



How Might Automated Driving Impact US Land Use?

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Prediction is very hard, especially about the future.

- Yogi Berra



Predictions

**Era of abundant
fuel has ended
for good**

**Romance with car
ending**

**Middle-class
returns to city,
avoids cars**

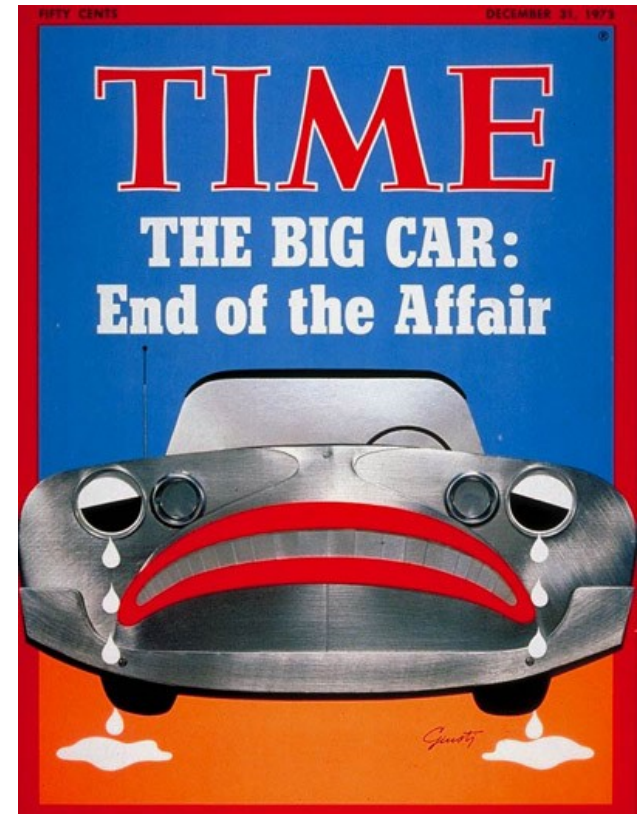
**Public
Transportation
Revival**

**One occupant-per-
car must end**

Predictions: 1973

The Painful Change to Thinking Small, Time Magazine, Dec 31, 1973

- *There have been multiplying signs that the long American romance with the big car may finally be ending.*
- *More likely, the heavy car will linger as a limited-purpose, special-use auto, but not again become the basic American vehicle*
- *Economists generally are agreed that the era of readily abundant fuel has ended for good.*
- *Public transportation will experience a revival*
- *Car pooling will have to increase...the one-occupant-per-car habit is simply too expensive to be continued.*
- *Socially, there could be a movement of middle-class whites back to the city, where they can get away from auto dependence.*



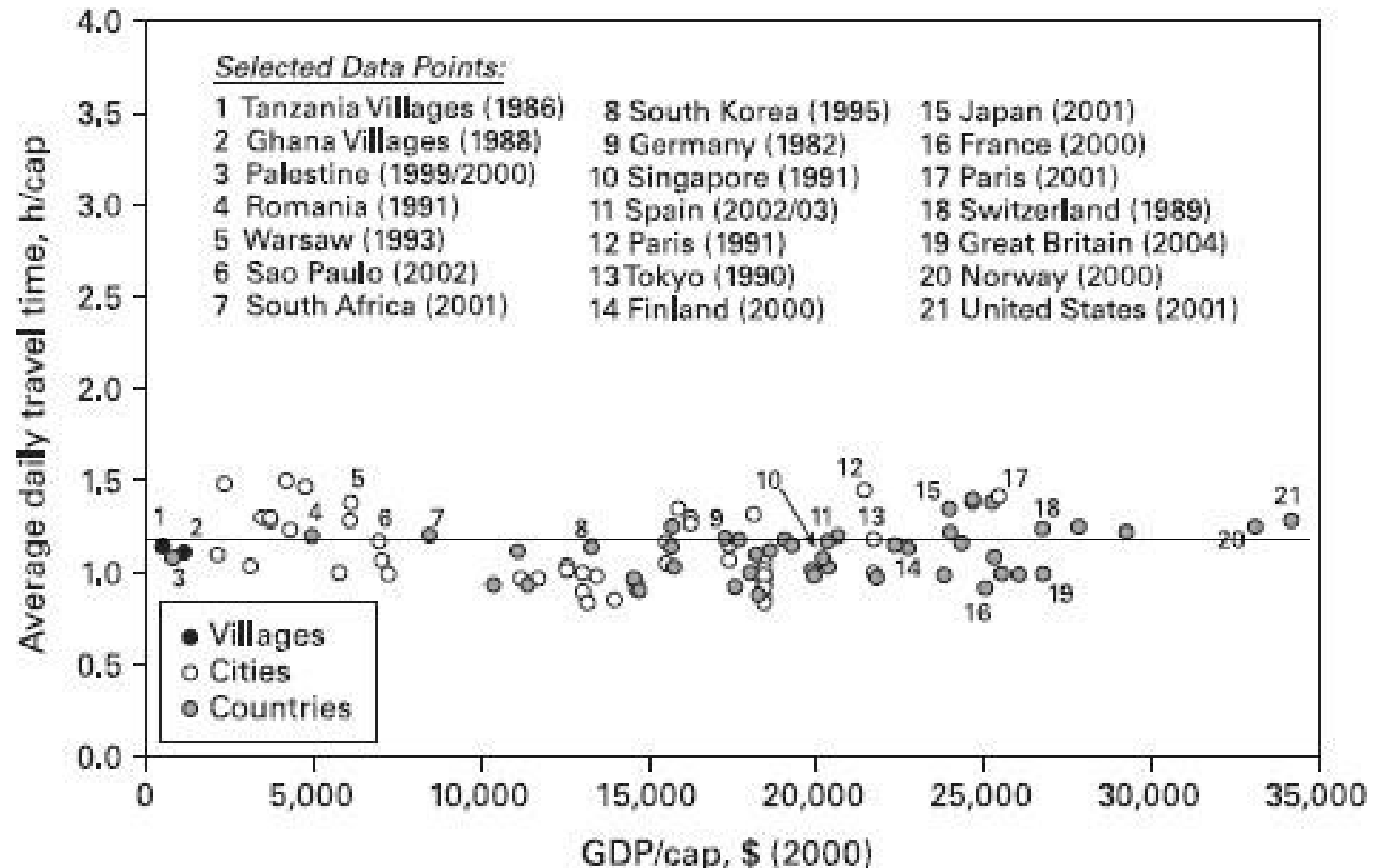
Summarizing AVS14: AD Level 2+3 and Highways

- Level 2+3 currently easiest on highways, likely first locations of AD.
- Predicted Impacts on highways:
 - Fewer accidents
 - Less traffic congestion
 - Lower environmental impact per mile
 - Faster average speeds

My Own Predictions

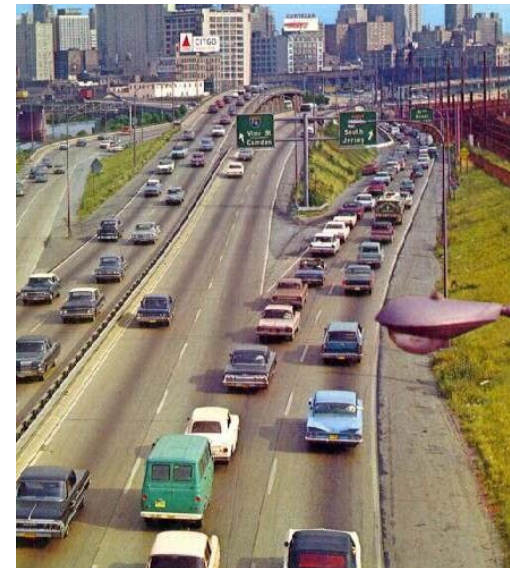
- Without policy changes, in the US, Level 2+3 Automated Driving will likely:
 - Increase highway speeds (mostly via reduced congestion and accidents)
 - Increase automobile VMT
 - Increase commute distances (with roughly same commute time as today)
 - Accelerate ongoing trend towards suburbanization of homes and jobs

