MARGINAL COST PRICING AND SUBSIDY OF TRANSIT IN SMALL URBANIZED AREAS

Jeremy Mattson
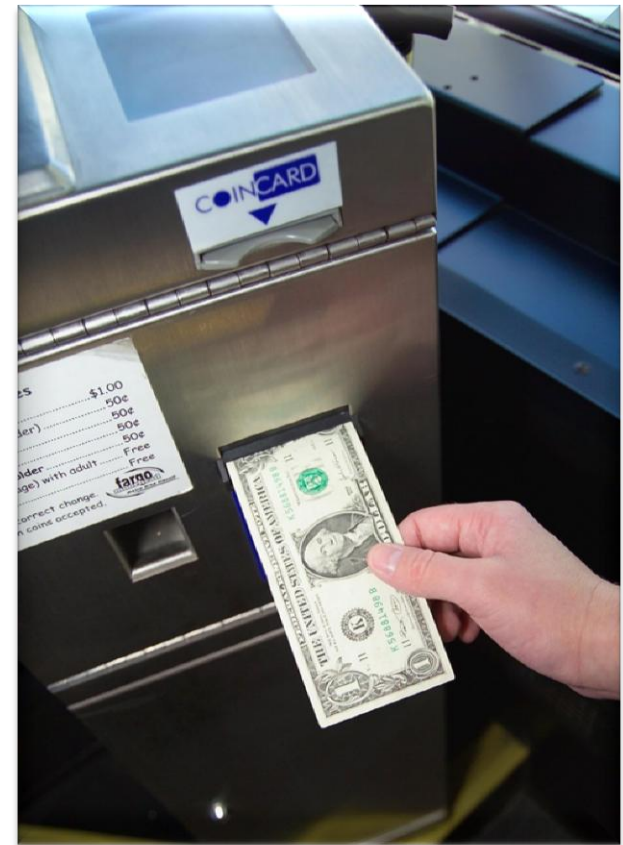Small Urban & Rural Transit Center

UGPTI Seminar Series
November 1, 2011

Overview

- Survey of transit agencies
  - Changes in fares, service levels, funding
- Rationale for subsidies
- Marginal cost pricing
- Cost model
- Estimates of economies of density, economies of scale, marginal cost, required subsidies
- Conclusions and other areas for research

Survey

- Transit agencies in small urbanized areas (50,000 to 200,000 population)

- Conducted Nov-Dec 2010

- Online survey sent to 305 transit agencies across the country

- Responses from 141 transit agencies (46% response rate)

Agencies that have made cuts in service since January 1, 2009, or are considering cuts (n=140)

Made cuts
30%

No cuts
61%
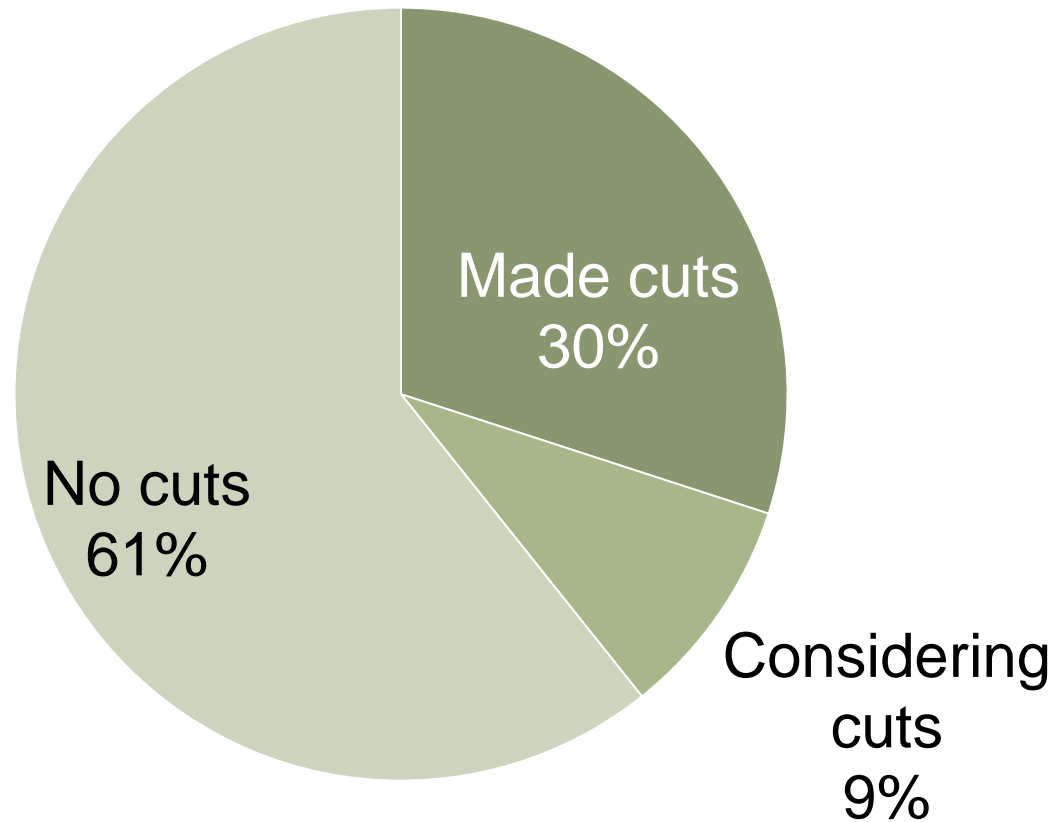
Considering
cuts
9%

Cuts by transit agencies that have made service reductions (n=38)
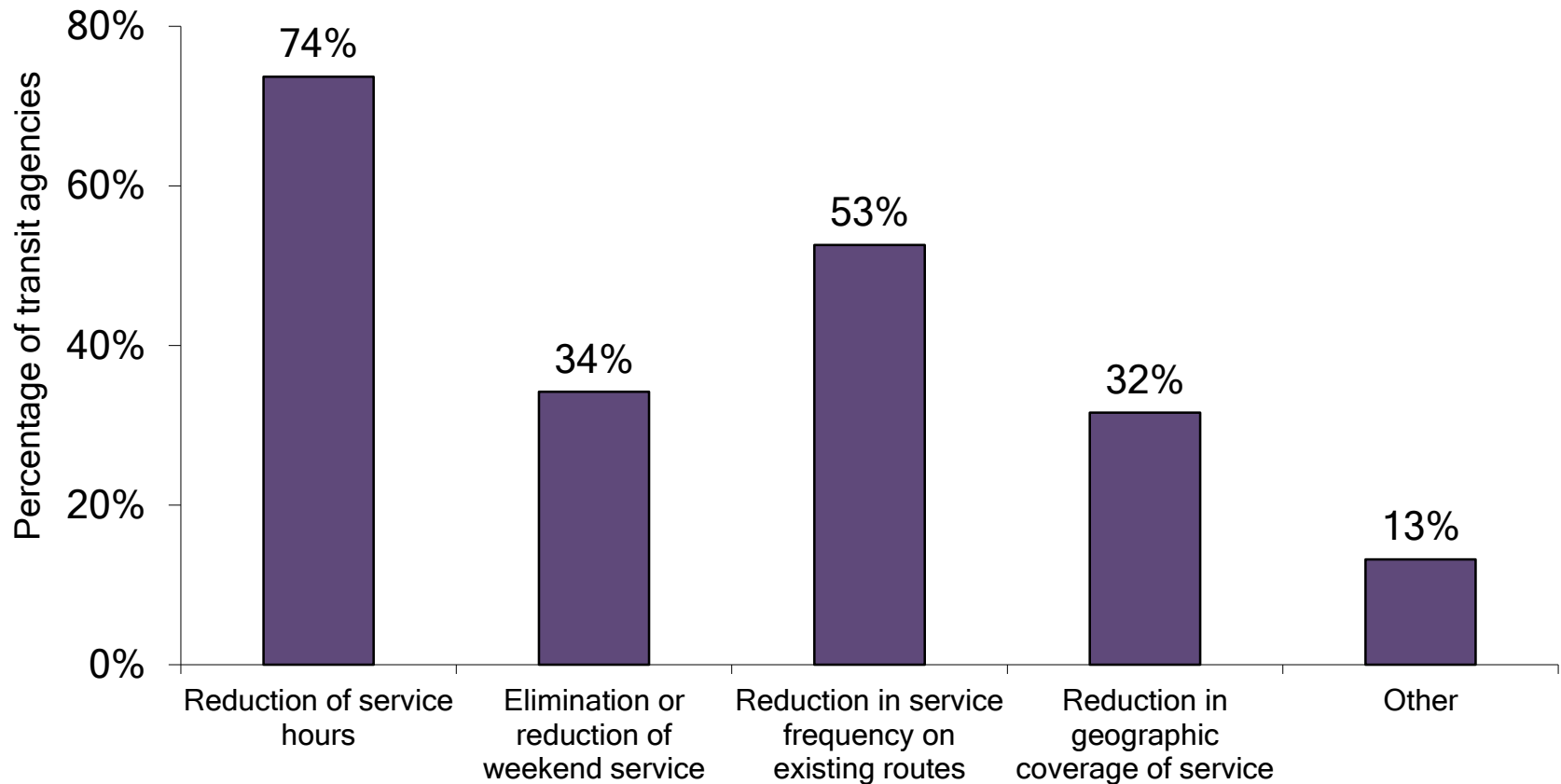
Factors that motivated decisions to cut transit service (n=38)

