MEET

THE BTA

[Balanced Transportation Analyzer]

July 22, 2009

2. Final Calculations

1. Vehicle Hours in Traffic Within Cordon	17,561	5,605	91,963	21,666	60,325	193,187	37,070	427,377
Calculated as quotient of Row 108 VMT figures in Motor Vs worksheet by Row 123 speeds. Numerator uses Motor Vs VMT figures to ensure that delays are calculated on 'baseline' vehicle volumes only and do not [spuriously] reflect delays experienced by the hypothesized additional vehicles								
Baseline vehicle hours in traffic within cordon	17,561	5,604	91,866	21,645	60,271	192,914	36,834	426,697
Taken fro… respo…ent…								
Difference … hours in traffic with…cordon, as a r…t of hypothesized additional vehicles								680
2. Outside C…	220,425	73,344	1,023,242	260,946	809,662	2,365,237	558,282	5,311,138
Calculate… quotient …ow …MT figures … Vs works… by Row 108 speeds in this worksheet. Numerator uses Motor Vs VMT figures to ensure that delays are calculated on 'baseline' vehicle volumes … and do n… spur… de… nced b… hypothesized additional vehicles.								
Baseline vehicle hours in traffic outside cordon	220,425	73,337	1,023,052	260,900	809,512	2,364,610	557,361	5,309,197
Taken from corresponding entry in Motor Vs. Row 854								
Difference in number of hours in traffic outside cordon, as a result of hypothesized additional vehicles								1,941
3. Within and Outside Cordon, combined	Note: figures in next row apply to trips whose inbound leg is taken in the period 'selected' in Row 58.							
Difference in number of hours in traffic per time period, combined	0.001	0.008	0.286	0.067	0.203	0.899	1.156	2,621
Delay time attributable to each additional vehicle trip into the cordon (whose inbound leg is taken in the period selected in Row 58).								**2.62 hours**

	In cordon	Out Cordon	
Share of delay experienced in area:	26%	74%	100%

		2.02
Traffic-weighted average delay		**3.26 hours**
		= 196 minutes

Method 1 for Displaying Results: Delays (due to one additional cordon trip) broken down by time periods in which delays are caused and experienced

Delay figures in array are in hours and are totals for each period.

Array shows Row 130 results if all addit'l trips are assigned to period chosen via Switch in Row 58.

Example: Highlighted fig. in A.M. Peak col. in Row 149 is delay hrs experienced in A.M. Peak period per extra trip in Midday Peak.

	Graveyard 6 hour(s)	A.M. Pre-pk 1 hour(s)	A.M. Peak 3 hour(s)	A.M. Post-pk 1 hour(s)	Midday Pk 4 hour(s)	P.M. Peak 6 hour(s)	P.M. Post-pk 3 hour(s)	TOTAL (delay hrs caused by one extra trip in row shown)	Baseline trips (from Motor Vs)
Graveyard	**0.007**	0.008	0.290	0.068	0.205	0.915	0.146	**1.64**	75,881
A.M. Pre-pk	0.001	**0.373**	0.290	0.068	0.205	0.915	0.146	**2.00**	30,533
A.M. Peak	0.001	0.008	**0.290**	0.068	0.205	0.915	0.146	**3.75**	176,092
A.M. Post-…	0.001	0.008	0.290	1.664	0.205	0.915	0.146	**3.20**	52,092
Midday Pk	0.001	0.008	0.290	0.068	**1.361**	0.915	0.146	**2.79**	168,036
P.M. Peak	0.001	0.008	0.290	0.068	0.205	**3.302**	0.146	**4.02**	272,736
P.M. Post-pk	0.001	0.008	0.290	0.068	0.205	0.915	**1.168**	**2.66**	94,830
TOTAL	**0.02**	**0.59**	**0.87**	**1.92**	**2.70**	**5.31**	**2.36**	**3.25**	870,201

(delay hrs experienced in period in column, due to one ex…

Method 2 for Displaying Results: Delays broken down by amounts that the other travelers experienced on inbound or outbound leg of their trips

	Graveyard	A.M. Pre-pk	A.M. Peak	A.M. Post-pk	Midday Pk	P.M. Peak	P.M. Post-pk
Total Delay based on time of entry	1.646	2.006	3.761	3.214	2.798	4.030	2.659
Delay caused by the inbound leg	0.006	0.366	2.137	1.576	1.165	2.425	1.022
Delay caused by the outbound leg	1.640	1.640	1.624	1.637	1.633	1.605	1.636

Inbound values	Outbound values
1.637	1.624

Balanced Transportation Analyzer

{ A spreadsheet model to assess benefits, impacts and costs of time-variable traffic and transit pricing in New York City }

Outputs:

- Agency revenues
- Motor vehicle travel speeds
- Time savings to vehicle users (hours and dollar equivalents)
- VMT and transit ridership
- Emissions and other vehicle externalities

Balanced Transportation Analyzer

{ A spreadsheet model to assess benefits, impacts and costs of time-variable traffic and transit pricing in New York City }

Inputs:

Baseline motor vehicle data

- Cordon entries
- Time of day and Day of week
- Cordon and non-cordon speeds

Baseline subway and bus data

- Ridership and revenue
- Time of day and Day of week

Elasticities (price and time sensitivities)

Origins

Ted Kheel vision of free transit, 1960s – 2000s

"BTA" — *Balancing* free transit and congestion pricing

Enhanced BTA 1.1

- Time of day pricing
- Explicit treatment of speed-volume relationships
- Weekends modeled separately from weekdays
- Sensitivity analyses
- Easier to use

Why

Traffic pricing essential to improving vehicle travel

Traffic pricing a revenue source for transit

Time-varied pricing can

- Maximize time savings
- Provide choice
- Ease subway crowding

Instant modeling to screen policies

- Toll changes
- Fare hikes / rollbacks
- Service changes
- Public Space re-allocation

Transparency → understanding → trust

BTA Strengths

Time-variable tolling

- Up to 7 time periods
- Trade-off between toll and scheduling

Weekends separate from weekdays

Time-variable subway pricing

- Up to 24 time periods

Interactivities between driving and transit

Interactivities between traffic speeds and volumes (rebound effect)

Anyone can use

BTA Limitations

Cordon pricing only
(Manhattan Central Business District)

No geographic differentiation

Carpooling not treated explicitly

Deterministic, not probabilistic

BTA Other Strengths

Toll Incidence (by county)

Cost-Benefit

- Value of time
- Valuation of reduced pollution, crashes, etc.

Bus Boarding

Delay Costs

Robust w/r/t Elasticities

Baseline Vehicle Trip Volumes

CBD trips separated into six types

- Auto work, auto non-work, through-trips, medallion taxi, truck, bus
- Average trip miles (CBD portion, non-CBD portion)
- Source: Household Interview Survey
- Source: Schaller Consulting

Each trip type separated into seven periods (covering 24 hrs)

- Source: Manhattan River Crossings

42 trip sub-groups (6 x 7)

Motor Vs worksheet

B. Baselines -- Traffic Estimates and Trip Costs disaggregated into different weekday time periods

This section assigns weekday VMT's for each trip category to different time periods, and establishes basic cost and time parameters for each combination of trip type and period.

Note: *Tolls* in charging periods are easily varied (in **User Inputs** worksheet), but *make-up of the periods*, i.e., hours in each, is fixed.

ALL MOTOR VEHICLE TRIPS

	Graveyard 11 pm - 5 am	A.M. Pre-pk 5 am - 6 am	A.M. Peak 6 am - 9 am	A.M. Post-pk 9 am - 10 am	Midday Pk 10 am - 2 pm	P.M. Peak 2 pm - 8 pm	P.M. Post-pk 8 pm - 11 pm	Totals
Hours in period	6	1	3	1	4	6	3	24
Periods were drawn to group similar hourly volumes of vehicles entering CBD. See **By Hours** worksheet. User may change, but some spreadsheet reprogramming of **By Hours** is required.								
1. Baseline Auto Cordon Crossings, inbound -- Trips and VMT								
Daily cordon auto entries (figures are vehicles, not persons)	75,881	30,533	176,092	52,092	168,036	272,736	94,830	**870,201**
Each figure in first column block is sum of respective figures in subsequent column blocks for the six trip types. Sources for those figures are shown further to right.								
%'s of daily auto crossings into cordon in respective periods	9%	4%	20%	6%	19%	31%	11%	100%
Hourly cordon entries (vehicles)	12,647	30,533	58,697	52,092	42,009	45,456	31,610	
Row 83 figures divided by Row 79 figures.								
Hourly cordon entries as % of maximum hourly cordon entries	22%	52%	100%	89%	72%	77%	54%	
These percentages will help estimate traffic speeds within respective periods, since speeds are essentially a function of traffic volumes (densities).								
Cordon VMT from cordon entries	136,529	49,002	268,873	79,535	263,103	437,641	161,399	1,396,082
Daily cordon entries in Row 83 times Cordon VMT per entry in Row 48.								
2. Baseline Auto Cordon Crossings, outbound -- Trips and VMT								
Daily cordon auto return trips (figures are vehicles, not persons)	103,369	20,975	120,903	38,020	151,180	313,926	121,828	**870,201**
Each figure in first column block is sum of respective figures in subsequent column blocks for the six trip types. Sources for those figures are shown further to right.								
%'s of daily auto return trips from cordon in respective periods	12%	2%	14%	4%	17%	36%	14%	100%
Hourly cordon return trips (figures are vehicles, not persons)	17,228	20,975	40,301	38,020	37,795	52,321	40,609	
Cordon VMT from cordon return trips (period return trips x cordon VMT per entry)	164,153	34,236	197,348	61,857	243,574	501,116	193,797	1,396,082
Daily cordon return trips in Row 94 times Cordon VMT per entry [which is same as per return] in Row 48.								
3. Baseline Auto Travel in Cordon that Didn't Cross Cordon -- VMT								
% of 24-h volume that occurs in respective period	10.5%	2.9%	16.6%	5.1%	18.2%	34.1%	12.7%	100%
Calculated as mean of inbound and outbound percentages for respective periods, in **By Hours** worksheet.								
Cordon VMT from motor vehicle trips that didn't cross cordon	114,442	31,220	180,027	54,872	197,536	369,933	137,740	1,085,771

