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Transportation Research Board

Getting involved is free!

Be a Friend of a Committee bit.ly/TRBcommittees

- Networking opportunities
- May provide a path to Standing Committee membership

Join a Standing Committee bit.ly/TRBstandingcommittee

Work with CRP https://bit.ly/TRB-crp

Update your information www.mytrb.org

#TRBAM is going virtual!

- 100th TRB Annual Meeting is fully virtual in January 2021
- Continue to promote with hashtag #TRBAM
- Registration is open!
- Check our website for more information

TRB turns 100 on November 11, 2020

Help TRB:

- Promote the value of transportation research;
- Recognize, honor, and celebrate the TRB community; and
- Highlight 100 years of accomplishments.

Learn more at

www.TRB.org/Centennial

#TRB100

MOVING IDEAS: ADVANCING SOCIETY—100 YEARS OF TRANSPORTATION RESEARCH