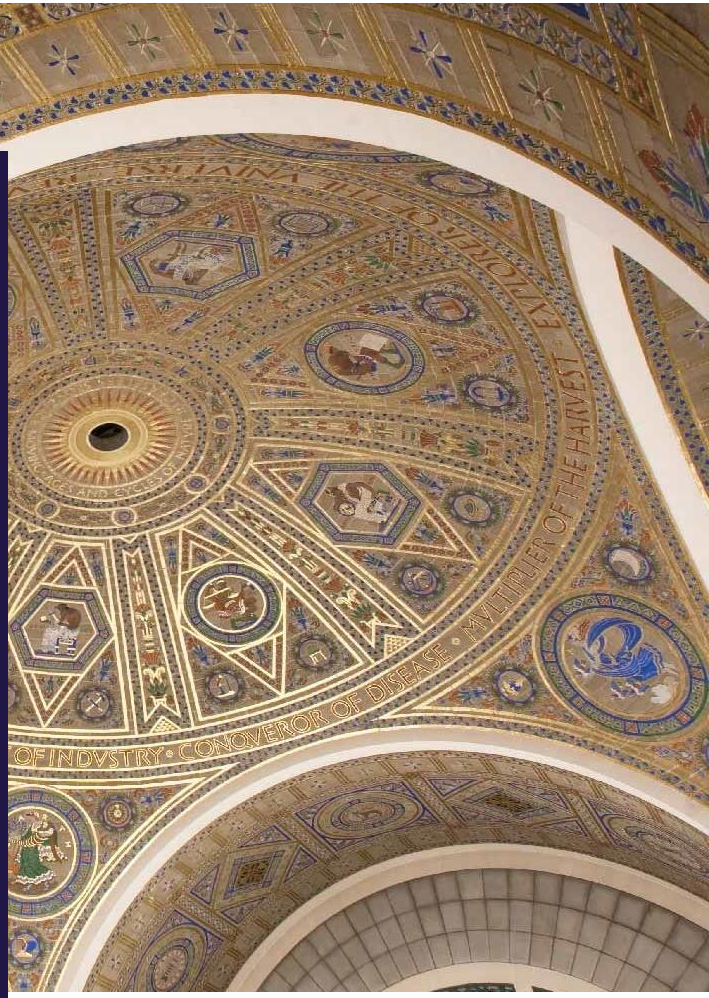
NATIONAL ACADEMIES Sciences Engineering Medicine

TRB TRANSPORTATION RESEARCH BOARD

TRB Webinar: Trends in Transit Ridership—Analysis, Causes, and Responses

December 13, 2022

1:00 – 2:30 PM



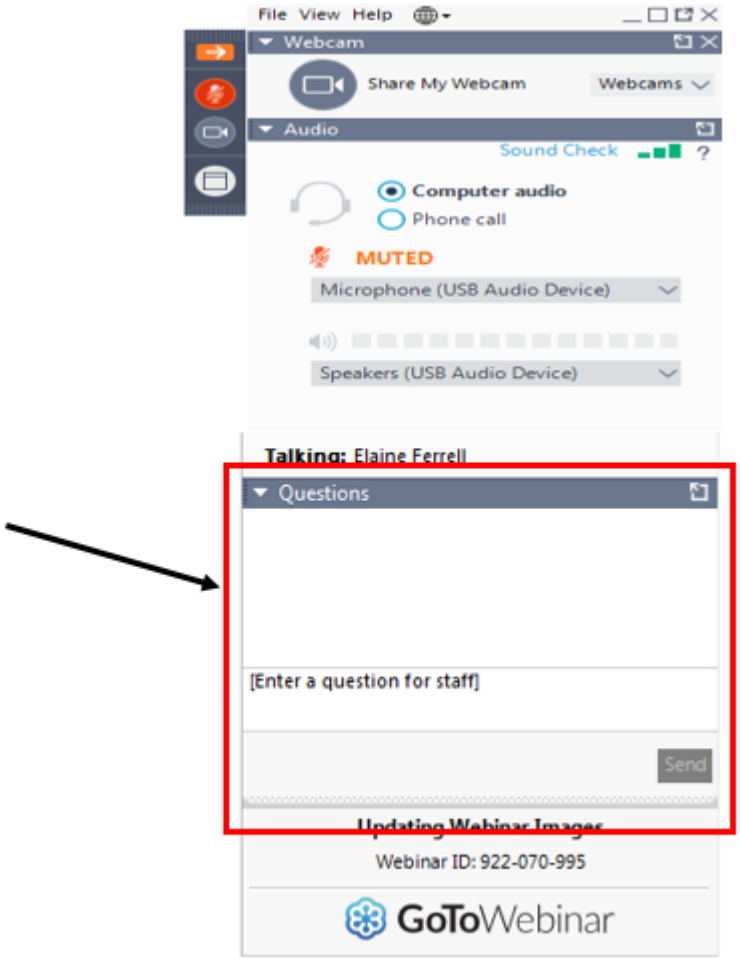
NOVEMBER 2022 UPDATE

Learning Objectives

- Understand what factors lead to ridership declines pre-COVID
- Understand strategies agencies can use to combat ridership declines

Questions and Answers

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many as time allows



Today's presenters

Dr. Kari Watkins
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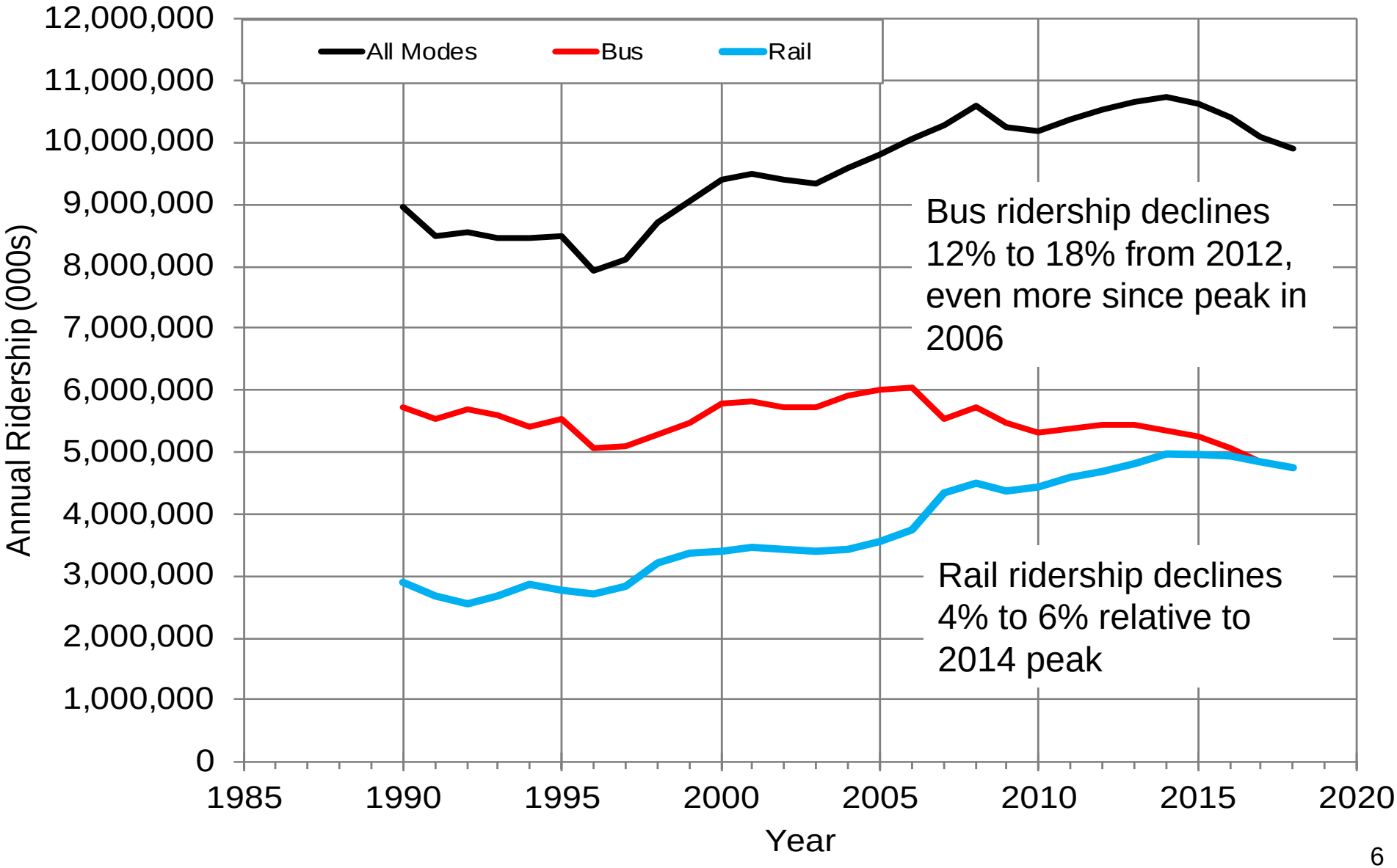
TRB WEBINAR: TRENDS IN TRANSIT RIDERSHIP – ANALYSIS, CAUSES AND RESPONSES

