Valuing Rail Service Attributes through Rating Surveys

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The values and views expressed in this paper are those of the authors and are not necessarily supported by RailCorp.

1. Introduction

Stated Preference surveys have been used frequently over the last 10-20 years to value qualitative attributes such as vehicle design, station facilities and cleanliness. Such surveys can be costly to design and implement however and resultant valuations have not without criticism for inflating valuations by focusing undue attention on individual attributes.

As an alternative approach, a simple rating approach has been undertaken of Sydney rail passengers. Rating based valuations have a prima facie appeal for measuring qualitative service attributes since by benchmarking quality, as perceived by the passenger, it is possible to interpolate or extrapolate the likely benefit from changes in quality. Thus, it is possible to gauge the likely rating to a station refurbishment by surveying the existing station rating, forecasting the likely rating after improvement and assessing the value of the rating change.

Two market research surveys were carried out to develop the rating model. The first survey asked respondents to rate a series of attributes on a one (very poor) to nine (excellent) scale. The second survey focussed on four rail service attributes: on-train time, frequency on service, reliability and seat availability and by asking passengers to give the on-train time that they would rate as excellent, it was possible to translate the rating results into equivalent on-train time measures.

In 2005, between the two surveys, RailCorp introduced a new rail timetable principally to improve reliability. The two surveys therefore provide a 'before and after' passenger assessment of the timetable change. The rating of reliability improved appreciably between the two surveys. However, the ratings of on-train time and seat availability declined slightly. By using the rating valuation model, it was possible to make an overall assessment of the timetable change and value the passenger benefit in dollar terms.

It is not argued that the rating valuation model is a replacement for Stated Preference market research. Indeed, in order to translate the service attribute values into dollar terms, the results of a 'Value of Rail Time' Stated Preference market research were needed. However, the rating valuation model does offer an alternative way to develop relative attribute valuations that can be used in demand forecasts, service level assessments and economic evaluations.

2. Background

In 2004, RailCorp engaged Douglas Economics to re-estimate the values for rail service quality factors that are used in economic appraisals. The existing values were ten years old, dating to a 1995 study that used a mixture of Stated Preference and priority indicators to derive a set of valuations, PCIE (1995).

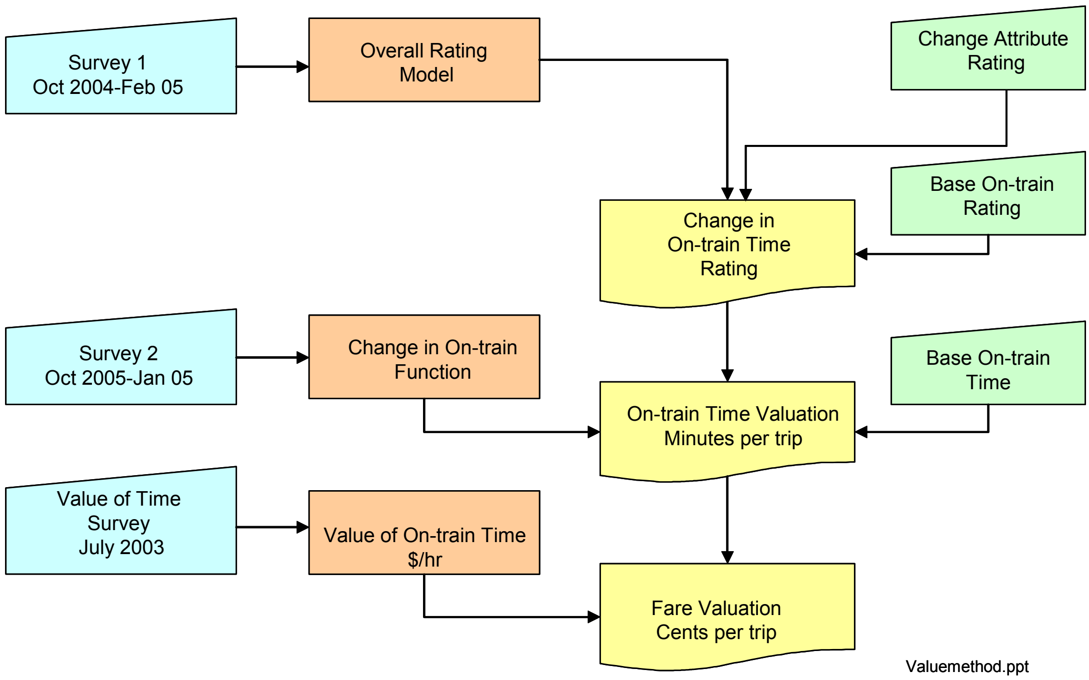
The aim of the 2004 study was to produce relative values for train frequency; train service reliability; train overcrowding; train appearance and facilities; station appearance and facilities and personal security on trains and at stations.

