RSG
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Comprehensive Benefit-Cost Analysis

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Overview

Types of Economic Analysis

BENEFIT-COST ANALYSIS

- Good for Prioritzation
- Measures Cost-Effectiveness / “Bang for your Buck”
- Compares Users/Societal Savings to Agency Costs
- Focus on project and its direct effects
- Life-cycle perspective – story of effects over time
- Grounded in established theory
- More objective, geography doesn’t matter

ECONOMIC IMPACT ANALYSIS

- Good for Political / Public Suport
- Measures Economic Growth, Not normalized by project costs
- Focus on the economy (indirect & induced effects)
- Snapshot of the future
- More controversial / disputed theoretical basis
- Subjective, regional, our gain vs. their loss

Benefit-Cost Analysis (BCA)

EXPERIENCE

- Why should you listen to me?
- Experience with BCA in 8 states
- Recent efforts of interest
  - PM for development of 1st BCA tool for activity-based model (San Diego)
  - FHWA research on new methods
    - *New open-source tool in AMPO's ActivitySim framework (but works for both trip-based and activity-based models)*
    - *Applications in San Diego, Tampa, Portland*
  - Contributing enhancements to NCSTM's BCA methods

NEW BENEFITS & EQUITY ANALYSIS

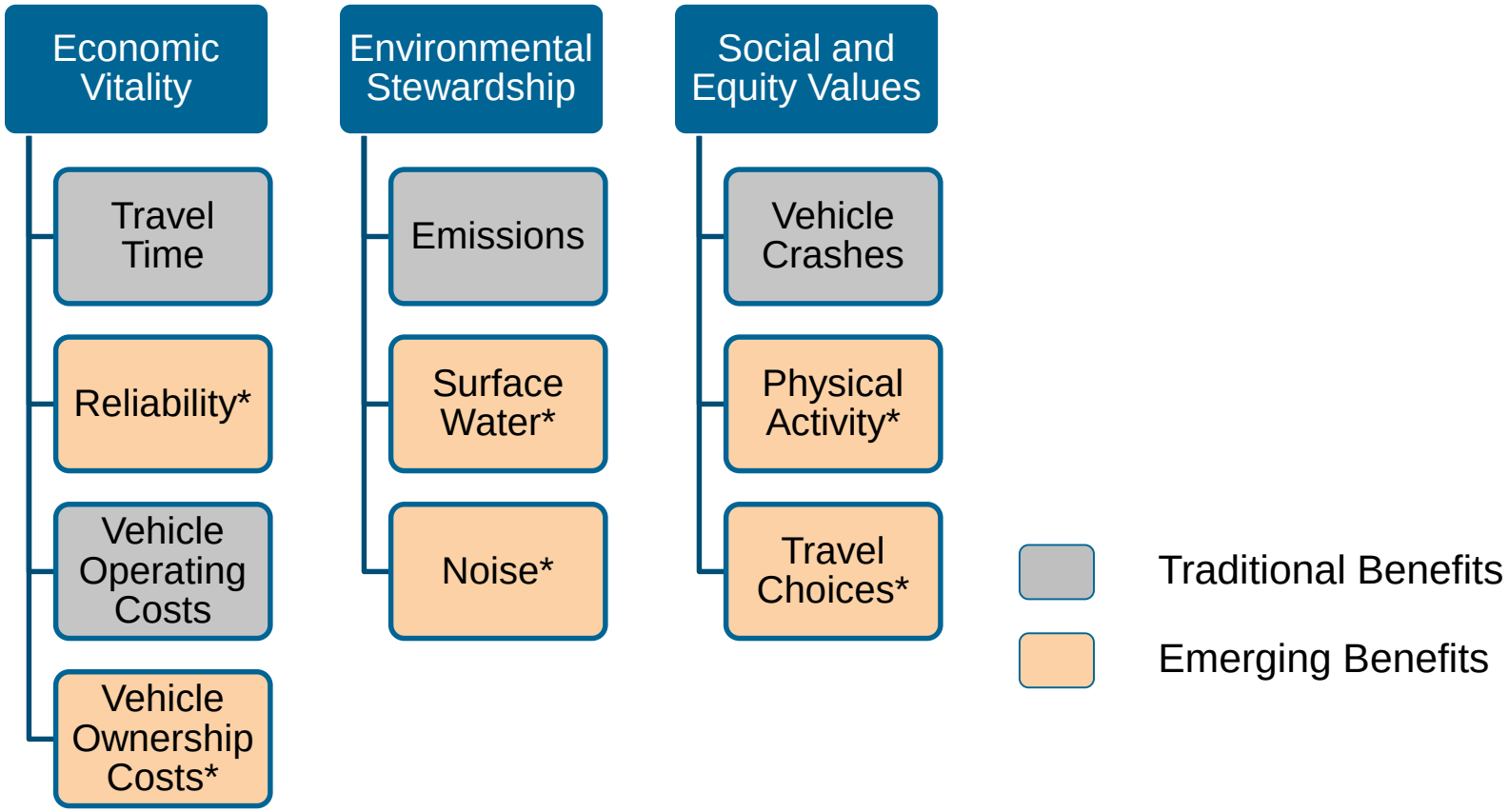
- Travel Time Reliability Improvements
- Environmental Impacts
- Active Transportation & Public Health Impacts
- Vehicle Ownership Cost Savings

Good Benefit-Cost Frameworks

- All benefits taken together should provide a ***comprehensive*** evaluation
- Benefits should be ***mutually exclusive***
- Benefits should be ***measurable***
  - Talk without measurement is “cheap”
  - Trying to count things, even when we fail, imposes a logical discipline
- Should produce an understanding of who benefits – ***equity***
- Framework should be ***transparent***
  - Engage stakeholders meaningfully
  - Publish both overall and component evaluation results
  - Fully disclose all analytic methods, assumptions, and limitations
  - Fully disclose all criteria composition and monetization methods
    - ***Monetization*** should be ***well-grounded***

