INTEGRATION OF METRO WITH OTHER MODES OF TRANSPORT - CUSTOMER SATISFACTION: A CASE OF DELHI

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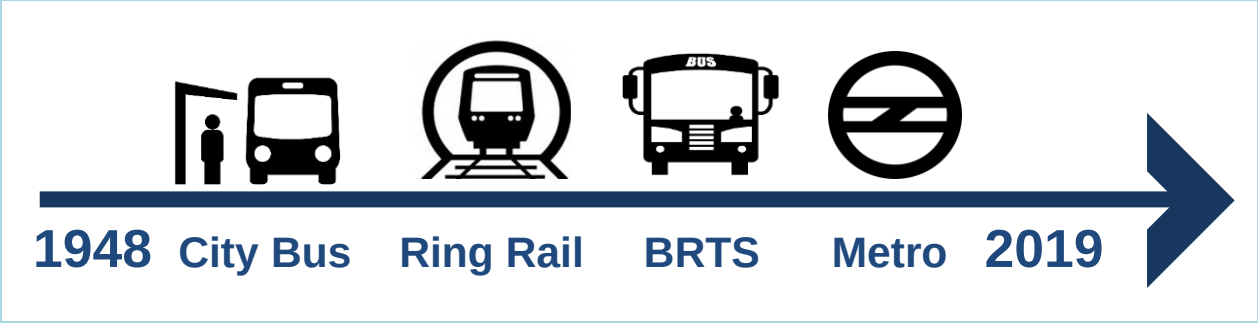
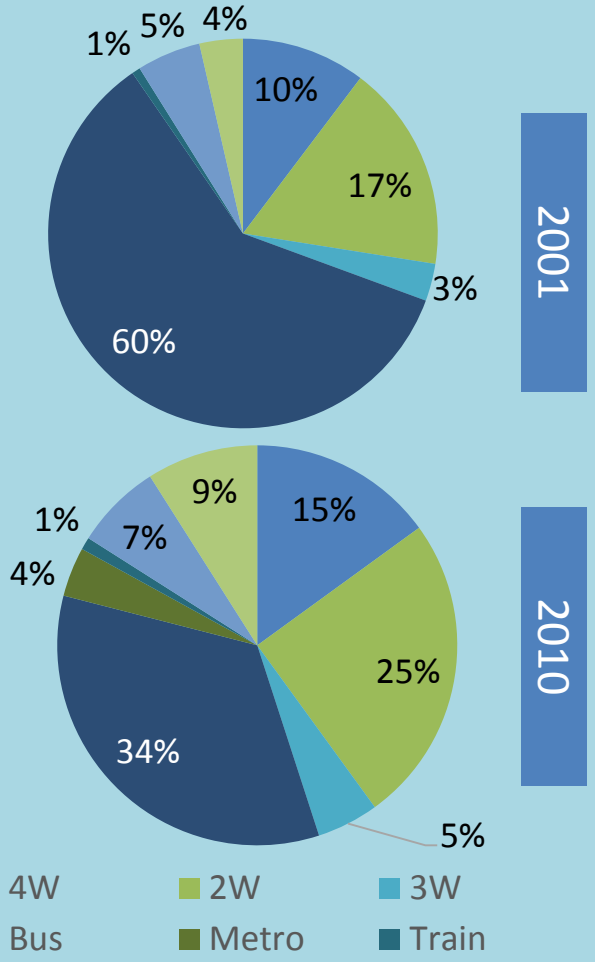
INTRODUCTION

NEED OF STUDY



- NUTP (2006) encourages city development **'more for People and less for Cars'** with focus on improving public transportation system of users
- NTDPC (2014) Public Transport mode share for large cities: **38%**
- In Delhi, Mode share of **Public Transport** has **declined by 21%** and **Private vehicle increased by 13%** in 9 Years.
- Factor Identification that influences users satisfaction is essential to **enhance Quality of Service and increase patronage of Public Transport**



Mode Share of Trips in Delhi

Source: Department of Transportation GNCTD 2008; Centre for Science & Environment 2010

Aim

'To enhance the quality of services and increase the patronage of Public Transportation in Delhi'

Objective

- To identify the factor that influences satisfaction of public transport users

Scope and Limitations

- The study is focused on User Perception
- Perception surveys are done for capturing Satisfaction and Importance of Bus and Metro users
- Surveys are done at Bus Stops and Metro Stations with respect to selected metro Lines

RESEARCH METHODOLOGY

LITERATURE REVIEW → **USER PERCEPTIONS** | **MULTIMODAL INTEGRATION** | **MULTIMODAL TRANSFER** | **TOOLS & TECHNIQUES**

OBJECTIVE	DATA REQUIRED	PRIMARY SURVEY & ANALYSIS		OUTPUT
To Identify Factors that Influences Satisfaction of Public Transport Users	Identification of Attributes of User Satisfaction Factors adopted from Cheriyan, C. (2015) Formulation of Focused groups	Site Visit With Structured Questionnaire of User Importance and Satisfaction ratings for Selected Variables	IS Analysis + SEM To assess the collected responses	Factors influencing user's satisfaction With respect to transfers type and Passenger Group

Conclusions

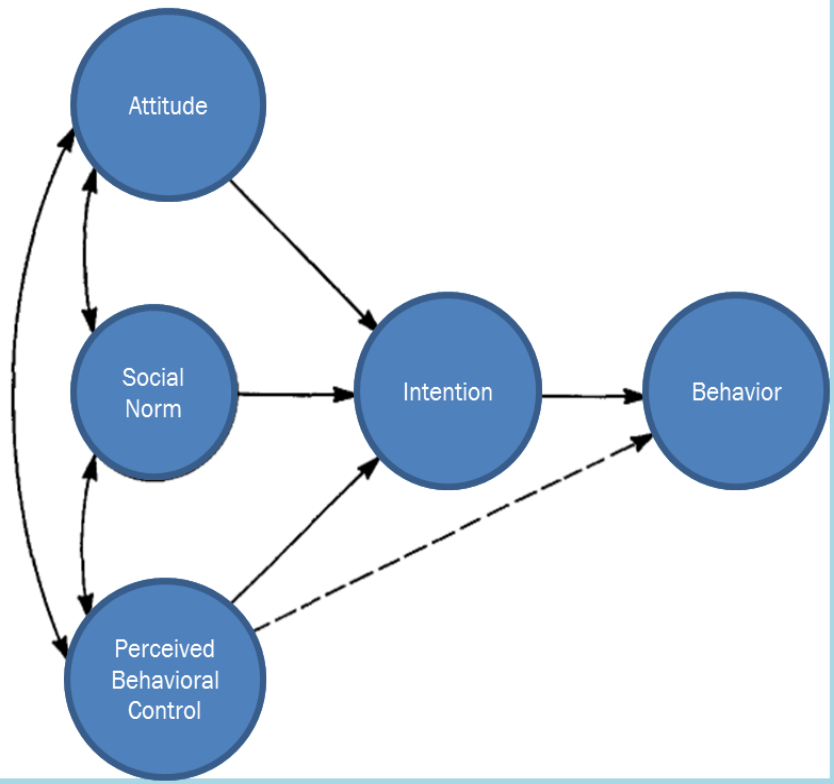
Source: Assessment of Transit Transfers Experience: Case of Bangalore Cheriyan, C. (2015)

LITERATURE STUDY

USER PERCEPTION

Theory of Planned Behavior (TPB) – *Icek Ajzen (1991)*

- TPB intent to **reflect users behavior** based on **willingness to change** choice
- According to *Ajzen* **Improvement in Level of Service** is necessary **to increase Ridership** But this **can be limited** when influenced with user travelling Behavior



Theory of Consumer Satisfaction *(1980)*

- According to the theory: Initially the **expectation is formed** by the consumer, and then **with respect of the system performance, satisfaction is derived**
- Consumer Satisfaction study attempt to **assess user attitude** towards Product, Service or Brand and prioritize specific area that needs to improvements