The valuations are presented in terms of passenger ratings: in essence, the value of a 10% increase in the passenger rating of an attribute is valued in terms of the increase in onboard rail time that would exactly compensate the passenger i.e. maintain the passenger's overall rail rating at the before level. The onboard rail time measures can then be translated, via 'values of rail travel time', into the compensating fare change that passengers would be willing to pay for the attribute improvement thereby leaving them indifferent to the change. As well as the absolute change in fare, the percentage fare change can be calculated by dividing by the average fare.

3. Survey Approach

The valuation approach is shown schematically in Figure 1. The approach uses models and parameters estimated in three surveys.

Figure 1: Valuation Approach



The first rating survey undertaken between October 2004 and February 2005 asked respondents to rate 46 aspects of the rail service. The survey response was used to develop an overall rating model and an improvement priority model. The overall rating model uses the individual attribute ratings to explain the overall rating thus enabling the importance of each individual factor was then measured relative to rail onboard time.

The second rating survey undertaken between October 2005 and January 2006 asked passengers to rate on-train time, frequency on service, reliability and seat availability. By also asking passengers to give the on-train time that they would rate as excellent, the survey was able to translate the change in on-train rating into on-train time minutes. Similarly, by asking respondents how often their rail service departs and their experience of trains being late, the service interval and reliability ratings could be translated into minutes of service interval and minutes of expected lateness.

The "*Value of Rail Travel Time"* study surveyed 1,578 passengers using Stated Preference questions to value onboard rail time in dollars per hour, Douglas Economics (2004). The survey also derived relative valuations of service interval in onboard rail time which were able to be compared with the rating based valuations.

4 Sample Sizes and Profile

Both surveys involved self-completion questionnaires that were distributed and collected on board trains by fieldworkers. The survey covered Suburban and Intercity services (Newcastle, South Coast and Blue Mountains).

- Short: up to 25 minutes on-train time (<15.1 kms)
- Medium trips: 25 - 59 minutes on-train time (≥15.1 & < 50 kms)
- Long trips: trips of 60 or more minutes of on-train time (≥ 50 kms) six categories:

Peak and off-peak response was classified by train departure time (peak respondents were passengers on 0600-0930 weekday trains or 1500-1830 weekday trains).

The first rating survey (04-05) was the largest survey with 2,732 completed questionnaires, Table 1. With 1,096 completed questionnaires, the second rating survey (05-06) was 40% as large. The ‘Value of Rail Time’ survey had a sample size of 1,578 interviews.

Table 1: Sample Sizes

	Peak			Off-Peak					
	Short	Medium	Long	Short	Medium	Long	Peak	Off-Peak	ALL
Survey	<25	25-59	>59	<25	25-59	>59	All	All	All
Rating 04-05	155	1,098	500	169	595	215	1,753	979	2,732
Rating 05-06	154	394	234	63	148	103	782	314	1,096
Rating All	309	1,492	734	232	743	318	2,535	1,293	3,828
Value of Time	255	256	268	262	268	269	779	799	1,578

RailCorp Surveys, Douglas Economics Analysis Valuation06_5.xls!Sample

Peak trips tended to be over sampled and off-peak trips under-sampled in the Rating Surveys when compared with CityRail trip shares of 57% peak and 43% off-peak. Short distance trips were also under-represented with peak short trips representing only 15% of the first Rating survey compared to a CityRail share of 30%. A set of weights was used to factor the survey segment shares to the CityRail ‘population’ segment shares.

The sample profiles were compared against the CityRail profile derived from CityRail Compendium. Key sample descriptors are presented in Table 2.

