Marginal Cost Pricing and Subsidy of Transit in Small Urbanized Areas

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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)

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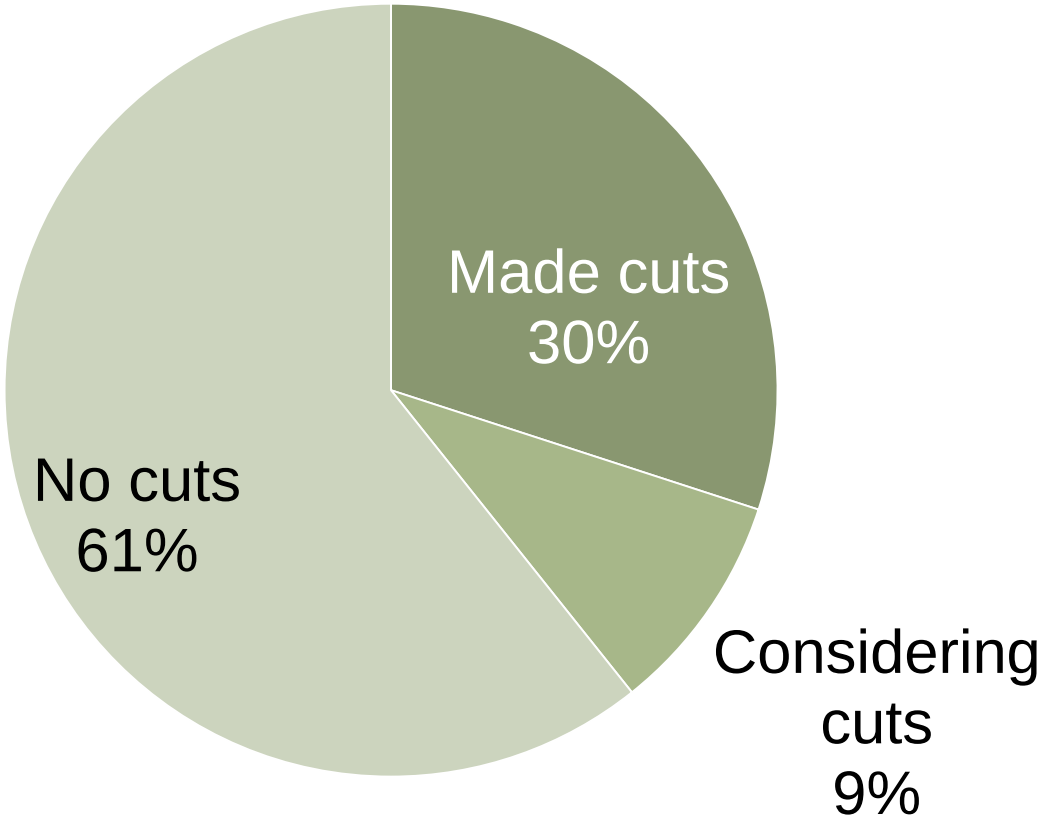
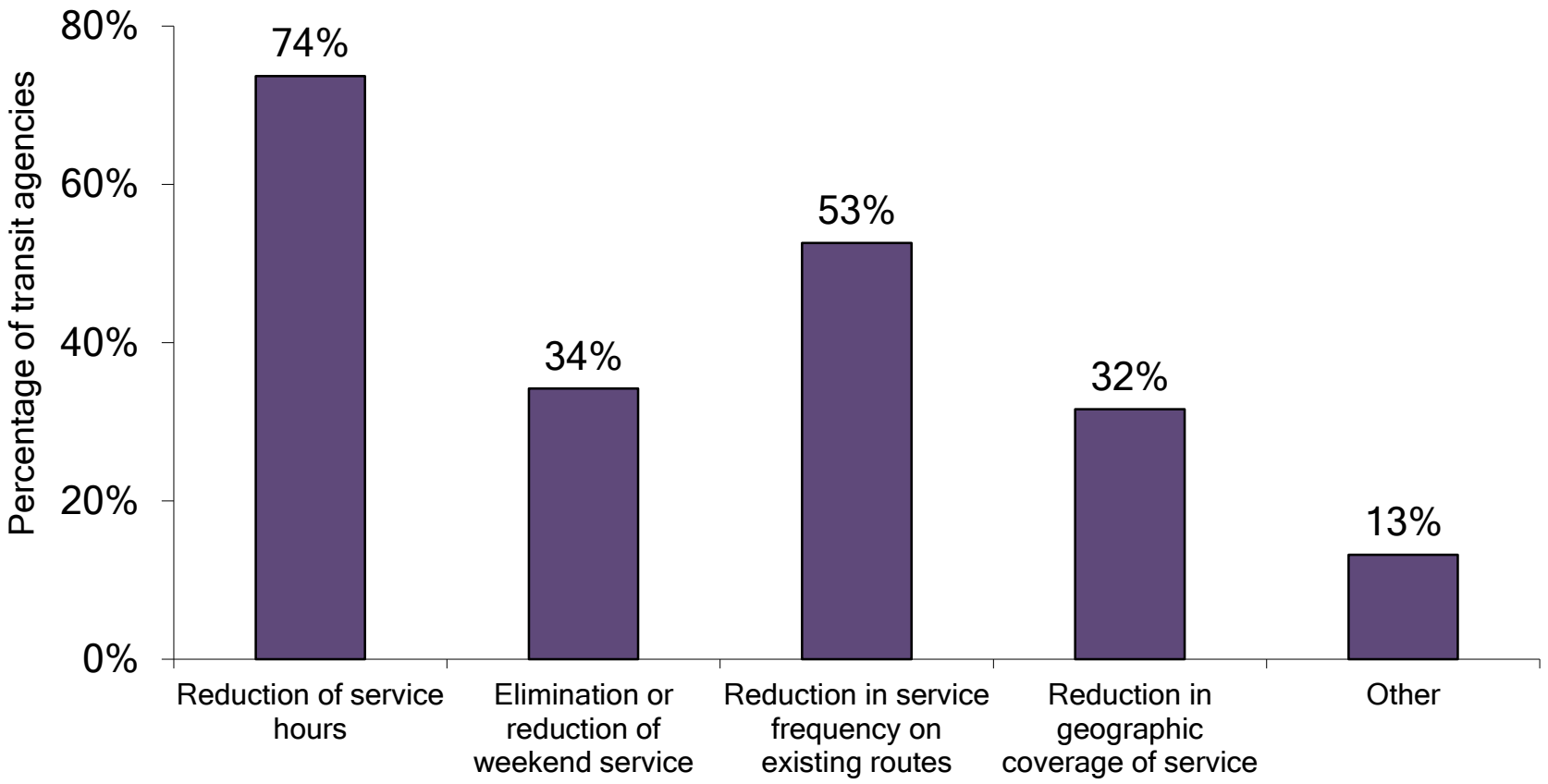
Agencies that have made cuts in service since January 1, 2009, or are considering cuts (n=140)