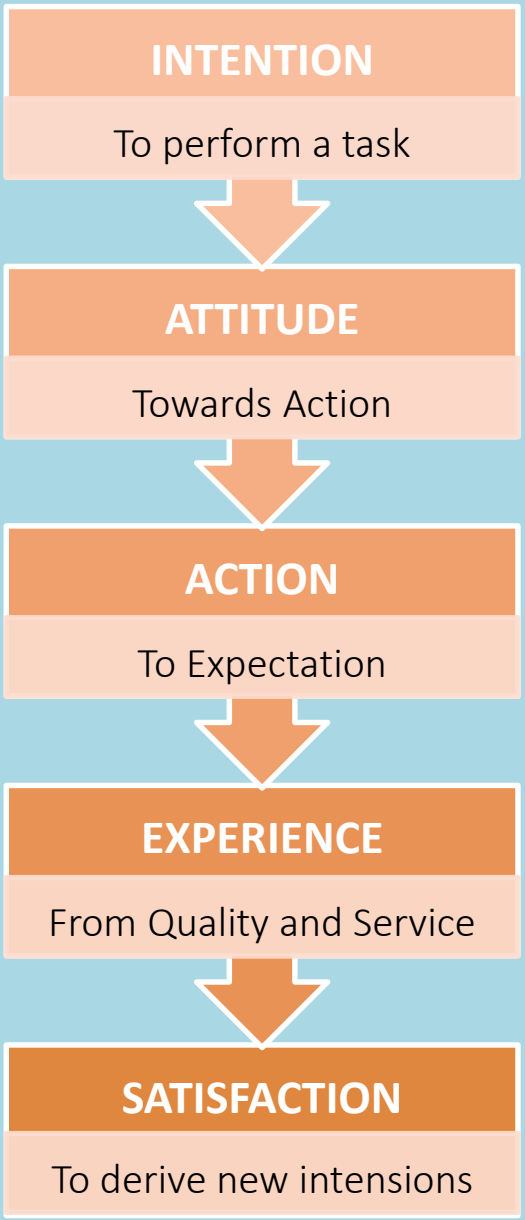
Sources: Theory of Customer Satisfaction 1980, Theory of Planned Behaviour (Icek Ajzen, 1985), An Investigation of Public Transport Users' Willingness To Select Route With Transfers (2014)

LITERATURE STUDY

USER PERCEPTION

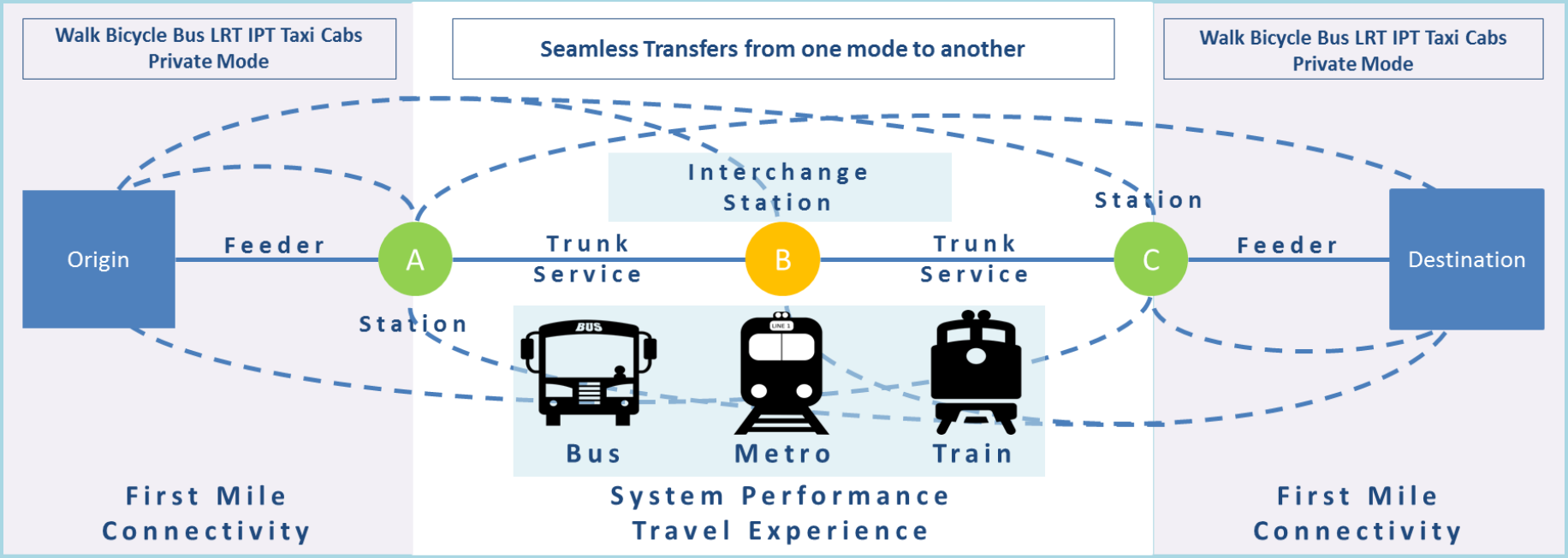
- According to *Daniel McFadden* – Both **User Behavior and Services** derives Consumer Satisfaction
- According to *Arroyo et al.,* - passenger's travelling behaviour are based on ***'Actively Travelling Comparison'*** *which means 'more the people use modes, more they are attracted towards there modes Choice'* and each mode have its own influencing factor

Behavior	• **Users choice based on willingness to change the choice** • According to the theory, inadequate connectivity/transfer facilities may lead to force passenger to seek for an alternative option to reach the desired destination
Satisfaction	• **Consumer Satisfaction** suggest that Users form Satisfaction Judgement by evaluation experiences



Sources: Theory of Customer Satisfaction, Theory of Planned Behaviour (Icek Ajzen, 1985), An Investigation of Public Transport Users' Willingness To Select Route With Transfers (2014)

MULTIMODAL INTEGRATION

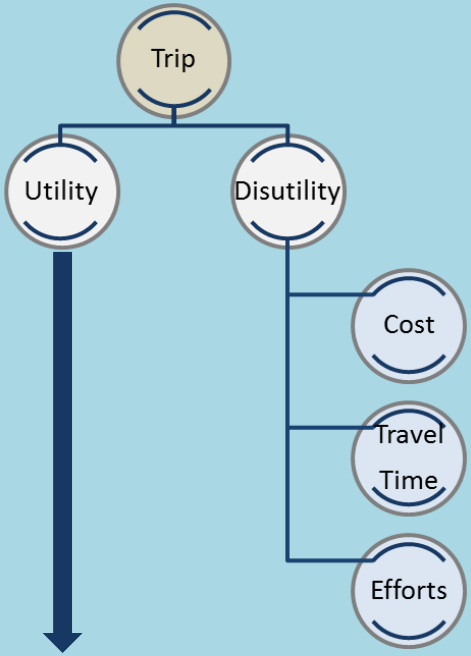


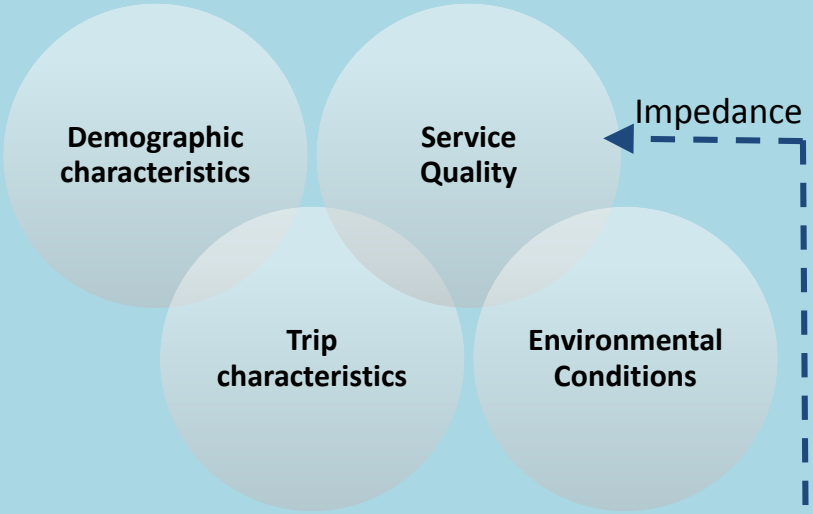
"**Coordination of services** to form a uniform system which operates on a common platform that provide **seamless travelling** through different modes of Transportation to the commuters"

- In a multimodal trip, **transfer plays an important role**
- Presence of **quality of transfers determine selection of mode**

Sources: Performance Evaluation of Multimodal Transportation Systems 2013, Inter-modality for public transport in a metropolitan area, Key success factors of Integrated Transport System 2013; Assessment of Potential Improvement to Metro-Bus Transfer in Bangkok, Thailand (2012), An Investigation of Public Transport Users' Willingness to Select routes with Transfers (2014)

MULTIMODAL TRIP





Impedance

Penalties

- Change in level or distance of transfer
- Increase in transfer time
- Longer waiting time
- Weather conditions
- Penalties for the transfer of different modes (eg. Bus to Metro transfer) are larger than the penalties for the transfer within the same modes (eg: Bus to Bus, Metro to Metro)

Walk - Wait – Transfer

$$U = \beta_1 t_{bus} + \beta_2 t_{train} + \beta_3 t_{transfer} + \beta_4 C + \beta_5 \delta$$

t_{bus} = in- vehicle time in bus

t_{train} = in- vehicle time in train

$t_{transfer}$ = time between arrival of mode (bus/ train) & departure of other — Out vehicle time

