Evidence-Based Transportation Demand Analysis

Data for Disaggregate Modelling & Stated Preference Techniques

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Outline

- Data type
- Stated Preference
- Example

Data for Choice model

- Choice/Preference based on observed and experienced information (**Revealed/Retrospective Preference: RP**) may have problems:
  - ✓ Attribute values (levels) are limited by the maximum and minimum values of observed values.
  - ✓ Attribute correlations in RP data may be due to the 'relationship by chance' in empirical data.
  - ✓ Observational data for variations of attribute levels are time consuming and expensive to collect!

➢ Al alternative way of overcoming limitations of RP based choice data collection is: **Stated Preference (SP) method**

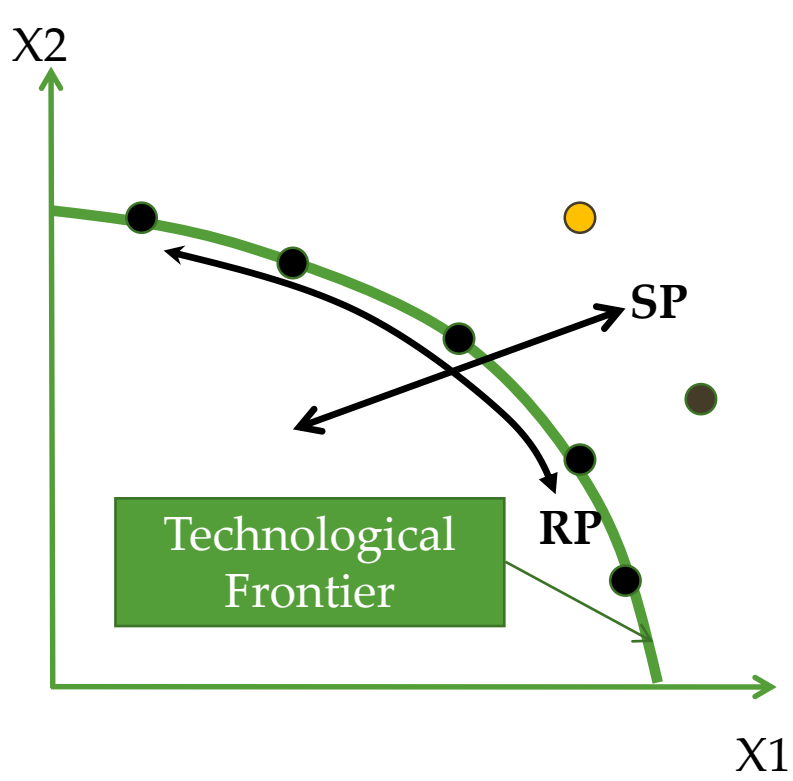
  - ✓ Creating hypothetical choice context by combining various attributes and corresponding levels.
  - ✓ Ask respondents to make choice.

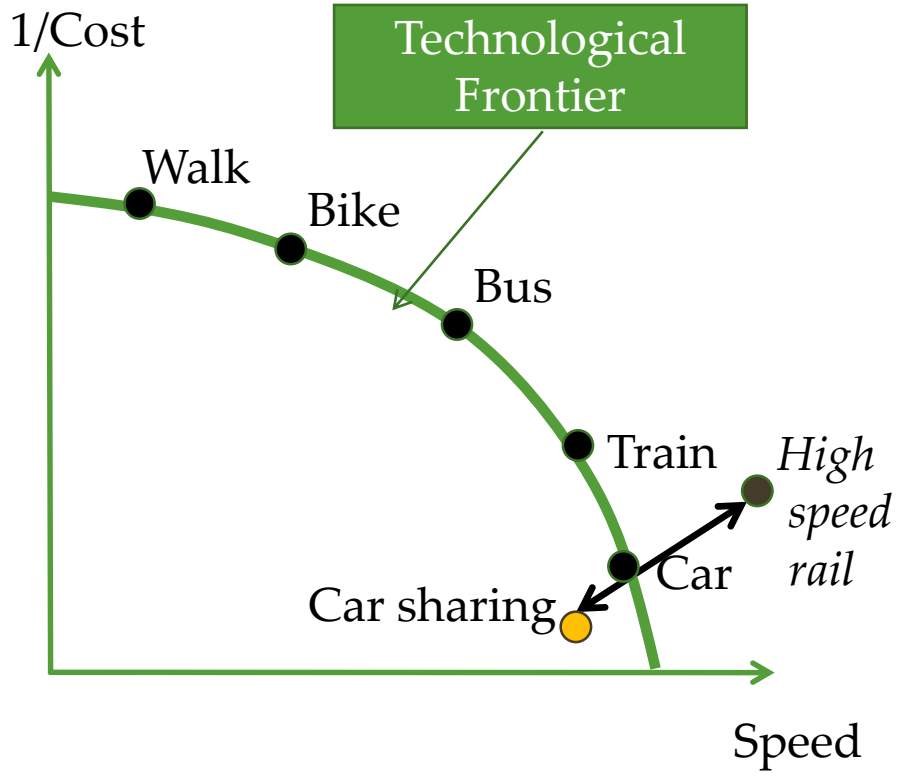
RP *versus* SP

SP data are necessary in case of attributes levels that are not currently observed:

