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Travel Time Variability Modelling of Selected Bus Routes in India

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CONTENTS

INTRODUCTION

- Travel time has become a crucial performance parameter for
  - evaluating urban corridors and networks for traffic control and regulation as a short term measure
  - system enhancement as a long term measure.

- To evaluate performance of a facility beyond the peak hour and also the effect of non-recurring events.

- To evaluate highway traveler perceptions.

- During peak hours, the travel time can increase significantly as compared to other time periods.

- An average travel time cannot fully capture these changes and a reliability measure is necessary.

- Information on time of travel between a pair of origin and destination is key input for decision regarding time of departure, mode of travel and route by an individual traveler.

- Variation in Travel times during
  - Different time in a day
  - Day of the week
  - Month or Season of the year

Major factors affecting travel time variability

Factor	Closed BRTS	Hybrid BRTS	Mixed traffic route
Passenger demand	√	√	√
Traffic volume (HOD & DOW)		√	√
Delays at intersections	√	√	√
Events or incidents	√	√	√
Land Use		√	√
Road width			√
Free flow travel time			√

RELIABILITY MEASURES

- Buffer Measures:-Based on estimates or direct measurement of travel time
  - 90th- or 95th-percentile travel time
  - Buffer index
  - Planning time index
  - Percentage of trips “on time”
- Statistical measures
  - Travel time window
  - Percent variation
  - Variability index

RELIABILITY INDICES DEFINITIONS

$$\text{Buffer Time Index (BTI)} = \frac{\text{95th\% travel time-Average travel time}}{\text{Average travel time}} * 100$$

$$\text{Planning Time Index (PTI)} = \frac{\text{95th\% travel time}}{\text{Free flow travel time}}$$

$$\text{Travel Time Index (TTI)} = \frac{\text{Average travel time}}{\text{Free flow travel time}}$$

*http://www.wsdot.com/traffic/seattle/traveltimes/reliability/

OBJECTIVES & SCOPE

- To analyse bus travel time variation with respect to space and time for different type of segments like uninterrupted segments, segments with intersections, and segments with intersections and bus stops in case of BRT.
- To analyse bus travel time variation with respect to space and time for different land use in case of non-BRT.
- To identify the effective reliability measure for developing reliability based LOS for performance evaluation purpose.
- To evaluate the effect of different factors like period of the day, day of the week, land use, the number of intersections, delay, and the number of bus stops on travel time variability.

STUDY ROUTES

SURAT BRT ROUTE

- BRT route in Surat city connects Udhana Darwaja and Sachin GIDC with a length of 9 kilometres with 17 stops in between the origin and destination.
- The selected BRT route represents a segregated bus lane throughout the stretch surpassing through intersections without transit signal priority.
- 102 UP (Udhana Darwaja - Sachin GIDC) and 102 DOWN (Sachin GIDC - Udhana Darwaja)

INDORE ROUTE

- Bus route-7 in Indore city connects Tejaji Nagar and Gandhi Nagar
- The route has a length of 19 km with 23 stops in between the source and destination.
- The selected road stretch represents a typical Indian urban roadway with varying roadway, geometric and land use characteristics under heterogeneous traffic conditions.
- Few sections along this bus route have divided carriageway and some sections are undivided in nature.

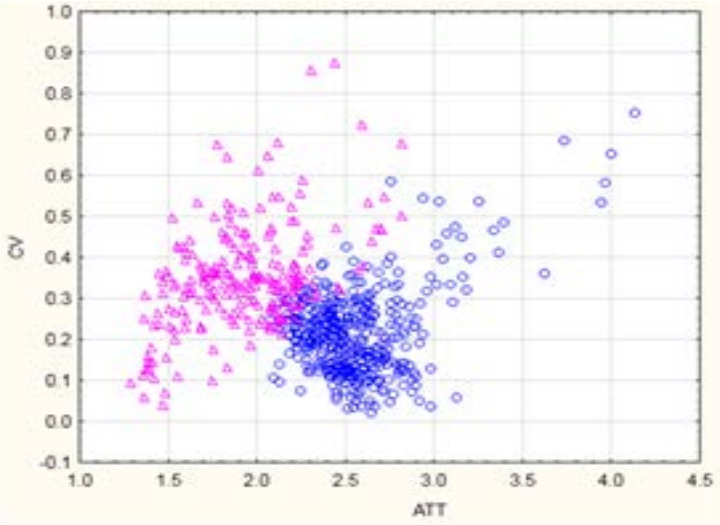
DATA COLLECTION

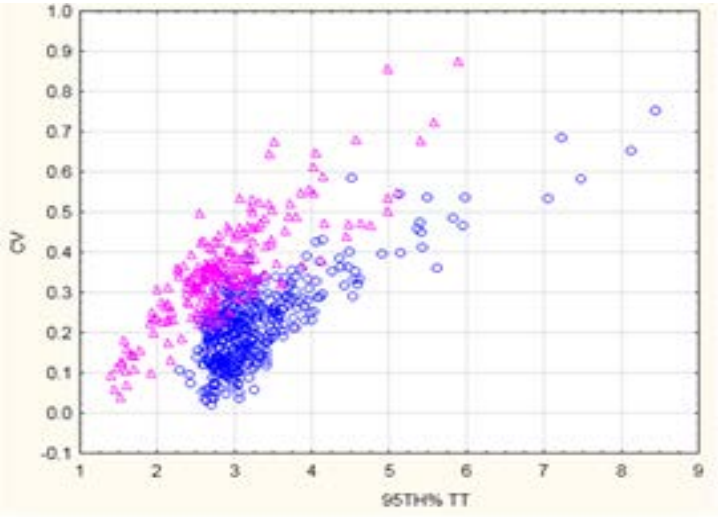
- BRT route is synthesized into individual segments of 300 meters.
- GPS travel time data is collected from BRT Sitilink Pvt Ltd, Surat for a duration of 30 days i.e., from 13th February – 12th March 2016.
- GPS based time stamps of bus trips at every bus stop along Indore route for duration of about six months is considered based on the type and format of data availability.
- Total route is segregated into individual segments with respect to bus stops.