DECEMBER 13, 2022

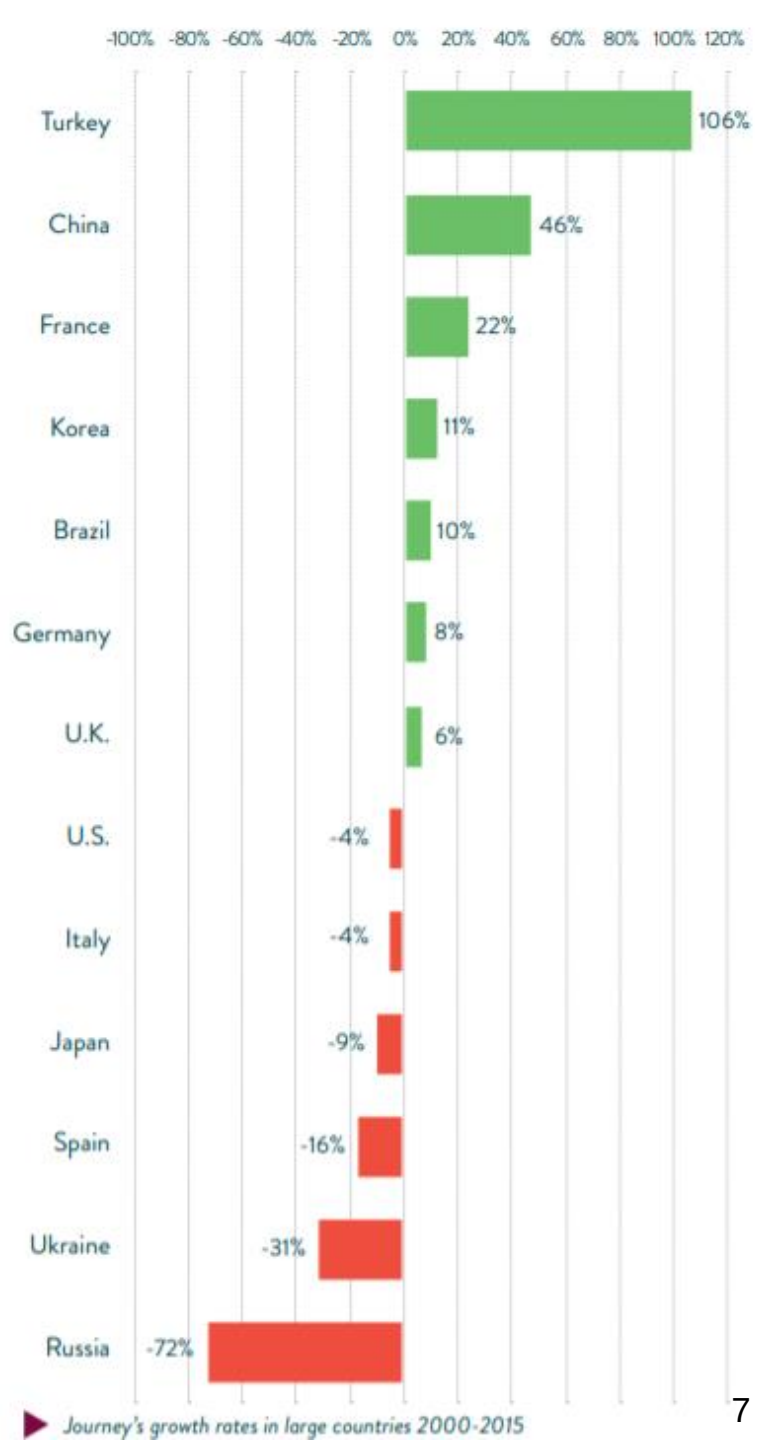
US Transit Ridership by Mode



International Changes in Ridership

US is not alone in their ridership losses, but most countries with similar losses have poor economic conditions or substantial changes in demographics.

Graphics Source: UITP (2017)

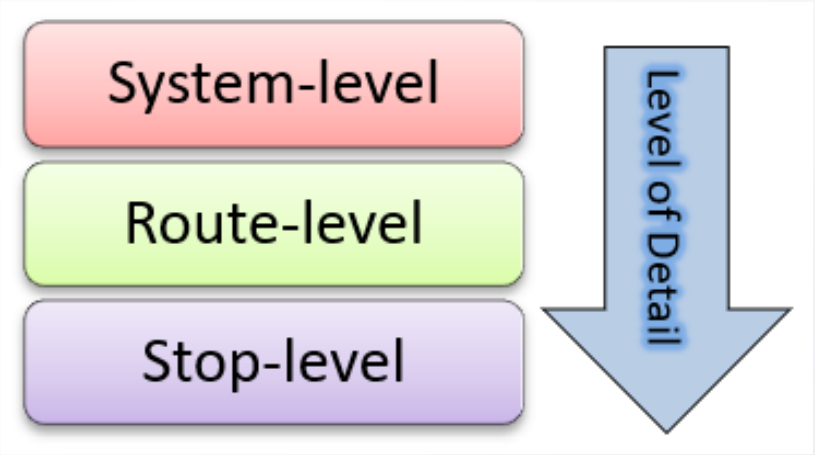


TCRP Report 231: Trends in Transit Ridership – Analysis, Causes and Responses

- The objectives of this research are three-fold:
  - To understand the **factors** contributing to the **recent decline** in transit ridership in the United States and **quantify the relative contribution** of each.
  - To identify **strategies** to mitigate or reverse those declines and to **evaluate the effectiveness** of those strategies.
  - To develop **recommendations** for how public transportation agencies can **respond to the ridership challenges** they are currently facing.

TCRP Report 231 Research Tasks

- **Review of Causes and Solutions**
  - **Dr. Kari Watkins & Team**
- **Multi-city Evaluation**
  - **Dr. Greg Erhardt & Team**
- Stop-level Ridership Analysis
  - Dr. Kari Watkins & Dr. Simon Berrebi
- Route-level Ridership Analysis
  - Dr. Candace Brakewood & Team
- Future Strategy Evaluation
  - Dr. Greg Erhardt & Dr. Josie Kressner & Team
- **Lessons Learned Circle-back**
  - **Dr. Brendon Hemily**