Bar chart. Y-axis: Percentage of transit agencies (0% to 100%).

- Decrease in funding: 82%
- Decrease in other revenues: 13%
- Increase in fuel costs: 16%
- Increase in other costs: 16%
- Decrease in service demand: 16%
- Other: 16%
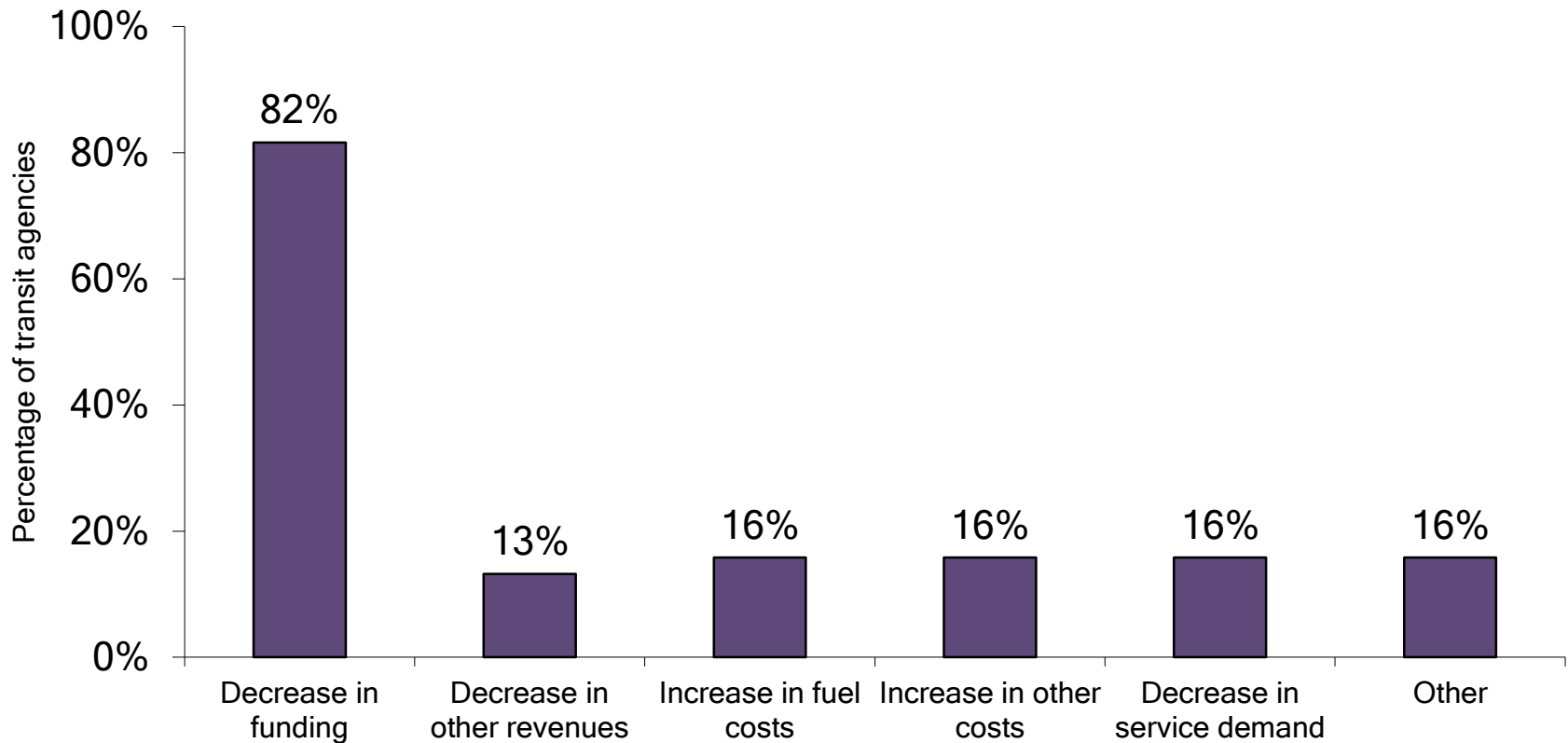
Transit agencies that have added service since January 1, 2009, or are considering increases (n=138)