Across cultures and decades, people travel approx. 1.2 hrs/day



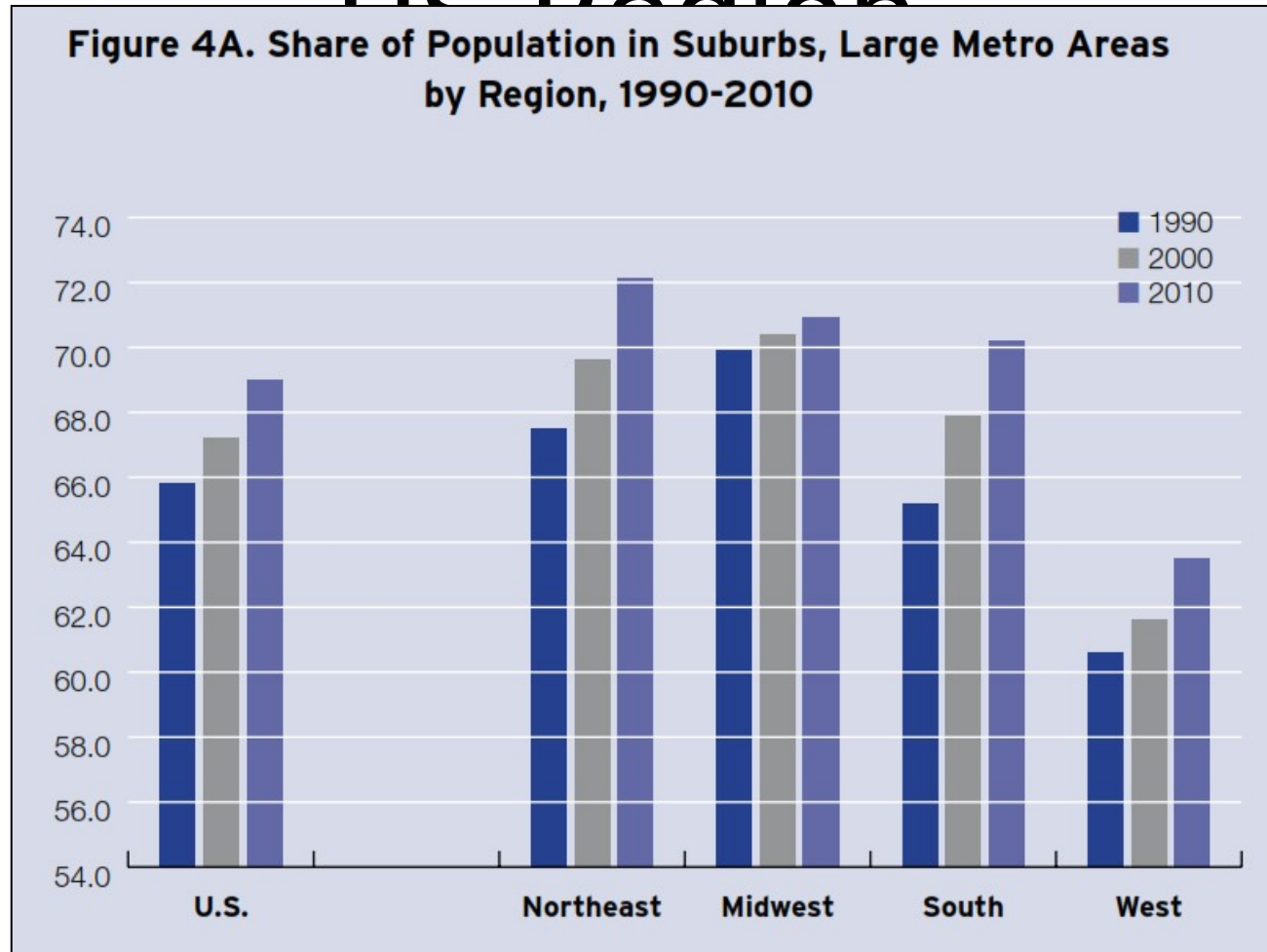
Average daily travel time in hours per person as a function of GDP per capita. Source: updated dataset of Schäfer, A., D.G. Victor, 2000. The Future Mobility of the World Population, *Transportation Research A*, 34(3): 171-205.

For over 100 years, each new US commuting mode, offering higher speed, has increased commute distances



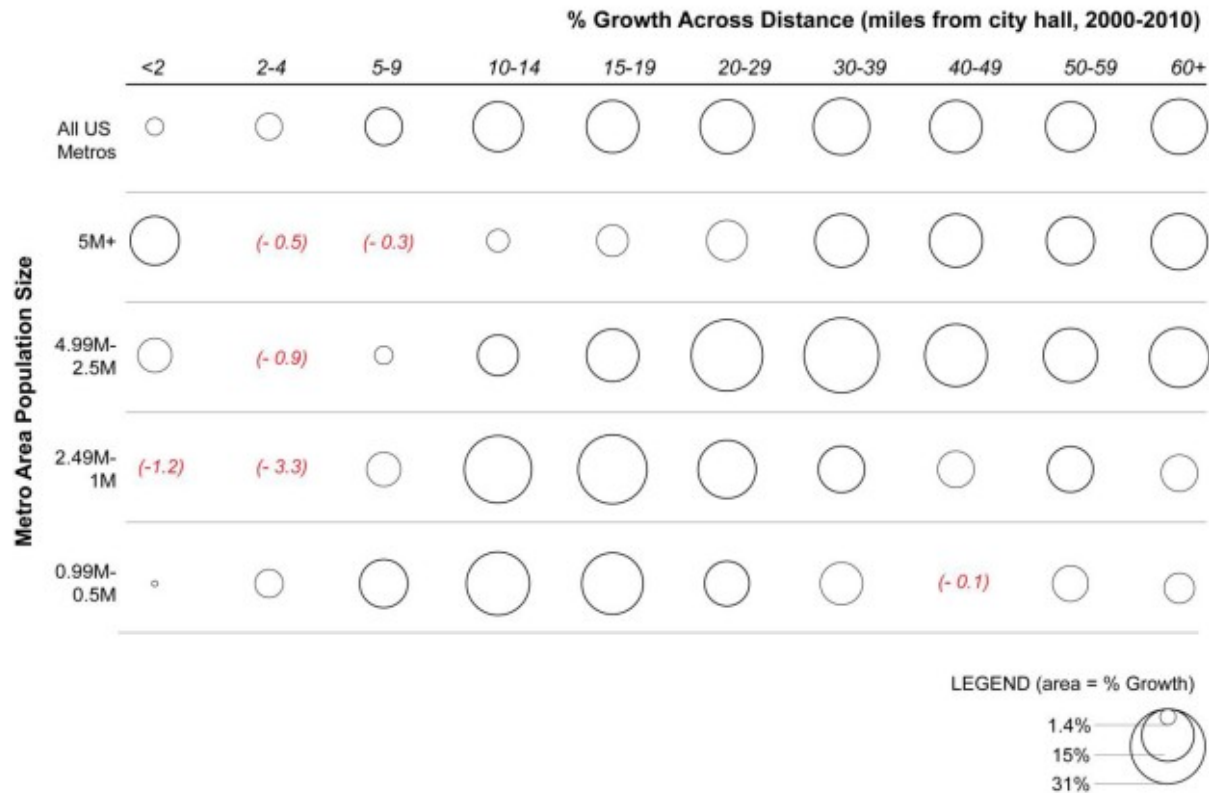
Suburbs are growing in every

US Region



US Suburbs share of population grows the last 20 yrs, in every region. [Source: W. Frey, Brookings Inst., 2012]