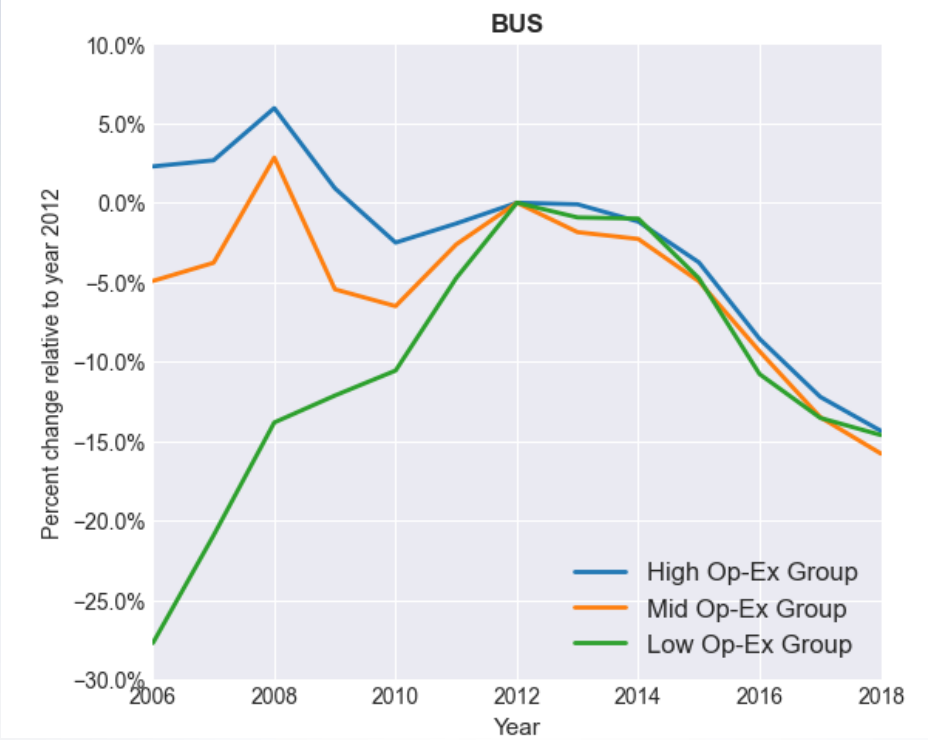
Review of Possible Causes and Solutions

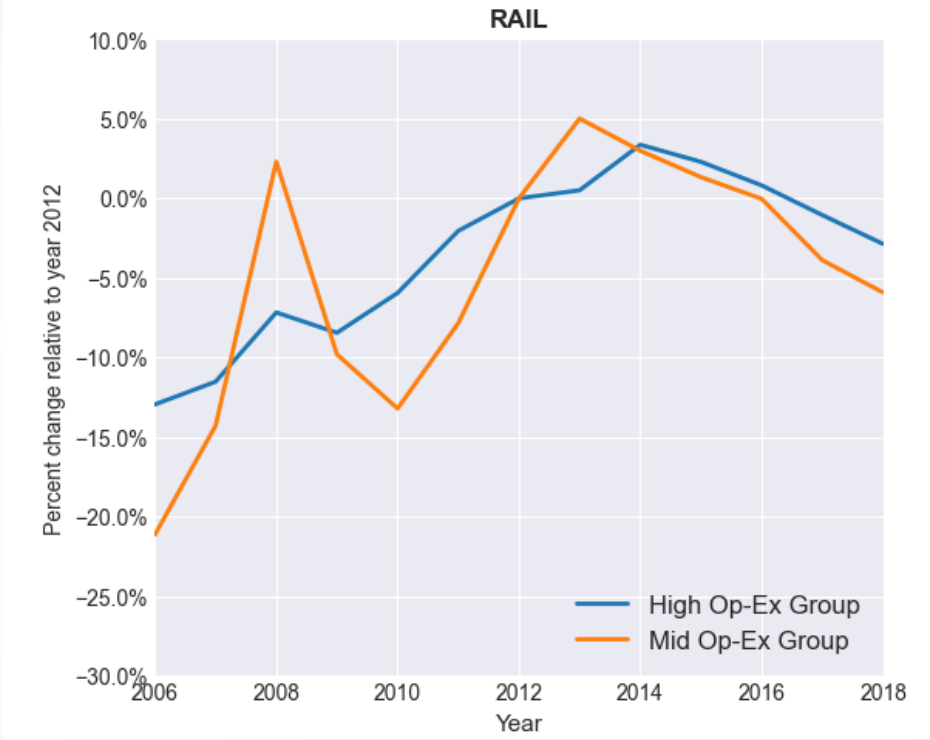
	Internal	External
Traditional	• **Service Quantity** • **Fares** • Speed & Reliability • **Service Concentration** • Access to Transit • Security • Service Quality	• **Density** • **Population** • **Employment** • **Income** • **Gas Prices** • Commute Policies • **Car Ownership** • **Demographics**
Emerging	• **Restructuring transit networks** • Demand response, flex route services, and microtransit pilots & partnerships • New fare media & fare integration • Real-time information • **Maintenance Issues** • **Dedicated transit right-of-way** • School & employer partnerships • **Fare discounts or elimination**	• Gentrification • **Aging Population** • **Millennials** • **Telecommuters** • Delivery services • Congestion & parking pricing • **Shared Mobility (ride-hailing, bikeshare, carshare, scooters)**

Dr. Greg Erhardt

MULTI-CITY RIDERSHIP CHANGE EVALUATION

Between 2012 and 2018 bus ridership in the US declined 15% and rail ridership declined 3%





The decline is:

- Widespread
- Especially steep from 2014-2018
- During a period of economic growth
- In contrast to most other countries

Why?

Service cuts?

Higher incomes?

Fare increases?

Car ownership?

Poor maintenance?

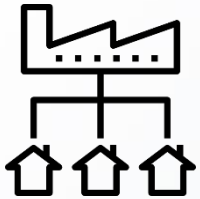
Gas price?

Aging population?

Ride-hail?

Telework?

Low-density development?



Suburbanization of poverty?

E-scooters?

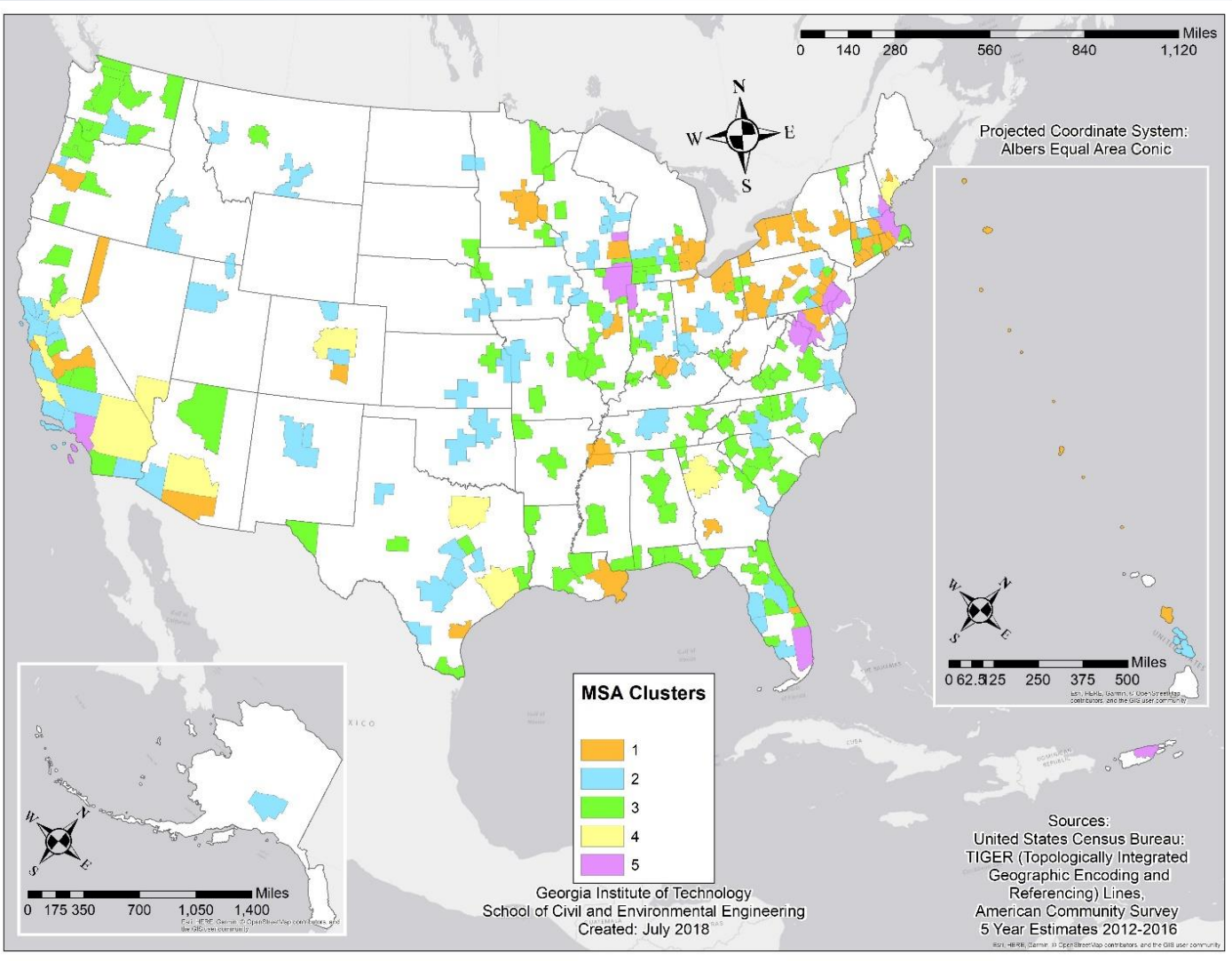
Bike share?