Cuts by transit agencies that have made service reductions (n=38)



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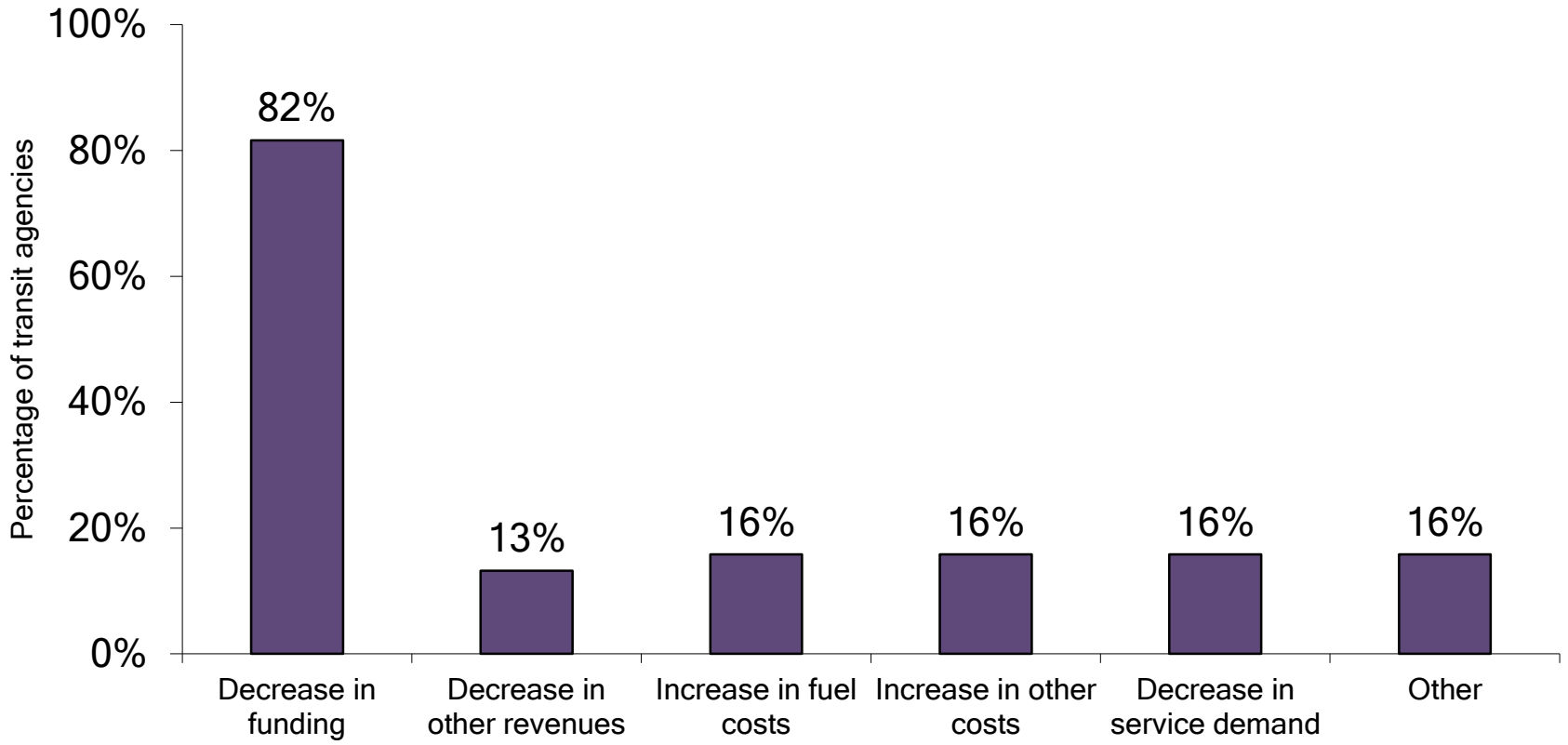
Factors that motivated decisions to cut transit service (n=38)



