Making advanced travel forecasting models affordable through model transferability

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Acknowledgments

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  - California DOT
  - Fehr & Peers
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  - Fresno County COG
  - Sacramento Area COG
  - San Joaquin County COG
 - San Diego Association of Governments

Outline

- Introduction
- Transferability testing methods
- Results

Objective

- Empirically test and demonstrate the transferability of activity-based (AB) models between regions

- Why? Reduce AB development costs
  - large household survey
  - estimating entirely new models

Six regions in study

Sacramento
Fresno
San Diego
Northern San Joaquin Valley
Jacksonville
Tampa
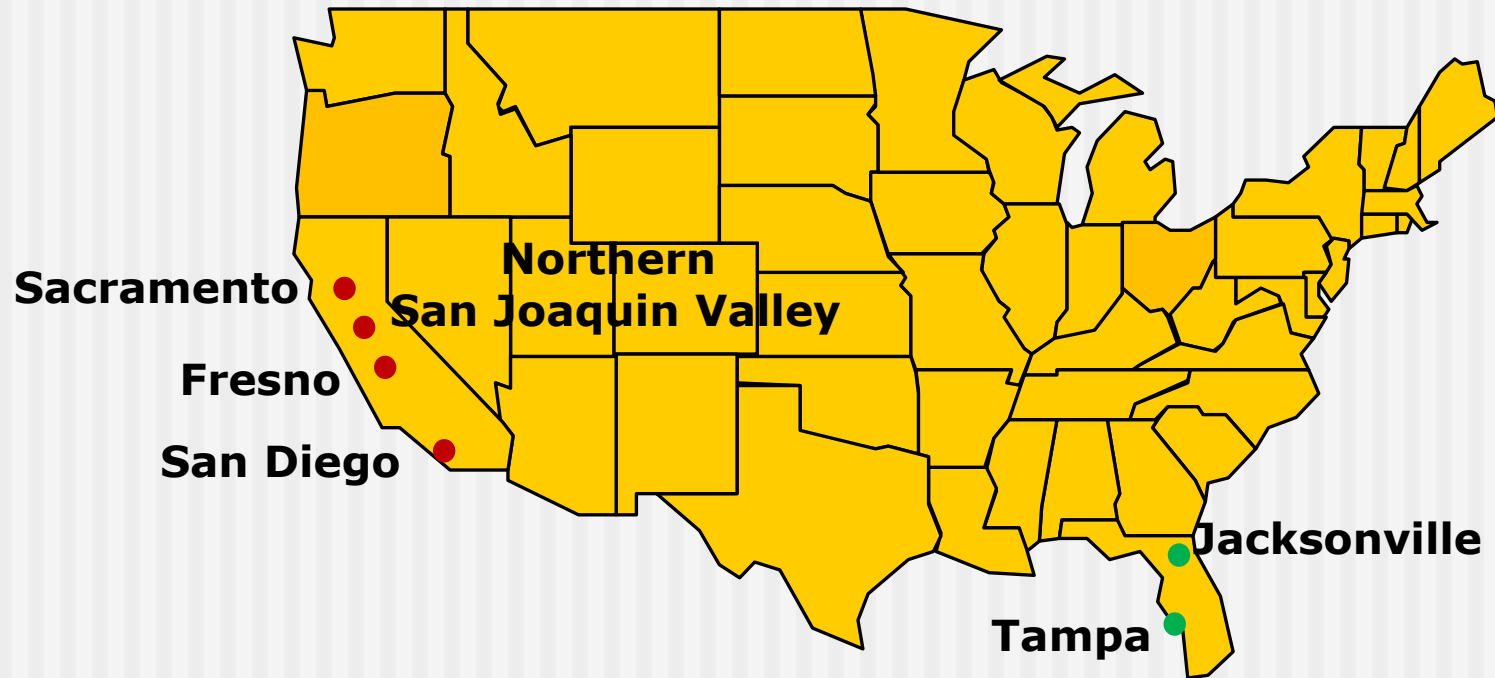
AB Model Framework

Long Term Choice (once per household)

Usual locations (once per person)

| **Work** (Non-student workers) | → | **School** (All students) | → | **Work** (Student workers) |

↓

Auto Ownership (Household)

Within-Day Choice (once per person-day)

Day Pattern (activities & Home-based tours for each person-day)

Tours (once per person-tour)

Aggr. LogSums   LogSums

Primary Activity Destination

No./Purp. Of Wk-Based SubTours

Main Mode → **Primary Activity Time of Day**

Half-tours (twice per person-tour)

Number & Purpose of Intermediate Stops

Aggr. LogSums

Intermediate stops and trips (once per trip)

Activity Location → **Trip Mode** → **Activity/Trip Time of Day**

TRB Annual M

Fifteen tested model components

Model Type	Number of coefficients
Usual work location	48
Auto ownership	24
Person-day tour generation	126
Exact number of tours	86
Work tour time of day	69
Work tour mode (detailed LOS)	58
Work tour mode (combined LOS)	31
Work-based subtour generation	14
School tour mode	32
Other tour destination	62
Other tour time of day	86
Other tour mode	41
Intermediate stop generation	100
Intermediate stop location	66
Trip time of day	45
Total	888

