Transportation Cost Index:
A New Comprehensive Performance Measure for Transportation and Land Use

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Outline

- Why we need yet another performance measure (YAPM)?
- Transportation Cost Index: the idea and implementations
- Demo applications
- Ongoing and future work

Performance Measures: Mobility vs Accessibility

Credit: Paul Waddell

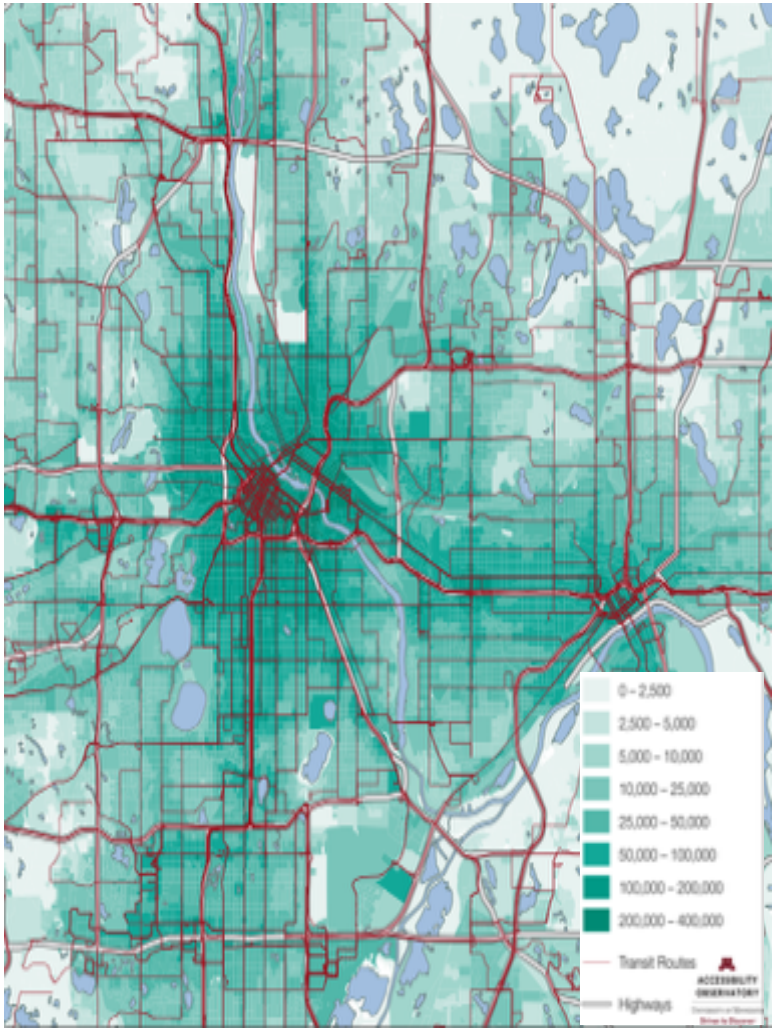
Need for Accessibility Measures

- As a supplement/replacement of traffic-centric measures: LOS, travel delays
- MAP-21 emphasizes use of performance measures in transportation planning & operation
- State legislations: Oregon Job and Transportation Act (OJTA)

Existing Accessibility Measures

- Handy and Niemeier, 1997
- Geurs and van Wee, 2004
- NCHRP Report 446, 618, 694, 708 ...

Market Potential Measures



Employment accessible within 30 minutes by public transit during a.m. peak

- Easy to interpret/understand
- Opportunities, mode, time-of-day and time budget specific

Source: University of Minnesota, Accessibility Observatory

Utility-based Measures

$$E(CS) = \ln\left(\sum_{m'} \exp\left(U_{m'kj}\right)\right) + C$$

Logsum as an accessibility measure

- Elegant, composite measures for all modes; possible to derive net user benefit between scenarios
- Hard to interpret by itself; unable to compare across regions/times (benchmarking)

Generalized Costs Indicator

Table 4
Generalised costs indicator, for private car, 2007 (2000=100) by type of trip.

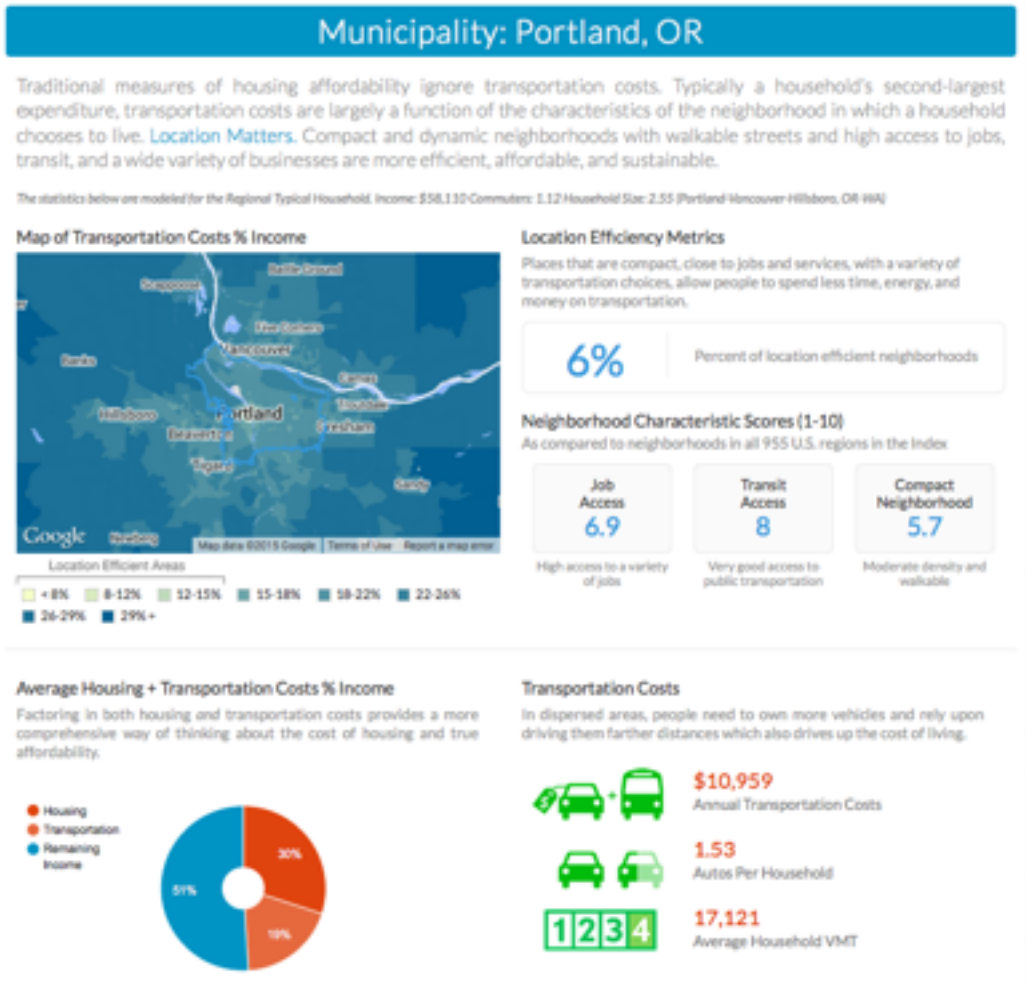
Location:	Randstad	107
	Outside Randstad	105
Time of day	Rush hour	109
	Outside rush hour	105
Trip purpose	Business	102
	Commuter	110
	Other	106
Distance (km)	Up to 15	105
	15 to 30	110
	30 to 50	108
	More than 50	104

Per distance generalized costs for motorized trips

- Easy to interpret/ understand; able to monitor trends and compare scenarios
- ignores land use system; mode, time-of-day specific

Source: Koopmans, et al, 2013

H+T® Affordability Index



- Tracks out-of-pocket monetary costs of transportation and adds them to housing costs as a location efficiency measure;
- Ignores time costs; does not track the performance of transportation system except for Auto/Transit mode split and VMT.

Source: Center for Neighborhood Technology (CNT)

Wish List for YAPM

- A comprehensive measure able to present an overall picture of transportation and land use;
- Fill gaps in policy areas not adequately covered by existing performance measures, such as the equity and compatibility aspects (Reiff and Gregor, 2005)
- Easy to interpret/understand;
- Applicable to use cases ranging from prioritization, scenario evaluation/comparison, to benchmarking and standard;

Applicability of Performance Measures

Application	Prioritization	Comparison	Long-term Benchmark	Near-team Standard or Threshold
Transportation System Planning / Subarea Plans / Multi-jurisdictional Corridor Planning				
Project / Corridor Planning				
Plan Amendments / Zone changes subject to TPR				
Development Review				

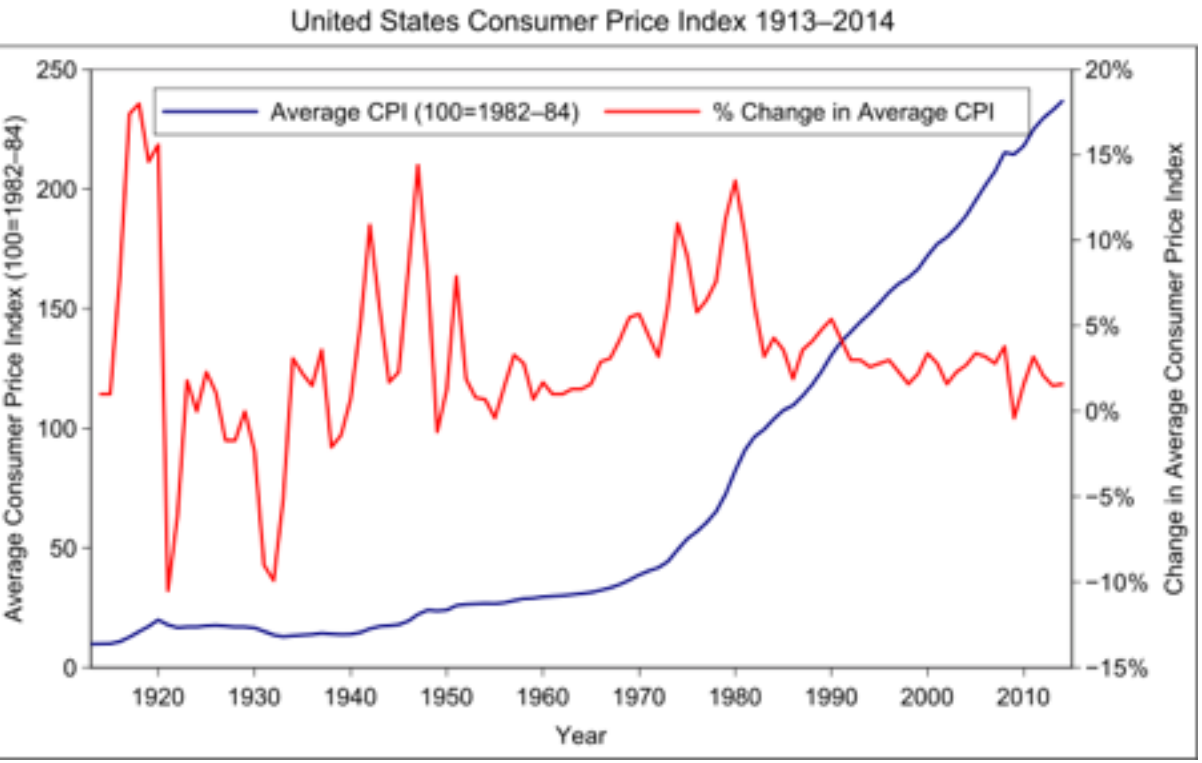
Selection Criteria:

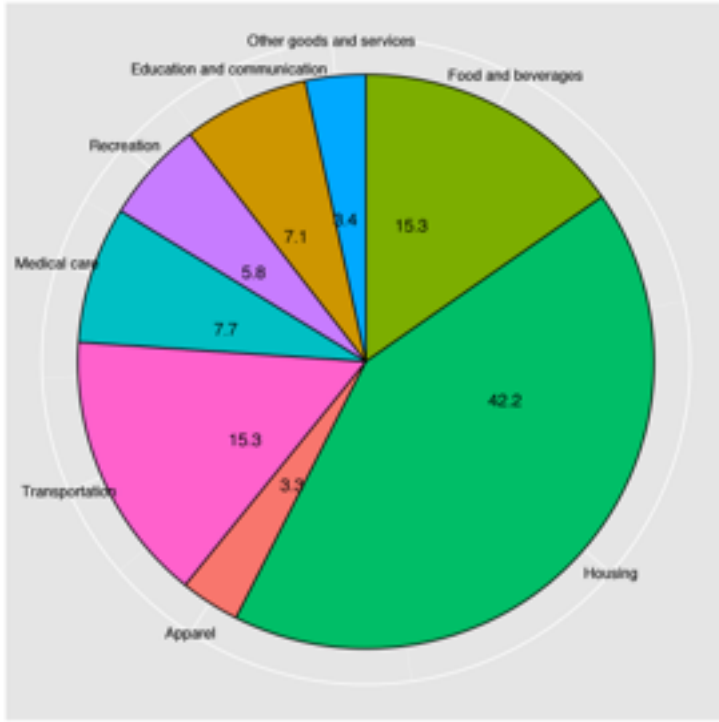
- Easy to apply
- Objective quantitive measure
- Good data availability
- Easy to understand

Source: Kittleson & Associations, Washington County Multimodal Performance Measures and Standards

TCI: the idea and implementations

Consumer Price Index (CPI)





From CPI to Transportation Cost Index (TCI)

Measure changes in the “price level” of a market basket of trips/destinations meeting households’ daily needs:

1. Identify a basket of trips/destinations based on pre-defined groups (e.g. trip purpose categories);
2. Track the costs of accessing trips/ destinations in the basket.

Transportation Cost Index (TCI)

- Comprehensive measure of transportation and land use;
- Able to serve as a performance measure for policy areas including equity, transportation and land use compatibility and balance;
- Easy to interpret/understand;
- Based on widely available data sources, possible for all uses, esp. benchmarking and scenario evaluation/comparison

Implementation A: Travel Survey-based Method

Relies primarily on input from household activity survey, e.g. Oregon Travel & Activity Survey (OTAS)

1. Construct travel baskets based on activity diaries or a sample of trips/tours that are representative of regional travel pattern, potentially by trip purpose, household size, income group and geography;
2. Track the time and monetary costs of making these trips/tours.

Suitable for prioritization and benchmarking applications.

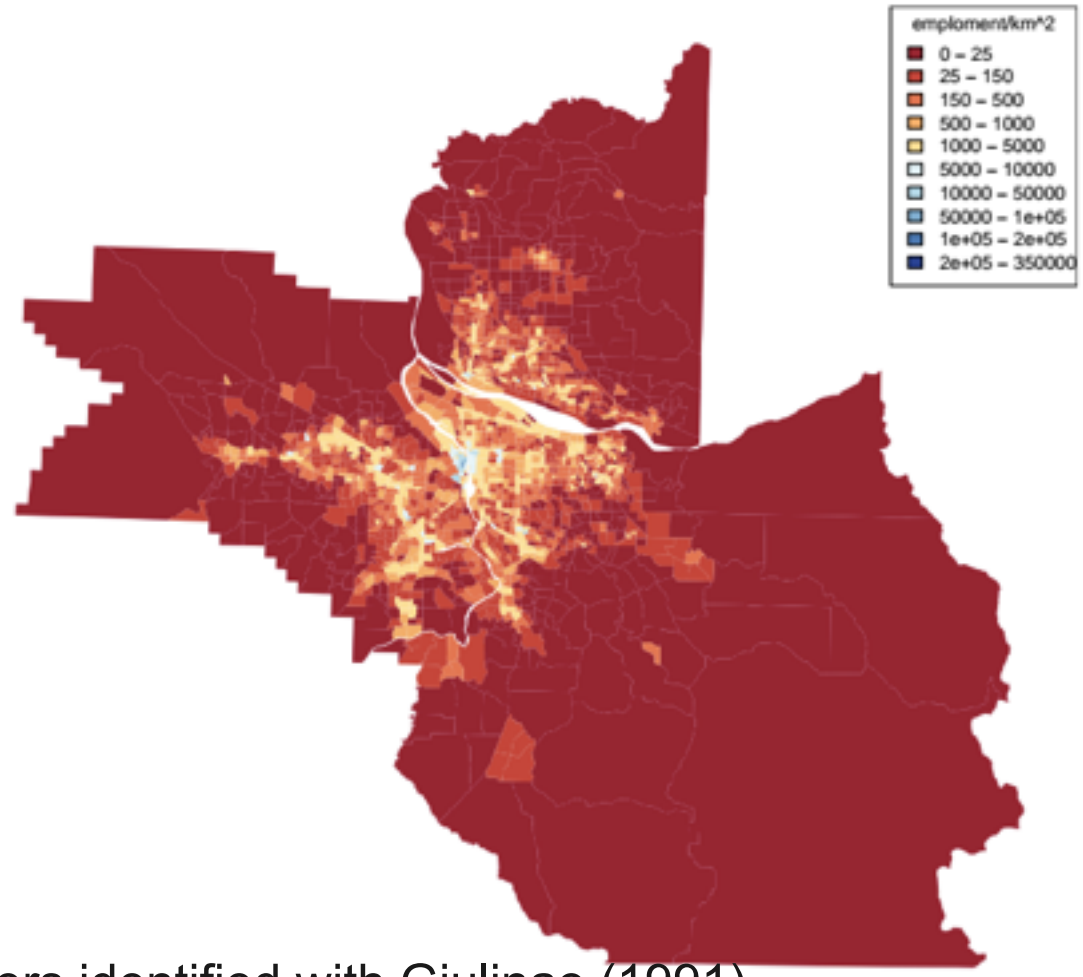
Implementation B: Cluster-based Method

Relies on inputs from travel demand model

- Data readily available for regions w/ TDM;
- Identify spatial clusters of regional activities/ destinations as travel market baskets;
- Track the time and monetary costs of accessing the basket of destinations;
- Theoretically can calculate the transportation cost for every income group and for every TAZ.

Suitable for scenario evaluation/comparison.

Implementation B: Cluster-based Method



Employment centers identified with Giulinao (1991)

Implementation C: Hybrid Method

Relies on inputs from household activity survey and TDM data

1. Construct travel baskets based on activity diaries by trip purpose;
2. Track the time and monetary costs of making the basket of trips/tours; potentially by income level, household size, and geography.

Most closely resemble CPI algorithm.

Calculate Travel Costs: Cost Estimate by Mode

$$C = C_0 + k \cdot TD + w \cdot TT$$

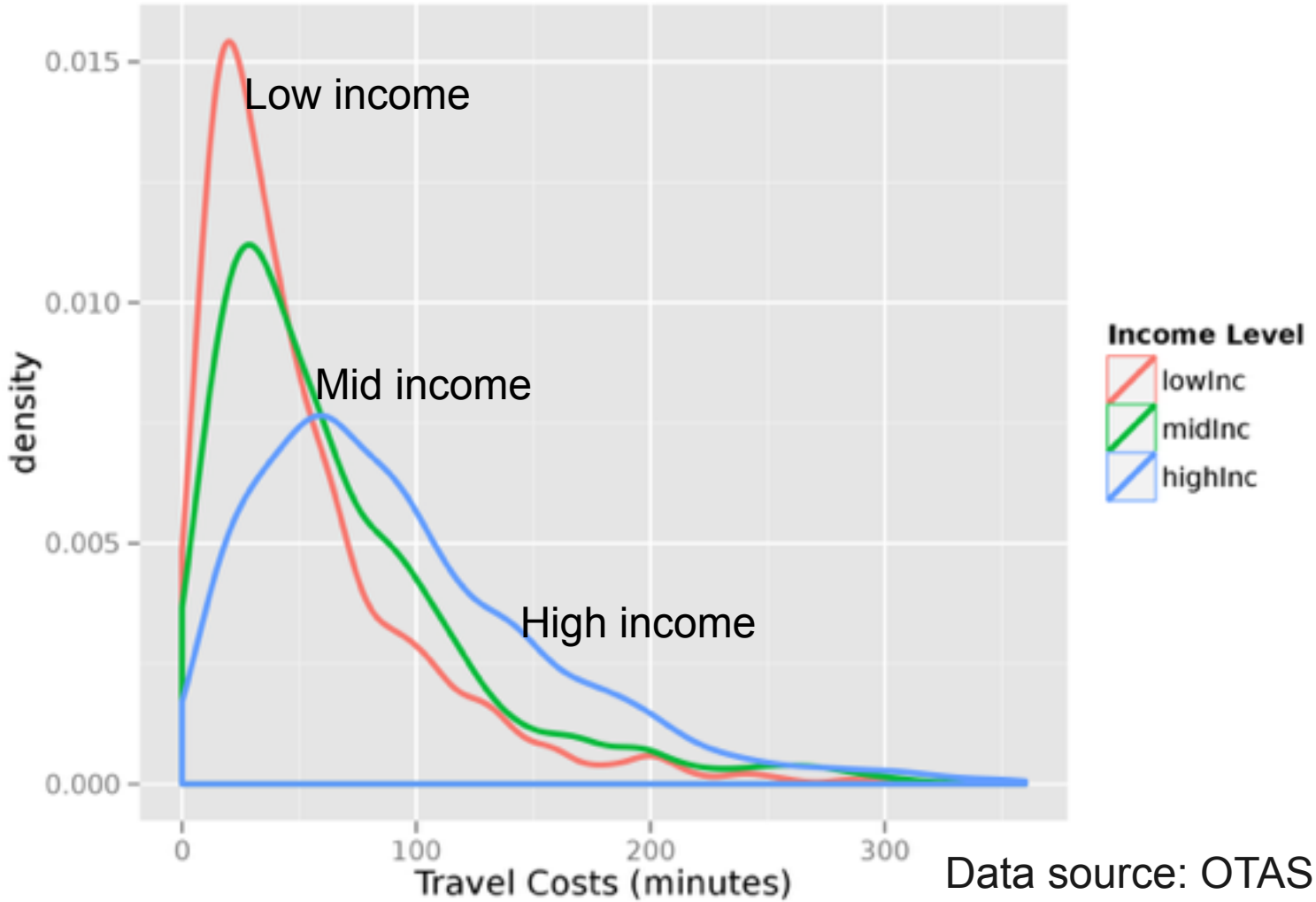
C_0 - Constant

$k \cdot TD$ - Monetary costs (Fuel and tire costs, Ownership costs, insurance, etc) of travel