Benefits by "Triple-Bottom Line" Category

Portland Metro MCE Toolkit Example



Economic Vitality Benefits

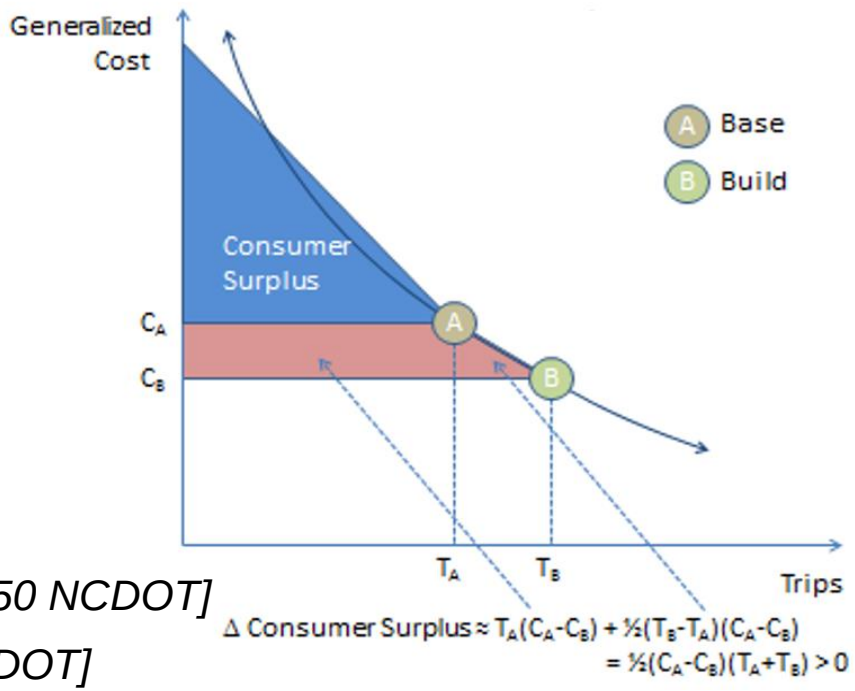
Travel Time

A Mobility Benefit

Economic Vitality

CONSUMER SURPLUS THEORY

- Travel time savings for existing trips are equal to difference between base and build
- Travel time savings for induced trips are half that of existing trips



MONETIZATION

- Value of time based on US DOT guidance and other research
- $14.66/hour for all passengers *[$12.50 NCDOT]*
- $41.00/hour for all trucks *[$50.00 NCDOT]*

IMPLEMENTATION

- Includes auto, transit and truck time savings
- Excludes walk and bike time savings
- Matrix-based “Rule of Half” RoH (linearizing demand function)
- No threshold/location criterion to deal with noise *[new location criterion for NCSTM]*

Travel Time Reliability

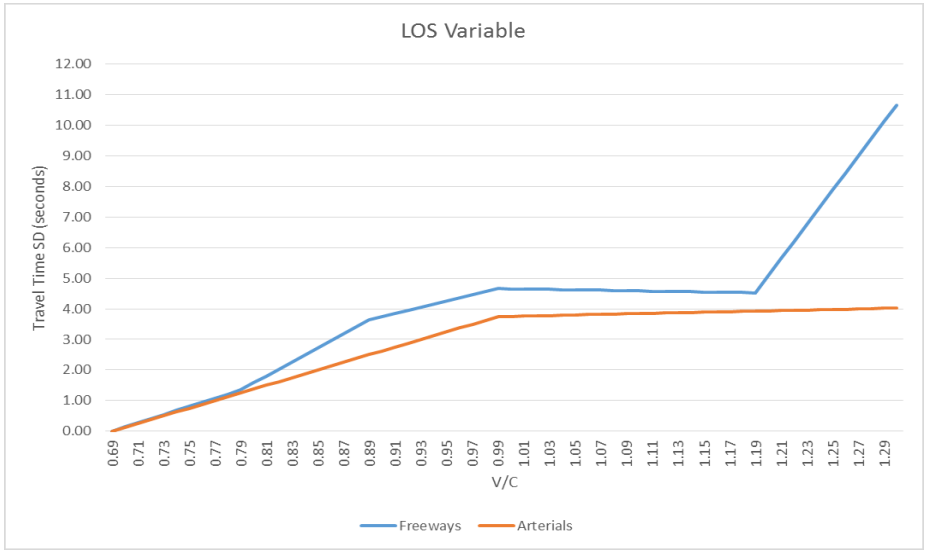
A Mobility Benefit

Emerging Method

Economic Vitality

FUNCTION OF V/C

- Several methods now demonstrated (consistency with assignment)
  - **Mean-Variance / "Reliability Ratio" (RR) from SHRP2 C04**
  - Buffer Time
  - Perceived Time
- Based on level-of-service, travel time, speed, length, lanes, interchange distance, intersection control
- Reflects reliability on arterials and freeways



IMPLEMENTATION

- Estimated as a post-process to travel model
- Can also be incorporated in assignment / demand models (in the future)

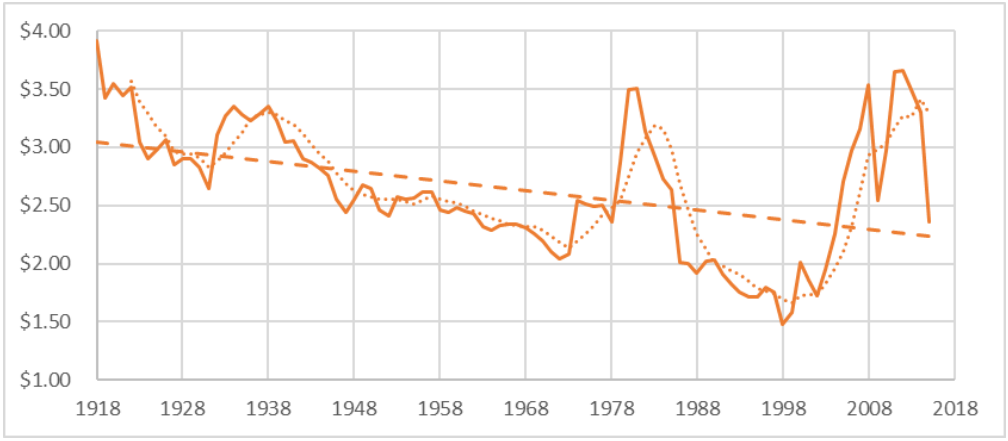
Vehicle Operating Costs

A Mobility Benefit

Economic Vitality

FUEL COSTS

- Fuel consumption from MOVES by speed bin, vehicle type, year, and facility type
- Monetization
  - $2.80/gallon for passenger cars
  - $3.08/gallon for trucks



Inflation Adjusted US Gas Prices, 1918-2015

NON-FUEL COSTS

- Includes maintenance and tire costs for autos and trucks
- Includes fixed ownership costs (purchase, finance, insurance) for trucks
- Non-fuel operating costs by vehicle type
  - Cars = 6.28 cents/mile
  - SUVs = 7.22 cents/mile

All Light Vehicles = 6.49 cents/mile

All Trucks = 50.70 cents/mile

Vehicle Ownership Costs

A Mobility Benefit

Emerging Method

Economic Vitality

AUTO OWNERSHIP MODEL

- Applies only to passenger cars
- Produces vehicles per household for 0, 1, 2, 3+ categories