C = Total cost of trip

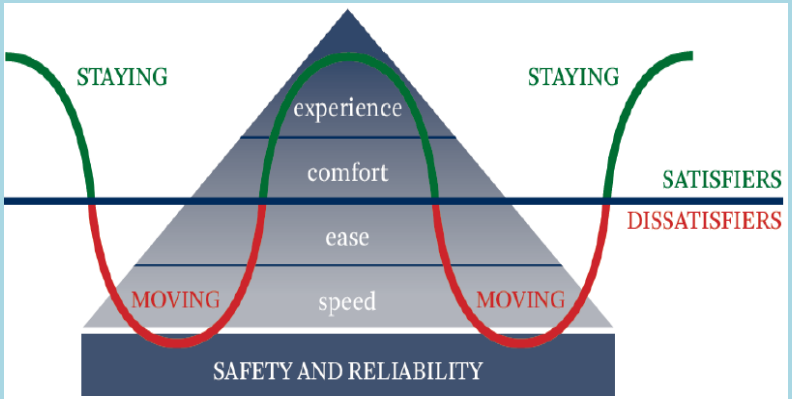
δ = penalty or the effort needed for transfer

$\beta_{1\ldots 5}$ = weights attached to each element of disutility

Sources: Valuation of a Transfer in a Multimodal public transport trip (Schakenbos, 2014), User perception of transfers in multimodal urban trips (Cascajo, Lopez, Herrero, & Monzon, 2018), Estimating the Passenger Cost of Station Crowding (Douglas & Karpouzis, 2016), Exploring passenger anxiety associated with train travel (Cheng, 2010), How Do People Perceive Service Attributes at Transit Facilities? (Iseki & Smart, 2012)

MULTIMODAL TRANSFERS

- VAN HAGEN (1961), identifies the hierarchy of user's need according to the importance
- **Safety and Reliability** are the two most important dimensions followed by satisfaction, ease, comfort and experience
- J.M PRESTON (2008), **Ease & Speed** are important for the moving travellers while **Experience and Comfort** are important for staying travellers



Van Hagen & J.M. Preston
Users Need Dimensions Pyramid

User's Satisfaction

- **Cost**
  - Fare
- **Time**
  - Walking
  - Waiting Time
  - Transfer Time
  - Service Quality
- **User's Perception**
  - Safety Reliability
  - Travel Information
  - Station facilities
  - Transfer type
  - Ticketing facilities
  - Crowding
  - Transfer experience
  - Environment
- **Personal Characteristics**
  - Gender
  - Age
  - Familiarity
  - Travel frequency
- **Trip Characteristics**
  - Mode
  - Trip purpose
  - Access or Egress

Sources: Waiting Experience at Train Stations Hagen, M. Van. (1961),

TOOLS & TECHNIQUES

Research (Author, Year)	Objective(s)	Tools & Techniques	Determinants	Findings
User perception of transfers in multimodal urban trips: A qualitative study (Cascajo, Lopez, Herrero, & Monzon, 2018)	To identify the factors affecting user perception of transfers to reduce the penalty associated with transfers by comparing two cities- Vitoria Gasteiz and Madrid	**Stated Preference Method**	Built, environment, Pure Penalty, Personal, transfer & trip characteristics, Time (with sub-Categories)	Identification of 2 new factors- mental effort & activity disruption

Focus Groups

Vitoria-Gasteiz
- Workers/Student + age<65 years
- Retired + age>65

Madrid
- Young adults age <30 years
- Adult workers + age <65
- Retired + age >65

Table 2. Summary of statistics on focus groups participants.

		Young adults Madrid	Adults Madrid	Adults Vitoria	Elderly Madrid	Elderly Vitoria
Participants		8	7	6	5	4
Age (mean, years)		24.0	40.1	35.0	73.6	69.5
Male		62.5%	28.6%	50.0%	20.0%	50.0%
Frequency of PT use	Every day	50.0%	85.7%	50.0%	20.0%	50.0%
	Every week	12.5%	14.3%	33.3%	60.0%	25.0%
	Occasionally	37.5%	0.0%	16.7%	20.0%	25.0%
	Never	0.0%	0.0%	0.0%	0.0%	0.0%
Trip motive	Work	33.3%	100.0%	66.7%	0.0%	0.0%
	Study	83.3%	14.3%	16.7%	0.0%	0.0%
	Leisure	66.7%	85.7%	83.3%	100.0%	50.0%
	Other	33.3%	85.7%	33.3%	80.0%	75.0%
Make transfers		100.0%	100.0%	83.3%	100.0%	100.0%
Type of transfer most used	Bus-bus	0.0%	42.9%	83.3%	80.0%	100.0%
	Rail mode*-bus	66.7%	57.1%	50.0%	20.0%	25.0%
	Bus-rail mode	33.3%	57.1%	33.3%	40.0%	0.0%
	Rail mode-rail mode	100.0%	100.0%	0.0%	80.0%	0.0%

*Rail mode is metro in Madrid and light rail in Vitoria.

Sources: User perception of transfers in multimodal urban trips (Cascajo, Lopez, Herrero, & Monzon, 2018)

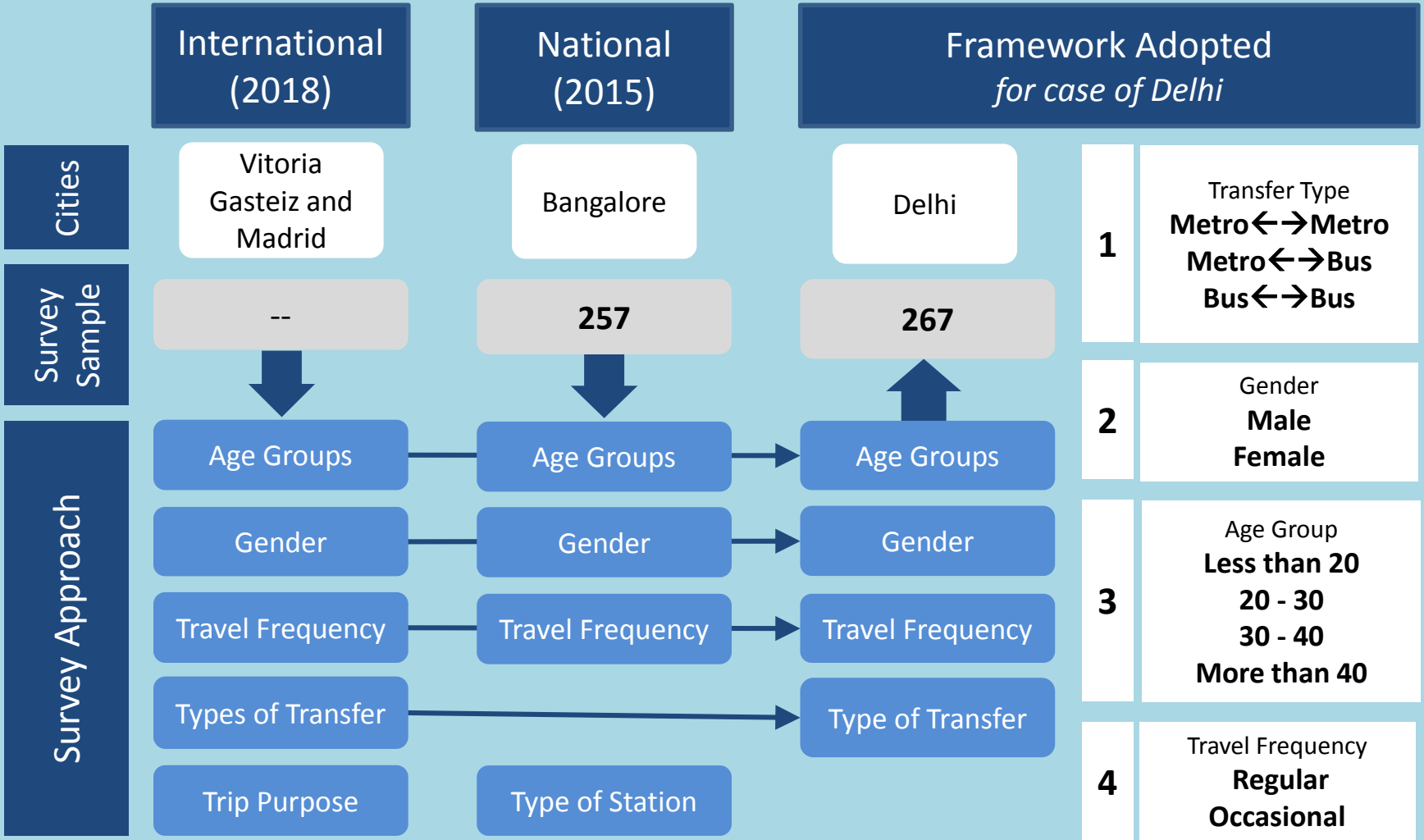
TOOLS & TECHNIQUES

Research (Author, Yr)	Objective(s)	Tools & Techniques	Determinants
Assessment of Transit Transfers Experience: Case of Bangalore Cheriyan, C. (2015)	To evaluate the role of transfers in public transport journey for passengers	**IS Analysis Structural Equation Modelling**	Station Design, Service/ Reliability, Fares & Ticketing System, Information, Amenities, Safety & Security (with sub-Categories)

