The Fundamental Law of Road Congestion Revisited: a micro-based approach to estimating commuter responses to investments in public infrastructure

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Traffic Congestion in the U.S.

- Congestion cost in 2012

  $121 billion

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- Mitigation strategies
  - Lane additions

Fundamental Law of Road Congestion

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- Empirical evidence:
  - Elasticity of demand between driving and road supply is 1 (Duranton and Turner 2011)
  - Other Studies (Fulton et. al 2000, Hansen and Haung 1997, Noland and Cowart 2000)

Motivation

- Previous studies are based on aggregate level data

MSA	Year	Lane Miles	Vehicle Miles Travelled (millions of miles)
Atlanta	2000	6487	75
Atlanta	2005	6587	83

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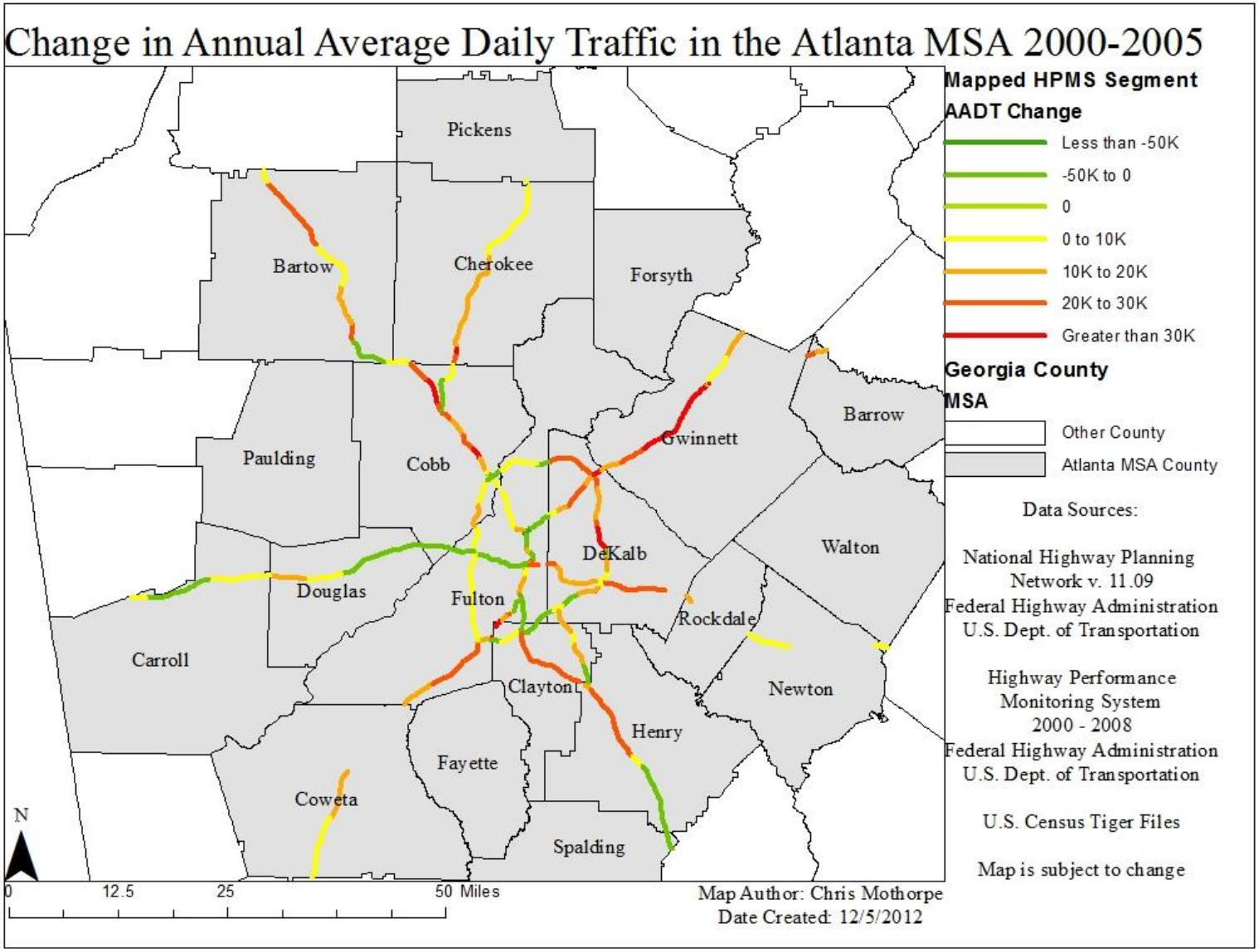
  - No Intra-city variation
    - Increase in driving cannot be link to any particular segment/area
    - Underlying causes of the Fundamental Law cannot be determined

