Analysis of MBTA Commuter Rail Electrification

Extended electrification of Metro North Harlem Line in 1984

Effect of electrification and high-level platforms on trip times

Train Station	Distance to GCT (miles)	1976 trip time (min)	1993 trip time (min)	Trip time change (min)	Trip time change (%)
Brewster	52	91	81	-10	-11.0
Katonah	41	75	66	-9	-12.0
Chappaqua	32	60	53	-7	-11.7
Pauling	64	113	106	-7	-6.2
Hawthorne	28	50	47	-3	-6.0

Effect of electrification and high-level platforms on ridership

	1984	1994	Percent Increase	Average Annual Increase
Dover Plains Branch				
Total Annual Weekday Ridership	33,500	157,000	370%	17%
Total Annual Weekend Ridership	14,500	103,000	610%	22%
Total Annual Ridership	48,000	260,000	440%	18%
Upper Harlem Line – Brewster and Brewster North Stations only				
Total Annual Weekday Ridership	420,000	1,010,000	140%	9%
Total Annual Weekend Ridership	90,000	190,000	111%	8%
Total Annual Ridership	510,000	1,200,000	135%	9%

Controlling for other variables

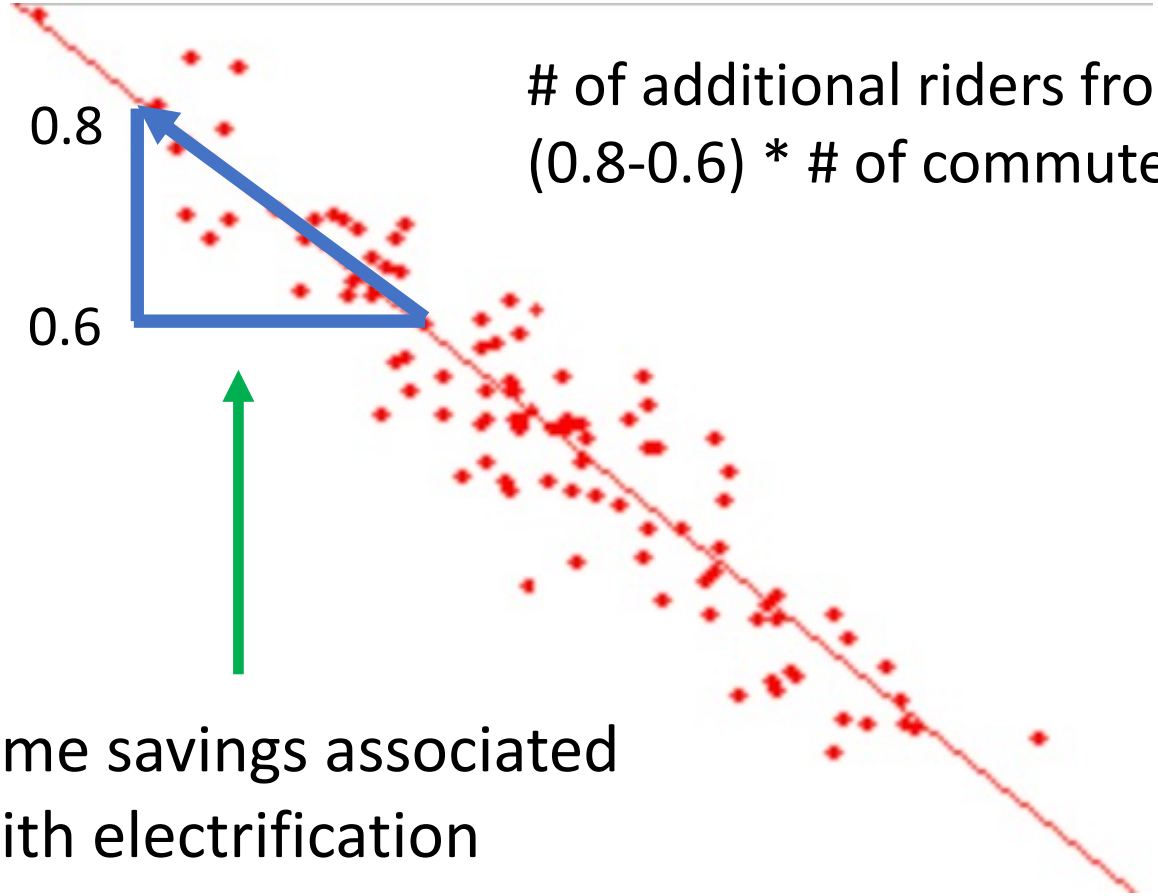
- Ridership growth on other Metro North lines not nearly as dramatic
- Population growth in region served by Harlem Line not substantial
- Increase in frequency of train service no different from other lines

Train Station	Metro North line	Total Trains to GCT (1976)	Total Trains to GCT (1993)	% Change
Fairfield	New Haven Line	20	31	55
Stamford	New Haven Line	59	81	37.3
Norwalk	New Haven Line	25	31	24
Garrison	Hudson Line	15	19	26.7
Croton-Harmon	Hudson Line	37	44	18.9
Peekskill	Hudson Line	15	19	26.7
Brewster	Harlem Line	22	25	13.6
Katonah	Harlem Line	23	25	8.7
Chappaqua	Harlem Line	23	26	13.0

Guiding question

How many new riders would the MBTA add from the trip time savings associated with the electrification of its commuter rail system?