Growth by Metro Size

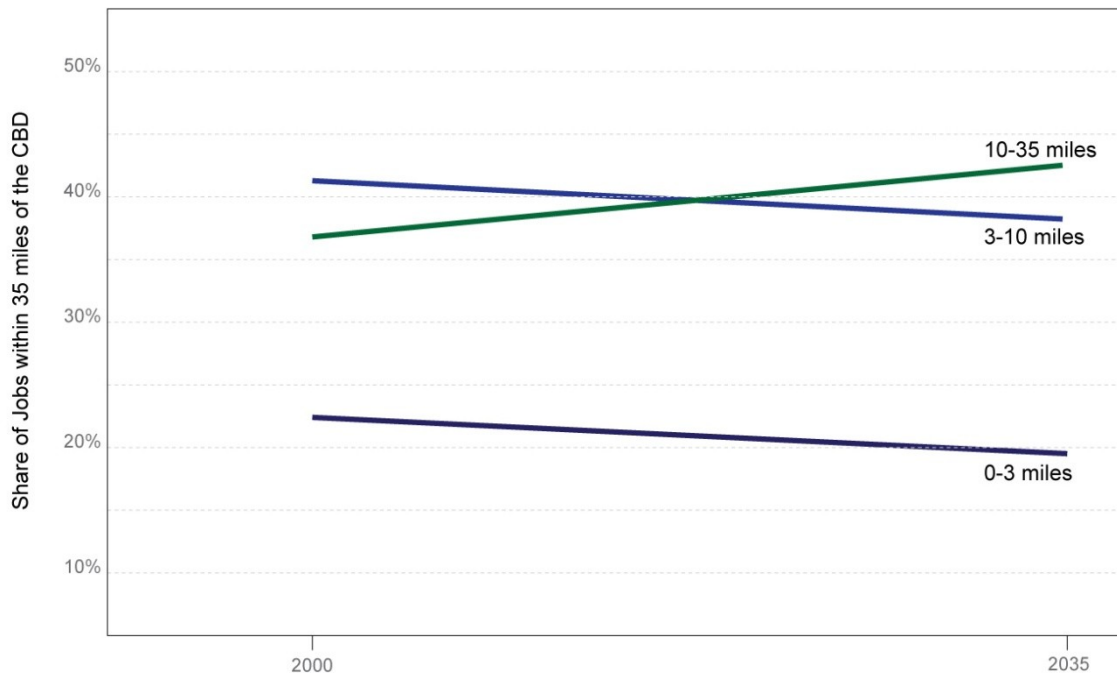


“Where Americans Live: A Geographic and Environmental Tally”, A. Berger, C Brown, C. Kousky, K. Laberteaux, R. Zeckhauser, *Harvard Journal of Real Estate*, May 2013.

Denver 2010-2035

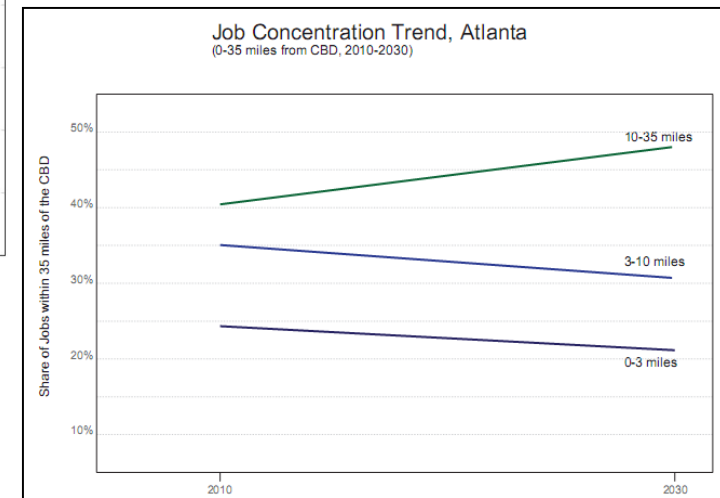
Employment Regional Share

Job Concentration Trend, Denver
(0-35 miles from CBD, 2000-2035)



- Majority of jobs will soon be > 10 mi from Central Business District (CBD)
- Outer suburbs only region growing in share of jobs.

for comparison



In Atlanta, trend is even stronger

US Suburbanization-by the numbers

| | CHICAGO | ATLANTA | DENVER | |
|---|-----------|-----------|-----------|----------|
| Population 2010 | 9,461,105 | 5,268,860 | 2,543,482 | |
| City Population 2010 | 2,695,598 | 420,003 | 600,158 | |
| % Growth Metro Area, 2000-2010 | 4.0% | 24% | 17% | |
| % Growth City, 2000-2010 | -6.9% | 1.0% | 8.2% | |
| Urbanized Land Area sq. mi., 2010 | 2,443 | 2,645 | 668 | |
| New Urbanized Area (Areas > 1,000 pers/sq. mi 2040, 2030, 2035) | 189 | 275 | 190 | *Derived |
| % Commuting by Transit ACS, 2008/2009 | 11.5% | 3.7% | 4.6% | |
| % VMT - Highway 2010 | 42% | 43% | 44% | *Derived |
| % VMT - Arterials/Streets 2010 | 58% | 57% | 56% | *Derived |
| % Jobs w/in 3 mi. of CBD 2010 | 20% | 10% | 22% | |
| % Jobs 10-35 mi. of CBD 2010 | 67% | 65% | 37% | |
| % Jobs Accessible by Transit < 90 min. | 24% | 22% | 47% | |
| Projected Jobs Added CBD | 143,000 | 39,800 | 164,000 | *Derived |
| Projected Jobs Added Suburban Areas | 1,190,000 | 788,000 | 728,000 | *Derived |

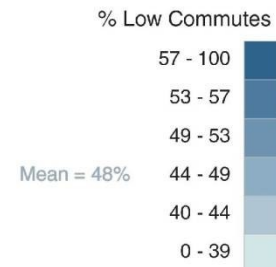
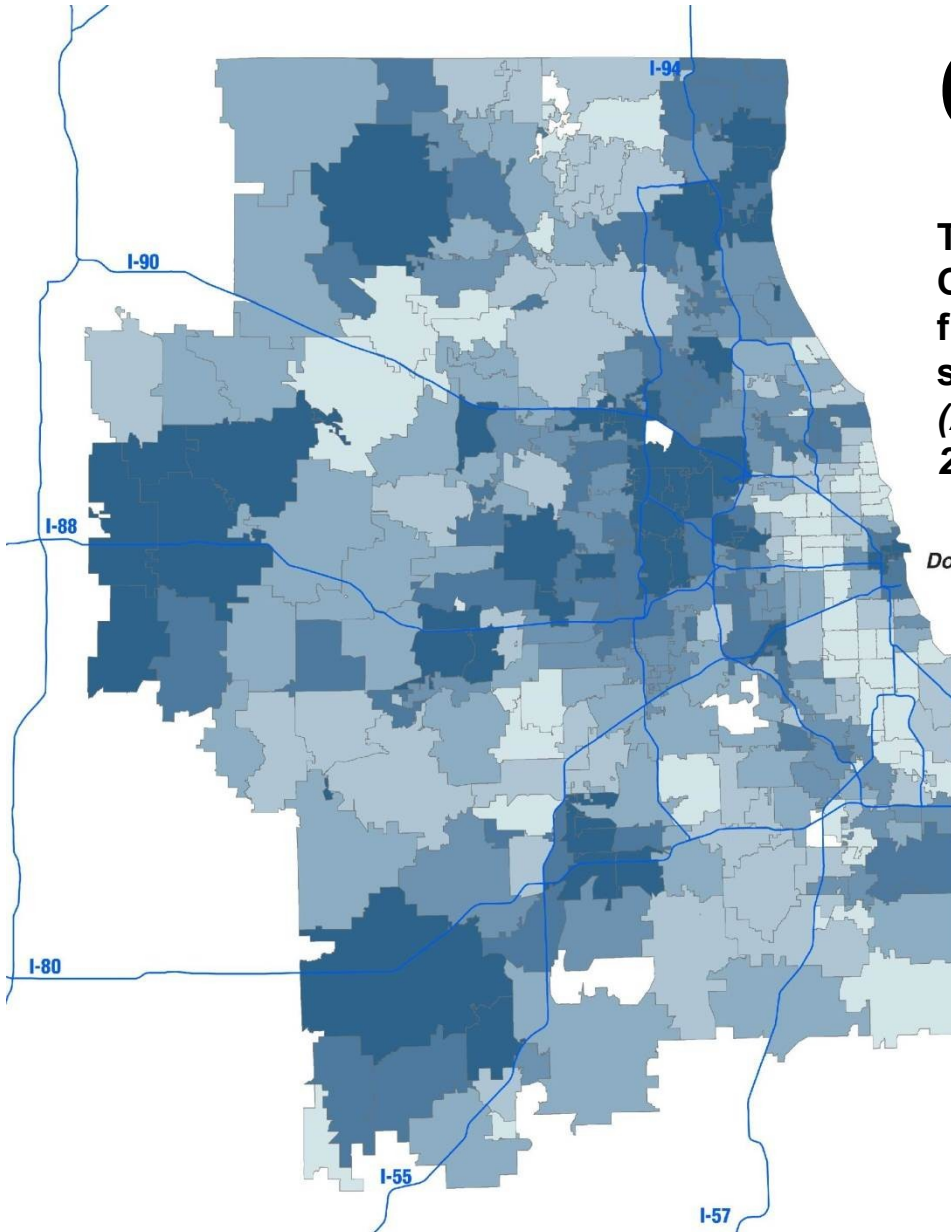
Visualizing Why