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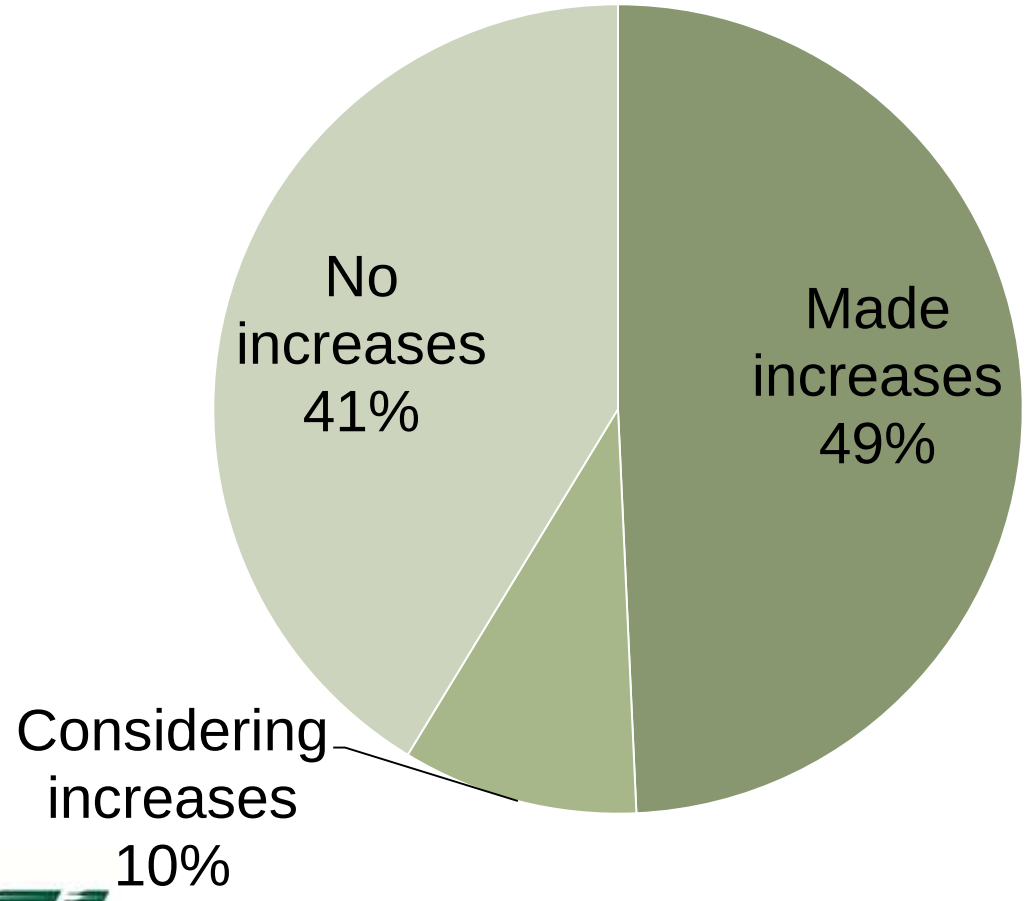
Transit agencies that have added service since January 1, 2009, or are considering increases (n=138)