No increases 41%

Made increases 49%

Considering increases 10%
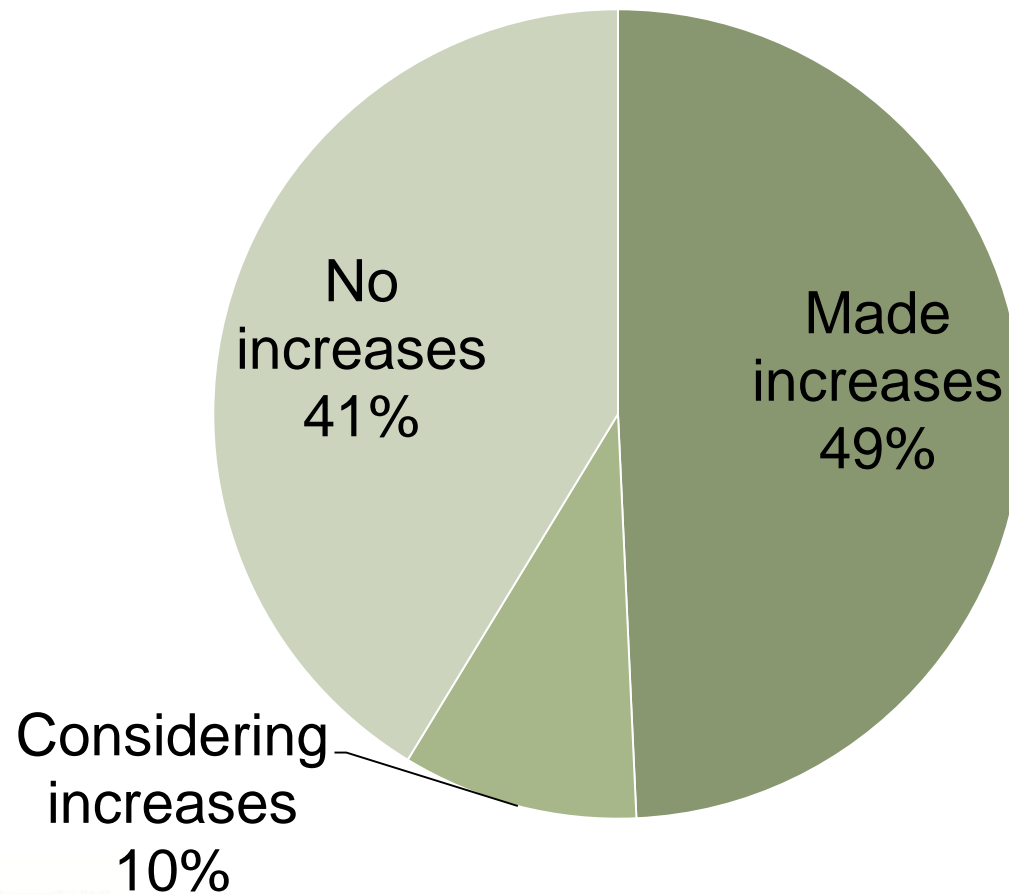
Types of services added by transit agencies that have made service increases (n=68)
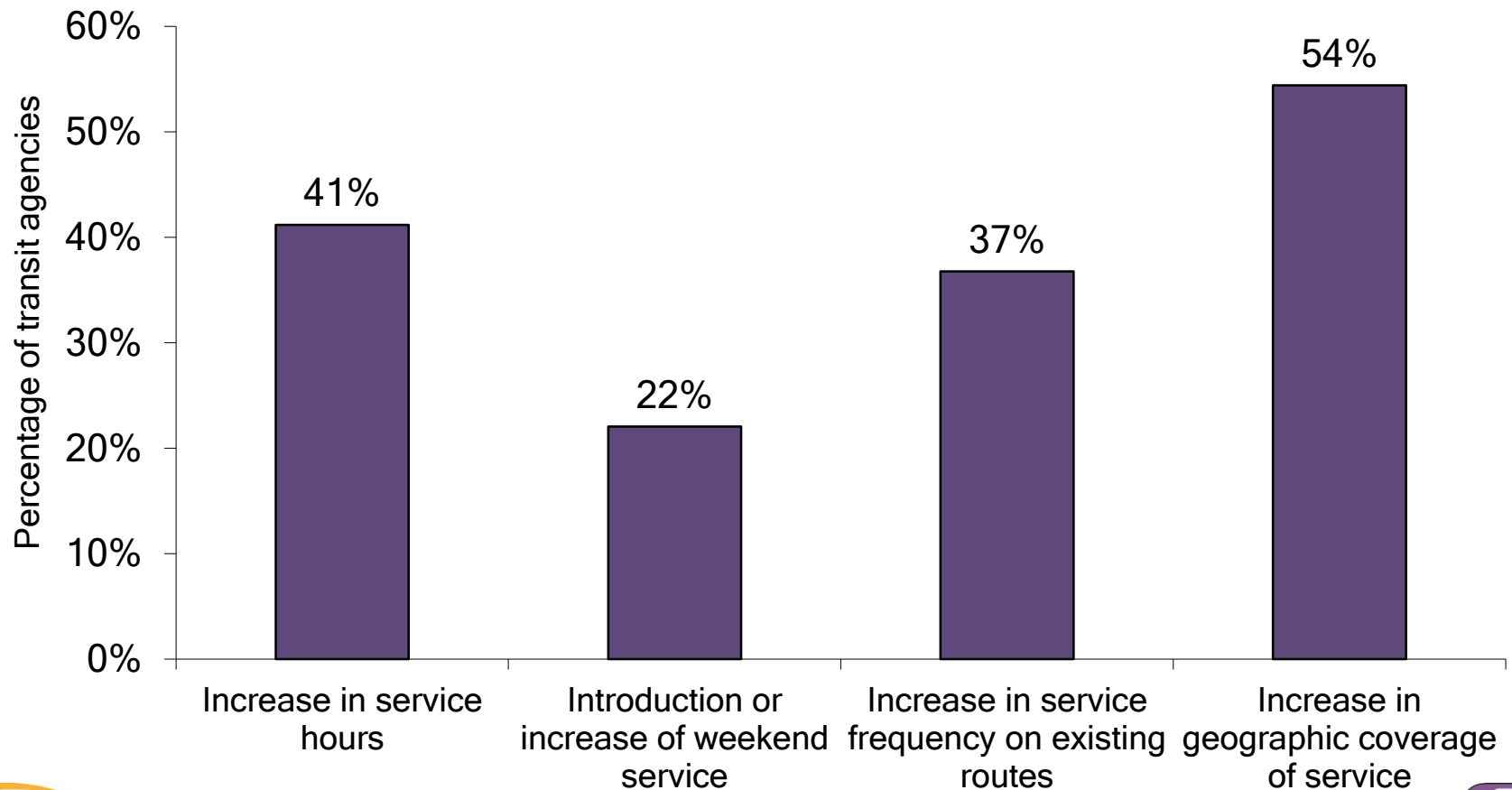
Percentage of transit agencies that have