$w \cdot TT$ - Time costs of travel

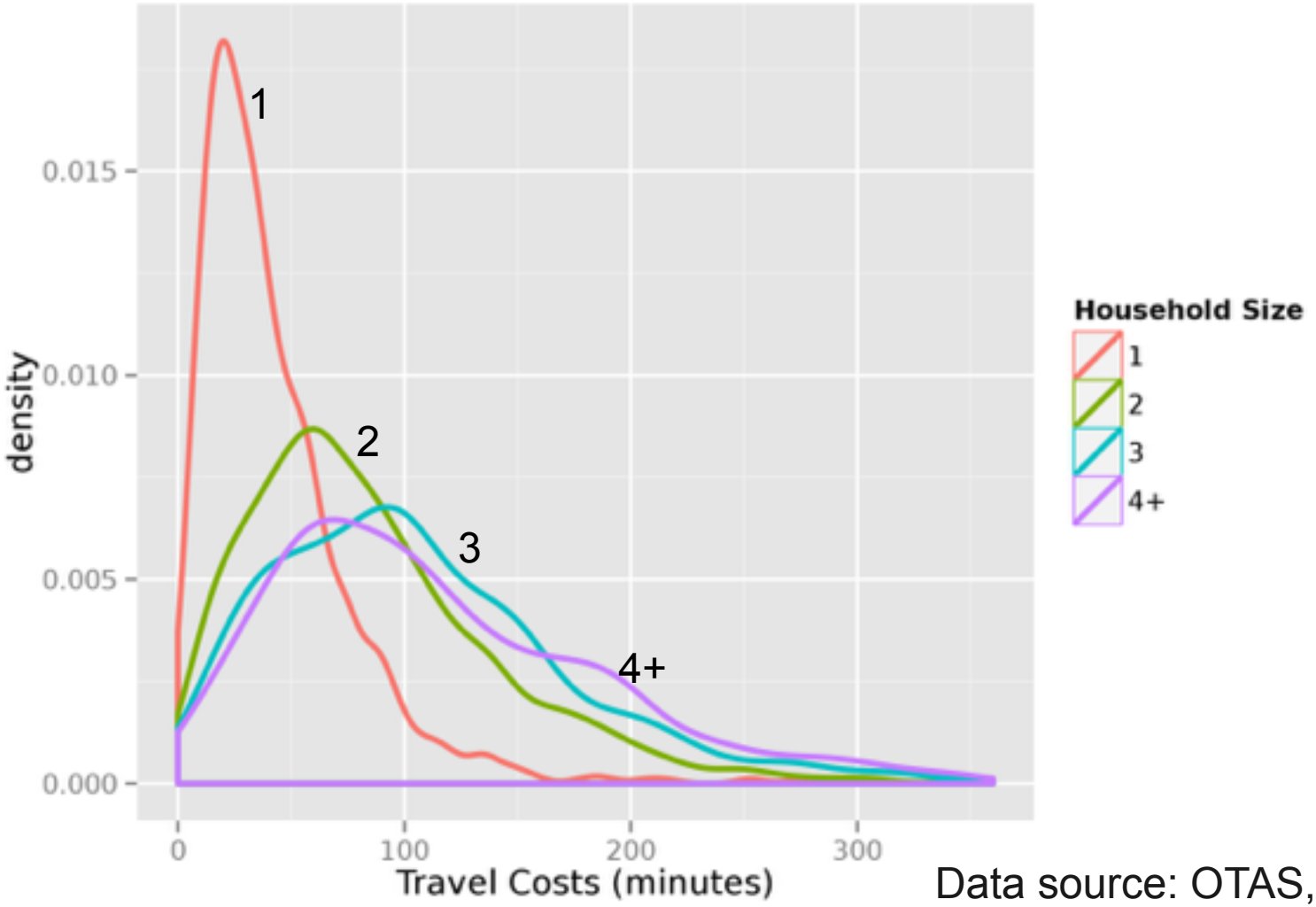
Applications and Demonstration

Generalized Costs by Household Income Level for Portland 2011



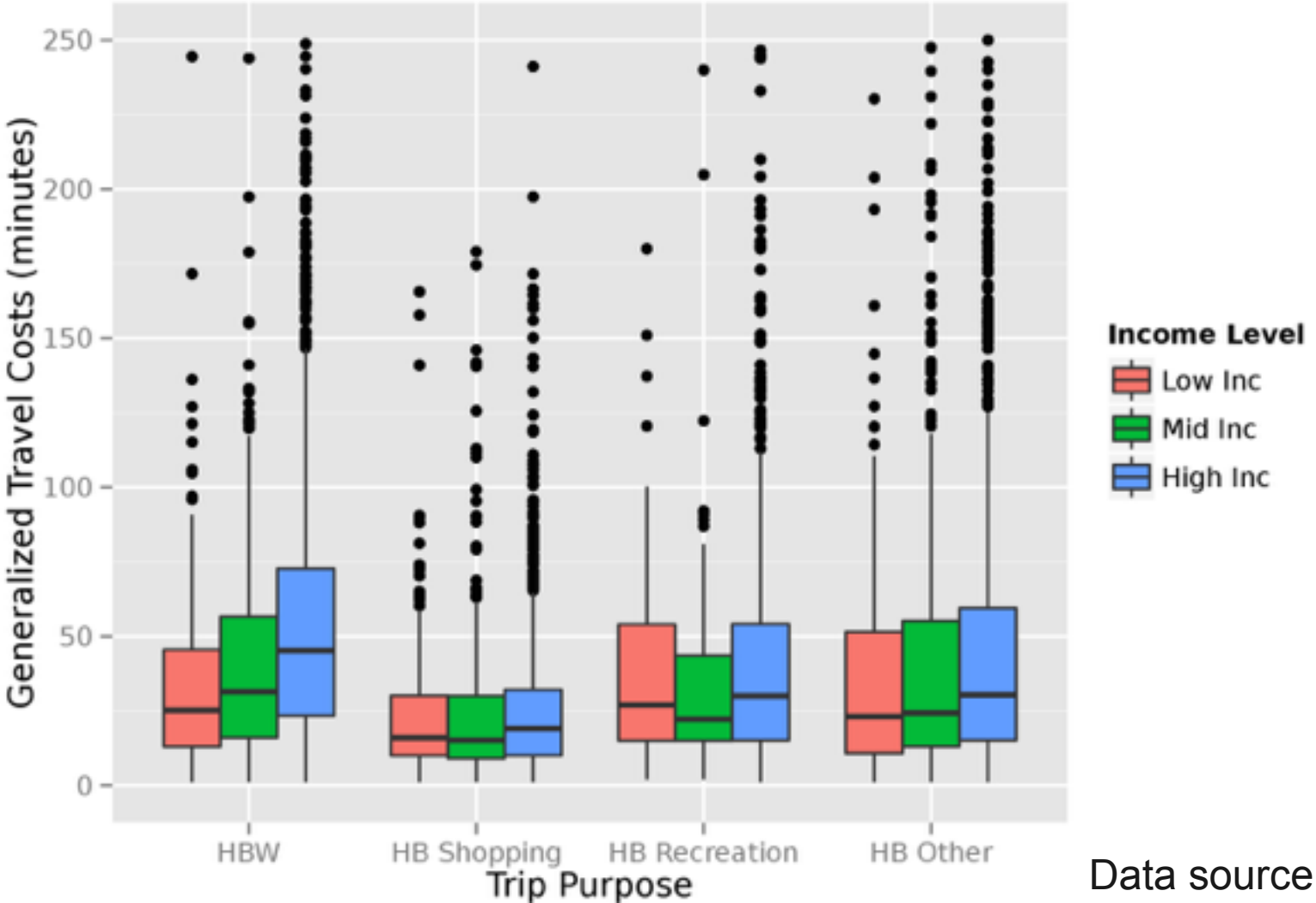
Data source: OTAS, 2011

Generalized Costs by Household Size for for Portland 2011



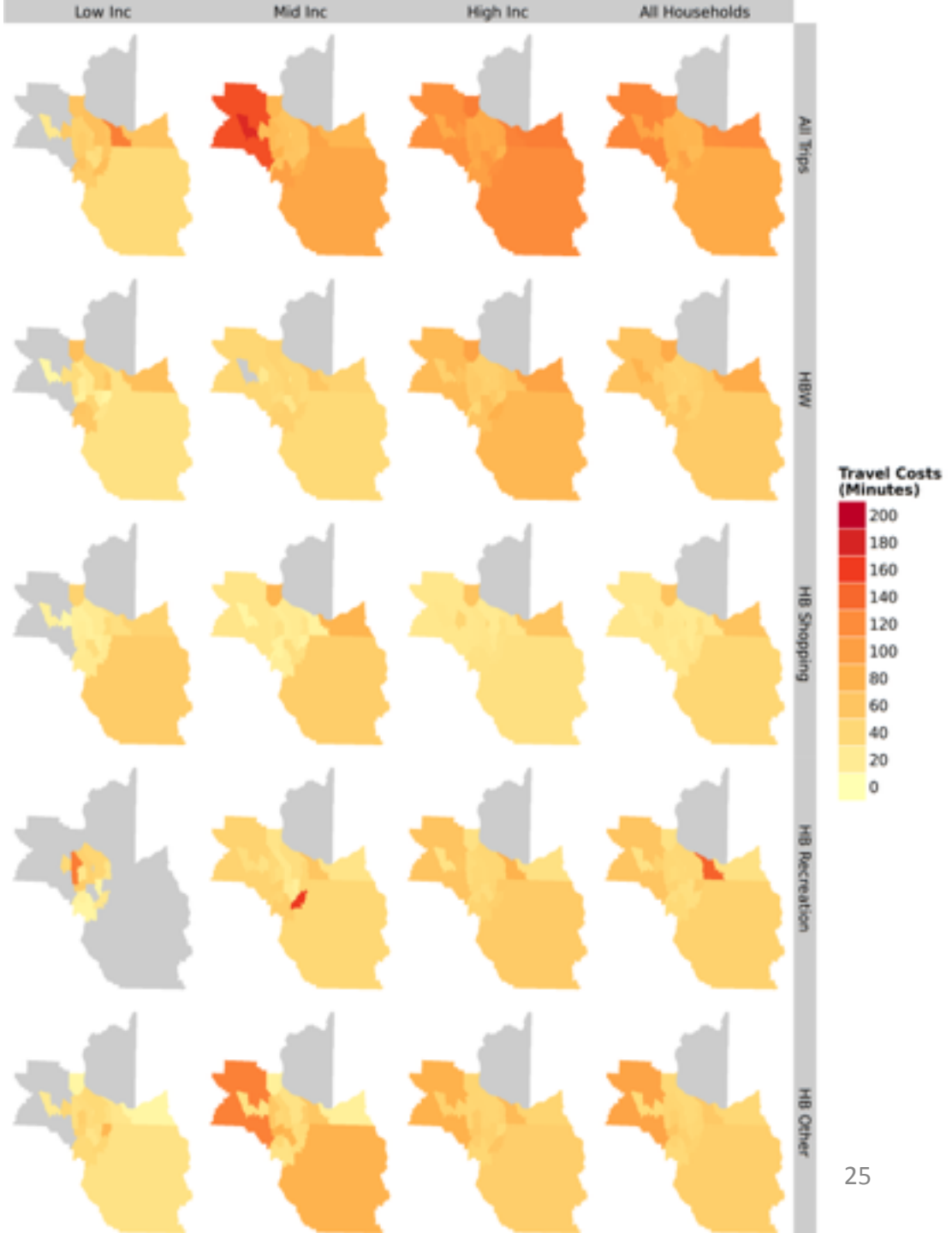
Data source: OTAS, 2011

Generalized Costs by Purpose & Income Level for Portland, 2011



Data source: OTAS, 2011

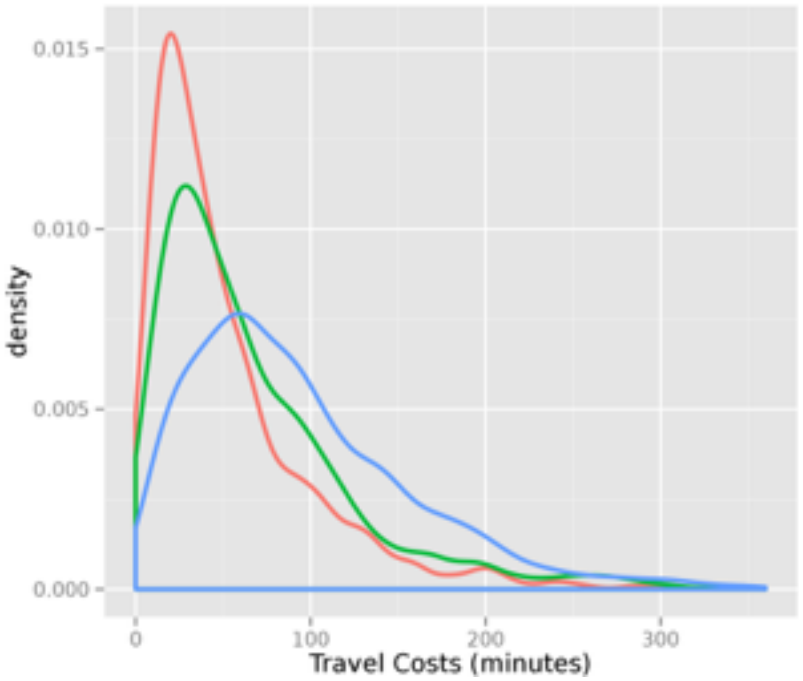