Baseline Motor Vehicle Trip Costs

Out-of-pocket trip cost for all 42 sub-groups

- Tolls
  Average of tolled and untolled crossings
- Parking
  Average of unpaid, metered and private
- Gas
  Reflects impacts of travel speeds on mpg
- Other
  Perceived expected value of crashes, tickets, etc.

Baseline Motor Vehicle Speeds

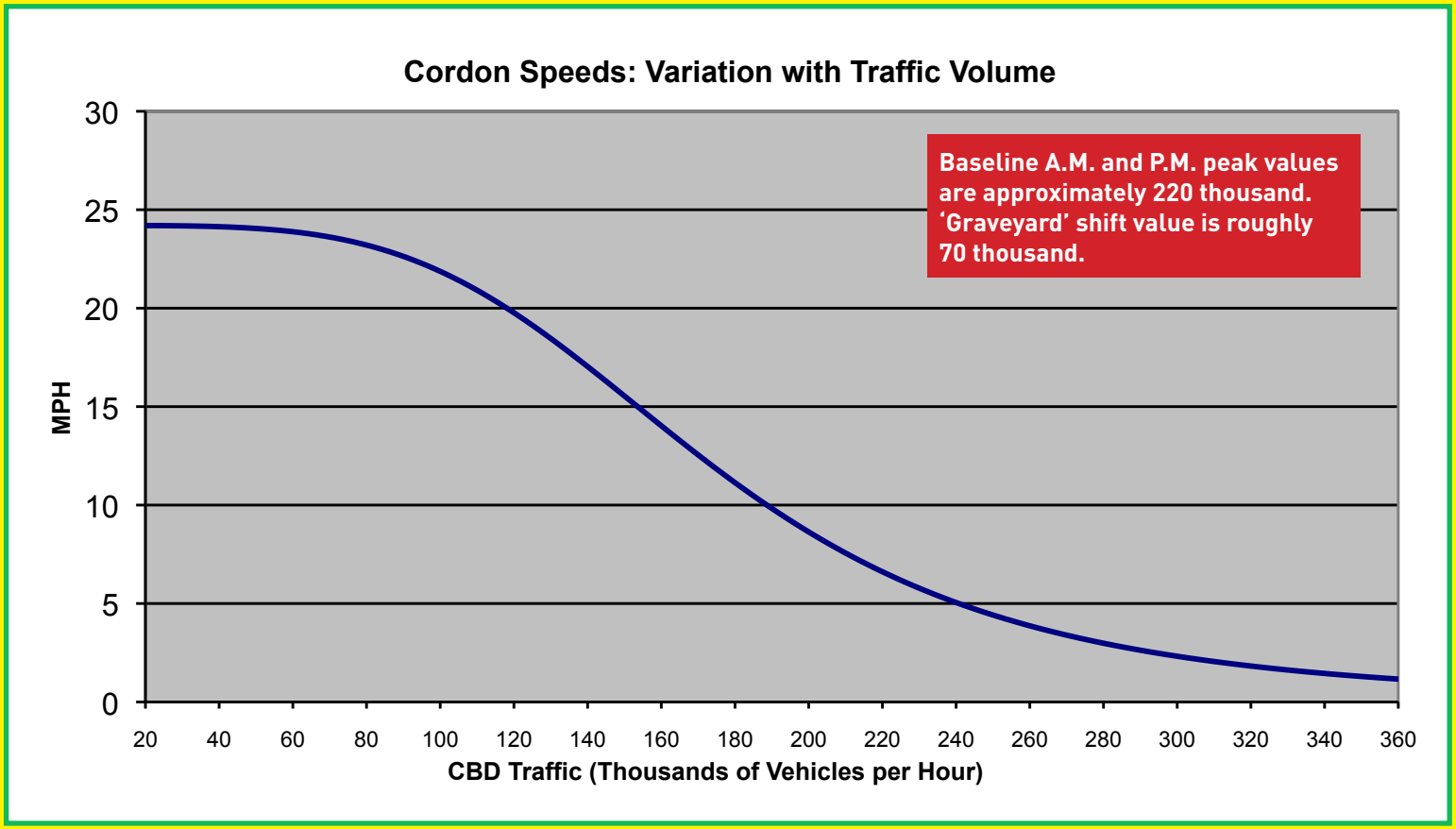
CBD

- PlaNYC: 6 am – 6 pm average = 8 mph
- Speed-volume relationship: U-C economist Ken Small (Toronto observations)

7 Weekday Periods	Cordon Speeds
Graveyard	23.6
A.M. Pre-peak	20.4
A.M. Peak	7.0
A.M. Post-peak	9.1
Midday Peak	11.7
P.M. Peak	6.8
P.M. Post-peak	13.4
Traffic-wghtd avg 6 am – 6 pm	8.00

Baseline Motor Vehicle Speeds

CBD



Baseline Motor Vehicle Speeds

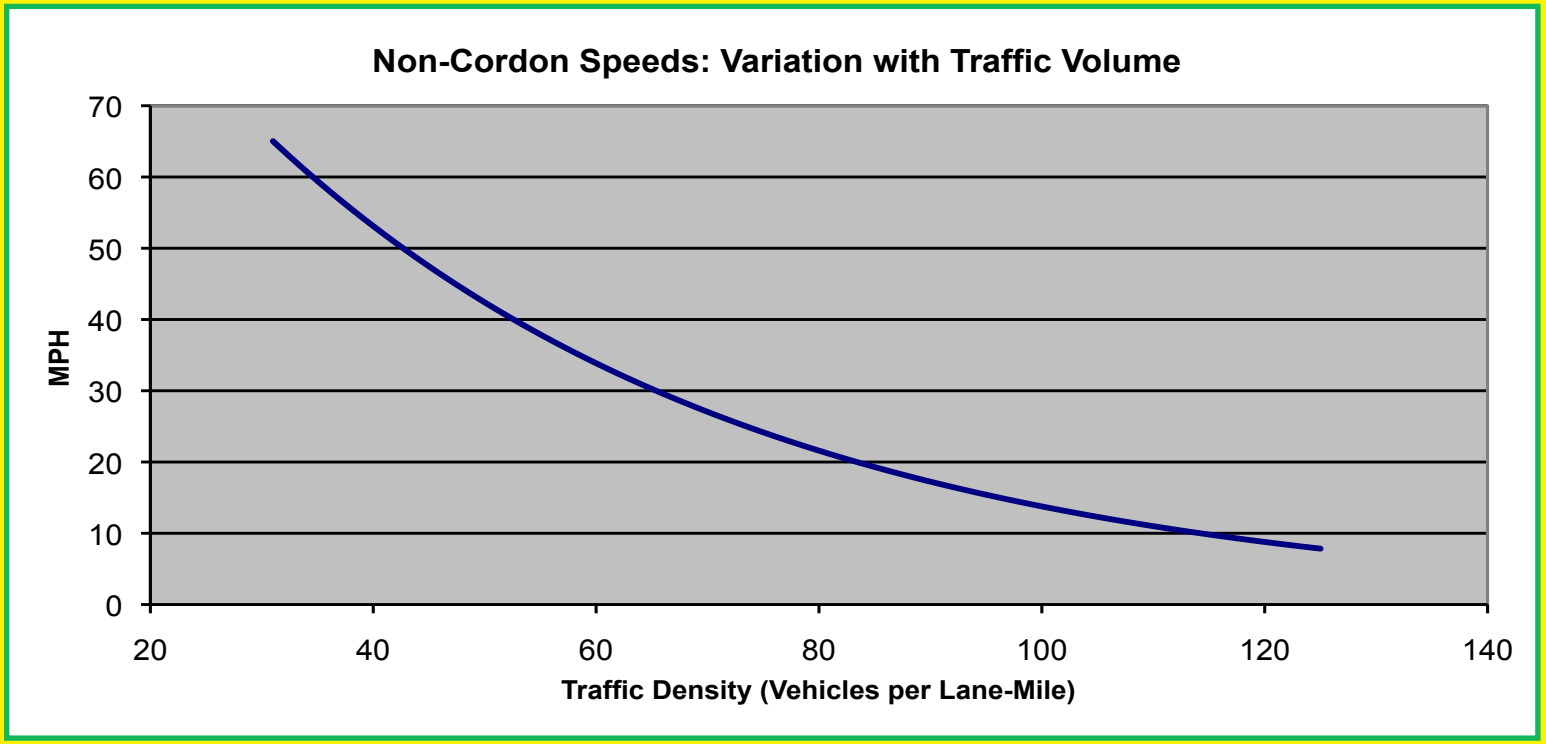
non-CBD

- PlaNYC 6 am – 6 pm average = 18.22 mph
- Speed-volume relationship: Santa Clara (CA) freeways

