Modelling with mixed RP and SP data

Scale Factor

$$\sigma_{\varepsilon}^{2} = \mu^{2}\sigma_{\tau}^{2} \qquad (1)$$

Where μ is an unknown *scale coefficient* which leads to the following utility functions for a certain alternative A_i:

$$\mu\, U_{i}^{SP} = \mu\,(\theta\, \mathbf{X}_{\mathbf{i}}^{\mathbf{SP}} + \phi\, \mathbf{Z}_{\mathbf{i}}^{\mathbf{SP}} + \tau_{i}) \qquad (2)$$

$$U_{i}^{RP} = \theta\, \mathbf{X}_{\mathbf{i}}^{\mathbf{RP}} + \alpha\, \mathbf{Y}_{\mathbf{i}}^{\mathbf{RP}} + \varepsilon_{i} \qquad (3)$$

Where, α, ϕ and θ are parameters (vector) to be estimated

X^{RP} and X^{SP} are vectors of common attributes to both types of data

Y^{RP} and Z^{SP} are vectors of attributes that only belong to the RP or SP data sets respectively

Joint Likelihood Function

$$L(\theta,\mu,\alpha,\phi) = \left(\prod_{n=1}^{N^{RP}} \prod_{Ai \varepsilon A(q)} P_{iq}^{RP} \right) * \left(\prod_{n=1}^{N^{SP}} \prod_{Ai \varepsilon A(q)} P_{iq}^{SP} \right)$$

$$\mathrm{P_i^{RP}} = \frac{\exp(\theta\, \mathbf{X_i^{RP}} + \alpha\, \mathbf{Y_i^{RP}})}{\sum_j \exp(\theta\, \mathbf{X_j^{RP}} + \alpha\, \mathbf{Y_j^{RP}})}$$

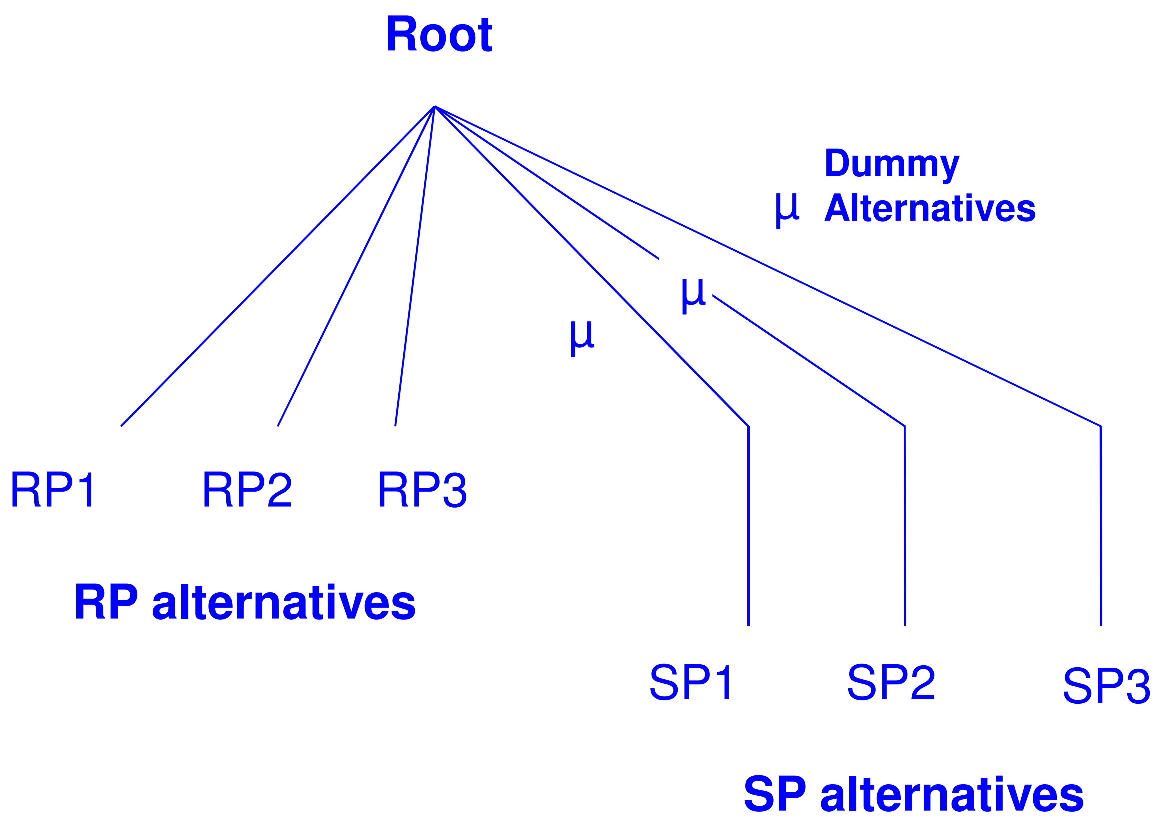
$$P_i^{SP} = \frac{\exp \mu\, (\theta\, \mathrm{X_i^{SP}} + \phi\, \mathrm{Z_i^{SP}})}{\sum_j \exp \mu\, (\theta\, \mathrm{X_j^{SP}} + \phi\, \mathrm{Z_j^{SP}})}$$

Simultaneous Estimation Method†

- Construct an artificial tree with twice as many alternatives as in reality
- Half are labeled as RP alternatives and the other half as SP alternatives
- Utility functions are U^{RP} and U^{SP}
- RP alternatives are placed below the root of the tree. Each of the SP alternatives are placed in a single-alternative nest
- For RP observations, the SP alternatives are set unavailable and the choice is modeled in a standard logit model structure
- For an SP observation, RP alternatives are set unavailable and the choice is modeled by a nested logit structure

†Bradley, M. A., and Daly, A. J. (1991). "Estimation of Logit Choice Models Using Mixed Stated Preference and Revealed reference Information." Paper presented to the *6th International Conference on Travel Behavior,* Quebec, May 22-24, 1991

Simultaneous Estimation



Artificial tree structure for mixed RP and SP data

Simultaneous Estimation

The main utility of the dummy-alternative can be computed as suggested by Daly (1987) and is given by

$$V^{COMP} = \mu \log \sum \exp(V^{SP}) \qquad \textbf{(4)}$$

as there is only one alternative in the nest the expected maximum utility (EMU) of the nest becomes equal to the utility of the alternative itself and can be given as

$$V^{SP} = \theta X^{SP} + \phi Z^{SP} \qquad \textbf{(5)}$$

Therefore, the utility of the nest will become

$$V^{SP} = \mu(\theta X^{SP} + \phi Z^{SP}) \qquad \textbf{(6)}$$

which is exactly the same required and presented in the equation (2). The scale factor should take the same value for all the SP alternatives.

Sequential Estimation Method

The procedure is as follows (Ben-Akiva and Morikawa, 1990):

- Estimate the SP model according to utility functions given in equation (7) in order to obtain the estimators of $\mu\theta$ and $\mu\phi$. Then, define a new variable

$$\hat{V}_i^{RP} = \mu\theta X_i^{RP} \qquad (7)$$

- estimate the following RP model with the new variable included, in order to estimate the parameters λ and α:

$$U_i^{RP} = \lambda \hat{V}_i^{RP} + \alpha Y_i^{RP} + \varepsilon_i \qquad (8)$$

where $\lambda = 1/\mu$.

- multiply X and Z of SP data by μ to obtain a modified SP data set. Pool the RP data and the modified SP data and then estimate the two models jointly.

Stated Preference
Car Ownership Model

Organistation of SP car ownership Model

SP Data and Methodology

Design of Stated Preference Experiment

SP Sample Size

Administering of SP Experiment

SP Survey Results and Analysis

Calibration of SP Car Ownership Model

Results and Discussions

SP Data and Methodology

Study Area

A work place based SP survey of car ownership was conducted in MMR

The MMR covers an area of about 4355 square kilometers

The Greater Mumbai a major part of MMR as per population and covers an area 468 square kilometers

Population has increased from 9.9 million in 1981 to 17.7 million in 2001

MMR is well served by major rail and road networks.

SP Data and Methodology

Study Area

The Greater Mumbai (Mumbai city), the economic capital of India, generates about 5% of India's GDP and contributes over one third of country's tax revenues.

The city of Mumbai with its present population of over12 million generates about 11 million trips per day, with about 88% of the total trips catered by suburban railway and the PT services provided by BEST.

Average lead being 22.15 kilometers for rail and 4.67 kilometers for buses.

BEST with its fleet strength of 3458 buses carries about 4.7 million passengers per day.