Seven untested model components

Model Type
Usual school location
Work tour destination
Escort tour mode
Work-based subtour mode
School tour time of day
Work-based subtour time of day
Trip mode

Eleven variable types

Variable Type	Number of coefficients
A-constant	192
P-person	184
H-household	149
D-day pattern	76
T-tour/trip	199
I-impedance	110
U-land use	99
W-time window	45
C-logsum	24
G-size variable	35
L-log size multiplier	3
Total	1116

Transferability testing: two approaches

- Application-Based
  - Apply model system developed for another region
  - Compare predictions to observed aggregate outcomes
- Estimation-Based
  - Estimate coefficients for both regions
  - Compare them for statistical differences

Strengths of the estimation-based approach

- Explicit statistical tests
  - Can address a wide variety of hypotheses
  - Can test transferability of specific variable types and model components

Data issues

- Data problems can confound transferability test results
  - Inconsistent data
  - Small samples

Estimability questions

- What estimation sample size is adequate?

- How does combining samples improve estimability?

- Which models are more estimable at the regional level?

Transferability Hypothesis 1

Variables that apply to population segments defined by characteristics of individuals and/or their situational context (i.e. segment-specific variables) will tend to be more transferable than variables that are more generic and apply to all individuals.

Transferability Hypothesis 2

Variables that are segment-specific will tend to be more transferable than alternative-specific constants.

Transferability questions
about types of coefficients

- Are coefficients defined by **individual characteristics** or **population segments** more transferable than those defined for the **entire population**?

- Are coefficients defined by **population segments** more transferable than **alternative specific constants**?

Transferability Hypothesis 3

Models that deal with social organization (activity generation and scheduling) will be more transferable than models that deal mainly with spatial organization (mode choice and location choice)

Transferability questions
about types of models

- Are models that deal with social organization (activity generation and schedule) more transferable than those that deal mainly with spatial organization (mode and destination)?

Transferability Hypothesis 4

Models for different regions within the same state will tend to be more transferable than models for regions in different parts of the country

Transferability questions
about geography

- Which models are more transferable across states? Within CA? Within FL?

- Can a region use models developed from a state or multi-state sample?

- Are CA and FL models more transferable within-state than across CA and FL?

- Is a region's model essentially the same as the combined within-state or two-state model?
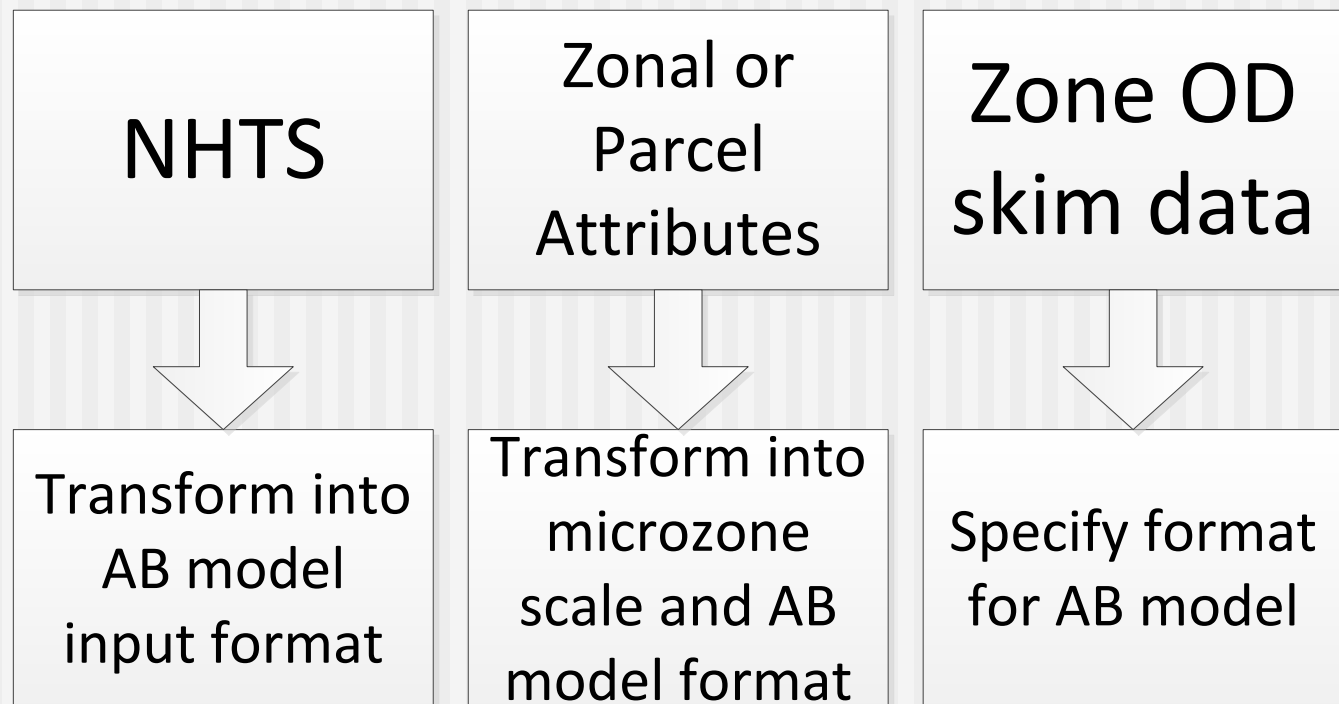
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Testing method overview