1. For estimating demand for new product/response to new policy with new attribute and features.
2. For explanatory variables of any choice that have little variability in the market place→ competition between two transit services with similar fare system.
3. Explanatory variables are highly collinear in the market place: such as travel cost and travel time
4. New variables are introduced that now explain choices: →same transit system, but different fare collection technology

RP *versus* SP





SP and RP data are in fact complementary

Revealed Preference: RP	Stated Preference: SP
Based on actual market behavior: Market equilibrium	Based on hypothetical scenarios
Choice set is ambiguos	Choice set is specified
Attributes are subject to measurement errors	Attributes are free from measurement errors but are subject to perception errors
Range of attribute level is limited	Range of attribute level can be extended
Attributes may be high correlated	Correlation between attributes may be avoided or minimized
Difficult to incorporate intangible attributed (e.g. reliability, comfort, etc.)	Can incorporate intangible attributes
Cannot provide direct information on new (non-existing) alternatives	Can elicit preference for new (non-existing) alternatives
Preference indicator is “choice” (most preferred alternatives)	Can elicit any reasonable preference indicator (rating, ranking, choice)

Stated Preference Techniques

- A data collection technique for elasticity/sensitivity analysis, modelling, simulation and policy evaluations.

- Types of SP methods/techniques:
  1. The Transfer Price or Willingness-to-Pay method: Asking directly about willingness
  2. Conjoint Analysis: Choice Experiments / SP experiment to allow respondent comparing a set of alternatives and making a choice

SP Techniques: Conjoint Analysis

1. Hypothetical choice scenarios are presented to the interviewees.
2. Alternatives are presented based on their attributes
3. Attribute values are defined a priori by the investigators
4. Hypothetical scenarios are defined based on experimental design theory
5. Responses are measured by using one of the three methods:
    a) Rank-order judgment method
    b) Rating-scale judgment method
    c) Discrete choice experiment
    d) Discrete choice experiment with rank ordering

SP Techniques: Rank Order

	Mode	Average Travel Time, min	Cost of Travel	Comfort & Safety rating	Respondent's Evaluation (rank number)
1	Drive alone	40	$ 4.0	3	2
2	Auto Passenger	45	$3.5	3	5
3	Transit walk access	60	$2.75	5	3
4	Park and Ride	55	$3.75	4	4
5	Carpool	46	$3.0	3	6
6	New High Speed Rail	30	$5.0	10	1

SP Techniques: Rating Scale

Lowest Travel Time but Most Costly								Cheapest but longest Travel Time
☐	☐	☐	☐	☐	☐	☐	☐	☐
Strongly Prefer Left				No preference				Strongly Prefer Right

SP Techniques: Discrete Choice

	Mode	Average Travel Time, min	Cost of Travel	Comfort & Safety rating	Respondent's Choice
1	Drive alone	40	$ 4.0	3	□
2	Auto Passenger	45	$3.5	3	□
3	Transit walk access	60	$2.75	5	□
4	Park and Ride	55	$3.75	4	□
5	Carpool	46	$3.0	3	□
6	New High Speed Rail	30	$5.0	10	□✓

SP Techniques: Discrete Choice with Rank Ordering

	Mode	Average Travel Time, min	Cost of Travel	Comfort & Safety rating	Respondent's Choice
1	Drive alone	40	$ 4.0	3	☐
2	Auto Passenger	45	$3.5	3	☐
3	Transit walk access	60	$2.75	5	☐
4	Park and Ride	55	$3.75	4	☐
5	Carpool	46	$3.0	3	☐
6	New High Speed Rail	30	$5.0	10	☐✓

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SP Discrete Choice Experiment

- Aspect of SP design: Designing choice scenarios of SP Choice tasks
  - **Choice Alternatives**
  - **Choice set size** : The number of alternatives in a scenario.
  - **Attributes/Factors**: Variables defining the alternatives in the choice set.
  - **Attribute Level** : Values of the attributes used in the choice set scenario.
  - **Purpose**: quantify the effects of attributes on choice –Valuation and elasticity calculation, etc

SP Discrete Choice Experiment

- Choice attributes
  - ✓Identify attributes that are making individual alternatives attractive/un-attractive.
  - ✓Attributes that are related to policy under investigation.
  - ✓Referencing attributes with respect to current/RP attributes.
  - ✓Total number of attributes per alternatives should be as small as possible.
  - ✓Total number of attributes across the alternatives should be as small as possible.