increased fares since January 1, 2009, or are considering fare increases (n=134)
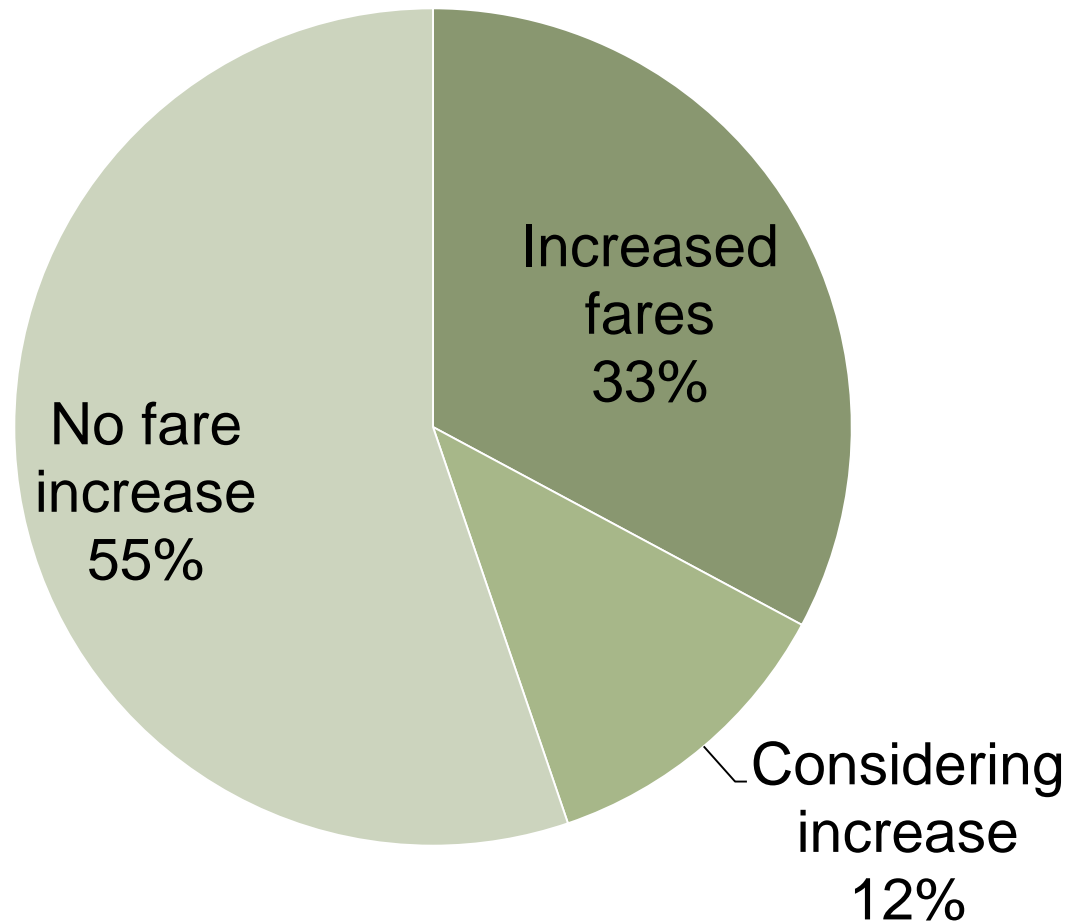
Motivations for fare increases (n=44)
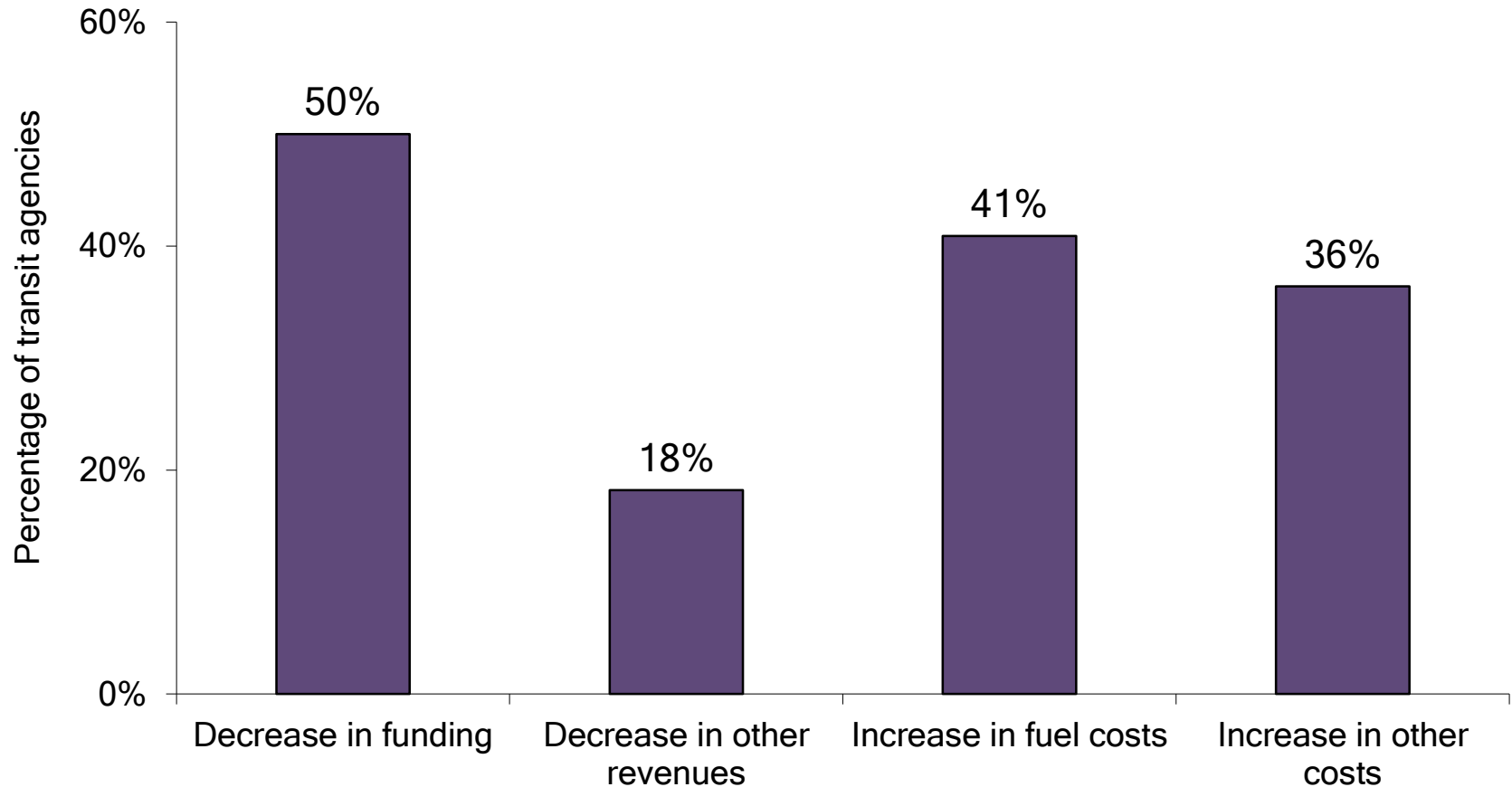
Other Actions Taken by Agencies that Have Cut Service or Increased Fares