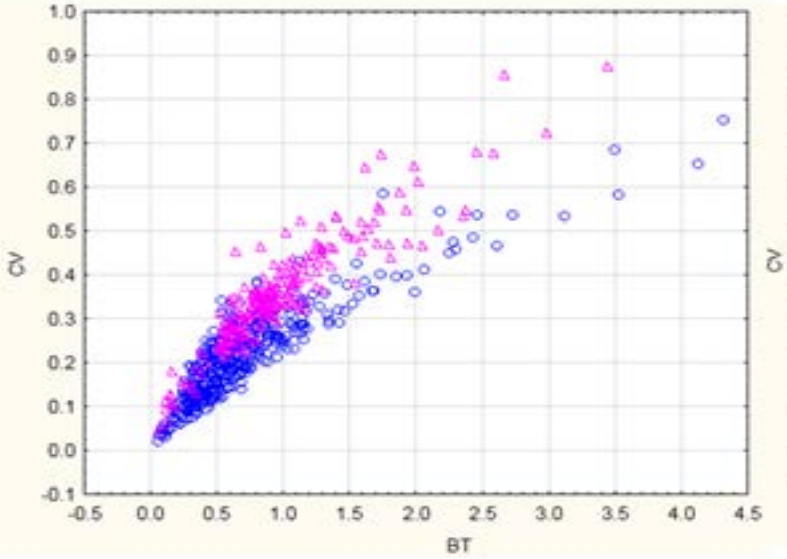
SURAT BRTS- CLUSTERING

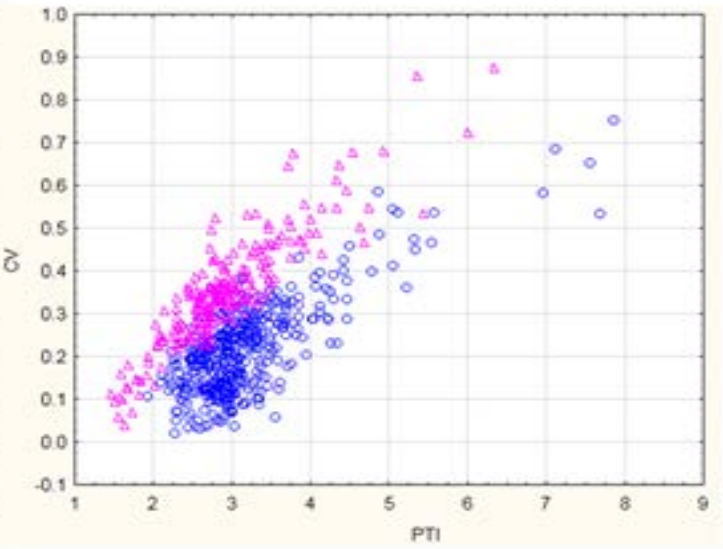
- Each individual segment is classified into three categories, namely, Uninterrupted, Bus stops, Bus stops and Intersections.
- Uninterrupted segments have uninterrupted roadway sections with or without median separators inside the BRTS carriageway.
- Segments with bus stops indicate the segment contains one or more bus stops without containing any intersections.
- Segments with bus stops and intersections indicate the segment contains one or more bus stops with containing any intersections.
- For given hour of the day and day of the week, reliability indicators per unit distance are evaluated for a given segment based on the available data set.