MONETIZATION

- Includes purchase and depreciation, financing, insurance
  - avoid double-counting of maintenance under vehicle operating costs
- Based on AAA's Your Driving Costs
  - Average annual ownership costs for autos = $6,611

UNCERTAINTY

- Impact of ride-sharing services and emerging technologies such as automated vehicles is uncertain and not reflected yet – but will be in future

Environmental Stewardship

Vehicle Emissions

An Environmental Benefit

Environmental Stewardship

MOVES

- What level of consistency with MOVES / conformity analysis?
- Produce emissions by pollutant using link-based emission rate tables from MOVES by speed bin, vehicle type, year, and facility type

Pollutant	Abbreviation	Unit Cost ($ per Metric Ton)	Source
Carbon Dioxide Equivalents	CO_2e	$51.81	2010 Bay Area Air Quality Management District and San Diego Pollution Control District
Oxides of Nitrogen	No_x	$7,300	
Volatile Organic Compounds	VOCs	$37,900	
Fine Particulate Matter	$PM_{2.5}$	$459,000	
Particulate Matter	PM_{10}	$139,000	2012 Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters

Surface Water Pollution

An Environmental Benefit

Emerging Method

Environmental Stewardship

DEFINITION

- Represents deposit of rubber particles, oil and other pollutants on roads that wash into storm water
- Does not account for the cost to mitigate these impacts
  - Option to exclude benefits if mitigation is addressed
- Does not distinguish
  - Cars and trucks
  - Drainage approaches on different roads

FUNCTION OF VMT

- Per VMT rate for all vehicles = $0.01625/mile
- Based on research from WSDOT, Volpe Institute, and Victoria Transport Policy Institute

Noise Pollution

A Livability Benefit

Emerging Method

Environmental Stewardship

DEFINITION

- Largest source of noise pollution in urban environments
- Impacts public health
- General willingness to pay for noise reduction
- Does not account for the cost to mitigate these impacts
  - Option to exclude benefits if mitigation is addressed

FUNCTION OF VMT

- Marginal noise cost per 1,000 mile rates by functional class and vehicle type

Vehicle Type	Inter-state	Other Freeway	Principal Arterials	Minor Arterials	Collec-tors	Local Roads
Cars	$ 5.23	$ 7.51	$ 2.08	$ 1.01	$ 0.12	$ -
Medium Trucks	$ 15.02	$ 23.32	$ 12.40	$ 9.49	$ 1.86	$ -
Heavy Trucks	$ 29.49	$ 54.42	$ 35.46	$ 52.88	$ 8.71	$ -

- Source is Delucchi and Hsu (2004) as cited by AASHTO Red Book

Social / Equity Benefits

Motor Vehicle Crashes

A Safety Benefit

Social and Equity Values

HIGHWAY SAFETY MANUAL

- Source is the Interactive Highway Safety Design Model (IHSDM) / HSM
- Total accidents allocated to fatal, injury and property-damage-only (PDO)
- Annual valuation for fatalities is $9.4 million and for injuries is $441,800
- Annual user cost for PDOs is $1,522, including deductible and premium hikes

ROAD SEGMENTS (rs)

$$N_{rs} = C_r \times N_{SPFrs} \times CMF_1 \times \cdots \times CMF_n$$

Where C_r = calibration factor for a geographic area

N_{SPFrs} = Safety Performance Function (of congestion)

CMF = Crash Modification Factors (number of lanes, truck percentages and other factors)

INTERSECTIONS (int)

$$N_{SPFint} = \alpha + \beta ADTonHighestVolumeApproach + \gamma ADTonLowestVolumeApproach$$

Where α, β, and γ are parameters for a given facility type and sometimes other specifics such as number of lanes

Physical Activity

A Livability Benefit

Emerging Method

Social and Equity Values

WHO HEAT MODEL

- Mortality reduction assuming linear dose-response rate (to a max) to walking and cycling (minutes per week)
- Value assigned to expected lives saved per year

INTEGRATED TRANSPORT AND HEALTH MODELING (ITHIM)

- Monetizes cost per illness based on EPA value of life = $7.4 million in 2010
- Estimates mortality and morbidity reductions
  - Based on average active travel times by age and gender
- Requires local/regional calibration

IMPLEMENTATION

- New version of ITHIM in R
  - Existing deaths, years of life lost and years of life lost due to disability by age and gender
  - Costs per illness
  - Amount of time and distance spent walking and biking per day

Travel Options / Choices

An Accessibility Benefit

Emerging Method

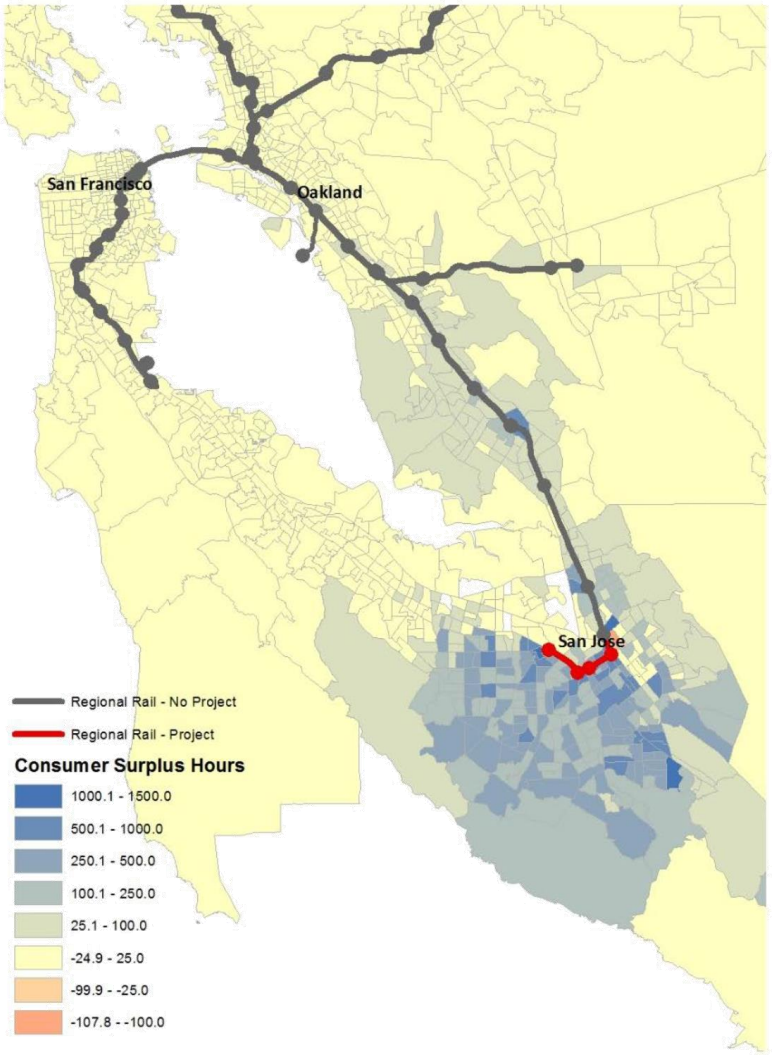
Social and Equity Values

DEFINITION

- Value of the availability of alternative modes and destinations
- Calculated by income group and trip purpose