Expected results before conducting analysis



# of additional riders from municipality X:
(0.8-0.6) * # of commuters from municipality X

Proportion of residents who take commuter rail

Time savings associated with electrification

Time savings from taking train instead of driving (%)

Methodology Part A: Proportion of commuters taking commuter rail

- Data source: U.S. Census Bureau 2009-2013 Commuting Flows by Travel Mode
- Focus on commuters into Boston since 84% of inbound commuter rail riders commute to Boston (2008-2009 Commuter Rail Passenger Survey)

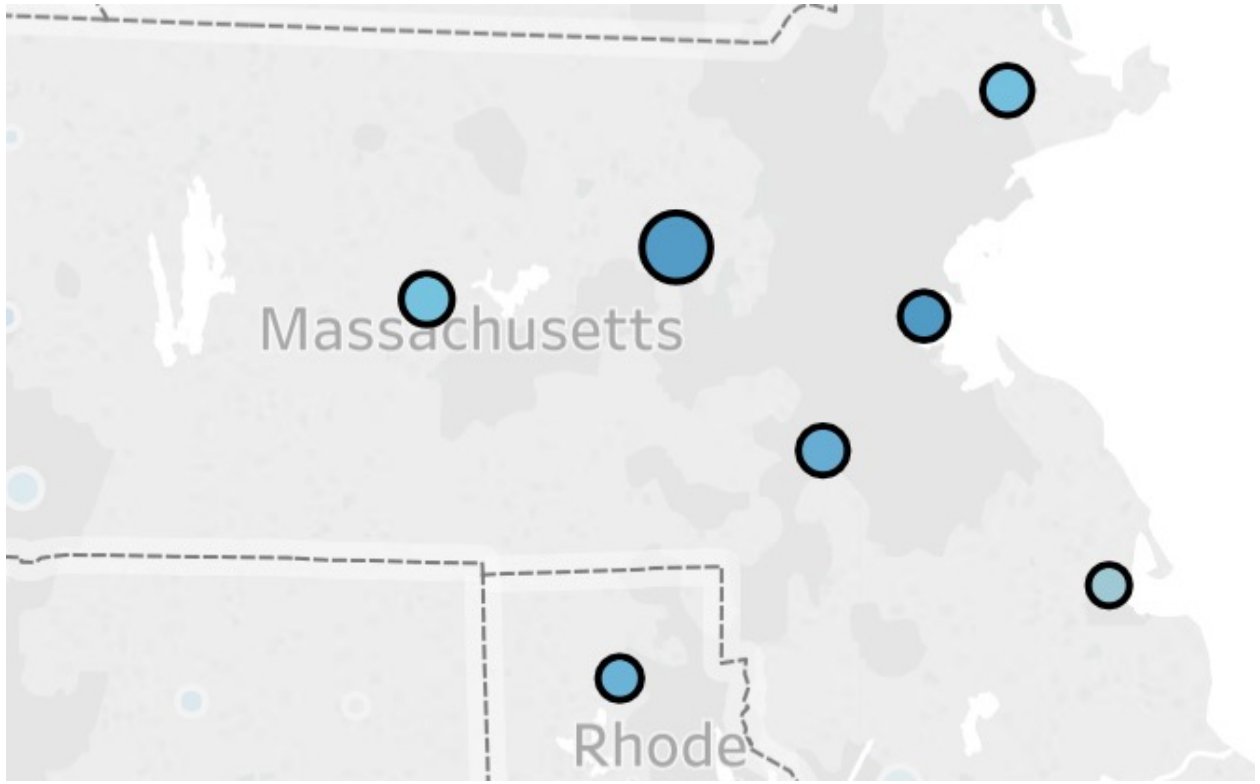
													#	MOE
Worcester C	Worcester ci	49340	Worcester, M	25	25	7000	Massachuset	Suffolk Coun	Boston city	14460	Boston-Caml	Car, truck, or	691	174
Worcester C	Worcester ci	49340	Worcester, M	25	25	7000	Massachuset	Suffolk Coun	Boston city	14460	Boston-Caml	Car, truck, or	153	83
Worcester C	Worcester ci	49340	Worcester, M	25	25	7000	Massachuset	Suffolk Coun	Boston city	14460	Boston-Caml	Public transp	641	204
Worcester C	Worcester ci	49340	Worcester, M	25	25	7000	Massachuset	Suffolk Coun	Boston city	14460	Boston-Caml	Other travel	59	54