Other Actions	Agencies that have:	
	Cut Service	Increased Fares
Cut Service		45%
Increased Service	38%	64%
Increased Fares	51%	
Decreased Fares	5%	11%

Service or Fare Actions Taken or Being Considered

	Implemented Since January 1, 2009	Considering Future Action	Implemented AND Considering additional Future Action	Implemented OR Considering Future Action
Service Cuts	30%	23%	14%	39%
Service Increase	50%	28%	18%	59%
Fare Increase	33%	17%	5%	45%
Fare Increase AND Service Cuts	14%	7%	3%	19%
Fare Increase OR Service Cuts	47%	33%	18%	61%

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Demand for Service

- Two-thirds of transit agencies responding to this survey said that demand for transit service in their community is increasing; 28% answered that demand is staying about the same, while just 4% said that demand is decreasing.

- Of those who said that demand is increasing, most (94%) said their agency is facing limitations in its ability to add service to meet this demand.

Changes in operational funding over the last year (n=132)

Chart: Percentage of transit agencies by funding source and change category.

	Decreased	About the same	Increased
Local/regional funding	36%	48%	16%
State funding	34%	57%	9%
Federal funding	11%	76%	13%

Legend: ☐ Decreased ■ About the same ☐ Increased
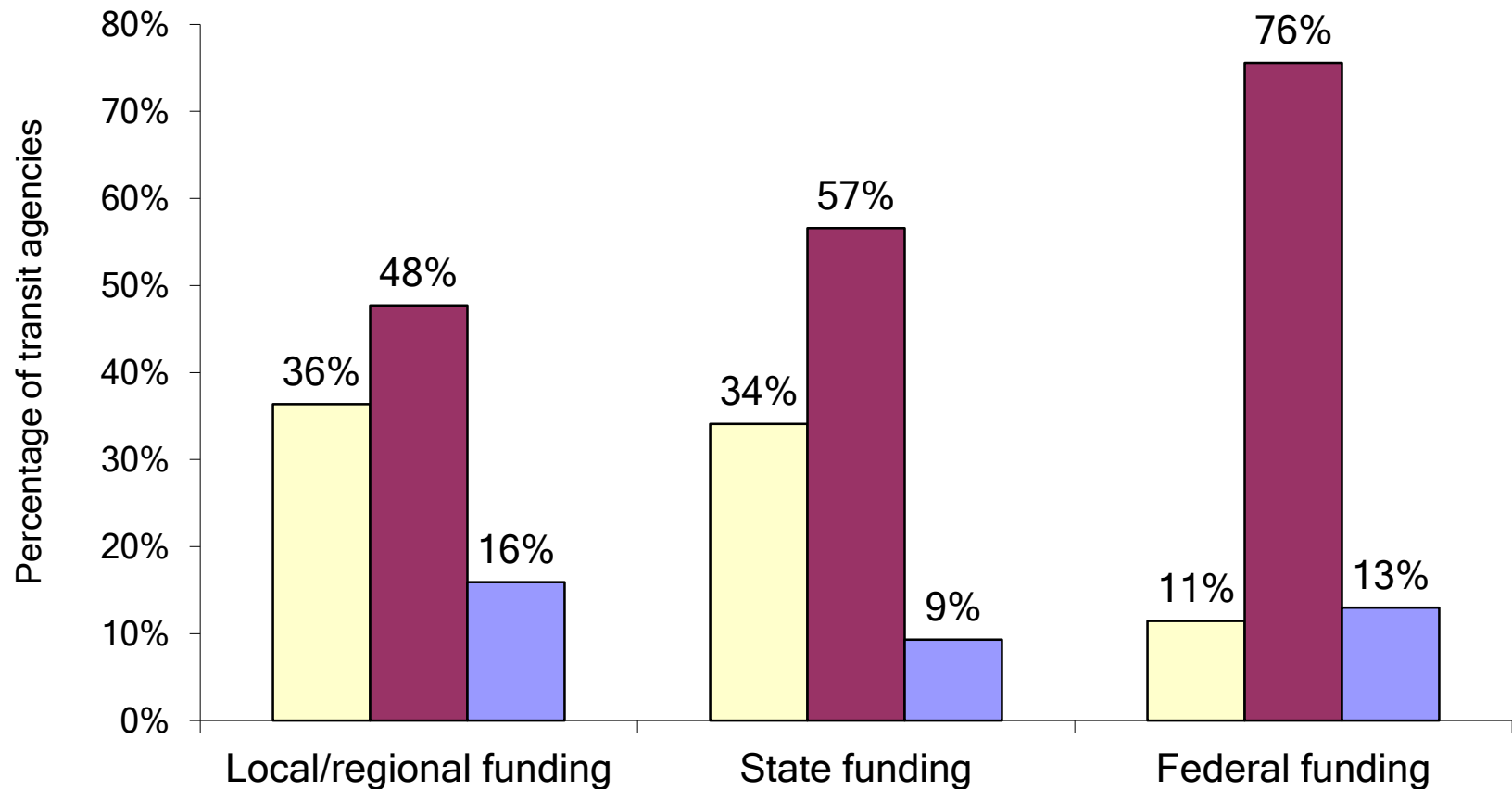
What Do Transit Systems View as the Rationale for Transit Subsidies?

Answer Options	Number	Percentage
To enhance mobility for the underprivileged	119	91%
To offset social costs of automobile travel	100	76%
To take advantage of economies of scale	83	63%

Other Rationale for Subsidies Given

Livability

- Enhance mobility to all segments of the population
- Enhance quality of life, promote livable communities
- Maintain an independent lifestyle for seniors
- Mobility enhancement for many groups - not just the underprivileged

Automobile subsidies

- All transportation is subsidized including roads/highways
- To compete vs. the auto, which is also subsidized
- Other modes are subsidized
- Roads are subsidized as well.
- To balance the last 70 years of road subsidy.

Providing alternatives

- Cheaper than building new roads.
- Address auto oriented land use
- Demonstrate to students that transit is a viable travel mode choice.
- Provide choice to auto dependent society
- Provide transportation choice to "choice" riders
- Options, safety, convenience
- Reduce student parking difficulty and cost
- Transit is part of the transportation infrastructure. As infrastructure requirements of an aging population change, the funding for those infrastructure components must also change.
- Urban area growth has increased demands on transit.

Economic development

- Transit provides economic viability, connectivity, job growth, and development.
- Economic- attracting employers, ride to work, ride to college/community college
- Economic development and providing a connection between affordable housing and jobs
- Used as an economic development tool and providing access to jobs.
- To encourage economic growth and business development.
- Increase economic activity among those unable or unwilling to use an auto

Percentage of transit agencies that refer to any of the following consequences of automobile travel when trying to obtain funding (n=132)
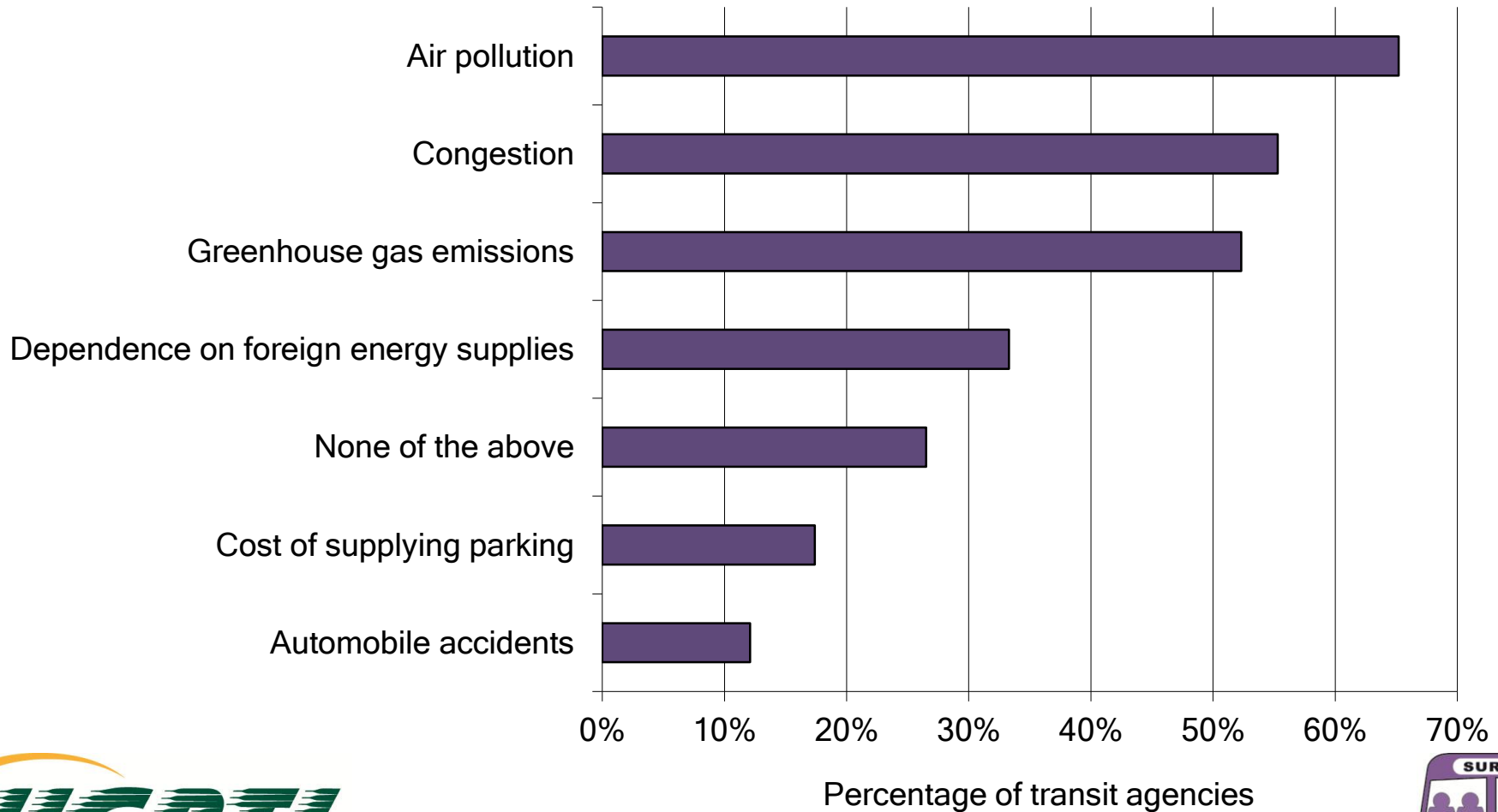
Percentage of transit agencies

Percentage of transit agencies that refer to any of the following consequences of automobile travel when marketing their services (n=132)