The Rating 04-05 Survey slightly over sampled females at 56% when compared with an even CityRail gender split. The Rating 05-06 and Value of Time Surveys were closer with 53% of respondents being female.

Relatively few education trips (2%) were surveyed in the 05-06 Survey compared to 12% reported in the Compendium whereas the 04-05 Survey and the ‘Value of Time’ Surveys were similar to the Compendium profile. The journey to and from work share was higher however than the Compendium share of 38% with 52% for the 05-06 survey, 54% for the ‘Value of Time’ Survey and 55% for the 04-05 Survey.

Relatively few young respondents (aged 15 or under) were interviewed compared to the 15% of CityRail trips estimated to be school age (15 or under). Respondents aged 16-19 were over sampled however with 33% of the 04-05 Survey and 31% of the 05-06 survey aged 16-19 compared to 19% reported by the CityRail Compendium. The under and over sampling of these two age groups helped keep the average age close to the average age of 35 years for the CityRail Compendium profile.

Table 2: Sample Profiles

Characteristic	Peak				Off-Peak				All			
	Rating 04-05	Rating 05-06	Value of Time	CityRail Profile	Rating 04-05	Rating 05-06	Value of Time	CityRail	Rating 04-05	Rating 05-06	Value of Time	CityRail Profile
Female %	58%	51%	53%	50%	53%	51%	53%	52%	56%	53%	53%	50%
To & From Work Trips %	74%	59%	71%	50%	30%	42%	32%	23%	55%	52%	54%	38%
To & From Education %	11%	2%	11%	16%	21%	2%	19%	17%	15%	2%	14%	12%
Other Purpose %	15%	39%	18%	34%	49%	56%	49%	60%	30%	46%	32%	50%
Aged 15 or Under %	1%	3%	2%	10%	1%	7%	1%	13%	1%	5%	2%	15%
Aged 16-24 %	26%	30%	16%	27%	42%	33%	24%	20%	33%	31%	19%	19%
Aged 25-59 %	68%	53%	72%	40%	44%	53%	57%	54%	57%	58%	65%	59%
Aged 60+ %	5%	14%	10%	23%	13%	7%	18%	13%	9%	6%	14%	7%
Average Age (Years)	37	35	34	34	36	34	38	38	37	35	35	35
Employed %	80%	71%	79%	68%	45%	62%	51%	50%	65%	67%	67%	62%
Unemployed %	1%	3%	3%	na	5%	7%	8%	na	2%	5%	5%	na
Student %	15%	19%	13%	23%	34%	18%	25%	23%	23%	19%	18%	22%
Houseperson %	1%	2%	1%	na	5%	4%	3%	na	3%	3%	2%	na
Retired %	3%	5%	4%	6%	11%	8%	13%	19%	7%	6%	8%	11%
Other %	0%	0%	0%	3%	0%	1%	0%	8%	0%	0%	0%	5%
Concesssion Entitled	22%	na	22%	19%	46%	na	41%	25%	32%	na	30%	21%
≥4 Days per Week	79%	68%	na	72%	58%	51%	na	57%	70%	60%	na	67%
1-3 Days per Week	13%	19%	na	15%	22%	30%	na	22%	17%	24%	na	17%
1-3 Days per Month	4%	7%	na	7%	11%	10%	na	11%	7%	8%	na	8%
<1 Day per Month	4%	6%	na	6%	9%	9%	na	10%	6%	8%	na	8%

RailCorp Surveys, Douglas Economics Analysis DEL Valuation06_5.xls!Profile

The socio-economic profiles were similar to the CityRail Compendium with over 60% employed and around 20% being students.

The Rating Surveys obtained a similar frequency of use profile to that reported in the CityRail Compendium. 70% of the 04-05 Survey and 60% of the 05-06 Survey respondents used CityRail on four or more days per week compared to 67% reported by the Compendium.

4. Explaining Overall Rail Service via Individual Attribute Ratings

Table 3 presents the 04-05 ratings for the 46 rail service attributes. The train ratings were asked in terms of the surveyed train whilst the station ratings were asked in terms of the board station. The overall train and station ratings are shown twice to accord with later tabulations.