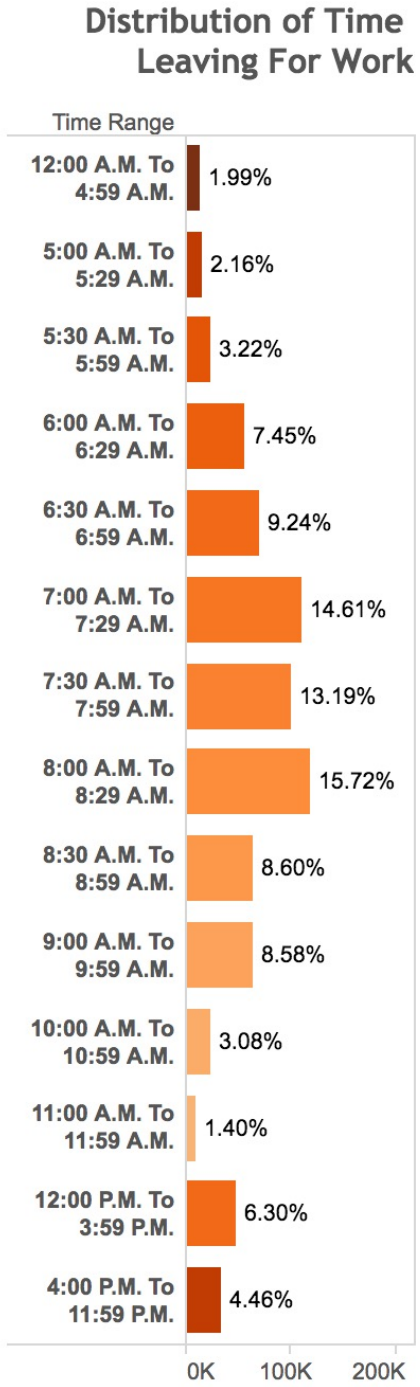
Methodology Part B:
Trip time using commuter rail

Monday to Friday

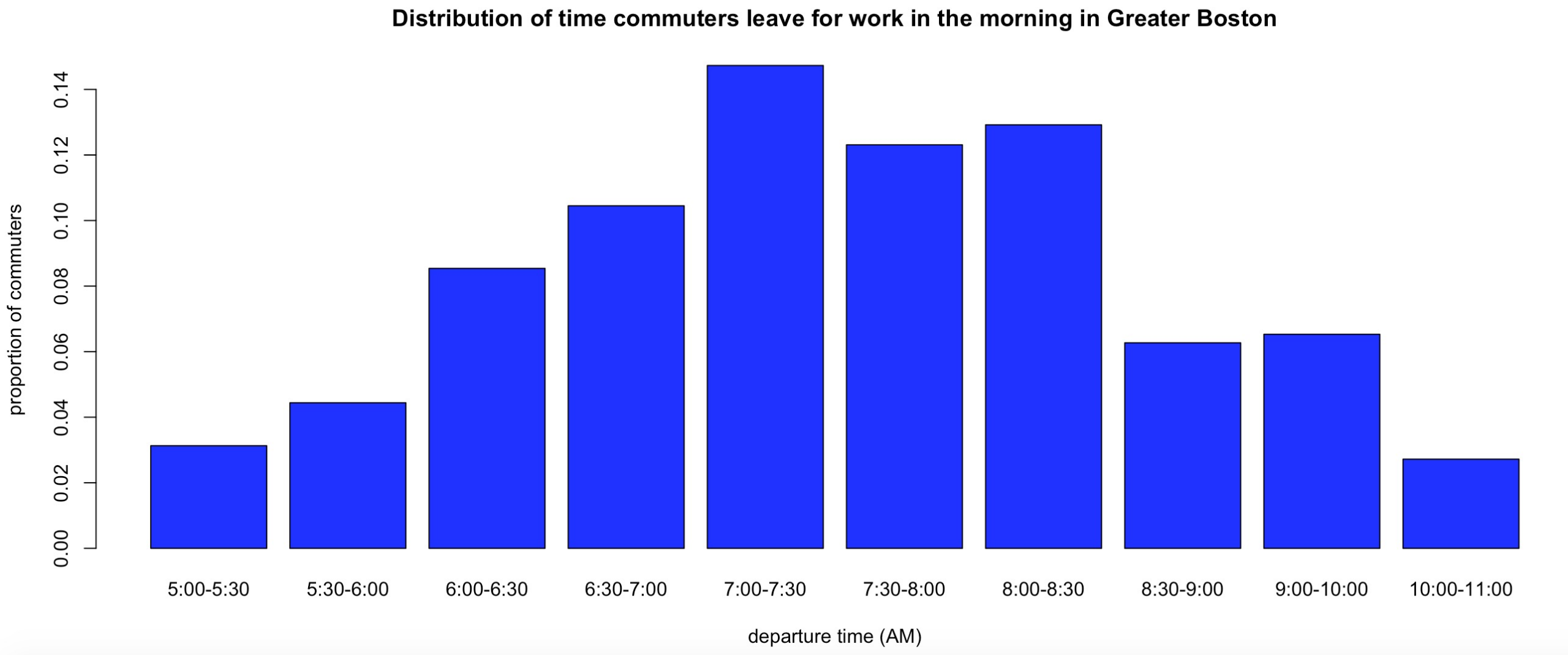
Inbound to Boston			AM										
ZONE	STATION	TRAIN #	500	502	582	504	584	506	586	508	588	510	552	590
	Bikes Allowed		🚲											
8	Worcester	♿	4:45	5:15	-	5:50	-	6:22	-	6:57	-	7:24	8:00	-
8	Grafton	♿	4:58	5:28	-	6:03	-	6:35	-	7:10	-	7:37	-	-
7	Westborough	♿	5:02	5:32	-	6:07	-	6:39	-	7:14	-	7:41	-	-
6	Southborough	♿	5:11	5:41	-	6:17	-	6:48	-	7:23	-	7:50	-	-
6	Ashland	♿	5:15	5:45	-	6:22	-	6:52	-	7:27	-	7:54	-	8:34
5	Framingham	♿	5:26	5:55	6:04	6:31	6:39	7:02	7:15	7:37	7:49	8:04	-	8:45
4	West Natick	♿	5:31	6:01	6:09	6:36	6:44	7:08	7:20	7:43	7:54	8:10	-	8:50
4	Natick Center		5:36	6:05	6:14	-	6:49	-	7:25	-	7:59	8:15	-	8:55
3	Wellesley Square		5:41	-	6:19	-	6:54	-	7:30	-	8:04	8:20	-	9:00
3	Wellesley Hills		5:45	-	6:23	-	6:58	-	7:34	-	8:08	8:24	-	9:04
3	Wellesley Farms		5:48	-	6:26	-	7:01	-	7:37	-	8:11	8:27	-	9:07
2	Auburndale		5:53	-	6:31	-	7:06	-	7:42	-	8:16	-	-	9:12
2	West Newton		5:56	-	6:34	-	7:09	-	7:45	-	8:19	-	-	9:15
1	Newtonville		5:59	-	6:37	-	7:12	-	7:48	-	8:22	-	-	9:18
1A	Boston Landing	♿	L 6:04	-	L 6:42	-	L 7:17	-	L 7:54	-	L 8:28	L 8:39	-	L 9:23
1A	Yawkey	♿	L 6:09	L 6:24	L 6:47	L 6:59	L 7:22	L 7:34	L 7:59	L 8:09	L 8:33	L 8:44	L 8:55	L 9:28
1A	Back Bay	♿	L 6:14	L 6:29	L 6:52	L 7:04	L 7:27	L 7:39	L 8:04	L 8:14	L 8:38	L 8:49	L 9:00	L 9:33
1A	South Station	♿	6:20	6:35	6:58	7:10	7:33	7:45	8:10	8:20	8:44	8:55	9:06	9:39