Generalized Costs by Purpose, Income Level and Transportation Districts for Portland 2011



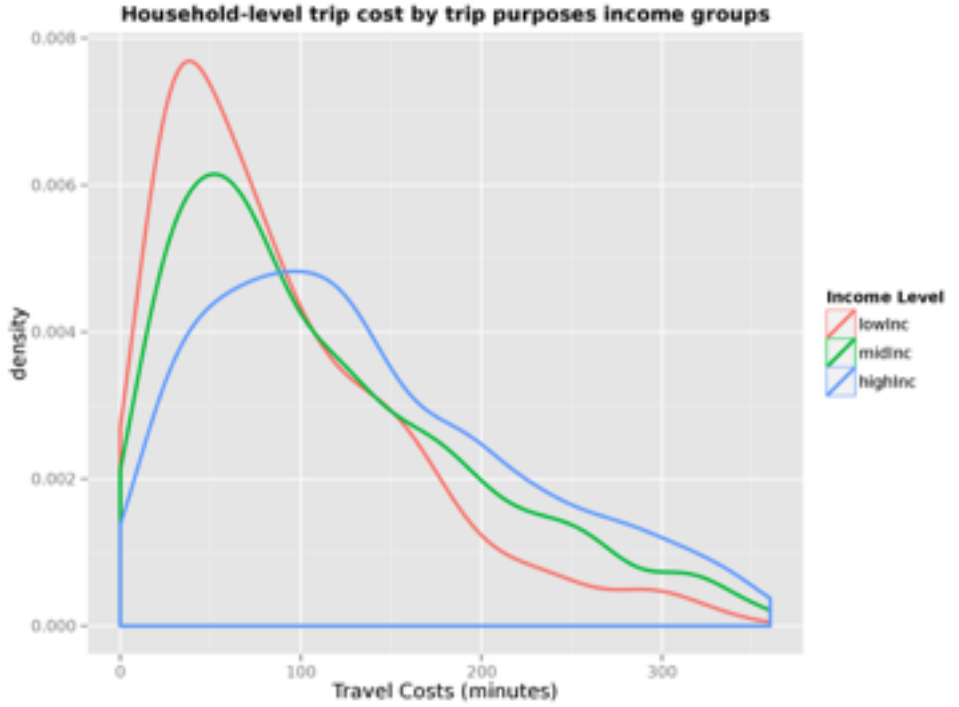
Data source: OTAS, 2011

Generalized Costs by Household Income Level for Portland 2011 vs 1994

2011



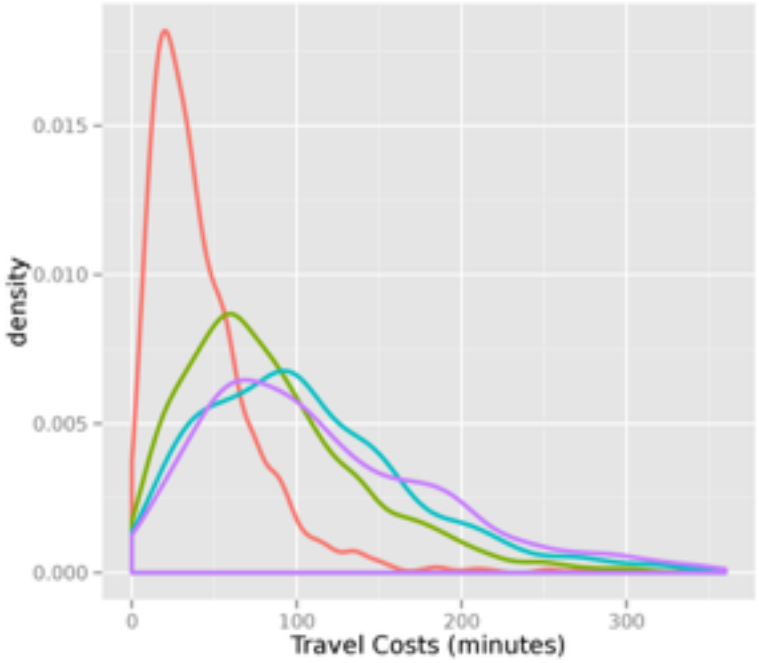
1994



Data source: OTAS, 2011; OHAS, 1994

Generalized Costs by Household Size for Portland 2011 vs 1994

2011



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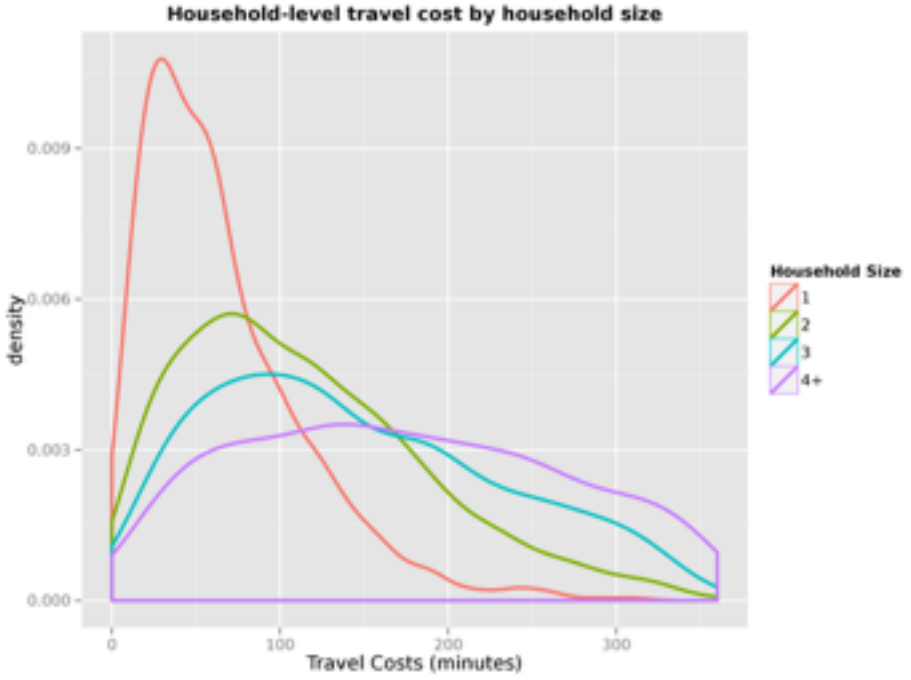
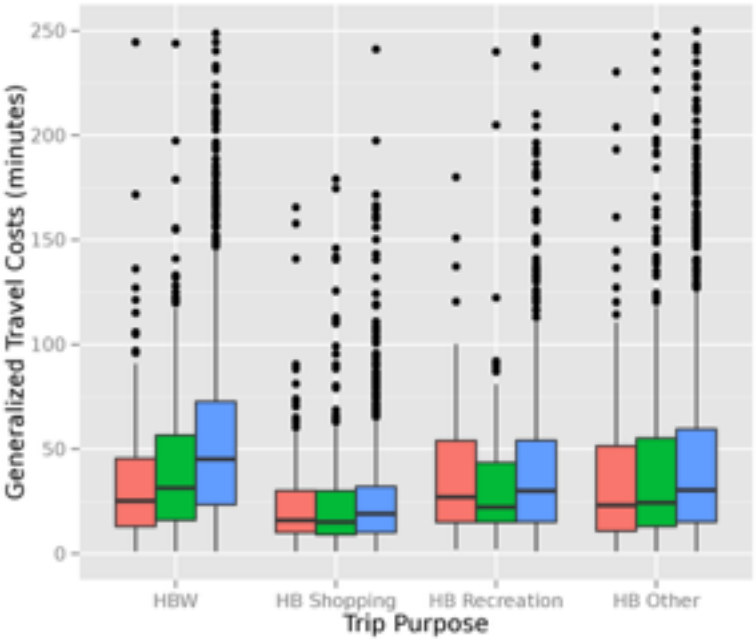


