Spatial Transferability of Travel Forecasting Models: A Review and Synthesis

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Overview

- Background & Motivation
- Review and Synthesis
- Transferability of Activity-Based Model systems
- Future Research

Background

- Travel Forecasting Models
  - Used to forecast future travel characteristics
- Transferability of Travel Forecasting Models
  - The ability to transfer models over ***time*** or across ***space***
- Temporal Transferability
  - Transferability of models developed for one point in time to another point
- Spatial Transferability
  - Transferability of models developed in one area to another area

Why Spatial Transferability?

- Can help in significant cost and time savings
- Recent shifts to the activity-based models
- Development of activity-based models requires significant data inputs, skilled staff, and long production times
- Not discussed with special attention in the recent past

Objectives

- Review
  - Theoretical and practical aspects of model transferability
  - Transfer methods
  - Assessment metrics
  - Empirical evidence on model transferability
- Discuss Transferability of Activity-Based Model Systems

Transferability-Theoretical Aspect

- Hierarchy of transferability levels by Ben-Akiva (1981) and Hensen (1981)
  - Underlying theory of travel behavior (e.g., utility maximizing decisions)
  - Mathematical Model (e.g., logit vs. probit)
  - Empirical Model Specification (e.g., specification of explanatory variables)
  - Parameter Values (e.g., coefficients of explanatory variables)

- Potential for transferability decreases from theoretical level to the parameter estimates
- Failure of transferability at any level reduces the potential for transferability at the lower level

Transferability-Practical Aspect

- Models are only abstractions of reality
- Unrealistic to expect models to be perfectly transferable
- More constructive to understand if models can be transferred up to ***certain acceptable practical criteria***

"The **usefulness** of the transferred model, information or theory in the new context" (Koppelman and Wilmot, 1982)

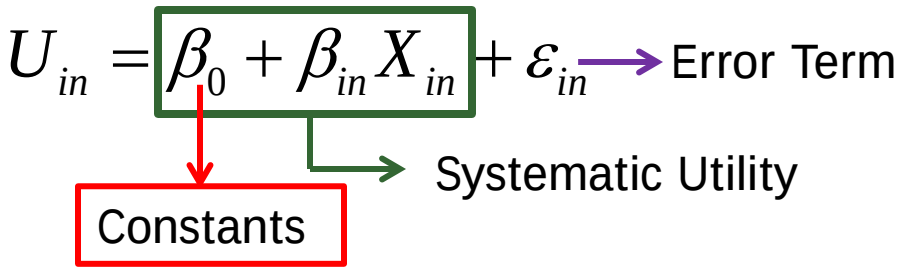
Transfer Methods

- Naïve Transfer
- Updating Constants
- Transfer Scaling
- Bayesian Updating
- Combined Transfer Estimator
- Joint Context Estimation

Methods Used to Enhance Model Transferability

Transfer Methods (Contd.)

- Base Context
  - The context from which a model is transferred
- Application Context
  - The context to which a model is transferred
- Transfer Bias
  - Differences in true parameters between base and application contexts
- Constants



Transfer Methods (Contd.)

Transfer Methods	Procedures	Limitations
Naïve Transfer	Parameters are transferred directly	Too general
Updating Constants	Parameters other than the ***constants*** are transferred directly	May not adequately represent behavior in the application context
Transfer Scaling	Parameters other than the constants are transferred up to ***a certain scale***	Sampling errors are not considered
Bayesian Updating	Base context parameters are ***combined*** with the application context parameters	Assumes transfer bias is zero
Combined Transfer Estimator	Uses mean square error (MSE) criterion, and takes into ***account the transfer bias***	Updated parameters can be equal (or inferior) to the estimates in the application context
Joint Context Estimation	Both ***common and context-specific*** parameters are estimated	Need data from the base context

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Transferability Assessment Metrics

- Statistical tests:
  - Model equality test statistic (METS)
  - Transferability test statistic (TTS)
  - t-tests of individual parameter equivalence
- Predictive ability measures:
  - Transfer rho-square
  - Transfer index (TI)

  } Disaggregate-level

  - Relative error measure (REM)
  - Root mean square error (RMSE)
  - Relative aggregate transfer error (RATE)
  - Aggregate prediction statistic (APS)

  } Aggregate-level

- Policy sensitivity comparisons

Transferability Assessment Metrics

- Statistical tests:
  - Model equality test statistic (METS)
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  - t-tests of individual parameters

  → reject model transferability

- Predictive ability measures:
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  - Relative error measure (REM)
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  - Relative aggregate transfer error (RATE)
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  → similarity in disaggregate level measures IMPLY equality of parameters

  → similarity in aggregate predictions IMPLY similarity in policy sensitivities

- Policy sensitivity comparisons

  → only a handful of studies used these tests

Empirical Evidence

- *Updating constants* helps in achieving aggregate shares but not clear whether it helps in achieving policy sensitivity
- *Joint context estimation* approach appears to perform better than other updating techniques
- *Statistical tests* are likely to reject model transferability
- Transferability results vary based on the *metrics* used to assess transferability

Gaps in the Literature

- Only a handful of studies on travel choices (e.g., destination choice) other than the mode-choice
- Simple model structures (e.g. multinomial logit) used
- Not clear how much of the difference between base and application context models (i.e. if a model is not transferable) is due to the
  - impreciseness of parameter estimates
  - other factors (such as differences in surveys and assessment metrics)
  - the actual differences in travel behavior between the contexts
- Neither specific guidelines for transferring models nor any framework for assessing the transferability of activity-based models

Transferability of Activity-Based Model Systems - A hierarchy

- Transferability of the Design Features of the Model System
  - The traveler markets to be modeled
  - Structure of the overall model system
  - Spatial and temporal resolution
- Transferability of Individual Model Components
  - Hierarchy of model components
    - Long-term choice components
    - Activity and travel generation
    - Tour scheduling models
    - Trip-level models
  - Model specification
  - Model parameter estimates
  - Linkages to other model components

Transferability of Activity-Based Model Systems - A hierarchy (Contd.)

- Issues with Transferring Design Features of the Model System
  - Attention to additional traveler markets (e.g., seasonal residents) may vary across regions
  - Planning priorities and needs vary considerably across regions
    - Some regions may need sophisticated framework
    - Some regions may need simpler framework
  - Spatial and temporal resolution requirements may vary across regions

"An ABM framework may have to be ***tweaked*** to transfer to a region

Transferability of Activity-Based Model Systems - A hierarchy (Contd.)

- Issues with Transferring Individual Model Components
  - Transferring model components *lower in the hierarchy* may be difficult
  - Transferring some components (e.g., activity and travel generation) may be *easier* compared to other components (e.g., destination choice)
  - Several factors can influence parameter estimates and variable specification
    - Differences in travel behavior
    - Differences in the activity-travel environment
    - Sampling errors
    - Measurement errors
    - Differences in the survey methods

Future Research

- Relative *influences of different factors* (e.g., differences in travel behavior, sampling error) on model transferability
- Effect of *differences in surveys* on model transferability
- Assess *updating methods* using policy sensitivity measures
  - Updating constants helps in achieving aggregate shares, but does it help in achieving appropriate policy sensitivity?
- Relationship between *different assessment metrics* of transferability
- Set *acceptable error threshold* to measure the transfer effectiveness

Future Research

- Relative Transferability of *different model components*: tour/activity generation, time-of-day, mode choice and destination choice
- Enhance model transferability by *pooling data* from different areas


Thank you