Quantifying Forecasting Risks

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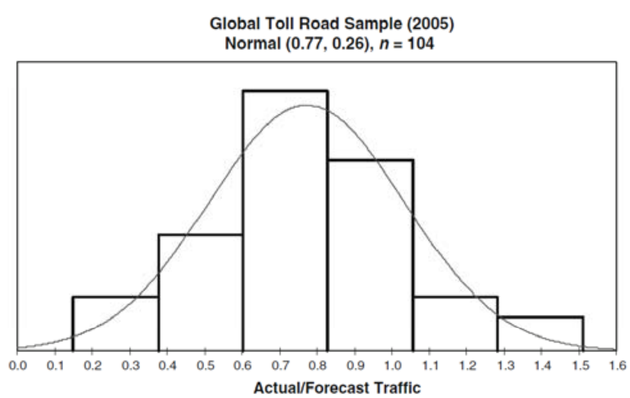
The Problem – Toll Road Projects

- Travel demand model forecasts are not always accurate



Source: Bain R, Error and Optimism Bias in Toll Road Traffic Forecasts, Transportation, Vol. 36, No. 5, 2009.

Three major sources of inaccuracy

- Model structure and data
  - Travel forecasting models are not perfect representations of actual travel behavior
  - Data used in models are not perfect representations of transportation system
- Analysis bias
  - General tendency to be overly optimistic
  - May be influenced be desired outcome
- Inherent uncertainties about future
  - Large uncertainties in many important future conditions
  - Uncertainties interact in ways not identified by simple sensitivity analyses

Improving the Reliability of Forecasting Models

There is broad recognition of issues with forecasting models and of the continuing need to improve their reliability.

- Improve the models that are used for forecasting
  - Progress has been made along a number of fronts
    - Model structure
    - Model inputs
- Improve the review and evaluation process
  - Lesson from transit ridership forecasting

Comparisons of FTA New Start predicted vs. actual ridership by year

Study	Average	50th Percentile	
"Pickrell" Report 1990	42.4%	41.4%	Before effective quality control
FTA 2003	68.9%	70.5%	After effective quality control
FTA 2007	74.5%	63.8%	

Source: Federal Transit Administration, TRB Session 371, January 2008

- Recognize and quantify inherent uncertainties and simplifications
  - Quantified probability analysis

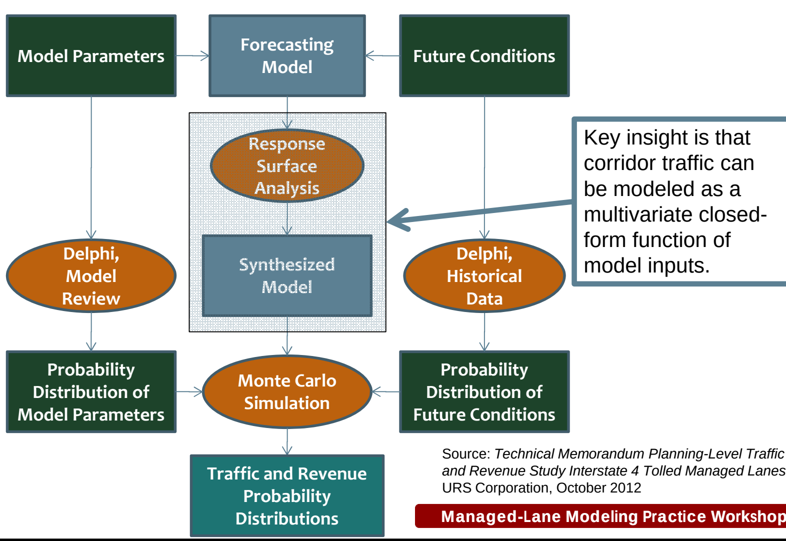
focus of this presentation

One Approach: Quantified Probability Analysis

- Quantified probability analysis involves two steps:
  1. Estimating the probability distribution associated with each model uncertainty
  2. Estimating the resulting probability distribution of the model outputs
- Step 1 can use a combination of quantitative and qualitative assessment – still better than just ignoring
- Step 2 can in some cases be calculated analytically, and in other cases using Monte Carlo simulation
- HOWEVER – most travel demand models take hours or days to run and so running them many times as required by Monte Carlo simulation becomes an intractable problem
  - Newer dynamic/agent-based/activity-based models are especially computation time-intensive