METHODOLOGY

- Based on destination and mode choice logsums
- Includes value of travel time and operating cost
- To avoid double-counting and isolate the benefit of additional options traditional benefits must be subtracted from the change in logsums



Equity Analysis

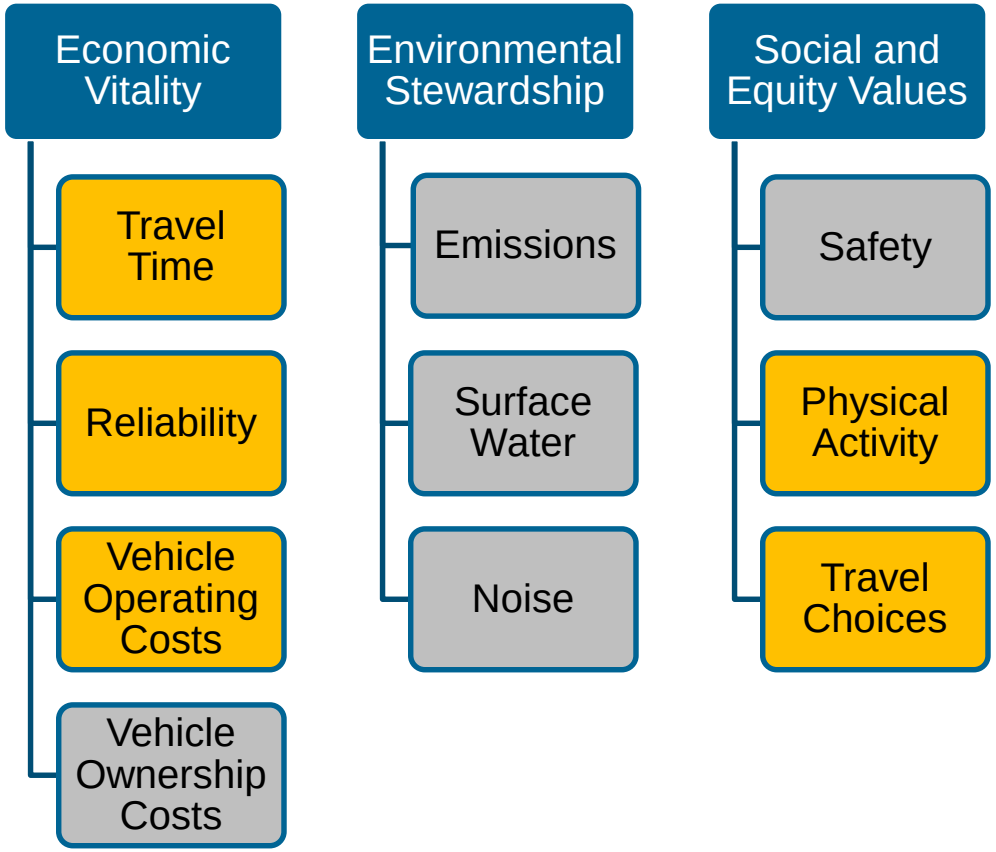
Defining Populations of Interest

	Type	SANDAG	MTC	PSRC
Low Income	Social	✓	✓	✓
Minority	Social	✓	✓	✓
Zero-Vehicle HH	Mobility	✓	✓	✓
Disabled	Mobility	✓	✓	✓
Seniors	Mobility	✓	✓	✓
Youth	Mobility			✓
Limited English	Social	✓	✓	
No High School Diploma	Social	✓		
Single Parent	Mobility		✓	
Rent-Burdened	Social		✓	
Regional Growth Centers	Mobility			✓
Manufacturing and Industrial Centers	Mobility			✓

Other Populations mentioned in the literature are licensed drivers, freight, visitors
http://www.vtpi.org/equity.pdf

Who Benefits?

Portland Metro MCE Toolkit Example



COMMUNITIES OF CONCERN

- Age Groups: Under 18 & Over 65
- Low English Proficiency (LEP)
- Household Income < $25k/year
- Racial & Ethnic Minorities

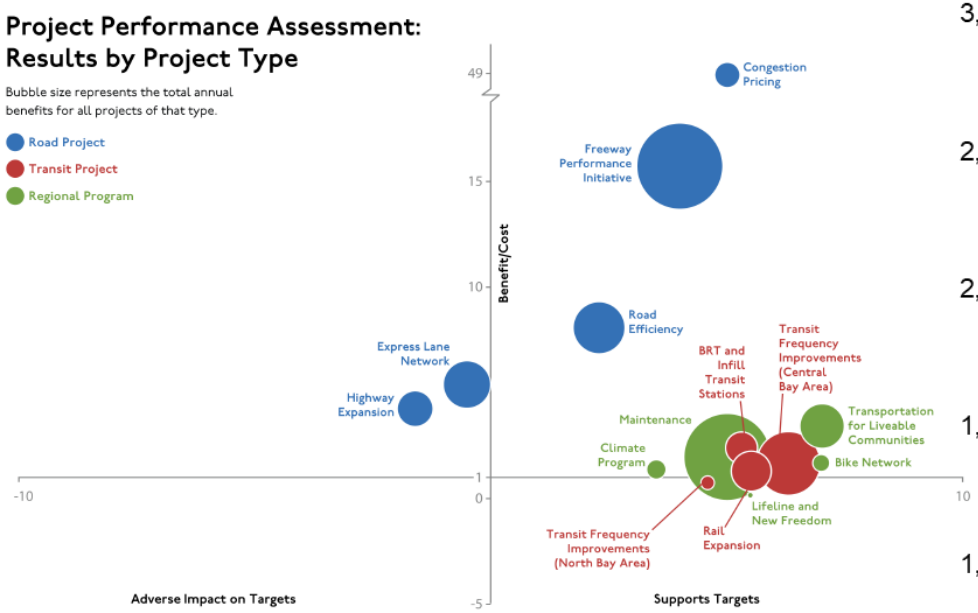
Primary Equity Measure

Not Proposed as Equity Measure (at this time)