SP Data and Methodology

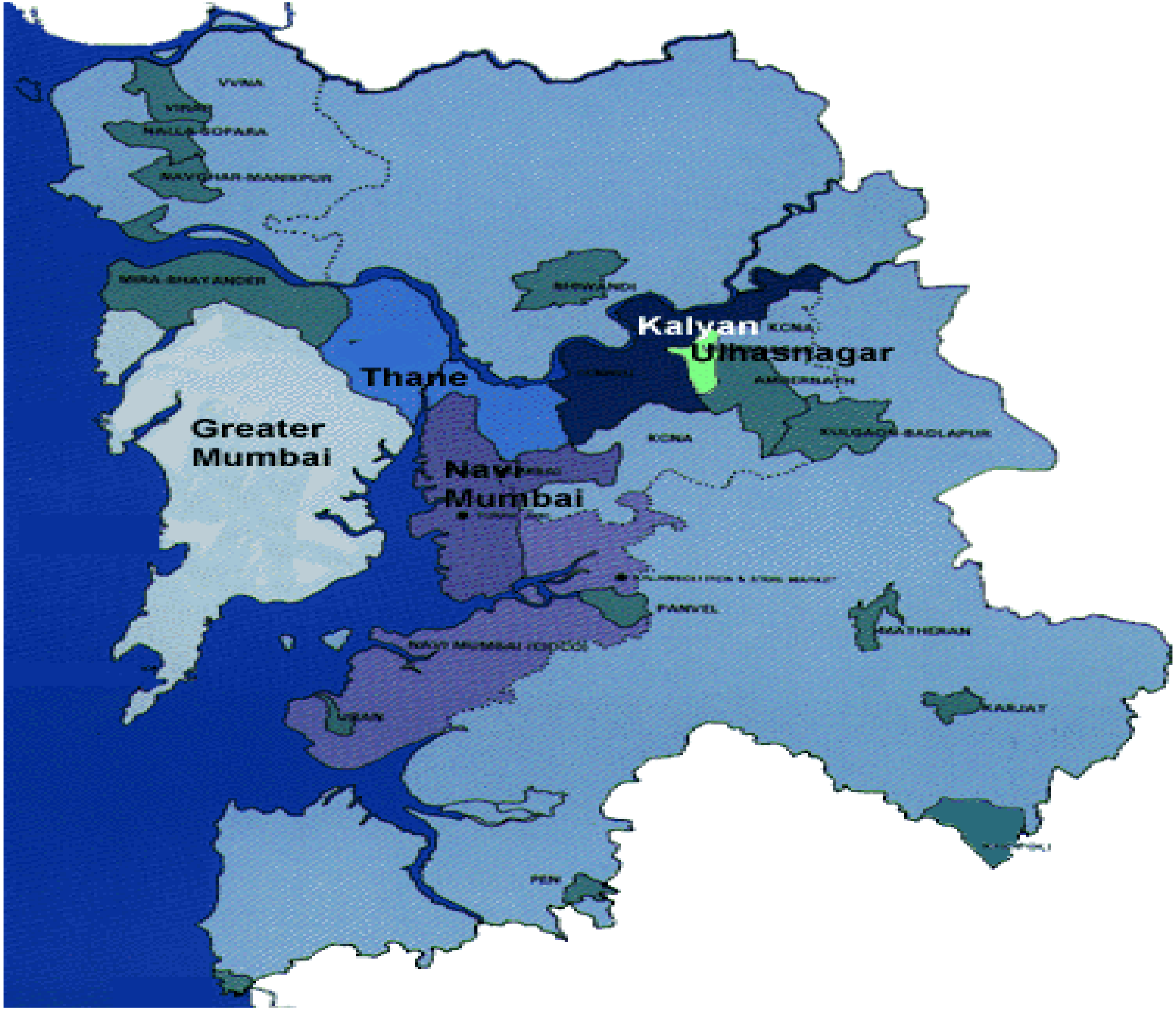
Study Area

Commuters are subjected to most severe over crowding in the world with 9 car rake carrying over 4000 passengers at 11 persons per square meter against normal capacity of about 1750 passengers.

The Mumbai city has 63679 taxies and 101829 Auto rickshaws, which are used as intermediate public transport modes, as per 2002 statistics.

The vehicle population in Mumbai city during the last 4 decades increased from 0.15 million in 1971 to 1.03 million in 2001. T

The population of MMR grew at less than 3% per annum during 1991-2001 whereas the vehicles have grown at over 7% per annum contributing to over 50% of cars.



STUDY AREA MMR

Design of Stated Preference Experiment

The attributes used in the car ownership SP experiment are

travel time,
travel cost,
projected family income,
car loan payment option and
servicing cost of car per annum.

The selection of attributes and levels identified in this experimental design is based on literature suggested by Kocur et al (1982)

The number of options is arrived at as per Kroes and Sheldon (1988).

Design of Stated Preference Experiment

The experimental design - fully factorial design.

because every possible of attribute levels is used.

Initially the experiment is designed by taking

2 attributes (travel time and travel cost) at 1 level,

3 attributes (projected family income, car loan payment options and service cost of the car) at 3 levels.

A full factorial design will yield 27 options.

simplified by taking the two attributes, car loan payment and servicing cost, together as one attribute due to their dependency.

Design of Stated Preference Experiment

The SP experiment is designed as a rating experiment: 9 options ($1 \times 1 \times 3 \times 3$) by car ownership with different attribute levels

Existing Work/Recreational Trip		Car Ownership	
Travel Time	*Stated*	Travel Time	*Computed*
Travel Cost	*Stated*	Travel Time	*Computed*
HH Income	*Stated*	Projected HH Income	*3 levels*
Level of Discomfort	*Stated*	Car Loan Payment	*3 levels*
Waiting Time	*Stated*	Servicing Cost	*3 levels*

Choice Scale				
Definitely Own a car	Probably Own a car	Can't Say	Definitely Stick to the Existing	Probably Stick to the Existing

Fig. 3.3: Structure of Stated Preference Experiment

Design of Stated Preference Experiment

The highway TT and TC skims computed for 110 internal traffic zones and the 3 external traffic zones from a working transportation planning model (Mumbai Metro Study, 2003).

The TC was computed based on 3 different types of cars and their mileages per liter petrol.

3 categories of cars - compact car (18 kms/liter petrol), midsize car (12 kms/liter petrol) and luxury car (10kms/liter petrol).

The TT and TC tables were prepared for travel by car between 10 potential residential areas and 5 selected work places.

The potential work/industrial/business : Nariman point, Bandra-Kurla Complex, Andheri, Seepz and Thane.

Design of Stated Preference Experiment

Table 3.6: Details of Car Loan Payment Options

Loan Details	Compact car	Mid-size car	Luxury car
Approximate cost	Rs. 2.25 Lakhs	Rs. 4 Lakhs	Rs. 8 Lakhs
Initial payment	Rs.56250	Rs. 1 Lakh	Rs. 2 Lakhs
Loan amount	Rs.168750	Rs. 3 Lakhs	Rs. 6 Lakhs
Number of installments	36	48	48
Monthly installment	Rs. 5366	Rs.7536	Rs. 15074
Rate of interest	9% per annum	9.5% per annum	Rs.9.5%
Mileage (liter petrol)	18 km	14 km	10 km

Design of Stated Preference Experiment

The attribute, *projected household income:* three levels

Rs. 20,000-00
Rs. 35,000-00
Rs. 50,000-00

The attribute, servicing cost of the car per annum: tree levels

Rs. 3000-00 (for compact car)
Rs. 5000-00 (for midsize car)
Rs. 6000-00 (for luxury car).

Each respondent was asked to rate 9 options for work trip and 9 options for recreation/social/shopping trip on a rating scale 1-5.

The respondents were told that the waiting time by car is zero and the discomfort level is 1 on a scale of 1 to 5.

Design of Stated Preference Experiment

Existing Work Trip		Car Ownership	
Travel Time	*40 min*	**Travel Time**	*30 min*
Travel Cost	*Rs.75*	**Travel Cost**	*Rs.40*
HH Income	*Rs.25000*	**Projected HH Income**	*Rs.35000*
Level of Discomfort	*4 (Non A/C standing)*	**Car Loan Payment**	*One Time: Rs.1 Lakh, Monthly: Rs. 7537*
Waiting Time	*15 min*	**Servicing Cost**	*Rs. 5000*
Choice:__________			

Definitely Own a car (1)	**Probably Own a car (2)**	**Can't Say (3)**	**Definitely Stick to the Existing (4)**	**Probably Stick to the Existing (5)**

Fig. 3.4: A typical SP option for work trip

SP Sample Size

More recent works reported in the literature suggest that 75-100 interviews per segment would be more appropriate (Pearmain and Swanson 1990; Bradley and Kroes 1990; and Swanson et al. 1992).

