Emerging markets, evolving roles:
Lessons from research on cost-effective ways to improve transit in the years ahead

2008 UCLA Lake Arrowhead Symposium

on the Transportation – Land Use – Environment Connection

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Game Plan

- What explains transit ridership?
- Thinking outside the bus
- Who rides transit, and how is that changing over time?
- How can transit achieve realistic goals more effectively?

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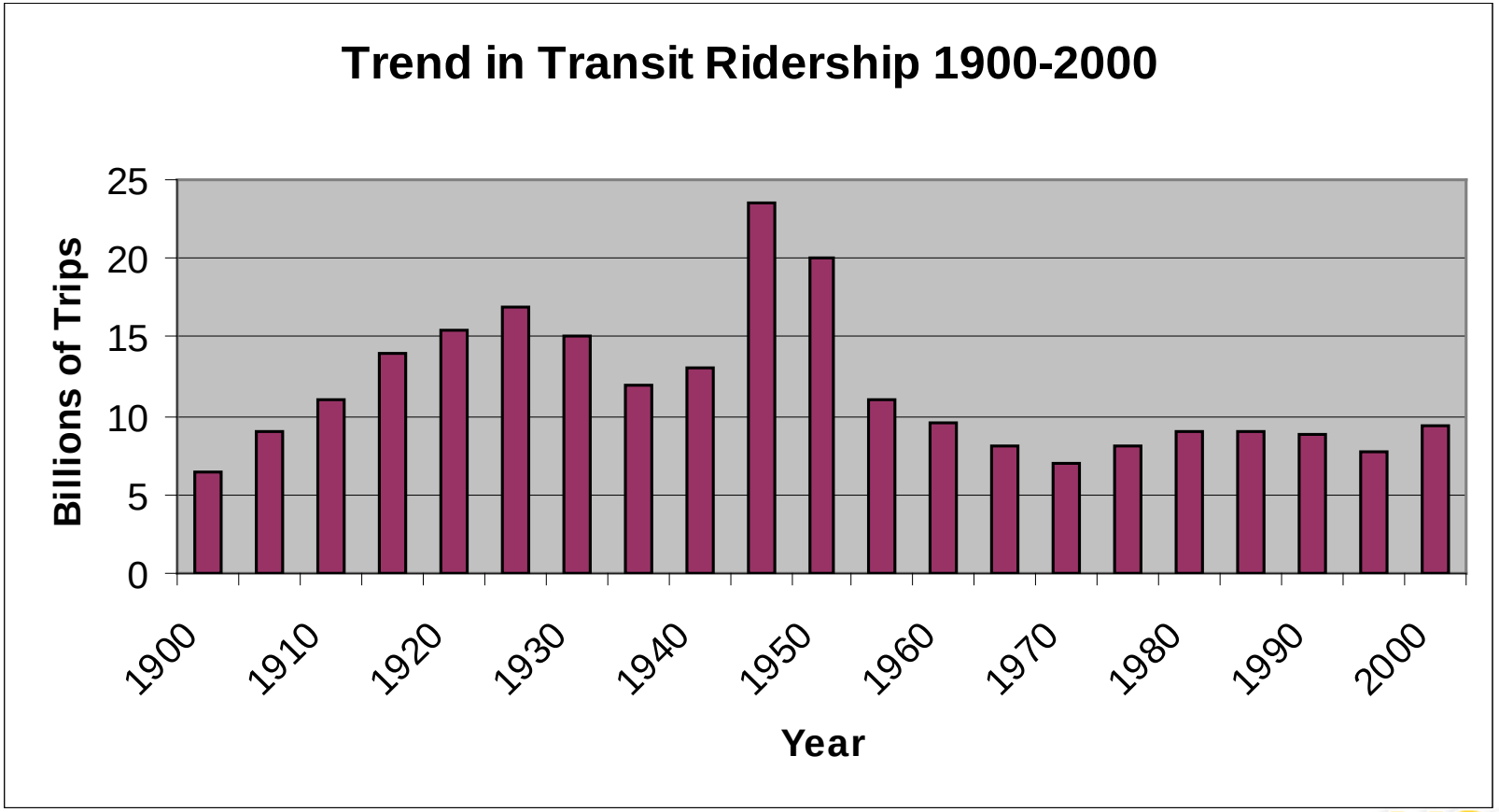
Transit Patronage Has Been Relatively Flat For Four Decades



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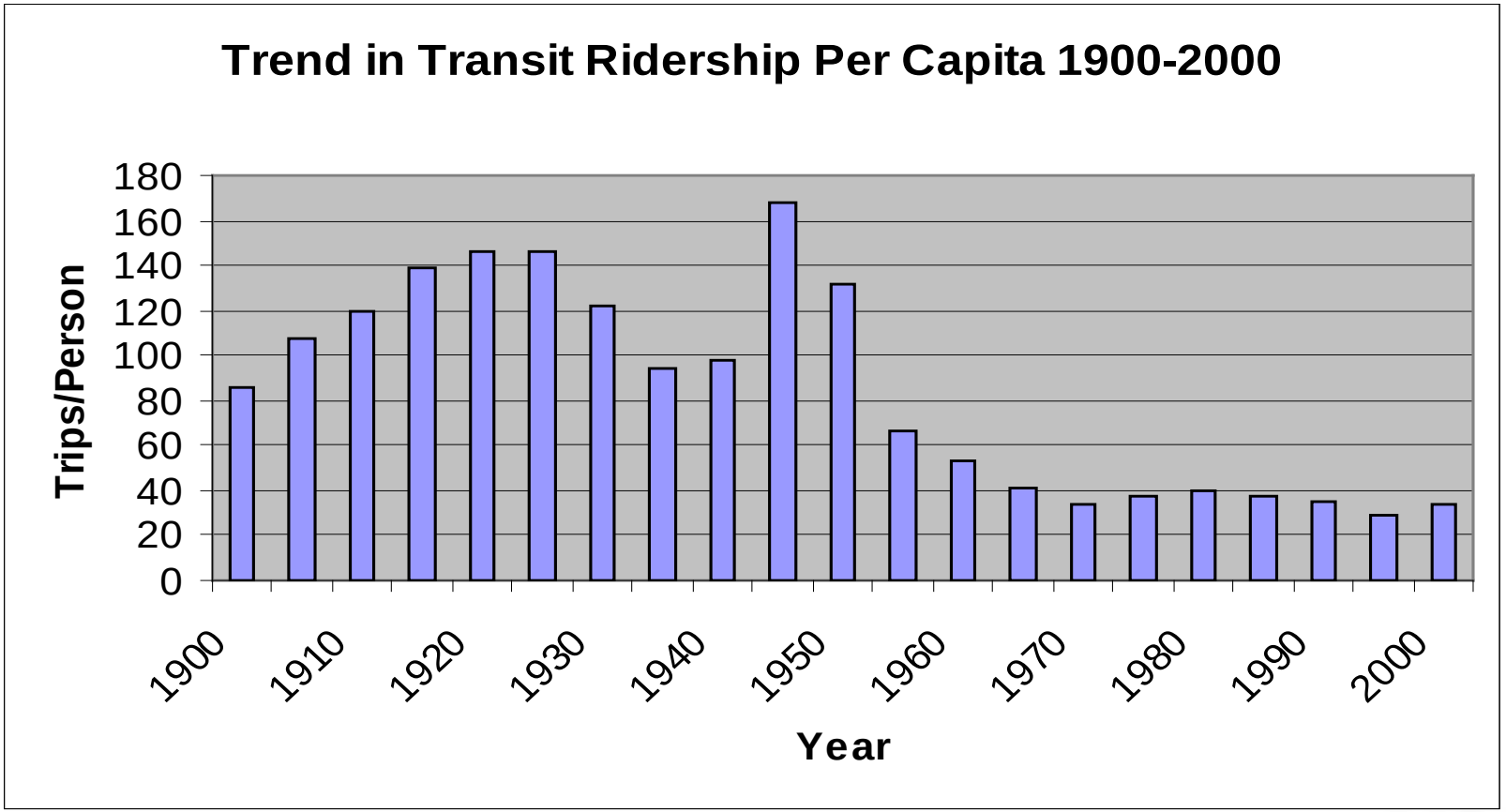
Fewer than 40 trips per capita since 1965



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What of Transit's Market Share?