7 Weekday Periods	Non-Cordon Speeds
Graveyard	64.7
A.M. Pre-peak	43.3
A.M. Peak	17.1
A.M. Post-peak	20.4
Midday Peak	24.0
P.M. Peak	15.5
P.M. Post-peak	25.4
Traffic-wghtd avg 6 am – 6 pm	18.22

Baseline Motor Vehicle Speeds

non-CBD



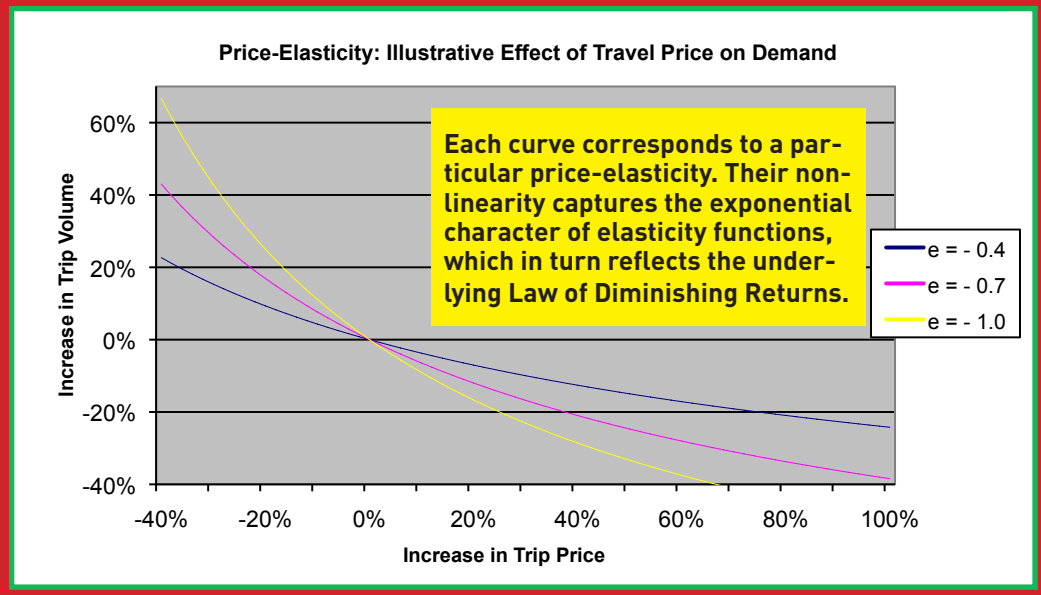
Toll Impacts on Traffic (Round 1)

% Change in trip cost due to cordon toll

Change in number of trips

Time-switching propensity between periods

Trip attraction (or repulsion) from bus/subway



Combine to calculate new trip levels

Rebound Effect

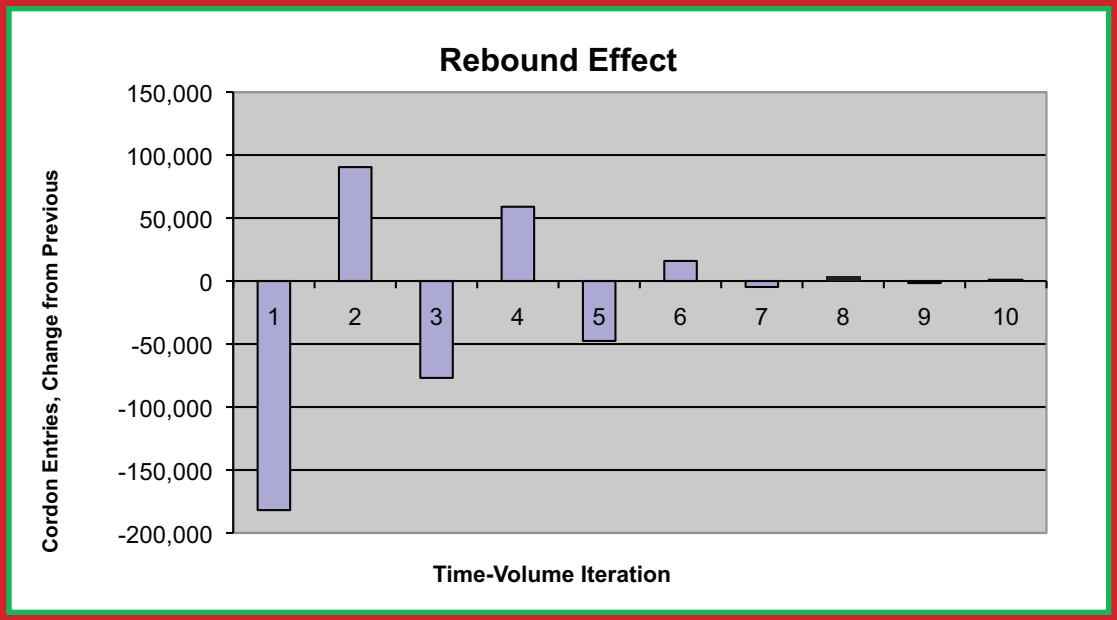
New volumes → new traffic speeds

- Speed-volume relationships (CBD and non-CBD)

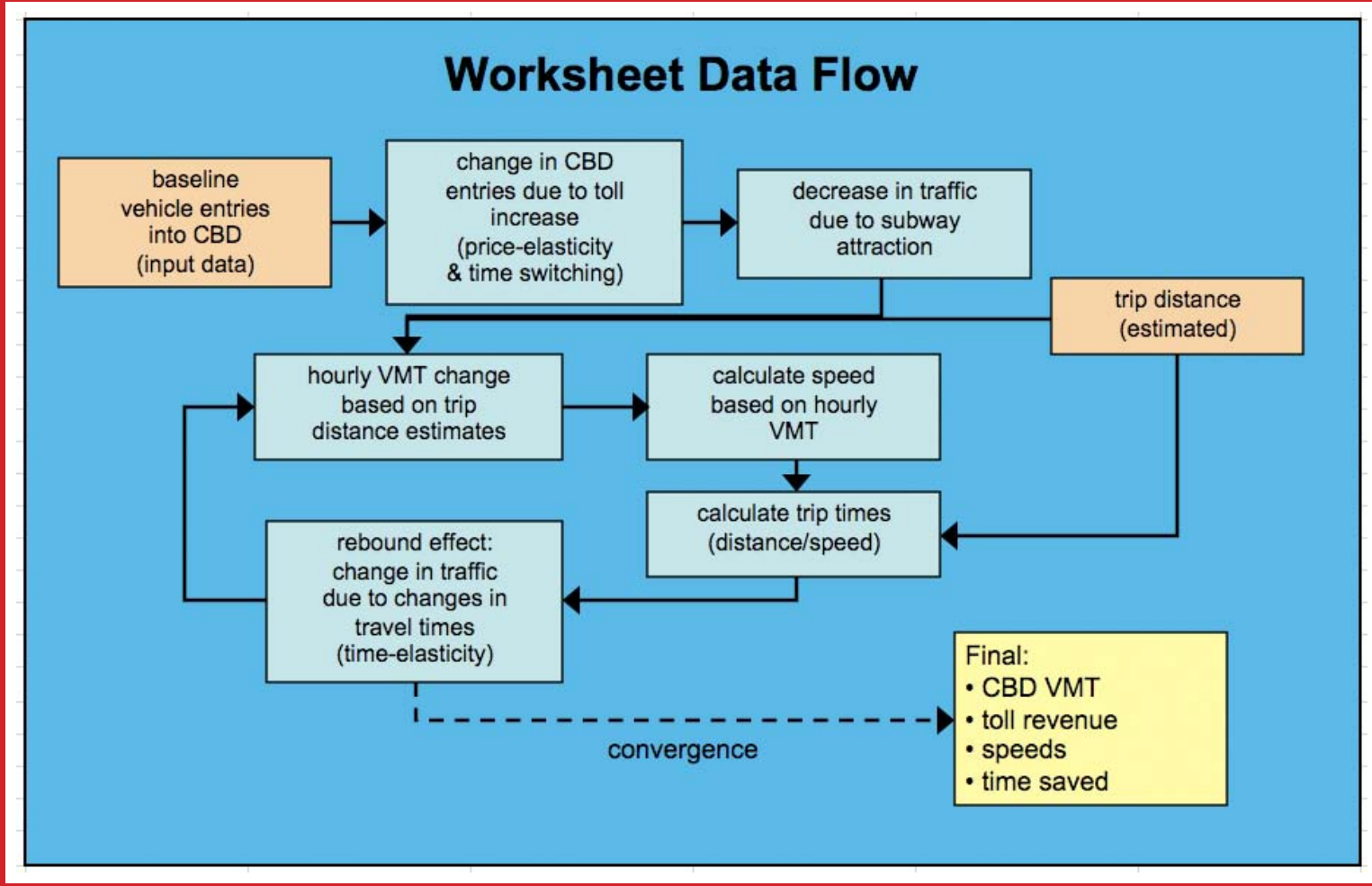
New traffic times (CBD and non-CBD)