Purpose of Research

- Map the Highway Performance Monitoring System (HPMS) & Census Transportation Planning Package (CTPP) data sets using optimized routing algorithms
- Combine data using spatial relationships

Purpose of Research

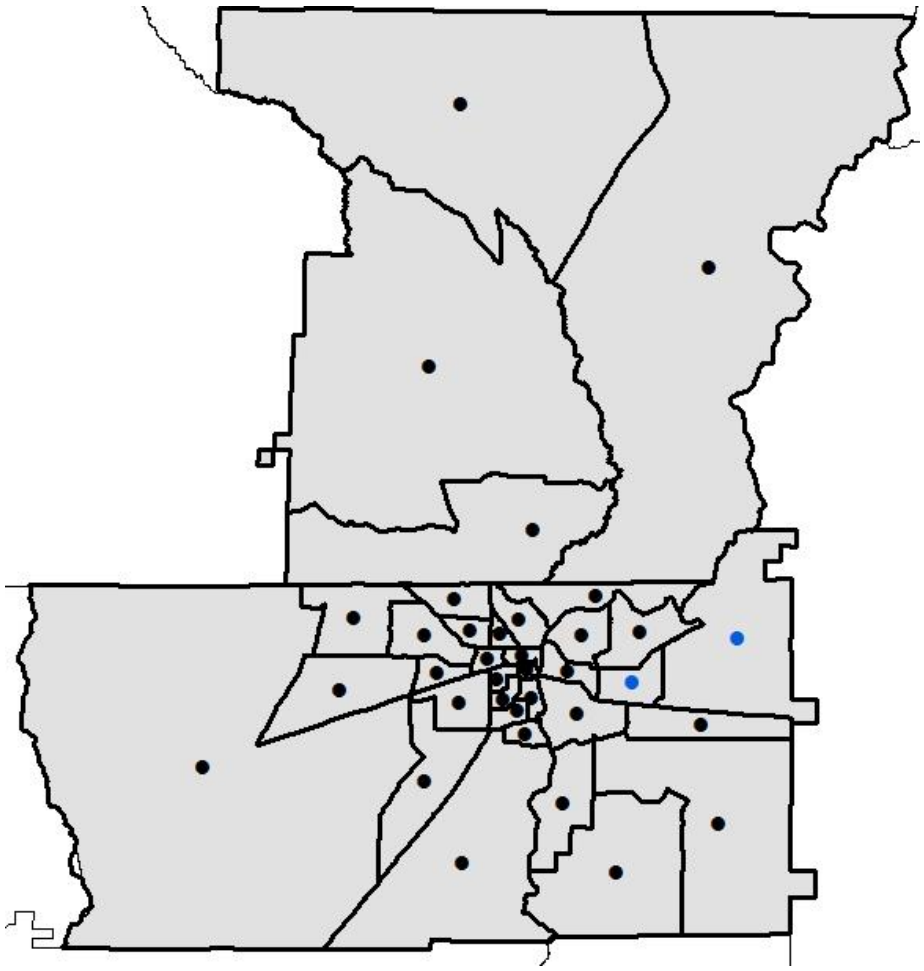


Purpose of Research

- Questions:
  - Does an increase in lane miles increase traffic on a highway segment?
  - Does an increase in lane miles cause a shift in housing demand?