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  - 3.2% public transit
  - 86.4% private vehicles

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  - 86.4% private vehicles
- ***Poor Metropolitan Workers 2000***
  - 11 times more likely to commute by private vehicle than by transit
- ***Poor Metropolitan Workers <u>in households with no vehicles</u> in 2000***
  - 38.1% <u>more likely</u> to commute by private vehicle than by transit

Why all of this driving?

- ***Average journey-to-work time in 2000***
  - Public transit: 56.0 minutes
  - Private vehicles: 22.9 minutes

Why all of this driving?

- ***Goods movements and personal business travel growing fastest***
  - Errands now outnumber work trips by more than 2.5:1
  - Increasing share of peak hour trips are chained into tours of trips with many stops

What of Transit's Market Share?

- But…
  - Transit mode shares are much, much higher in and around the centers of the oldest, largest U.S. cities
    - Especially New York City
      - 1/3 of all transit trips nationwide
      - "Top 10" carry 2/3 of all U.S. transit passengers

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- Two markets remain where traditional transit competes well with private vehicles
  1. To and from places where parking is limited and/or expensive
  2. By those with limited auto access (age, income, disability, etc.)

So What Explains Overall Transit Ridership?

- ***External*** (or environmental) factors
- ***Internal*** (or policy) factors

External (Environmental) versus Internal (Policy) Factors

External Factors

Factors exogenous to systems and transit managers

- Population
- Employment levels and growth
- Fuel prices
- Income
- Parking policies
- Residential and employment relocation

Internal Factors

Factors subject to the discretion of transit managers

- Level of service
- Service quality
- Fare levels and structures
- Service frequency and schedules
- Route design
- Marketing and information programs

What Explains Transit Ridership: A Conceptual Model

Transit Patronage

What Explains Transit Ridership: A Conceptual Model

Regional Geography

- Population
- Population Density
- Regional Topography/Climate
- Metropolitan Form/Sprawl
- Area of Urbanization
- Employment Concentration/Dispersion

What Explains Transit Ridership: A Conceptual Model

Metropolitan Economy
- Gross Regional Product
- Employment Levels
- Sectoral Composition of Economy
- Per Capita Income
- Land Rents/Housing Prices

What Explains Transit Ridership: A Conceptual Model

Population Characteristics
- Racial/Ethnic Composition
- Proportion of Immigrant Population
- Age Distribution
- Income Distribution
- Proportion of Population in Poverty

What Explains Transit Ridership: A Conceptual Model

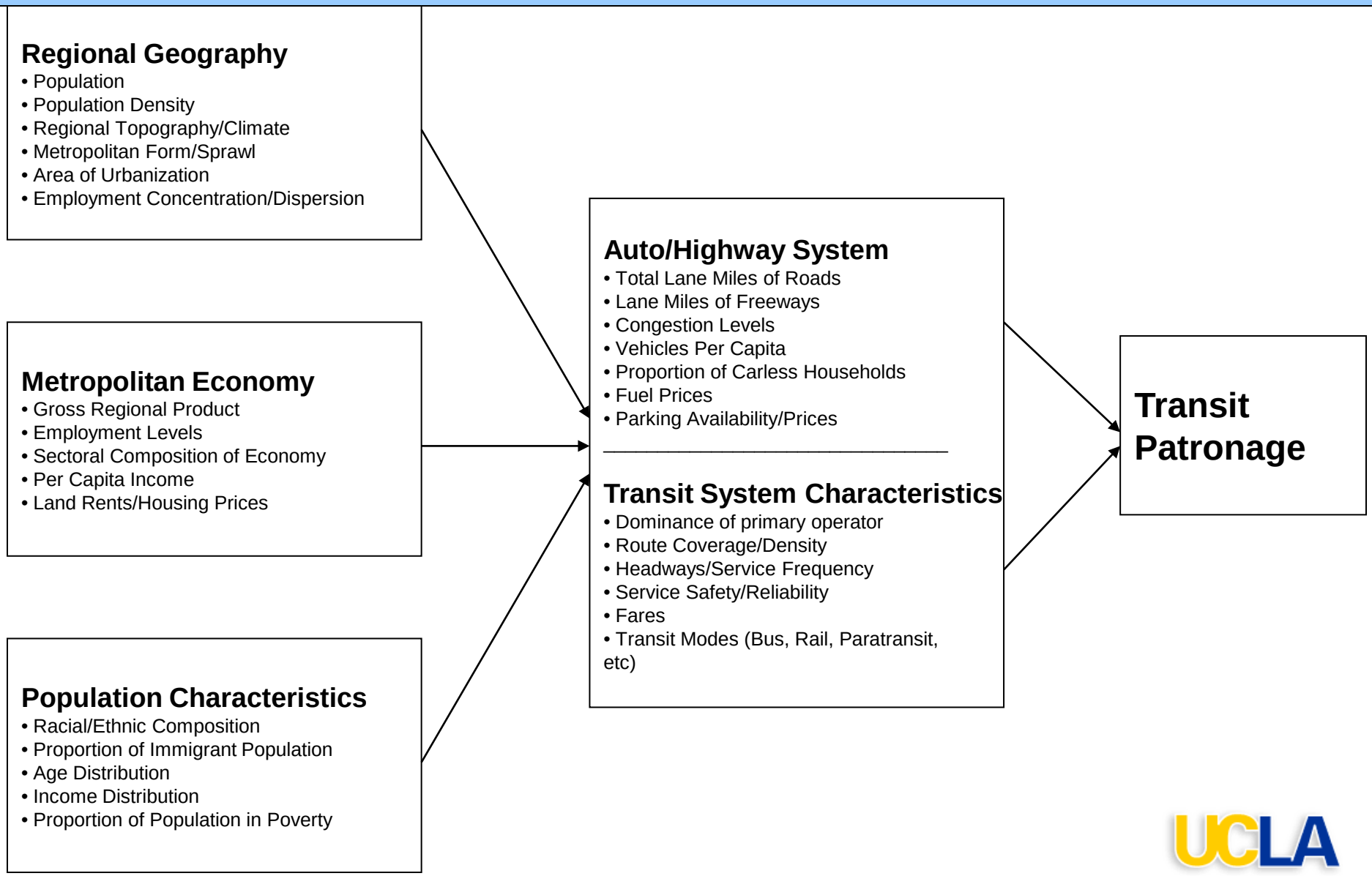
Auto/Highway System

- Total Lane Miles of Roads
- Lane Miles of Freeways
- Congestion Levels
- Vehicles Per Capita
- Proportion of Carless Households
- Fuel Prices
- Parking Availability/Prices