SP Discrete Choice Experiment

- Attribute levels:
  - ✓ Discrete versus Continuous Attributes
  - ✓ Quantitative versus Qualitative Attributes
  - ✓ Discrete number of levels for any attribute: at least 2 levels
  - ✓ Number of levels as per functional relationship between choice alternative and the specific attribute:
    - Only 2 level for linear relationship
    - More than 2 levels for non-linear effects
  - ✓ Wide range is better than narrow range (1 to 6 is better than 1.5 to 3): Differences should be perceived well by the respondent.
  - ✓ Too wider range is bad as it may lead to dominant alternative

SP Discrete Choice Experiment

- Attribute Effects Captured by Experiment:
  - ✓**Main Effects**: the effect of one of the independent variables on the choice (dependent variable), ignoring the effects of all other independent variables.
    - There is one main effect for every independent variables in the study
  - ✓**Interaction Effects**: A statistical interaction occurs when the effect of one independent variable on the choice (dependent variable) changes depending on the level of another independent variable.
    - ✓Two-way interaction effects
    - ✓Higher-level interaction effects

SP Discrete Choice Experiment

Key Decisions to Make:

- ✓ **Labeled versus un-labeled alternatives**:
  - if alternatives have specific name (A, B, C, …..) , it allows having alternative specific attributes.
- ✓ **Attribute level balancing**: Each level of an attribute appears equal number of time for each attributes → Ensures that the data points are uniformly distributed across the levels of each attributes.
- ✓ **Generic experiment** → all alternatives in each choice set / scenario are described by same set of attributes.
- ✓ **Common based option**→ not all alternatives in each scenario, but one or more alternatives are always common

SP Discrete Choice Experiment

Design Aspects:

- **Forced choice experiment** →respondents are forced to choose one of the presented options:
  - ✓ Contrary: We can allow, "none of these" or "Others" option
- **Dominance** → One or more alternatives are made attractive because of attribute level combinations:
  - ✓ Should avoid choice sets where one option is going to be chosen by all respondents.
- **Affirmation bias**: Respondents choose responses to be consistent with the study objective: Such as attractive picture, features etc.
- **Task complexity and Respondent efficiency**:
  - ✓ If too complicated because of too many attributes → too many options in choice set →Choice experiment is more variable than expected

SP Discrete Choice Experiment

- Experimental Design:
  - ✓ **Full Factorial Design**: Consider all Possible combinations → Main effects as well as interactions
  - ✓ **Fractional Factorial Design**: Consider a subset of full factorial designs:
    - ✓ ***Random Design:*** Randomly selected subset of full factorial.
    - ✓ ***Orthogonal Design***: Only main effects are considered.
    - ✓ ***Optimal Orthogonal Design***: Optimally selected main effects are considered.
    - ✓ **Efficient Design**: A fraction of full factorial is considered but all effects are included.

SP Discrete Choice Experiment

Efficient Design : D-efficient or A-Efficient desing

Model

$$V_1 = \beta_0 + \beta_1 x_1 + \beta_2 x_2$$
$$V_2 = \beta_1 x_3 + \beta_3 x_4$$

Experimental design

	x_1	x_2	x_3	x_4
1.	- 1	- 1	- 1	- 1
2.	- 1	- 1	- 1	1
3.	- 1	1	1	- 1
4.	- 1	1	1	1
5.	1	- 1	1	- 1
6.	1	- 1	1	1
7.	1	1	- 1	- 1
8.	1	1	- 1	1

Questionnaire

Which mode would you choose in the following situations?