Factors	Variables
Station / Facility Design	Access Time between two modes is < 5 Min
	Walking Time during transfers
	Adequate Lighting facility inside Station
	Ease of Accessibility to the Stations
Service/Reliability	Waiting time at Station is Less
	Services arrive in every 2 Mins (Frequency)
Fares and Ticketing System	No added fares in switching modes
	Purchasing tickets takes less times
Information	Adequate wayfinding facilities at station
	Availability of Route map
	Availability of Help Desk at Stations
Amenities	Availability of Seats at waiting area
	Environment at station is Comfortable
	Stations/Stops are Clean
	Availability of amenities (Rest Rooms)
	Basic facilities are easily accessible at station
Safety and Security	Using public transport during day/night is Safe
	Security guards are present at stations

Source: Assessment of Transit Transfers Experience: Case of Bangalore Cheriyan, C. (2015)

TOOLS & TECHNIQUES

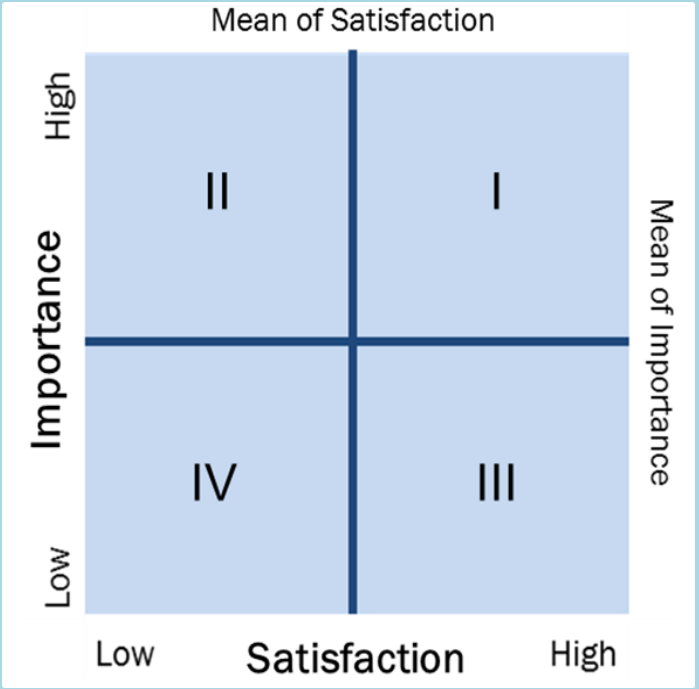


Sources: User perception of transfers in multimodal urban trips (Cascajo, LopeZ et al., 2018), Assessment of Transit Transfers Experience: Case of Bangalore Cheriyan, C. (2015)

TOOLS & TECHNIQUES

Importance Satisfaction Analysis (I-SA) | **IS = Importance x (1- Satisfaction) → Importance x Dissatisfaction**

- ISA is based on concept of emphasizing improvement to achieve overall satisfaction of users
- This technique is idealistic for the situations when financial resources are limit and investments are needed to improve the performance of service



Cartesian Diagram

High Importance With High/Low Satisfaction	**Low Importance** With High/Low Satisfaction
• Need to be Maintained • Determines High Priority **Q I – Continued Emphasis** Services are meeting users expectations **Q I I – Priority Improvement** Not performing well and Most Important for Users. Needs Significant Improvements	• Less Focus / No Improve • Determines Low Priority **Q I I I – Exceeded Expectation** Services are performing higher than users expectations **Q I V – Less Important** Services not performing well and also not important for users

Sources: ETC Institute I-S Analysis, (2018); Transportation System Performance Analysis Urban Area Public Transport (Putra, Adris A, 2013); Assessment of Transit Transfers Experience: Case of Bangalore Cheriyan, C. (2015)

TOOLS & TECHNIQUES

Structural Equation Modelling (SEM)

- SEM is a tool to identify the factor the determines the satisfaction of public transport commuters based on the performance of the system
- Factor which are most dominant within the responses or commonly proves the dissatisfaction to the users can be highlighted with Structural Equation Method

$$Y = \beta X + e$$

Where,
X = Satisfaction
Y = User Preferences/Ratings
e = Measurement of error term
β = Regression Weight
(Regression Coefficient of Beta)

KMO and Bartlett's Test:	Indicates Suitability of Data for Structure Detection
Principal Component Analysis	To Identify Linearly Uncorrelated variable called Components
Rotated Component Matrix	Determine Relation of Variable and Components
Regression Coefficient	Determines Impact of Components (or set of Variable)

Sources: CSI Index of Consumer's Satisfaction Applied in the Area of Public Transport (Poliaková, Adela, 2015); Passengers Preference and Satisfaction of Public Transport in Malaysia (Ambak, Ismail, Nor, Hafezi, 2015)

PRIMARY SURVEY
2019

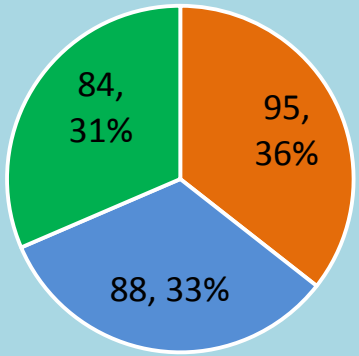
Location	Anand Vihar ISBT Terminal	Rajiv Chowk Metro Station

Rational for Station Selection:

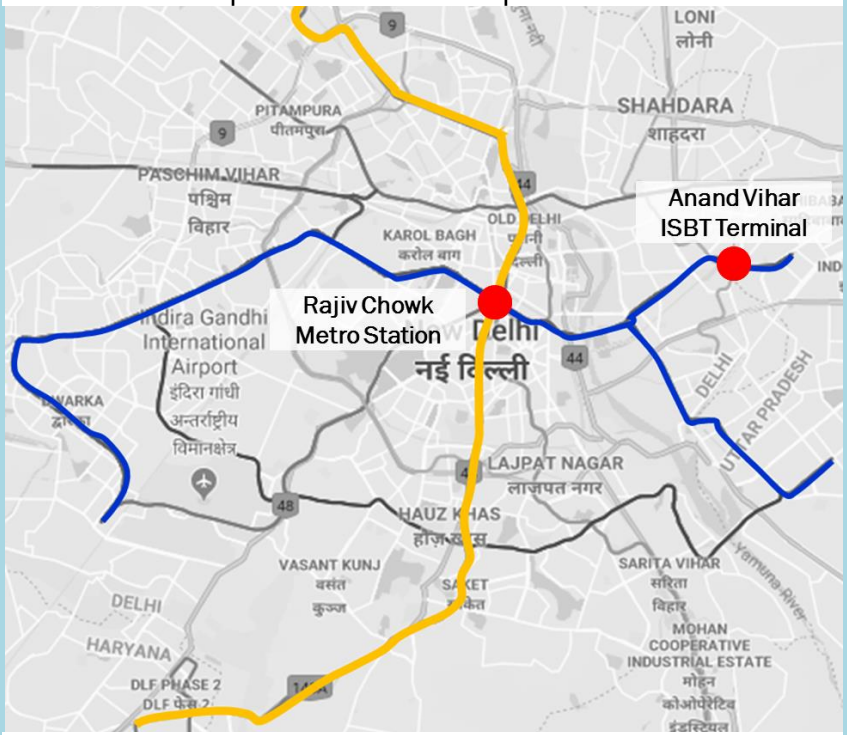
- Rajiv Chowk Station is Located in City Center and operating since 2010 as One of the Busiest Interchange Metro Station in Delhi NCT
- Anand Vihar is one of the Major Station which Connects City Bus services to Regional Bus Services and Metro Lines

Transfer	Metro ←→ Bus	Bus ←→ Bus	Metro ←→ Metro
Survey Sample Size	267		
	88	84	95

Balanced Surveys has been collected from each transfer groups.