New trip volumes (via time-elasticity)

Iterate



Rebound Effect



Subways

Similar approach to motor vehicles

- 24 one-hour periods
- Price elasticities (work and non-work trips)
- Time elasticities (work and non-work trips)
- Time-switching propensity between periods
- Trip attraction (or repulsion) from autos

Time-Switching

Port Authority study of 2001 variable-pricing

- Price-elasticity applied to toll ratios between periods
- Asymmetrical — more trips switch earlier

Puget Sound Regional Council Traffic Choices Study

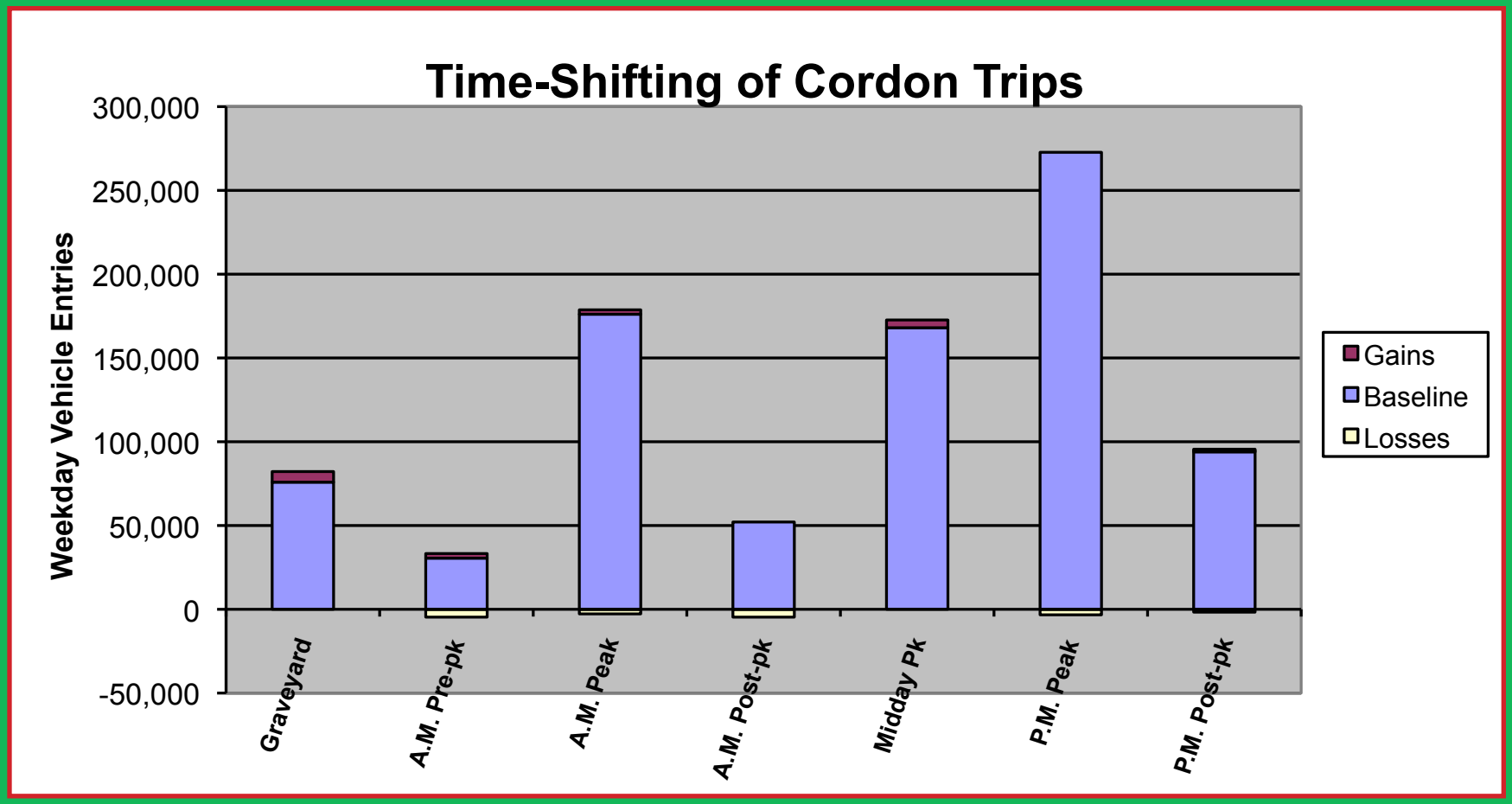
- Time-switching: function of toll and time differences

Adapt PA and PSRC to NYC roads and subways

- Normalize for income
- Adjust for subway lesser price-elasticity

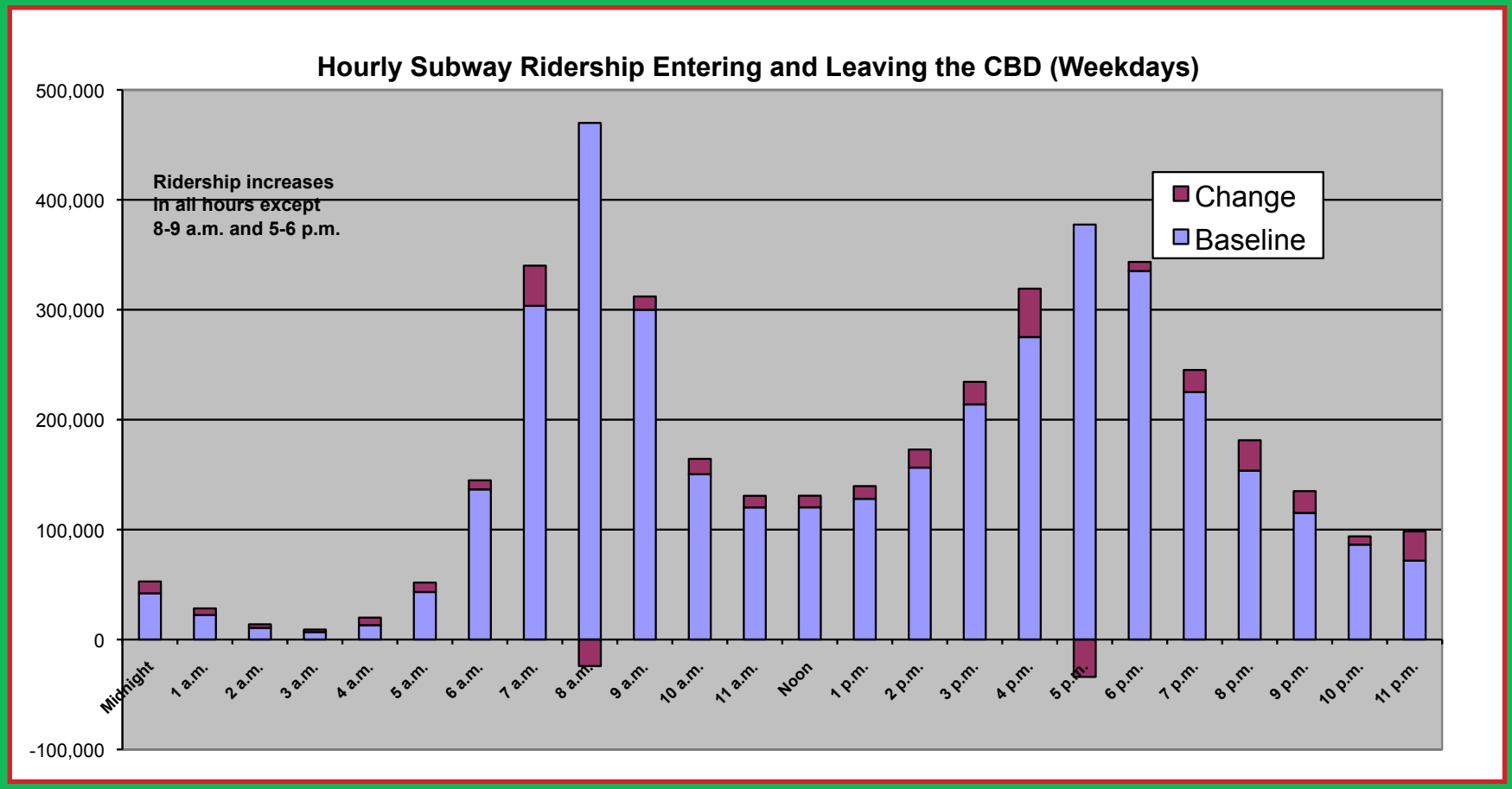
Some Time-Shifting Results

Motor Vehicles



Some Time-Shifting Results

Subways



Delay Costs: Time

Not a tolling issue ("upstream" of tolls)