- Most models of residential location choice are hard for non-specialists to use, due to complexity and/or impractical assumptions.
- I have concluded that three very important factors for housing location are
 - housing price,
 - school quality, and
 - commute time
- Mapped these for Metropolitan Statistical Area of Chicago

Commute Time

The average one-way commute time for Metro Chicago is 30 minutes. This graph shows the fraction of commuters in each zip code that have a shorter-than-average (<30 min) commute. (*American Community Survey, 5-yr Avg., 2007-2011*)

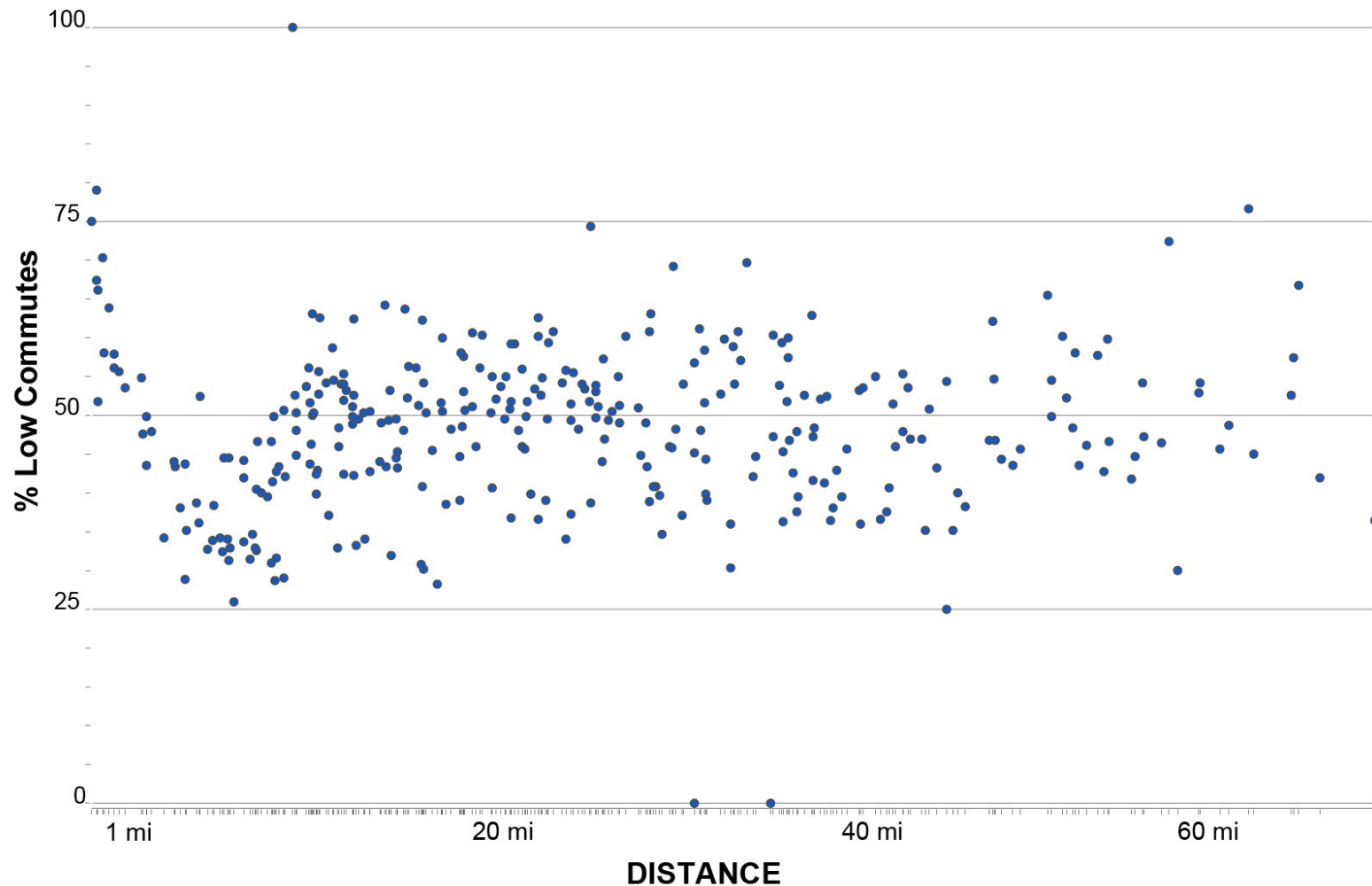
Downtown Chicago (CBD)



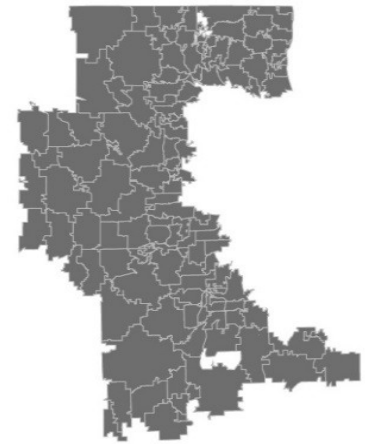
CHICAGO MSA - Commute Time

(Zip Code 5-digit, ACS 5-Yr Estimates, 2007-2011)

Do Suburbs require longer commutes?



Percentage of Low Commutes (<30 min. one-way). The average percentage of low commutes (48%) represents a strong clustering value for Chicago metro area. Percentages rarely go outside of 25-75% low commutes.



| | <i>CBD</i> | <i>City of Chicago</i> | <i>Inner Suburbs</i> | <i>Outer Suburbs</i> |
|--|-------------------|-------------------------------|-----------------------------|-----------------------------|
| Population <small>ACS, 2011</small> | 209,430 | 2,714,711 | 3,100,224 | 2,716,532 |
| Avg. Density (Zip Code) <small>ACS, 2011</small> | 16,300 | 14,800 | 4,320 | 1,460 |
| % Low Commutes <small>ACS, 2007-2011</small> | 65% | 44% | 50% | 48% |
| Avg. School Rating <small>Great Schools, 2012</small> | 6.3 | 3.8 | 6.4 | 6.4 |
| Med. Price per Sq. ft (\$) <small>Zillow, 2003-2013</small> | \$273 | \$197 | \$183 | \$128 |
| | | | <10-mi from City Line | >10 mi from City Line |

Conclusions

- Automated Driving Level 2+3 (NHTSA) predicted to increase travel comfort and speed, esp. on highway
- Long history of Americans turning higher speed travel into more VMT, keeping total travel time same. Why would AD be different?
- Increased speed offers house buyer larger area to trade-off price vs. location amenities (e.g. public school quality)

Final thought

It ain't over 'til it's over.