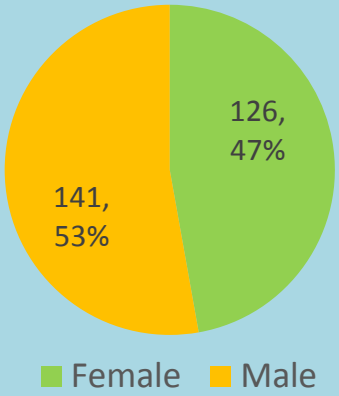
Station	Type of Station	Transfer Type
Rajiv Chowk	Transit Station	Metro ←→ Metro
Anand Vihar	Intermodal Terminal	Bus ←→ Metro Bus ←→ Bus



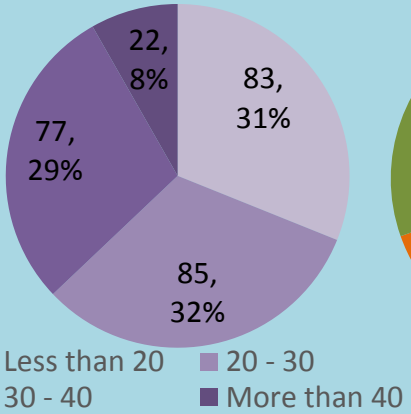
Map Showing Survey Locations with DMRC lines in Delhi NCT *(Image source: Google Maps)*

PRIMARY SURVEY

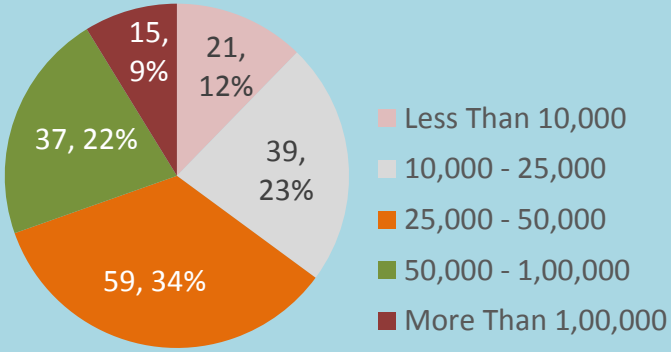
SOCIO-DEMOGRAPHIC CHARACTERISTICS



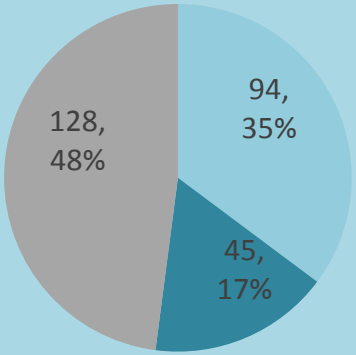
Gender



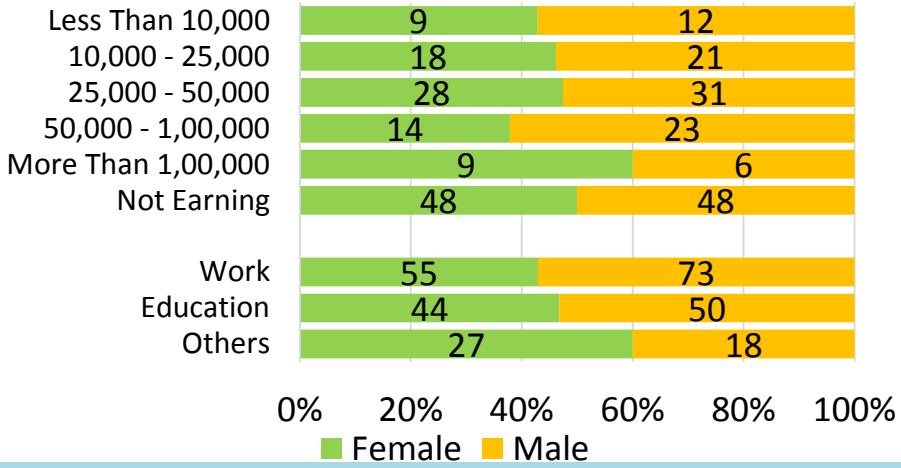
Age Group



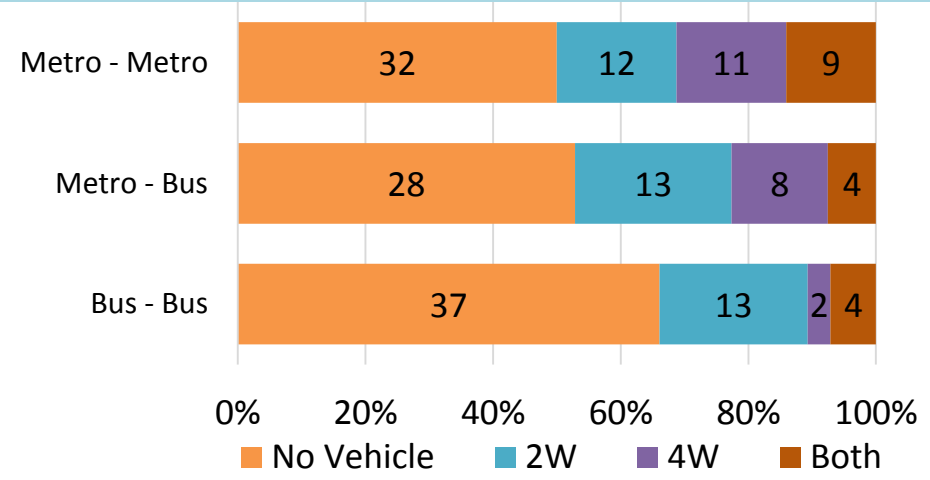
Income Group



Trip Purpose



Income Group and Trip Purpose w.r.t Gender

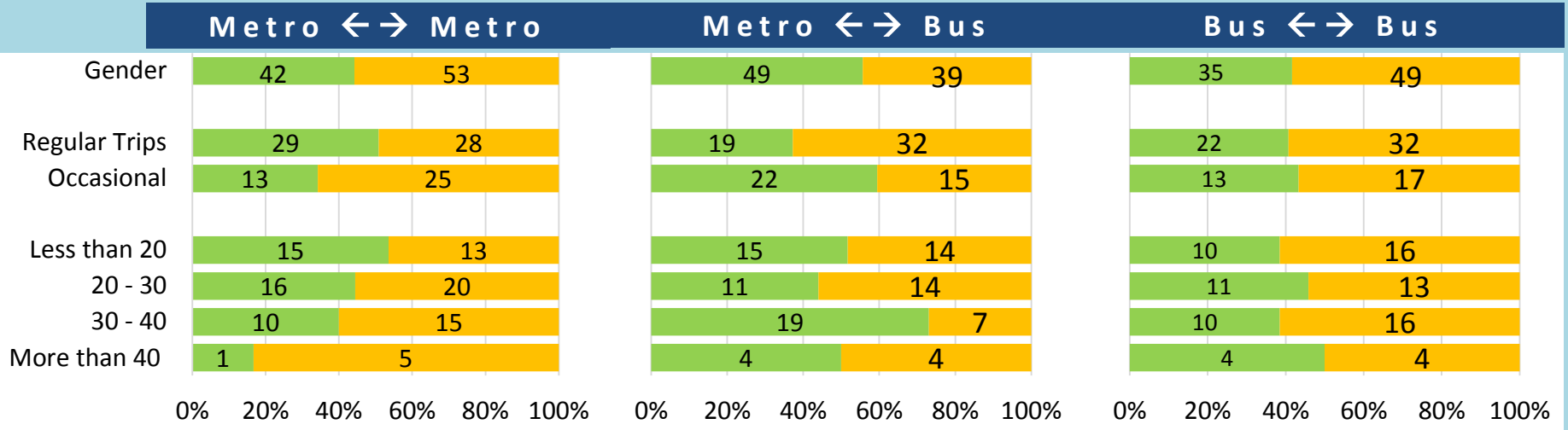


Vehicle Ownership w.r.t to Transfer Type

Source: Primary Survey, 2019

PRIMARY SURVEY

SOCIO-DEMOGRAPHIC CHARACTERISTICS



Metro - Metro

Gender	F	M	Total	%
	42	53	95	
Travel Frequency				
Regular	29	28	57	60%
Occasion	13	25	38	40%
Age Group				
Less than 20	15	13	28	29%
20 - 30	16	20	36	38%
30 – 40	10	15	25	26%
More than 40	1	5	6	6%

Metro - Bus

Gender	F	M	Total	%
	49	39	88	
Travel Frequency				
Regular	19	32	51	58%
Occasion	22	15	37	42%
Age Group				
Less than 20	15	14	29	33%
20 - 30	11	14	25	28%
30 – 40	19	7	26	30%
More than 40	4	4	8	9%