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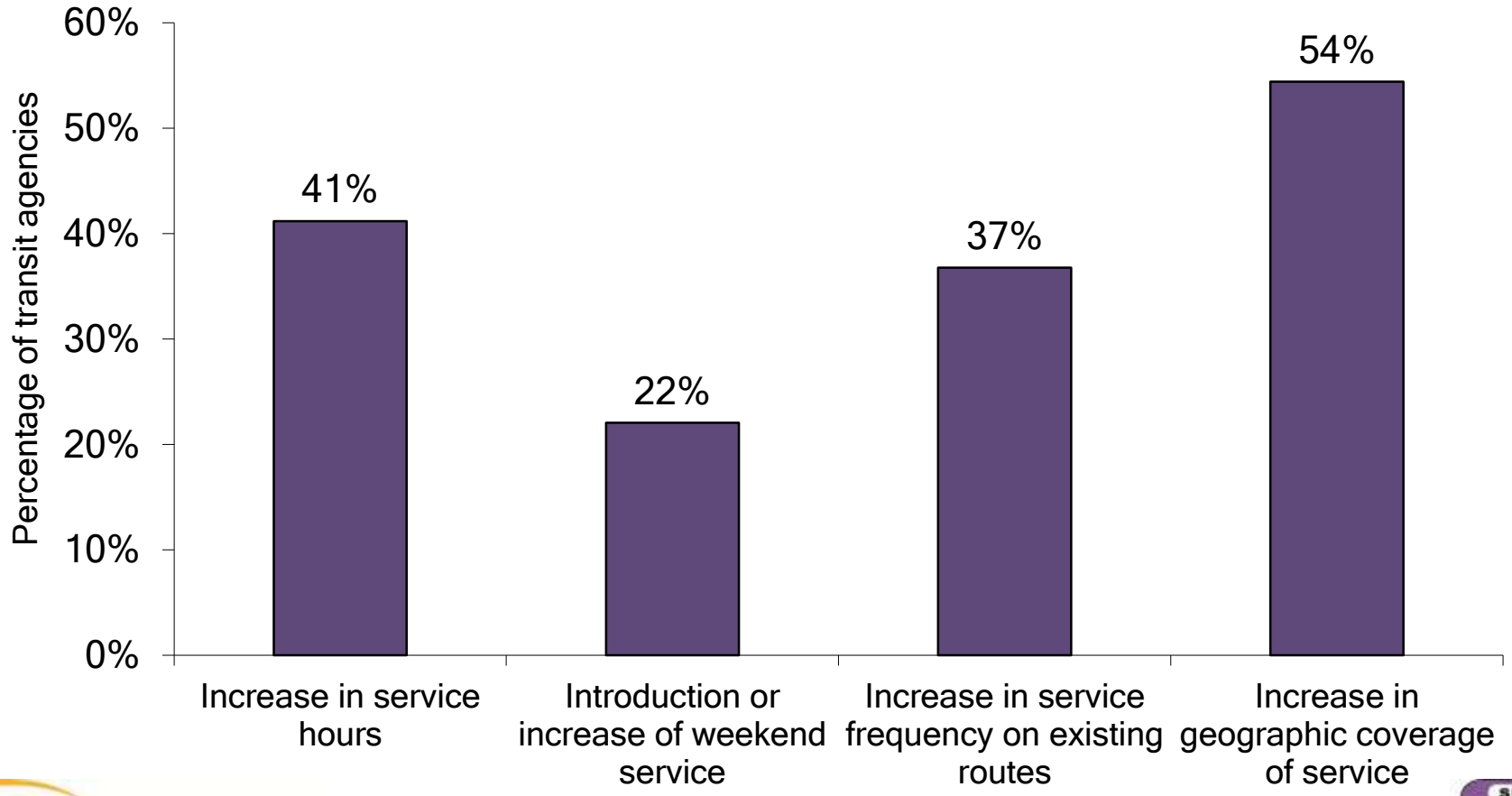
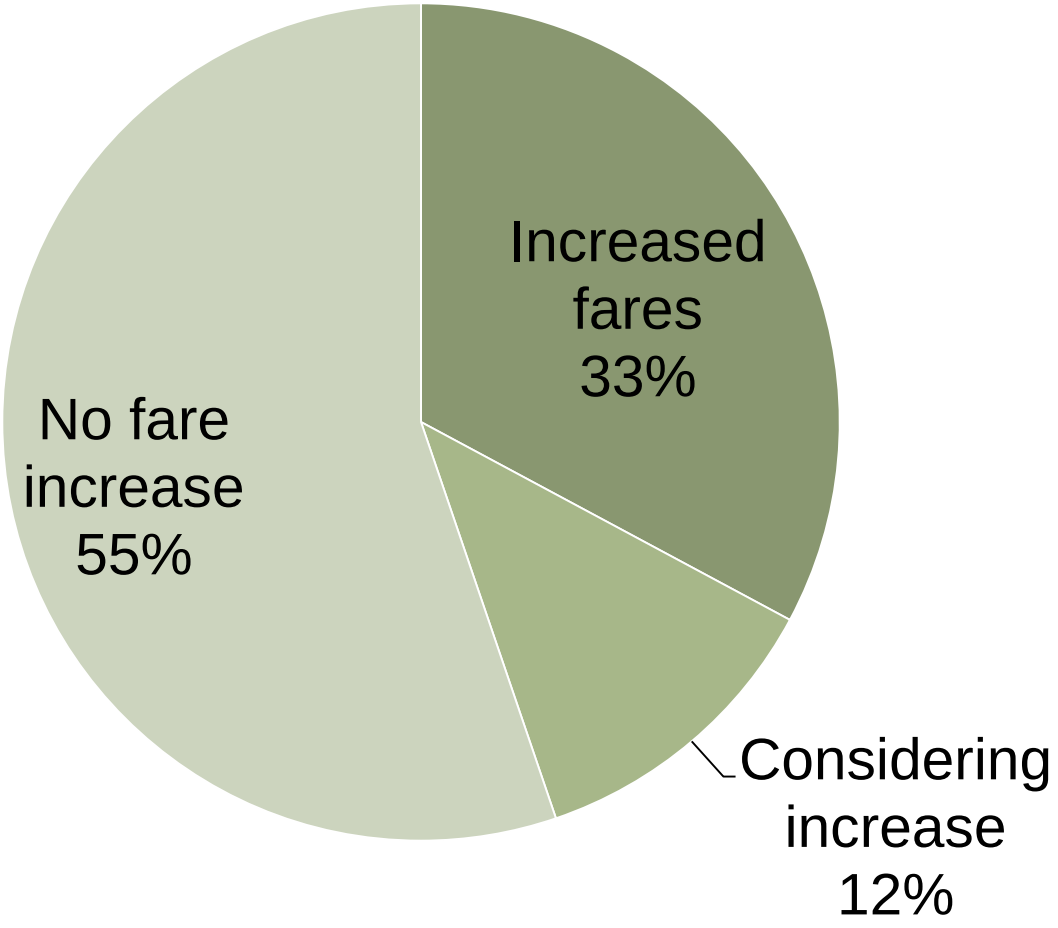