Transit System Characteristics

- Dominance of primary operator
- Route Coverage/Density
- Headways/Service Frequency
- Service Safety/Reliability
- Fares
- Transit Modes (Bus, Rail, Paratransit, etc)

What Explains Transit Ridership: A Conceptual Model



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Chicken or Egg?
Developing a Model to Account for Circular Causality

- ***First Stage***: Predict *Service Supply* using an array of independent factors for 265 U.S. Urbanized Areas

Chicken or Egg?
Developing a Model to Account for Circular Causality

- ***First Stage***: Predict *Service Supply* using an array of independent variables
- ***Second Stage***: Predict *Service Consumption* using an array of independent variables, including an instrumental variable to predict service supply estimated in the first stage

First Stage: Predicting Overall Levels of Service Supply

		Adj R-Sq	0.8216
Variable	**Parameter Estimate**	**Pr > |t|**	**Standardized Estimate**
Intercept	-5.44638	<.0001	0
Total Population (lnpop)	1.15134	<.0001	0.89730
Percent Voting Democrat in 2000 Presidential Election (ln_dem)	0.71598	0.0071	0.07121

Urbanized Areas with the Greatest Deviations in Service Supply from Those Predicted by the First Stage Model

	Name	Unlinked Trips	Vehicle Revenue Hours	Total Population
Undersupply ↑	Kingsport TN-VA Urbanized Area	53,872	5,957	95,766
	Montgomery, AL Urbanized Area	21,363	9,657	196,892
	Lewiston-Auburn, ME Urbanized Area	123,492	11,295	50567
	Key West, FL Urbanized Area	350,222	14,734	35,866
	Greenville, SC Urbanized Area	578,508	33,015	302,194
	Port Arthur, TX Urbanized Area	160,776	14,616	114,656
	St. Joseph, MO-KS Urbanized Area	171,298	23,539	77,231
	Hagerstown, MD-WV-PA Urbanized Area	290,725	28,036	120,326
	Phoenix--Mesa, AZ Urbanized Area	35,812,539	1,057,971	2,907,049
	Benton Harbor-St. Joseph, MI Urbanized Area	27,805	3,899	61,745
Oversupply ↓	Olympia-Lacey, WA Urbanized Area	2,782,800	126,744	143,826
	Bremerton, WA Urbanized Area	3,538,482	119,046	178,369
	Bellingham, WA Urbanized Area	2,918,916	86,818	84,324
	Seaside-Monterey-Marina, CA Urbanized Area	4,016,332	189,351	125,503
	Johnstown, PA Urbanized Area	1,534,473	63,654	76,113
	Ithaca, NY Urbanized Area	2,571,605	115,688	53,528
	Athens-Clarke County, GA Urbanized Area	1,363,068	39,472	106,482
	Florence, SC Urbanized Area	179,295	35,369	67,314
	Rome, GA Urbanized Area	966,960	24,990	58,287
	Iowa Falls, IA Urban Cluster	1,256,482	45,716	4,908

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Second Stage:
Final Total UZA Ridership Model

	Adj R-Sq		0.9105
Variable	**Parameter Estimate**	**Pr > |t|**	**Standardized Estimate**
Intercept	-1.85237	0.1899	0
Predicted Revenue Hours	1.08126	<.0001	0.77391
Population Density	0.42365	0.0086	0.07435
Percent Carless Households	1.19041	<.0001	0.18057
Percent of Recent Immigrants	0.19278	0.0015	0.08582
UZA in the South	-0.12621	0.0014	-0.07823
Transit Fare	-0.42660	<.0001	-0.13004
Service Level	0.50284	<.0001	0.13793
Percent Population Enrolled in College	0.22837	0.0182	0.05905

dies

Conclusions

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It's "nature" more than "nurture"

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  - *Regional Geography* (regional location, population, population density)

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  - *Metropolitan Economy* (median household income)

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  - *Population Characteristics* (percent Democratic voters, African-American, recent immigrants, and college students)

It's "nature" more than "nurture"

- Total and per capita UZA ridership are primarily a function of external factors:
  - *Regional Geography* (regional location, population, population density, and land area)
  - *Metropolitan Economy* (median household income)
  - *Population Characteristics* (percent Democratic voters, African-American, recent immigrants, and college students)
  - *Auto/Highway System* Characteristics (0 vehicle households)

But…

- Policy and planning do matter

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  - After controlling for external factors…
  - Transit service frequency and fare levels are associated with about a doubling (or halving) transit use in a given area

Policy and Planning do matter

- 2 factors;
  - *Service frequency* and *fare levels*
  - exert far more influence over ridership than any other policy variables tested

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- More than…
  - The presence of rail transit, route network density, one versus many operators in an area, and so on

Game Plan

- What explains transit ridership?
- Thinking outside the bus
- Who rides transit, and how is that changing over time?
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Thinking outside of the bus

- The research is clear…
  - Passengers view walking, waiting, and transferring as far more onerous (and, thus, important) than time spent in transit vehicles

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- The research is clear…
  - Passengers view walking, waiting, and transferring as far more onerous (and, thus, important) than time spent in transit vehicles
  - Reducing the *perceived* burden of waiting and transferring is key to substantially increasing the attractiveness of transit

Thinking outside of the bus

- From an ongoing study of over 700 waiting and transferring passengers in LA County:

Thinking outside of the bus

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- The most important factor in determining passengers' satisfaction with their transfer experience…

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- The most important factor in determining passengers' satisfaction with their transfer experience…

"I don't have to wait long for my bus or train"

Passengers Hate to Wait

- ***Value of time*** is a factor to convert actual time into the time perceived by the average transit traveler: (relative to in-vehicle time = 1.0)

  - **Waiting**:

    Overall: 1.47 - 3.41

    First 7.5 min.: 4.00 - 4.36

    Over 7.5 min.: 0.88 - 10.78

    Transfer wait time: 1.58 - 4.36

  - **Walking**:

    Overall: 1.66 - 2.72

Factors Influencing the Perceived Burden of Walking, Waiting, and Transferring

- **Waiting**:
  - Safety and security
  - Certainty (or uncertainty) of an arrival time of the next vehicle
  - Whether or not waiting is forced
  - Whether or not waiting is productive
  - Weather

- **Walking**:
  - Distance
  - Safety (personal and traffic)
  - Route familiarity
  - Weather

After wait time, what do passengers care most about?

Nnumber of observations: 512
LR chi2(8) = 255.37 Prob > chi2 = 0.0000
Log likelihood = -349.8149 Pseudo R2 = 0.2674

	Survey Questions	Category	Coef.	Std. Err.	z	P>|z|
I-4	My bus / train is usually on time.	Connection & Reliability	1.270	0.397	3.20	0.00
P-4	Having security guards here makes me feel safer.	Security & Safety	1.244	0.228	5.45	0.00
O-4	This station is well lit at night.	Security & Safety	1.102	0.330	3.34	0.00
L-4	I feel safe here during the day.	Security & Safety	1.049	0.310	3.39	0.00
L-3			0.961	0.265	3.63	0.00
K-4	It is easy to get around this station / stop.	Access	0.934	0.282	3.31	0.00
F-4	The signs here are helpful.	Information	0.555	0.262	2.12	0.03
G-4	It's easy to find my stop or platform.	Access	0.516	0.256	2.02	0.04
	Cut point between "strongly disagree and disagree" & "agree"		-0.175	0.235	(Ancillary	
	Cut point between "agree" and "strongly agree"		2.262	0.265	parameters)	

No amenities variables are statistically significant.