Bus - Bus

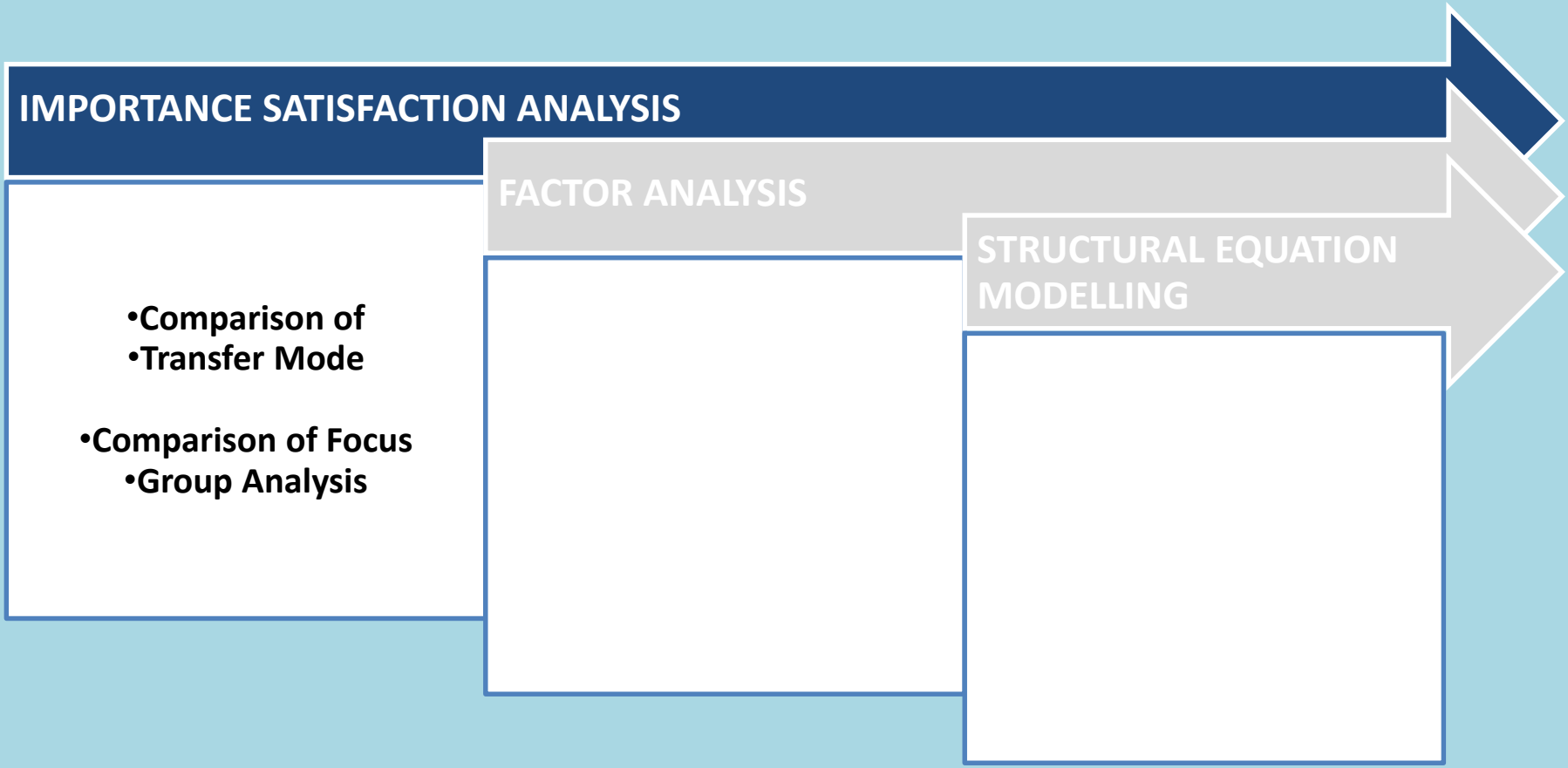
Gender	F	M	Total	%
	35	49	84	
Travel Frequency				
Regular	22	32	54	64%
Occasion	13	17	30	36%
Age Group				
Less than 20	10	16	26	27%
20 - 30	11	13	24	25%
30 – 40	10	16	26	27%
More than 40	4	4	8	8%

- **Adequate Data Collected** for Focused Group for Satisfaction Analysis
- Survey Sample for **More than 40 Age are not considered in analysis** due to very small sample size

Legend ■ Female ■ Male

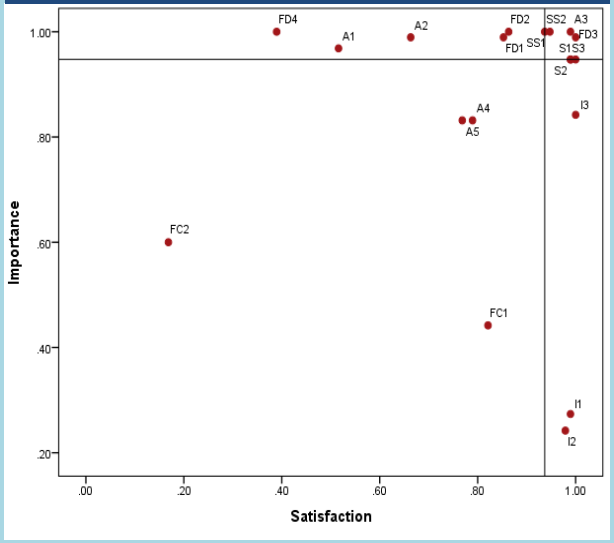
Source: Primary Survey, 2019

SATISFACTION ANALYSIS PROCESS

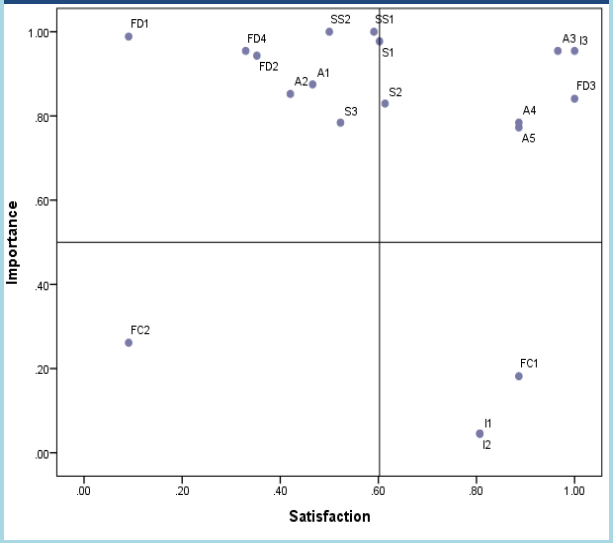


I-S ANALYSIS BASED ON TRANSFER TYPE

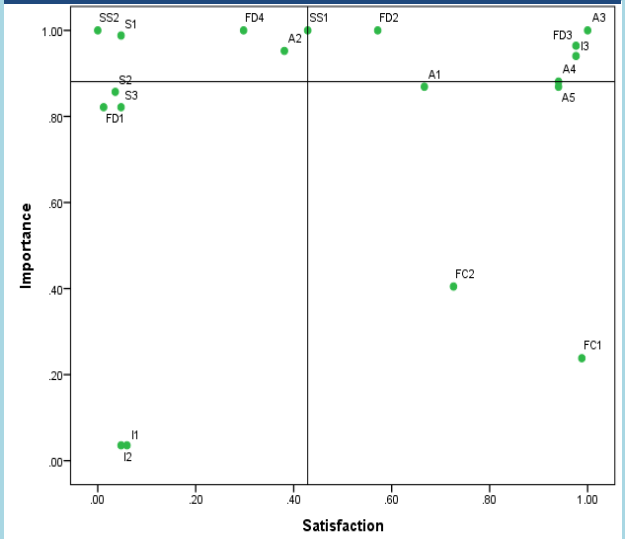
Metro ←→ Metro

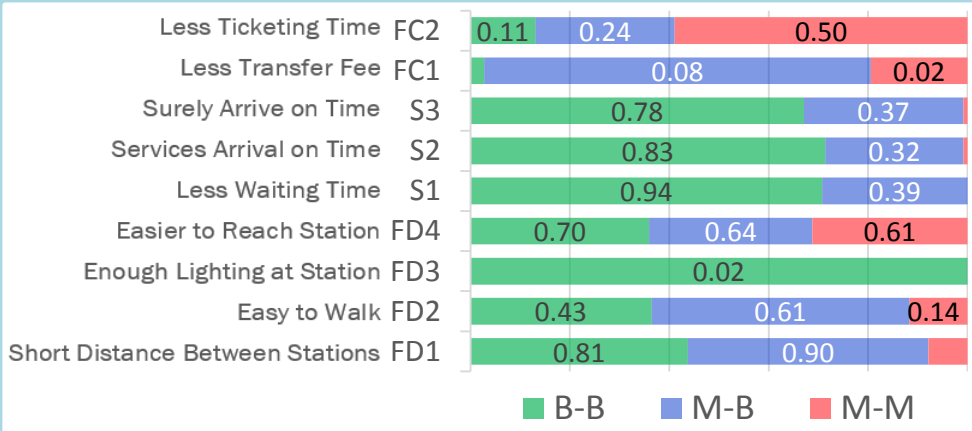


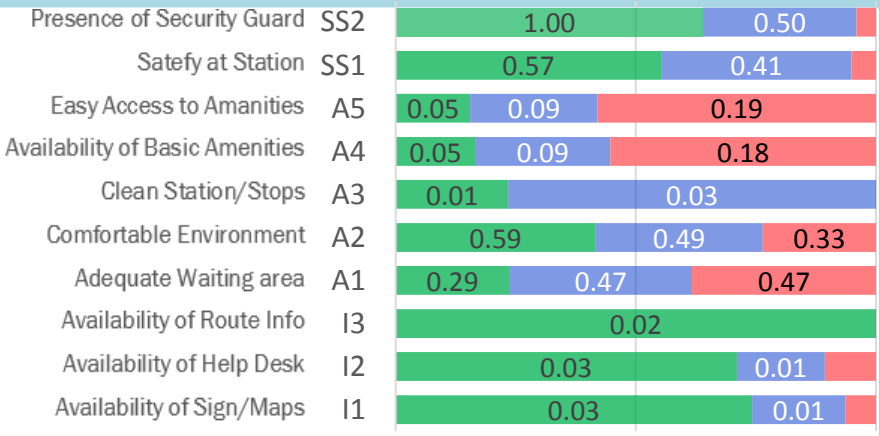
Metro ←→ Bus



Bus ←→ Bus







12th Urban Mobility India Conference & Expo 2019

- Bar Charts Showing Comparison of Dissatisfaction of Public Transport Users during Transfers