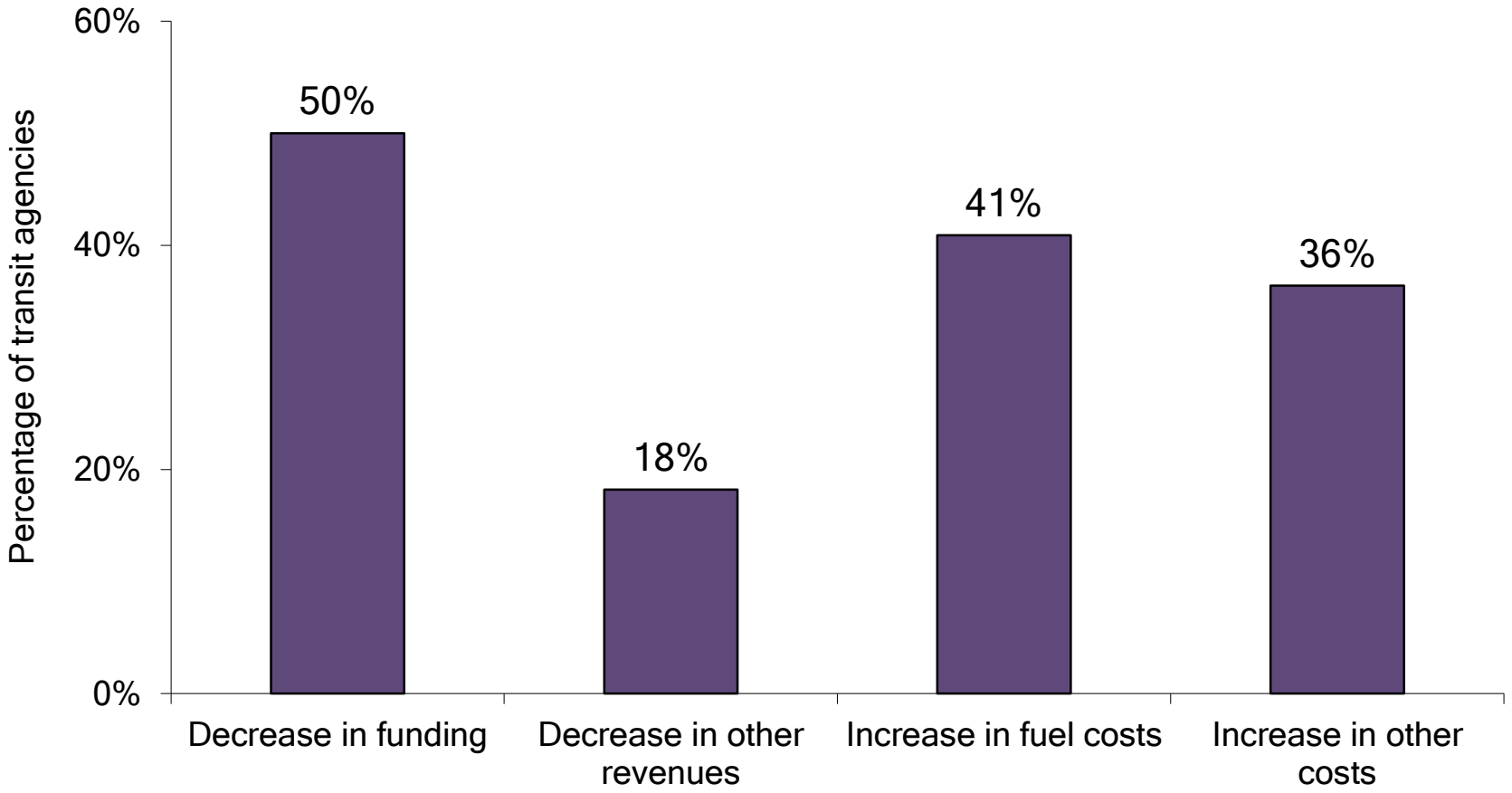
Types of services added by transit agencies that have made service increases (n=68)