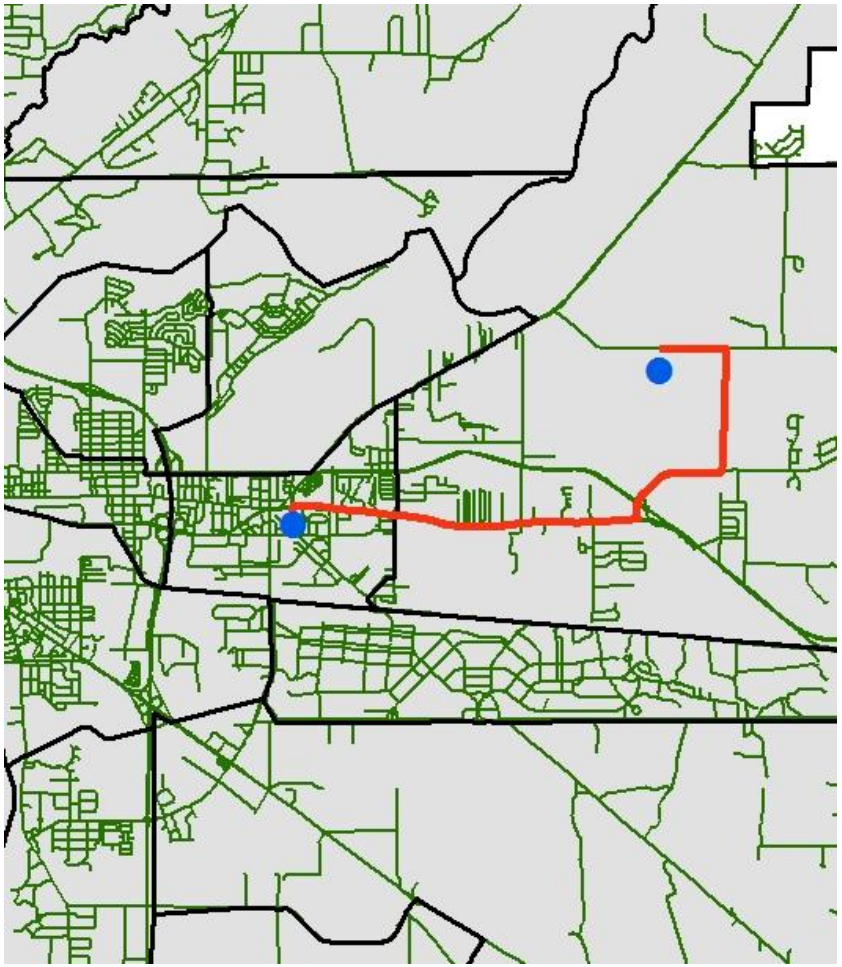
Census Transportation Planning Package (CTPP)

- Reports data for Census Tract to Tract home to work flows
  - Number of people & mode of transportation



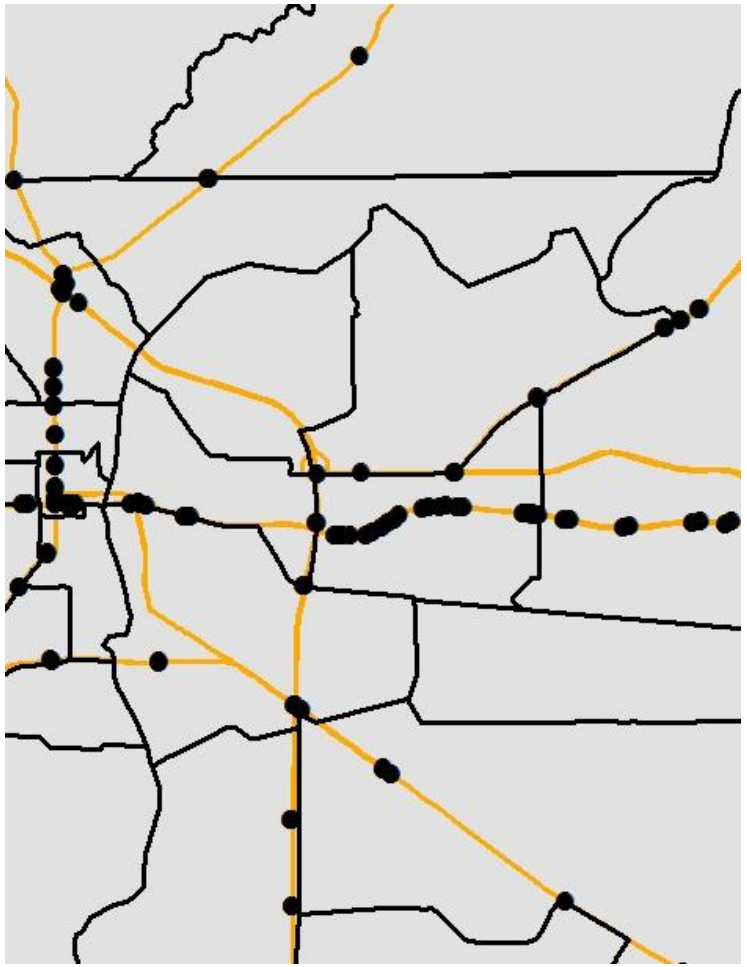
Census Transportation Planning Package (CTPP)