Category	Percentage of transit agencies
Air pollution	~61%
Congestion	~55%
Greenhouse gas emissions	~48%
Dependence on foreign energy supplies	~26%
Cost of supplying parking	~25%
None of the above	~21%
Automobile accidents	~11%

Percentage of transit agencies
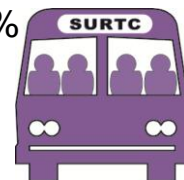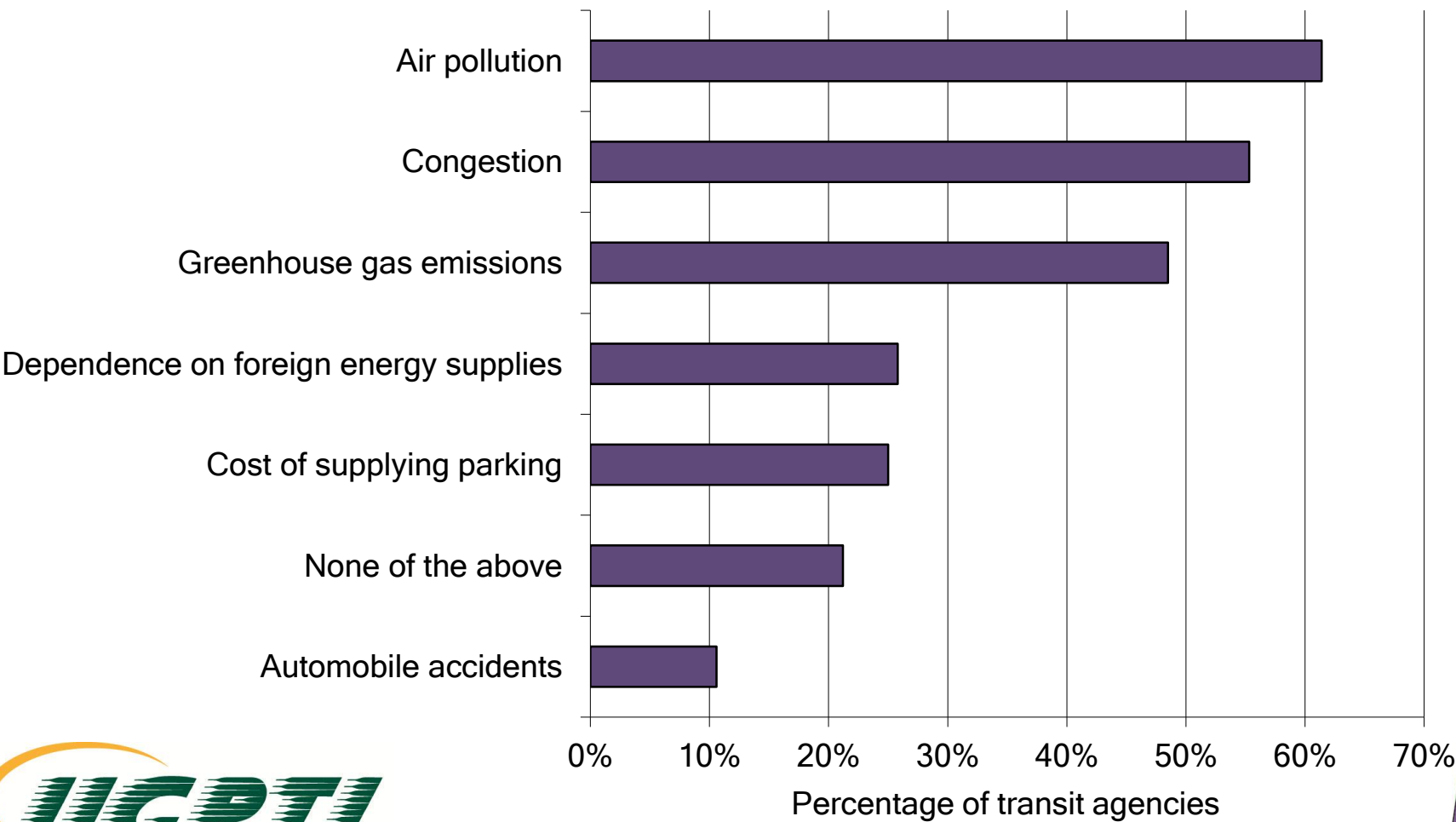
Concepts

- Economies of scale
- Economies of density
- Marginal cost
- Externalities

Rationale for Subsidies

- Special needs for transit by the underprivileged
- Existence of subsidies to other modes of travel
  - Second-best pricing
- Economies of scale in transit
  - Mohring Effect
- Positive externalities associated with transit

Transportation Cost Categories

Cost	Description
Vehicle Ownership	Fixed costs of owning a vehicle.
Vehicle Operation	Variable vehicle costs, including fuel, oil, tires, tolls and short-term parking fees.
Travel Time	The value of time used for travel.
Internal Crash	Crash costs borne directly by travelers.
External Crash	Crash costs a traveler imposes on others.
Internal Activity Benefits	Health benefits of active transportation to travelers (a cost where foregone).
External Activity Benefits	Health benefits of active transportation to society (a cost where foregone).
Internal Parking	Off-street residential parking and long-term leased parking paid by users.
External Parking	Off-street parking costs not borne directly by users.
Congestion	Congestion costs imposed on other road users.
Road Facilities	Roadway facility construction and operating expenses not paid by user fees.

Source: Litman (2009), www.vtpi.org/tca

Transportation Cost Categories (cont.)

Cost	Description
Land Value	The value of land used in public road rights-of-way.
Traffic Services	Costs of providing traffic services such as traffic policing, and emergency services.
Air Pollution	Costs of vehicle air pollution emissions.
Greenhouse Gas Pollution	Lifecycle costs of greenhouse gases that contribute to climate change.
Noise	Costs of vehicle noise pollution emissions.
Resource Externalities	External costs of resource consumption, particularly petroleum.
Barrier Effect	Delays that roads and traffic cause to nonmotorized travel.
Land Use Impacts	Increased costs of sprawled, automobile-oriented land use.
Water Pollution	Water pollution and hydrologic impacts caused by transport facilities and vehicles.
Waste	External costs associated with disposal of vehicle wastes.

Source: Litman (2009), www.vtpi.org/tca

Marginal Cost Pricing

- Social welfare is maximized when prices equal marginal cost
- If there are increasing returns to scale
  - MC < AC
  - Subsidy is required