Equity Summaries

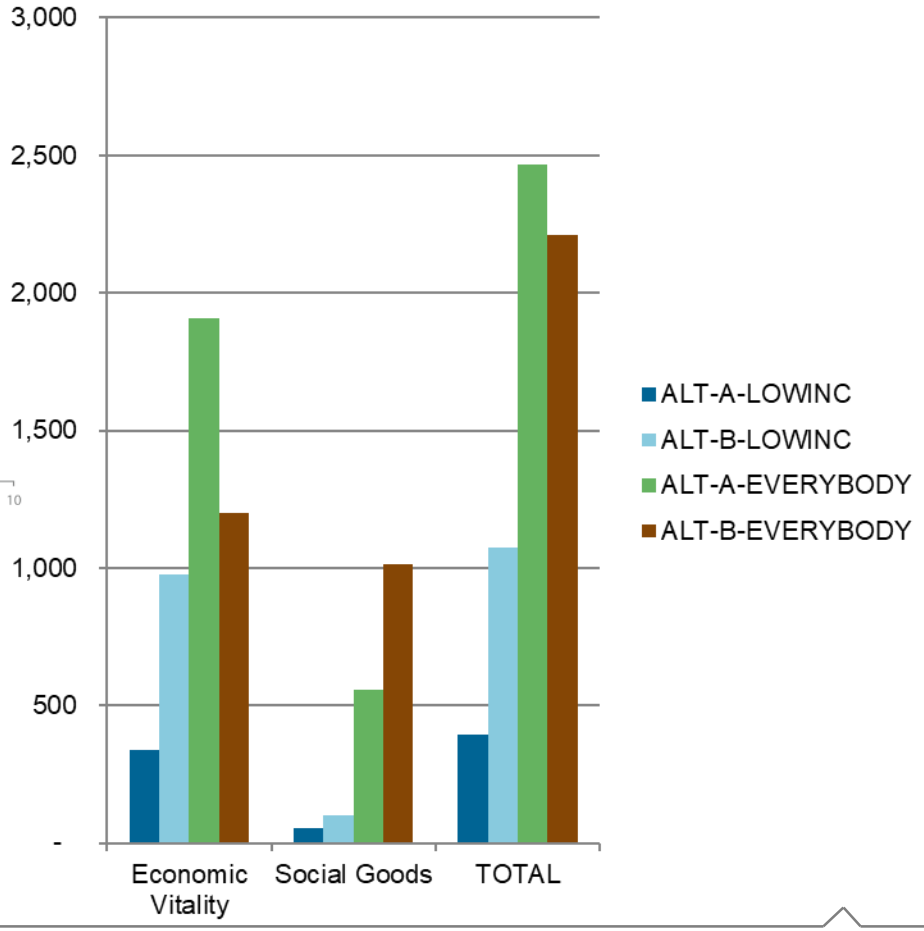
SAN FRANSICO

- LRTP projects by category



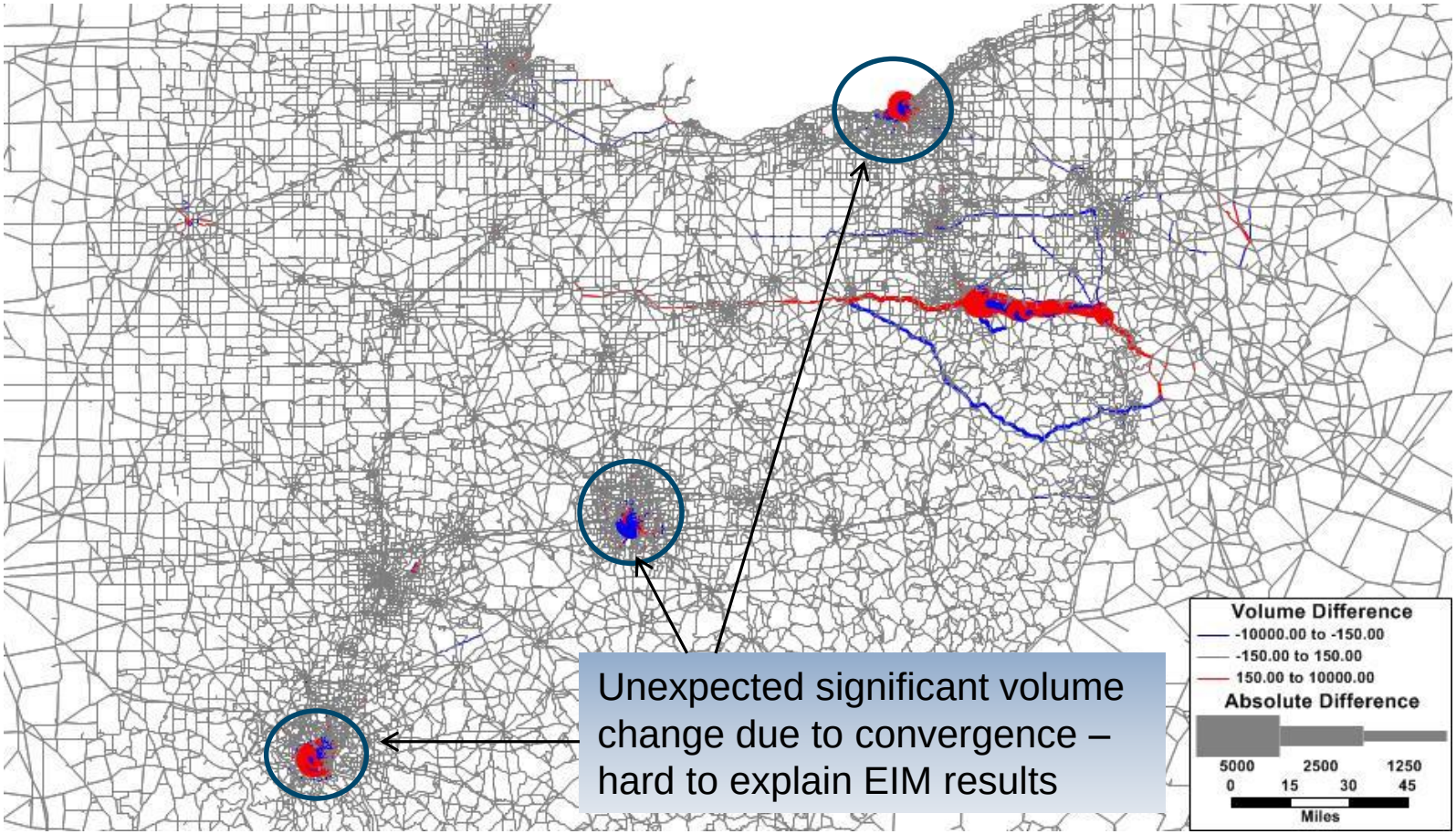
PORTLAND

- Test Case Forecast 2040 Annual Equity Benefit Measures Low Income vs. All Travelers (thousands of 2040 $)