The ratings are on a 1-9 scale with one being very poor, five being average and nine being excellent. The overall rail service rated 4.8 (or 48% on a percentage scale {R%-1}/8. The highest rating was 6.6 obtained by two attributes: ease of train boarding/alighting and train lighting.

Service reliability rated the poorest at 4.2. Night-time station security was second worst with 4.6 and station toilets were third worst at 4.5.

In general, attribute rankings were consistent across the six market segments although there were some differences. Off-peak respondents making long trips tended to rate train quality higher than off-peak respondents making short trips. Long distance passengers also tended to give higher overall station ratings than passengers travelling short or medium distances.

Table 3: Base Rail Service Ratings

October 2004 - February 2005 Survey

Attribute	Peak Short	Peak Medium	Peak Long	Off-Peak Short	Off-Peak Medium	Off-Peak Long	Peak	Off-Peak	ALL
Service Frequency	4.8	4.4	4.6	4.7	4.7	5.2	4.7	4.8	4.7
On-Train Time	5.2	4.6	4.8	5.1	4.9	5.4	4.9	5.1	5.0
Reliability	4.2	3.8	4.1	4.2	4.0	5.1	4.1	4.3	4.2
Seat Availability	5.8	5.8	6.0	6.0	6.2	6.4	5.8	6.1	6.0
Train Security Day	6.1	5.7	5.8	5.8	5.9	6.1	5.9	5.9	5.9
Train Security Night	4.8	4.3	4.2	4.7	4.5	4.6	4.5	4.6	4.6
Station Security Day	6.1	5.8	5.9	6.1	6.1	6.3	6.0	6.1	6.0
Station Security Night	4.5	4.1	4.2	4.4	4.2	4.4	4.4	4.3	4.3
Train Overall	5.8	5.6	5.8	5.7	5.9	6.2	5.7	5.8	5.8
Station Overall	5.8	5.5	5.9	5.5	6.0	6.1	5.7	5.8	5.7
Total Rail Service	4.8	4.5	4.6	5.0	5.0	5.6	4.7	5.1	4.8
Train Outside	5.3	5.2	5.4	5.0	5.5	5.7	5.3	5.2	5.3
Ease of Boarding	6.3	6.2	6.3	6.1	6.6	6.8	6.3	6.4	6.3
Seat Comfort	5.5	5.4	5.5	5.5	5.9	6.3	5.5	5.8	5.6
Smoothness of Ride	5.5	5.5	5.7	5.7	5.8	6.1	5.5	5.8	5.6
Quietness	5.3	5.4	5.6	5.6	5.6	6.0	5.4	5.7	5.5
Air Conditioning	5.2	5.1	5.6	5.5	5.4	5.8	5.2	5.5	5.4
Lighting	6.1	6.0	6.4	6.4	6.4	6.8	6.1	6.4	6.3
Graffiti	5.9	5.9	6.1	5.8	6.0	6.2	5.9	5.9	5.9
Cleanliness	6.0	5.9	5.9	5.7	6.0	6.2	5.9	5.9	5.9
Announcements	5.2	5.2	4.9	5.3	5.3	5.9	5.2	5.4	5.3
Layout	5.6	5.6	5.8	5.6	5.9	6.0	5.6	5.8	5.7
Train Overall	5.8	5.6	5.8	5.7	5.9	6.2	5.7	5.8	5.8
Station On-Off	6.0	6.0	6.3	6.0	6.3	6.5	6.0	6.2	6.1
Weather Protection	6.1	5.6	5.5	5.7	6.2	6.2	5.8	5.9	5.9
Platform Seating	4.8	4.6	4.7	4.8	4.9	5.2	4.7	4.9	4.8
Platform Surface	5.6	5.4	5.8	5.3	5.7	6.0	5.6	5.5	5.5
Subway-OverBridge	5.5	5.3	5.8	5.2	5.6	5.9	5.5	5.5	5.5
Station Building	5.6	5.4	5.8	5.4	5.9	6.1	5.6	5.6	5.6
Lifts & Escalators	5.4	5.2	5.7	4.9	5.5	5.8	5.4	5.3	5.3
Signing	5.6	5.5	5.8	5.4	5.8	6.2	5.6	5.7	5.6
Announcements	5.4	5.2	5.4	5.5	5.4	5.8	5.3	5.5	5.4
Information	5.4	5.0	5.2	5.0	5.3	5.7	5.2	5.2	5.2
Lighting	5.9	5.7	6.0	5.7	6.0	6.3	5.9	5.9	5.9
Cleanliness	5.9	5.8	6.2	5.8	6.0	6.3	5.9	5.9	5.9
Graffiti	5.9	5.8	6.1	5.7	5.9	6.1	5.9	5.8	5.9
Toilets	4.3	4.2	4.8	4.5	4.4	5.2	4.4	4.6	4.5
Staff	5.7	5.3	5.3	5.4	5.6	5.9	5.5	5.5	5.5
Car Park	5.3	5.2	5.6	5.4	5.4	5.9	5.3	5.5	5.4
Car Drop Off	4.7	4.3	5.1	4.2	4.5	5.2	4.6	4.4	4.5
Taxi	4.6	4.5	5.2	4.5	4.6	5.3	4.7	4.7	4.7
Bus	5.2	4.9	5.3	5.1	5.2	5.4	5.1	5.2	5.1
Bicycle	5.7	5.2	5.4	5.3	5.5	5.5	5.5	5.4	5.4
Telephone	4.8	4.5	4.8	4.4	4.7	4.8	4.7	4.6	4.6
Retail	5.4	4.8	5.0	4.8	5.1	5.5	5.1	5.0	5.1
Ticketing	5.4	4.9	4.8	4.9	5.2	5.2	5.2	5.0	5.1
Station Overall	5.8	5.5	5.9	5.5	6.0	6.1	5.7	5.8	5.7