In the present study travelers are segmented based on their income groups like

Rs.5-10 thousand,
Rs.10-20 thousand,
Rs. 20-30 thousand etc.

It was attempted to satisfy the above sample size requirement.

Administrating of SP Experiment

A Team of about 8 enumerators was thoroughly trained for a week.

The face-to-face work based pilot survey was conducted at Nariman Point.

The number of people contacted in the pilot survey was 175.

The number of people satisfying the laid down criteria was 76 and those who expressed to participate in the SP interview were 25.

Out of this number, 5 people discontinued in the half way.

The minimum and maximum time consumed for each interview was 15 and 30 minutes respectively.

SP Survey Results and Analysis

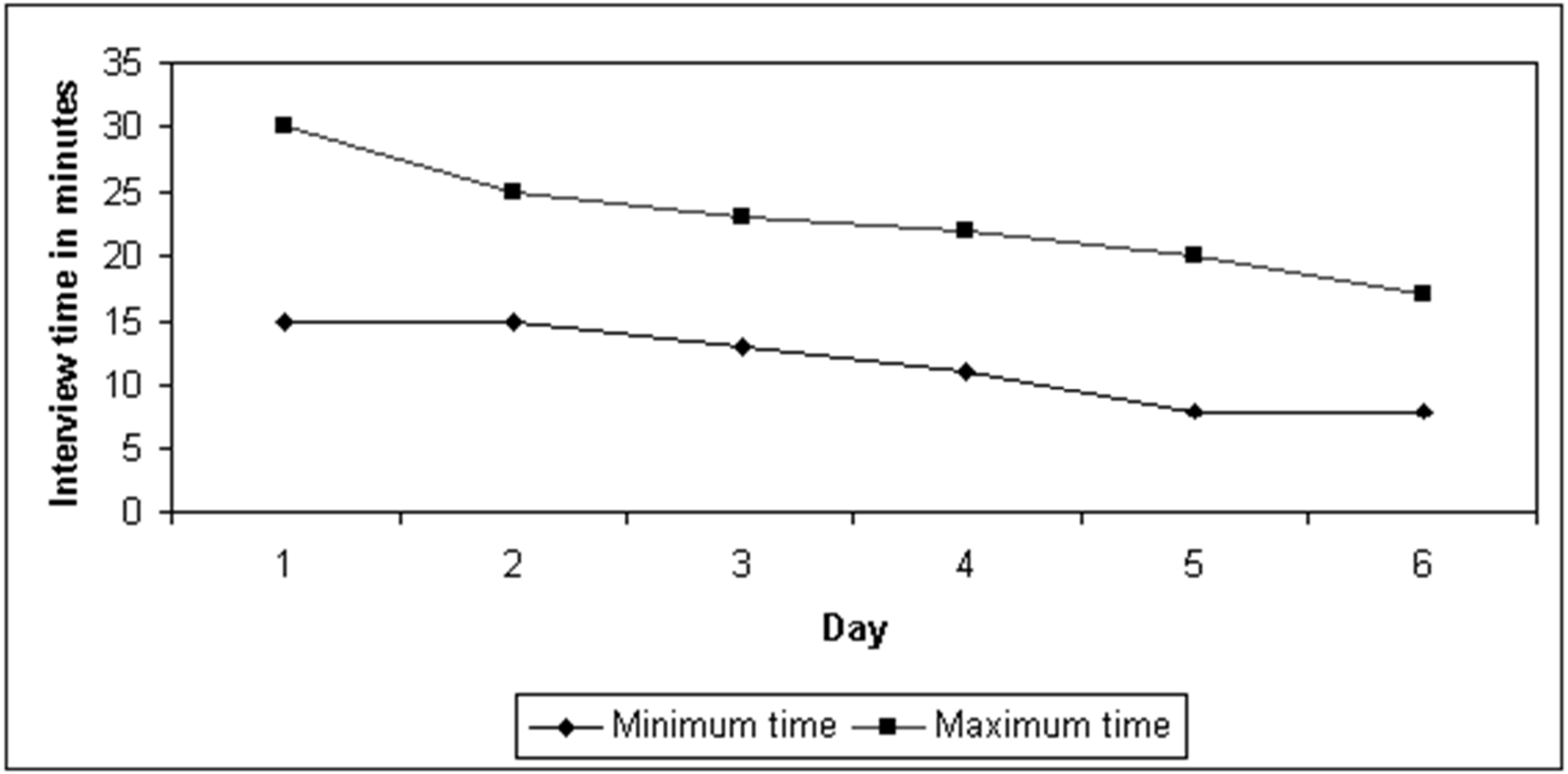


Fig. 3.5: Variation in the duration of SP Interview from Day 1 to Day 6

SP Survey Results and Analysis

Table 3.7: Details of SP Survey Efficiency at Different Locations

Location	Number of people contacted	Number satisfying the criteria	Number willing to participate	Number discontinued (half-way)	Number completed
Nariman Point*	523	243	85	12	73
B-K Complex	369	156	103	12	91
Andheri	401	195	88	13	75
SEEPZ	402	174	106	11	95
Thane	368	162	71	7	64
Total	2063	930	453	55	398

SP Survey Results and Analysis

Relating to the completeness of information in the SP survey sheets

100 % - information in 65% samples
90 % - information in 15% samples
75% - information in 10% of samples,
50% - information in the remaining 10% samples collected.

Relating to the erroneous entries

70% - samples without any wrong entries,
10% - samples with 15 % wrong entries,
10 % - samples with 30 % wrong entries and the
10% - samples with more than 50 % wrong entries

SP Survey Results and Analysis

Table 3.8. Valid Samples obtained at Different Locations

Location	Total samples	Valid samples
Nariman Point	73	65
B-K Complex	91	82
Andheri	75	67
SEEPZ	95	85
Thane	64	58
Total	398	357