UNINTERRUPTED

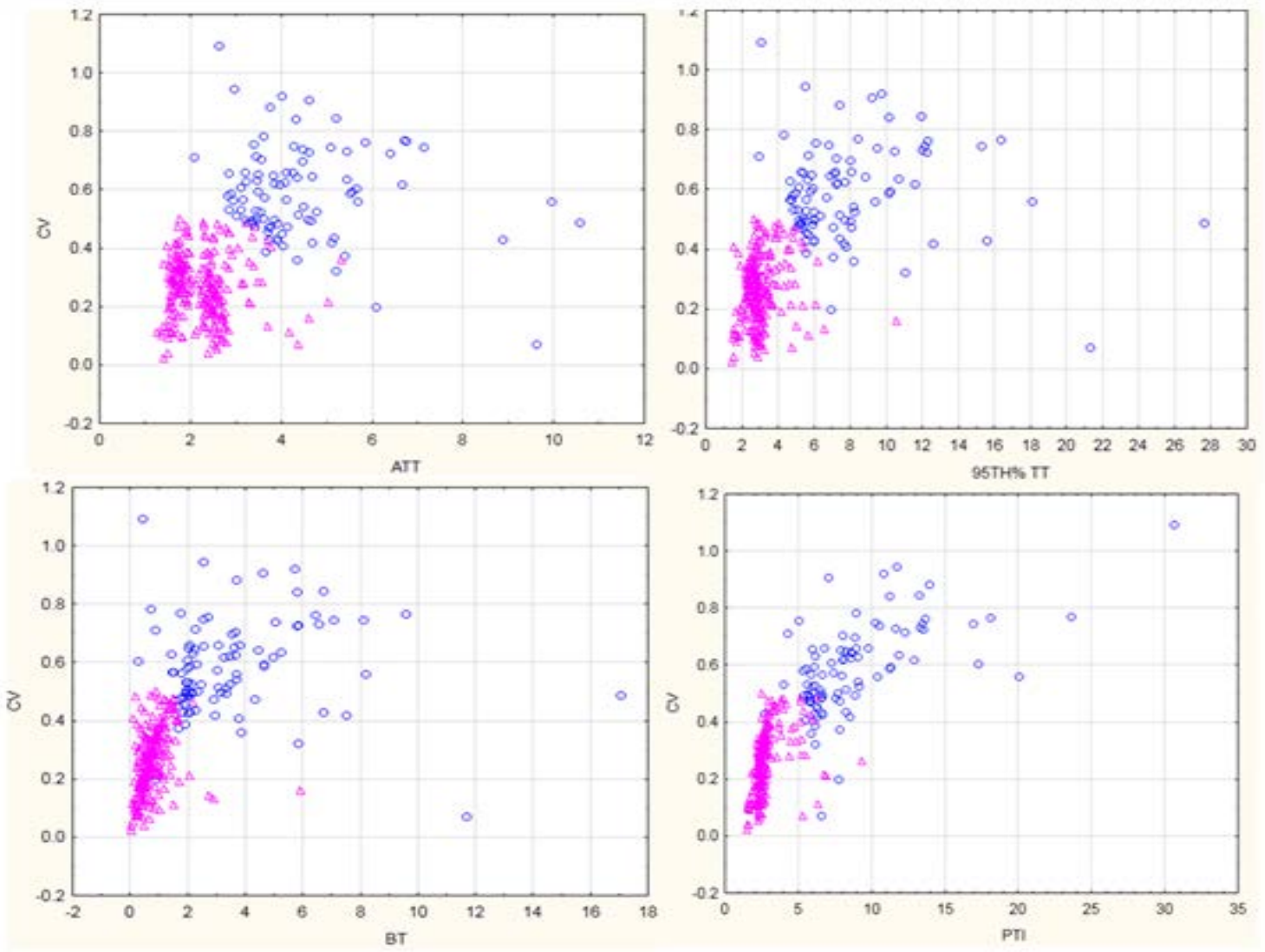




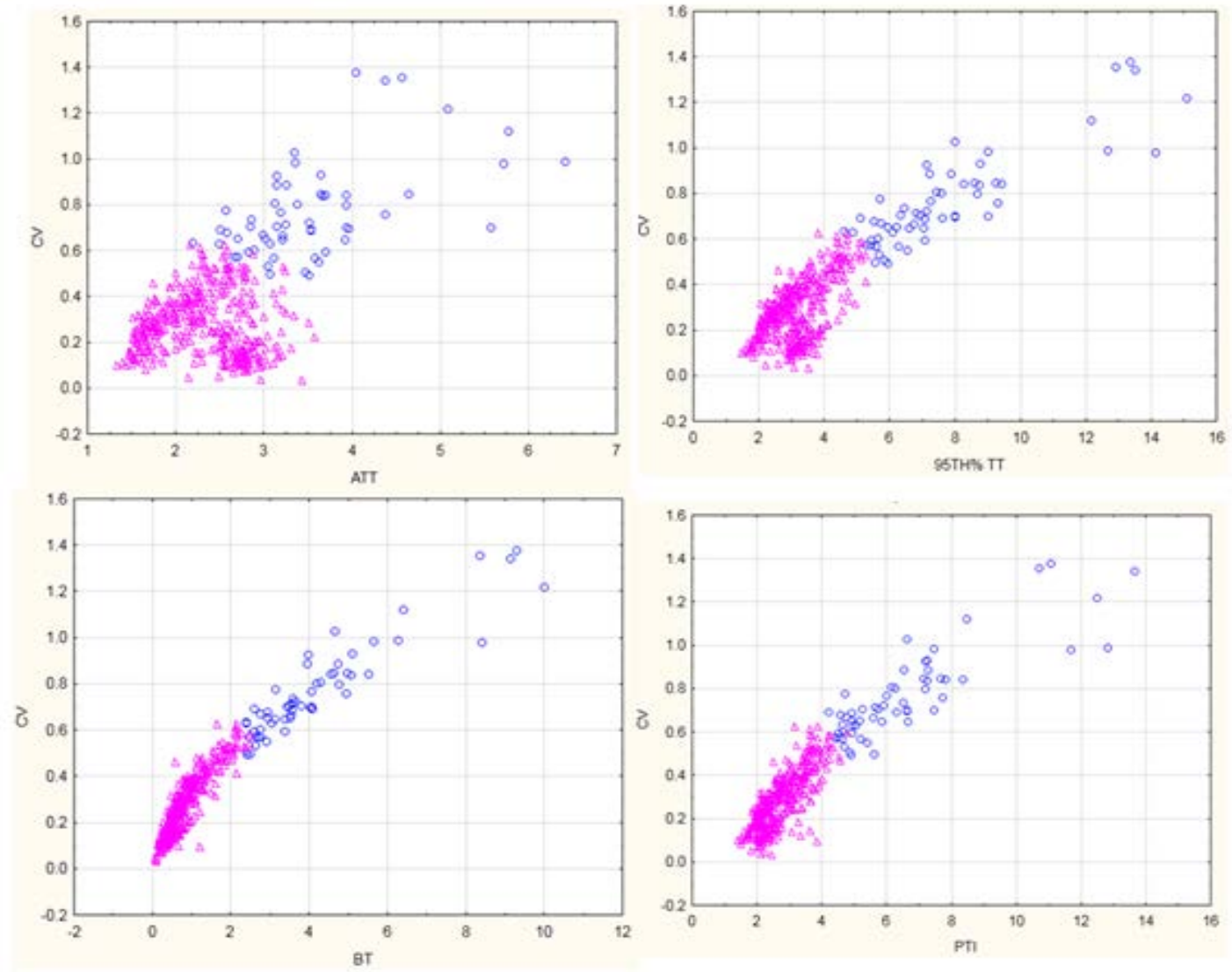




INTERSECTIONS



INTERSECTIONS & BUS STOPS



SILHOUETTE & THRESHOLDS

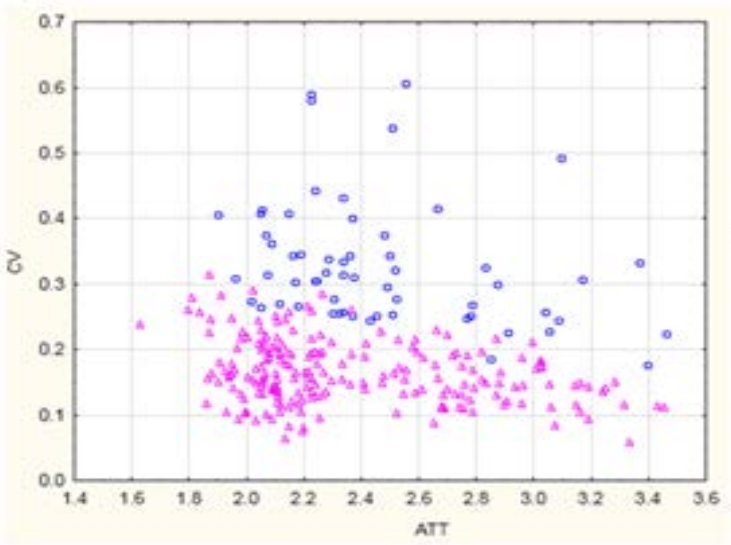
Cluster	Silhouette value		
	Bus Stop	Intersections	Intersections and bus stops
2-clusters	0.33	0.50	0.65
3-clusters	0.16	0.40	0.53
4-clusters	0.16	0.39	0.24