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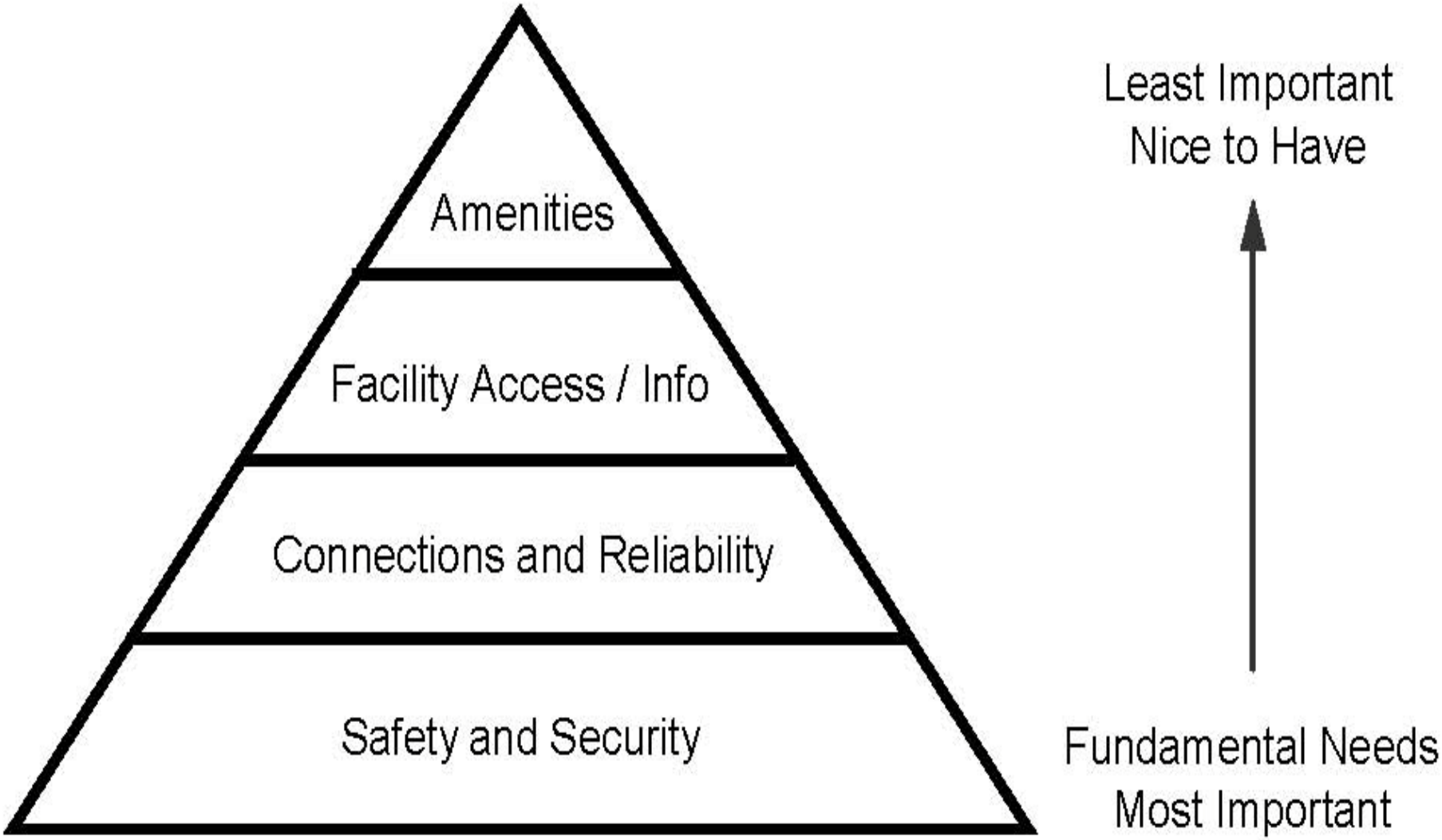
A Hierarchy of Transit User Needs



Conclusions II

- But the best way to close the gap between perceived and actual wait and transfer times is *certainty*
  - Passengers who are reliably certain of when their bus or train will arrive tend to find waiting to be far less onerous

Hate to wait (or transfer)

- The most obvious way to reduced *perceived* wait/transfer times…
  - Is to reduce *actual* wait/transfer times with more frequent service

"When is that @#$%& bus/train going to get here?"*

- Best way to close the perceived/actual wait and transfer time gap: *certainty*

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- How can passengers be made more reliably certain of when their bus or train will arrive?

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- How can passengers be made more reliably certain of when their bus or train will arrive?
  - Good schedule adherence
  - Clear, easy-to-read schedules posted at stops, on the web, etc.
  - Reliable, real-time "next bus" indicators at busy stops

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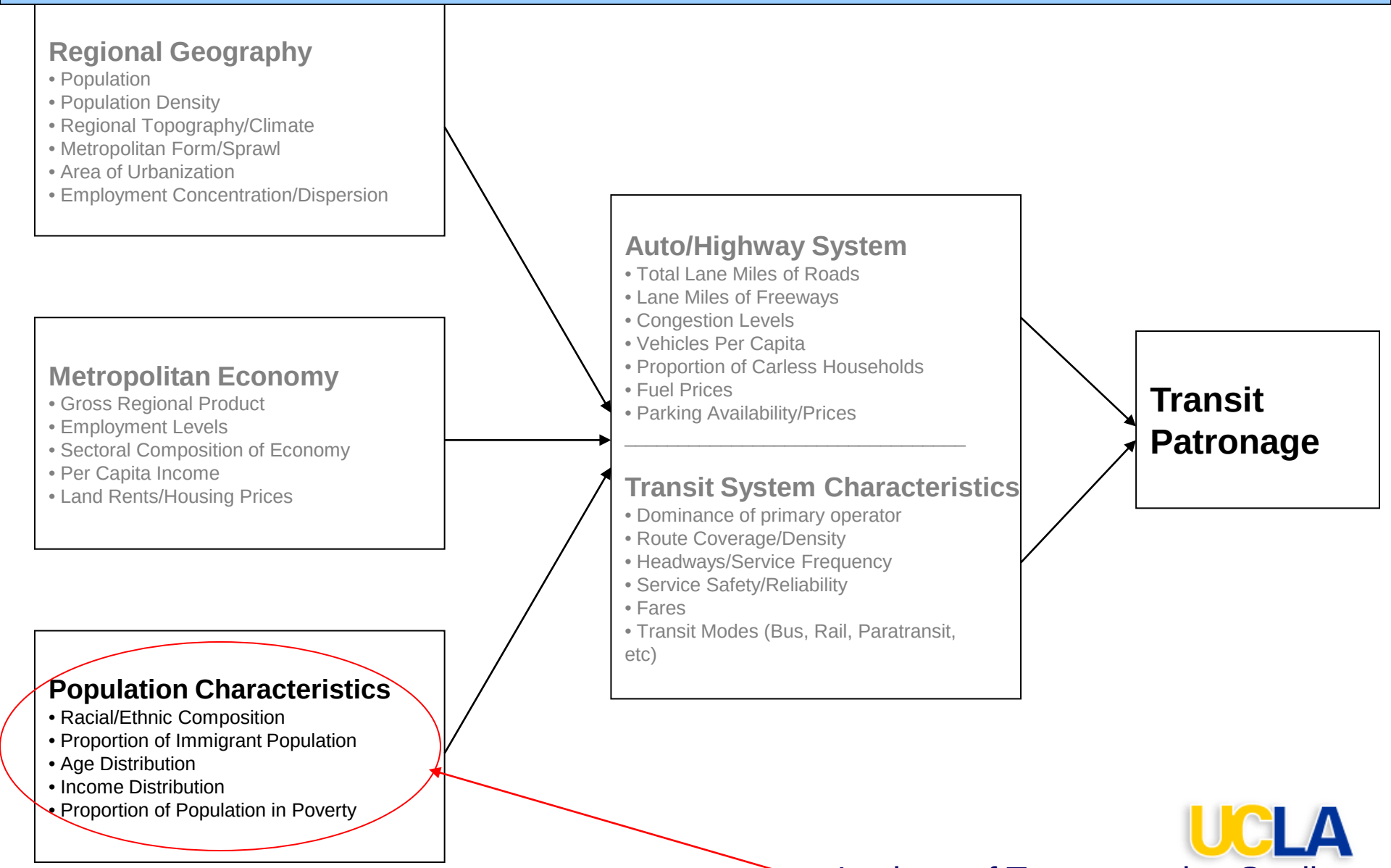