How can we distinguish among these factors?

With many factors changing at once, we need a way to distinguish the effect of each.

We can do so because they change at different rates in different places.

Consider change in bus & rail ridership in each of 215 MSAs annually from 2012-2018.



What did we find?

The Short Story

Causes of net transit ridership gains: 2012-2018

Two factors contributed to **net increases in transit ridership** from 2012-2018:

- **More service:** On average, transit agencies increased service, resulting in more transit ridership. Service increases were bigger on rail than bus.
  - **More service** results in **3% more** bus ridership.
  - **More service** results in **10% more** rail ridership.

- **Land use:** Metro areas grew in both population and employment over this period, contributing to net increases in transit ridership. However, as they grew, metro areas became slight less centralized, partially offsetting some of those gains.
  - **Land use changes** result in **1.4% more** bus and rail ridership.

Causes of net transit ridership decline: 2012-2018

Four factors contributed to **net decreases** in transit ridership from 2012-2018:

- **Income and household characteristics:** Over this period, median incomes increased, car ownership increased, and more people worked at home. Each of these three factors contributed to declining transit ridership.
  - **Combined changes in these factors** result in **about 2% less** bus and rail ridership.

- **Transit travel becomes more expensive:** After adjusting for inflation, average bus and rail transit fares are higher in 2018 than in 2012 for most metro areas. The changes are not uniform, with bigger fare increases on rail and in the low operating expenses group.
  - **Fare increases** result in **0.6% less** bus ridership.
  - **Fare increases** result in **2.6% less** rail ridership.

Causes of net transit ridership decline: 2012-2018

- **Driving becomes less expensive:** After adjusting for inflation, average gas prices have declined about $4.00 per gallon in 2012 to about $2.85 per gallon in 2018, depending on the metro area. The lower cost of driving contributes to the transit ridership decline.
  - **Cheaper gas** results in **4% less** bus and rail ridership.

- **New modes compete with bus:** New competing modes entered many metro areas over this period. Ride-hail has a negative and significant effect that varies in magnitude based on the mode and cluster. **Bike share** has a positive effect and **e-scooters** have a negative effect, but both are statistically **insignificant**.
  - **Ride-hailing** leads to **10% less bus** ridership.
  - For MSAs with the largest transit operators, **ride-hailing** effect **insignificant**.
  - For MSAs with mid-sized transit operators, **ride-hailing** leads to **10% less rail** ridership.

What did we find?

https://www.pinterest.com/pin/574279389959263106/

The Long Story

Data and Methods

1. **Compile** annual data for 215 Metropolitan Statistical Areas (MSAs) from National Transit Database and other sources.
2. **Estimate** the sensitivity to each factor using 2012-2018 data.
3. **Multiply** the estimated elasticity by the observed change in each variable.
4. **Validate** against 2002-2011 data.

Estimated Sensitivities

Fixed-effects panel model of the log of bus and rail ridership in each MSA (part 1)

Description	Transf.	Coeff.	t-statistics
Service			
Vehicle Revenue Miles (Bus)	Log	0.449	14.66
Vehicle Revenue Miles (Rail)	Log	0.662	16.05
Major maintenance event		-0.133	-1.89*
Network restructure		0.047	1.35**
Fare			
Average Fare (in 2018$) (Bus)	Log	-0.579	-16.29
Average Fare (in 2018$) (Rail)	Log	-0.346	-4.3
Land Use			
Population + Employment	Log	0.218	2.78
Percent of total employees living and working in Transit Supportive Density in an MSA		0.399	1.39**
Gas Price			
Average Gas Price (in 2018$)	Log	0.143	7.77

** Not statistically significant at 90% confidence interval
* Statistically significant at a 90% confidence interval but not at a 95% confidence interval

R-squared = 0.54

Estimated Sensitivities

Fixed-effects panel model of the log of bus and rail ridership in each MSA (part 2)

Description	Transf.	Coeff.	t-statistics
Median Per Capita Income (in 2018$)	Log	-0.071	-1.19**
% of Households with 0 Vehicles		0.002	0.78**
% Working at Home		-0.008	-2.86
New Competing Modes			
Effect of the Presence of TNCs on Bus Ridership			
At MSAs where transit operating expenses exceed 300M		-0.019	-4.71
At MSAs where transit operating expenses are less than 300M		-0.033	-12.66
Effect of the Presence of TNCs on Rail Ridership			
At MSAs where transit operating expenses exceed 300M		0.002	-0.46**
At MSAs where transit operating expenses are between 30M to 300M		-0.023	-3.85
Presence of Bike Share		-0.011	-1.51**
Presence of Electric Scooters		-0.039	-3.28

** Not statistically significant at 90% confidence interval
* Statistically significant at a 90% confidence interval but not at a 95% confidence interval

R-squared = 0.54

Contributions to bus ridership change between 2012 and 2018

estimated elasticity * observed change in value, summed across entities

Description	Change in Average Values by Operating Expenses Group			Ridership Effect by Operating Expenses Group		
	High	Mid	Low	High	Mid	Low
Service						
VRM	4.2%	11.9%	9.0%	2.5%	4.7%	4.0%
Network Restructure	0.03	0.03	0.0	0.1%	0.1%	0.0%
Subtotal				*2.6%*	*4.9%*	*4.0%*
Fare						
Average Fare (2018$)	0.0%	1.6%	17.8%	-0.3%	-0.3%	-4.0%
Subtotal				*-0.3%*	*-0.3%*	*-4.0%*
Land Use						
Population + Employment	6.3%	7.9%	5.8%	1.4%	1.7%	1.1%
Percent of Population + Employment in Transit Supportive Density	-0.2%	-1.2%	-1.9%	0.0%	-0.2%	-0.1%
Subtotal				*1.4%*	*1.5%*	*1.0%*
Gas Price						
Average Gas Price (2018$)	-26.4%	-28.8%	-29.5%	-3.4%	-3.8%	-3.9%
Subtotal				*-3.4%*	*-3.8%*	*-3.9%*

Contributions to bus ridership change between 2012 and 2018

estimated elasticity * observed change in value, summed across entities

Description	Change in Average Values by Operating Expenses Group			Ridership Effect by Operating Expenses Group		
	High	Mid	Low	High	Mid	Low
Household and Income Characteristics						
Median Per Capita Income (2018$)	12.5%	9.5%	8.4%	-0.8%	-0.6%	-0.6%
Percent of Households with 0 Vehicles	-8.7%	-12.8%	-4.8%	-0.2%	-0.2%	-0.1%
Percent Working at Home	22.7%	32.5%	35.1%	-0.8%	-1.0%	-0.9%
Subtotal				*-1.7%*	*-1.8%*	*-1.5%*
New Competing Modes						
Years Since Ride-Hail Start	5.68	3.86	3.26	-10.2%	-11.8%	-9.8%
Bike-Share	0.79	0.74	0.54	-0.8%	-0.8%	-0.5%
Electric Scooters	0.54	0.41	0.07	-1.9%	-1.3%	-0.3%
Subtotal				*-12.9%*	*-13.9%*	*-10.5%*
Total Modeled Ridership				-14.4%	-13.4%	-15.0%
Total Observed Ridership				-14.4%	-15.8%	-14.6%
Unexplained Change				0.1%	-2.4%	0.4%