Marginal Cost Pricing and Social Welfare
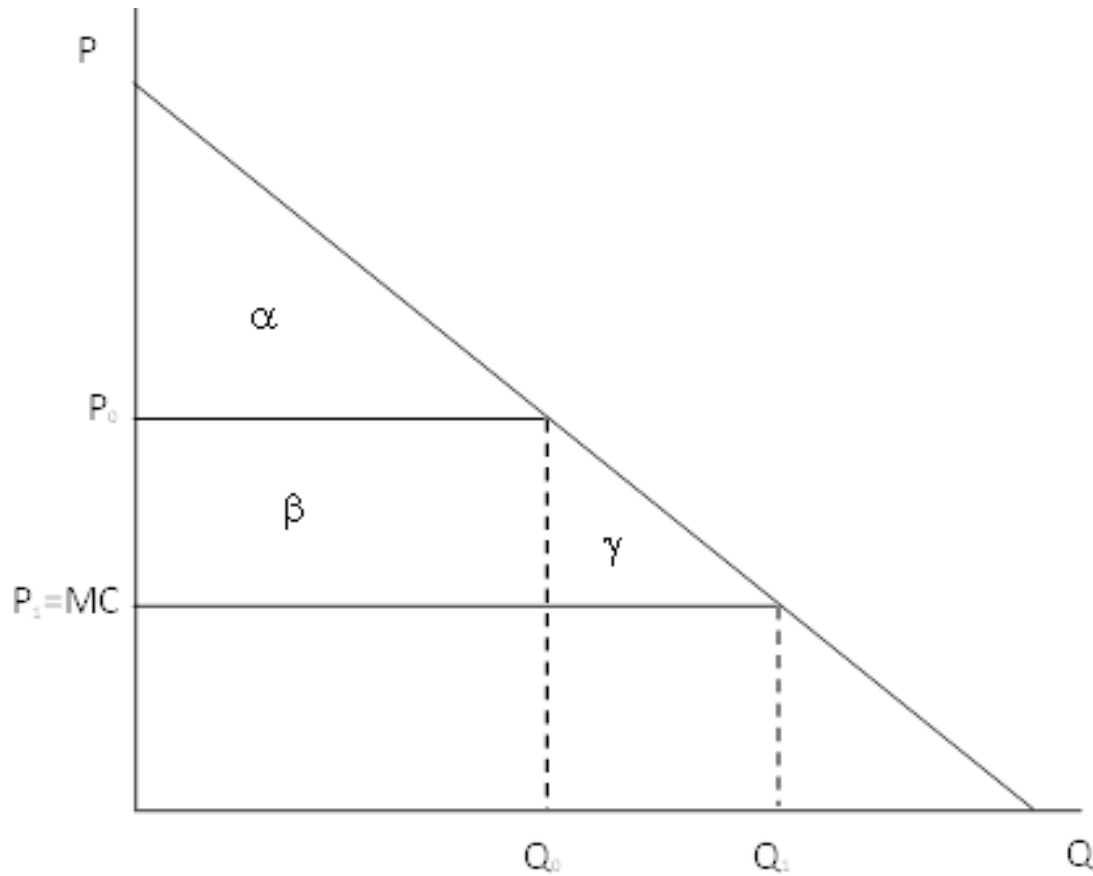
Relationship Between Long-Run Average Cost and Long-Run Marginal Cost
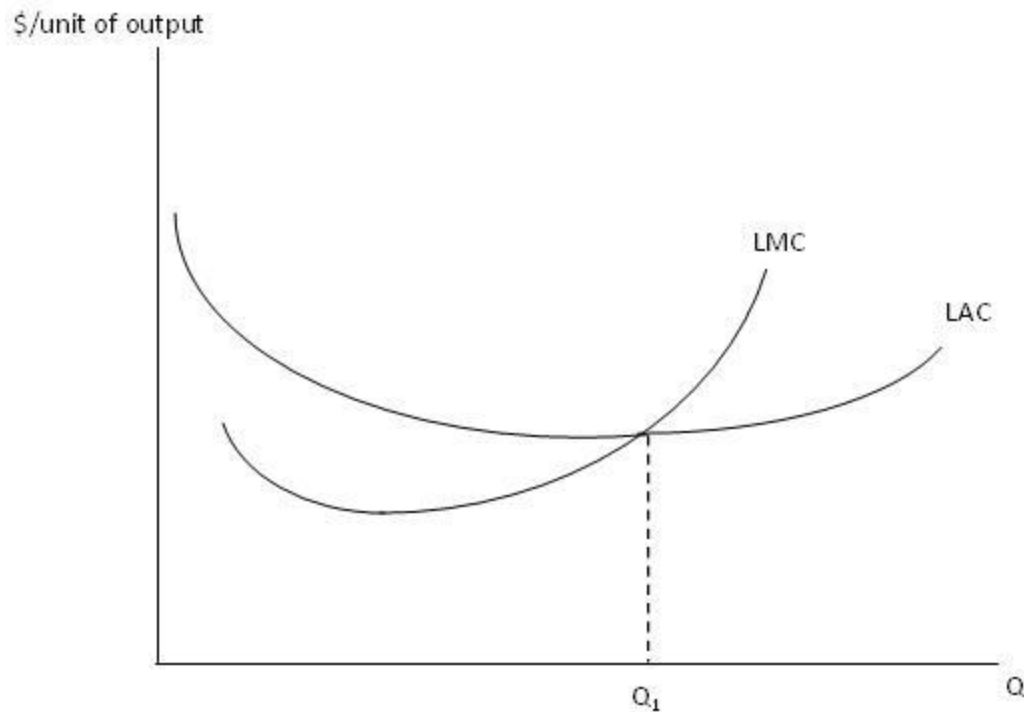
Long-Run Small Urban Transit Cost Model

- Translog function
- $TC = f(Y, N, P_i, Z)$
  - Where TC = total cost, Y = output, N = network size, P_i = input prices, Z = environmental variables
  - Vehicle revenue miles is used as the output
- Limited to agencies that directly operate fixed-route service, and
- Section 5307 agencies with population no greater than 200,000
- Used data from NTD for 2006-2009 for 168 agencies

Descriptive Statistics

Variable	Mean	St. Dev
Vehicle Revenue Miles	1,525,181	2,161,787
Total Cost	3,914,416	4,021,933
Labor share	72%	
Fuel share	14%	
Maintenance share	7%	
Capital share	7%	
Fleet size	30	22
Average age	8.9	3.5
Seats/vehicle	27.8	8.9

Data for Transit Agencies by Size

Output Percentile	Vehicle Revenue Miles ('000 miles)	Fleet size	Wage rate	Labor share	Fuel share	Maint. share	Capital share	Average cost (per vehicle mile)
1-10	232	11	22.08	68%	15%	6%	11%	4.59
11-30	459	19	22.79	70%	14%	7%	9%	4.02
31-50	726	25	22.16	71%	14%	7%	8%	3.96
51-70	1112	32	24.47	73%	14%	7%	7%	3.52
71-90	2077	43	24.80	74%	13%	6%	6%	3.02
>90	6315	54	29.00	77%	11%	6%	5%	1.51

Results from Cost Model

Variable	Parameter estimate	t-value
Intercept	0.337	11.13
Wage	0.721	145.30
Fuel	0.137	40.00
Maintenance	0.070	36.63
Capital	0.073	11.86
Output	0.908	33.85
Output*Output	0.160	6.41
Output*Wage	0.052	11.57
Output*Fuel	-0.009	-3.30
Output*Maintenance	-0.013	-8.33
Output*Capital	-0.027	-5.03
Area	0.005	0.14
Area*Area	0.184	2.40
Area*Wage	-0.025	-3.99
Area*Fuel	0.016	3.92
Area*Maintenance	0.006	2.73
Area*Capital	0.002	0.36
Area*Output	-0.120	-3.41
Seats/Vehicle	0.006	8.51
Average Length Trip	-0.010	-3.80

Estimates of returns to density, returns to scale, marginal cost, required subsidy at the sample mean

- $RTD = \dfrac{1}{\varepsilon_Y} = \dfrac{1}{0.908} = 1.101$

- $RTS = \dfrac{1}{\varepsilon_Y + \varepsilon_N} = \dfrac{1}{0.908 + 0.005} = 1.095$

- MC $= \dfrac{\partial C}{\partial Y} = \dfrac{\partial lnC}{\partial lnY} \dfrac{C}{Y} = \varepsilon_Y \dfrac{C}{Y} = 0.908*2.57 = \$2.33$ per vehicle mile

- Required subsidy = AC − MC = $0.24 per vehicle mile

Estimates for Transit Agencies Grouped by Size

Output Percentile	Returns to Density	Average cost	Marginal cost	Required subsidy
		--------------Per vehicle mile--------------		
1-10	1.65	4.59	2.78	1.80
11-30	1.40	4.02	2.88	1.14
31-50	1.27	3.96	3.12	0.83
51-70	1.17	3.52	3.02	0.50
71-90	1.04	3.02	2.89	0.13
>90	0.88	1.51	1.71	-0.20