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2004 Public Transit Expenditures by Mode

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- Buses:
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- Rail:
  - 37% of all passengers (mostly in NY)
  - 48% of all transit expenditures

Who Uses Public Transit?

- Who rides buses and trains?

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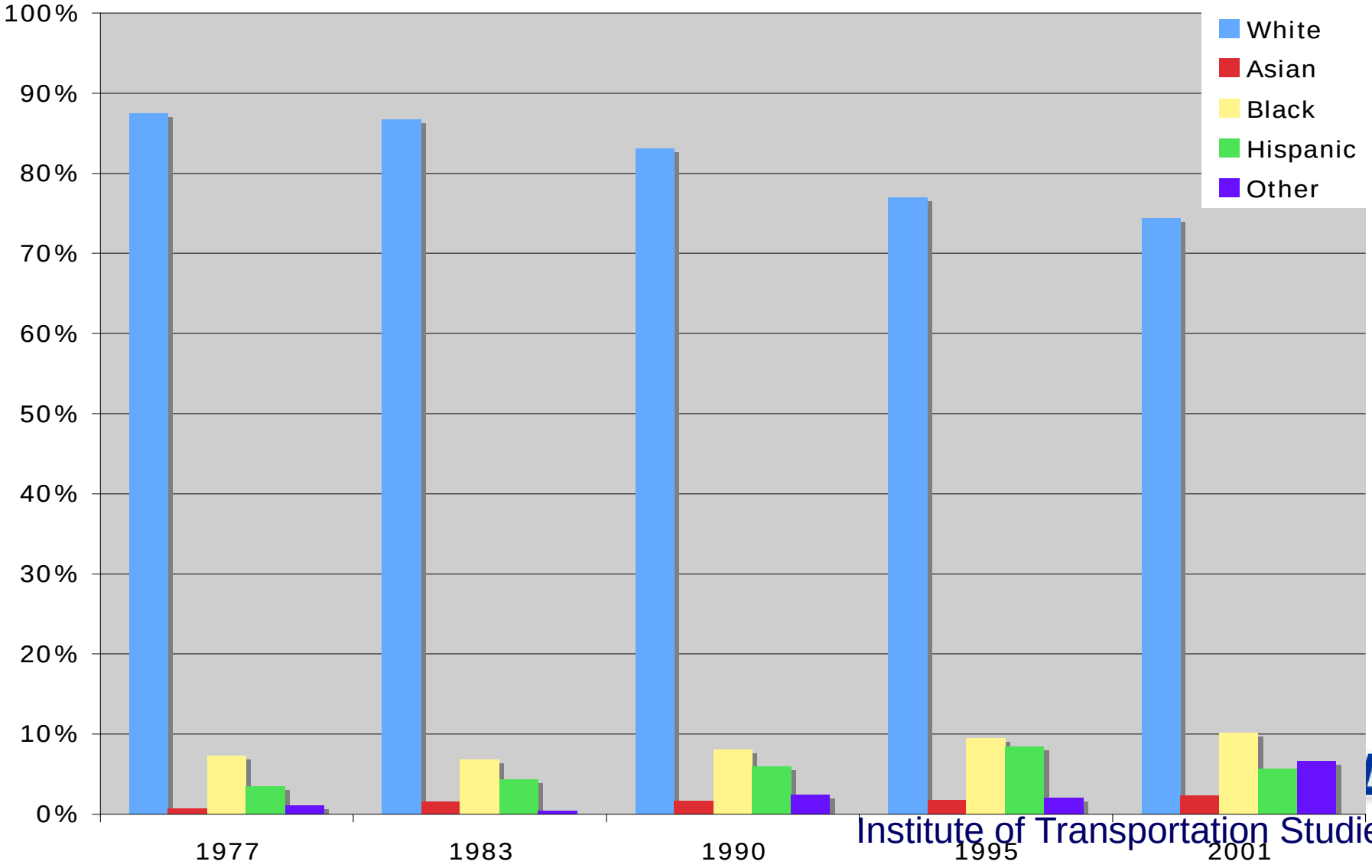
- How is this changing over time?
- What are the implications for the public subsidy of transit?

Trends in Ethnic Composition of Private Vehicle Travelers – 1977 to 2001 (All Trips)