- Report data for Census Tract-Tract home to work flows
  - Number of people & mode of transportation
- Link each tract-tract flow to the road network by choosing quickest route



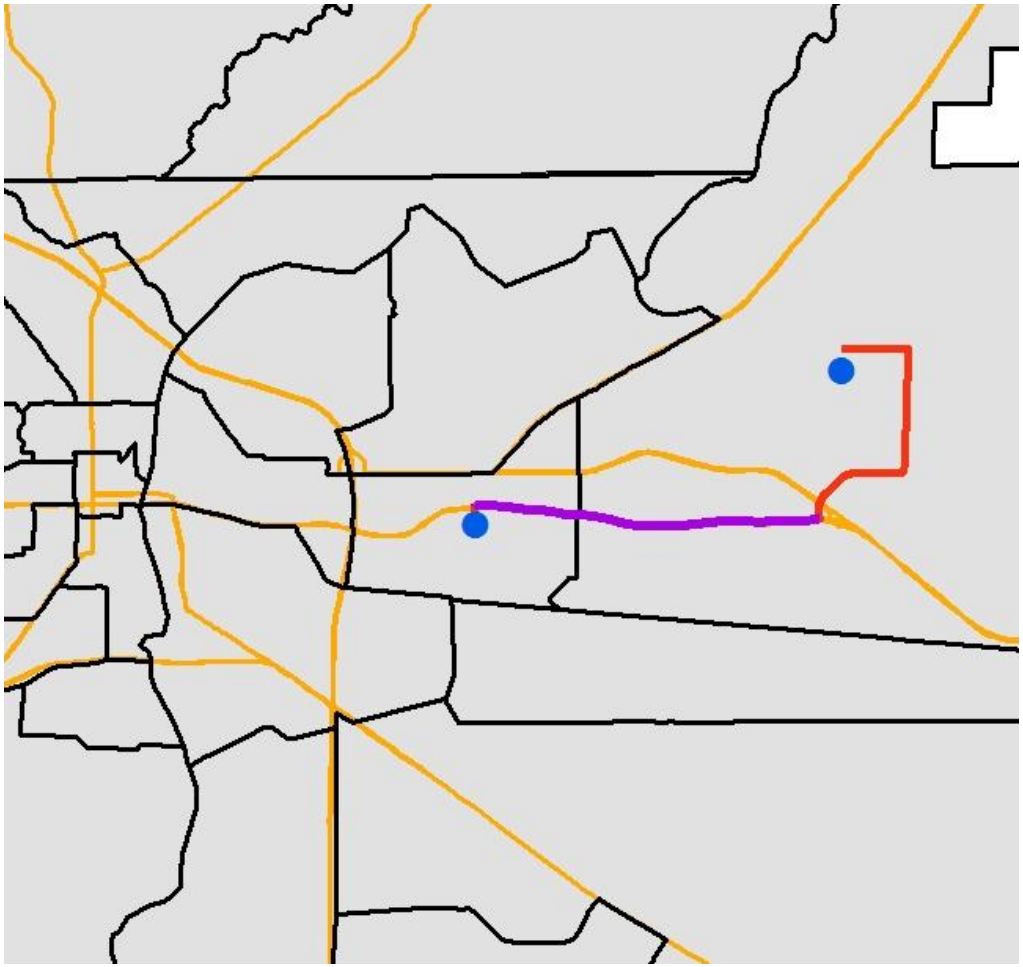
Highway Performance Monitoring System (HPMS) Datasets