- Yogi Berra



Contact



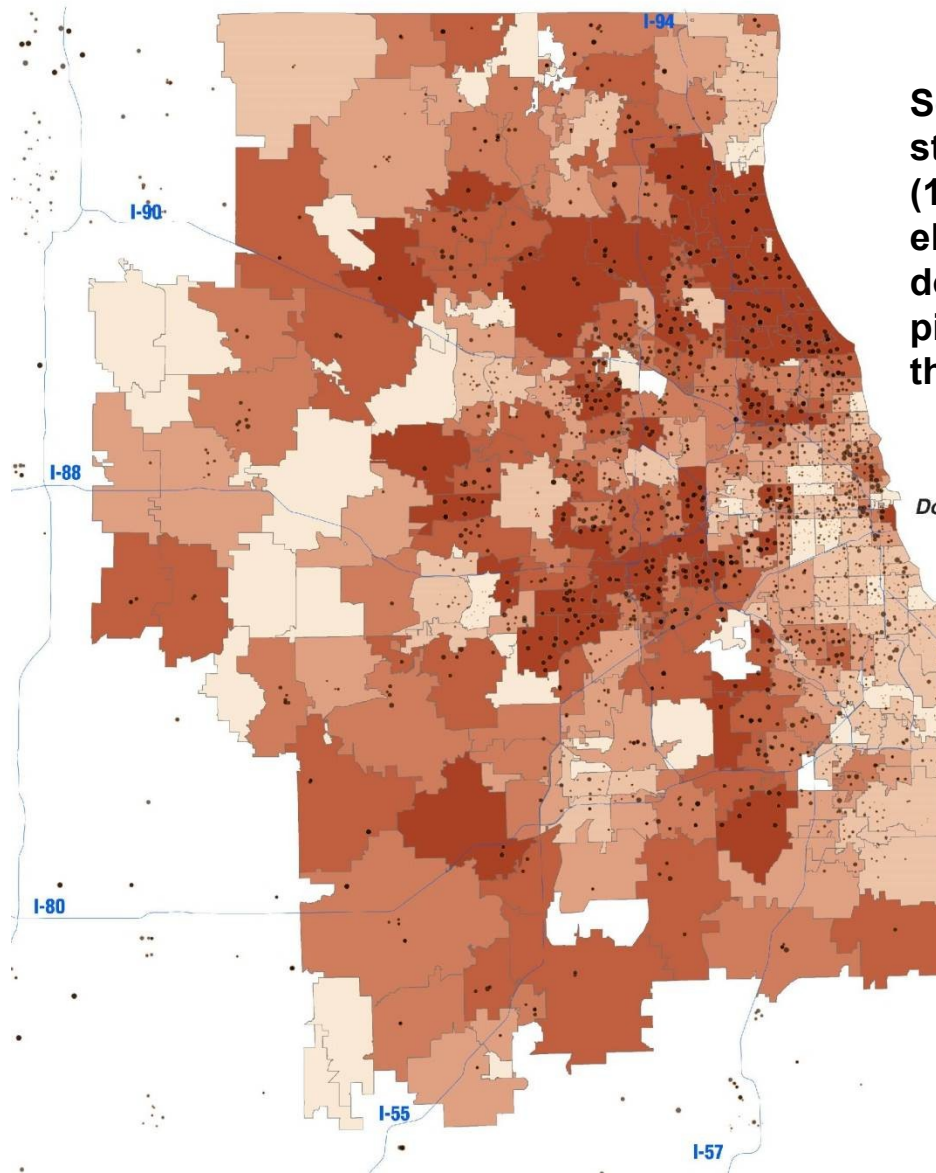
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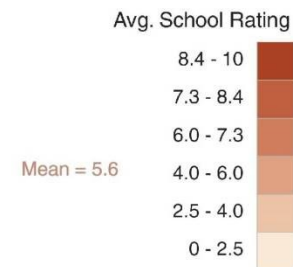
Backup

School Quality

School Quality is measured from a state-wide standardized test, with scores scaled from 0-10 (10=highest test score). Each dot indicates an elementary, middle, or high school. The larger the dot, the higher the test score for the school. The pink shading is an average of school test scores in the zip code. (Great Schools Rating, 2013)



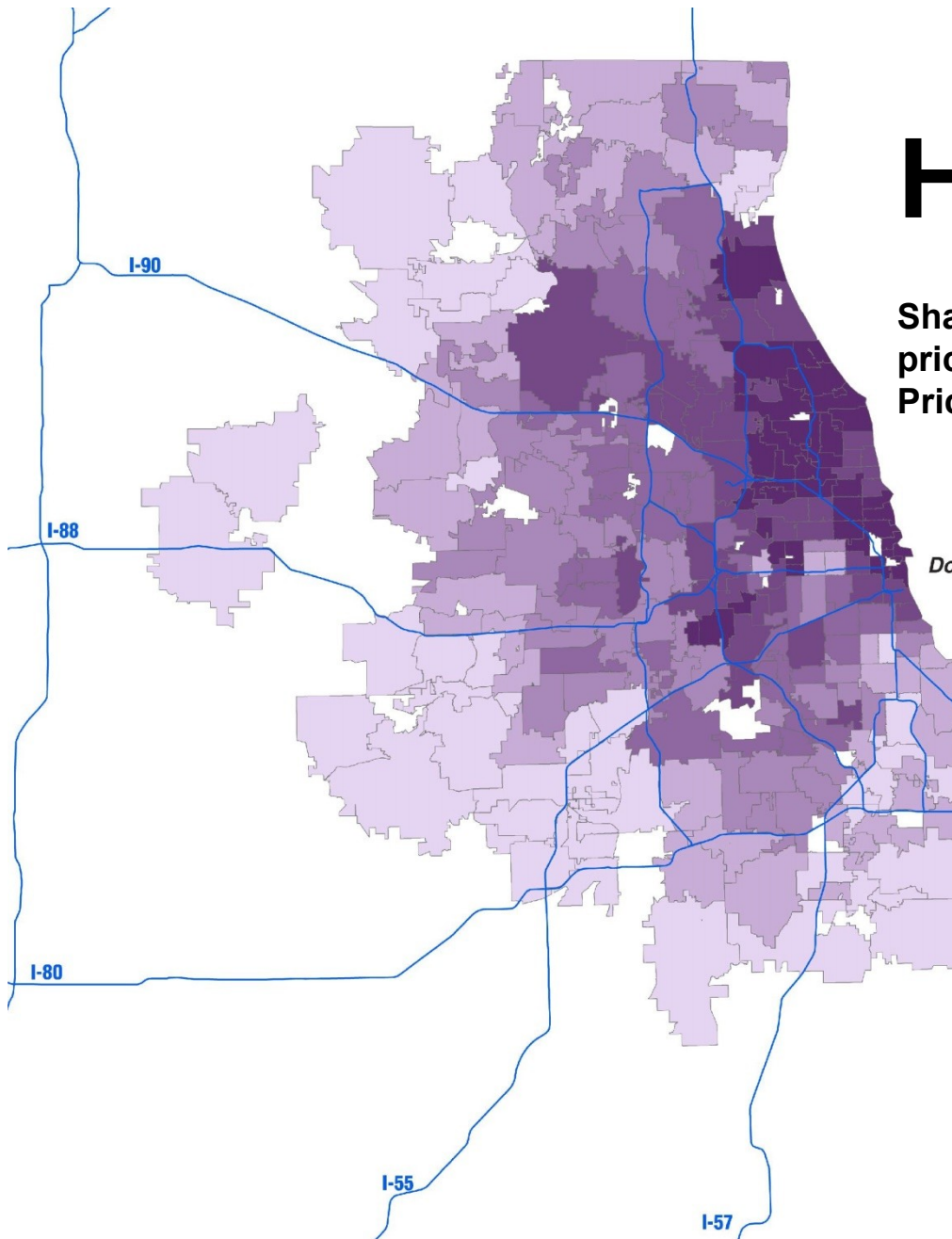
Downtown Chicago (CBD)



CHICAGO MSA - School Rating
(Zip Code 5-digit, Great Schools Ratings, 2013)

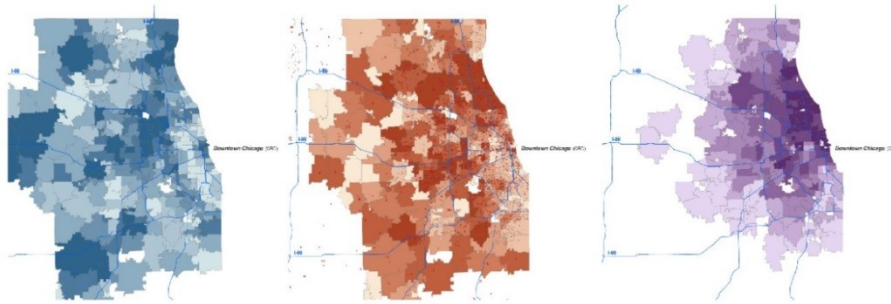
Housing Price

Shading for each zip code represents the average price of a square-foot of residential space. (Zillow Price Data, 10-yr. Median, 2003-2013)