1.	*Car*	*Train*
Travel time:	10 min.	10 min.
Cost/fare:	$1	$1
Your choice:	☐	☐

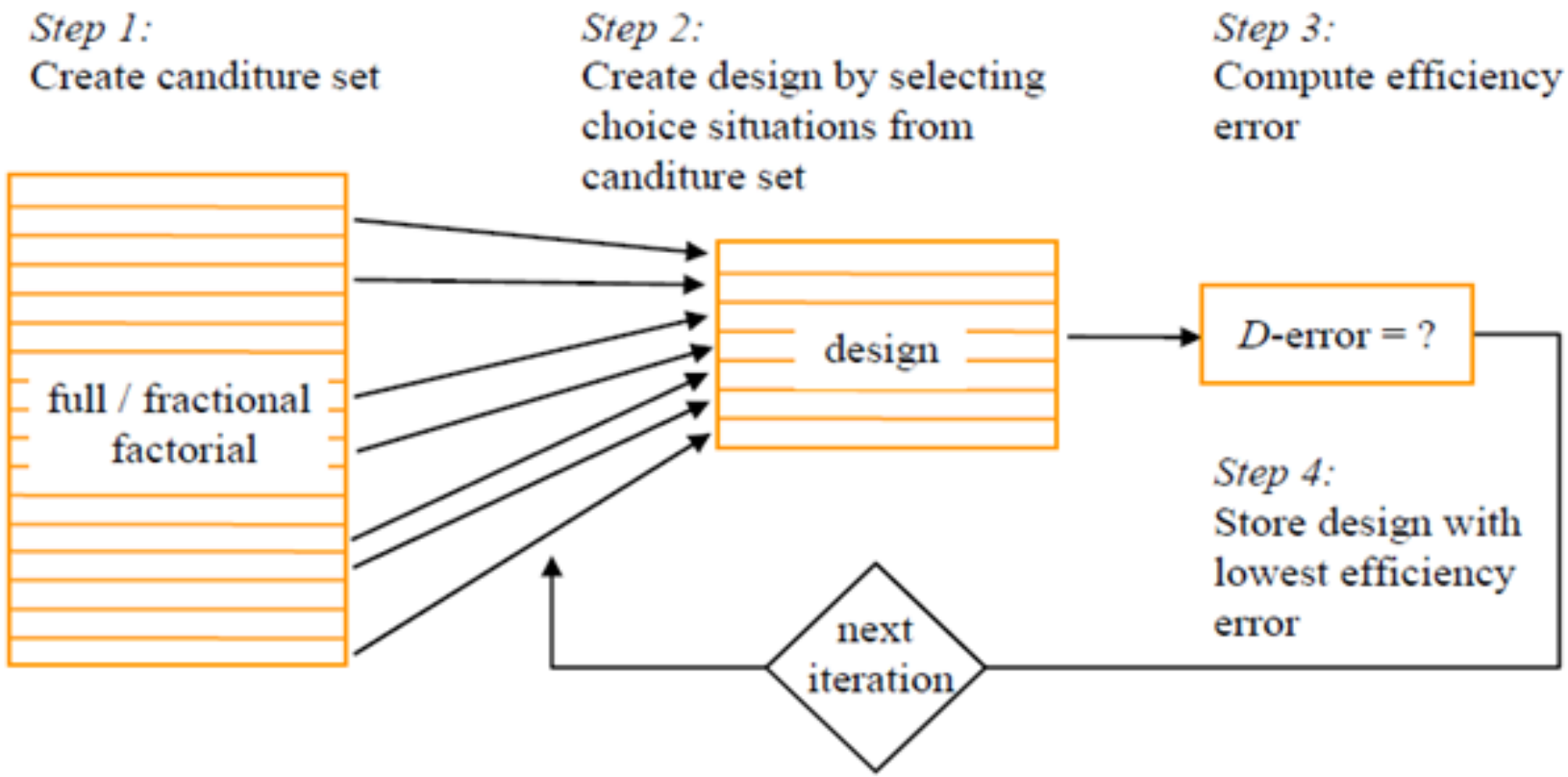
2.	*Car*	*Train*
Travel time:	10 min.	10 min.
Cost/fare:	$1	$1.50
Your choice:	☐	☐

3.	*Car*	*Train*
Travel time:	10 min.	15 min.
Cost/fare:	$1.50	$1
Your choice:	☐	☐

...
...

SP Discrete Choice Experiment

Efficient Design :