SP Survey Results and Analysis

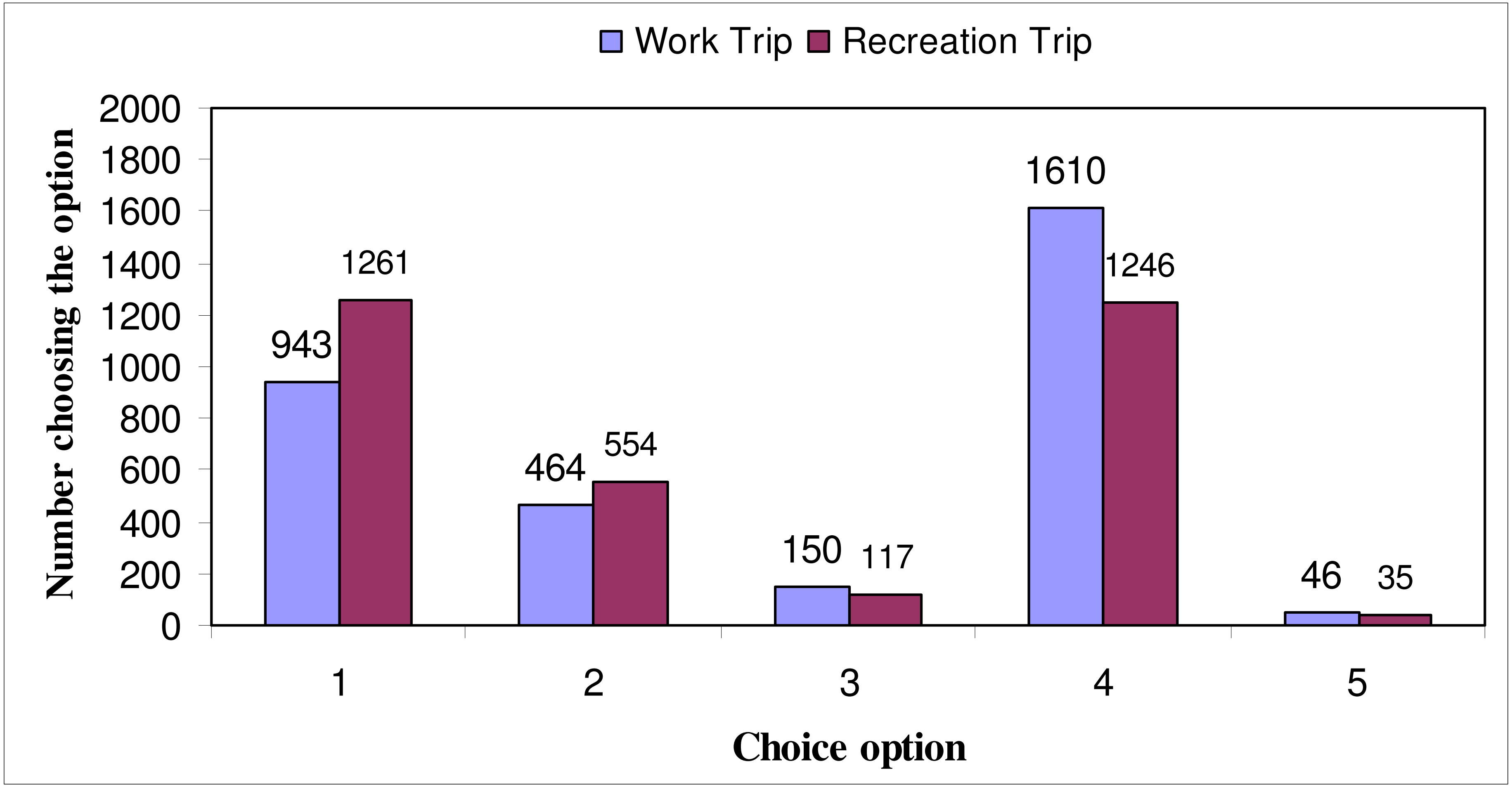


Fig. 3.6: Number Choosing the Option for Work Trip and Recreation Trip

SP Survey Results and Analysis

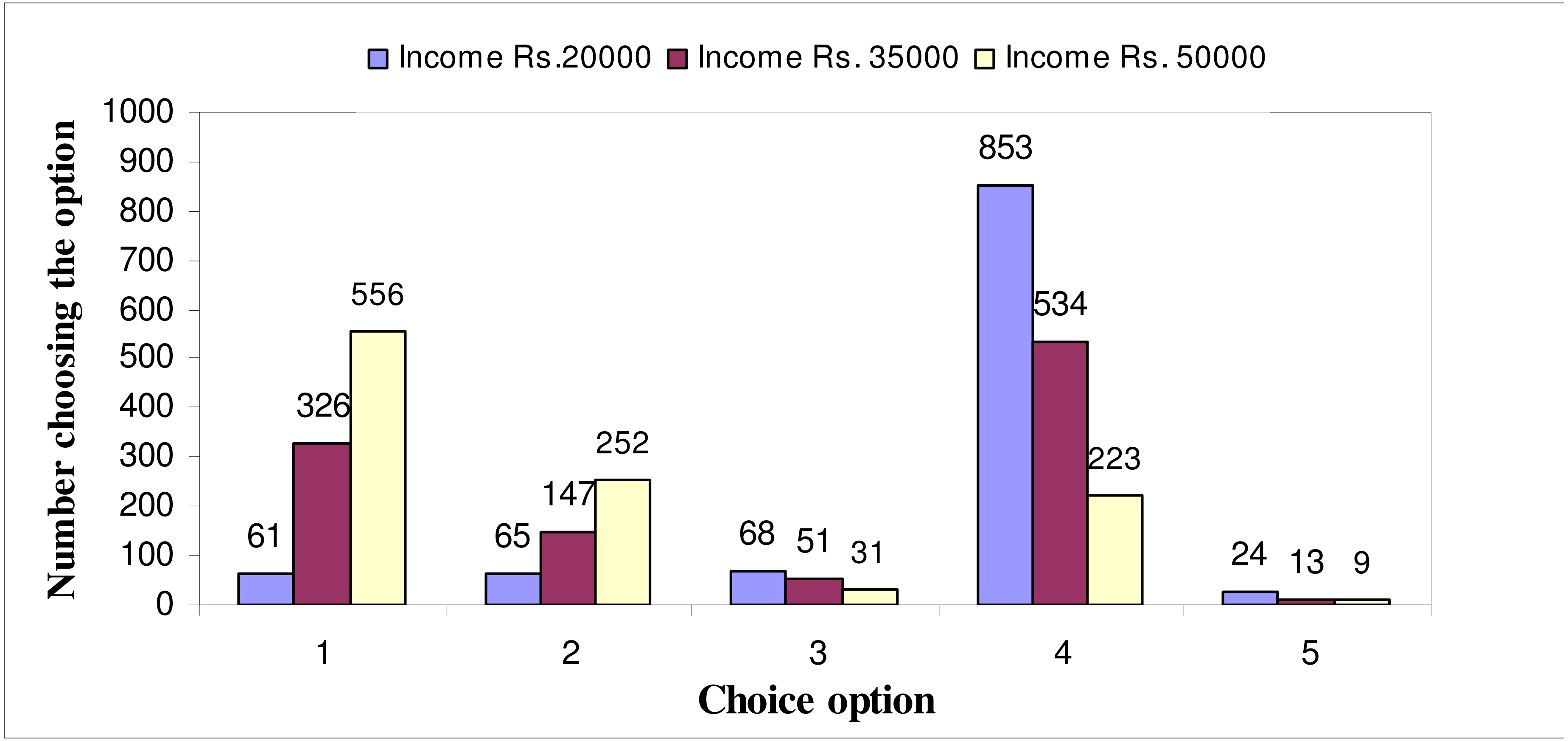


Fig. 3.7: Number Choosing the Option at Different Income Levels for Work Trip

SP Survey Results and Analysis

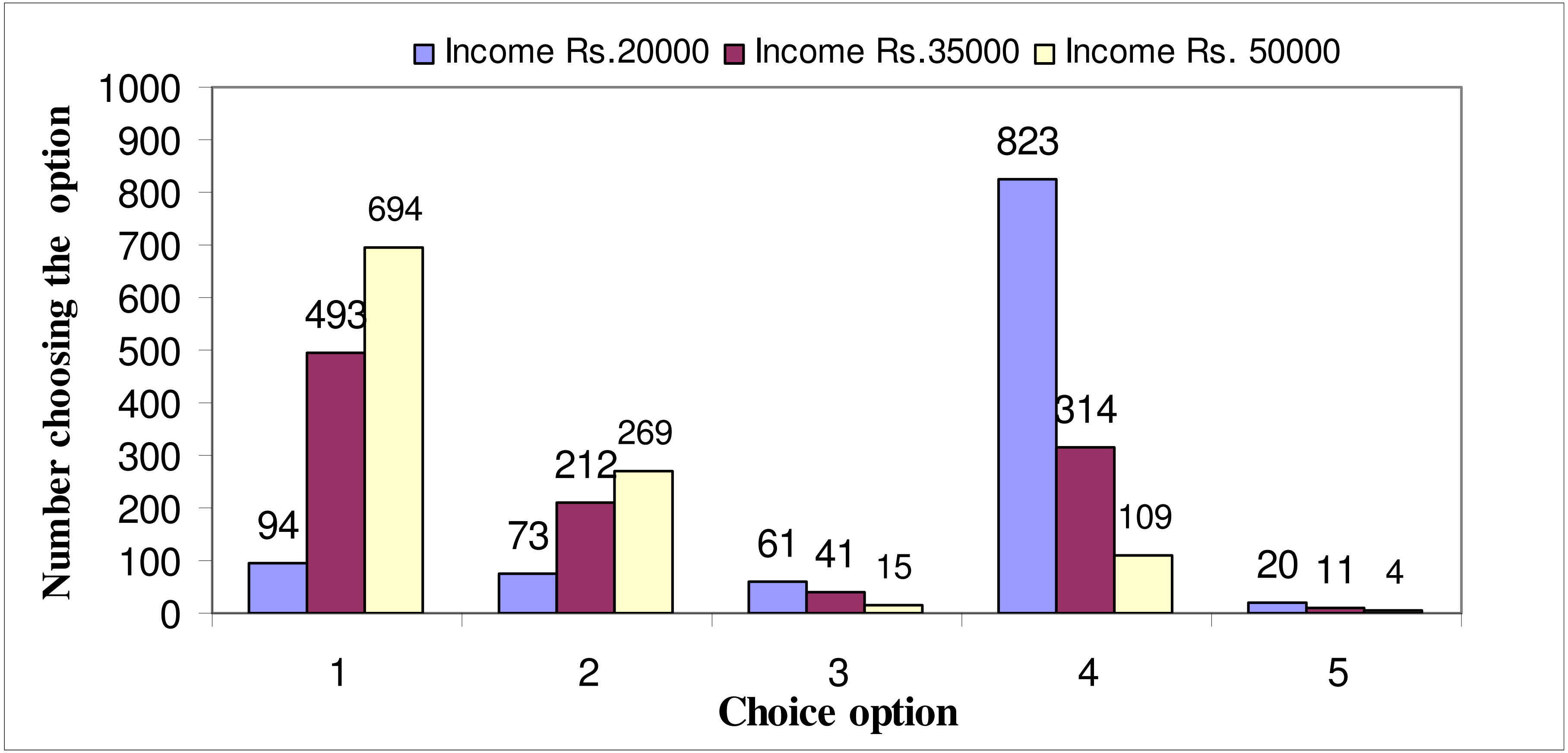


Fig.3.8:Number Choosing the Option at Different Income Levels for Recreation Trip

SP Survey Results and Analysis

The non-response rate - 42 %
The frequency of response for the choice

- **definitely own a car - 29%,**
- **probably own a car - 14.44% for work trip;**
- **definitely own a car - 39%,**
- **probably own a car - 17% for recreational trip.**

At different projected income levels the option "definitely own a car" chosen 6.47%, 34.57% & 51.91% times respectively for work trip and 7.45%, 39.09% & 53.46% for recreation trip at Rs.20000, Rs.35000 and Rs.50000 respectively.