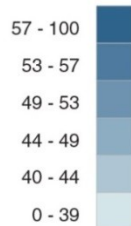


CHICAGO MSA - Housing Price
(Zip Code 5-digit, Median Price per sq. ft, Zillow, 2003- 2013)

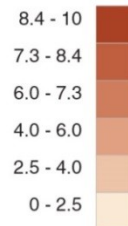
Commutes, Schools, Cost



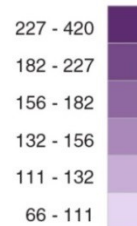
% Low Commutes



Avg. School Rating



Median Price per Sq. ft. (\$)



$$Z\text{-score} = \frac{(\text{Value}) - (\text{Average Value})}{(\text{Standard Dev. of Values})}$$

Z_score_Comm



Z_score_School



Z_score_Hsg_\$\$



+

+

$$\times (-1) = \text{Total Z-score}$$

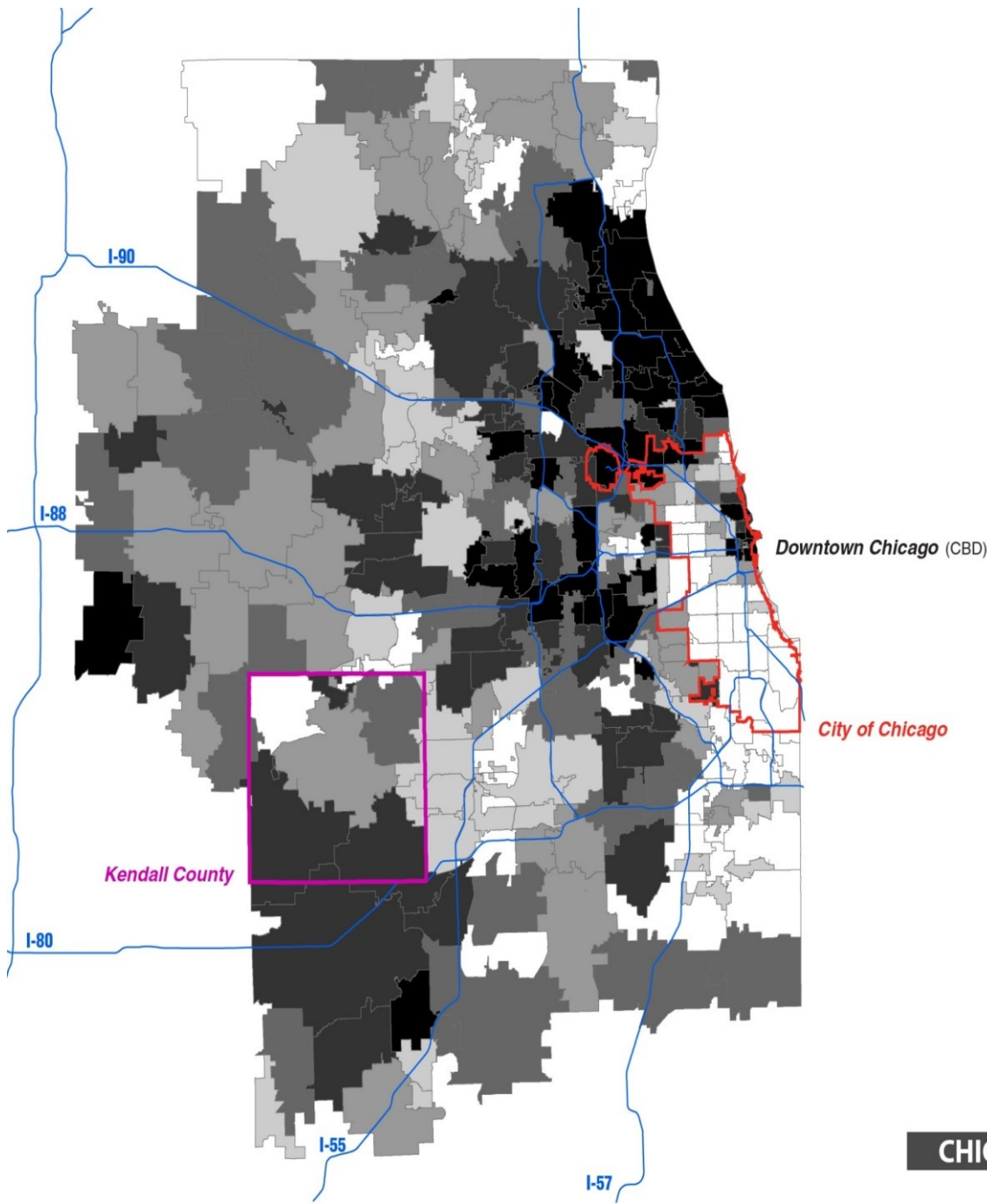
ACS 5-YR Estimates, 2007-2011

Great Schools, 2012
(Non-profit, ind. evaluation)

Zillow Sales Data, 2003-2013

Three Determinant Overlay

**Darker means
more attractive to
shoppers.**



Z-score Combined
(Indexed to max value)

1.5 - 0.6
0.6 - 0.3
0.3 - 0.0
0.0 - (0.2)
(0.2) - (0.6)
(0.6) - (1.4)

CHICAGO MSA - Z - Scores

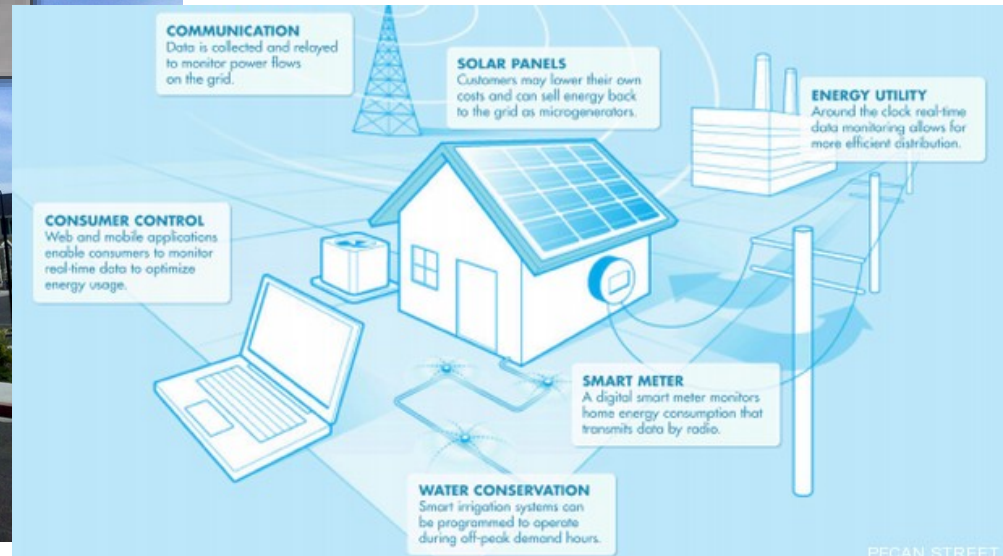
Can we make Suburbs more
sustainable?

Should we?