- Prepare data
- Estimate separate models
- Estimate comparison models
- Tabulate and analyze results

Data preparation overview

For each region:

NHTS	Zonal or Parcel Attributes	Zone OD skim data
↓	↓	↓
Transform into AB model input format	Transform into microzone scale and AB model format	Specify format for AB model

NHTS Sample Sizes

Region	Number of Households
Fresno	380
Northern San Joaquin Valley	660
Sacramento	1,310
San Diego	6,000
California Total	8,350
Jacksonville	1,050
Tampa	2,500
Florida Total	3,550
Two-state total	11,900

Testing method overview

- Prepare data

- Estimate separate models

- Estimate comparison models

- Tabulate and analyze results

Estimating separate models

- Using AB model software
  - Generate base model specs
  - Generate estimation data sets
- Using model estimation software
  - Estimate 90 separate models (15 models x 6 regions)
  - Constrain inestimable coefficients

Testing method overview

- Prepare data
- Estimate separate models
- **Estimate comparison models**
- Tabulate and analyze results

Estimating comparison models

For each of the 15 models:

- Using custom program
  - Combine data for all regions
  - Generate 36 estimation control files
- Using estimation software
  - Estimate 36 versions of each model
    - 12 base model versions
    - 24 difference model versions

12 Base model versions

- 6 region-specific versions
- 2 2-state versions
  - With region-specific ASCs
  - Without region-specific ASCs
- 2 FL versions (with & without region ASCs)
- 2 CA versions (with & without region ASCs)

24 Difference model versions

- Four versions for each region
- each with difference variables relative to a base version
  - 2 state base
  - 2 state base with region-specific ASCs
  - 1 state base
  - 1 state base with region-specific ASCs

Utility functions

- Base model:
$$V = a + bx$$

- Difference model:
$$V = a + bx + R\left(\hat{a} + \hat{b}x\right)$$

R is a dummy variable specific to the difference region

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Analyzing the Results

- Compile and tabulate results in a custom program
  - Tables for each model
  - Metadata file
    - One record per model coefficient
    - Includes summary statistics for each model
- Analyze and summarize metadata using SPSS script

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- Introduction
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  - Hypotheses tested
  - Most important conclusion

Transferability hypotheses

- (Hypothesis 1) Variables that apply to population segments defined by characteristics of individuals and/or their situational context (i.e., segment-specific variables) will tend to be more transferable than variables that are more generic and apply to all individuals. **(accepted)**