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)



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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%

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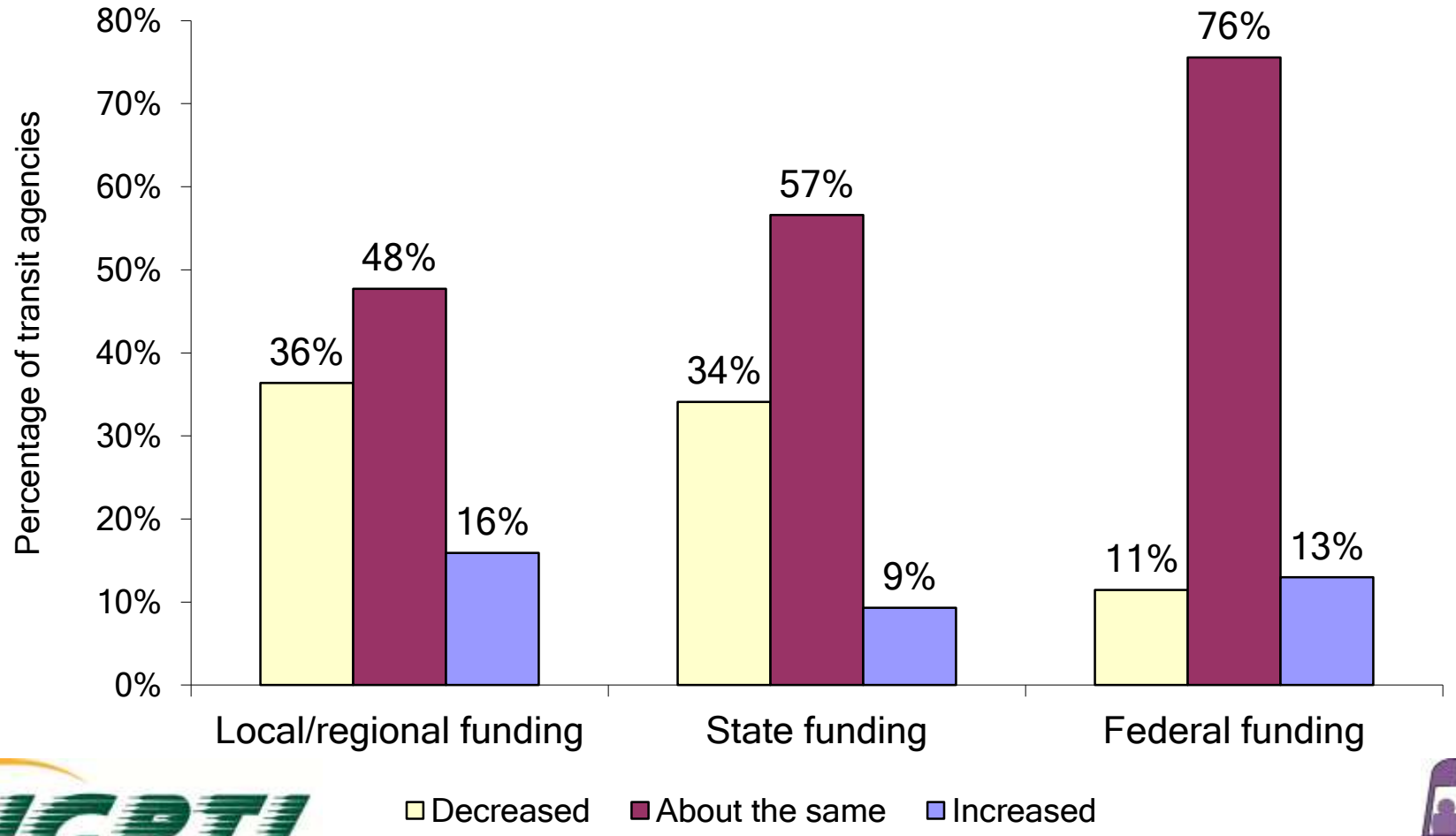
Demand for Service

- 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.