SP Discrete Choice Experiment

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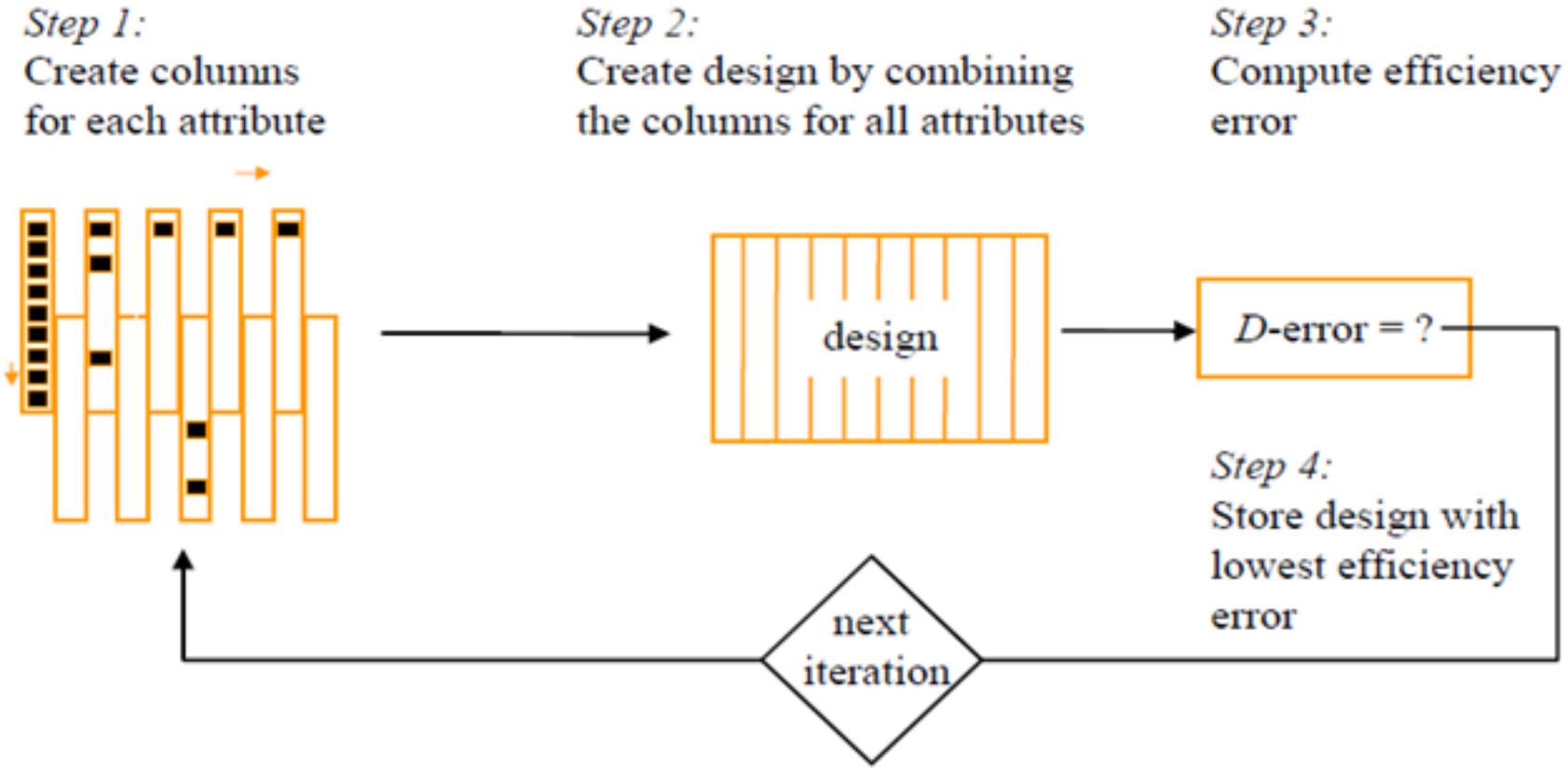
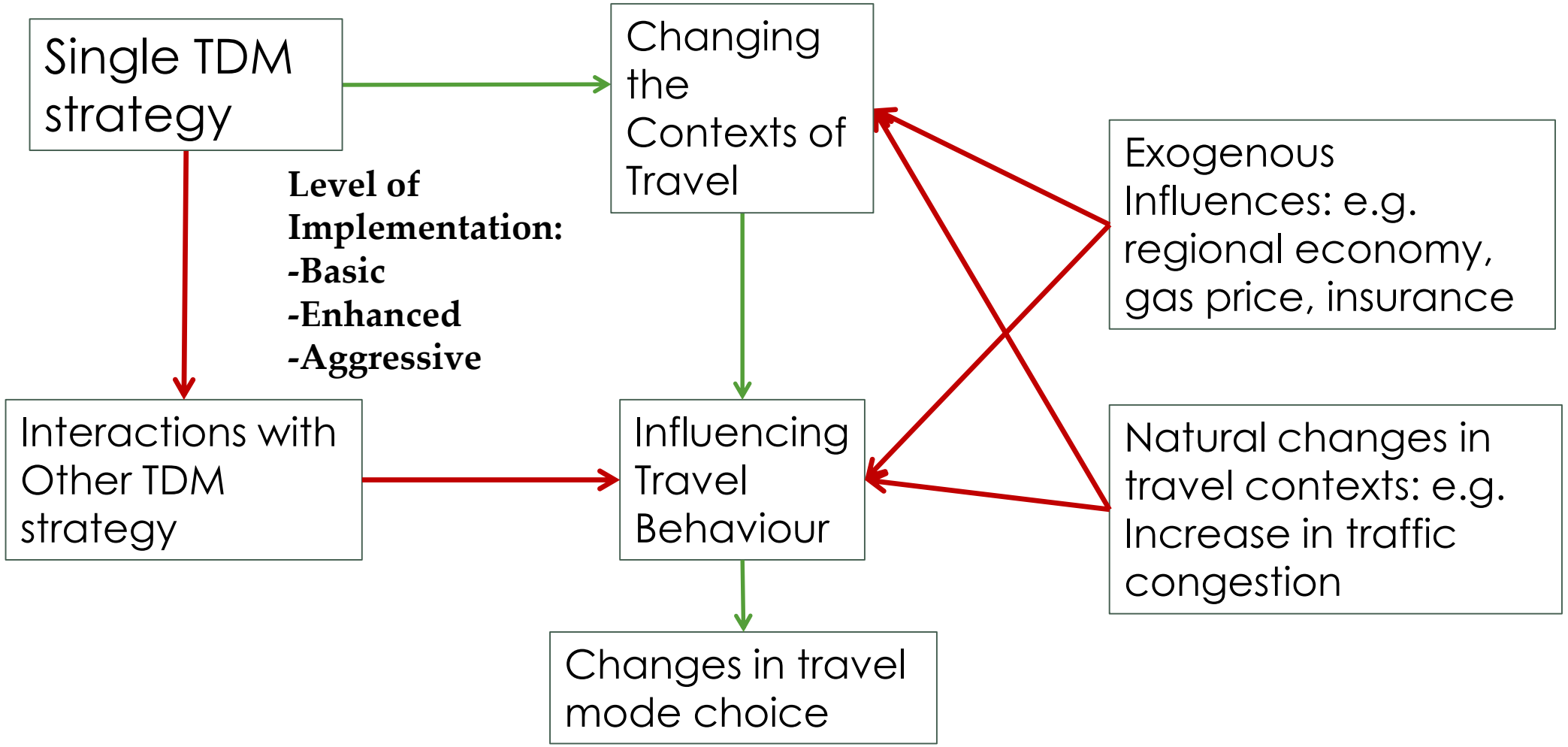