Application of quantitative probability analysis process

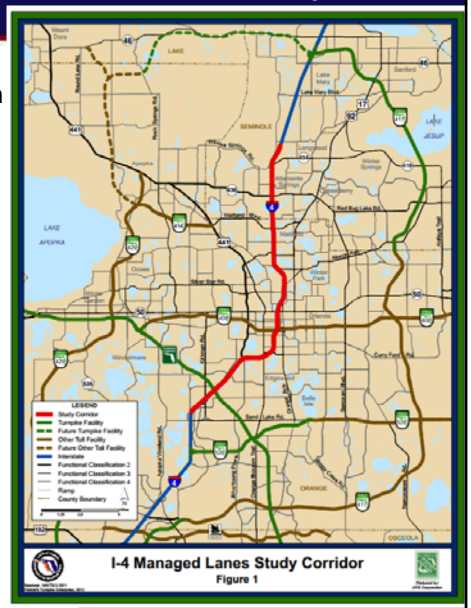
Uses additional steps to create information that supports a more complete enumeration all reasonable future conditions.



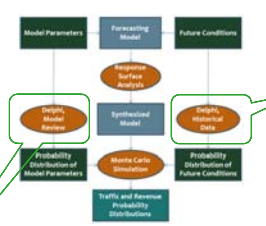
Source: *Technical Memorandum Planning-Level Traffic and Revenue Study Interstate 4 Tolled Managed Lanes*, URS Corporation, October 2012

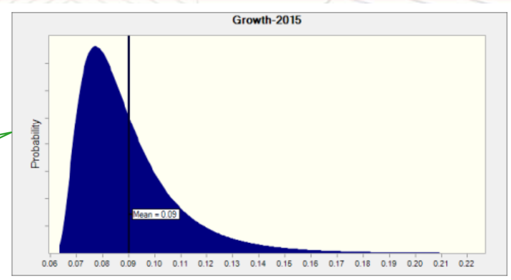
Example: Orlando I-4 Traffic and Revenue Study

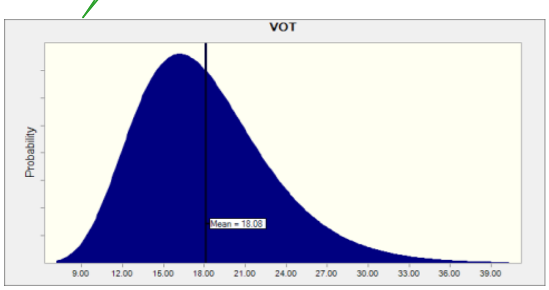
- 21-mile managed lane project
  - Existing highway has 4 lanes in each direction
  - Project will add 2 dynamically-priced lanes in each direction
  - Toll revenue will be important piece of project finance
  - Needed 75th percentile traffic and revenue estimates
- Regional travel demand model used to estimate demand
  - Travelers' values of time and regional growth rates are key drivers of demand
  - The actual future growth rate is highly uncertain
  - Model system takes 4-5 hours for a single run



Probability Distributions of Inputs







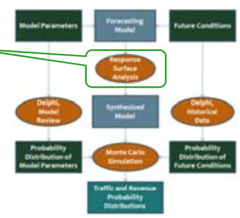
Land use growth distribution based on historical accuracy of Florida's official land use forecasts (BEBR); Value of time (VOT) distribution based on sampling error.