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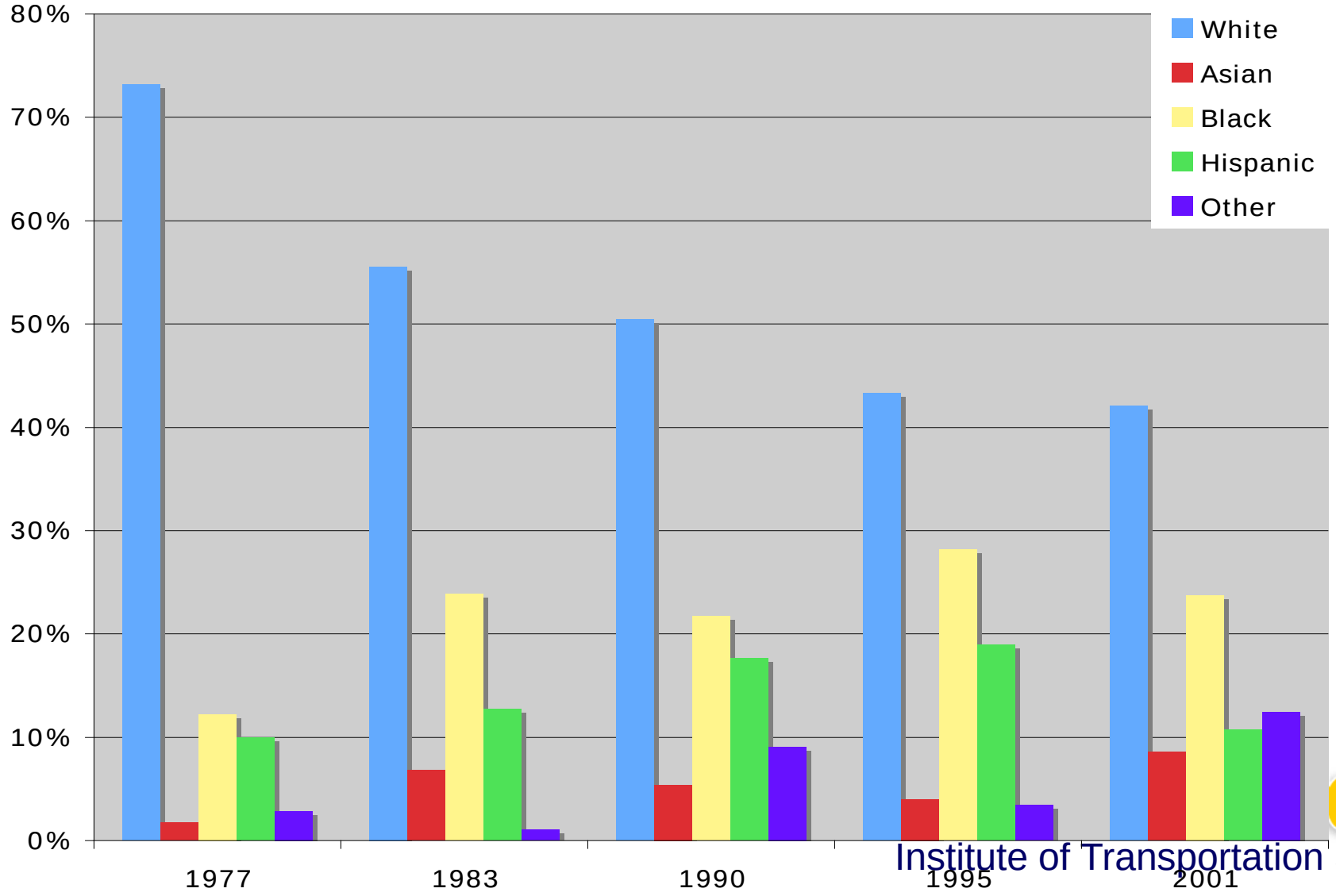
Trend in Ethnic Composition of Rail Riders – 1977 to 2001 (All Trips)



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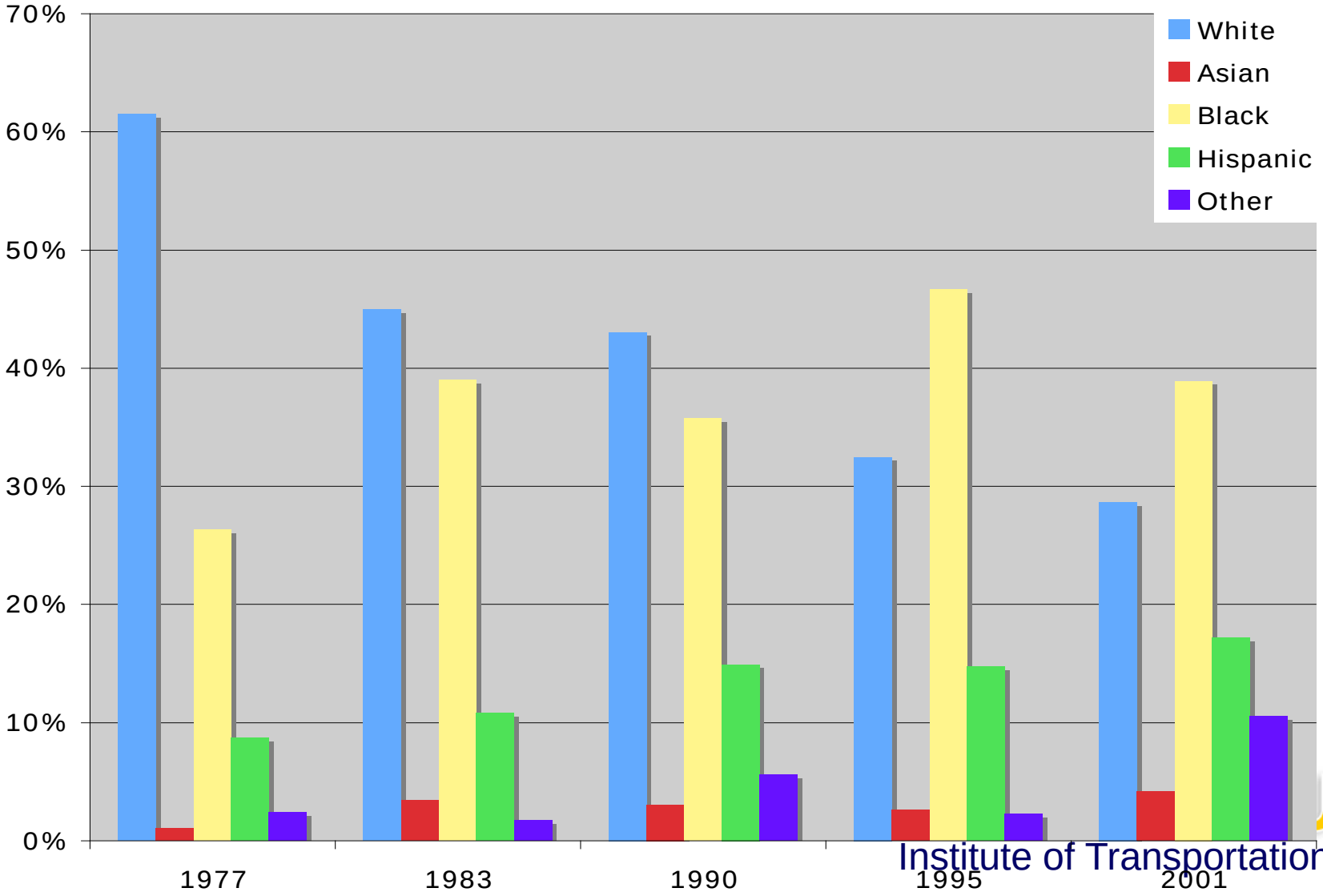