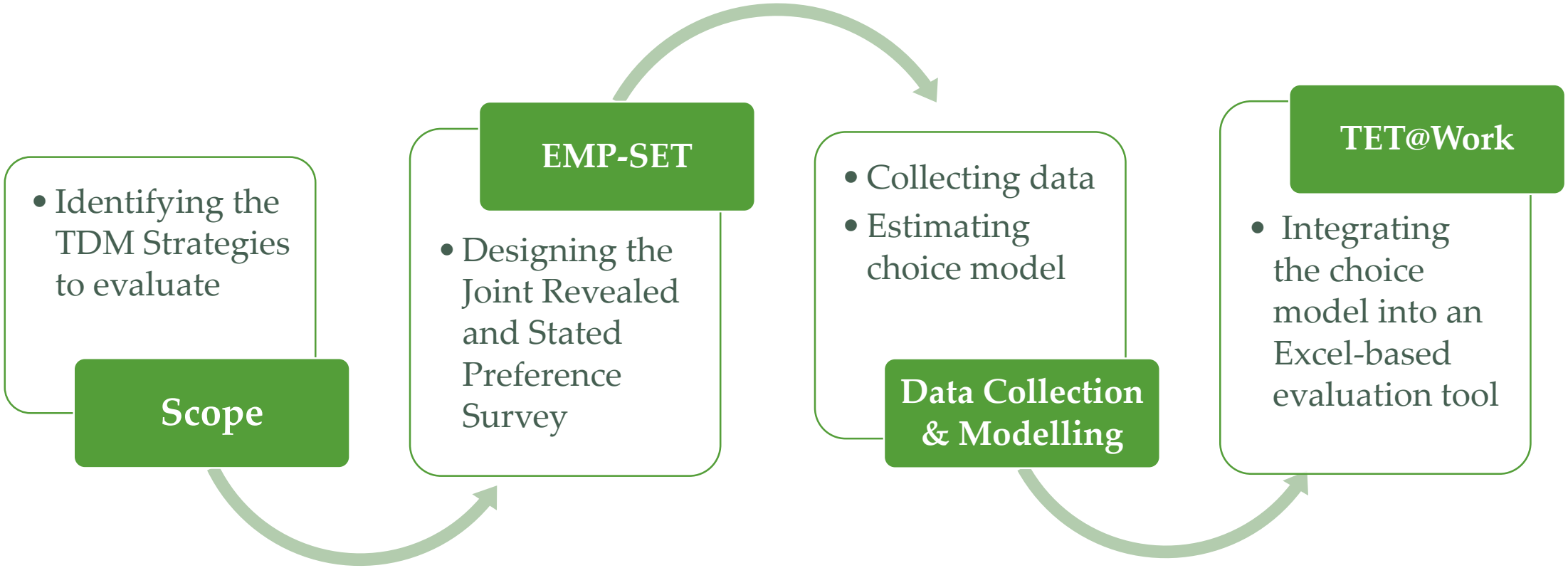
Data from Stated Preference Survey

- SP data should be used very carefully:
  - Simple cross-tabulation, frequency plot, descriptive statistics may not have real value unless the context of experiment is considered
  - Econometric approach is necessary to take care of biases and variations in SP choice data
  - Fusing RP data with SP data allows superior model estimation than using SP data alone
- Predicting future demand (share of alternative demands) by using SP data-based model needs to be carefully considered:
  - ASC of SP choice needs to be updated/calibrated carefully

Impact of TDM Strategies on Travel Demand



Methodology



RP Pivoted SP Survey

Current Home and Work Location

↓

Current Commuting Mode: RP Choice

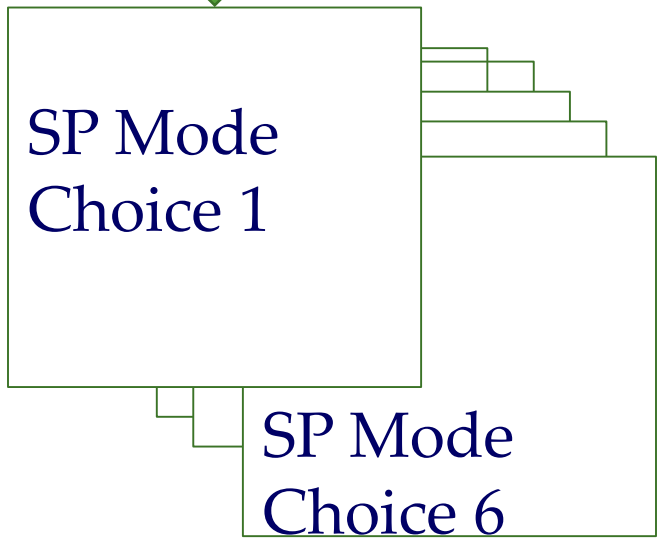
↓

Feasible Alternative Modes and base Level of Service Attributes

→

Mode Choice Model to define Optimum sets of six '**SP Scenarios**'