- (Hypothesis 2) Variables that are segment-specific will tend to be more transferable than alternative-specific constants. **(rejected)**
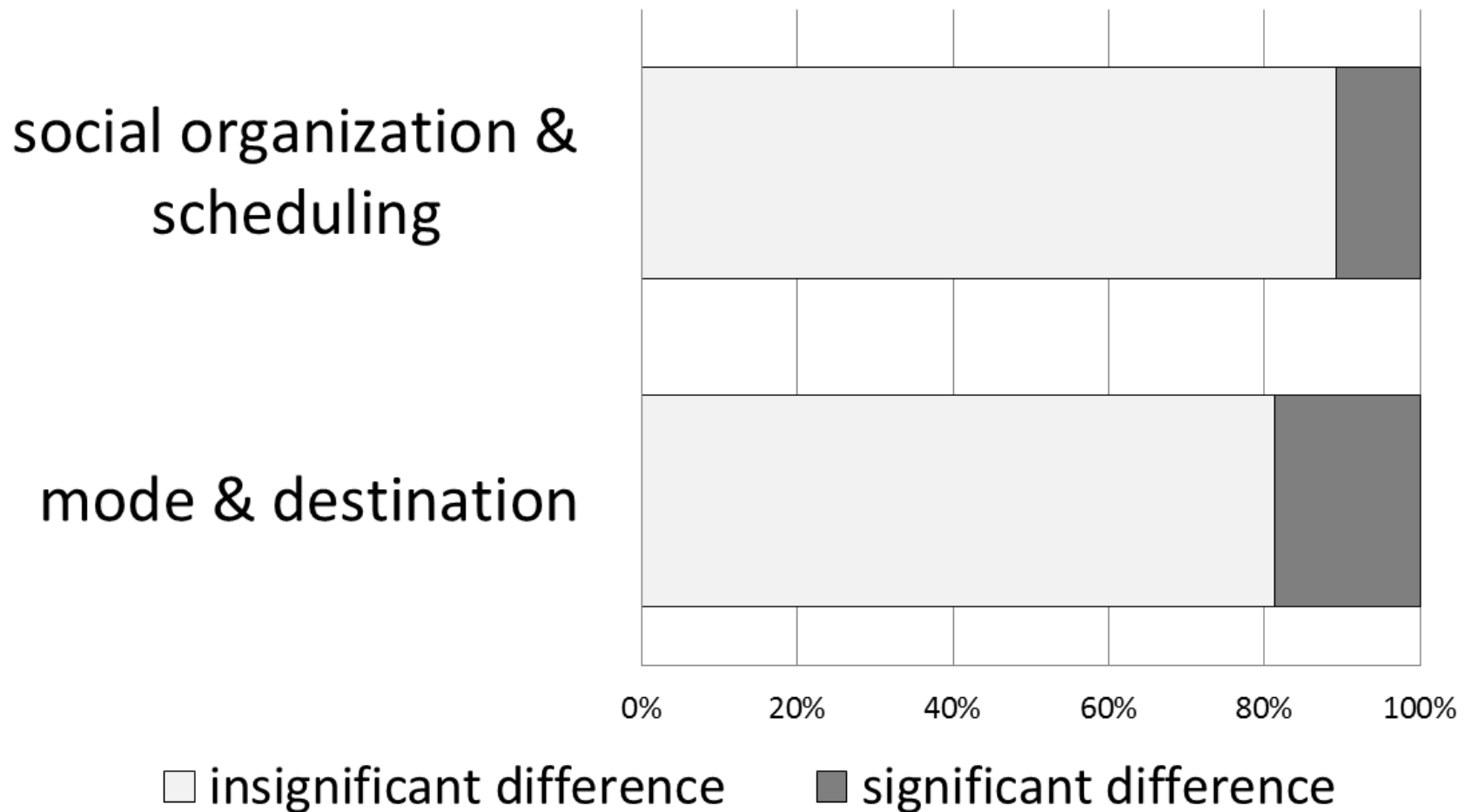
Significance of parameter estimate differences between regional and 2-state models by type of parameter (excluding inestimable parameters)
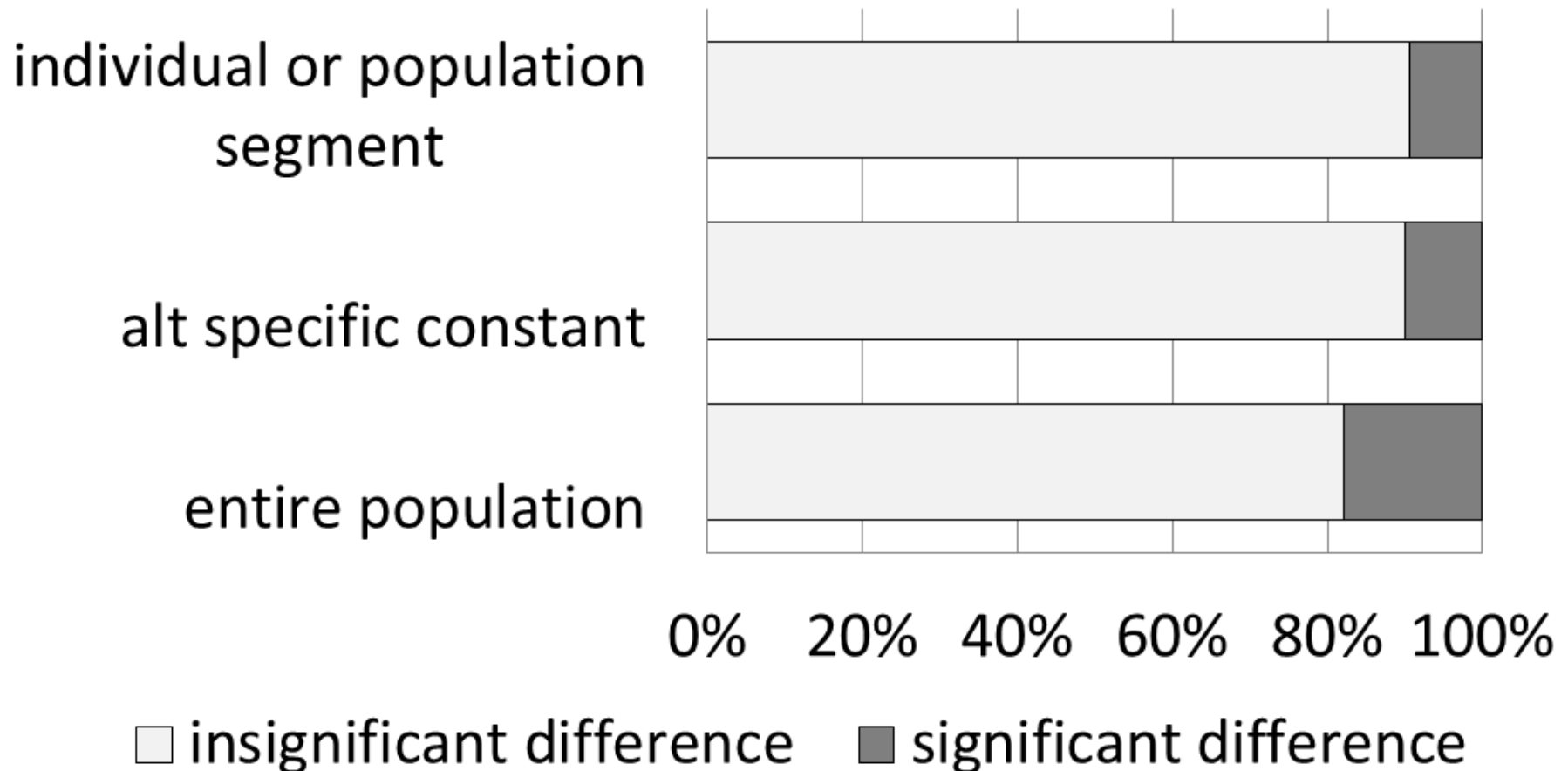
Transferability hypotheses

- (Hypothesis 3) Models that deal with social organization (activity generation and scheduling) will be more transferable than models that deal mainly with spatial organization (mode choice and location choice) (**accepted**)

Significance of parameter estimate differences between regional and 2-state models by type of model component (excluding inestimable parameters)

Chart comparing social organization & scheduling and mode & destination by percentage of insignificant difference (light) and significant difference (dark), scale 0% to 100%.