Data source: OTAS, 2011; OHAS, 1994

Generalized Costs by Purpose and Income Level for Portland 2011 vs 1994

2011



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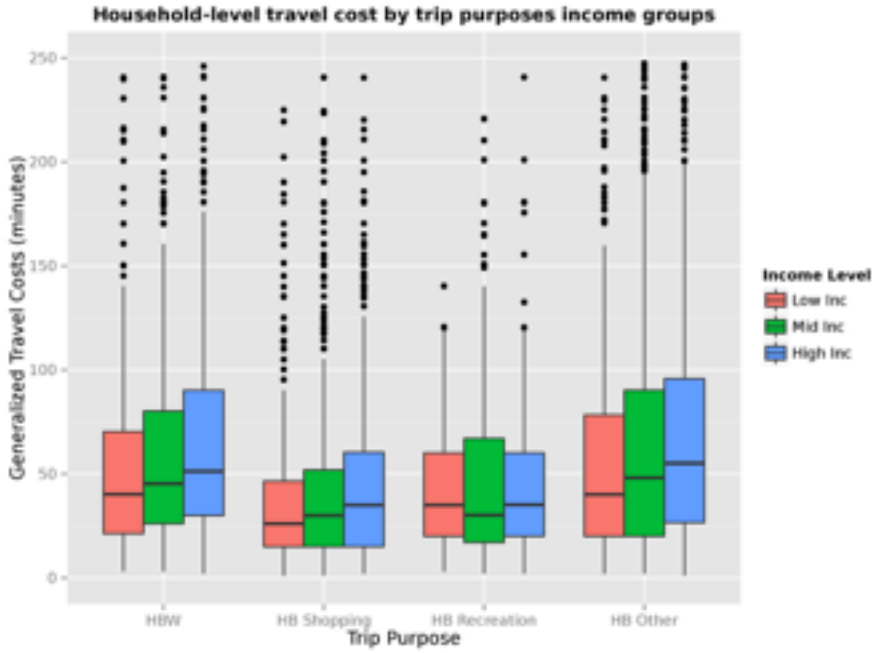
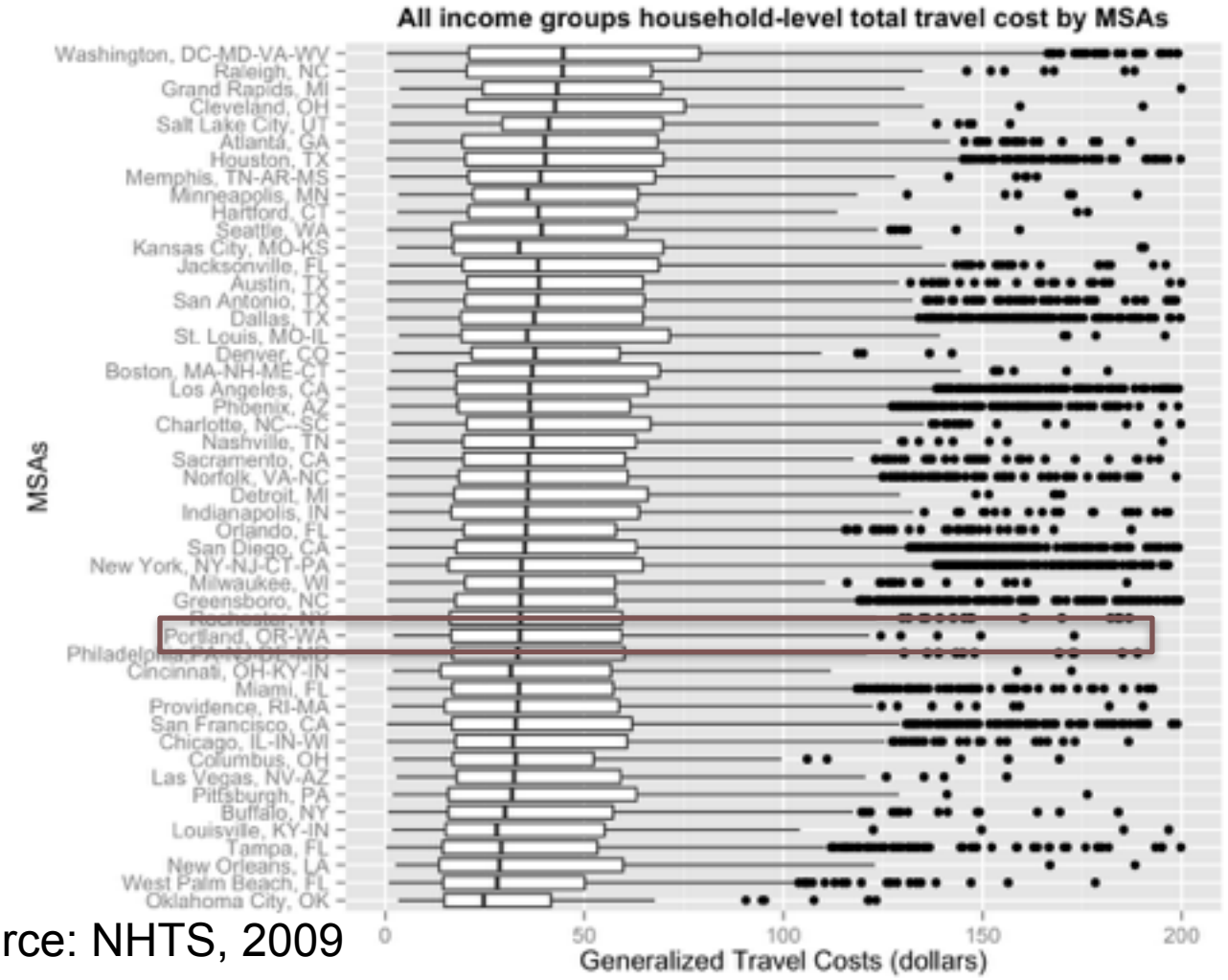


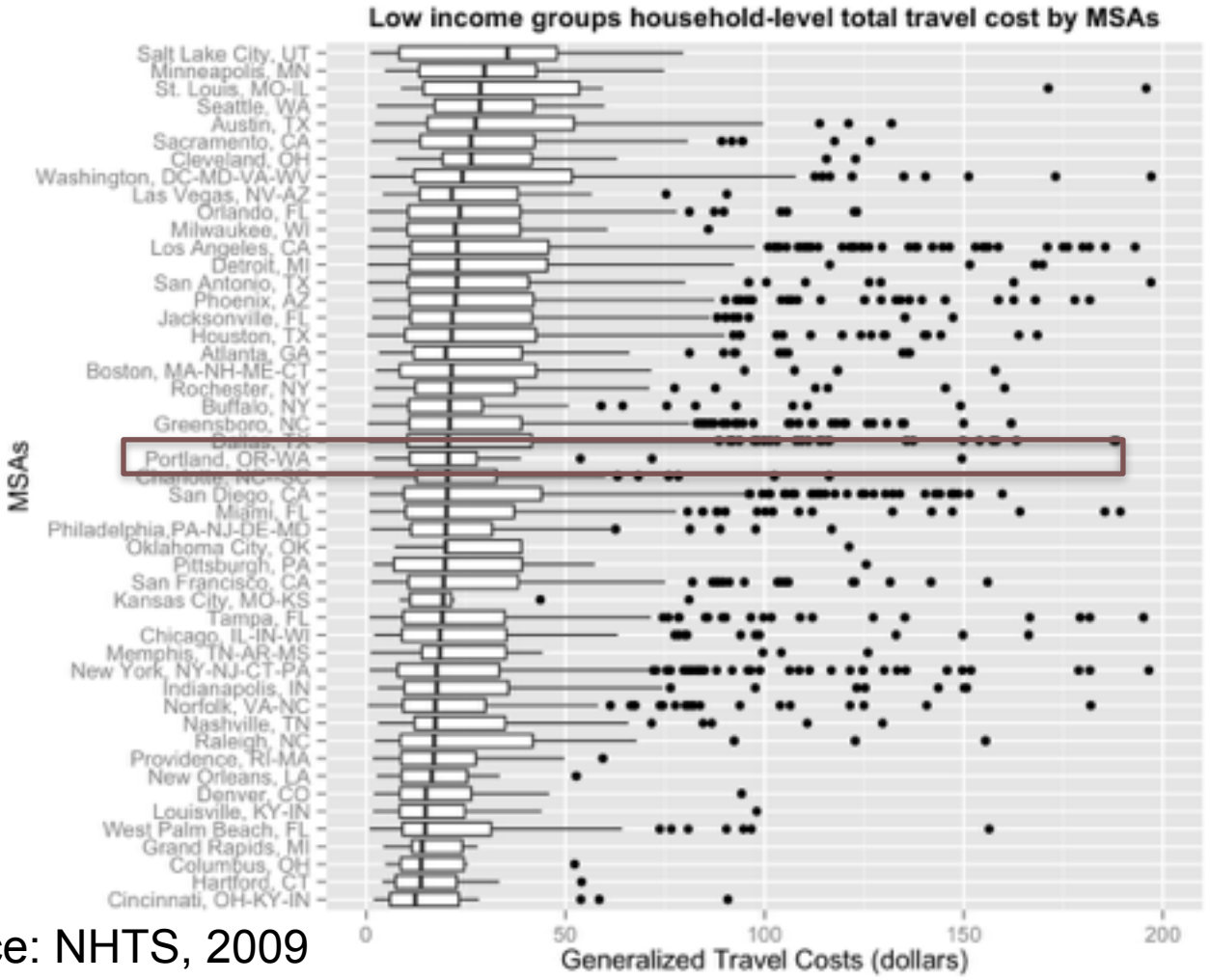
Data source: OTAS, 2011; OHAS, 1994

Transportation Costs by MSA (All households)