↓



SP Choice Scenarios

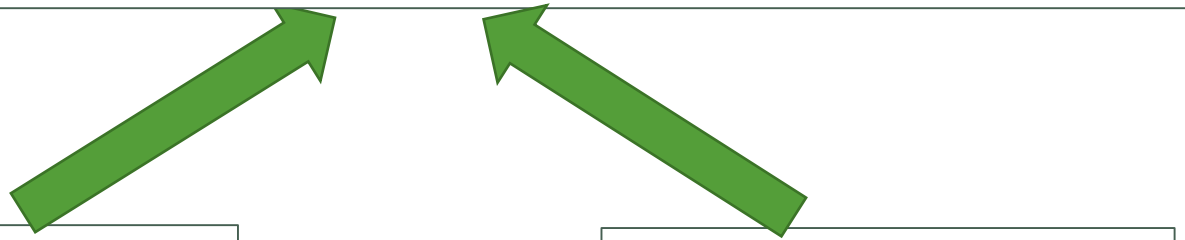
Attribute /Travel mode to work	Drive	Dropped off by household member	Carpool	Public Transit	Transit Bike Access(bring your bike on board)	Bike	Walk
Level of service values (travel time, travel cost, etc.). These remain consistent between scenarios.							
Total Drive Time (minutes)	13	13	15	----	----	----	----
Transit Walk/ Bike Time	----	----	----	51	17	----	----
Transit Wait Time (minutes)	----	----	----	6	6	----	----
Total Time Traveling in the Transit Vehicle	----	----	----	26	26	----	----
Travel Cost (Dollars)	$2.60	$2.60	$1.30	$2.8	$2.8	0	0
Travel Distance (Kilometers)	----	----	----	----	----	2.6	2.6
Employer based TDM polices. These change between scenarios.							
Daily or Monthly Parking Cost at Your Workplace (charged at a per day basis, or a monthly parking pass is offered at a discounted rate)	monthly	----	monthly	----	----	----	----
Employer pays for region of Peel (Miway or Brampton Transit) transit passes	----	----	----	no	no	----	----
Parking Cost (Daily and Monthly Rates) at Your Workplace	Monthly $36.00 (Daily rate: $1.80)	----	Monthly $0.00 (Daily rate: $0.00)	----	----	----	----
Indoor Car Parking at Your Workplace	yes	----	yes	----	----	----	----
Sheltered Bike Parking at Your Workplace	----	----	----	----	no	no	----
Showers and Changing Rooms at Your Workplace	----	----	----	----	yes	yes	----
Employer Owned Bikes Available to Rent (For Going Out to Lunch)	----	no	no	no	no	no	no
Bike Friendly Building Access (Ramps) at Your Workplace	----	----	----	----	yes	yes	----
Likelihood of Finding a Parking Spot Within 5 minutes walk to your Work Place (due to parking reductions)	100%	----	100%	----	----	----	----
Emergency Vehicle or Ride Home Program at Your Workplace	----	yes	yes	yes	yes	yes	yes
Employee Run Car Share Program at Your Workplace (for business related or short personal trips)	----	yes	yes	yes	yes	yes	yes
Please select your preferred travel option							

Modal Shares

	EMP-SET 2015:RP	Household Travel Survey	EMP-SET 2015:SP
Auto-Drive	84.09%	85.43%	41.01%
Carpool	3.31%	8.11%	28.30%
Auto-Passenger	4.41%		14.20%
Transit	6.30%	4.94%	10.48%
Bike on Board	0.63%	---	1.95%
Bike	0.63%	0.27%	2.53%
Walk	0.63%	1.25%	1.52%

Joint RP-SP Mode Choice Model

Joint RP-SP Mode Choice Model with Corrected Constants (to capture observed market share) and explanatory variable including level-of-service variables and TDM strategy indicators