Model Convergence

Poor Convergence: Build vs. No Build



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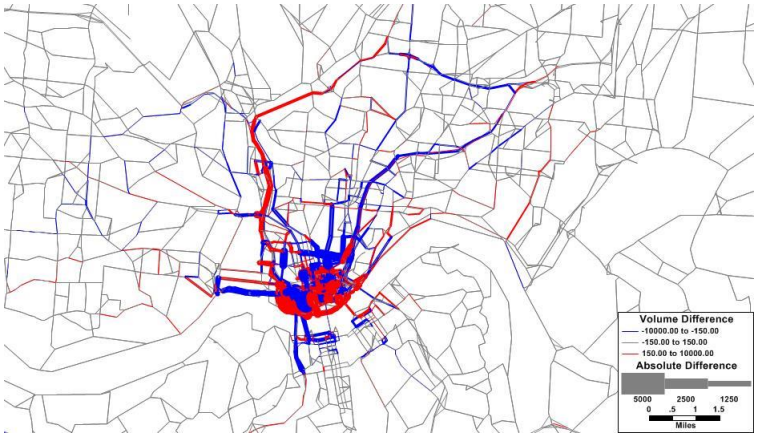
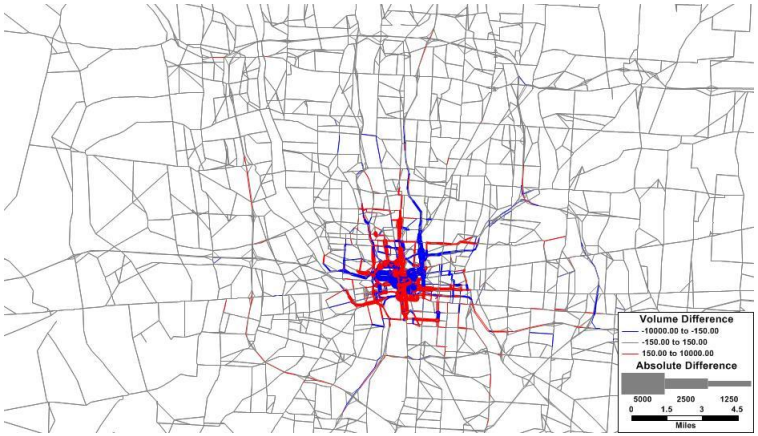
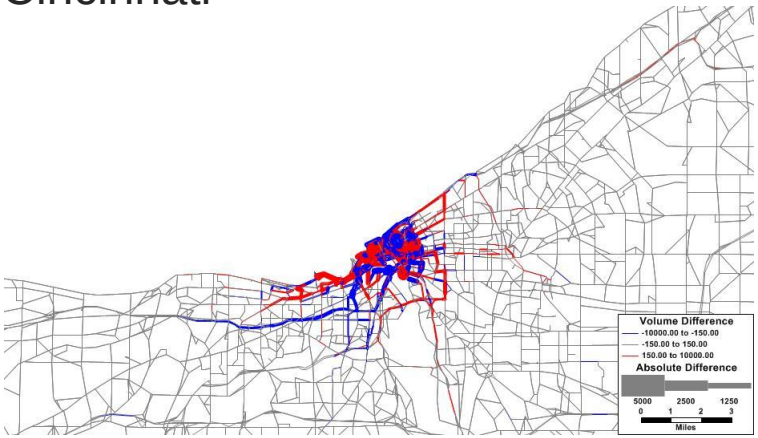