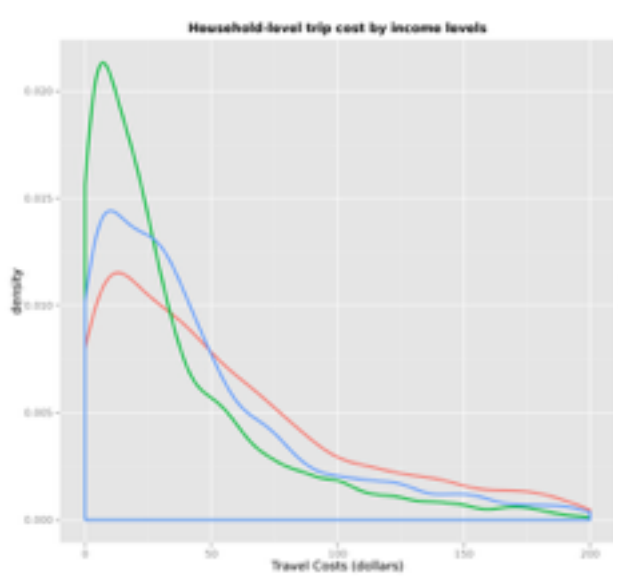
Data source: NHTS, 2009

Transportation Costs by MSA (Low Income)

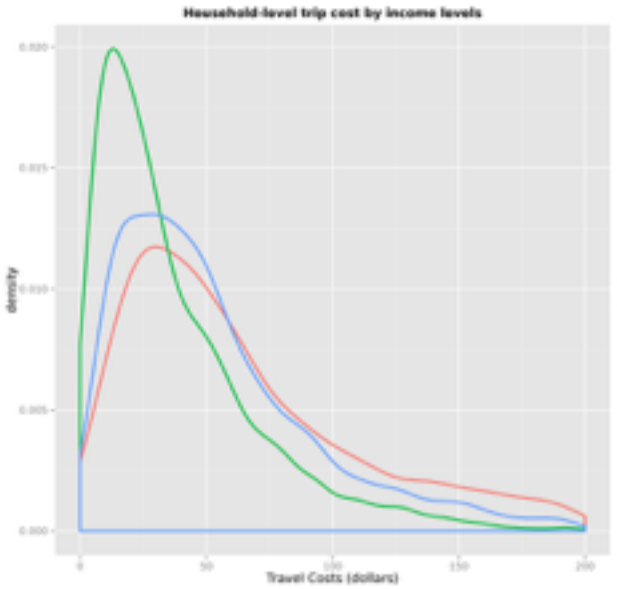


Data source: NHTS, 2009

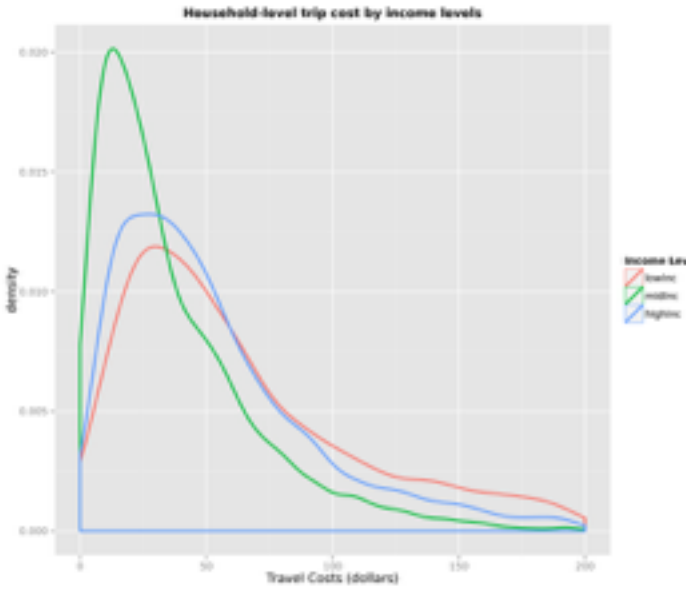
Generalized Costs by Household Income Level for Portland 2040



No Build RTP



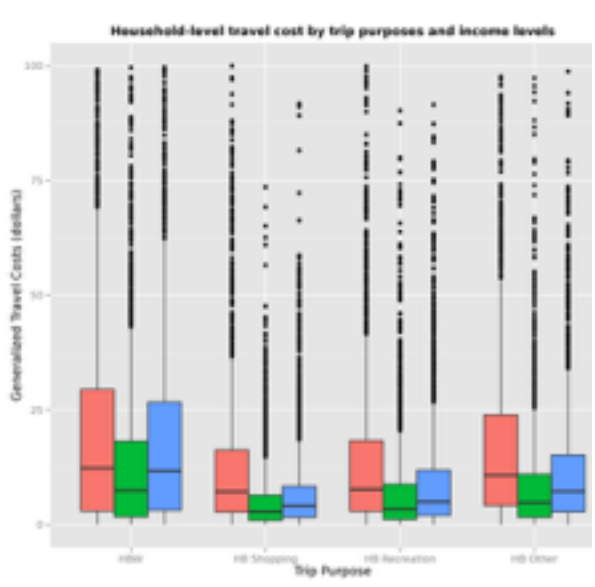
State RTP



True Financially Constrained RTP

Data source: Metro TDM

Generalized Costs by Household Income and Trip Purpose for Portland 2040



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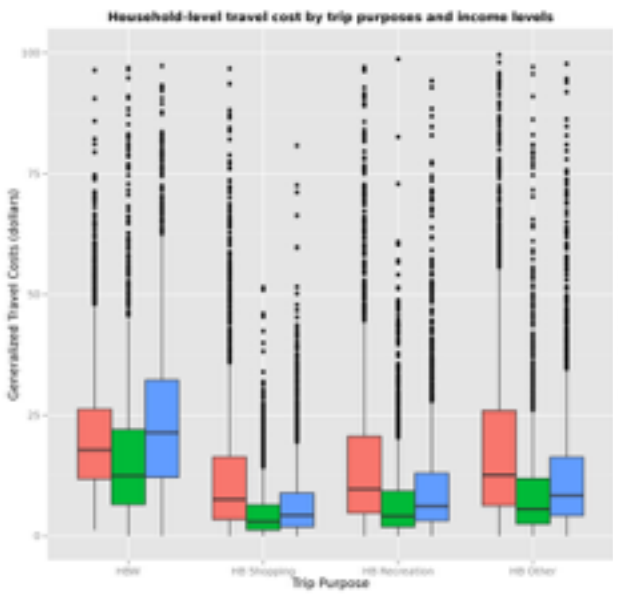
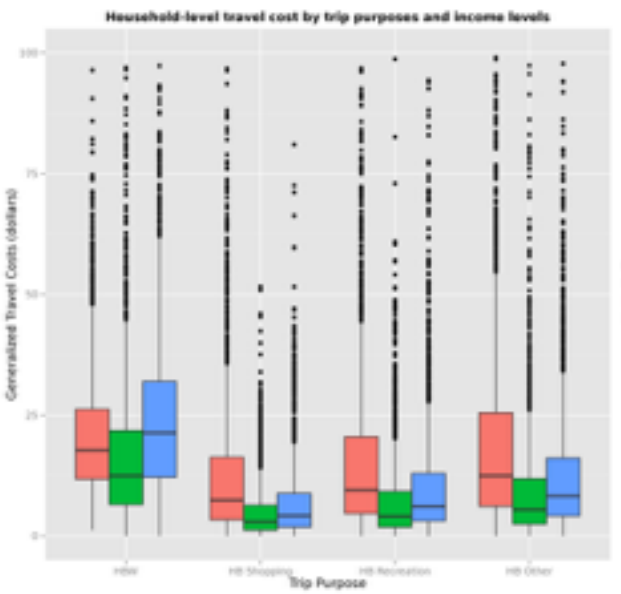


State RTP



True Financially Constrained RTP

Data source: Metro TDM

Ongoing and Future Work

- Adopted by the Oregon Mosaic project as one of the indicators for Least Cost Planning mandated by Oregon Jobs and Transportation Act

Ongoing and Future Work

- Test TCI usage in public engagement and policy making process
- Reconcile TCIs from the two methods;
- Verify patterns of transportation costs with information from alternative data sources, such as CES;
- Should external costs be included?

Code and Working Papers

- Code (under active development/testing) available at http://github.com/cities-lab/tci
- Working Papers:

1. Wang, Liming, Bud Reiff, Brian Gregor, Huajie Yang, and Jenny Liu, 2015. Transportation Cost Index: A Comprehensive Multimodal Performance Measure of Transportation and Land Use Systems, presented at the 94th Annual Meeting of Transportation Research Board, Washington, DC, January 11-15, 2015.
2. Wang, Liming, Huajie Yang and Jenny Liu, Transportation Cost Index as a Performance Measure for Transportation and Land Use Systems: New Approaches and Application in Portland, OR, to be presented at the 95th Annual Meeting of Transportation Research Board, Washington, DC, January 10-14, 2016.

Acknowledgements

National Institute for Transportation and Communities

Oregon DOT

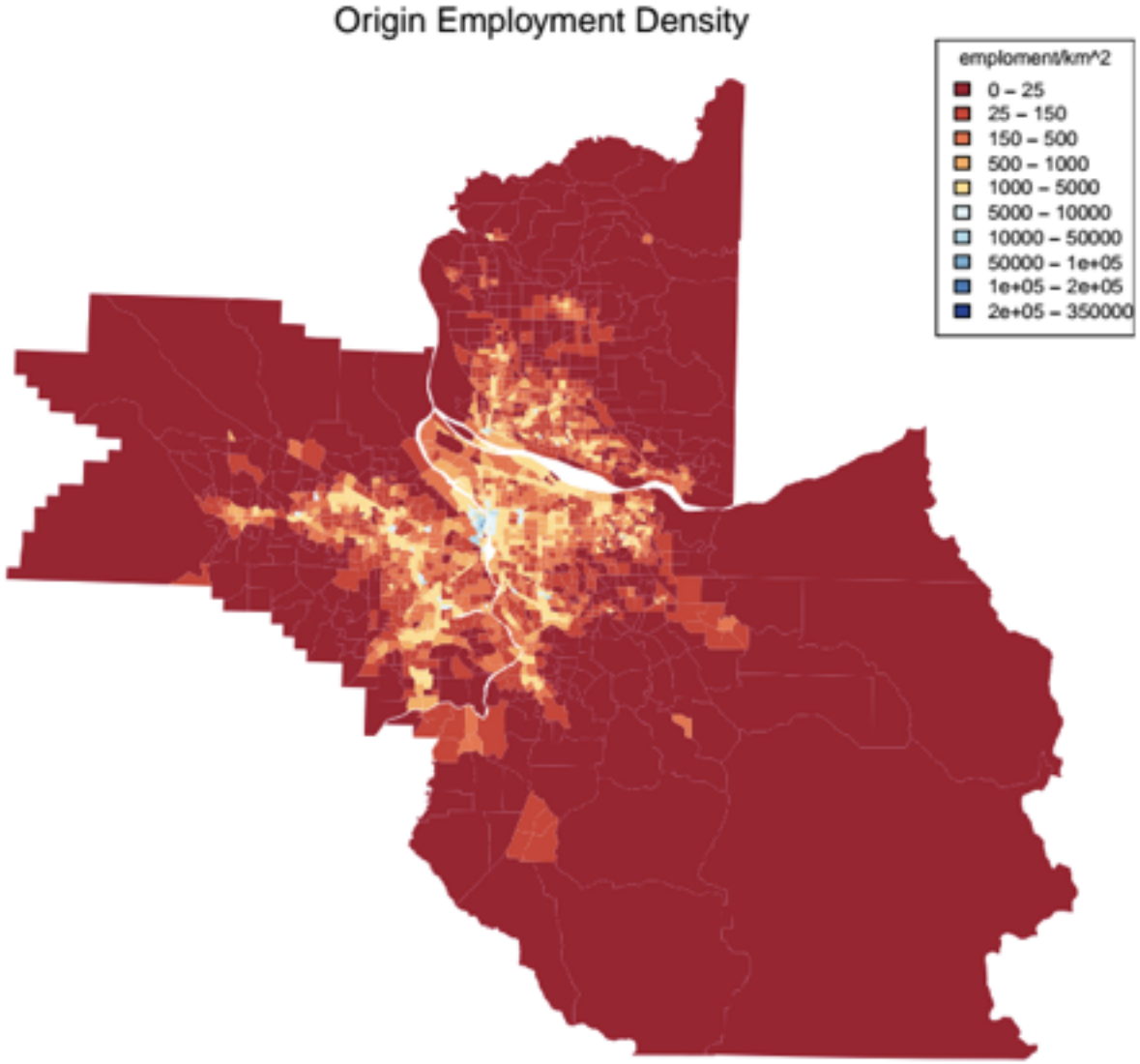
Extra Slides

Income Levels

To be consistent with the classification used in Metro's TDM, household income levels are classified with this scale (1994 dollars):