Source: RailCorp Surveys, Douglas Economics Analysis DEL Valuation06_6.xls!Model

A detailed analysis of the variation in rating by respondent characteristic (journey purpose, age, gender etc) was also undertaken. Key findings were:

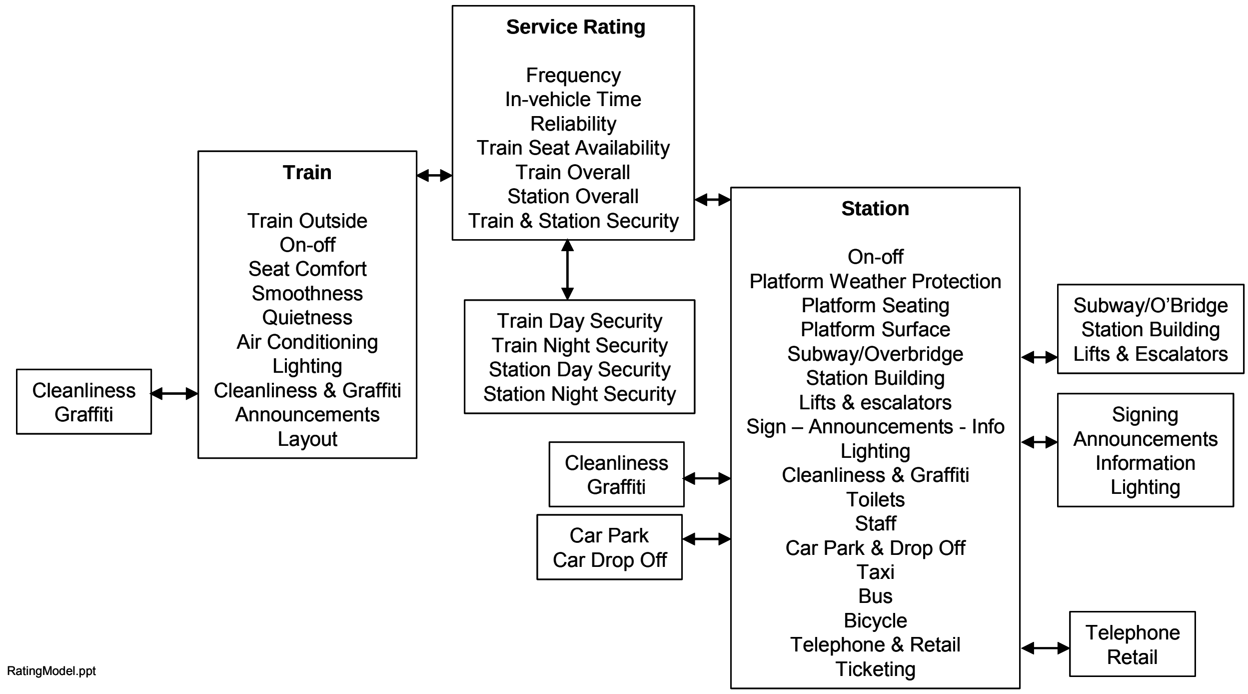
- Males tended to rate train and station personal security higher than females
- Older respondents (aged 60+) tended to rate higher than younger respondents
- Commuters tended to rate lower than passengers travelling on other purposes
- Regular users (which included students as well as commuters) also tended to rate their service lower than occasional CityRail users.