Contributions to rail ridership change between 2012 and 2018

estimated elasticity * observed change in value, summed across entities

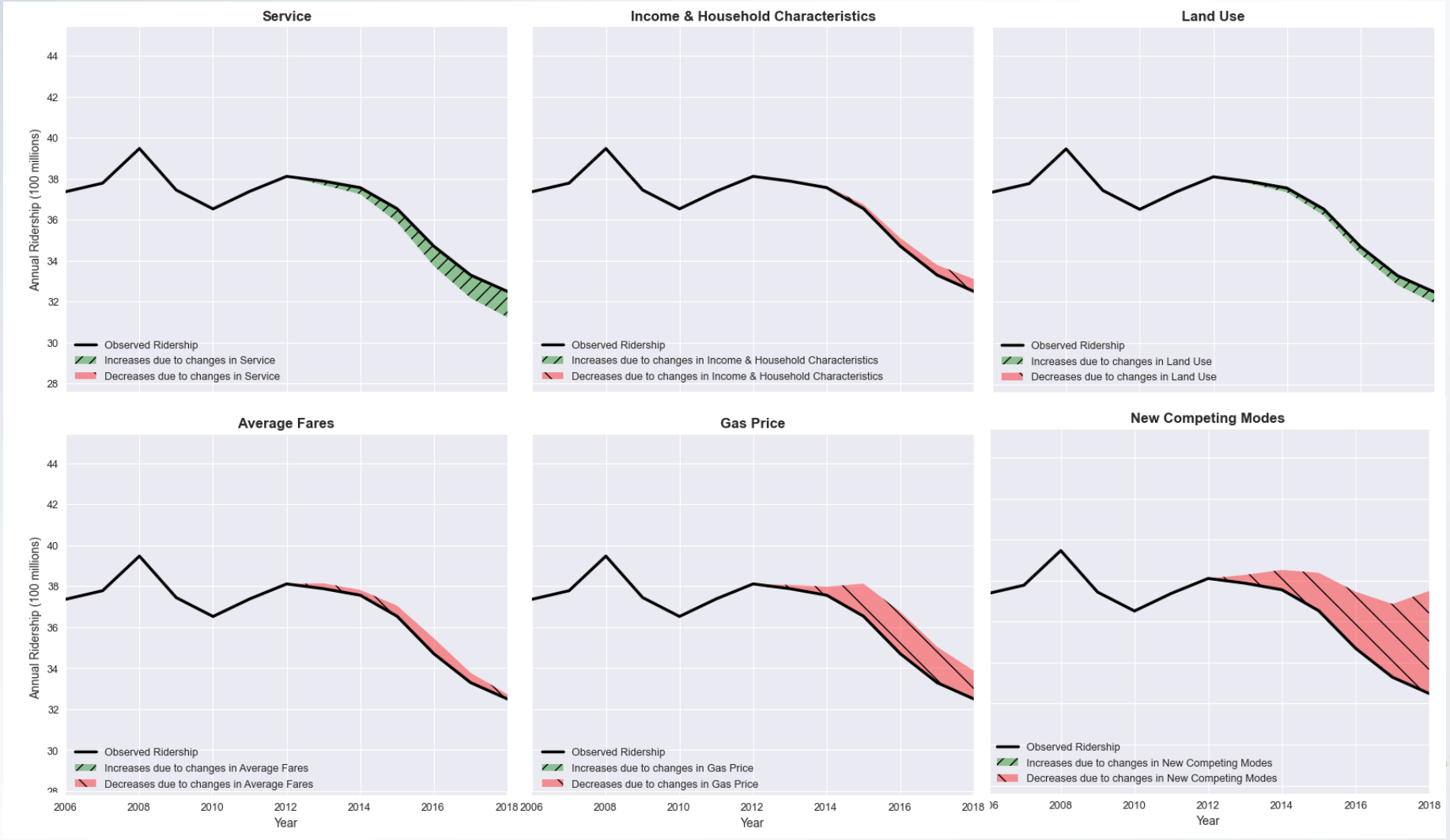
Description	Change in Average Values by Operating Expenses Group		Ridership Effect by Operating Expenses Group	
	High	Mid	High	Mid
Service				
VRM	11.8%	22.9%	10.0%	17.9%
Major Maintenance Event	0.09	0.0	0.0%	0.0%
Subtotal			*10.0%*	*17.9%*
Fare				
Average Fare (2018$)	12.7%	7.4%	-2.7%	-0.9%
Subtotal			*-2.7%*	*-0.9%*
Land Use				
Population + Employment	6.0%	6.0%	1.4%	1.5%
Percent of Population + Employment in Transit Supportive Density	0.1%	-2.0%	0.0%	-0.3%
Subtotal			*1.4%*	*1.2%*
Gas Price				
Average Gas Price (2018$)	-28.5%	-28.4%	-3.7%	-3.9%
Subtotal			*-3.7%*	*-3.9%*

Contributions to rail ridership change between 2012 and 2018

estimated elasticity * observed change in value, summed across entities

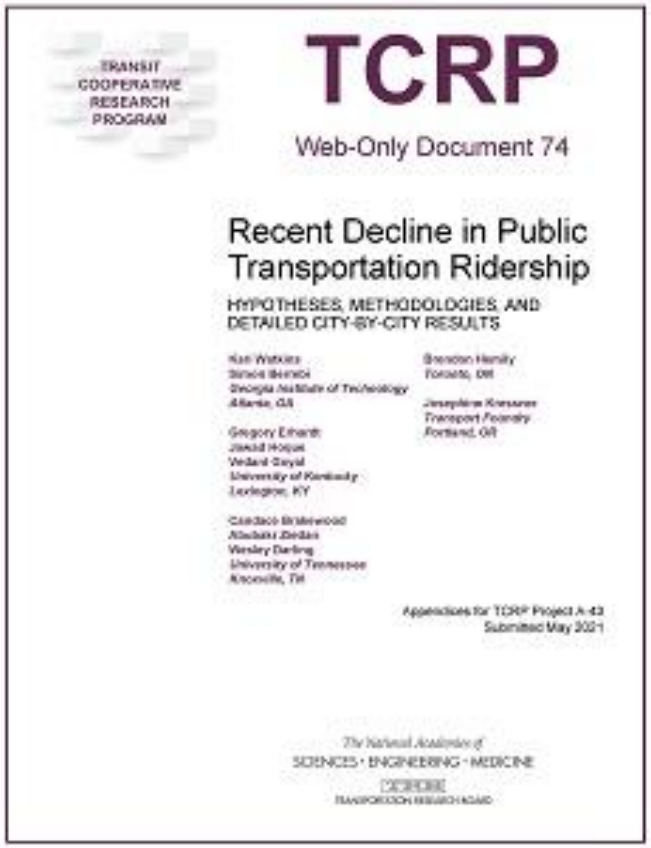
Description	Change in Average Values by Operating Expenses Group		Ridership Effect by Operating Expenses Group	
	High	Mid	High	Mid
Household and Income Characteristics				
Median Per Capita Income (2018$)	11.5%	9.4%	-0.8%	-0.7%
Percent of Households with 0 Vehicles	-7.1%	-13.5%	-0.2%	-0.2%
Percent Working at Home	24.1%	32.5%	-0.9%	-1.4%
Subtotal			*-1.8%*	*-2.3%*
New Competing Modes				
Years Since Ride-Hail Start	5.88	4.21	1.3%	-9.7%
Bike-Share	0.64	0.50	-0.7%	-0.6%
Electric Scooters	0.64	0.55	-2.4%	-2.2%
Subtotal			*-1.8%*	*-12.5%*
Total Modeled Ridership			1.3%	-0.5%
Total Observed Ridership			-2.9%	-5.9%
Unexplained Change			-4.2%	-5.4%