Methodology Part C: Trip time by car





Methodology Part C:
Trip time by car (cont.)



distance_matrix(**args*, ***kwargs*)

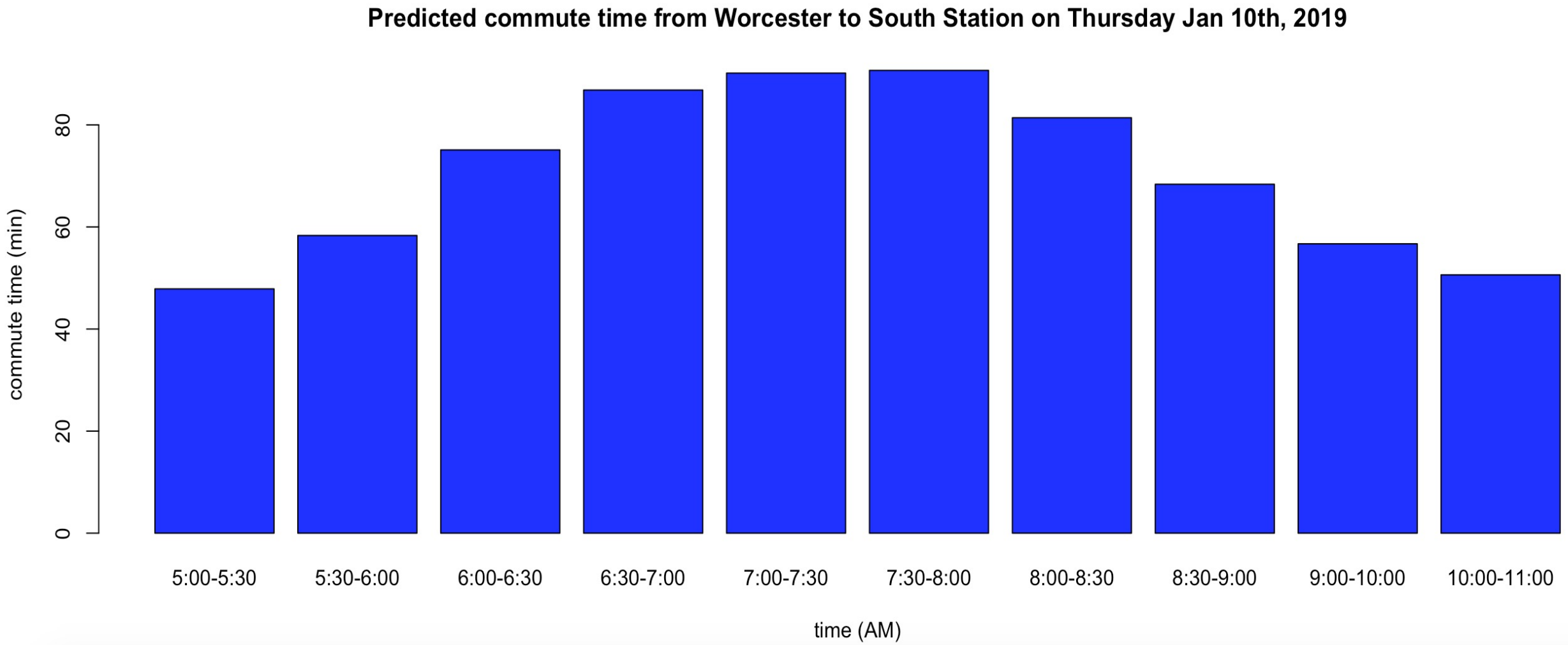
Gets travel distance and time for a matrix of origins and destinations.