Legend: □ insignificant difference   ■ significant difference
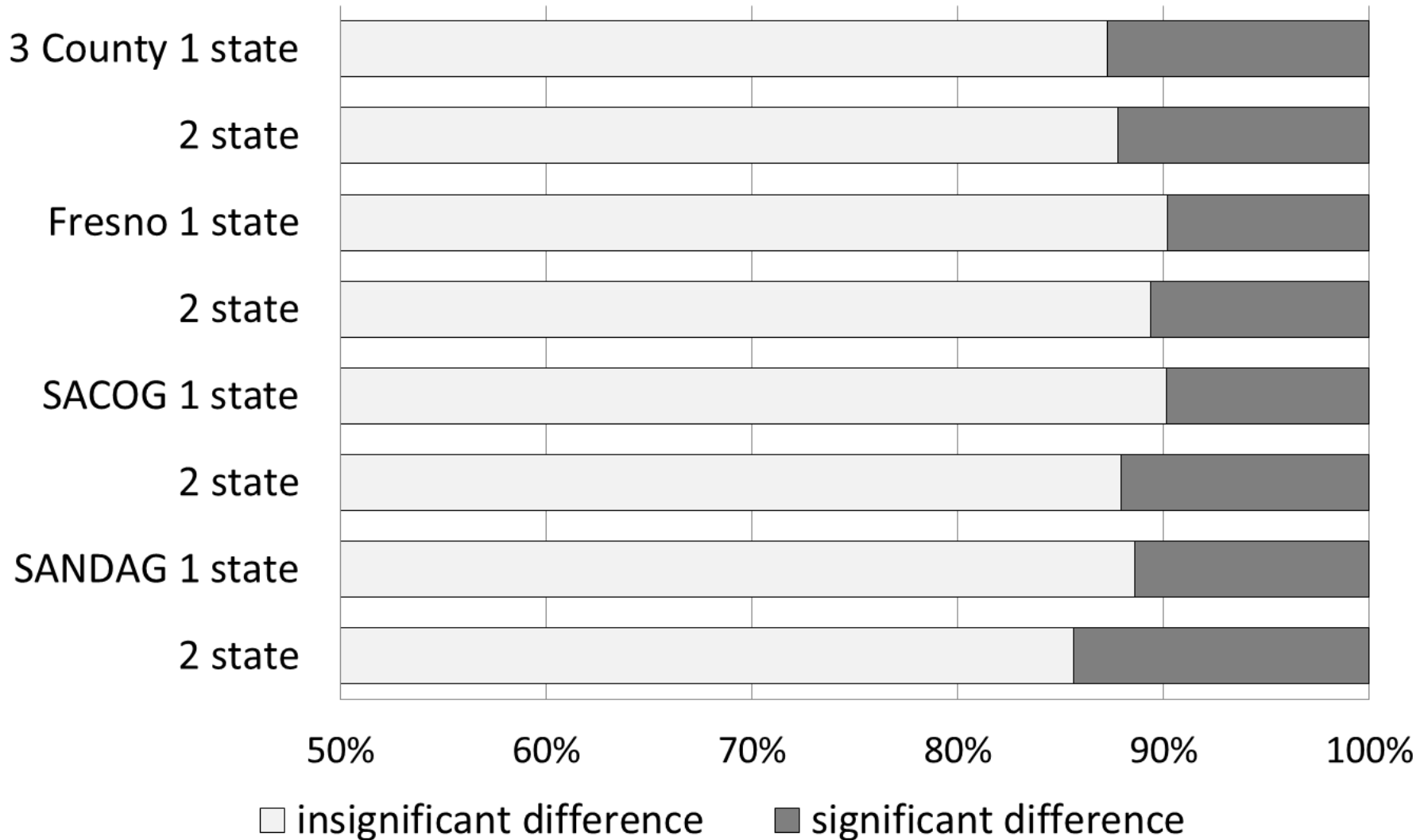
Transferability hypotheses

- (Hypothesis 4) Models for different regions within the same state will tend to be more transferable than models for regions in different parts of the country

  California—accepted (weakly) Florida—rejected, Jacksonville more transferable with California than with Tampa

California
Significance of parameter estimate differences between regional model and larger models by region (excluding inestimable parameters)

Chart showing percentage of insignificant difference vs significant difference by region:

Region
3 County 1 state
2 state
Fresno 1 state
2 state
SACOG 1 state
2 state
SANDAG 1 state
2 state