Transfer Type	B-B	M-B	M-M
IS Score	7.27	5.59	2.80

Source: Primary Survey, 2019

I-S ANALYSIS BASED ON FOCUSED GROUP

Variables	Code	Metro ↔ Metro							Metro ↔ Bus							Bus ↔ Bus						
		Gender		Travel Frequency		Age Group			Gender		Travel Frequency		Age Group			Gender		Travel Frequency		Age Group		
		M	F	R	O	<20	20-30	30-40	M	F	R	O	<20	20-30	30-40	M	F	R	O	<20	20-30	30-40
Short Transfer Distance	*FD1*	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Easy to Walk	*FD2*	1	1	1	1	1	1	1	2	2	2	1	2	2	1	1	1	1	3	1	1	1
Enough Lighting at Station	*FD3*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Easier to Reach Station	*FD4*	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Less Waiting Time	*S1*	1	1	1	1	1	1	1	1	1	1	1	2	2	1	2	2	2	2	2	2	2
Services Arrival on Time	*S2*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
Surely Arrive on Time	*S3*	1	1	1	1	1	1	1	1	2	1	1	1	1	1	2	2	2	2	2	2	2
Less Transfer Fee	*FC1*	2	2	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Less Ticketing Time	*FC2*	3	3	2	2	2	2	2	4	4	4	4	2	4	4	3	3	3	3	3	3	3
Availability of Sign/Maps	*I1*	1	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4
Availability of Help Desk	*I2*	1	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4
Availability of Route Info	*I3*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Adequate Waiting area	*A1*	1	1	1	1	1	1	2	2	1	2	1	2	1	2	1	1	1	1	1	1	1
Comfortable Environment	*A2*	1	1	1	1	1	1	1	2	2	2	2	2	1	2	2	2	2	2	2	2	2
Clean Station/Stops	*A3*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Availability of Basic Amenities	*A4*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Easy Access to Amanities	*A5*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Satefy at Station	*SS1*	1	1	1	1	1	1	1	1	1	1	2	1	2	2	2	2	2	2	2	2	1
Presence of Security Guard	*SS2*	1	1	1	1	1	1	1	1	2	2	1	2	2	2	2	2	2	2	2	2	2
		1	Need to Maintain						2	Need Improvement						3/4	Less Important					

Table Showing Quadrant from I-S Analysis for each Focused Group

Source: Primary Survey, 2019

SATISFACTION ANALYSIS PROCESS

IMPORTANCE SATISFACTION ANALYSIS

- Comparison of
- Transfer Mode

- Comparison of Focus
- Group Analysis

- Metro←→Metro Transfer: Dissatisfied with **Accessibility**
- Bus User are Least Satisfied with **Accessibility, Reliability (Services), Comfort and Safety**

FACTOR ANALYSIS

KMO and Bartlett's Test

Principal Component Analysis

Rotated Component Matrix

STRUCTURAL EQUATION MODELLING

FACTOR ANALYSIS

Step 1:

KMO and Bartlett's Test:

Indicates Suitability of Data for Structure Detection (>0.50)

Step 2:

Principal Component Analysis

Convers a set of observation of possible Correlated variable to set of Linearly Uncorrelated variable called Components

The Table shows extracted components explains 74% of variability in original 19 Variables

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		**.790**
Bartlett's Test of Sphericity	Approx. Chi-Square	3636.514
	df	171
	Sig.	**.000**

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.329	33.312	33.312	6.329	33.312	33.312	6.080	32.001	32.001
2	2.035	10.713	44.025	2.035	10.713	44.025	1.994	10.495	42.496
3	1.931	10.163	54.188	1.931	10.163	54.188	1.788	9.411	51.907
4	1.304	6.866	61.053	1.304	6.866	61.053	1.487	7.824	59.731
5	1.289	6.784	67.837	1.289	6.784	67.837	1.425	7.502	67.234
6	1.070	5.630	73.468	1.070	5.630	73.468	1.184	6.234	73.468
7	.912	4.798	78.266						
8	.800	4.208	82.474						
9	.726	3.820	86.294						
10	.580	3.052	89.346						
11	.478	2.516	91.863						
12	.423	2.226	94.088						
13	.306	1.613	95.701						
14	.266	1.400	97.101						
15	.180	.948	98.049						
16	.139	.731	98.781						
17	.117	.618	99.398						
18	.104	.548	99.946						
19	.010	.054	100.000						

Extraction Method: Principal Component Analysis.

Table Showing Total Variance Results from PCA *Source: Primary Survey, 2019*

FACTOR ANALYSIS

Variables	Code	Component					
		1	2	3	4	5	6
Less Waiting Time	S1	.904					
Services Arrival on Time	S2	.889					
Presence of Security Guard	SS2	.879					
Surely Arrive on Time	S3	.827					
Availability of Help Desk	I2	.826					
Availability of Sign/Maps	I1	.824					
Satefy at Station	SS1	.792					
Short Distance Between Stations	FD1	.713					
Availability of Basic Amenities	A4		.914				
Easy Access to Amanities	A5		.848				
Less Transfer Fee	FC1			.712			
Less Ticketing Time	FC2			.640			
Easy to Walk	FD2			.519			
Comfortable Environment	A2				.751		
Adequate Waiting area	A1				.578		
Availability of Route Info	I3					.827	
Easier to Reach Station	FD4						.864

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 20 iterations.

Table Showing Rotated Component Matrix

Component	Variables	Codes
Reliability and Safety	Less Waiting Time	*S1*
	Service arrive on Time	*S2*
	Presence of Security Guard	*SS2*
	Availability of Help Desk	*I2*
	Availability of Sign/Maps	*I1*
	Safety at Station	*SS1*
	Short Distance Between Stations	*FD1*
Amenities	Availability of Basic Amenities	*A4*
	Easy Access to Amenities	*A5*
Integration	Less Transfer Fee	*FC1*
	Less Ticketing Time	*FC2*
	Easy to Walk	*FD2*
Comfort and Waiting	Comfortable Environment	*A2*
	Adequate Waiting area	*A1*
Information	Availability of Route Info	*I3*
Accessibility	Easier to Reach Station	*FD4*

Step 3:

Rotated Component Matrix

- Output of Principal Component Analysis
- Contains Correlation of Variables and Components
- Correlation taken is More than 0.5

Step 4:

New Components are defined from Rotated Matrix Results

Source: Primary Survey, 2019

SATISFACTION ANALYSIS PROCESS

IMPORTANCE SATISFACTION ANALYSIS

•Comparison of
•Transfer Mode

•Comparison of Focus
•Group Analysis

- Metro←→Metro Transfer: Dissatisfied with **Accessibility**
- Bus User are Least Satisfied with **Accessibility, Reliability (Services), Comfort and Safety**