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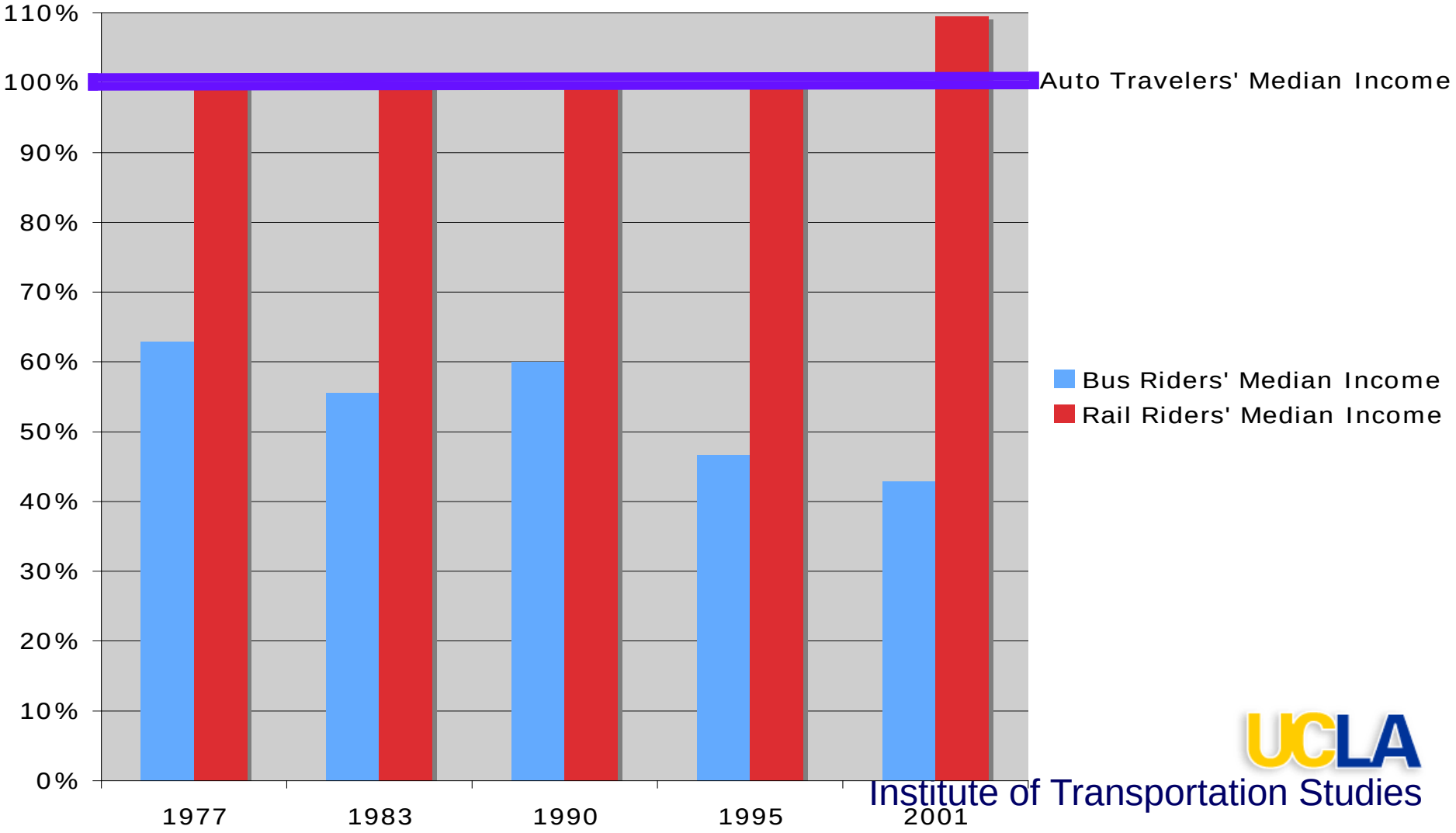
Trends in Transit Riders' Median Income as a Share of Auto Travelers' Median Income – 1977 to 2001 (All Trips)



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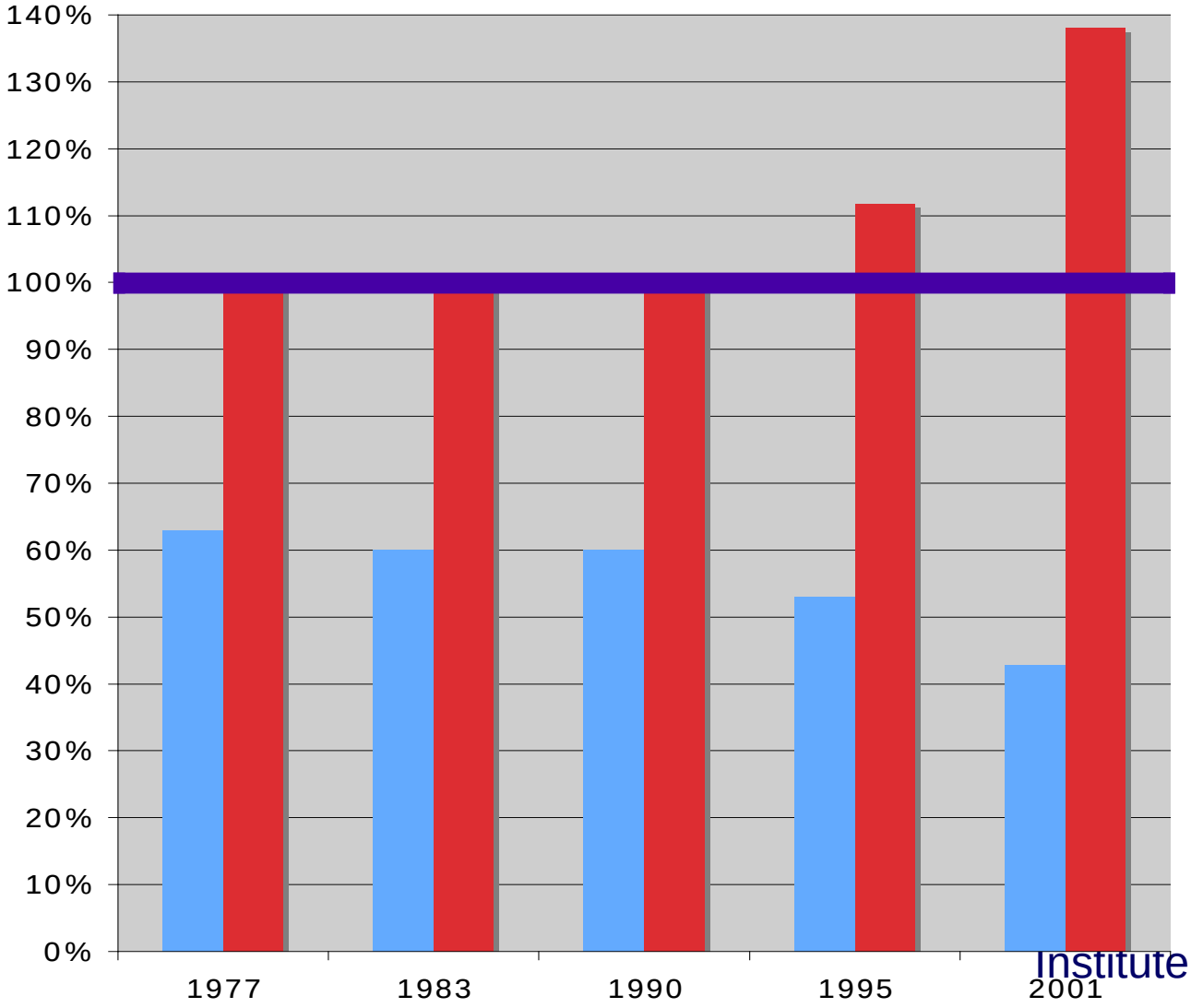
Trend Transit Riders' Median Income as a Share of Auto Travelers' Median Income – 1977 to 2001 (All Trips, excluding New York)



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Median Household Incomes of Metropolitan U.S. Trip-Makers in 2001

Trip Type	Travel Mode	Median Income	% of Private Vehicle
Work Trips	Private Vehicle	$57,500	100.0%
	Rail Transit	$67,500	117.4%
	Bus Transit	***$27,500***	***47.8%***
	Non-Motorized	$42,500	73.9%
	Other	$67,500	117.4%
	All Modes	$57,500	100.00%

Source: 2001 National Household Transportation Survey

Median Household Incomes of Metropolitan U.S. Trip-Makers in 2001

Trip Type	Travel Mode	Median Income	% of Private Vehicle
Non-Work Trips	Private Vehicle	$52,500	100.0%
	Rail Transit	$47,500	109.5%
	Bus Transit	***$17,500***	***33.3%***
	Non-Motorized	$47,500	90.5%
	Other	$47,500	90.5%
	All Modes	$52,500	100.0%

Source: 2001 National Household Transportation Survey

Findings

- Bus riders are becoming poorer and less white over time, relative to auto travelers

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- In 2001, bus riders outside of New York came from households with incomes 58% *lower* than auto travelers
  - while rail riders came from households with income 38% *higher* than auto travelers

Conclusions III

- Bus transit is increasingly a social service for the poor

Buses: *An important social service*

- Bus transit is increasingly a social service for the poor

- An important role and a compelling rationale for substantial public subsidies of transit

A political non-starter?