X-axis: 50% 60% 70% 80% 90% 100%

Legend: ☐ insignificant difference   ■ significant difference

Florida
Significance of parameter estimate differences between regional model and larger models by region (excluding inestimable parameters)
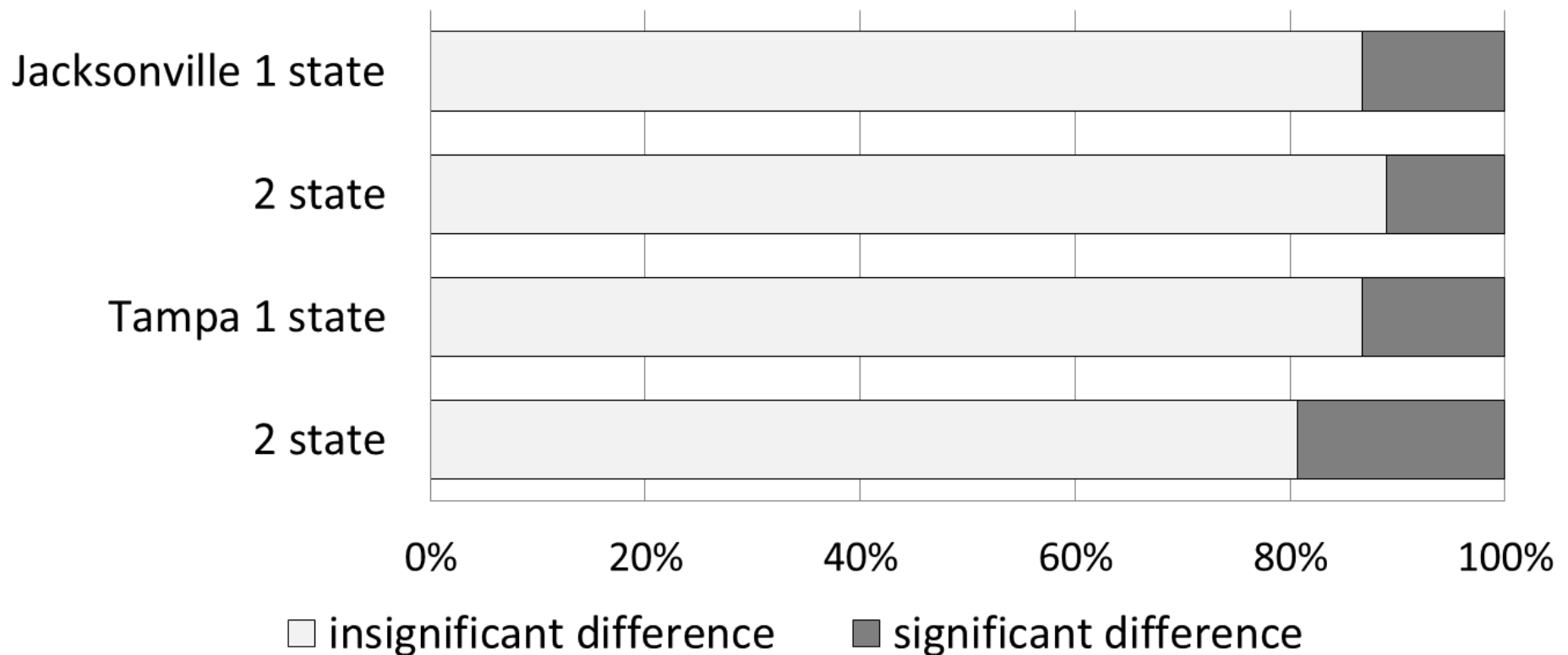
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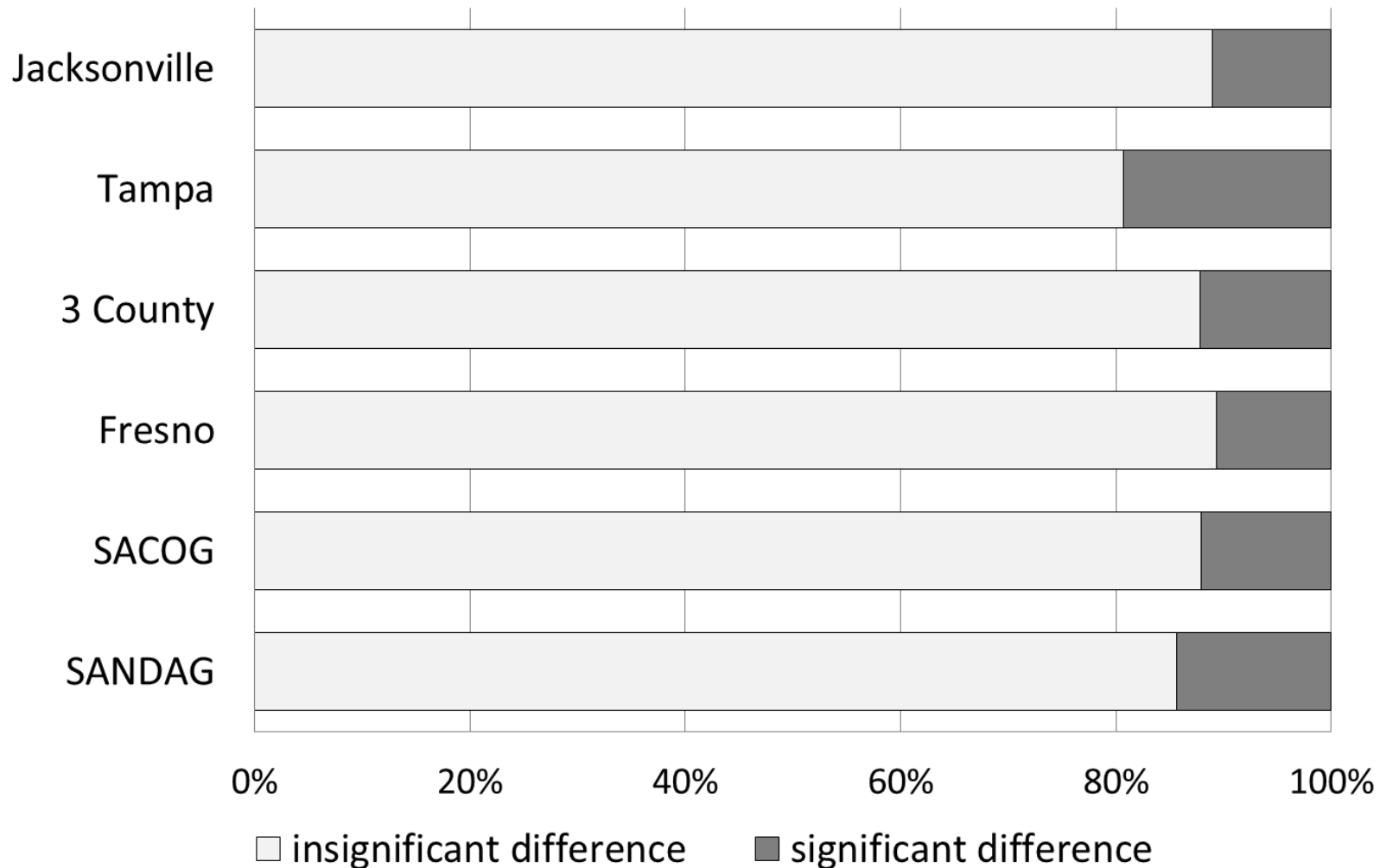 - Most important conclusions