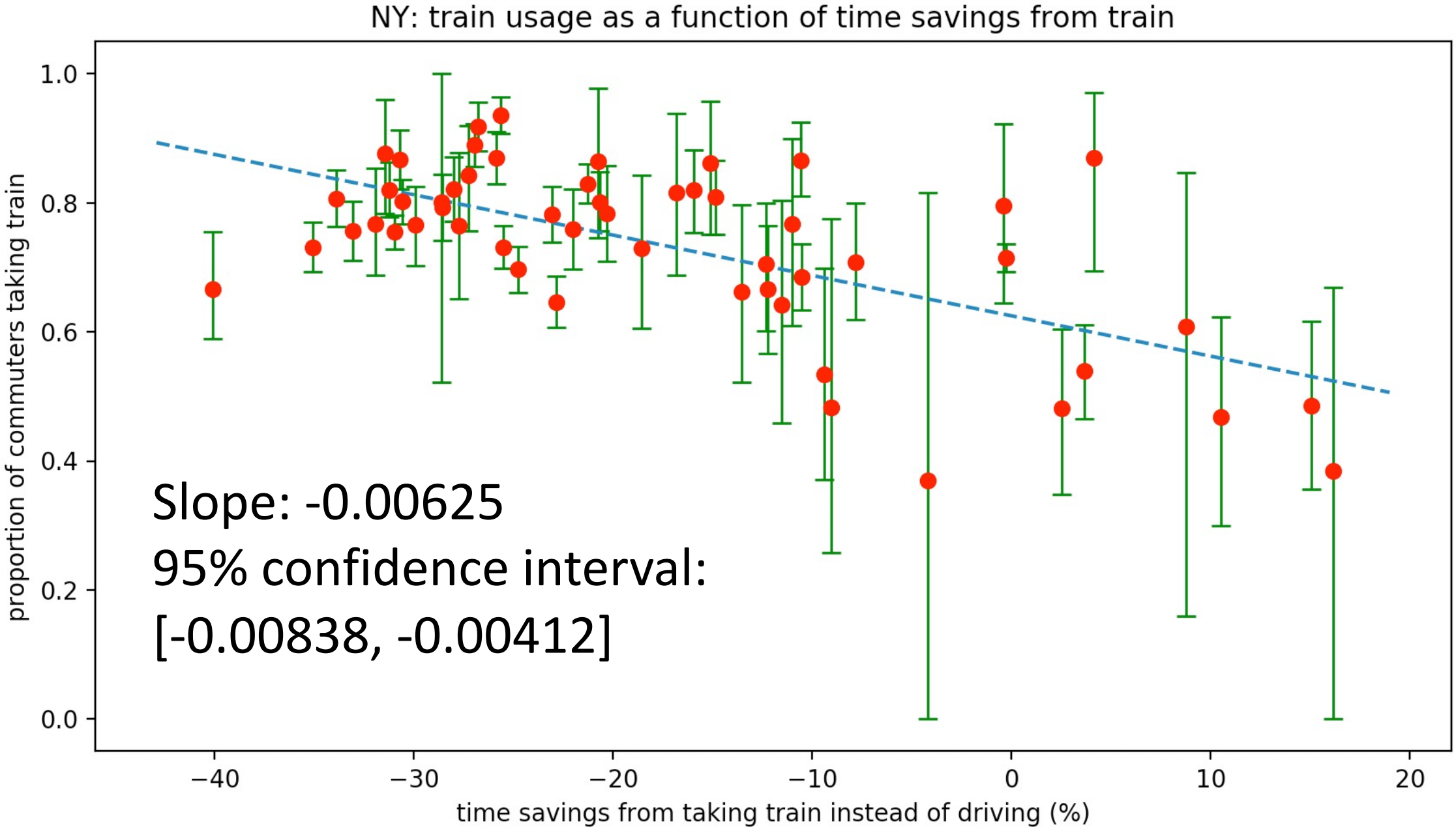
Parameters:

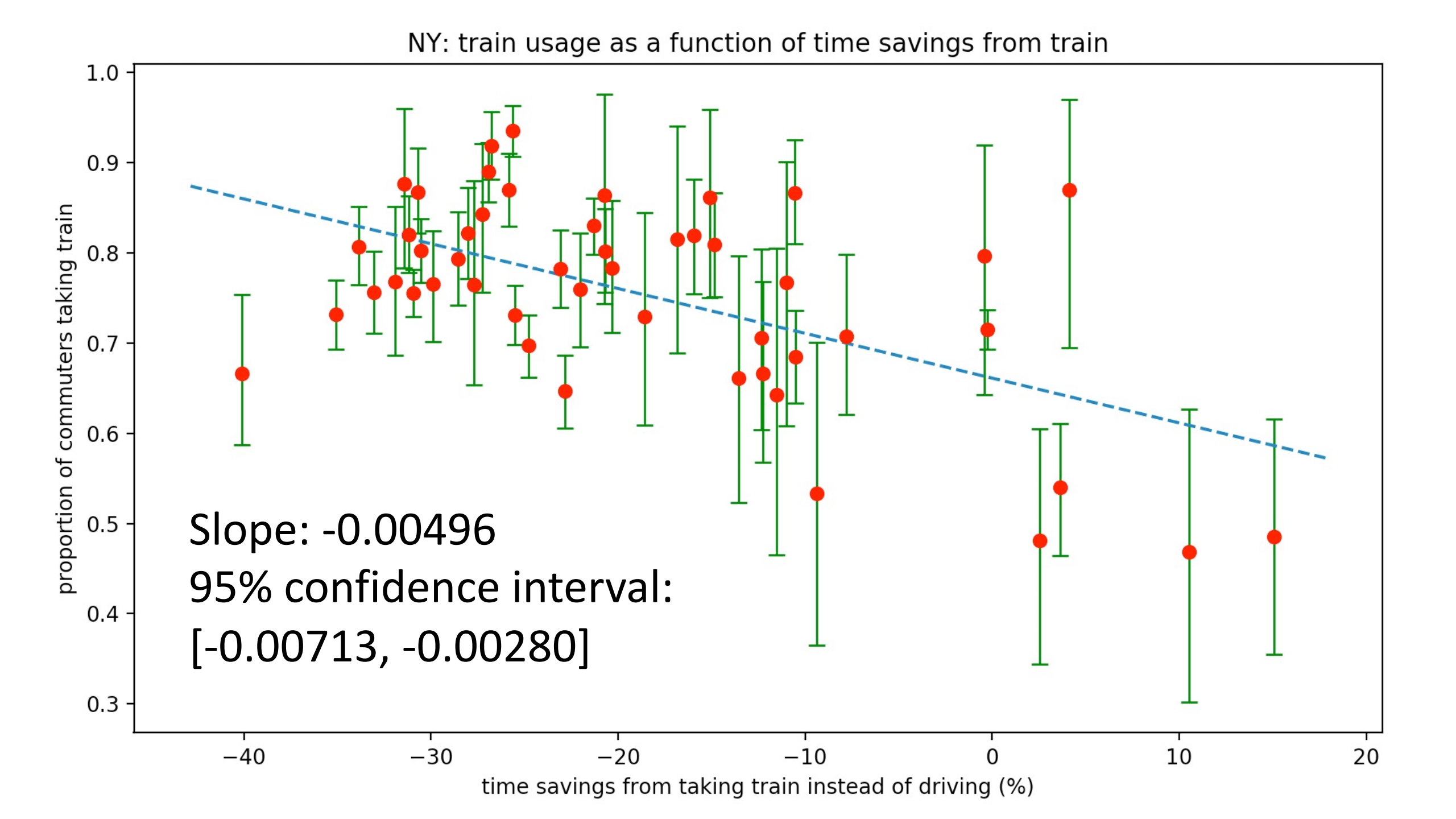
- **origins** (*a single location, or a list of locations, where a location is a string, dict, list, or tuple*) – One or more locations and/or latitude/longitude values, from which to calculate distance and time. If you pass an address as a string, the service will geocode the string and convert it to a latitude/longitude coordinate to calculate directions.
- **destinations** (*a single location, or a list of locations, where a location is a string, dict, list, or tuple*) – One or more addresses and/or lat/lng values, to which to calculate distance and time. If you pass an address as a string, the service will geocode the string and convert it to a latitude/longitude coordinate to calculate directions.
- **mode** (*string*) – Specifies the mode of transport to use when calculating directions. Valid values are "driving", "walking", "transit" or "bicycling".
- **language** (*string*) – The language in which to return results.
- **avoid** (*string*) – Indicates that the calculated route(s) should avoid the indicated features. Valid values are "tolls", "highways" or "ferries".
- **units** (*string*) – Specifies the unit system to use when displaying results. Valid values are "metric" or "imperial".
- **departure_time** (*int or datetime.datetime*) – Specifies the desired time of departure.
- **arrival_time** (*int or datetime.datetime*) – Specifies the desired time of arrival for transit directions. Note: you can't specify both departure_time and arrival_time.
- **transit_mode** (*string or list of strings*) – Specifies one or more preferred modes of transit. This parameter may only be specified for requests where the mode is transit. Valid values are "bus", "subway", "train", "tram", "rail". "rail" is equivalent to ["train", "tram", "subway"].
- **transit_routing_preference** (*string*) – Specifies preferences for transit requests. Valid values are "less_walking" or "fewer_transfers".
- **traffic_model** – Specifies the predictive travel time model to use. Valid values are "best_guess" or "optimistic" or "pessimistic". The traffic_model parameter may only be specified for requests where the travel mode is driving, and where the request includes a departure_time.
- **region** (*string*) – Specifies the prefered region the geocoder should search first, but it will not restrict the results to only this region. Valid values are a ccTLD code.