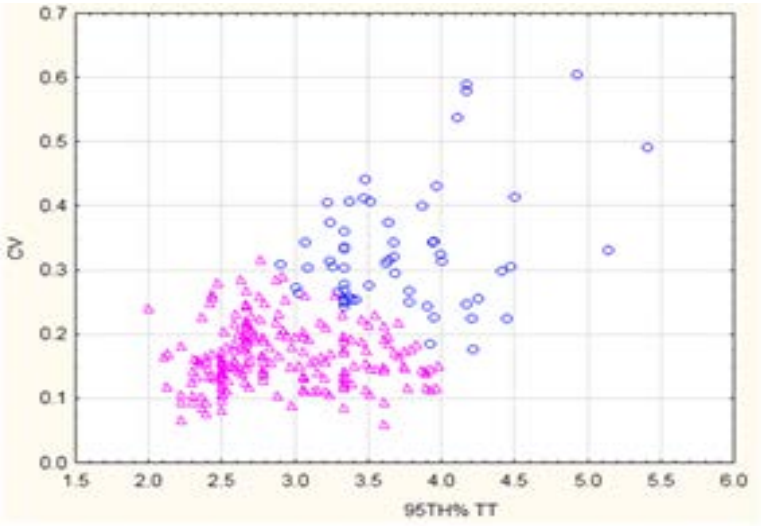
Cluster	Cluster Thresholds					
	Bus Stop		Intersections		Intersections and bus stops	
	CV	BT (mins)	CV	BT (mins)	CV	BT (mins)
Cluster-1	<0.4	<1.2	<0.5	<2	<0.6	<2.5
Cluster-2	0.4-0.7	1.2-2.8	0.5-1	2-8	0.6-1.4	2.5-10
Cluster-3	>0.7	>2.8	>1	>8	>1.4	>10

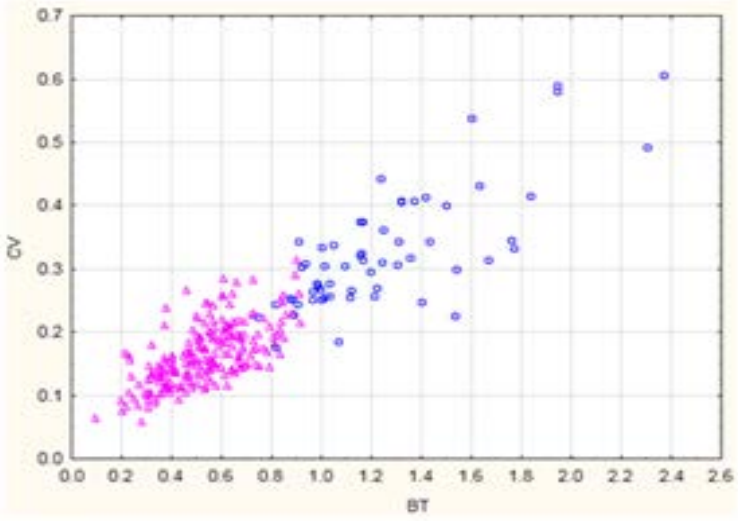
INDORE ROUTE

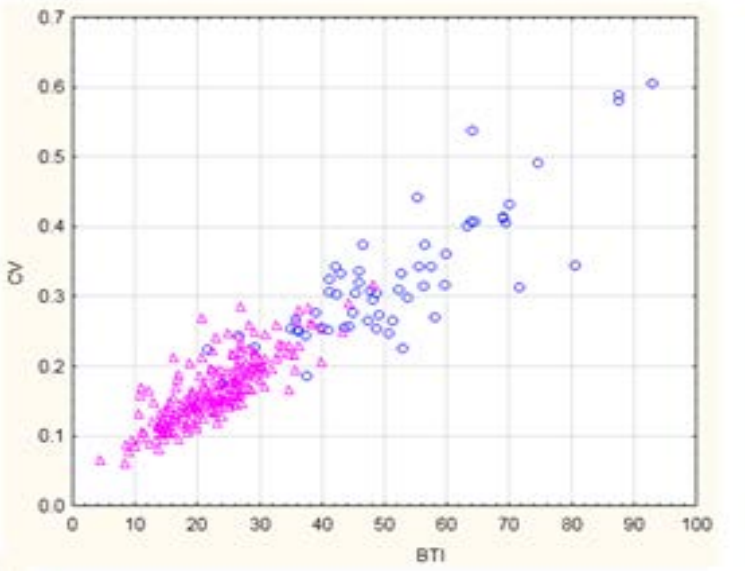
- Five different types of land use, namely, airport, mixed, commercial, residential are identified along the bus route.
- Airport land use comprise domestic airport in its premises and commercial land use implies the establishments of commercial centres like shopping malls, theatres etc.
- Residential land use signifies segments containing human settlements and institutional land use implies establishments such as educational institutions (schools, colleges, universities etc.), administrative buildings (like police stations, courts etc.).
- Mixed land use is considered for segments exhibiting combination of two or more land uses.
- All the individual segments pertaining to similar land use are segregated together and scatter plots for each land use are plotted.