Contributions to bus ridership change relative to 2012



Contributions to rail ridership change relative to 2012

These results are available online for every metropolitan area in our sample


TRANSIT COOPERATIVE RESEARCH PROGRAM

TCRP

Web-Only Document 74

Recent Decline in Public Transportation Ridership

HYPOTHESES, METHODOLOGIES, AND DETAILED CITY-BY-CITY RESULTS

Appendices for TCRP Project A-43
Submitted May 2021

The National Academies of SCIENCES · ENGINEERING · MEDICINE

TRANSPORTATION RESEARCH BOARD

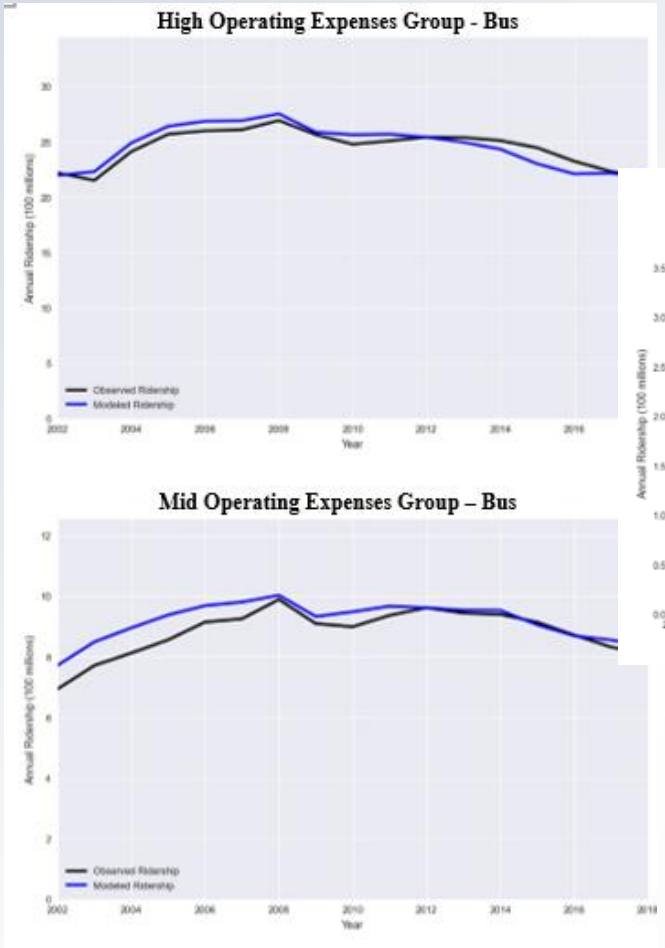
Jacksonville, FL Metro Area-Bus

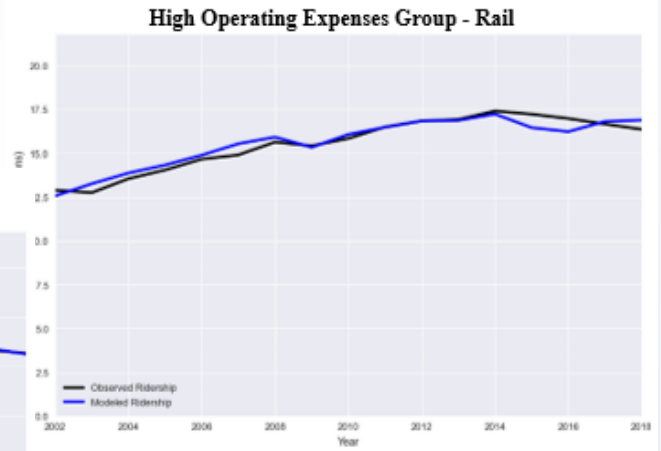
	Average Values			Ridership Effect	
Description	2012	2018	% Diff	Absolute	% Diff
Vehicle Revenue Miles	8,821,510	9,100,360	3.2%	159,430	1.4%
Average Fare (2018$)	1.13	0.99	-12.3%	436,000	3.8%
Network Restructure	-	1.000	-	534,945.44	4.8%
Major Maintenance Event	-	-	-	-	0.0%
Population + Employment	2,024,210	2,284,610	12.9%	296,790	2.6%
Share of Population and Employment in Transit Supportive Density	0.18	0.18	-1.7%	-14,380	-0.1%
Average Gas Price (2018$)	3.95	2.71	-31.3%	-459,400	-4.0%
Median Per Capita Income (2018$)	27,710	30,570	10.3%	-80,010	-0.7%
% of Households with 0 Vehicles	7	6	-17.4%	-27,660	-0.2%
% Working at Home	4.7	6.8	43.6%	-178,440	-1.6%
Years Since Ride-hail Start	-	4	4	-1,494,560	-13.1%
Bike Share	-	1	1	- 121,190	-1.1%
Electric Scooters	-	-	-	-	0.0%
New Reporters				-	0.0%
Total Modeled Ridership					-8.4%
Total Observed Ridership					-8.5%
Unexplained Change					-0.1%

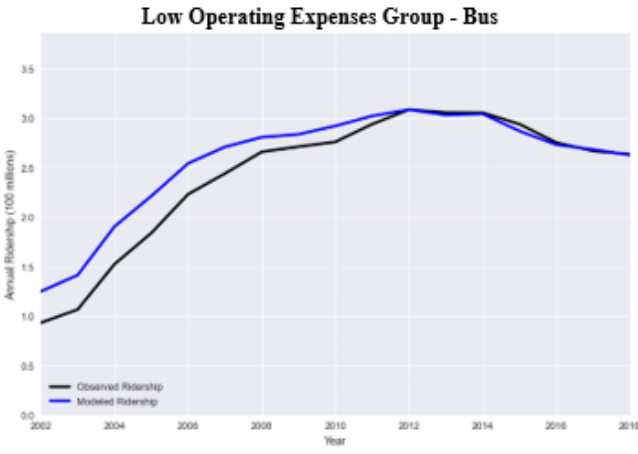
https://nap.nationalacademies.org/download/26494

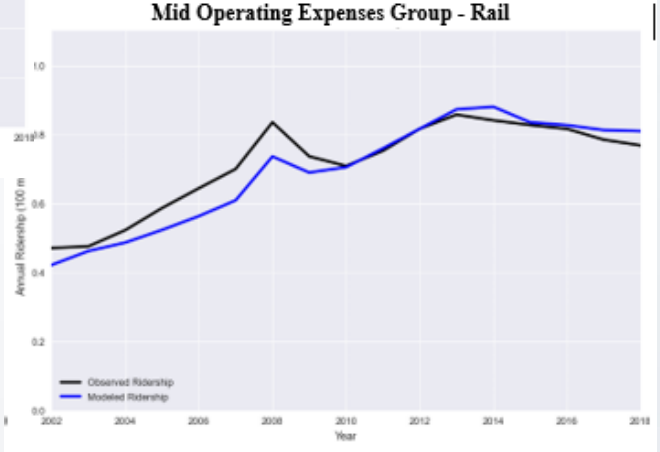
We tested the model for years outside the estimation range

Modeled ridership in blue vs observed ridership in black, by MSA group









Other research shows similar results within a city

Do Transportation Network Companies Increase or Decrease Transit Ridership? Empirical Evidence from San Francisco

Presentation: TRBAM-22-00042

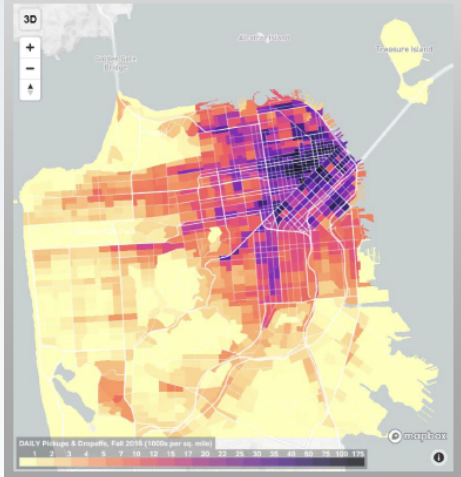
Gregory D. Erhardt[1], Richard Alexander Mucci[1], Drew Cooper[2], Bhargava Sana[2], Mei Chen[1], Joe Castiglione[2]

[1] *University of Kentucky,* [2] *San Francisco County Transportation Authority*

Background

Transportation Network Companies (TNCs), such as Uber and Lyft, have been hypothesized to both complement and compete with public transit. Existing research on the topic is limited by a lack of detailed data on the timing and location of TNC trips.

This study overcomes that limitation by using data scraped from the Application Programming Interfaces (APIs) of two TNCs, combined with Automated Passenger Count (APC) data on transit use and other supporting data. The data show that TNC use is highest in the densest parts of San Francisco where they compete directly with transit.



Daily TNC pickups and dropoffs for an average Wednesday in Fall 2016. Data and an interactive mapping tool are available at tncstoday.sfcta.org.

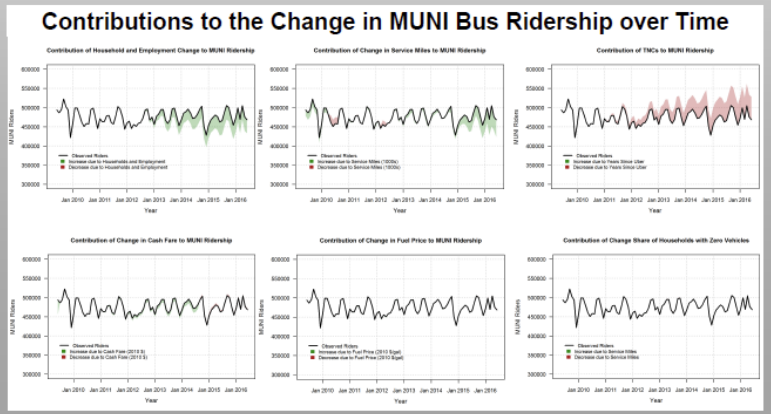
Between 2010 and 2015, **TNCs decreased Muni bus ridership** in San Francisco by about 10%.