It was observed from the data analysis that travelers are giving priority for recreational trip rather than work trip in owning a car.

Calibration of SP Car Ownership Model

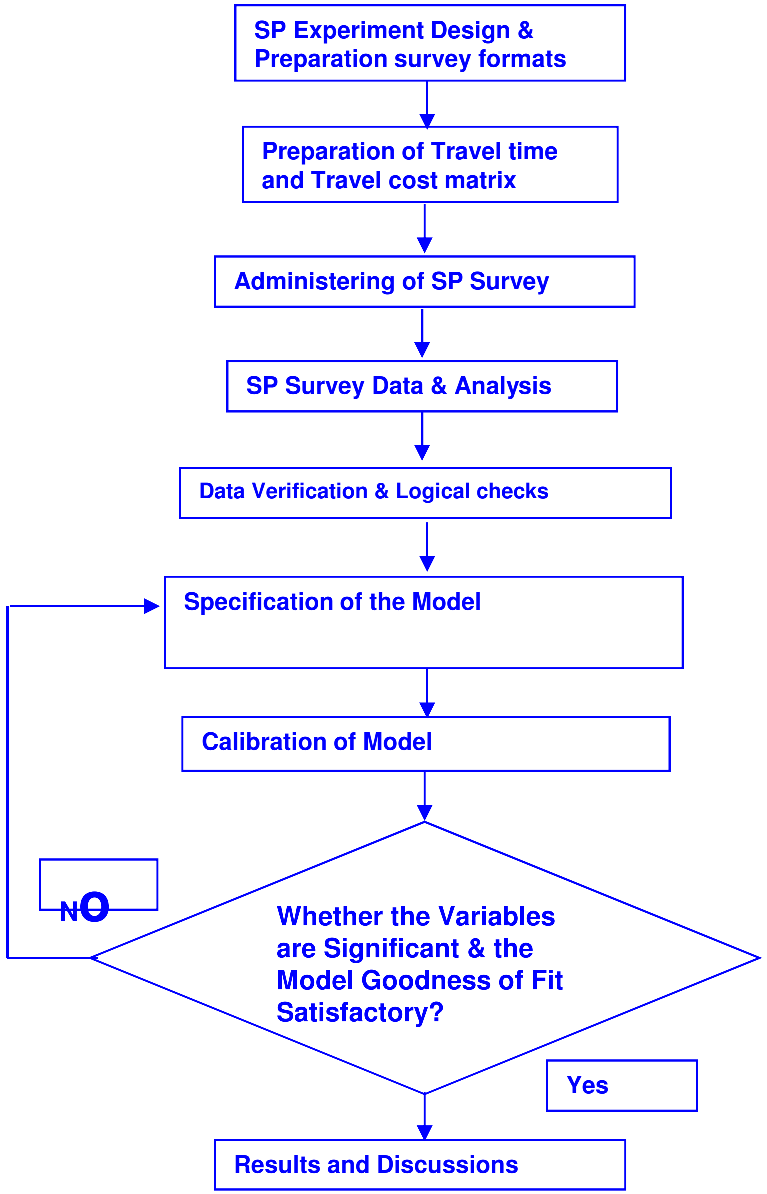


Fig. 3.9: Flow chart of SP car ownership model methodology

Calibration of SP Car Ownership Model

The socio-economic variables entered are

household income (HHINC),
family size (FS),
house ownership level (HOL),
built-up area (BA) and
number of car license holders in household (NCLH).

System variables are

Travel time (TT),
travel cost (TC),
waiting time (WT),
number of transfers (NOT),
discomfort level (DCL) and
car price index (CPI).

The CPI is calculated per month based on cost of the car and its maintenance which were floated in the SP experiment as attributes

Calibration of SP Car Ownership Model

The calibration was done for three types of SP data.

work trip (SP1)

recreation trip (SP2) and

combination of work and recreation (SP1+SP2).

The calibrated values of three different SP models for car ownership are given in Table 3.9

The statistical significance of SP2 model (recreation trip) is superior to the others in terms of ρ^2 and higher values of coefficients.

Therefore, it was observed that the travelers are more interested to own a car for recreation and social needs than for commuting to work trip.

Calibration of SP Car Ownership Model

Table 3.9: Goodness of Fit Statistics of Calibrated SP Data

Variable	SP1	SP2	SP1+SP2	Specific to
HHINC	0.7303	1.0540	0.8361	1 car
	(18.0)	(22.0)	(28.3)	
FS	-0.1658	-0.2097	-0.1810	1 car
	(5.7)	(6.6)	(8.5)	
HOL	-0.3674	-0.4763	-0.4075	1 car
	(6.0)	(7.2)	(9.1)	
HHINC	0.9103	1.0830	0.9464	2 car
	(12.0)	(15.2)	(18.7)	
HOL	-2.1380	-1.3660	-1.5780	2 car
	(8.4)	(9.0)	(12.3)	
FS	-0.3494	-0.4784	-0.4154	2 car
	(5.4)	(8.2)	(9.7)	
CPI	-0.0955	-0.0881	-0.0902	generic
	(16.5)	(15.0)	(22.1)	
Structural Parameters				
L(0)	-3529.84	-3529.84	-7059.68	-
L(c)	-2836.22	-2848.38	-5721.89	-
L (θ)	-2507.86	-2448.74	-5022.97	-
χ^2	2043.96	3122.53	4073.43	-
ρ^2 (0)	0.2895	0.3063	0.2885	-
ρ^2 (c)	0.1158	0.1403	0.1221	-
ρ^2 (adj)	0.2855	0.3037	0.2872	-
Samples	3213	3213	6426	-

Car Ownership Model
With
RP & SP Data

DATA USED

The two types of data sets used in the mixed estimation.

1. **RP data**
2. **SP data.**

The RP data contains two data sets

1. **MRTS, Thane (RP1) – 923 samples**
2. **collected during administration of SP survey for car ownership in MMR (RP2) - 357 samples**
3. **RP3 = RP1+RP2 – 1280 Samples**

The SP data contains one set SP observations

1. **work trip – 3213 observations - (SP1)**
2. **recreation trip – 3213 Observations – (SP2)**
3. **SP3 = SP1+SP2 - 6426 observations**

ARTIFICIAL STRUCTURE FOR MIXED RP/SP DATA ESTIMATION

The joint RP and SP models were developed utilizing the data in different combinations.

The various combinations of RP and SP data used in joint model estimation for shown in Table 4.1.

The calibration of joint estimation done with following methods.

- **Simultaneous Estimation**
- **Sequential Estimation**

ARTIFICIAL STRUCTURE FOR MIXED RP/SP DATA ESTIMATION

The difference between the RP and SP errors can be represented as function of their variances, such that:

$\mu^2 = var(\varepsilon_{iq}) / var(\eta_{iq})$ (4.7)

where μ is the scale factor, scaling the error in SP with respect to the error in RP.

Based on the above theoretical framework the utility functions in case of combination of RP and SP data can be written for an alternative 'i' A (Ben-Akiva and Morikawa, 1990) as

$$U_{iq}^{RP} = \alpha X_{iq}^{RP} + \beta Y_{iq}^{RP} + \varepsilon_{iq} \qquad (4.8)$$

$$\mu U_{qi}^{SP} = \mu(\alpha X_{qi}^{SP} + \gamma Z_{qi}^{SP} + \eta_{qi}) \qquad (4.9)$$

where, α, β & γ - parameters to be estimated;
X^{RP} and X^{SP} - vectors of common attributes to both type of data;
Y^{RP} and Z^{SP} are the vectors of attributes specific to RP or SP data.