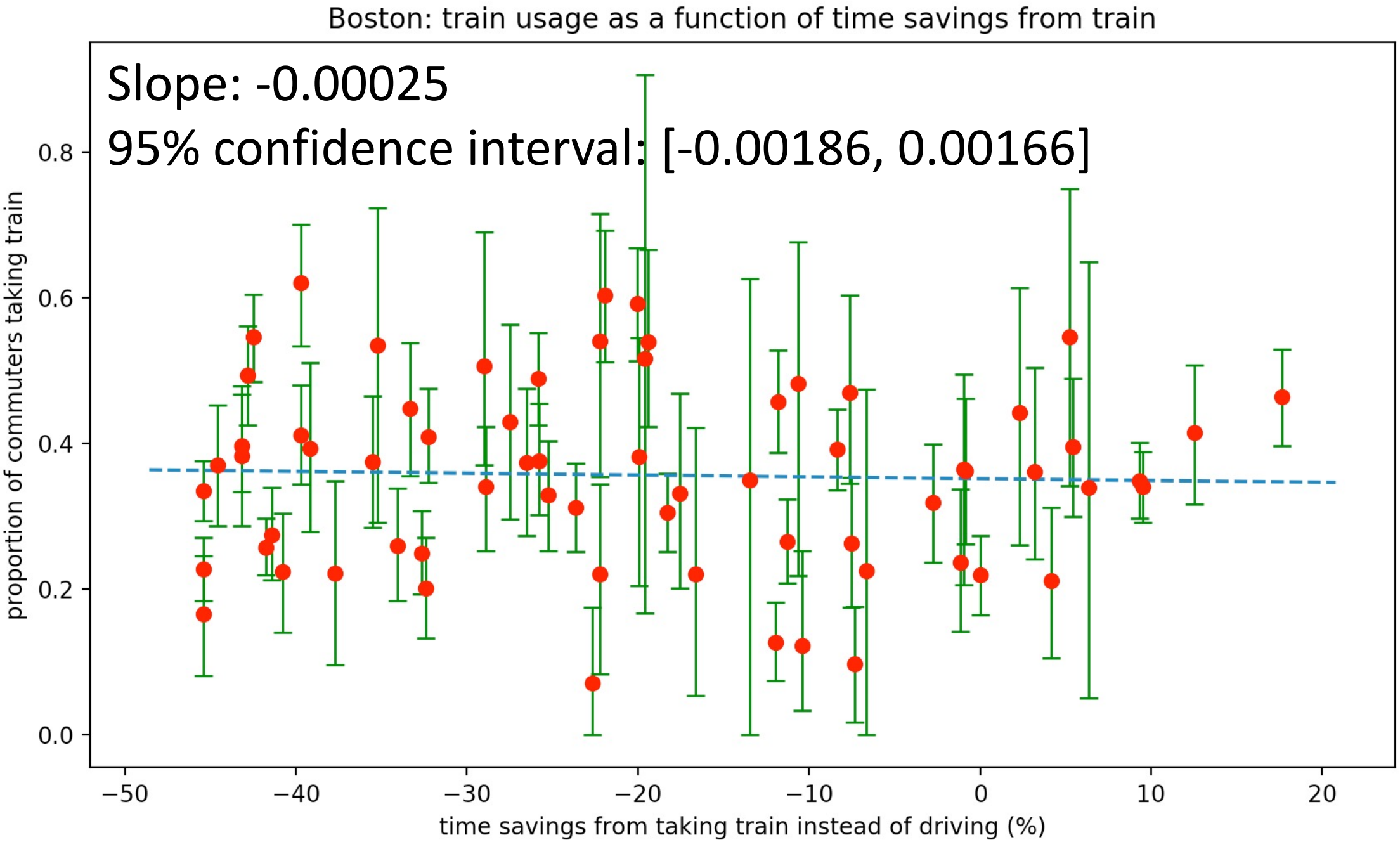
Return type: matrix of distances. Results are returned in rows, each row containing one origin paired with each destination.