FACTOR ANALYSIS

KMO and Bartlett's Test

Principal Component Analysis

Rotated Component Matrix

- Extracted 6 components explains 74% of variability in original 19 Variables

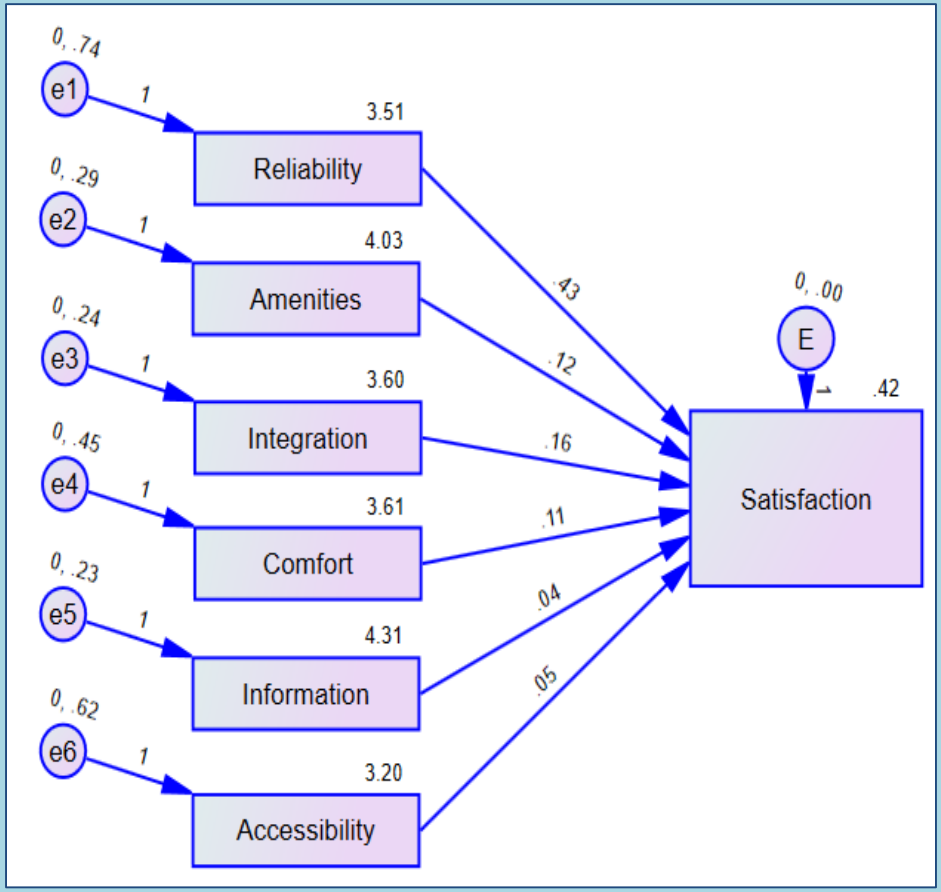
STRUCTURAL EQUATION MODELLING

Mean Value of Rating for New Compound Group

Identify Impact of Component on Satisfaction

SEM Results Comparison based on Focused Group

SEM ANALYSIS



Regression Coefficient of Components Using SEM

Components	Estimate	Std Error	Critical Ratio	p-Value
Reliability & Safety	**0.937**	0.002	180.964	***
Amenities	**0.163**	0.004	31.532	***
Integration	**0.197**	0.004	37.994	***
Comfort & Waiting	**0.194**	0.003	37.404	***
Information	**0.046**	0.004	8.978	***
Accessibility	**0.099**	0.003	19.2	***

Step 5:

Mean Value for Ratings for New Components as input values for SEM

SEM is done using IBM SPSS AMOS Software

SEM Results:

- **Amenities, Integration and Comfort** are factors that influences the satisfaction of Users
- **Reliability & Safety** has the highest Influence on Satisfaction
- **Information and Accessibility** have least influence on Public Transport User Satisfaction

Source: Primary Survey, 2019

SEM BASED ON TRANSFERS

For Metro - Metro Transfers:

- **Accessibility** is most influencing factor

Based on Groups:

- **Male Group** → **Accessibility**
- **Female Group** → **Safety and Ticketing**
- **Regular Travels** → **Information**
- **Age < 20** → **Accessibility & Facilities**

For Metro - Bus Transfers:

- **Service and Safety** are most influencing factor

Based on Groups:

- **Female Group** → **Safety and Services**
- **Age < 20** → **Safety**

For Bus – Bus Transfers:

- **Service and Information** are most influencing factor

Based on Groups:

- **Female Group** → **Safety and Services**
- **Age < 20** → **Ticketing and Amenities**

Commuter Group	Gender		Frequency		Age			Over All
Sub Group	M	F	R	O	< 20	20-30	30-40	
Mode	Metro ↔ Metro							
Accessibility	0.37	0.04	0.25	--	0.48	0.37	0.20	0.38
Service	0.14	0.15	--	0.28	--	0.16	0.08	0.12
Safety	0.16	0.43	0.07	--	--	0.16	--	--
Information	--	0.10	0.43	0.18	--	--	0.55	0.00
Facilities Design	0.20	0.07	0.15	0.26	0.52	0.19	0.11	0.23
Mode	Metro ↔ Bus							
Safety	0.11	0.22	0.11	0.14	0.31	0.18	0.11	0.20
Accessibility	0.13	0.11	0.13	0.25	0.07	0.25	0.14	0.13
Comfort	0.13	0.11	0.11	0.10	0.10	0.12	0.13	0.11
Facilities Design	0.15	0.13	0.16	0.14	0.12	0.13	0.24	0.12
Amenities	0.11	0.08	0.10	0.15	0.11	0.13	0.10	0.09
Services	0.23	0.21	0.22	0.11	0.17	0.10	0.16	0.21
Mode	Bus ↔ Bus							
Service Information	0.29	0.30	0.33	0.31	--	0.34	0.28	0.32
Amenities	0.12	0.09	0.12	0.10	0.49	0.17	0.09	0.12
Safety	0.15	0.20	0.11	0.12	--	0.08	0.14	0.09
Ticketing	0.10	0.13	0.10	0.14	0.51	0.16	0.13	0.13
Facilities Design	0.19	0.14	0.18	0.13	--	0.14	0.13	0.16
Comfort	0.15	0.14	0.16	0.20	--	0.11	0.24	0.17

Source: Primary Survey, 2019

USER SATISFACTION

For Bus ←→ Metro Users

- Male Group → **Services**
- Occasional Groups → **Waiting**
- **Facility Design and Information** has less influence in both Delhi and Bangalore Case Studies

For Bus ←→ Bus Users

- **Services and Comfort** are common and highly influencing factors for both the case study
  - Male Groups → Facility Design
  - Female Group → Safety/Security
- **Waiting and Amenities** have Least Influence in both the studies

Transfers Type	Bus←→Metro				
Case Study	Bangalore (Mantri Square)				
Commuter Group	Male	Female	Regular	Occasional	Overall
Comfort	0.08	0.19	0.17	0.27	0.16
Safety	0.20	0.14	0.17	0.32	0.16
Amenities	0.16	0.14	0.12	--	0.14
Services Integrat.	0.16	0.14	0.15	--	0.14
Information	0.12	0.14	0.15	0.14	0.14
Waiting	0.20	0.19	0.17	0.27	0.16
Facility Design	0.08	0.06	0.08	--	0.06
Case Study	Delhi NCT				
Comfort	0.13	0.11	0.11	0.10	0.11
Safety	0.11	0.22	0.11	0.14	0.20
Amenities	0.11	0.08	0.10	0.15	0.09
Services Integrat.	0.23	0.21	0.22	0.11	0.21
Information	0.16	0.14	0.17	0.11	0.14
Waiting	0.13	0.11	0.13	0.25	0.13
Facility Design	0.15	0.13	0.16	0.14	0.12

Transfers Type	Bus←→Bus					
Case Study	Bangalore			Delhi NCT		
Group	Male	Female	Overall	Male	Female	Overall
Comfort	0.16	0.16	0.21	0.15	0.14	0.17
Safety	--	0.23	0.21	0.15	0.20	0.09
Amenities	--	0.23	--	0.12	0.09	0.12
Services	0.27	0.16	0.19	0.29	0.30	0.32
Fare	0.20	--	0.09	0.10	0.13	0.13
Waiting	--	--	0.16	--	--	--
Facility Design	0.37	0.23	0.16	0.19	0.14	0.16

Source: Primary Survey 2019; Assessment of Transit Transfer Experience: Case of Bangalore (Cheriyan, 2015)

RESULTS

- ***Reliability and Safety:*** This Component plays an **important role for increasing the satisfaction of user**. Reliability and Safety has the 10x higher impact on user satisfaction than compared to any other component.
- ***Integration:*** The presence of limited travel card charging counters at metro station and limited stop of renewing monthly pass for bus users remain major contributor of increasing transfer penalties.
- ***Amenities:*** Availability of such amenities represent not just the physical presence of facilities at station, but it also demands proper functionalities of it.
- ***Comfort and Waiting:*** Comfort and Waiting are influenced by the public transport services as the attributes are less important for metro users and most important for Bus user and have 20% impact on satisfaction and need to be improved for Bus Service.
- ***Accessibility:*** This component is influenced/derived by the type of mode and may require extra efforts for improvement as this can be affected due to absence of external features such as pedestrian walkways, access/egress mode and distance, etc.
- ***Route Information:*** Since such facilities is available at both transfer levels, the attribute has least importance for all passenger group and thus have least impact on Satisfaction.

Source: Primary Survey, 2019

CONCLUSION

- All the attributes and variable are important for public transport users
- This study shows that **Passenger are more satisfied with physically integrated transport system** (Rajiv Chowk Metro Station). This is due to more reliable and safety/secure services at Metro station.
- Satisfaction study in Delhi also confirms the Hierarchy of user's needs identified by Van Hagen (1961), **as Reliability and Safety are the two most important factor that influences the satisfaction** of user and also have significant impact of user satisfaction as observed from SEM analysis
- This also indicates the **need for improving Bus services in Delhi** with high priority **as User are highly dissatisfied with Reliability and Security** for using Bus as Public Transport Mode.
- Taking learnings from TBP and Prestons (2008), **improvement in Bus services** is essential to have significant impact on Public Transport system **as Both Metro and Bus user are least satisfied with the Comfort** as shown in ISA
- Observations from I-S Analysis states that **all user groups are least satisfied with Access to station** (Ease of reaching station') and **transfers between two modes** (Short Distance between station) in the study. This confirms the need of integrated public transport system in Delhi with improved out vehicle time.
- As observed from SEM analysis, **Integration also has significant impact on Public Transport users satisfaction.**

Source: Primary Survey, 2019

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THANK YOU

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