MODEL RESPONSIVENESS TESTING

Project teams frequently use regional land use or travel demand models, developed and maintained by metropolitan planning organizations (MPOs), for land use and travel forecasting analysis in NEPA documents. To do so, they must confirm that the models are appropriately responsive to the scale and types of changes the project could introduce.

Prior to testing for responsiveness (often called “dynamic validation” or “sensitivity testing”), the project team should also test the model (or confirm that the tool has been tested) for its ability to replicate observed conditions (“static validation”). Once a model accurately reflects existing conditions, the question becomes how well it responds to changes in those conditions. This summary sheet discusses how to validate whether your model is responsive to particular types of changes – Is the model capable of altering results if particular inputs change. See the Sensitivity Analysis summary sheet for help determining whether a change in input data will impact the results.

Method Description

The project documentation should clearly demonstrate that the models used for project analysis are appropriately responsive to the type and scale of changes that the project will introduce and that the model results “tell a coherent story” about behavioral responses to changes in the transportation and land use system. To test for this responsiveness, the project team will:

- Identify the outputs of the model that will inform the environmental analysis. Brainstorm ways in which the project’s potential characteristics might result in changes to those outputs. Use literature review and collaborative judgment to establish the expected magnitude and direction of the output variable change for a given input variable.
- Next, conduct a series of incremental tests, modifying each model input variable by a small amount and gradually increasing that amount. Measure the resulting output variable change to determine how responsive the model is to the changes in that model input variable.
- Compare the modeled results for each test with the established expectations in terms of both direction and magnitude. Confirm that you are seeing the types of responses that the literature review and collaborative judgment expected.

Applicable Context

Any time a project team applies a forecasting model, it should be calibrated and validated for the scale and type of project. It may be possible that the model has been validated for similar characteristics as part of a separate effort, in which case a review of documentation may satisfy the project team and reviewers that the model is properly valid and

responsive. If the review is unsatisfactory or documentation is not available, the team should validate the model before conducting analysis.

Prerequisites

1. **A statically validated model** that accurately replicates observed conditions. For more information on static validation, see the California Transportation Commission's *2017 Regional Transportation Plan Guidelines for Metropolitan Planning Organizations* and FHWA's *Travel Model Validation and Reasonableness Checking Manual*.
2. **Full model documentation and complete set of model files.** Proper application of models requires documentation describing the model's estimation, calibration, and validation plus complete instructions on user applications. The user applications should include details about how to set up the model, including hardware and software requirements. Prior to conducting any project-related applications of the model, the user should verify that they can identically replicate the agency's model outputs for standard base year and future year runs.

Method Implementation

To validate the appropriateness of the models used to evaluate the effects of the project in environmental analysis:

1. Identify all model-provided outputs that will be used directly in, or inform other parts of, the environmental analysis, such as:
   - Link-level roadway volumes
   - Mode share
   - Person and vehicle trips by purpose
   - Trip lengths
   - Speeds
   - Travel times
   - Vehicle hours of travel (VHT)
   - Vehicle hours of delay (VHD)
   - Vehicle miles traveled (VMT)
   - Transit ridership
2. Identify which of those outputs may be influenced by the project. For example, a highway project in a rural area without transit service may require only vehicular outputs like roadway volumes and trip lengths, while a similar project in a higher-density area with available transit service may require mode share and transit ridership outputs in addition to the vehicular outputs.
3. Identify how project characteristics, particularly those that differ from the no-build scenario, are reflected as inputs to the model, such as:
   a. land use,
   b. transportation network (highway and transit),
   c. policy changes; and
   d. pricing.
4. Prepare a matrix with one axis showing the outputs identified in (2), and the second showing the inputs identified in (3). Identify which inputs and outputs are related.
5. Use available literature and collaborative judgment (see "Collaborative Judgment" method sheet for guidance) to establish the expected direction and magnitude of effect of each individual input change on each

model output (i.e., each cell of the matrix from [3]).

Prepare to test the model at the scale and location of the project and to evaluate the outputs of the model at all relevant scales of effect. For example, a regional travel demand model might not fully reflect the effects of a new interchange on vehicular volumes of adjacent local streets, but could be the appropriate tool for evaluating the redistribution of regional traffic patterns.

Use expert judgment to establish expected results on a case-by-case basis; some examples of potential tests and expected results in the context of a regional travel demand model are listed in the following table.