Methodology Part C:
Trip time by car (cont.)




NY: train usage as a function of time savings from train
proportion of commuters taking train
1.0
0.8
0.6
0.4
0.2
0.0
−40
−30
−20
−10
0
10
20
time savings from taking train instead of driving (%)
Slope: -0.00625
95% confidence interval:
[-0.00838, -0.00412]


NY: train usage as a function of time savings from train
proportion of commuters taking train
time savings from taking train instead of driving (%)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
−40
−30
−20
−10
0
10
20
Slope: -0.00496
95% confidence interval:
[-0.00713, -0.00280]


Boston: train usage as a function of time savings from train
Slope: -0.00025
95% confidence interval: [-0.00186, 0.00166]
proportion of commuters taking train
0.0
0.2
0.4
0.6
0.8
−50
−40
−30
−20
−10
0
10
20
time savings from taking train instead of driving (%)

Transit Matters Claim

"

Electrification and level boarding can cut travel time by 40%

level boarding can cut travel time by 40%.

Electrification makes the trains cleaner and quieter; self-powered electric trains, called electric multiple units (EMUs), also accelerate much faster than diesel locomotives and are significantly more reliable than current equipment. Level boarding and wider doors provide ADA-compliant access for wheelchair users and also let able-bodied passengers board faster, reducing the amount of time a train has to dwell at each station. We estimate that on most lines, electrification and

Train speeds: Boston vs. New York

	Average speed (MPH)	Average miles per stop (mi)
MBTA	32.54	4.21
Metro North	34.66	3.91
LIRR	31.11	4.29

South Coast Rail diesel vs. electric analysis (USACE)

Table 1-4 Train Station Stopping Pattern for All Rail Alternatives

Attleboro Alternatives		Stoughton Alternatives		Whittenton Alternatives	
New Bedford Trains	Fall River Trains	New Bedford Trains	Fall River Trains	New Bedford Trains	Fall River Trains
Whale's Tooth	Fall River Depot	Whale's Tooth	Fall River Depot	Whale's Tooth	Fall River Depot
King's Highway	Freetown	King's Highway	Freetown	King's Highway	Freetown
Taunton Depot Downtown Taunton	Taunton Depot Downtown Taunton	Taunton Depot Taunton	Taunton Depot Taunton	Taunton Depot Downtown Taunton	Taunton Depot Downtown Taunton
Barrowsville	Barrowsville	Raynham Place	Raynham Place	Raynham Place	Raynham Place
Mansfield	Mansfield	Easton Village	Easton Village	Easton Village	Easton Village
--	--	North Easton	North Easton	North Easton	North Easton
--	--	Stoughton	Stoughton	Stoughton	Stoughton
--	--	Canton Center	Canton Center	Canton Center	Canton Center
--	--	Canton Jct	Canton Jct	Canton Jct	Canton Jct
Route 128	Route 128	Route 128	Route 128	Route 128	Route 128
		Hyde Park	Hyde Park	Hyde Park	Hyde Park
		Ruggles		Ruggles	
Back Bay	Back Bay	Back Bay	Back Bay	Back Bay	Back Bay
South Station	South Station	South Station	South Station	South Station	South Station
9 Stops	9 Stops	15 Stops	14 Stops	16 Stops	15 Stops

Table 1-5 Train Trip Duration (hr:min) for all Rail Alternatives

	Attleboro Alternatives		Stoughton Alternatives		Whittenton Alternatives	
Motive Power	New Bedford Trains	Fall River Trains	New Bedford Trains	Fall River Trains	New Bedford Trains	Fall River Trains
Diesel	1:24	1:22	1:25	1:23	1:36	1:34
Electric	1:15	1:12	1:16	1:13	1:27	1:25

Average time savings due to electrification:

10.75%

MBTA diesel vs. electric analysis methodology

Trip Time (min)	Number of stops
10	0
12	1
14	2
16	3

Inference: each stops adds two minutes to total trip time

MBTA diesel vs. electric analysis results

Commuter Rail System	Cost per station (sec)
Metro North	59.1
LIRR	73.3
MBTA	103.6

Effect of electrification

- Time savings per station : 37.4 seconds
- Average trip time savings : **8.03%**

Boston: projected train times after electrification

	Average time savings (%)	Standard Deviation (%)
Current	-19.97	17.27
Post-electrification	-28.57	15.41

Conclusions

1. The faster travel times associated with electric trains would not significantly boost MBTA commuter rail ridership
2. The time savings due to electrification would not be nearly as large as claimed by Transit Matters

What I’m not concluding

- Electrification won’t have a major impact on commuter rail ridership
  - Consequences of electrification that may increase ridership:
    - More frequent train service
    - Higher on-time performance
    - Increased reliability
- The MBTA shouldn’t electrify its commuter rail system
  - Other benefits include:
    - Less pollution
    - Lower maintenance costs
    - Improved system reliability