Most Important Conclusions

- evidence of broad comparability among all the regions, with one region, Tampa, standing out as less comparable than the others

- sample sizes of 6,000 households or more provide much better information for estimating coefficients than samples of 2,500 or less.

Better to transfer models based on large sample from comparable region than to estimate new models using a much smaller local sample
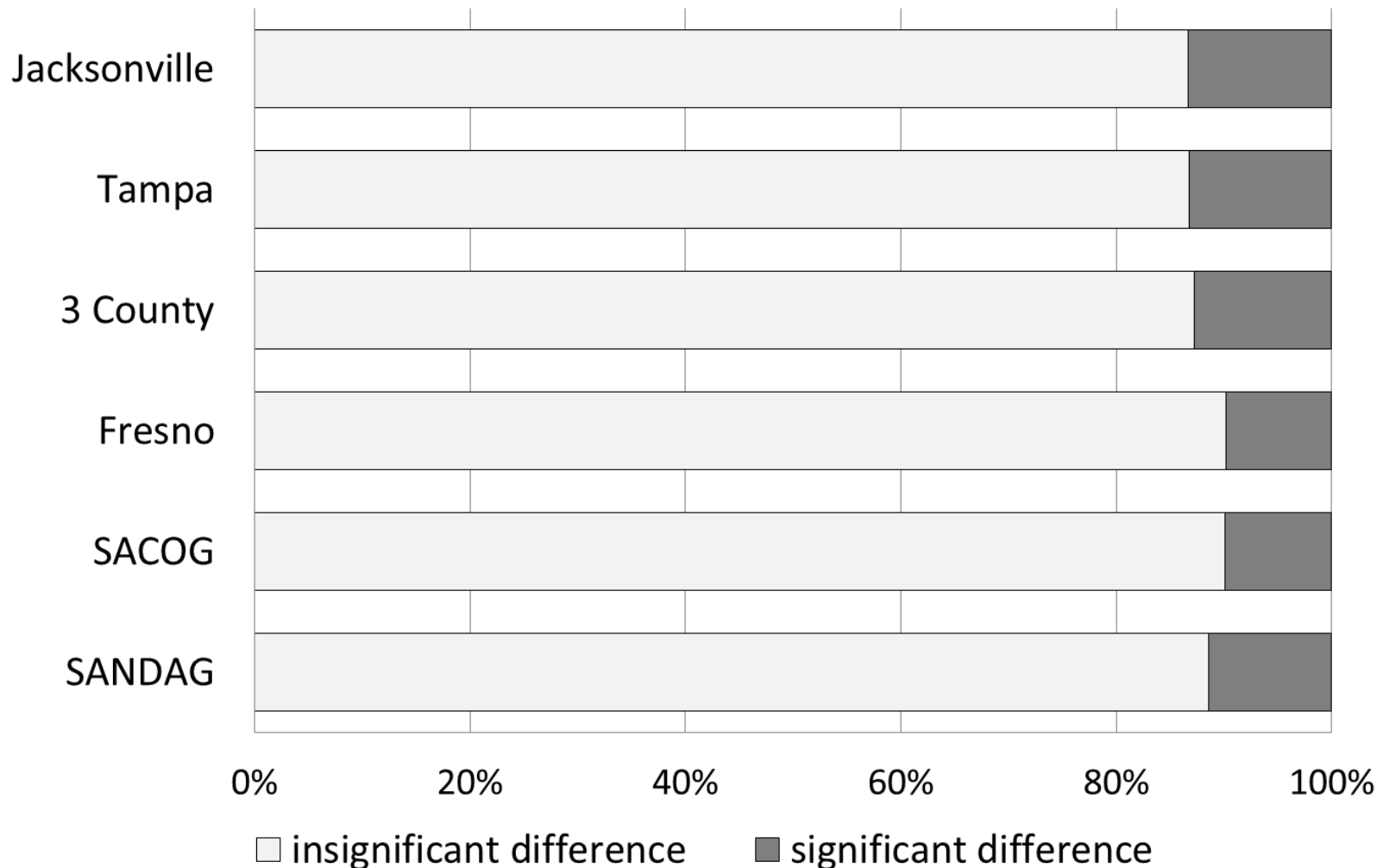
Comparability—2 state