Full Cost Model

External costs (Litman 2009, http://www.vtpi.org/tca/)

- Pollution: $0.13 per vehicle mile
- Greenhouse gas emissions: $0.09 per vehicle mile
- Roadway facilities: $0.04 per vehicle mile
- Crash costs: $0.27 per vehicle mile
- Total: $0.53 per vehicle mile

Full Cost Model

Marginal external waiting benefit

- $MEWB = -\frac{\delta WT}{\delta Q} * X * VOWT$

- $WT \propto \frac{1}{Freq}$

- $Freq = \frac{Q}{NL}$

- WT = 2.0 minutes +
      0.3*headway

Estimates for Marginal External Waiting Benefit

Scenario	Estimate ($ per vehicle mile)
Base Case	0.18
VOWT 5	0.09
VOWT 15	0.27
Riders -50%	0.09
Riders +50%	0.27
Headway 15 min	0.09
Headway 1 hour	0.35
Q 500	0.31
Q 1500	0.10

Estimates for Example Systems

Transit Agency	Route miles	Average headway	Vehicle miles (thousand)	Returns to Density	Avg. cost	Internal Marginal Cost	External marginal cost	Marginal external waiting benefit	Total social marginal cost	Required subsidy
		(hours)			----------------------------$ per vehicle mile----------------------------					
Fond du Lac, WI	60									
Middletown, OH	59									
Cheyenne, WY	107									
Grand Forks, ND	80									
Rome, GA	328									
Billings, MT	181									
Waterloo, IA	118									
Davis, CA	81									
Sioux Falls, SD	195									
Odessa, TX	203									
Santa Fe, NM	124									
Wilmington, NC	138									
58-system Average	117									

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Middletown, OH	59	1.02	205							
Cheyenne, WY	107	1.10	367							
Grand Forks, ND	80	1.08	382							
Rome, GA	328	2.28	451							
Billings, MT	181	1.17	555							
Waterloo, IA	118	0.81	580							
Davis, CA	81	0.59	719							
Sioux Falls, SD	195	1.24	719							
Odessa, TX	203	1.13	721							
Santa Fe, NM	124	0.73	942							
Wilmington, NC	138	0.49	1,443							
58-system Average	117	1.05	490							

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Santa Fe, NM	124	0.73	942	1.20	4.01	3.33	0.53	0.13	3.73	
Wilmington, NC	138	0.49	1,443	1.11	3.24	2.92	0.53	0.08	3.37	
58-system Average	117	1.05	490	1.45	4.39	3.11	0.53	0.63	3.01	

Estimates for Example Systems

Transit Agency	Route miles	Average headway	Vehicle miles (thousand)	Returns to Density	Avg. cost	Internal Marginal Cost	External marginal cost	Marginal external waiting benefit	Total social marginal cost	Required subsidy
		(hours)			---------------------------$ per vehicle mile---------------------------					
Fond du Lac, WI	60	1.17	160	1.83	5.94	3.25	0.53	0.77	3.01	2.93
Middletown, OH	59	1.02	205	1.70	3.48	2.04	0.53	0.72	1.85	1.63
Cheyenne, WY	107	1.10	367	1.47	2.54	1.73	0.53	0.35	1.91	0.63
Grand Forks, ND	80	1.08	382	1.46	3.91	2.69	0.53	0.46	2.75	1.16
Rome, GA	328	2.28	451	1.40	5.11	3.64	0.53	0.82	3.36	1.75
Billings, MT	181	1.17	555	1.34	5.37	4.00	0.53	0.41	4.13	1.24
Waterloo, IA	118	0.81	580	1.33	3.90	2.94	0.53	0.22	3.25	0.65
Davis, CA	81	0.59	719	1.27	5.35	4.21	0.53	0.62	4.12	1.23
Sioux Falls, SD	195	1.24	719	1.27	4.64	3.66	0.53	0.41	3.78	0.87
Odessa, TX	203	1.13	721	1.27	2.95	2.33	0.53	0.16	2.70	0.26
Santa Fe, NM	124	0.73	942	1.20	4.01	3.33	0.53	0.13	3.73	0.28
Wilmington, NC	138	0.49	1,443	1.11	3.24	2.92	0.53	0.08	3.37	-0.12
58-system Average	117	1.05	490	1.45	4.39	3.11	0.53	0.63	3.01	1.39

Additional considerations

- External costs of automobile travel and second-best pricing
- Economic benefits of improving mobility
- Distortionary effects of subsidies

Benefits of Public Transportation
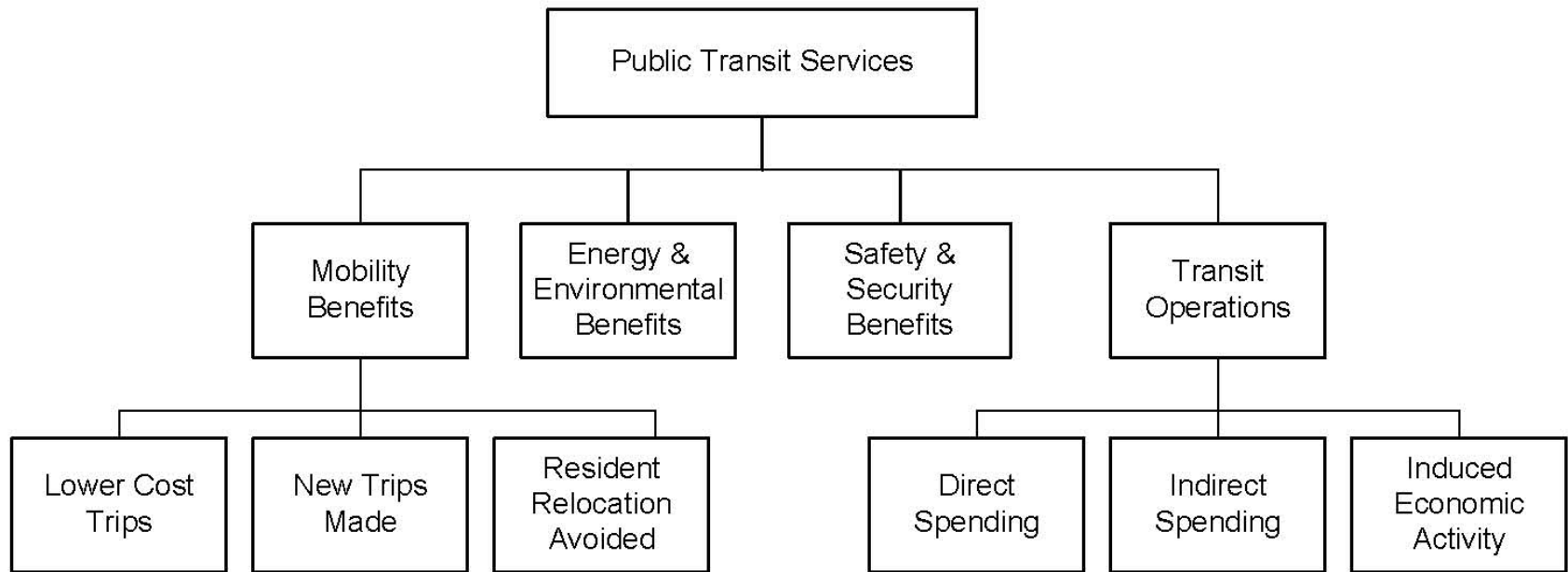
Conclusions

- Close to half of transit agencies in small urban areas have either reduced service or increased fares over the last two years.
- The main reason for these actions has been a decrease in funding.
- Economies of scale and economies of density are found to exist for small urban transit systems, providing rationale for subsidies.

QUESTIONS?