Example: Pecan Street (Austin, TX)



High Density Zoning Neighborhood



Example: West Village (Davis, CA)



Example: Low-carbon Society Project (Toyota City, JP)



All 67 homes have:

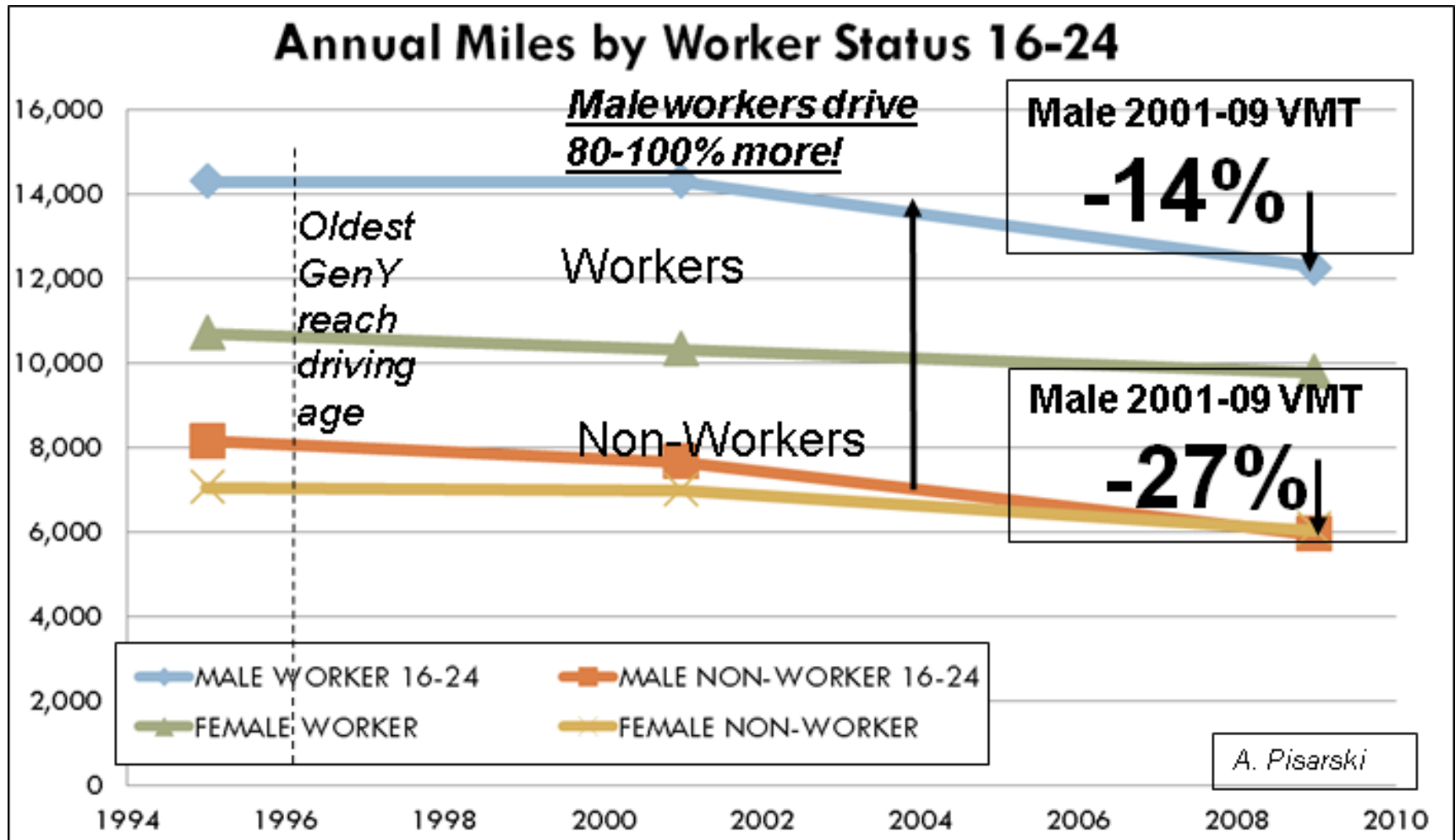
- PV Solar Panels
- Plug-in Vehicle
- Home Energy Management
- House battery

Soon

- Carsharing
- Multi-modal navigation

Show Video

GenY drives much less



Will GenY culture change car-dependent environment in US?

Gen Y: Life-cycle effect is delayed

Marital Status When They Were 18-28

% by generation

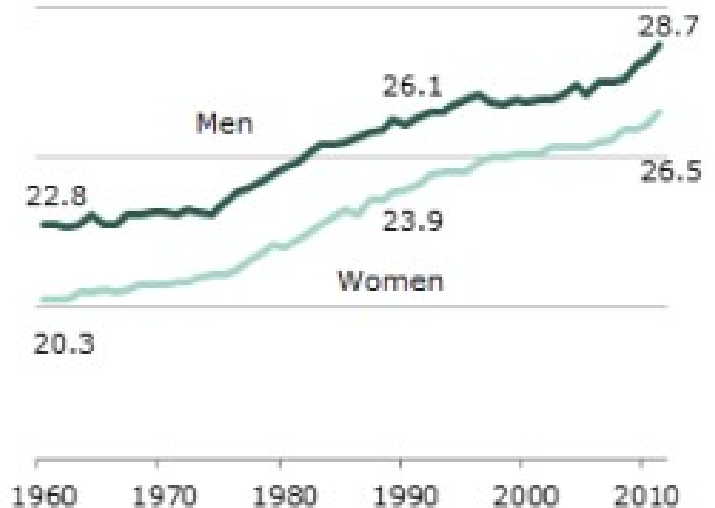


Source: Pew Research Center tabulations from the March Current Population Surveys (1963, 1978, 1995 and 2009) for the civilian, non-institutional population

PewResearchCenter

Median Age at First Marriage, 1960-2011

in years



Source: Current Population Survey, March and Annual Social and Economic Supplements.

PEW RESEARCH CENTER

A new care-free 20s demographic creating noticeable consumer shifts, exaggerated due to economic crisis

Gen Y: Still want a Family

How Millennials View Marriage and Children

% saying they...

■ Want ■ Not sure ■ Don't want

Do you want to get married?



Do you want to have children?



Note: Based on ages 18-29, unmarried and without children, n=305.

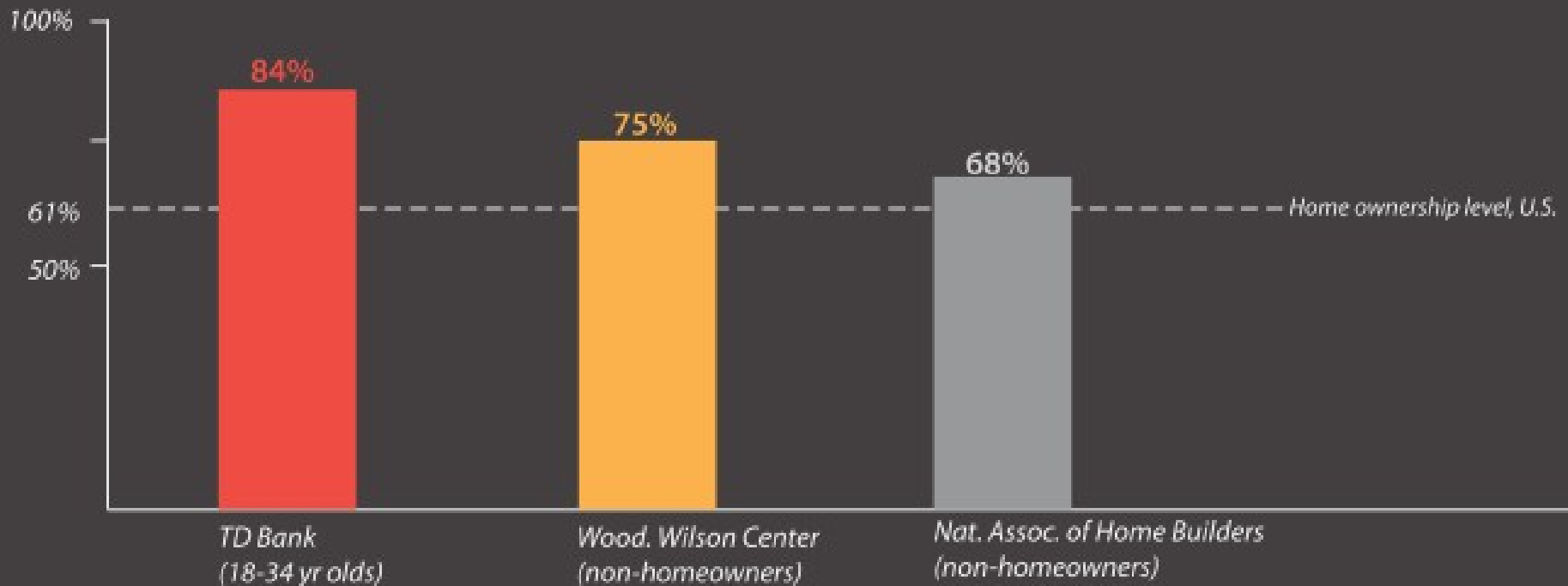
PEW RESEARCH CENTER

Gen Y: marriage and family is important, plan to get married and have children.