AIRPORT LAND USE

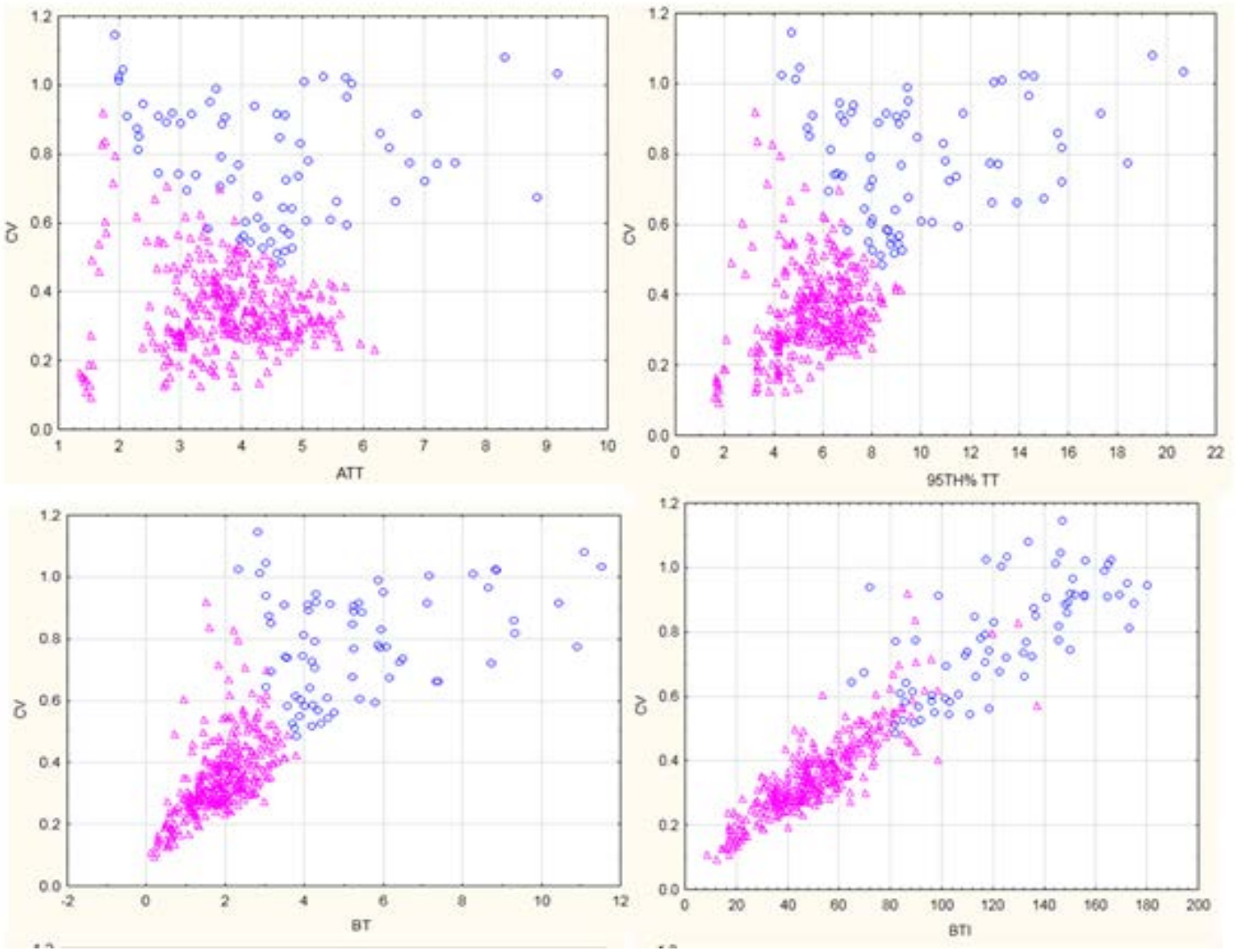




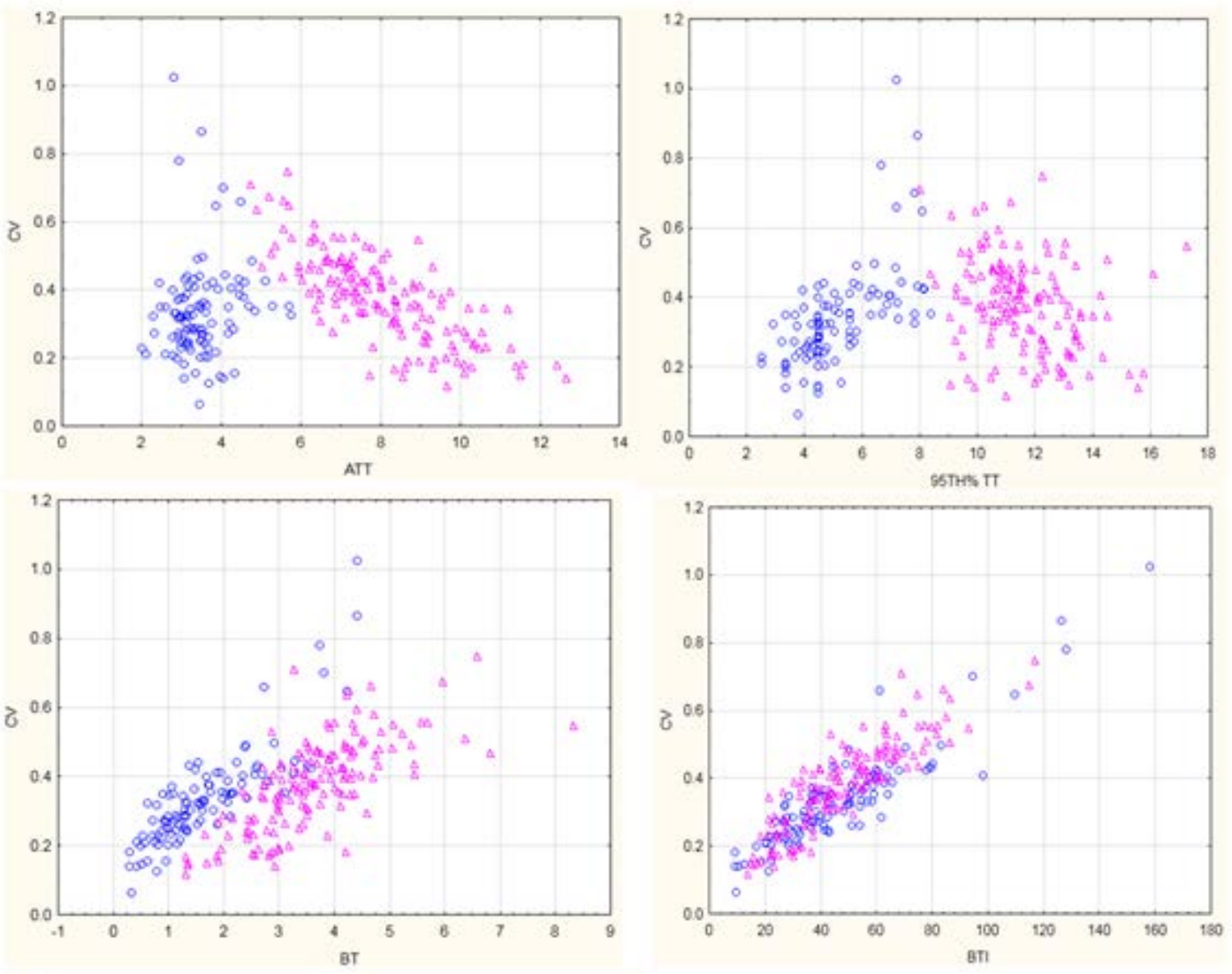




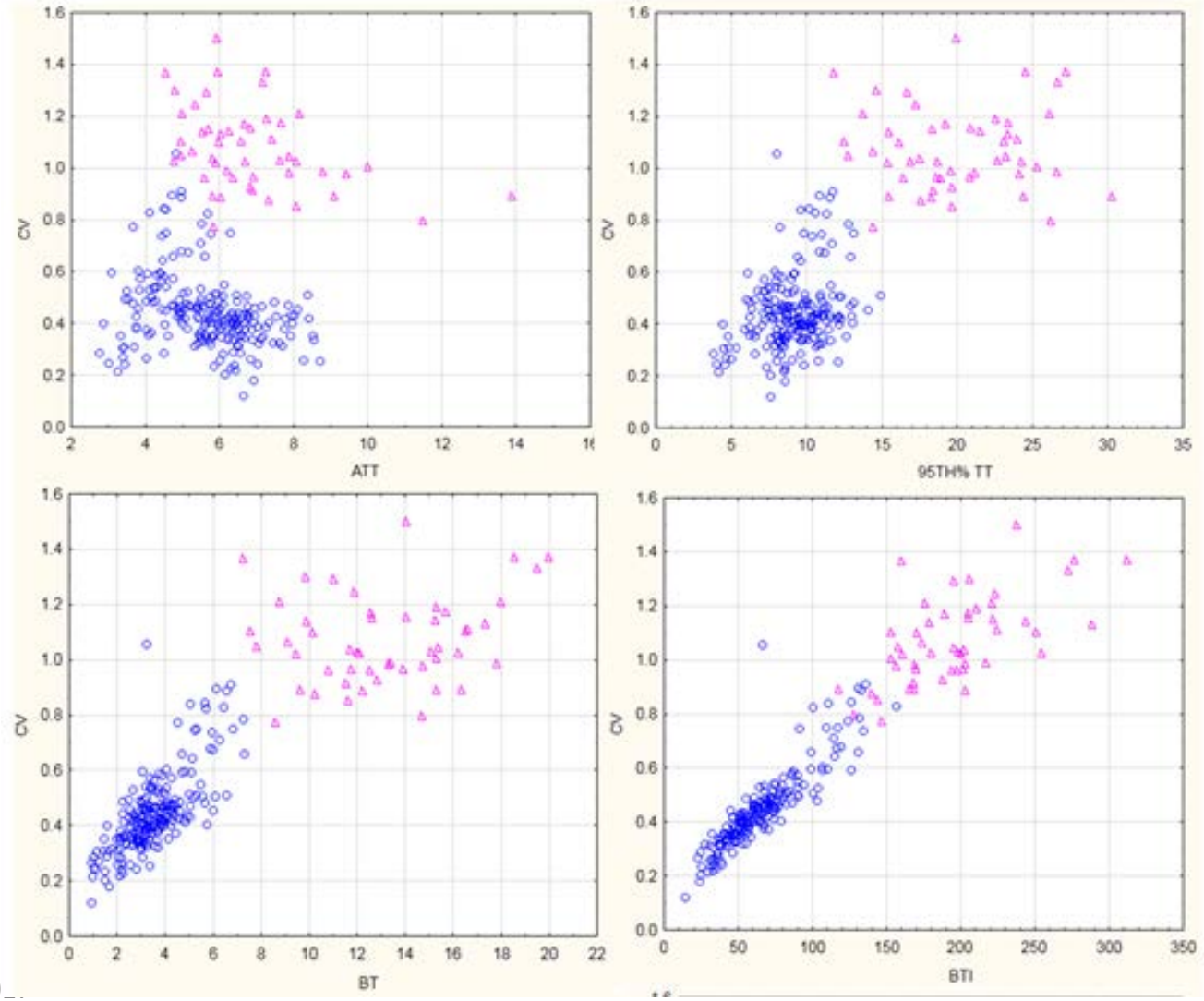
RESIDENTIAL LAND USE



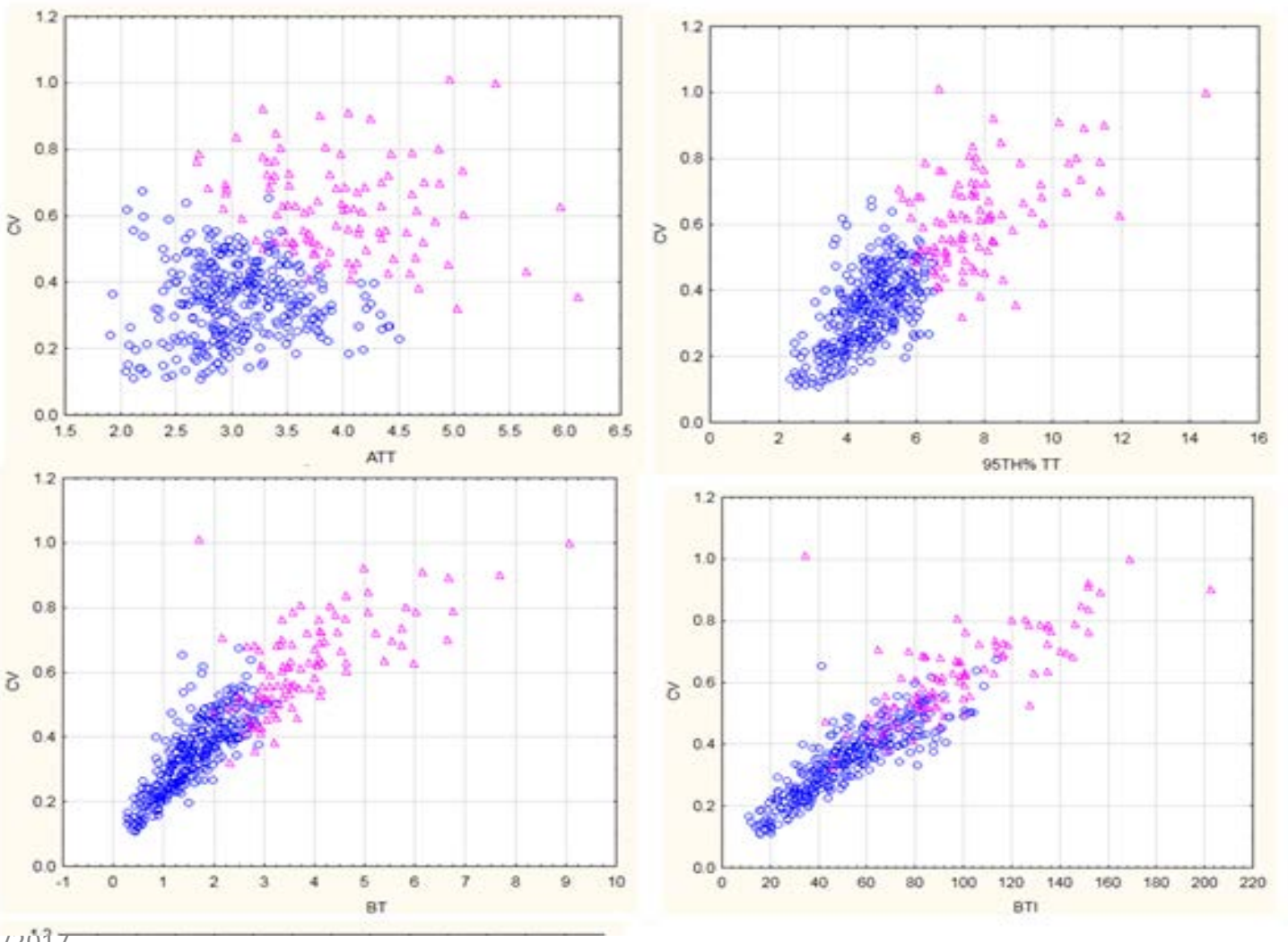
COMMERCIAL LAND USE



MIXED LAND USE



INSTITUTIONAL LAND USE



SILHOUETTE & THREHSOLDS

Cluster Thresholds										
	Airport		Residential		Commercial		Mixed		Institutional	
	CV	BTI	CV	BTI	CV	BTI	CV	BTI	CV	BTI
Cluster-1	<0.25	<40	<0.5	<80	<0.4	<40	<0.2	<25	<0.4	<70
Cluster-2	0.25-0.5	40-80	0.5-0.8	80-160	0.4-0.8	40-100	0.2-0.8	25-150	0.4-0.8	70-`140