- But when redistributive social policies are increasingly scrutinized and questioned…
  - transit's central role as a social service for the poor is not widely touted by transit managers

Selling transit

- Instead, goals like…
  - congestion reduction,
  - environmental improvement, and
  - and transit-oriented development are often emphasized

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Trends in Travel and Transportation Investments

- ***Between 1993 and 2003…***
  - Miles of new freeway: + 3.6%
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  - Vehicle miles of freeway travel: + 35.4%
  - Service miles of rail transit: + 26.7%
  - Rail transit ridership: + 23.1%

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  - Miles of new freeway: + 3.6%
  - Vehicle miles of freeway travel: + 35.4%
  - Service miles of rail transit: + 26.7%
  - Rail transit ridership: + 23.1%
  - Overall transit ridership: + 11.0%
  - Inflation-adjusted government subsidies of transit: + 57.1%

Public Investment in Transit is Waxing in the U.S.

- Between 2000 and 2004…
  - Annual patronage on public transit edged up 2.3% (to 9.6 billion trips)

Public Investment in Transit is Waxing in the U.S.

- Between 2000 and 2004…
  - Annual patronage on public transit edged up 2.3% (to 9.6 billion trips)
  - But total inflation adjusted subsidy expenditures per unlinked passenger trip increased almost 8 times faster (18%) to $3.68 (in 2006 dollars).

Public Investment in Transit is Waxing in the U.S.

- Recent increases in fuel prices have helped to increase transit ridership
  - Though subsidies remain high and growing

- So while the increases in public support of transit are welcome…

Public Investment in Transit is Waxing in the U.S.

- While the increases in public support of transit are welcome…

- The declining average levels of productivity are worrisome

Why are rising public subsidies of transit not attracting more riders?

- My theory
  - Transit systems nationwide are being asked to do too much

Premise:

The public asks too much of public transit

- Provide mobility for those without

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- Add transportation capacity in a politically acceptable way

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- Add transportation capacity in a politically acceptable way
- Reduce congestion and the need for additional road capacity
- Reduce emissions, energy consumption, and auto dependence
- Act as a anchor/magnate for transit-oriented development
- Signal our jurisdiction as attractive, progressive

Keep your eyes on the prize

- Focus on problems (congestion, mobility for those without, etc.) in need of solutions

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- And not on solutions (new rail line, new airport, new highway, etc.) not clearly linked to problems

Keep your eyes on the prize

- Do the problem definition and proposed solutions match?
  - Congestion levels are increasing across the road network…
  - Regulating auto use is unpopular…
  - Let's try to lure more drivers onto public transit...

Keep your eyes on the prize

- Do the problem definition and proposed solutions match?
  - Congestion levels are increasing across the road network…
  - Regulating auto use is unpopular…
  - Let's try to lure more drivers onto public transit...
  - Rail lines and busways are dramatic and sexy
    - they are more likely to interest drivers than boring old buses
    - Even if they cover just a tiny fraction of possible origins and destinations

Keep your eyes on the prize

- Be careful of those who define problems in terms of their preferred solutions
  - The *problem* is that Fresno doesn't have rail transit (major league sports franchise, new airport, stadium with luxury boxes, etc.)

Keep your eyes on the prize

- Be careful of those who define problems in terms of their preferred solutions
  - The *problem* is that Fresno doesn't have rail transit (major league sports franchise, new airport, stadium with luxury boxes, etc.)
- Better to ask…
  - Traffic congestion, emissions, or mobility for those without are serious problems
    - What are the most cost-effective ways to address them?

OK, so it's complicated
What does the research tell us?

- #1: Travel time reliability
  - Travelers like speed, but they like reliability even more (and more over time)
  - Wait and transfer times are especially burdensome (1.5 to 3+ times more than in-vehicle time)
    - Frequent, reliable service with few transfers will beat fast, uncertain service with more transfers every time
  - Lesson: Increasing service frequency and schedule adherence attracts lots of riders

OK, so it's complicated
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- #1: Travel time reliability
  - Lesson: Increasing service frequency and schedule adherence attracts lots of riders
  - Cost-effective ways to improve reliability
    - Better tracking and management of vehicle spacing
    - Realistic schedule setting
    - Real-time "Next Bus" information at major stops
    - Transit signal prioritization
    - Queue jumper and, in limited cases, bus-only lanes

OK, so it's complicated
What does the research tell us?

- #2: Price
  - The cost of providing transit varies a lot
    - Peak hour, peak direction, and rail service costs a lot more than off-peak, contra-flow, and bus service
  - But transit fares tend to be "flat," per trip or even per month
    - Long-distance, peak hour, peak direction rail passengers get the biggest government subsidies, while short bus trips in the off-peak tend to require little subsidy
    - This encourages inefficiency

OK, so it's complicated
What does the research tell us?

- #2: Price
  - Conventional wisdom holds that lowering fares is a costly way to add riders
  - Fare elasticity research:
    - Fare increases chase away a few higher-income riders (who can switch to cars)
    - Fare reductions attract a surprising number of lower-income riders (who have fewer choices)

OK, so it's complicated
What does the research tell us?

- #2: Price
  - Lesson: Use smartcards to vary fares to reflect costs
    - Lower fares for inexpensive-to-provide trips (short, off-peak, backhaul trips)
    - Higher fares for expensive-to-provide trips (long, peak-period, peak direction, express and rail trips)
    - Would encourage better utilization of existing capacity, such as by adding rapid turnover short trips
      - Would add riders without adding much to costs

OK, so it's complicated
What does the research tell us?

- #2: Price
  - Lesson: Use smartcards to vary fares to reflect costs
    - Would increase both system performance and social equity
    - since higher-income riders disproportionately consume expensive-to-provide trips and lower-income riders disproportionately consume inexpensive-to-provide trips

We Must Solve the Ribbon Cutting Problem

- So how can we get public officials excited about ribbon-cutting media events for things like…
  - More frequent bus service
  - Better schedule adherence
  - Variable fares to reflect variable costs
  - Real time information at busy stops
  - Shorter, more reliable headways through signal pre-emption, wider stop spacings, and occasional queue-jumper and bus-only lanes?

We Must Solve the Ribbon Cutting Problem

- How can we make ribbon-cutting media events out of things like…
  - More frequent bus service
  - Better schedule adherence
  - Variable fares to reflect variable costs
  - Real time information at busy stops
  - Shorter, more reliable headways with signal pre-emption, wider stop spacings, and occasional queue-jumper and bus-only lanes

- Now that’s a challenge

Emerging markets, evolving roles: Lessons from research on cost-effective ways to improve transit in the years ahead

- **Questions? Comments?**

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