- Annual dataset containing information on road and traffic conditions
  - Unit of Observation is a segment – a section of road with consistent traffic and road conditions.
  - Segments geographically referenced using a linear referencing system
  - Each segment has length, annual average daily traffic and number of lanes



Combined CTPP-HPMS Data

- Spatial overlay of commuter routes and mapped HPMS Data links the number of people and other Census data to road and traffic conditions



Motivating the Empirical Strategies

- People change behavior to capitalize on lower transportations costs
  - Re-optimizing location choice
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Motivating the Empirical Strategies

- People change behavior to capitalize on lower transportations costs
  - Re-optimizing location choice
    - Baum-Snow (2007), Baum-Snow (2007)
  - Triple convergence
    - Downs (1962, 1992)
  - Drive more
    - Duranton and Turner (2011)

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- Regressing changes in VMT on changes in lane miles would be computationally intensive
- Segments were people benefit from lane expansions will experience an increase in traffic
- Create a variable capturing the percentage of people benefitting for lane expansions on their commuting path

Does increasing lane miles increase driving?

- *Benefitting Trips* variable:
  - Weighted average of percent change in lane miles for all commuters using the segments
  - Two Parts:
    - 1) Percentage of People in that flow on the segment
    - 2) How much people in the flow benefit from lane expansions any where in their commute

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  - Two Parts:
    - 1) Percentage of People in that flow
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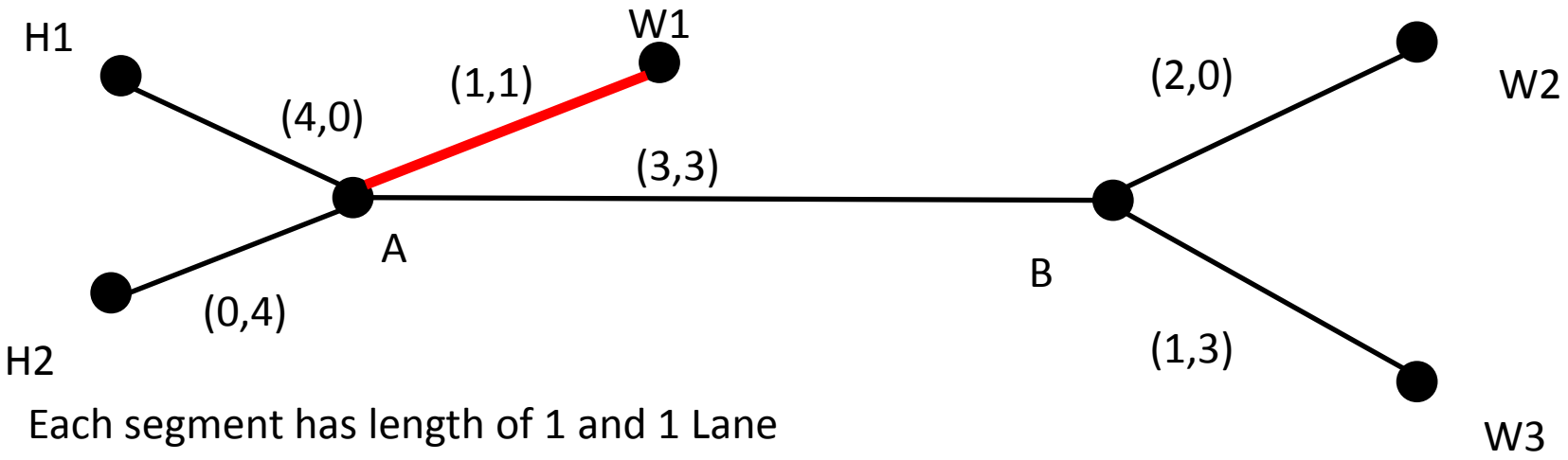
  - Spatial structure of network is embedded in the variable
  - Percent change in lane miles is calculate from 2000 to 2005