Model recalculates speeds if 100 additional cars enter CBD

- Speeds within CBD
- Speeds outside CBD
- Return legs distributed randomly

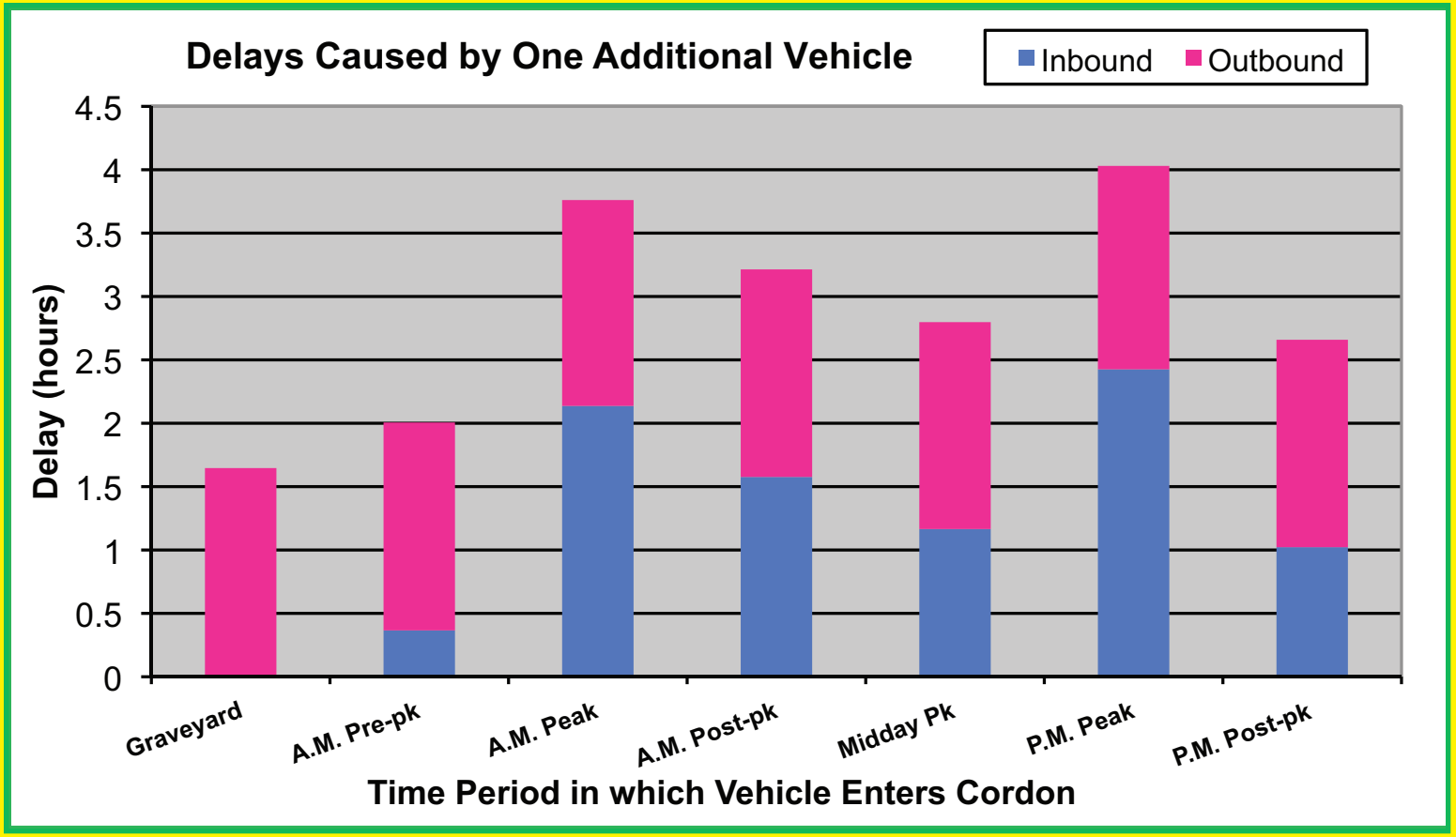
Calculate new trip times

New vs. Old time = total delay

"Delta" divided by 100 = time delays from one extra trip

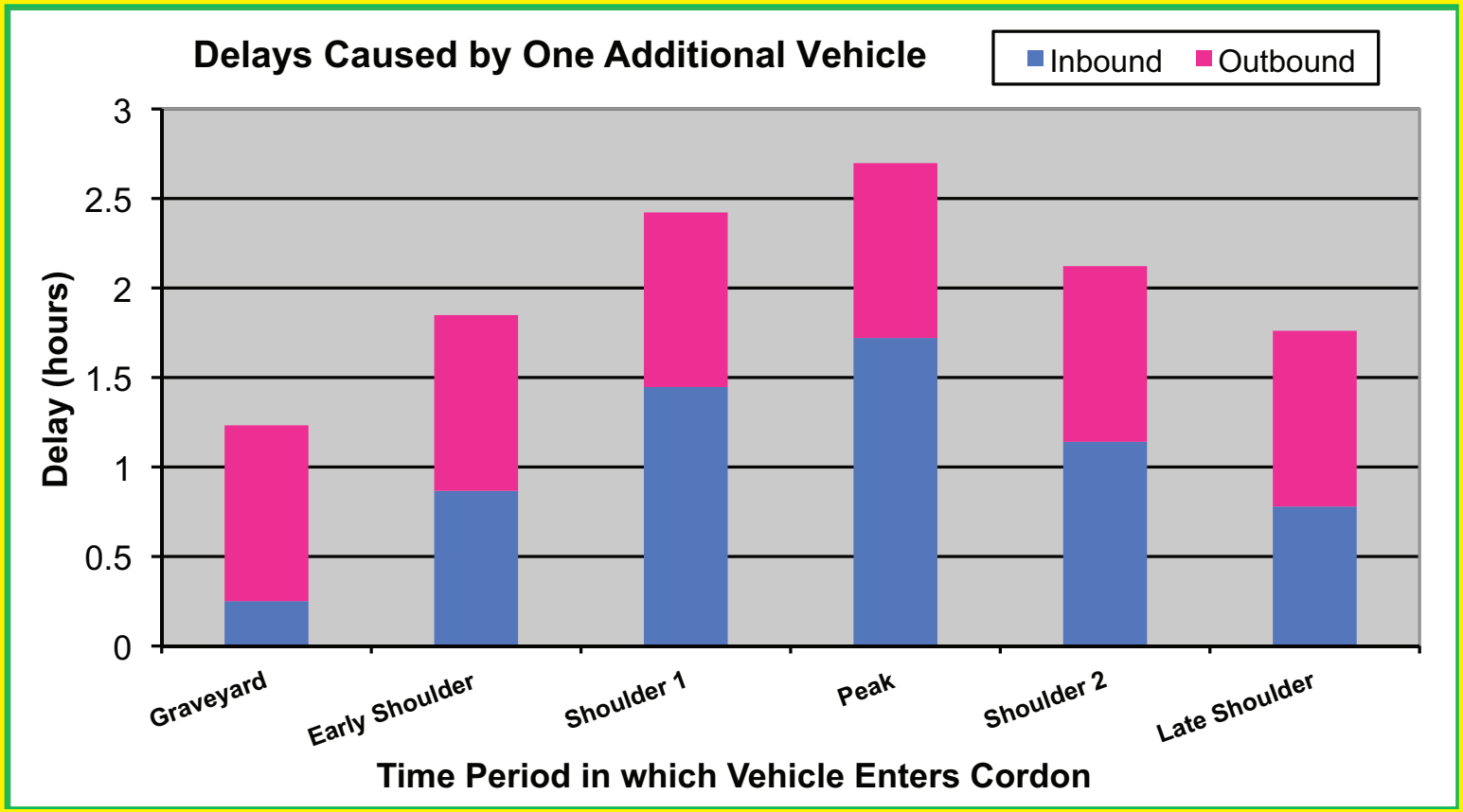
Time Delays

Weekday



Time Delays

Weekend



Delays, breakdown by time period

Weekday

	Graveyard 6 hour(s)	A.M. Pre-pk 1 hour(s)	A.M. Peak 3 hour(s)	A.M. Post-pk 1 hour(s)	Middday Pk 4 hour(s)	P.M. Peak 4 hour(s)	P.M. Post-pk 6 hour(s)	TOTAL
Graveyard	0.007	0.008	0.290	0.068	0.205	0.915	0.146	1.64
A.M. Pre-pk	0.001	0.373	0.290	0.068	0.205	0.915	0.146	2.00
A.M. Peak	0.001	0.008	2.407	0.068	0.205	0.915	0.146	3.75
A.M. Post-pk	0.001	0.008	0.290	1.634	0.205	0.915	0.146	3.20
Midday Pk	0.001	0.008	0.290	0.068	1.361	0.915	0.146	2.79
P.M. Peak	0.001	0.008	0.290	0.068	0.205	3.302	0.146	4.02
P.M. Post-pk	0.001	0.008	0.290	0.068	0.205	0.915	1.168	2.66
TOTAL	0.02	0.59	3.55	2.70	2.22	5.31	2.36	3.25