Will Gen Y resist economic incentives to suburbs when they start families?

Gen Y: Still want Homes

Share Who Intend to Own a Home, 2012



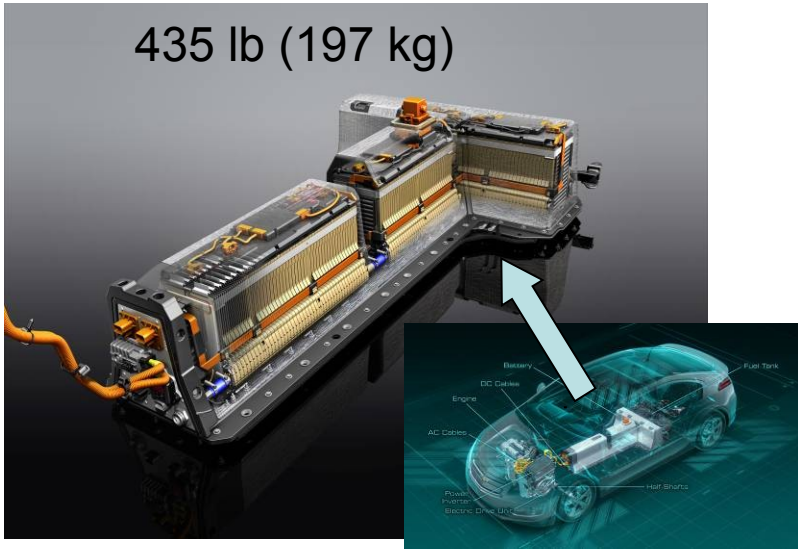
Cost drives adoption rates

- Which would you buy (in 2004)?
 - 2004 Corolla \$13.5k 34 MPG
 - 2004 Prius \$20.5k 46 MPG
- At time, criticism from both sides, i.e. industry observers (bad value trade-off) and environmentalists (not green enough).
- But, over 2M Prii sold, saved millions of tons CO₂

Batteries Have a Long Way to Go

Chevy Volt Battery

435 lb (197 kg)



≈ 37 mi ≈

10-12 hr charge (L1)

3-4 hr charge (L2)



\$3.50

6 lb (2.7 kg)

Compared to the same range of gas, the battery is
75 times heavier
1000 times more expensive

Assumes prices of \$3.50/gal of gas and at least \$250/kWh for the battery

CMAP POPULATION

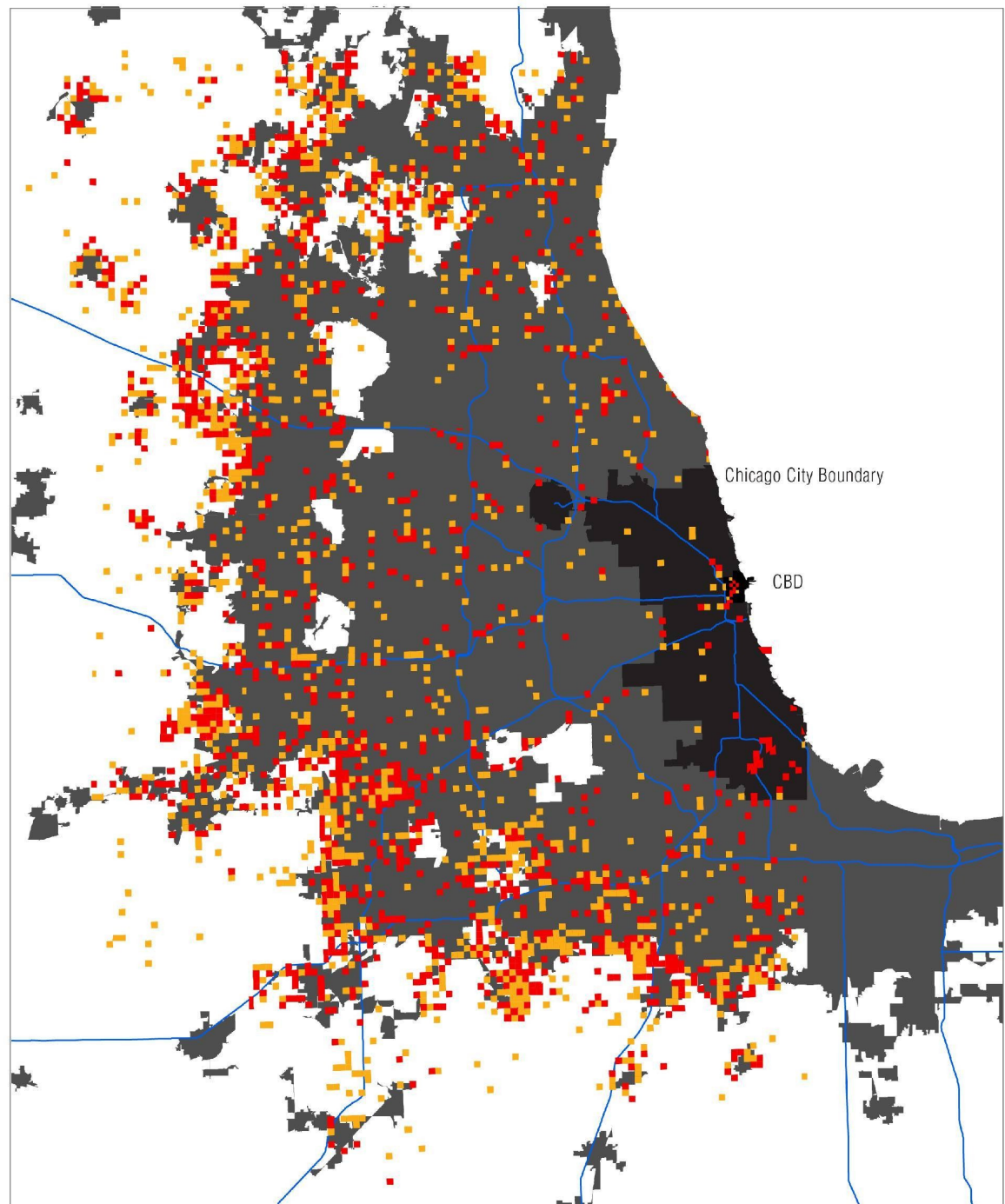
Percentage Change, 2010-2040

 CITY of CHICAGO
 2010 Urbanized Area

 Interstate

Population Growth
(Mean pop. change by 2040 = 265%)

 243 - 436%
 436% +

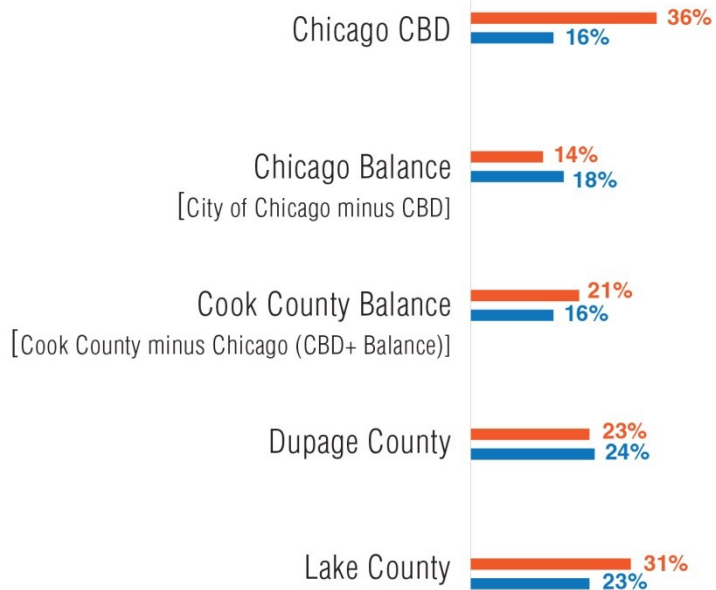


CMAP Projections 2010-2040

% Growth (population)
% Growth (employment)

100% Growth

200% Growth



OUTER SUBURBAN