Contributions to the Change in MUNI Ridership

Category	Bus Panel Model Estimate	Bus Time-Series Model Estimate	Rail Panel Model Estimate
Households and Employment / Accessibility	2.0%	7.6%	2.1%
Transit Service	6.6%	7.1%	0.3%
Transit Fare	n/a	-1.0%	n/a
Gas Price	n/a	-0.5%	n/a
Car Ownership	n/a	0.1%	n/a
Transfers from Regional Transit	1.2%	n/a	2.0%
Income	1.0%	n/a	0.7%
TNCs	-8.6%	-10.8%	3.8%
Unexplained Change	-1.9%	-2.2%	4.2%
Total Ridership	0.3%	0.3%	13.1%

Findings: We find that changes in other factors, primary household and employment growth combined with transit service expansions, are expected to result in bus ridership growth over this period. However, bus ridership does not increase because those expected gains are offset by losses due to competition with TNCs. We do not find a statistically significant relationship between TNCs and Muni light rail ridership.

Contributions to the Change in MUNI Bus Ridership over Time



University of Kentucky

Methods

This result is confirmed by two separate statistical models that control for other changes in the city over that time, including changes to households and employments, transit service, fares, gas price, car ownership and transfers from regional transit systems.

Time-Series Model of MUNI Bus Ridership

Model Structure

Model Form	Regression on time-series data
Differencing	12-month 1st difference
Dependent Variable	$\log(Y_t) - \log(Y_{t-12})$ Where Y_t = average weekday Muni bus ridership in month t

Exogenous Variables (X_t)

Description	Transformation	Coefficient	Standard Error	T-Stat
Households and Employment:				
Households	$\log(X_t) - \log(X_{t-12})$	0.2545	0.3991	0.64
Employment Rate (Workers / Population)	$\log(X_t) - \log(X_{t-12})$	1.1118	0.3707	3.00
Transit Service:				
Service miles, 1000s	$\log(X_t) - \log(X_{t-12})$	0.5541	0.0957	5.79
Transit Fare:				
Cash fare (2010 USD)	$\log(X_t) - \log(X_{t-12})$	-0.2730	0.0684	-3.99
Gas Price:				
Gas Price (2010 USD)	$\log(X_t) - \log(X_{t-12})$	0.0282	0.0348	0.81
Car Ownership:				
Share of 0-Car Households	$\log(X_t) - \log(X_{t-12})$	0.1346	0.1764	0.76
TNCs:				
Years Since TNC Launch	$X_t - X_{t-12}$	-0.0226	0.0100	-2.26

Model Statistics

Number of Time Periods	85
Log-Likelihood	163.4
AIC	-310.79
R-squared	0.563
Box-Pierce test p-value	0.19

Panel Model of MUNI Bus and Rail Ridership

Model Structure

Dependent Variable	Log(Bus or Rail Ridership)
Model Form	Fixed-effects panel data regression

Exogenous Variables

Description	Transformation	Smoothing	Coefficient	Standard Error	T-Stat
Accessibility:					
Accessibility (Jobs + HH w/i 30 minutes by transit)	Log	TAZ Only	0.1324	0.0445	2.98
Transit Service:					
Number of Routes Serving TAZ	Log	TAZ Only	0.3146	0.0477	6.60
Trip Stops: Bus	Log	TAZ Only	0.9816	0.0441	22.25
Trip Stops: Light Rail	Log	TAZ Only	0.2242	0.0736	3.05
Online Performance (Share of vehicles +1 to -5 min)		TAZ Only	0.3317	0.0574	5.77
Competing Bus Trip Stops	Log	Nearby TAZs	-0.4935	0.0869	-5.68
Transfers from Regional Transit:					
BART + Caltrain, Average of Ons + Offs	Log	Nearby TAZs	0.3121	0.0771	4.05
Income:					
Share of Households in Lowest Income Quartile		Nearby TAZs	2.1997	0.6250	3.52
Share of Households in Highest Income Quartile		Nearby TAZs	-0.7763	0.3944	-1.97
TNCs:					
Average of TNC Ons + Offs: Bus	Log	Nearby TAZs	-0.0254	0.0047	-5.42
Average of TNC Ons + Offs: Rail	Log	Nearby TAZs	0.0111	0.0086	1.29
Unexplained Change:					
Systemwide Changes (Time Effect)		Everywhere	0.0139	0.0167	0.83

Model Statistics

Number of Entities	3679
Number of Time Periods	2
Log likelihood	1909.9
R-squared between groups	0.853
R-squared within groups	0.326

Acknowledgments

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Dr. Brendon Hemily

KEY LESSONS LEARNED AND STRATEGIES

Key Lessons Learned and Strategies

- Rethink Mission, Service Standards, Metrics and Service Delivery
- Use Fare Discounts / Rethink Fare Policy
- Give Transit Priority
- Careful Partnerships with Mobility Providers (e.g., Micromobility, TNCs)
- Encourage Transit-Oriented Density

Key Lessons Learned and Strategies

- **Rethink Mission, Service Standards, Metrics and Service Delivery**
  - Service = ridership
  - Ridership was peaking, although COVID impacts could reverse this
  - Time to rethink metrics to reflect twin missions of good transit
    - Respectfully serve those who rely on transit on a day-to-day basis
    - Efficiently provide mobility in urban areas.
  - **Considerations:**
    - Consider a Mobility Management Mission for the Organization
    - Adopt a More Wholistic Perspective on Performance Measurement that is Human-Centric

Key Lessons Learned and Strategies

- **Rethink Fare Policy**
  - Fare free promotions for students, kids in summer, seniors, and veterans showed significant positive impacts on bus ridership
  - **Considerations:**
    - Strategy for Fare Discounts
    - Model Business Impacts of Fare Discounts
    - Ensure Flexibility and Periodic Re-Evaluation
    - Pay Attention to Practical Set-up and Monitor Usage
    - Assess Impact of Fare Discounts on ADA Paratransit Service
    - Rethink Fare Policy for a Post-Covid New Normal

Key Lessons Learned and Strategies

- **Give Transit Priority**
  - Light Rail in Twin Cities substantially increased ridership with reductions in service and little impact to bus ridership
  - BRT in Twin Cities and Cleveland increased ridership as well
  - **Considerations:**
    - Build Partnership with Traffic Engineering Counterparts
    - Pay Considerable Attention to Parking Strategy
    - Explicitly Consider Enforcement
    - Take Advantage of All Road or Utility Work to Insert Priority Treatments
    - Develop Multi-Tiered Communications Strategy to Engage Riders and Address Concerns of Local Merchants
    - Use of a Pilot Project for Rapid Testing of a Concept
    - Importance of Concept of Operations for Implementing TSP
    - Coalition Building and Maintenance for the Long Haul is Key to Success and Critical in Early Stages of Project Management

Key Lessons Learned and Strategies

- **Careful Partnerships with Micro Providers**
  - Shared e-scooters do not have a significant impact on local bus ridership
  - Shared e-scooters could complement express bus routes as first/last mile connectors to a small degree
  - Ride-hail reduced ridership substantially

  - **Considerations:**
    - Define the Problem or Service Gap of Concern and the Related Goal of the Partnership
    - Assess the Desirable and/or Feasible Level of Cooperation, Coordination or Integration with Microtransit, Micromobility, or TNC Providers
    - Consider All Alternatives and Carefully Model Business Impacts
    - Regulatory Compliance is a Major Issue in Negotiations with TNCs
    - Agreement on Data Sharing is a Major Challenge in Negotiations with TNCs

Key Lessons Learned and Strategies

- **Encourage Transit-Oriented Density**
  - Density and development supportive of transit can keep transit competitive
  - **Considerations:**
    - Increasing Transit-Oriented Density is a Long-Term Process and Requires Transit Participation in Metropolitan-Level Vision and Planning
    - Develop Transit-Oriented Community Vision and Promote with Developers, Local Business Leaders and Municipal Policymakers
    - Build Ongoing Partnership with Municipal Planners to Develop Zoning and Shape Development