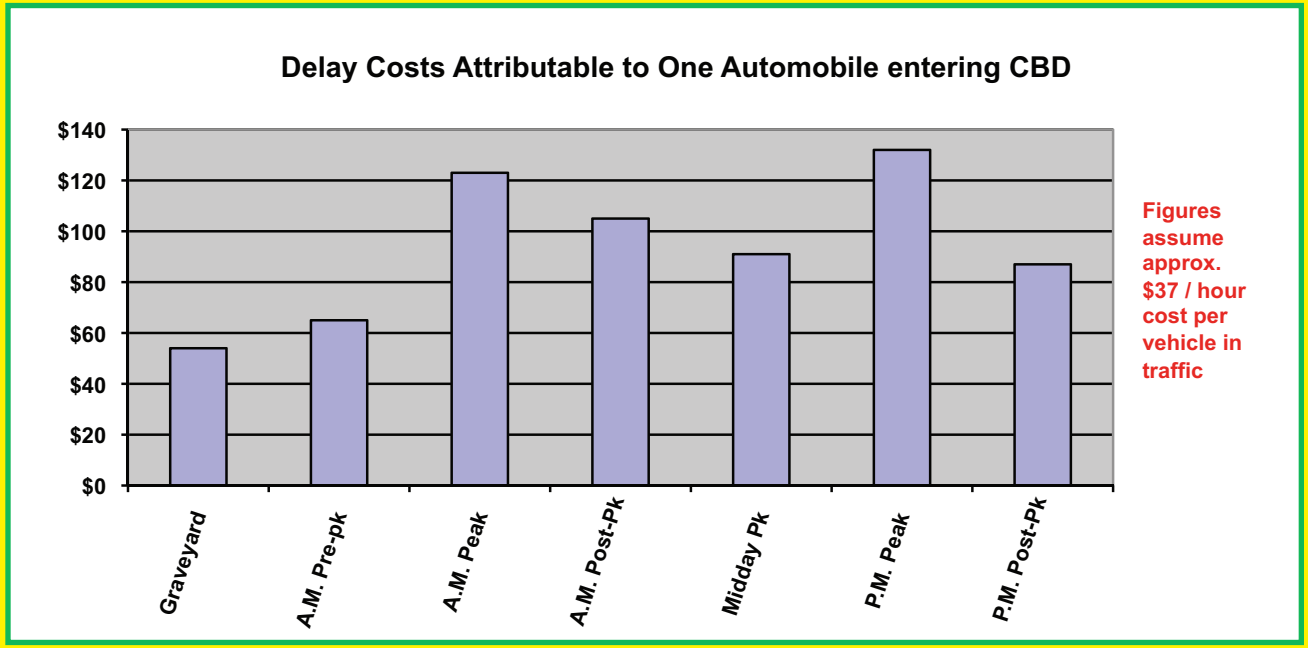
Hours of delay caused by one additional cordon trip