Benefitting Trips Variable



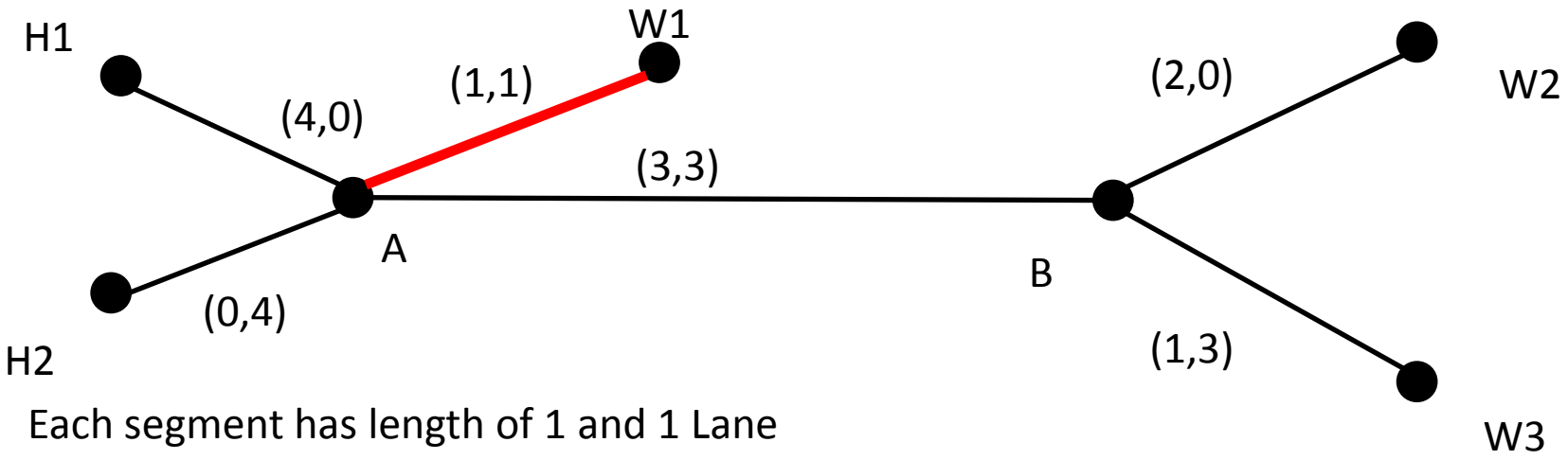
Each segment has length of 1 and 1 Lane

Expand Segment: A-W1 (50% Increase)

Calculations for A-W1 Segment

Path	Total Trips	% Change in Lane Miles	Weight (A-W1)
H1-A-W1	1	0.5	0.5
H2-A-W1	1	0.5	0.5
Benefitting Trips		0.5 x 0.5 + 0.5 x 0.5 = 0.5	

Benefitting Trips Variable



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Expand Segment: A-W1 (50% Increase)

Calculations for H1-A Segment

Path	Total Trips	% Change in Lane Miles	Weight (A-W1)
H1-A-W1	1	0.5	0.25
H1-A-B-W2	2	0	0.5
H1-A-B-W3	1	0	0.25
Benefitting Trips		0.5 x 0.25 + 0 x 0.5 + 0 x 0.25 = 0.125	

Does increasing lane miles increase driving?

$$\Delta VMT_i = \alpha + \beta * \mathrm{B}enefitting\ \_Trips_{\mathrm{i}} + \gamma * Controls_{i2000} + \varepsilon_i$$

- VMT_i : vehicle miles travelled on road segment i
- *Benefitting Trips*: Weighted average of percent change in lane miles for all commuters using the segments. Calculated from 2000 to 2005

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- VMT_i : vehicle miles travelled on road segment i
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- Changes in VMT from 2000 to 2008;
- Controls weighted average of census tract level variables

Do Lane Expansions Impact Housing Demand?