Significance of parameter estimate differences between regional model and 2 state model by region (excluding inestimable parameters)

□ insignificant difference ■ significant difference

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Comparability within state

Significance of parameter estimate differences between regional model and 1 state model by region (excluding inestimable parameters)

Regions (top to bottom): Jacksonville, Tampa, 3 County, Fresno, SACOG, SANDAG

X-axis: 0%, 20%, 40%, 60%, 80%, 100%

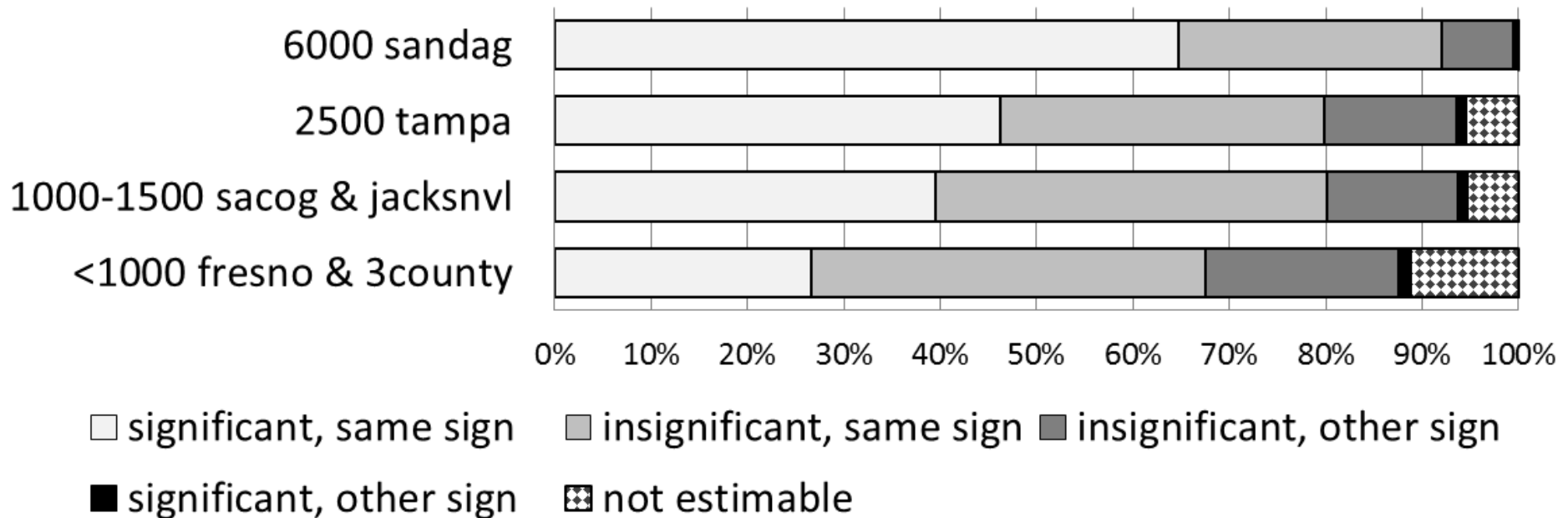Legend: □ insignificant difference ■ significant difference

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Better to transfer models based on large sample from comparable region than to estimate new models using a much smaller local sample

Need for large samples

Significance and sign of parameter estimates by number of survey households

- □ significant, same sign
- □ insignificant, same sign
- ▣ insignificant, other sign
- ■ significant, other sign
- ▨ not estimable

Most Important Conclusions

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Followup Research

- More regions in the study
- Additional research objectives recommended by peer review panel

Add 7 regions to the study

Add 7 regions to the study

Existing Regions	NHTS HHs
San Diego	6,002
Tampa	2,517
Jacksonville	1,335
Sacramento	1,311
Northern San Joaquin	657
Fresno	381

New Regions	NHTS HHs
Dallas-Fort Worth	5,875
Piedmont	4,681
San Antonio	2,054
Albany	1,617
Rochester	730
Nashville	617
Indianapolis	300

Extract more insights from existing results

- Estimability and transferability by variable type
- Elasticity comparisons for key variables

Improve estimation and testing approach

- Reduce confounding of results caused by small sample sizes

- Implement a better model-level transferability index

- Enhance the model specifications to improve transferability

- Investigate potential scale issues

Other additional objectives

- Study transferability with sample sizes between 2500 and 6000 HH (using random subsets of the San Diego data)

- Test transferability within groupings defined other than by state borders (e.g., by urban density)