Delay Valuation

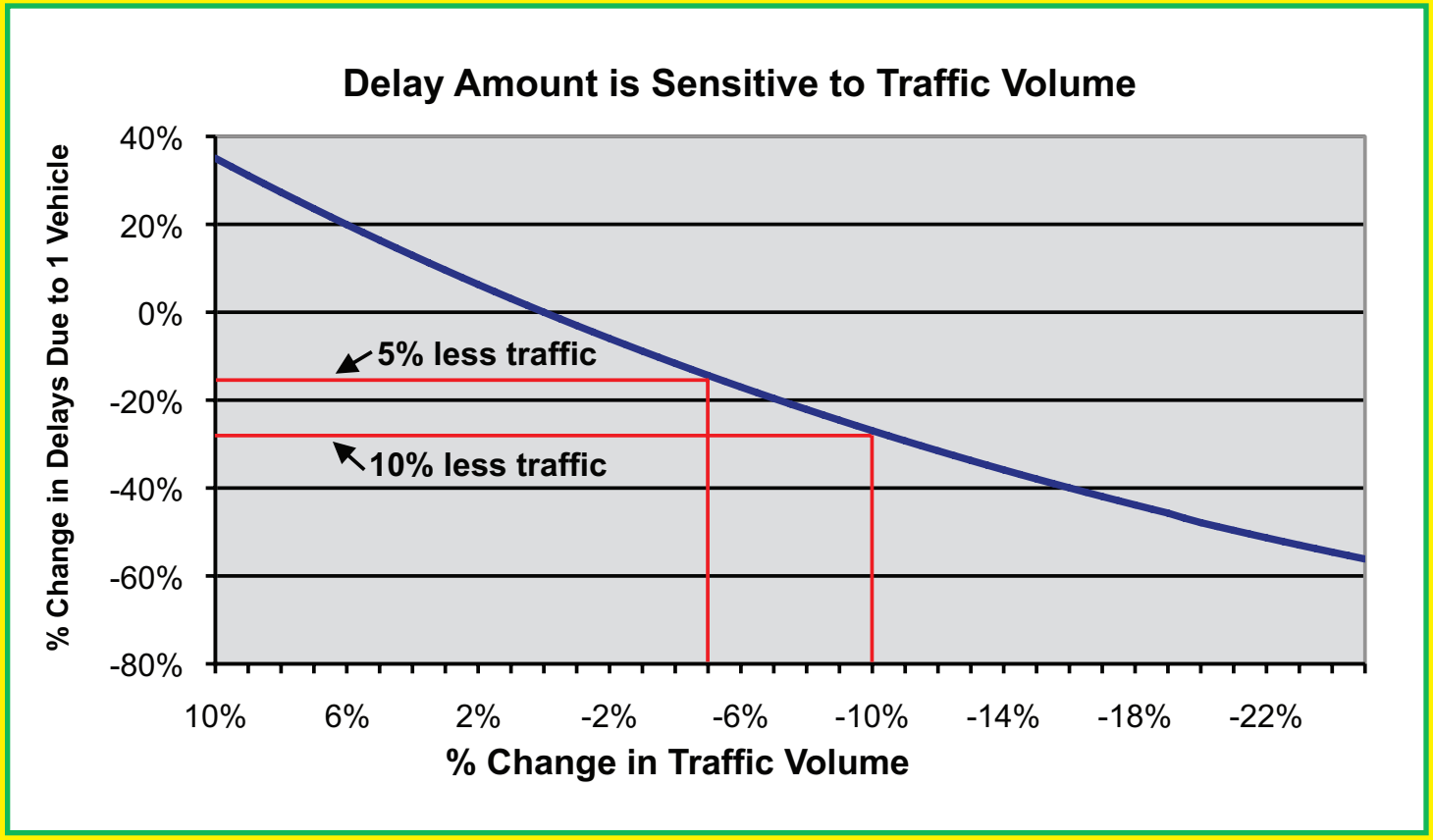
Costs per vehicle-hour

	Weekdays	Weekends
Within CBD	$48.89	$29.33
Outside CBD	$32.59	$19.55

Delay costs per trip



Delays Vary with Baseline Traffic Level

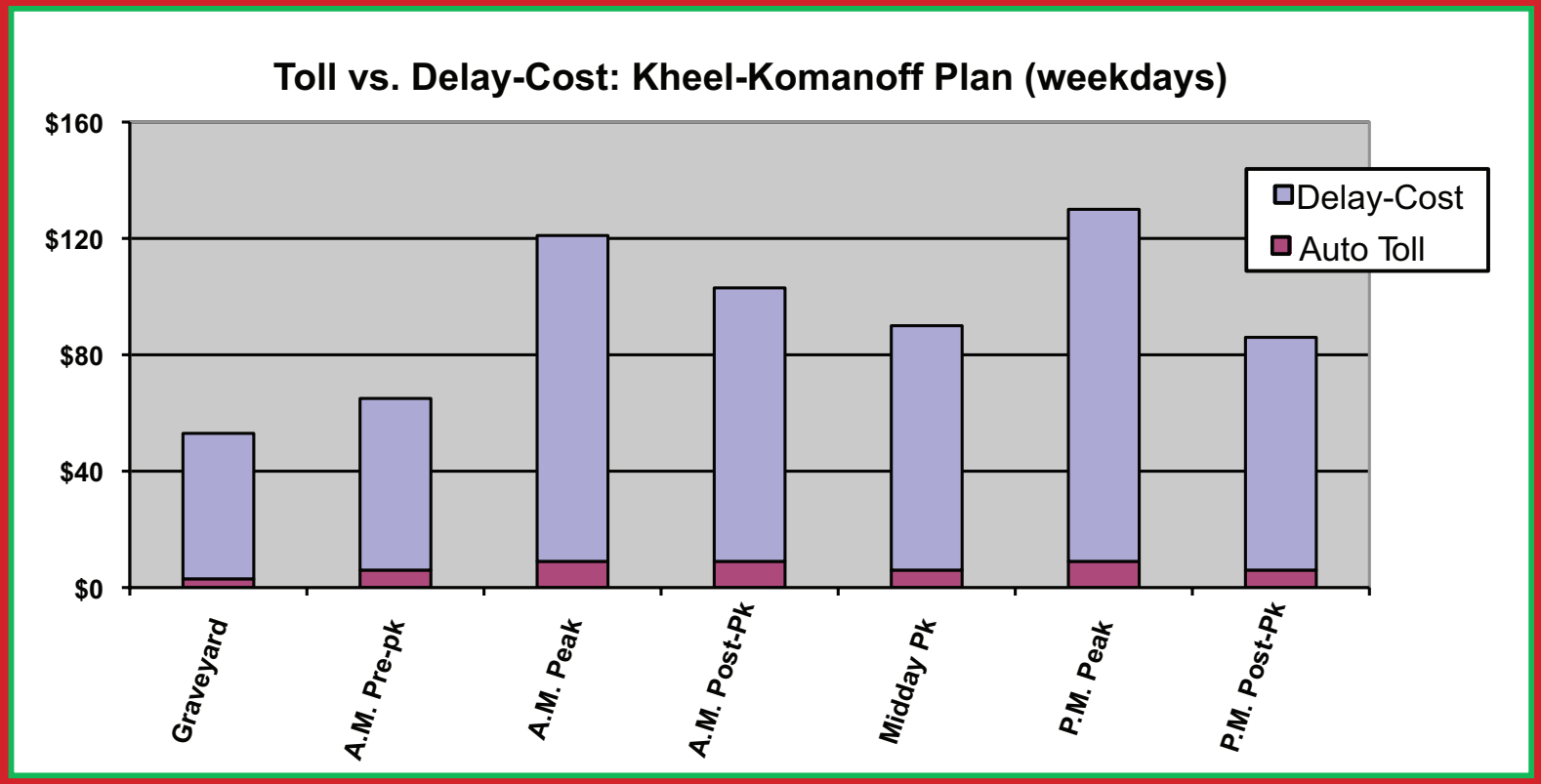


BTA: Key Elasticities

	Work Trips	Non-work Trips	Thru Trips (across CBD)
Transit Volume w/r/t Transit Cost	-9.0%	-23.4%	
Transit Volume w/r/t Transit Time	-50.0%	-55.0%	
Auto Volume w/r/t Auto Cost	-50.0%	-90.0%	-66.9%
Auto Volume w/r/t Auto Time	-100.0%	-124.0%	-110.2%

W

Toll Design: Vary with Delay-Cost



Toll Design: Features

Toll levels (weekday / weekend / time of day)

Does toll increase or replace current tolls?

Truck toll (vis-à-vis autos)

Taxi surcharge (drop / mileage / time)

Taxi industry's share of surcharge $$

Street space reclaimed from autos

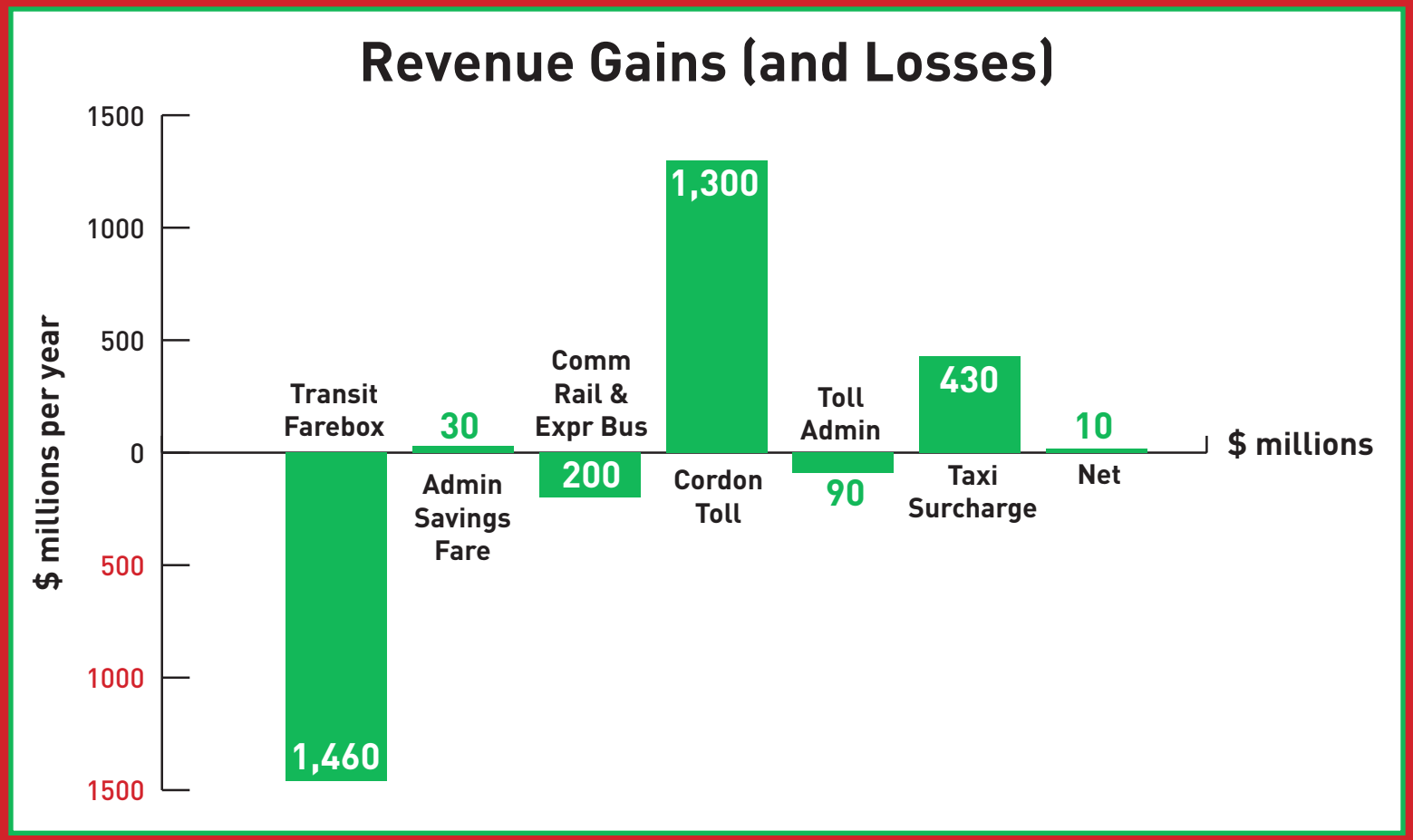
Subway and bus fares

Make in-city commuter bus/rail free?