- < $25K: Low Income
- $25-50K: Mid Income
- > $50K: High Income

Identify Activity Centers (Travel Market Basket)



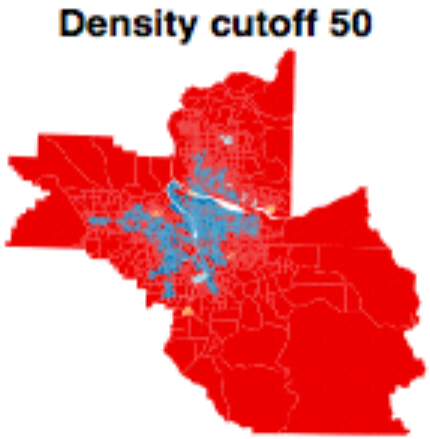
Steps (Giulinao, 1991)

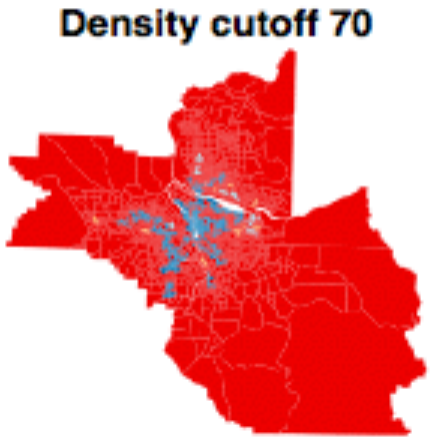
1. Calculate employment/size term density;
2. Identify TAZs with densities greater than density cutoff D and group contiguous TAZs identified into preliminary centers;
3. Calculate total employment or size terms for each center identified in step 2 and eliminate centers with total employment or size terms below total cutoff E from centers identified in step 2. The remaining are activity centers.

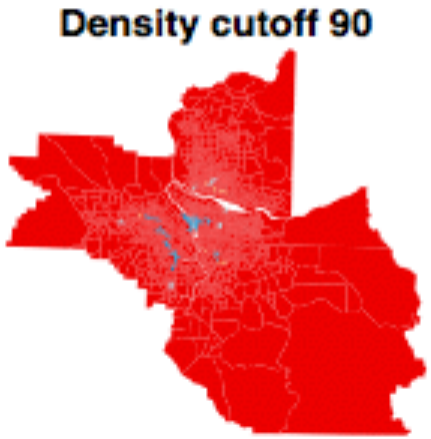
Determine Cutoffs

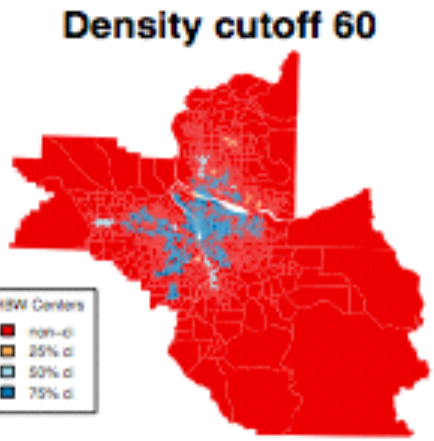
- Giulinao (1991) provides no guidance in selecting density cutoff (D) or total cutoff (E). They relied on expert knowledge
- Sensitivity Tests to determine cutoffs