Cluster-3	>0.5	>80	>0.8	>160	>0.8	>100	>0.8	>150	>0.8	>140

Cluster	Silhouette values				
	Airport	Residential	Institutional	Mixed	Commercial
2-cluster	0.59	0.62	0.41	0.73	0.37
3-cluster	0.14	0.51	0.26	0.26	0.37
4-cluster	0.15	0.24	0.17	0.22	0.33

Variability model for Surat BRTS

Variable	Calculation	Variable data type
Percent variation (Dependent)	Standard deviation per unit ATT	Scale
Dependent variables		
Land Use	1 to 4	Nominal
Intersections	Intersections per kilometer	Scale
Passenger demand	Demand at each bus stop	Scale
Delay	Difference between 95th% travel time and FFTT	Scale
Day of the week (DOW)	Sunday to Saturday (1 to 7)	Nominal
Hour of the day (HOD)	7 AM to 8 PM (1 to 13)	Nominal

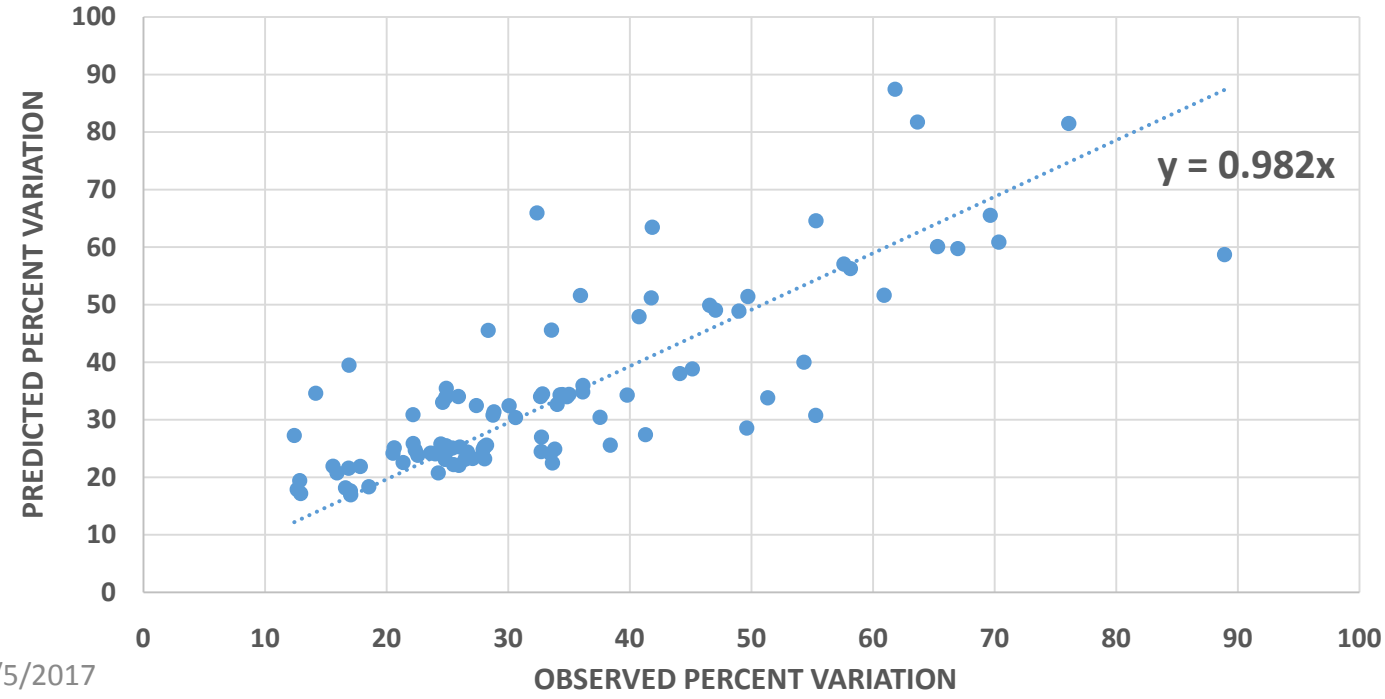
Travel Time Variability Modelling of Selected Bus Routes in India

Model		Unstandardized Coefficients	t	Sig.
		B		
1	(Constant)	10.771	3.954	.000
	DOW	-.323	-.687	.493
	HOD	.041	.309	.758
	PAX	.049	1.792	.074
	BUSSTOPS	.387	.863	.389
	INTERSECTIONS	2.359	6.611	.000
	LANDUSE	1.266	1.979	.049
	DELAY	4.841	21.730	.000