Model Runs to Estimate Response Surface

- Forecasting model runs: 9 orthogonal fractional factorial experiments
- Different from sensitivity analysis where inputs are varied individually

I-4 Managed Lanes Experimental Design

Alternative	VOT/hour	Economy	Network	Toll Rate/Mile
P1	$10.67	BEBR Med-Low	E+C	$0.05
P2	$10.67	BEBR Med	150	$0.15
P3	$10.67	BEBR Med-High	125	$0.10
P4	$18.08	BEBR Med-Low	125	$0.10
P5	$18.08	BEBR Med	150	$0.05
P6	$18.08	BEBR Med-High	E+C	$0.15
P7	$25.49	BEBR Med-Low	125	$0.15
P8	$25.49	BEBR Med	E+C	$0.10
P9	$25.49	BEBR Med-High	150	$0.05



Source: Technical Memorandum Planning-Level Traffic and Revenue Study Interstate 4 Tolled Managed Lanes, URS Corporation, October 2012

E+C is existing plus committed highway projects; 150 and 125 represent additional improvements necessary to keep traffic on all links within 150% and 125% of capacity, respectively

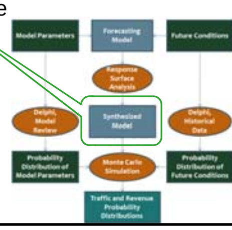
The Synthesized I-4 Models

$$Traffic = 128686 + 48486 * growth - 91138245 * (tollRate / VOT) + 9432 * \ln(rampUp) - 11099 * roadEC - 15820 * road150 + yearCon$$

$$Revenue = -6130 + 7.9 * (Traffic * tollRate) + 3532 * roadEC + 2088 * road150 + yearCon$$

Where: *Traffic* is the number of daily one-way trips that use the I-4 Express Lanes
Revenue is the estimated gross revenue from the trips on the I-4 Express Lanes
growth is the ratio of dwelling units in the given year to dwelling units in 2010 minus one
tollRate is the average toll rate charged on I-4 in 2010 $
rampUp is the number of years the project has been operating in the given year
roadEC represents the road improvements included only in the E+C conditions
road150 represents an improvement program that maintains all roads below V/C of 1.5
yearCon is a vector of constants representing the years for which the forecasts are being made

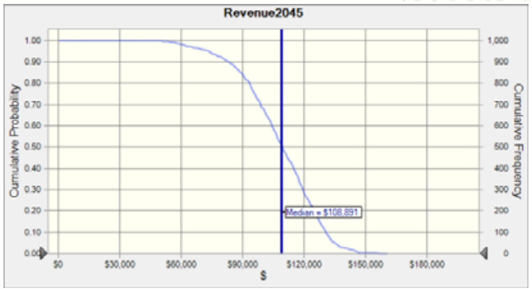
Model R^2 = 0.98

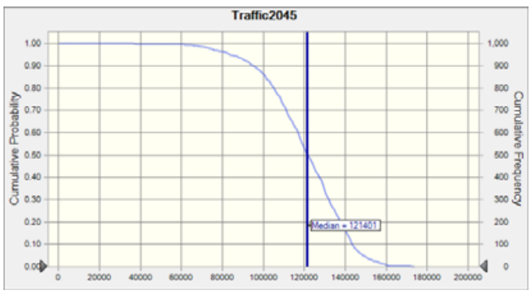


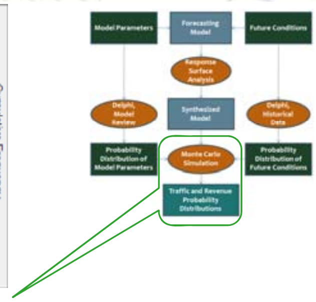
Source: Technical Memorandum Planning-Level Traffic and Revenue Study Interstate 4 Tolled Managed Lanes, URS Corporation, October 2012

Managed-Lane Modeling Practice Workshop

*Illustrative Distributions of Outputs**







Outputs reflect 1 million Monte Carlo draws from input distributions; runs took ~30 min. each.

*Note: The data in these graphs are illustrative only and do not reflect the final I-4 project forecasts

Conclusions

- Uncertainties and, thus, risks are inherent in travel demand forecasts
- For some types of projects, such as those financed by toll revenues, quantification of risks is especially important
- Travel demand models are too cumbersome to be used to directly simulate the probability distributions of their outputs
- Sensitivity analyses that are commonly conducted do not provide robust information about these distributions because they do not consider interactions among variables
- Response surface methods can be used to develop closed-form models that very effectively estimate the effects of key model inputs on corridor traffic and revenue
- Response surface models in turn can be used to effectively simulate risks associated with much more complex travel demand forecasting models