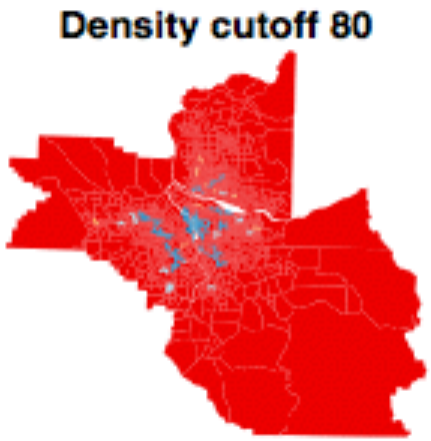
Sensitivity Tests: HBW

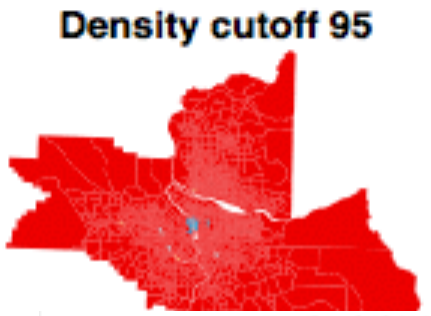


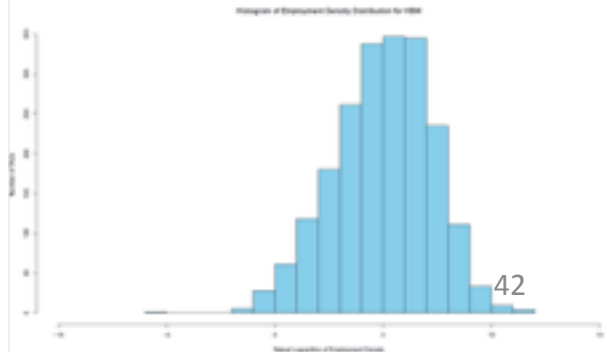






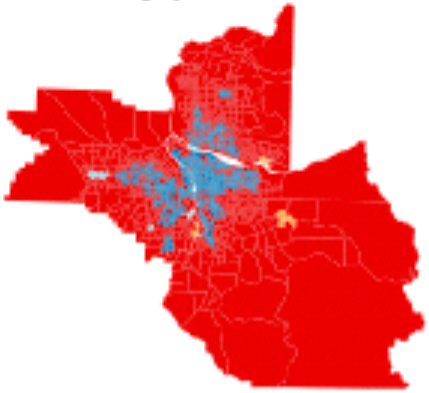




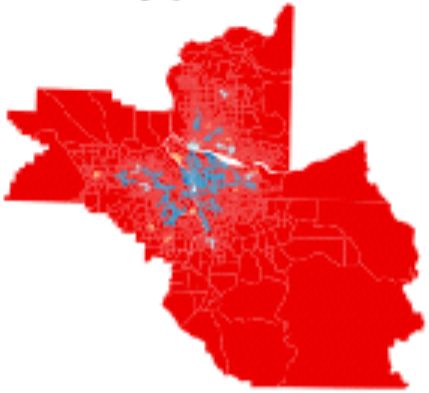


Sensitivity Tests: HBS

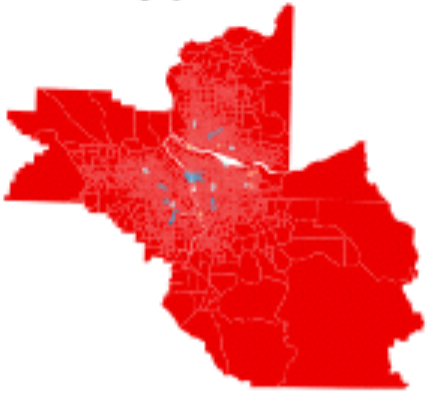
Density percentile 50



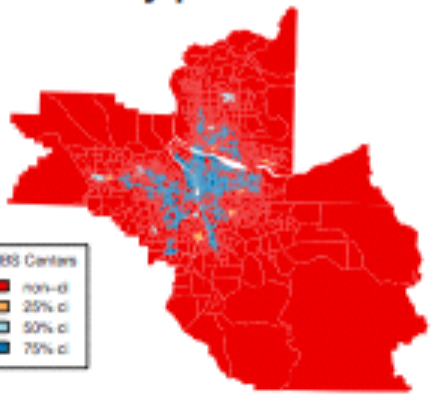
Density percentile 70



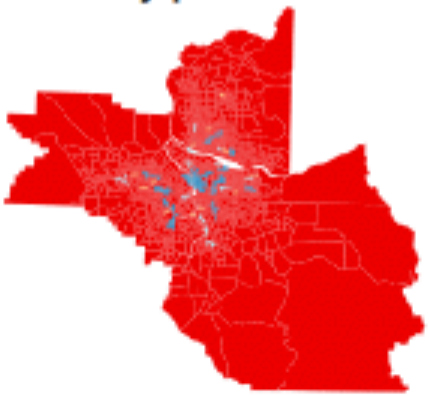
Density percentile 90



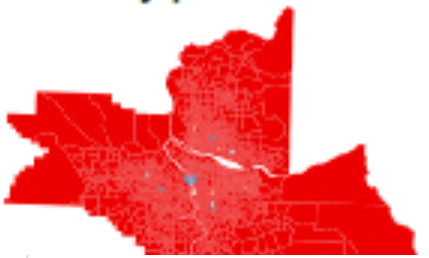
Density percentile 60

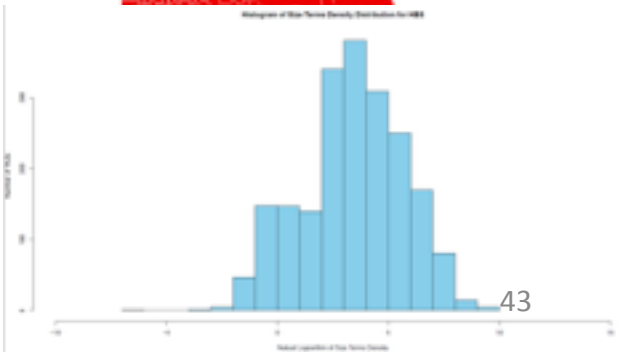


Density percentile 80

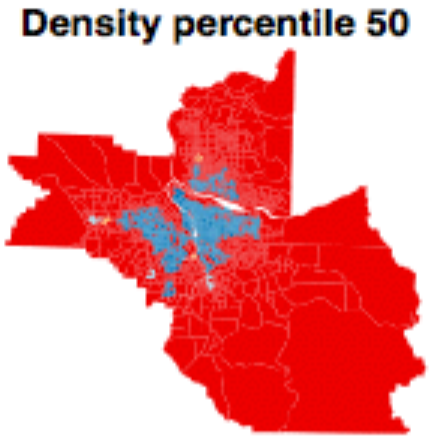


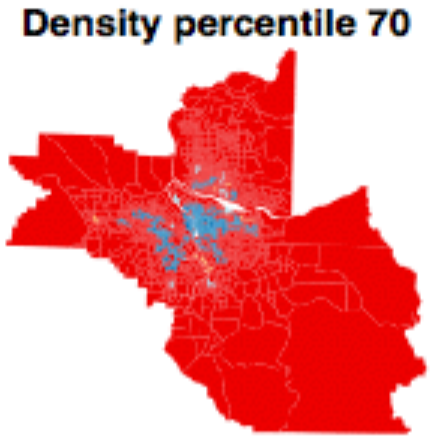
Density percentile 95

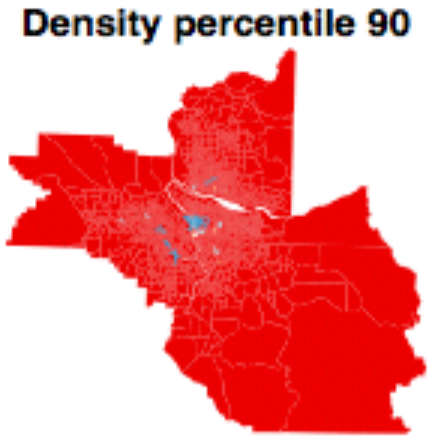


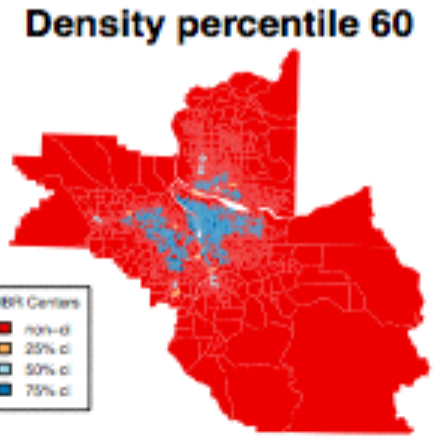


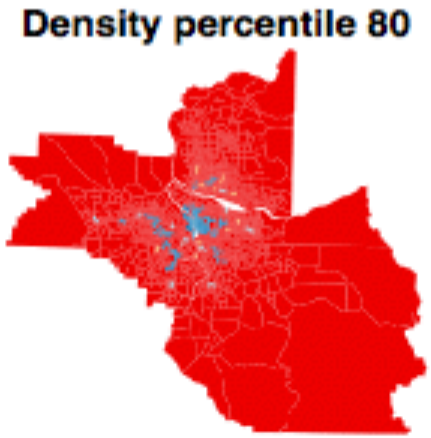
Sensitivity Tests: HBS

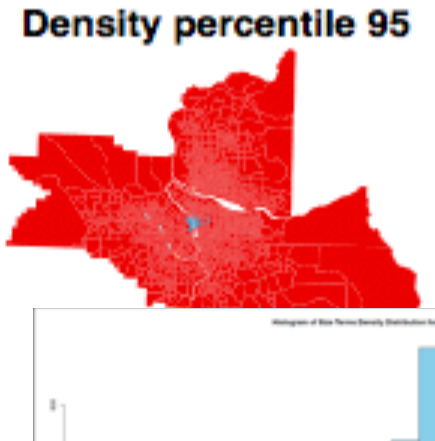


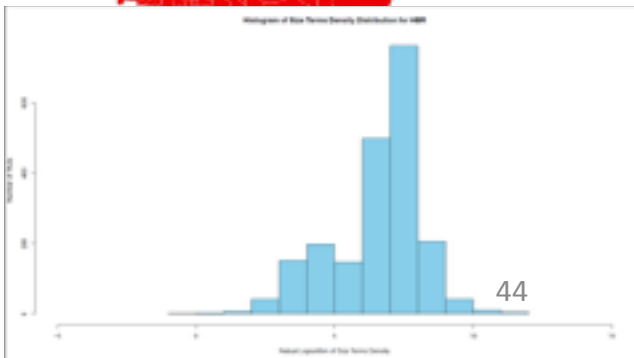






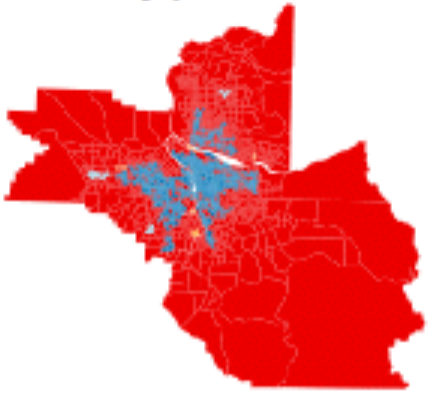




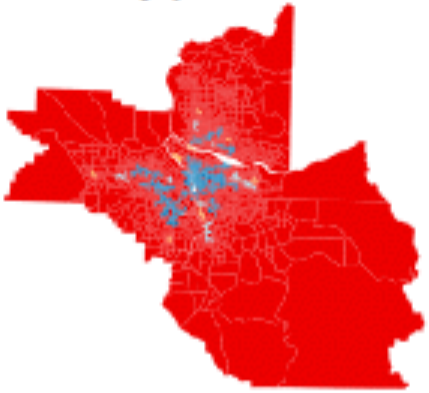


Sensitivity Tests: HBO

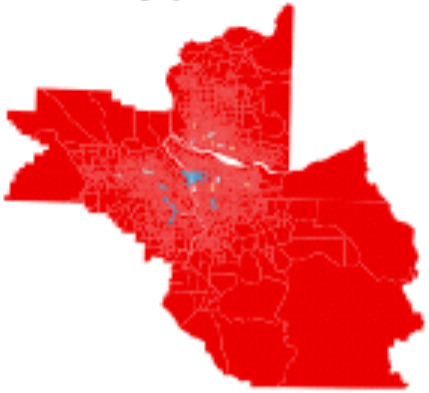
Density percentile 50



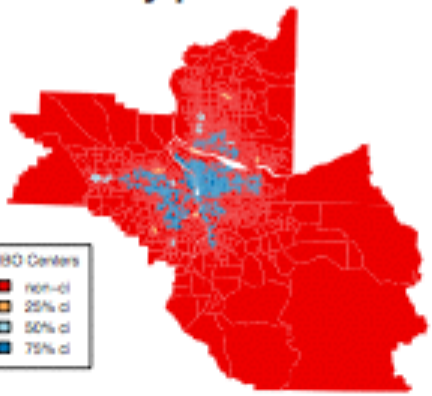
Density percentile 70



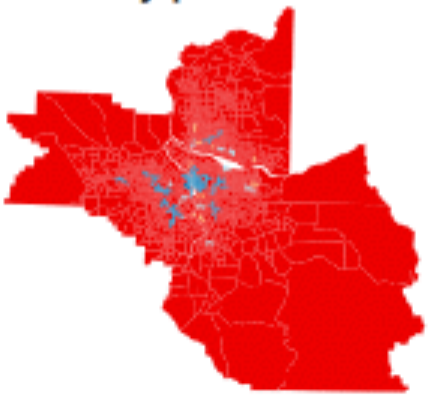
Density percentile 90



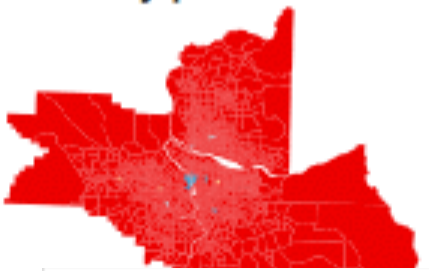
Density percentile 60

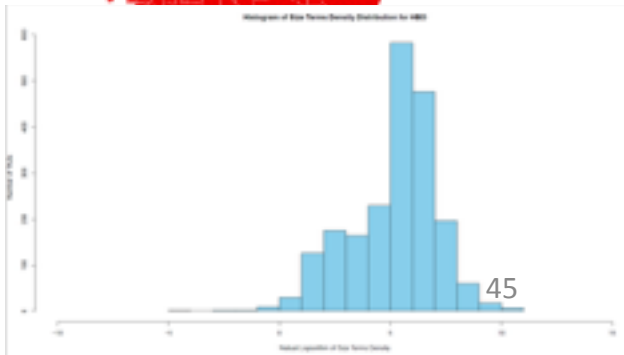


Density percentile 80



Density percentile 95





Travel Costs Calculation: Cost Estimate by Mode

- Auto

$$C_{auto} = C_{auto0} + k_{auto} \cdot TD_{auto} + w_{auto} \cdot TT_{auto}$$

  - C_{m0} - Constant
  - $k_{auto} \cdot TD_{auto}$ - Monetary costs (Fuel and tire costs, Ownership costs, insurance, etc) of driving
  - $w_{auto} \cdot TT_{auto}$ - Time costs of driving

Travel Costs Calculation: Cost Estimate by Mode

- Public Transit:

$$C_{public} = \text{fare} + w_{public} \cdot TT_{public}$$

  - Fare: Transit fares
  - $w_m \cdot TT_{public}$: Time costs of riding transit

- Non-motorized modes (bicycling and walking)

$$C_{bicycle} = C_{bicycle0} + w_{bicycle} \cdot TT_{bicycle}$$

$$C_{walk} = w_{walk} \cdot TT_{walk}$$

  - Time costs of Bicycling and Walking

Parameters

VOT (ratio to hourly wage):
walk=0.5 bike=0.5
auto / van/ truck driver=0.5
auto / van / truck passenger=0.35
bus=0.35 rail=0.35
dial-a-ride/paratransit=0.35
taxi=0.35 school bus=0.35
carpool / vanpool=0.35
other (specify)=0.5
driveAlone=0.5
drivePass=0.5
pass=0.35 busWalk=0.35
parkAndRideBus=0.35

Monetary costs per mile:
walk=0 bike=0
auto / van/ truck driver=$0.592
auto / van / truck passenger=$0.592
bus=$1.01 rail=$1.38
dial-a-ride/paratransit=0
taxi=$2.6 school bus=0
carpool / vanpool=0
other (specify)=$0.296
driveAlone=$0.592
drivePass=$0.592
pass=$0.592 busWalk=$1.01
parkAndRideBus=$1.01