RP Mode Choice Model

Repeated SP Mode Choice Model

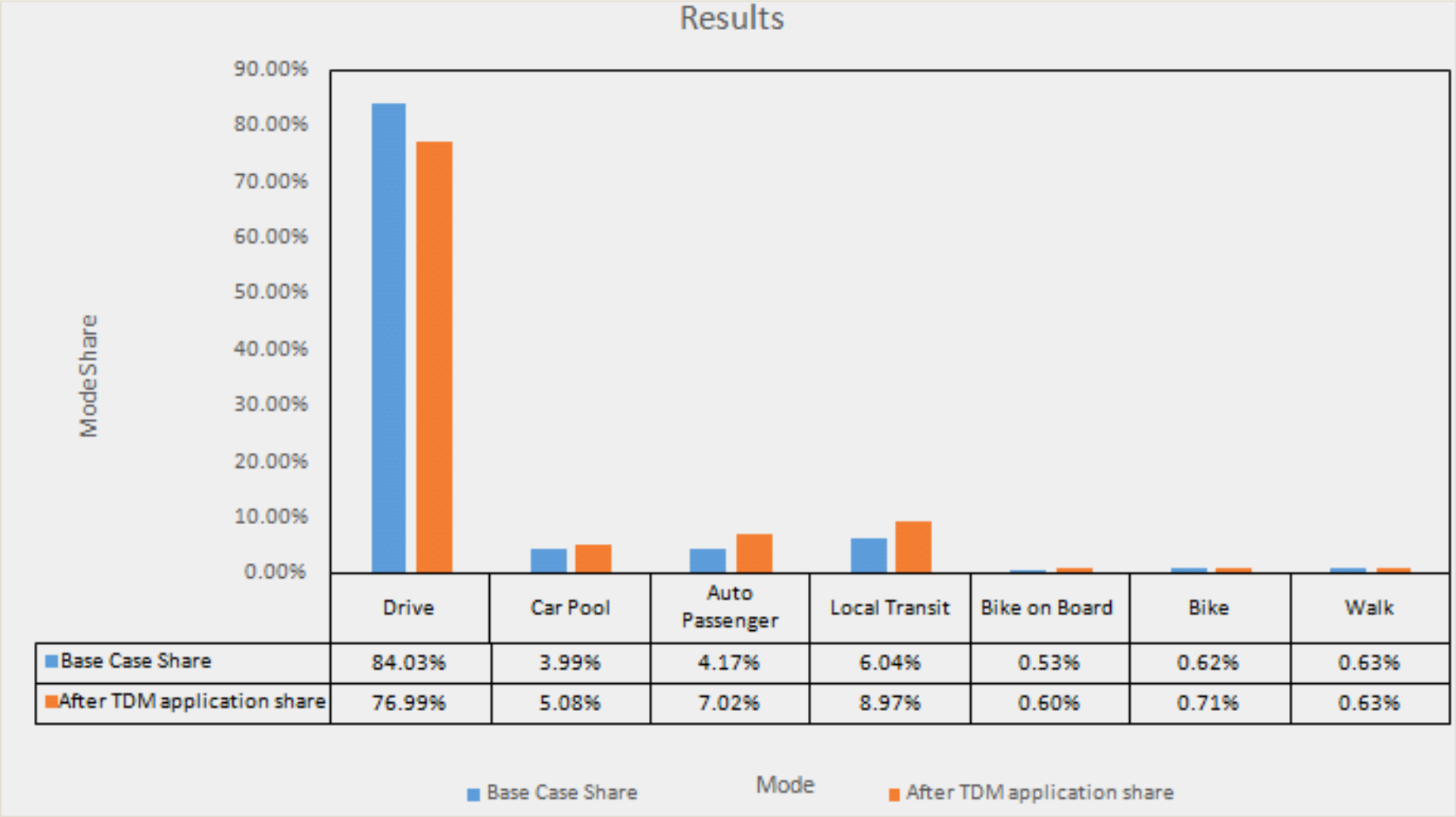
Explanatory Variables:
-Inferred level of service attributes, e.g. travel time, distance and cost of alternative modes

Explanatory Variables:
Stated level of service attributes and indicators of specific TDM Strategies

Joint RP-SP Mode Choice Model

Log Likelihood of full model	-4917.83	
Log Likelihood of null model	-5767.36	
Rho-square value against null model	0.15	
Number of Observation	635	
Parameters	Estimates	T-Stat
ASC_D	1.80	5.74
ASC_CP	0.47	2.20
ASC_AP	0.00	
ASC_T	0.66	6.17
ASC_BOB	-0.66	-2.79
ASC_B	0.33	1.45
ASC_W	-0.02	-0.14
TT(IVTT+Aceess)	-0.02	-10.52
cost/ln(distance)	-0.02	-2.18
ln(distance) for bike	-0.66	-9.69
ln(distance) for walk	-0.93	-8.15
Monthly Parking Cost	-0.22	-2.58
Daily Parking Cost	-0.14	-2.19
Indoor Park	0.34	2.82
Emergency Vehicle Home	0.42	2.84
Bikeshare	0.41	2.42
carshare	0.15	1.01
locker	0.24	0.86
Bike access	0.10	0.40

Scenario Analysis



	Drive	Car Pool	Auto Passenger	Local Transit	Bike on Board	Bike	Walk
Base Case Share	84.03%	3.99%	4.17%	6.04%	0.53%	0.62%	0.63%
After TDM application share	76.99%	5.08%	7.02%	8.97%	0.60%	0.71%	0.63%

Thank You

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