Coefficient Correlations					
Model			DELAYS	LANDUSE	INTERSECTIONS
1	Correlations	DELAYS	1.000	-.006	-.461
		LANDUSE	-.006	1.000	-.117
		INTERSECTIONS	-.461	-.117	1.000

- Percent variation = 8.129 + (2.929*Intersections) + (1.582* Land use) + (6.064* Delays)
- MAE- 6.85%

Predicted versus Observed Percent Variation



Variability model for Indore 7 UP

Variable	Calculation	Variable data type
Percent variation (Dependent variable)	Standard deviation per unit ATT	Scale
Dependent variables		
Land Use	1 to 4	Nominal
Intersections	Intersections per kilometer	Scale
Road width		Scale
Passenger demand		Scale
Delay		Scale
Day of the week (DOW)		Nominal
Hour of the day (HOD)		Nominal

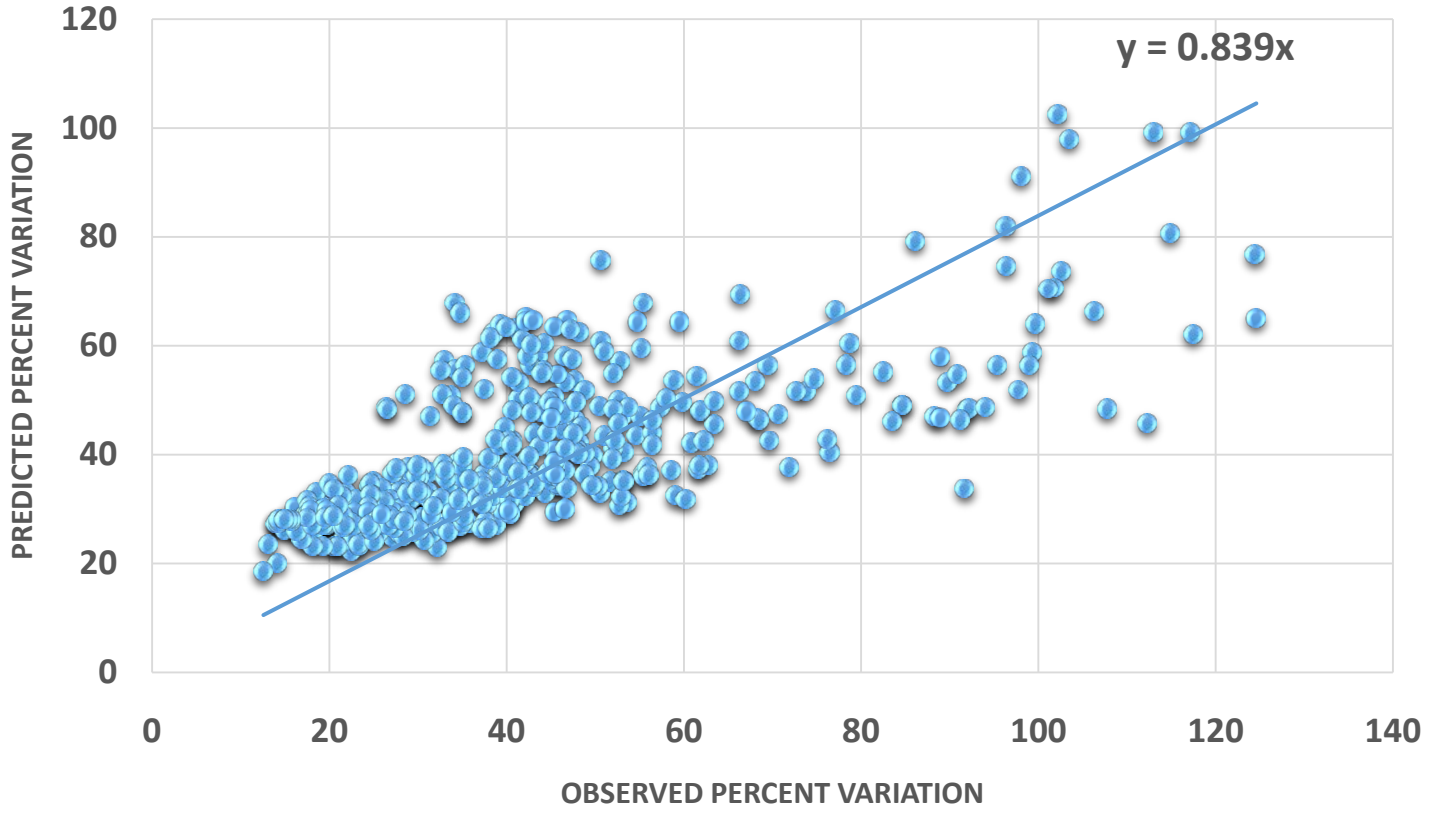
Variability model 7 UP

Percent variation = 16.375 – (6.521* FFTT) + (0.271* road width) + (0.88*Intersections) + (1.47* Land use) + (3.656* Delays)

Coefficient correlation matrix

	FFTT	DELAY	ROADWIDTH	INTERSECTIONS	LANDUSE
FFTT	1.000	-.051	.008	.261	.243
DELAY	-.051	1.000	.071	-.121	-.339
ROADWIDTH	.008	.071	1.000	-.166	.015
INTERSECTIONS	.261	-.121	-.166	1.000	.377
LANDUSE	.243	-.339	.015	.377	1.000

Predicted versus Observed Percent Variation



CONCLUSIONS

Surat BRT:

- The 95th percentile travel time and BT are observed to be effective in capturing travel time variations under segments with varying characteristics.
- Uninterrupted segments exhibited very low travel time variability.
- Segments with intersections and bus stops exhibited higher travel time variations when compared to that of uninterrupted segments and segments with intersections.
- It can be seen that delays have high coefficient compared to other variables.
- Also, the coefficients of independent variables are observed to be positive.

Indore Route:

- BTI is observed to be effective in capturing travel time variations under segments with varying characteristics.
- BTI thresholds are observed to be similar for airport and commercial land use; residential and institutional land use despite different road widths and type.
- For mixed land use, thresholds are less comparatively.
- The correlation coefficient is observed to be less than 0.5 for all the combinations of the variable cases in the regression model. Maximum correlation of about 37% is observed between land use and intersections
- It was observed that FFTT and delays have high coefficient compared to other variables.

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THANK YOU