Simultaneous Estimation

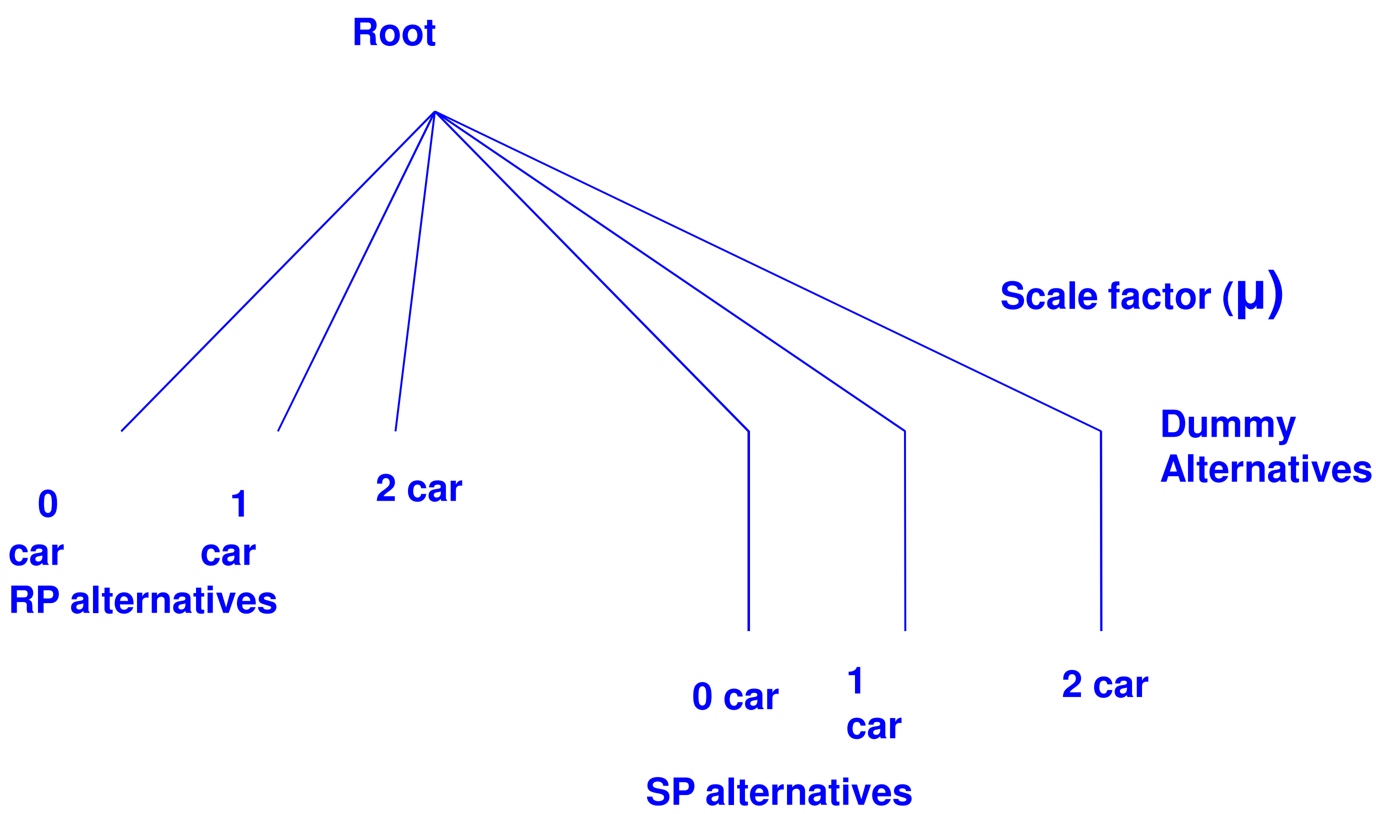


Fig. 4.1 Artificial tree structure for mixed RP and SP data

Simultaneous Estimation

The main utility of the dummy-alternative can be computed as suggested by Daly (1987) and is given by

$$V^{COMP} = \mu \log \sum \exp(V^{SP}) \qquad \textbf{(4.10)}$$

as there is only one alternative in the nest the expected maximum utility (EMU) of the nest becomes equal to the utility of the alternative itself and can be given as

$$V^{SP} = \alpha X^{SP} + \phi Z^{SP} \qquad \textbf{(4.11)}$$

Therefore, the utility of the nest will become

$$V^{SP} = \mu(\alpha X^{SP} + \phi Z^{SP}) \qquad \textbf{(4.12)}$$

which is exactly the same required and presented in the equation (4.9). The scale factor should take the same value for all the SP alternatives.

Sequential Estimation Method

The procedure is as follows (Ben-Akiva and Morikawa, 1990):

(a) Estimate the SP model according to utility functions given in equation (4.13) in order to obtain the estimators of $\mu\theta$ and $\mu\phi$. Then, define a new variable:

$$\hat{V}_i^{RP} = \mu\theta X_i^{RP} \quad (4.13)$$

(b) estimate the following RP model with the new variable included, in order to estimate the parameters λ and α:

$$U_i^{RP} = \lambda \hat{V}_i^{RP} + \alpha Y_i^{RP} + \varepsilon_i \quad (4.14)$$

where $\lambda = 1/\mu$.

(c) multiply *X* and *Z* of SP data by μ to obtain a modified SP data set. Pool the RP data and the modified SP data and then estimate the two models jointly.

Various combinations of RP and SP data

Table 4.1:Various combinations of RP&SP data used in joint model estimation

Joint Model	Data type	RP Sample	SP Sample	Total Samples	Joint Model With
1	RP1&SP1	923 (22.32%)	3213 (77.68%)	4136	RP1
2	RP1&SP2	923 (22.32%)	3213 (77.68%)	4136	RP1
3	RP1&SP3	923 (12.56%)	6426 (87.44%)	7349	RP1
4	RP2&SP1	357 (10.00%)	3213 (90.00%)	3570	RP2
5	RP2&SP2	357 (10.00%)	3213 (90.00%)	3570	RP2
6	RP2&SP3	357 (5.26%)	6426 (94.74%)	6783	RP2
7	RP3&SP1	1280 (28.49%)	3213 (71.51%)	4493	RP3
8	RP3&SP2	1280 (28.49%)	3213 (71.51%)	4493	RP3
9	RP3&SP3	1280 (16.61%)	6426 (83.39%)	7706	RP3

goodness-of-fit statistics of the individual models

Table 4.2:Coefficient estimates& goodness-of-fit statistics of the individual models

Variable	RP1	RP2	RP1+RP2	SP1	SP2	SP1+SP2	Specific to
BA	0.5746 (4.4)	0.6704 (2.2)	0.2531 (2.7)	-	-	-	1 car
NPEMSSC	0.2376 (3.0)	-	-	-	-	-	1 car
NCLH	1.4960 (7.7)	2.818 (9.1)	1.7730 (11.9)	-	-	-	1 car
HHINC	0.5057 (7.8)	-	0.6605 (11.9)	0.7303 (18.0)	1.0540 (22.0)	0.8361 (28.3)	1 car
FS	-0.2870 (3.8)	-0.1864* (0.9)	-0.2531 (3.7)	-0.1658 (5.7)	-0.2097 (6.6)	-0.1810 (8.5)	1 car
NBPHH	0.2262* (1.5)	-	-	-	-	-	1 car
HOL	-	-	-	-0.3674 (6.0)	-0.4763 (7.2)	-0.4075 (9.1)	1 car
HHINC	0.8367 (7.9)	2.058 (2.0)	0.9341 (10.0)	0.9103 (12.0)	1.0830 (15.2)	0.9464 (18.7)	1 car
BA	0.2738* (1.3)	0.7206 (1.0)	-	-	-	-	2 car
HOL	-1.7410 (3.0)	-0.9570* (1.6)	-1.7620 (3.3)	-2.1380 (8.4)	-1.3660 (9.0)	-1.5780 (12.3)	2 car
FS	-0.2802 (2.4)	-0.6655* (1.6)	-0.3257 (2.8)	-0.3494 (5.4)	-0.4784 (8.2)	-0.4154 (9.7)	2 car
NBPHH	0.3427 (1.8)	1.714 (2.1)	0.3984 (2.3)	-	-	-	2 car
Constant	4.4030 (10.6)	5.082 (4.4)	4.3430 (11.9)	-	-	-	0 car
CPI	-	-	-	-0.0955 (16.5)	-0.0881 (15.0)	-0.0902 (22.1)	common
Structural parameters							
L(0)	-1014.02	-392.21	-1406.22	-3529.84	-3529.84	-7059.68	-
L(c)	-685.01	-200.51	-893.97	-2836.22	-2848.38	-5721.89	-
L (θ)	-426.27	-75.15	-539.05	-2507.86	-2448.74	-5022.97	-
χ^2	1175.49	634.11	1734.33	2043.96	3122.53	4073.43	-
ρ^2 (0)	0.5796	0.8084	0.6167	0.2895	0.3063	0.2885	-
ρ^2 (c)	0.3777	0.6252	0.3970	0.1158	0.1403	0.1221	-
ρ^2 (adj)	0.5687	0.7979	0.6090	0.2855	0.3037	0.2872	-
Samples	923	357	1280	3213	3213	6426	-