Cincinnati



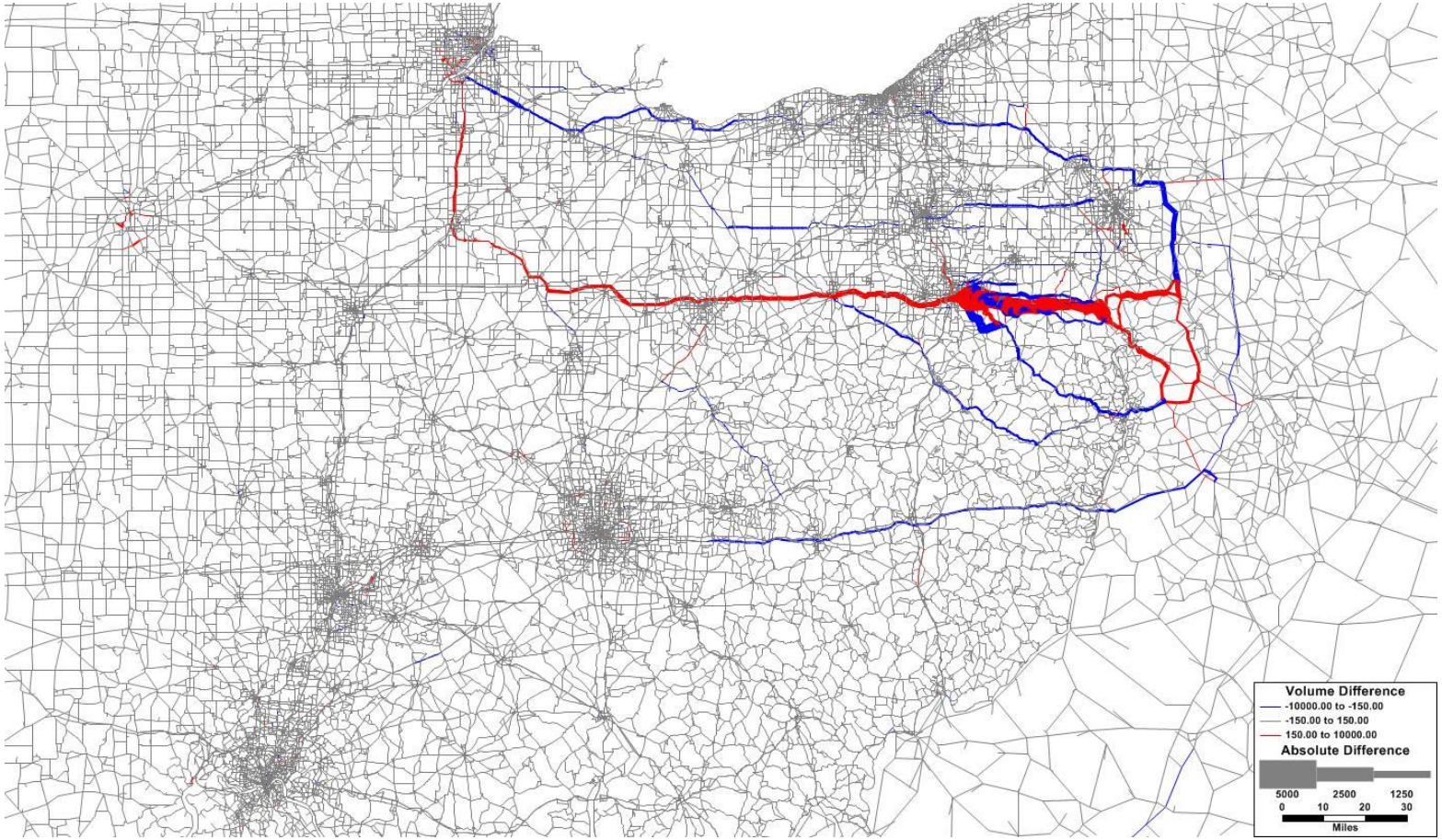
Columbus



Cleveland

Issue: Geographic distribution of economic impact doesn't make sense

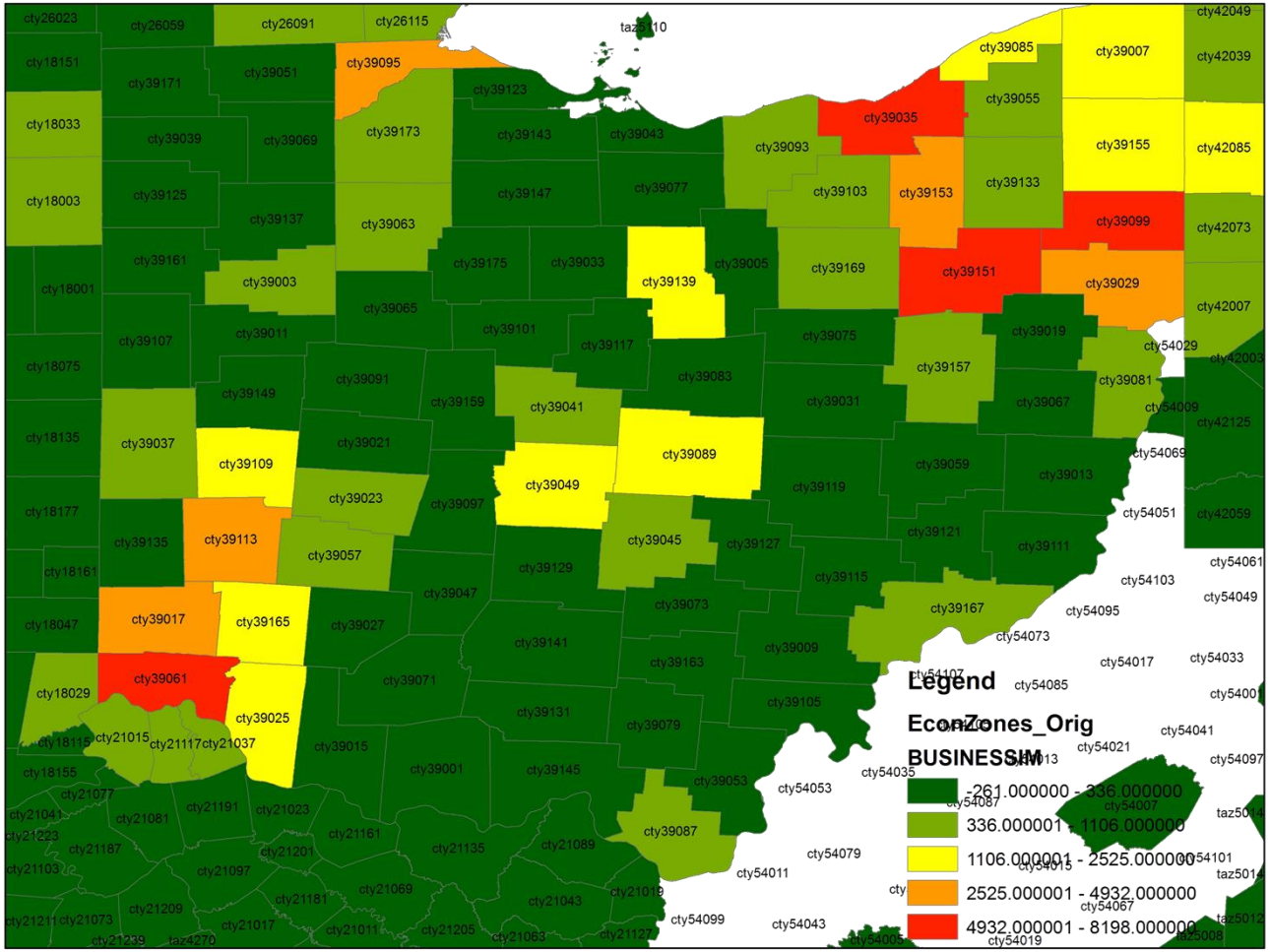
Ok Convergence: Build vs. No Build



Why Convergence Matters

Economic Impacts

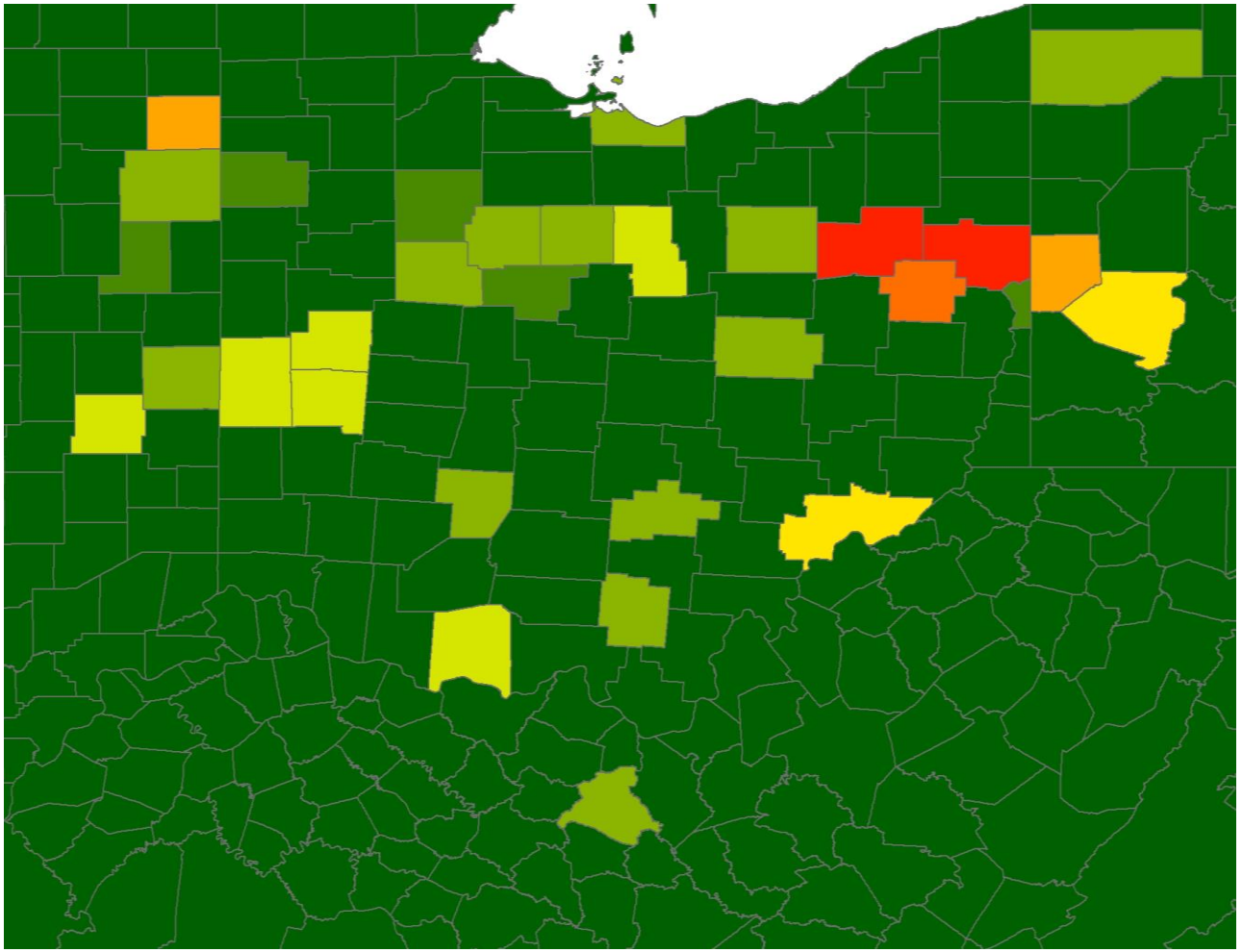
- **Loosely converged assignment results for improved US 30 east of Canton show major benefits in Cincinnati, Cleveland, Toledo, etc.**



Why Convergence Matters

Economic Impacts

- Tighter, but still not totally converged results show economic impacts mostly clustered properly in the US 30 corridor, but still some noise elsewhere



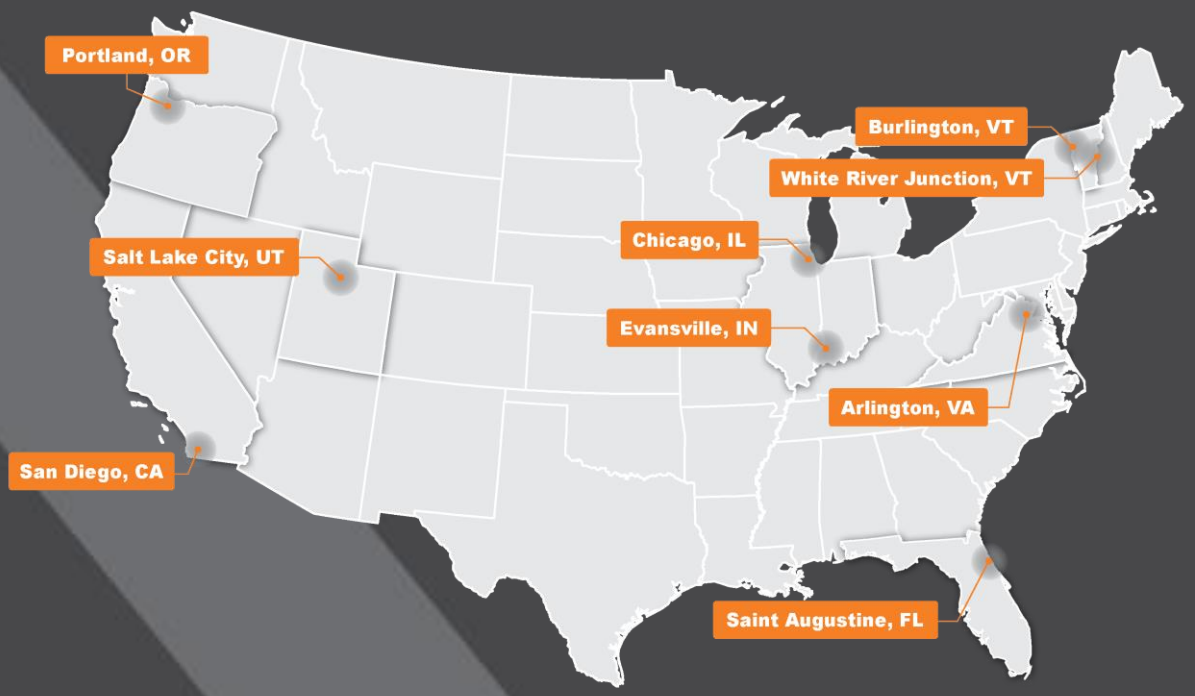
Final Thoughts

Potential for Benefit-Cost Analysis

A Tool for Compromise

COUNTING WHAT MATTERS TO EVERYONE

- In the past, BCA in transportation planning was commonly critiqued
  - Overly focused on economic considerations
  - Not sensitive to environmental / social concerns
  - Not fair to non-auto modes
- New, comprehensive benefit methods combined with equity analysis address these concerns and make BCA a potential tool for getting political buy-in from disparate groups who subjectively value different benefits (if there is buy-in / acceptance of the monetization scheme)
- Can help remove ideological blinders for the public / elected officials:
  - Can help economic/highway oriented to recognize cases where other modes might actually make more economic sense
  - Can help socially/environmentally oriented to recognize some highway projects really make sense and have significant social benefits even when environmental concerns, etc., have been factored in



Contact

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Summary of Benefits

	Benefit	Source	Agency Use
Economic Vitality	Travel Time	US DOT	Extensive
	Travel Time Reliability	SHRP2 C04	SANDAG
	Vehicle Operating Costs	EPA, AAA, ATRI	Extensive
	Vehicle Ownership Costs	AAA	Extensive
Environmental Stewardship	Vehicle Emissions	EPA, BAAQMD, Caltrans	SANDAG
	Surface Water Pollution	VTPI, Volpe	WSDOT
	Noise Pollution	Delucchi and Hsu	AASHTO, VTPI
Social and Equity Values	Motor Vehicle Crashes	AASHTO	Extensive
	Physical Activity	CIPH, CADPH	SANDAG, MTC, SACOG, Nashville
	Travel Options / Choices	FHWA	Tampa