Baseline traffic reduction

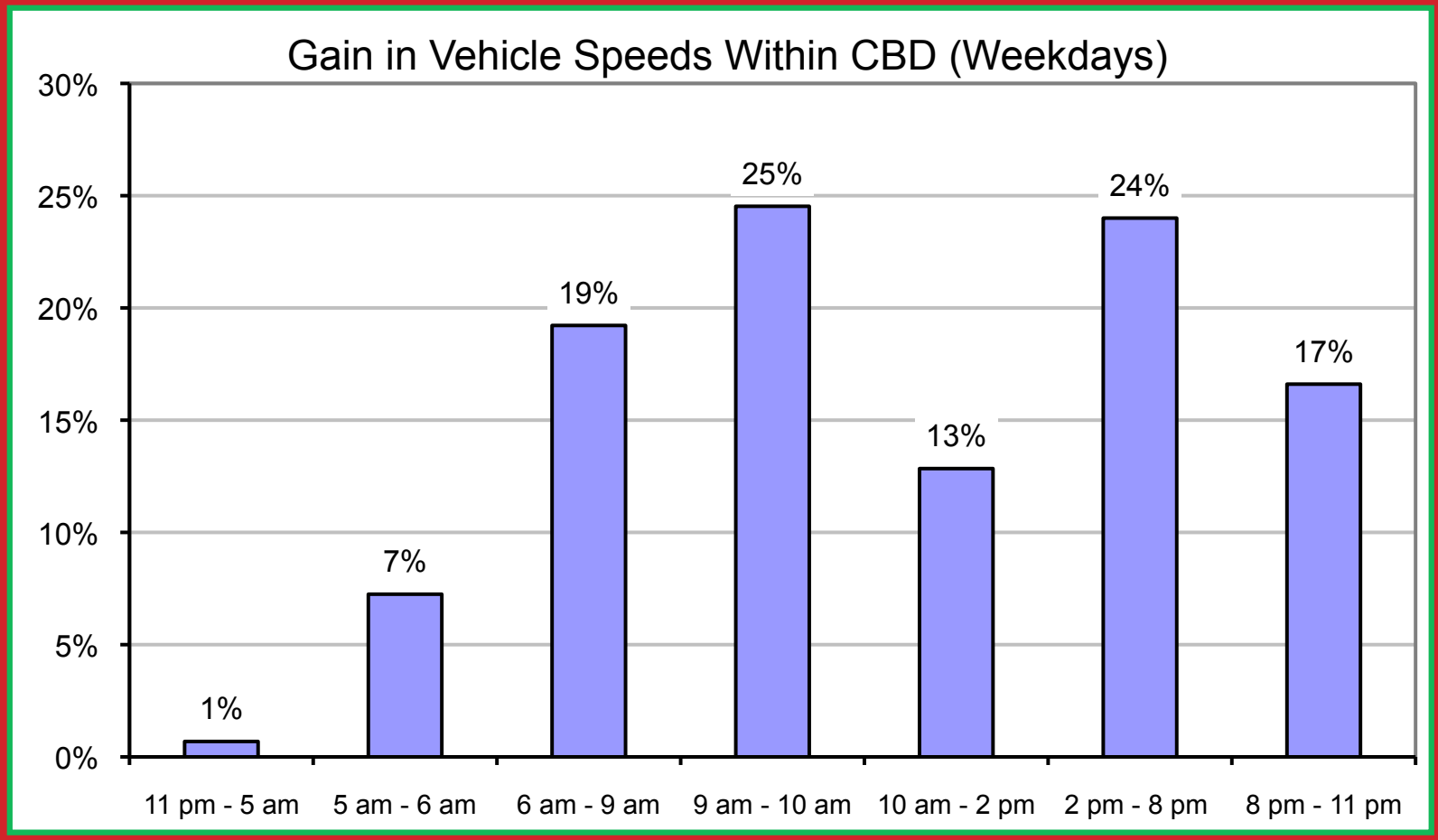
Revenue Impacts

Kheel-Komanoff Plan



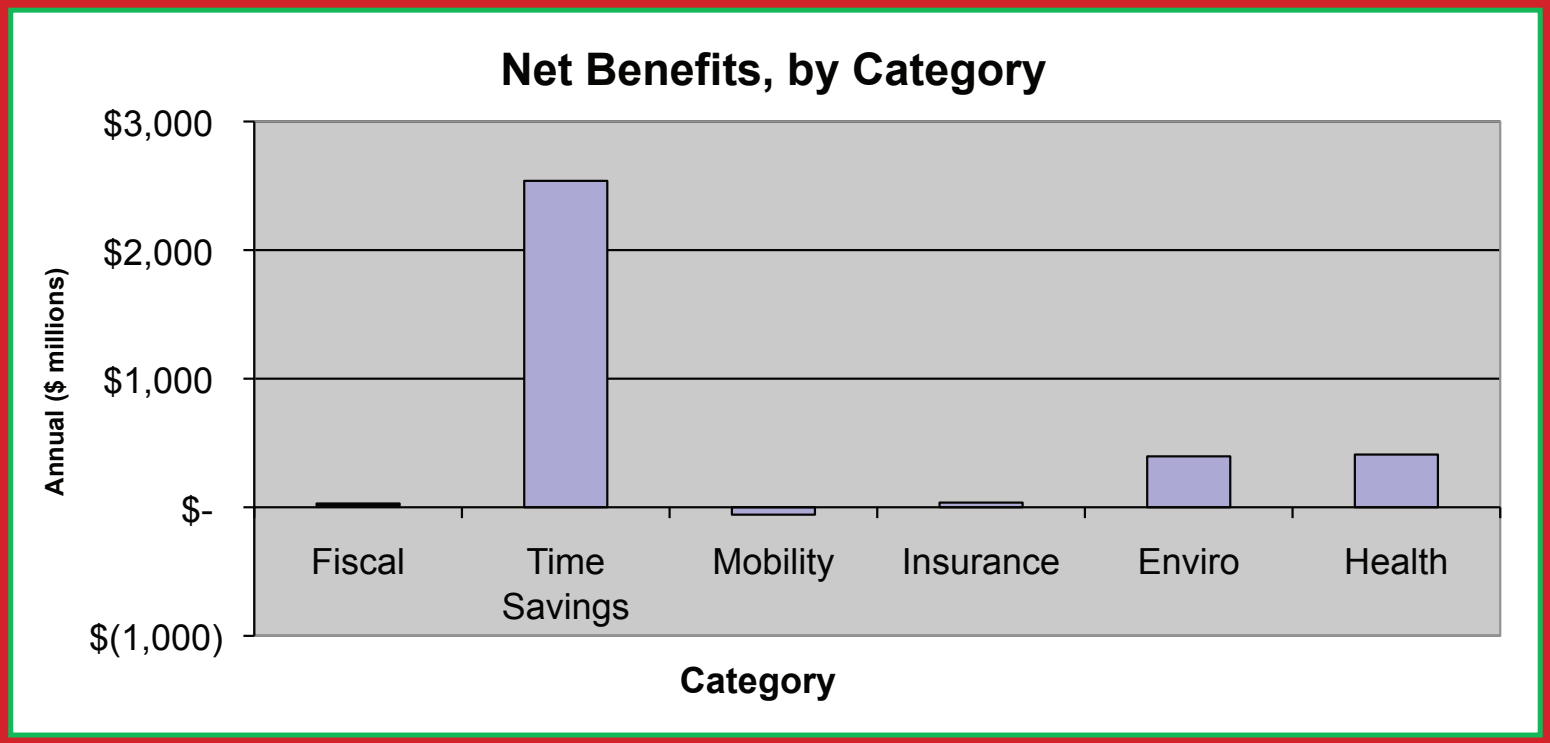
CBD Vehicle Speed Impacts

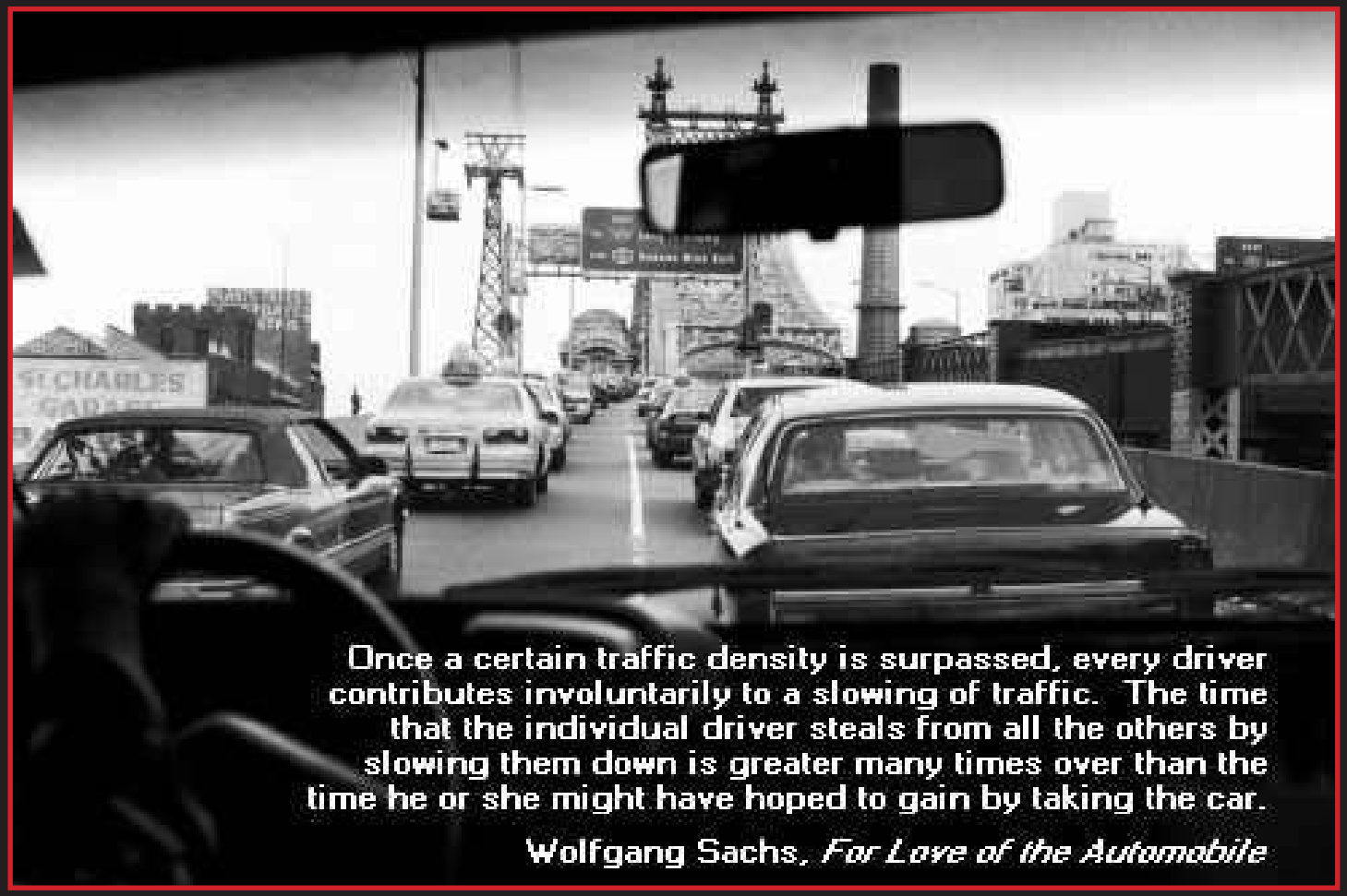
Kheel-Komanoff Plan



Benefits

Kheel-Komanoff Plan





Once a certain traffic density is surpassed, every driver contributes involuntarily to a slowing of traffic. The time that the individual driver steals from all the others by slowing them down is greater many times over than the time he or she might have hoped to gain by taking the car.

Wolfgang Sachs, *For Love of the Automobile*