Table 4.3: Calibration Results of Joint Models with RP 1 data

Variable	RP1+SP1		RP1+SP2		RP1+(SP1+SP2)		Specific to
	SIM	SEQ	SIM	SEQ	SIM	SEQ	
HOL	-0.2649	-0.2605	-0.4763	-0.2547	-0.2603	-0.2579	1 car
	(5.0)	(5.5)	(7.2)	(5.8)	(6.7)	(7.5)	
BA	0.5355	0.5401	0.5419	0.5440	0.5360	0.5388	1 car
	(4.2)	(4.3)	(4.2)	(4.3)	(4.2)	(4.3)	
EMSSC	0.1548	0.1587	0.1329	0.1349	0.1352	0.1378	1 car
	(2.1)	(2.2)	(1.8)	(1.9)	(1.8)	(1.9)	
NCLH	1.513	1.512	1.5350	1.5340	1.528	1.527	1 car
	(7.8)	(7.8)	(7.8)	(7.8)	(7.8)	(7.9)	
FS	-0.1428	-0.4103	-0.1284	-0.1277	-0.1282	-0.1273	1 car
	(5.2)	(6.2)	(5.7)	(6.9)	(6.5)	(8.6)	
NBPHH	0.1265	0.1311	0.0996	0.1021	0.1052	0.1083	1 car
	(0.9)	(0.9)	(0.7)	(0.7)	(0.7)	(0.8)	
HHINC	0.5342	0.5241	0.5641	0.5592	0.5524	0.5462	1 car
	(9.7)	(18.6)	(9.9)	(22.3)	(9.9)	(27.5)	
MTREXP	-0.4819	-0.4735	-0.7534	-0.7454	-0.6587	-0.6487	1 car
	(3.7)	(3.7)	(6.5)	(7.3)	(6.6)	(7.8)	
HOL	-1.573	-1.542	-0.7655	-0.7589	-1.028	-1.016	2 car
	(6.5)	(8.1)	(6.5)	(8.6)	(7.6)	(11.5)	
BA	0.5705	0.5754	0.5675	0.5694	0.6069	0.6092	2 car
	(3.7)	(3.8)	(3.9)	(4.0)	(4.2)	(4.3)	
FS	-0.2589	-0.2552	-0.2683	-0.2668	-0.2742	-0.2721	2 car
	(4.9)	(5.4)	(6.5)	(8.1)	(7.0)	(9.4)	
NBPHH	0.4156	0.4181	0.4408	0.4420	0.4500	0.4515	2 car
	(2.2)	(2.2)	(2.4)	(2.4)	(2.4)	(2.4)	
HHINC	0.7167	0.7024	0.6183	0.6127	0.6340	0.6264	2 car
	(8.6)	(13.5)	(8.9)	(16.1)	(9.1)	(18.9)	
MTREXP	-0.2395	-0.2300	-0.3458	-0.3387	-0.2257	-0.2180	2 car
	(1.0)	(1.0)	(2.2)	(2.2)	(1.6)	(1.6	
CPI	-0.0733	-0.0719	-0.0499	-0.0496	-0.06073	-0.0602	commo
	(8.1)	(15.9)	(8.1)	(14.5)	(8.9)	(21.3)	n
Constant	4.824	4.810	5.0260	5.0160	4.950	4.936	0 car
	(14.70)	(15.9)	(10.6)	(16.0)	(15.4)	(15.9	
μ	1.354	1.3843	1.8690	1.8843	1.559	1.5743	-
	(8.7)	(9.9)	(9.0)	(9.9)	(9.4)	(9.9)	
$\rho^2_{(0)}$	0.3653	0.3652	0.3794	0.3793	0.3350	0.3352	-
$\rho^2_{(\theta)}$	0.1742	0.1741	0.1944	0.1942	0.1560	0.1560	-
$L_{(0)}$	-4012.9	-401.9	-4010.0	-4010.0	-7008.9	-7008.9	-
$L_{(c)}$	-3084.4	-3084.4	-3089.0	-3089.0	-5520.7	-5520.7	-
$L_{(\theta)}$	-2547.0	-2547.4	-2488.6	-2489.0	-4658.74	-4659.6	-
Sample size	4136	4136	4136	4136	7349	7349	-

Table 4.4: Calibration Results of Joint Models with RP 2 data

Variable	RP2+SP1		RP2+SP2		RP2+(SP1+SP2)		Specific to
	SIM	SEQ	SIM	SEQ	SIM	SEQ	
HOL	-3.498	-0.5930	-1.614	-0.5621	-2.235	-0.5807	1 car
	(3.0)	(5.5)	(2.7)	(6.7)	(3.1)	(8.5)	
BA	0.8532	0.8506	0.9049	0.9059	0.8858	0.8862	1 car
	(3.0)	(3.0)	(3.2)	(3.3)	(3.1)	(3.2)	
EMSSC	-	-	-	-	-	-	1 car
NCLH	2.851	2.849	2.858	2.859	2.857	2.857	1 car
	(9.1)	(9.2)	(9.1)	(9.1)	(9.1)	(9.2)	
FS	-0.2745	-0.2701	-0.2535	-0.2568	-0.2657	-0.2687	1 car
	(3.0)	(5.4)	(2.8)	(6.3)	(3.1)	(8.1)	
NBPHH	-	-	-	-	-	-	1 car
HHINC	1.472	1.161	1.269	1.227	1.342	1.216	1 car
	(3.3)	(16.6)	(3.0)	(20.5)	(3.3)	(26.2)	
MTREXP	-1.222	-1.20	-1.747	-1.732	-1.525	-1.498	1 car
	(2.5)	(4.0)	(2.7)	(7.4)	(3.0)	(7.8)	
HOL	-0.6036	-3.436	-0.5591	-1.618	-0.5797	-2.229	2 car
	(2.8)	(7.7)	(2.7)	(8.3)	(3.0)	(11.2)	
BA	0.0354	0.8506	-0.1222	-0.1204	-0.0582	-0.0516	2 car
	(0.1)	(3.0)	(0.3)	(0.3)	(0.1)	(0.1)	
FS	-0.6049	-0.5948	-0.5844	-1.618	-0.6127	-0.6177	2 car
	(2.9)	(5.4)	(2.8)	(8.3)	(3.1)	(9.4)	
NBPHH	1.382	1.377	1.251	1.252	1.295	1.295	2 car
	(2.3)	(2.3)	(2.1)	(2.1)	(2.2)	(2.2)	
HHINC	1.181	1.447	1.225	1.271	1.219	1.338	2 car
	(3.3)	(11.2)	(2.9)	(14.3)	(3.2)	(17.4)	
MTREXP	-0.0997	-0.0944	-0.487	-0.4649	-0.262	-0.2317	2 car
	(0.2)	(0.2)	(1.4)	(1.4)	(0.8)	(0.8)	
CPI	-0.1605	-0.1576	-0.108	-0.108	-0.1336	-0.1336	commo
	(3.2)	(15.5)	(14.2)	(14.2)	(3.2)	(21.0)	n
Constant	5.443	5.450	5.725	5.725	5.609	5.598	0 car
	(5.3)	(5.4)	(5.6)	(5.6)	(5.5)	(5.5)	
μ	0.6099	0.6210	0.853	0.853	0.7052	0.7037	-
	(3.2)	(3.0)	(2.9)	(2.9)	(3.2)	(3.0)	
$\rho^2_{(0)}$	0.3537	0.3537	0.3711	0.3711	0.3265	0.3265	-
$\rho^2_{(0)}$	0.1570	0.1570	0.1817	0.1818	0.1459	0.1459	-
L(0)	-3391.09	-3391.09	-3388.23	-3388.23	-6387.11	-6387.11	-
L(c)	-2599.88	-2599.88	-2604.52	-2604.52	-5036.23	-5036.23	-
L (θ)	-2191.79	-2191.79	-2130.96	-2130.96	-4301.67	-4301.41	-
Sample size	3570	3570	3570	3570	6783	6783	-