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- People want to move into area to capture benefit from lower transportation costs
- Create a variable measuring tract level transportation costs for drivers

Transportation Index

$$\text{Trans\_Index}_k = \sum_j \frac{\text{Ppl. commuting from k to j}}{\text{All people in tract k}} * \text{Lane Miles}(k, j)$$

- *Transportation Index:* a Laspeyres index indicating the weighted average in lane miles faced by all commuters the tract

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- Represents the average commuting costs faced by all people in the census tract

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- Interested in changes in commuting costs

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- Interested in changes in commuting costs
- Changes taken from 2000 – 2005; constant flow from 2000 CTPP
- Represents the change in average commuting costs faced by all people in the census tract

Do Lane Expansions Impact Housing Demand?

$$\Delta \ln(\mathrm{HV_k}) = \alpha + \beta * \Delta Trans\_Index_{\mathrm{k}} + \delta \Delta X_k + \varepsilon_k$$

- Dependent Variables: census tract level housing value or population density

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- Dependent Variables: census tract level housing value or population density
- Changes defined 2000 – 2009
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- Other covariates: housing and socio-demographic factors at the tract level

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- Road way expansions & housing demand shifts may be endogenous to changes in traffic
- Strategy 1: rely on OLS since Duranton and Turner (2011) found it to be unbiased at the MSA level
- Strategy 2: use instruments
  - Land features (soil type, elevation)
  - Voting Patterns

Summary

- Combines HPMS and CTPP data creating a unique data set exploiting intra-city variation and relates road and traffic conditions to commuting patterns and other census tract level data

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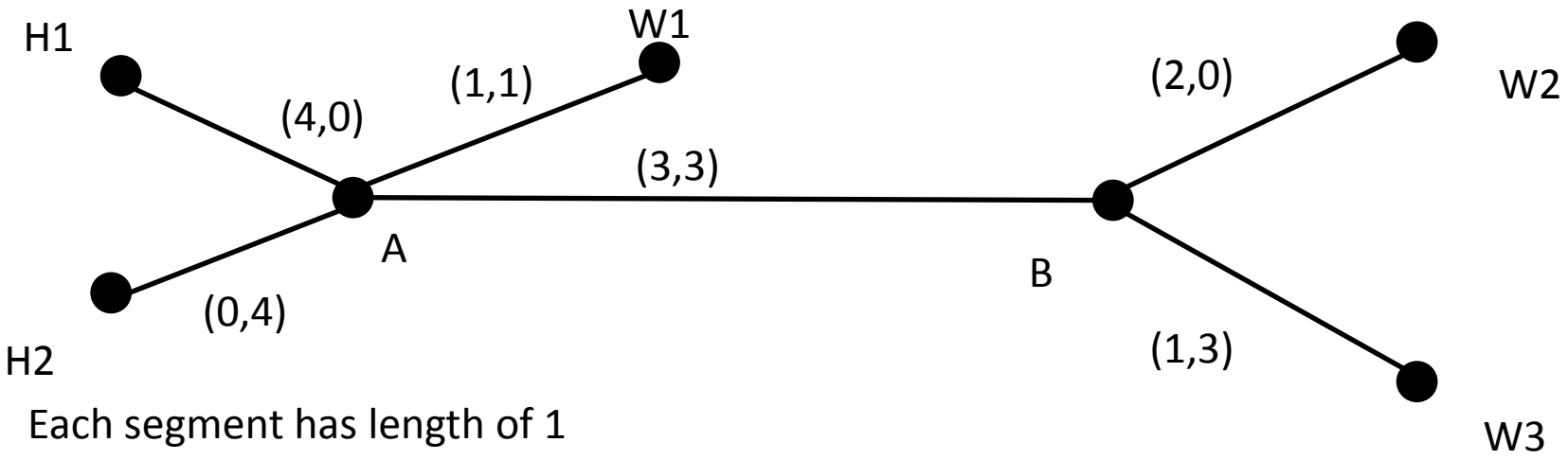
- Combines HPMS and CTPP data creating a unique data set exploiting intra-city variation and relates road and traffic conditions to commuting patterns and other census tract level data
- Create two variables (Benefitting Trips and Transportation Index) with embedded spatial structure estimate if lane expansions change traffic or housing demand

Transportation Index Example



Each segment has length of 1

Segment A-B receives an additional lane

Tract H1	Calculation	Flow Value
H1-A-W1	0.25 x 0	0
H1-A-B-W2	0.5 x 1	0.75
H1-A-B-W3	0.25 x 1	0.5