Table: Example Responsiveness Testing Expectations

Input Change	Test	Expected Results
Residential land use	Add 10, 100, 1,000, 5,000, and 10,000 households to a residential-only TAZ without changing the mix of household categories. Test one location near the urban core and one more suburban location.	Person trip rates should be similar for each increment. Vehicle trip rates should be similar with each increment until density exceeds about 7 dwelling units/households per acre. At this and higher densities, trip rates should decline based on relevant research such as Boarnet, Marlon and Handy, Susan. 2010. "*DRAFT Policy Brief on the Impacts of Residential Density Based on a Review of the Empirical Literature.*" http://arb.ca.gov/cc/sb375/policies/policies.htm. VMT per household should be lower for TAZ near urban core and SOV share should decrease.
Roadway capacity	Add lanes to links in two locations: one on a major facility across a constraint (e.g., river); another on a minor street.	Parallel facility should show similar magnitude decrease in volume. Screenline should show slight increase. The influence area should be greater for the major street compared to the minor street. In both cases, changes should be concentrated near the subject link.
Transit fares	Double and halve systemwide transit fares.	The model should respond in the range of ridership/fare elasticities documented in literature (e.g., *Traveler Response to Transportation System Changes Handbook, Third Edition*).

6. Make a series of incremental (starting small and progressing to larger changes) changes to individual inputs, running the model for each input change. Record the responses of each output variable of interest.

7. Compare the modeled results with the expectations established by literature review and collaborative judgment.

Documentation

Document methodology and findings, including capabilities and limitations of the model, such that the results would be reproducible by others. Documentation should include summary data, explanatory text, and a complete list of references sufficient to allow an outside party to reproduce the analysis. Chapter 11.0 of the *Travel Model Validation and Reasonableness Checking Manual* includes detailed guidance on model validation documentation.

Documentation should include discussion of the model limitations where satisfactory validation could not be achieved. If models have responsiveness limitations, explain the potential influence on project traffic forecasts and related environmental effects. This may require modifications to the model through study area calibration and validation to improve sensitivity and the development of new forecasts. At a minimum, any known limitations should be acknowledged in the documentation and a qualitative discussion should be included about how the limitation may have influenced project effect analysis results.

Project Examples

Modifying an Alternative to Include High-Occupancy Toll Lane

During the alternatives analysis stage of a freeway capacity expansion project, a modified build alternative was added to include a high-occupancy toll (HOT) lane. Other build alternatives include adding a general purpose lane or adding a high-occupancy vehicle (HOV) lane. The model used for the project had not been evaluated for responsiveness to HOT lane pricing prior to starting the project.

To understand the travel demand effects of the new alternative, the study team prepared a series of model responsiveness tests to determine how the model's traffic volume, speed, and travel time forecasts would change when travel costs changed within the range anticipated for the HOT lane. The tests consisted of per mile costs being added in increments of $0.10 per mile starting at $0.10 and increasing up to $1.00 per mile.

The team used available literature (such as *Economics: Pricing, Demand, and Economic Efficiency, A Primer,* FHWA, 2008 and *Impacts of Road User Pricing on Passenger Vehicle Use and Greenhouse Gas Emissions,* California Air Resources Board, 2014) to identify that increasing the cost of vehicle travel will reduce demand. The ARB research states, "The sensitivity of traffic volume to price changes, given in terms of elasticities, falls within a range of -0.1 and -0.45. This means that a one percent toll increase would result in a 0.10 to 0.45 percent decrease in traffic volume on the tolled segment."

The tests revealed that the model showed only a small decrease in demand resulting from the increased costs and that it was much lower than the elasticities estimated in the literature. Investigation into the results revealed that the model was performing correctly; the cause of the limited responsiveness was due to insufficient congestion in the adjacent general purpose lanes. This information was used to explain the differences in alternatives' performance and environmental effects to strengthen the NEPA documentation.

Resources

California Transportation Commission. (2017). *2017 RTP Guidelines for MPOs*. http://www.dot.ca.gov/hq/tpp/offices/orip/rtp/docs/2017RTPGuidelinesforMPOs.pdf

FHWA. (2010). *Travel Model Validation and Reasonableness Checking Manual.* https://www.fhwa.dot.gov/planning/tmip/publications/other_reports/validation_and_reasonableness_2010/fhwahep10042.pdf

Transportation Research Board of the National Academies. (2004). *Traveler Response to Transportation System Changes.* http://www.trb.org/Publications/TCRPReport95.aspx

Victoria Transport Policy Institute. (2019). *Transit Price Elasticities and Cross-Elasticities.* https://www.vtpi.org/tranelas.pdf