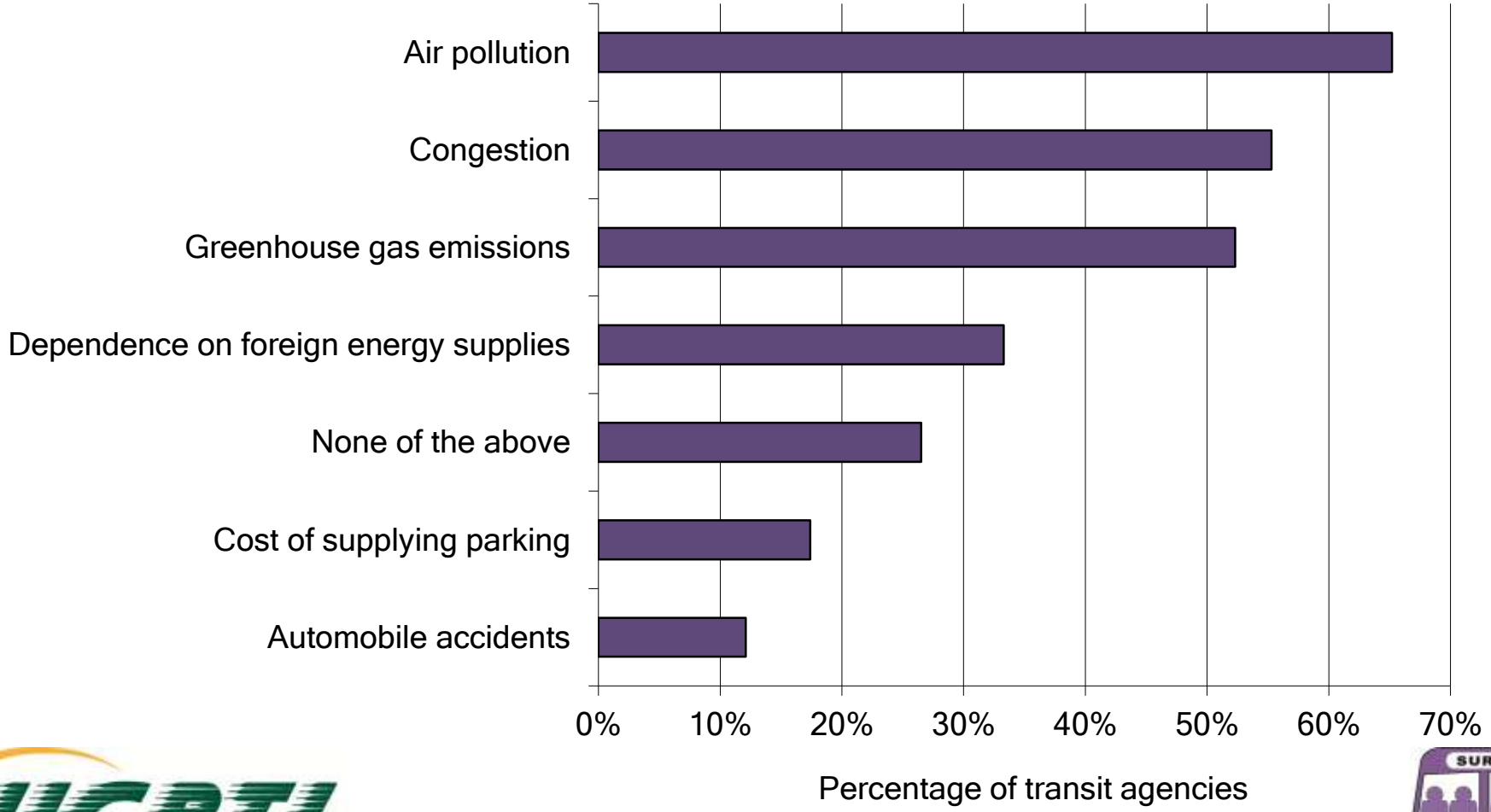
Changes in operational funding over the last year (n=132)



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%

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



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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

Marginal Cost Pricing

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

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

- $RTD = \frac{1}{\varepsilon_Y} = \frac{1}{0.908} = 1.101$
- $RTS = \frac{1}{\varepsilon_Y + \varepsilon_N} = \frac{1}{0.908+0.005} = 1.095$
- MC = $\frac{\partial C}{\partial Y} = \frac{\partial lnC}{\partial lnY}\frac{C}{Y} = \varepsilon_Y \frac{C}{Y}$ = 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

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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 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

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?