Key Lessons Learned and Strategies

- **Circle-Back: Key Resources / References**
  - Rethink Mission, Service Standards, Metrics and Service Delivery (6)
  - Use Fare Discounts / Rethink Fare Policy (5)
  - Give Transit Priority
    - Transit Priority Physical Measures (4)
    - Transit Signal Priority (2)
    - Bus Rapid Transit (4)
    - Light Rail Transit (4)
  - Careful Partnerships with Mobility Providers (e.g., Micromobility, TNCs) (7)
  - Encourage Transit-Oriented Density (4)

Key Lessons Learned and Strategies

- **Future Transit Ridership Impacts**
  - Telecommuting impacts on transit will likely continue
  - Population density may continue to decline
  - Low gas prices hurt transit ridership *(but impact of higher gas prices uncertain)*
  - Potential exists for higher transit fares *(but depends on subsidy framework)*
  - Impact on new modes is unknown

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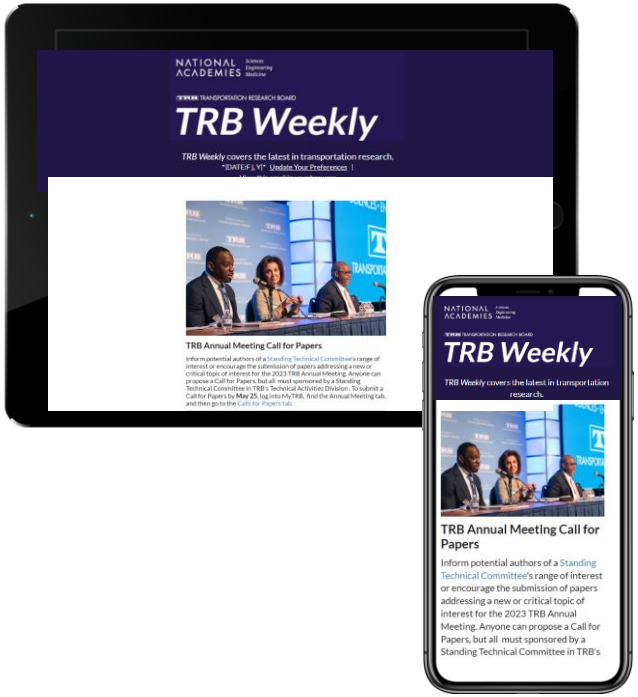

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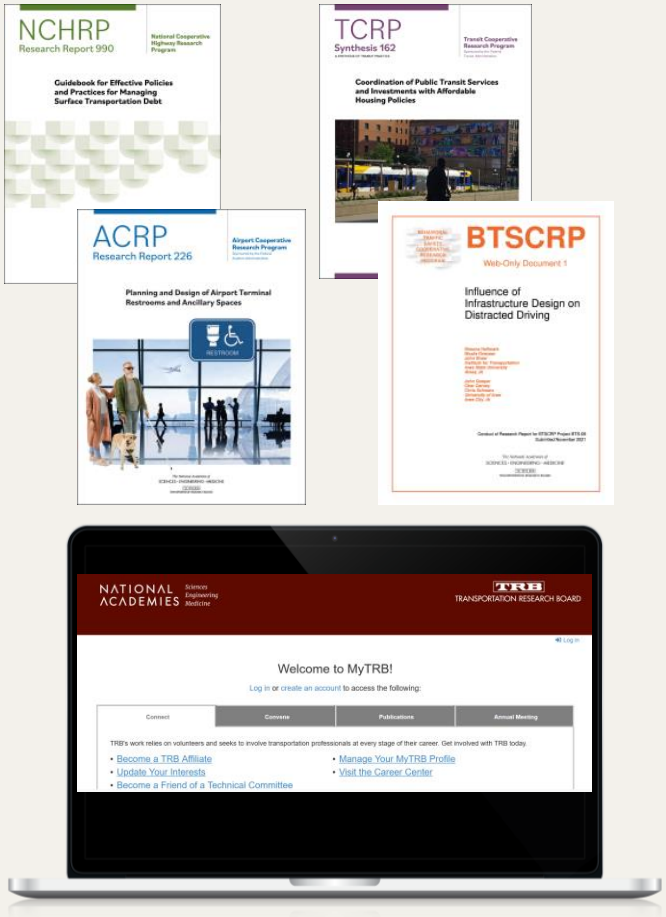

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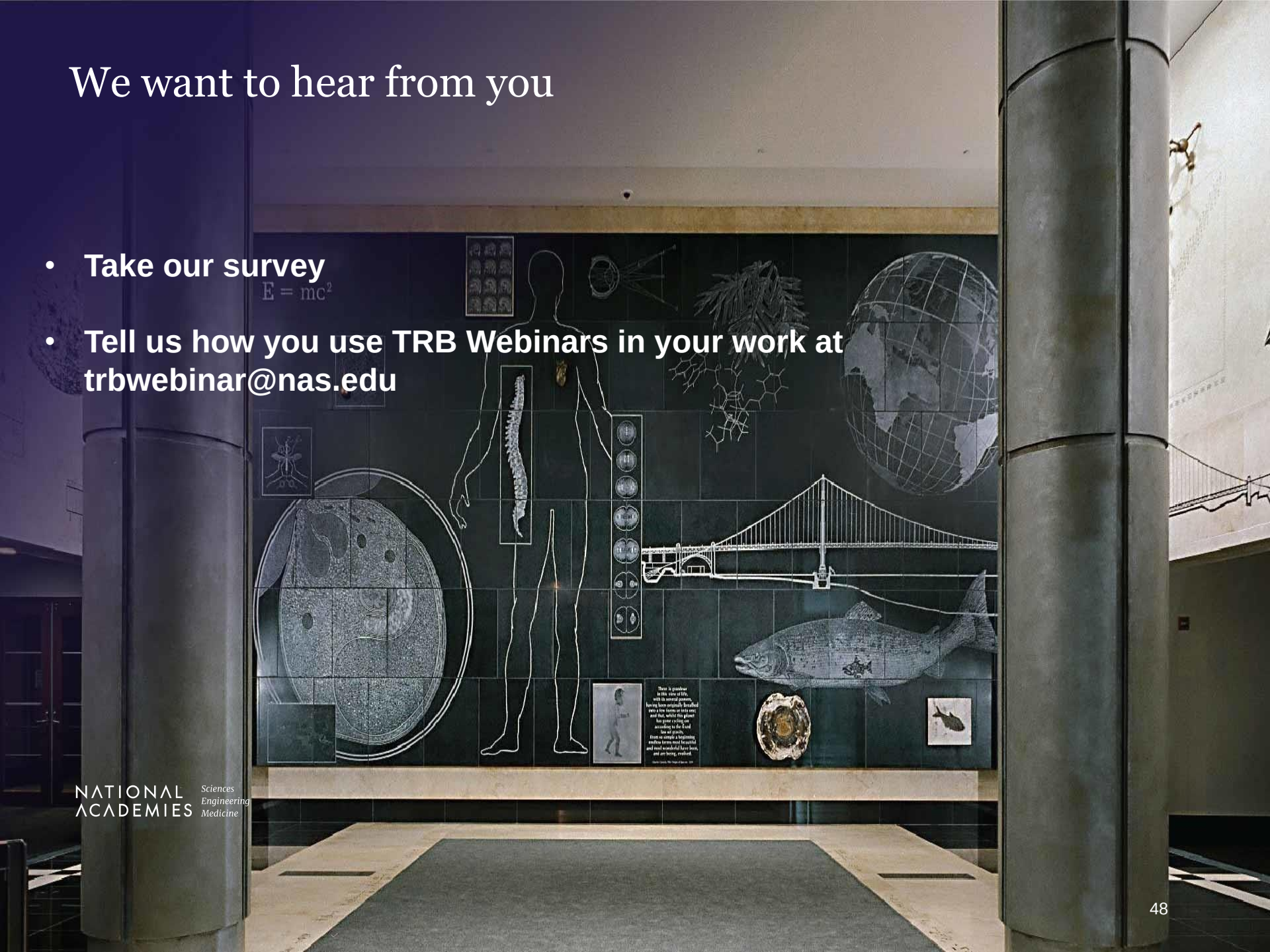

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