Table 4.5: Calibration Results of Joint Models with RP 3 data

Variable	(RP1+RP2)+SP1		(RP1+RP2)+SP2		(RP1+RP2)+(SP1+SP2)		Specific to
	SIM	SEQ	SIM	SEQ	SIM	SEQ	
HOL	-0.320 (5.2)	-0.3132 (5.5)	-0.3056 (6.3)	-0.3014 (6.7)	-0.3130 (7.5)	-0.3070 (8.4)	1 car
BA	0.1435 (1.8)	0.1493 (1.9)	0.1224 (1.6)	0.1270 (1.7)	0.0916 (1.2)	0.0977 (1.3)	1 car
NCLH	1.774 (12.0)	1.772 (12.0)	1.790 (12.0)	1.787 (12.0)	1.787 (12.0)	1.784 (12.1)	1 car
FS	-0.1752 (5.9)	-0.1695 (6.4)	-0.1576 (6.4)	-0.1554 (7.1)	-0.1574 (7.5)	-0.1544 (8.8)	1 car
HHINC	0.6566 (13.2)	0.6425 (20.6)	0.6849 (13.7)	0.6733 (24.0)	0.6718 (13.60)	0.6570 (29.0)	1 car
MTREXP	-0.5935 (3.9)	-0.603 (4.1)	-0.9018 (7.3)	-0.8871 (7.5)	-0.7914 (7.5)	-0.7741 (8.0)	1 car
HOL	-1.843 (7.2)	-1.799 (8.3)	-0.9263 (7.4)	-0.9078 (8.8)	-1.238 (8.9)	-1.209 (11.6)	2 car
FS	-0.3123 (5.3)	-0.3033 (5.6)	-0.3233 (7.2)	-0.3185 (8.3)	-0.3295 (8.0)	-0.3234 (9.5)	2 car
NBPHH	0.5142 (3.1)	0.5136 (3.1)	0.5707 (3.6)	0.5716 (3.6)	0.6070 (3.8)	0.6079 (3.9)	2 car
HHINC	0.9027 (11.5)	0.8828 (16.0)	0.7760 (11.7)	0.7614 (18.1)	0.7952 (11.9)	0.7763 (20.7)	2 car
MTREXP	-0.4978 (2.0)	-0.4967 (2.1)	-0.5368 (3.0)	-0.5205 (3.0)	-0.4027 (2.5)	-0.3854 (2.5)	2 car
CPI	-0.09056 (9.9)	-0.0876 (16.2)	-0.0614 (9.9)	-0.0603 (14.9)	-0.0745 (11.30)	-0.0728 (21.6)	common
Constant	4.342 (16.5)	4.314 (17.8)	4.521 (18.6)	4.487 (20.7)	4.365 (18.6)	4.322 (21.1)	0 car
μ	1.105 (10.8)	1.1464 (13.6)	1.538 (11.5)	1.5736 (13.8)	1.282 (12.3)	1.3149 (13.7)	-
$\rho^2_{(0)}$	0.3966	0.3965	0.4095	0.4095	0.3554	0.3553	-
$\rho^2_{(\theta)}$	0.1929	0.1928	0.2117	0.2117	0.1674	0.1672	-
$L_{(0)}$	-4405.11	-4405.11	-4402.25	-4402.25	-7401.13	-7401.13	-
$L_{(c)}$	-3293.34	-3293.34	-3297.98	-3297.98	-5729.69	-5729.69	-
$L_{(\theta)}$	-2658.22	-2658.28	-2599.74	-2599.63	-4770.62	-4771.72	-
Sample size	4493	4493	4493	4493	7706	7706	-

Calibration Results of Joint Models

The standard error of μ in the RP3+SP1 (0.102&0.084), RP3+SP2 (0.134&0.114)and RP3+SP3 (0.104&0.096) be calculated for SIM and SEQ methods.

Thus the null hypothesis of μ=1 yields the following t-ratios for above cases:

(1.105-1)/0.102 = 1.03 (SIE), (1.146-1)/0.084 = 1.74 (SEE) for RP1+SP1

(1.538-1)/0.134 = 4.02 (SIE), (1.574-1)/0.114 = 5.03(SEE) for RP3+SP2 and

(1.28-1)/0.104 =2.71 (SIE), (1.32-1)/0.096=3.28 for RP1+SP3.

Later two cases the t-ratios are higher than the critical value (1.96) at the 95 percent level.

Out of all these values RP2+SP2 case the t-ratio obtaining more, which indicating the best fit.

Calibration Results of Joint Models

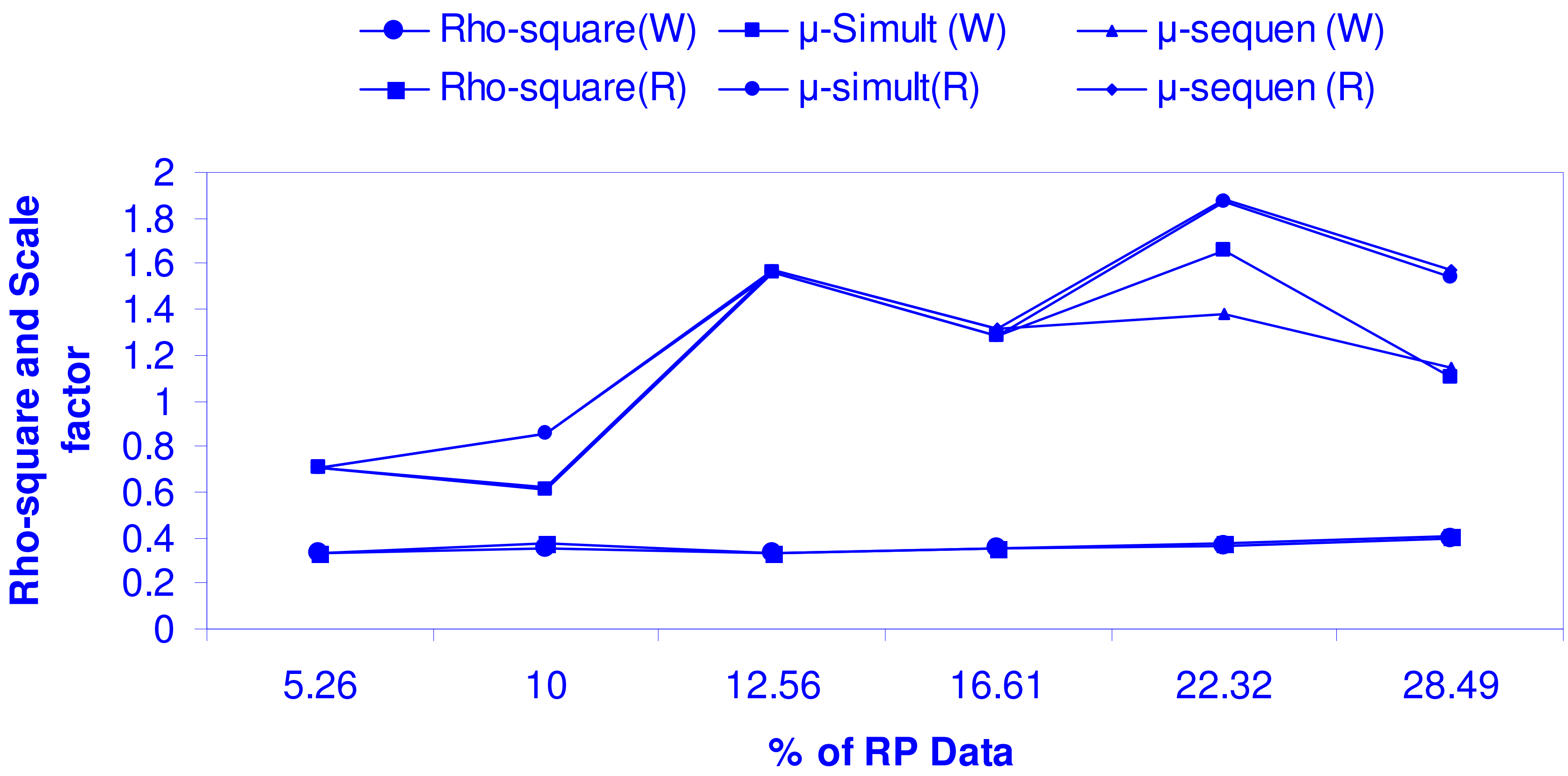


Fig. 4.2: Rho-square and scale factor values at different RP proportions