The individual attribute ratings were used to explain the overall rail rating. In doing so, the change in the overall rail service rating resulting from a one rating point improvement in an individual service attribute (X) was referenced to an 'importance' parameter (ζ_X). By dividing each attribute importance parameter by the importance parameter for on-train time, the equivalent change in the on-train rating required to produce the same change in overall rating can be determined.

The hierarchical approach shown in Figure 2 was used to minimise the effect of attribute correlations. Three models were fitted. At the top level, the overall rail service rating was modelled on the ratings of frequency, on-train time, reliability, seat availability, train, station and personal security. At the second level, the overall train rating was modelled on the individual train attribute ratings: train outside, ease of boarding and alighting, seat comfort, smoothness, quietness, aid conditioning, lighting, cleanliness, graffiti, train announcements, and layout.

Figure 2: Relative Importance Model

October 2004 - February 2005 Survey



Similarly, the overall station rating was modelled on the individual station attribute ratings: ease of platform boarding and alighting, weather protection, platform seating, platform surface, subway-overbridge, station building, lifts and escalators, signing, station announcements, information, lighting, cleanliness, graffiti, toilets, staff, car park, car drop off, taxi, bus, bicycle, telephone, retail and ticketing.

High correlations between 'intra-group' ratings especially in the station model required the creation of some 'composite' attributes in the train model. These composite ratings were derived by regressing the overall rating on the individual attribute ratings. Then, the relative size of the parameter estimates was used to develop a weighted average rating.

The estimation model (equation 1) explained the variation in overall rating (transformed to a probability score) across respondents in terms of the variation in the rating of the individual scores which were also transformed to probability (0-1) scores. A logistic or 'S' shaped function was fitted to the data to constrain the rating to the response interval.

$$\Pr(R_{ALL}) = \frac{\exp(\zeta o + \sum_{k} \zeta_X R_X)}{1 + \exp(\zeta o + \sum_{k} \zeta_X R_X)} \quad .....(1)$$

where:

$\Pr(R_{ALL})$ = overall rating expressed as a probability (0-1) score

R_X = rating of attribute X on probability scale 0 = very poor, 0.5 = average & 1 = excellent

$\zeta o, \zeta_X$ = estimated parameters

Train and station rating models were fitted as well as an overall rating model. The third column of Table 4 presents the estimated parameters.

Proportionate weights were calculated to combine the train and station parameters with the overall model parameters. For the train quality model, a weight of 0.249 was calculated as the proportion of the train (or station) quality parameter in the overall model to the sum of the train attribute parameters in the train quality model, equation 2. The station weight was similarly calculated at 0.14. The weights are shown in the fifth column of Table 4.

$$w_{TQ} = \frac{\zeta_{TQ}}{\sum_{X} \zeta_X} = \frac{1.03}{4.13} = 0.249 \quad .....(2)$$

where:

w_{TQ} = weight for train quality attributes

The 'final' parameters (ζ'_X) were calculated as the respective model weight (w_M) multiplied by the estimated attribute parameter (ζ_X), equation 3.

$$\zeta'_X = w_M \zeta_X \quad .....(3)$$

Thus, the parameter for 'train outside' reduced from 0.46 in the train model to 0.11 after multiplication of the model weight of 0.249.

The final parameters are in the sixth column of Table 4. The seventh column shows the relative importance of each attribute (calculated as the ratio of the individual parameter to the sum of all parameters). Equation 4 shows the calculation for train outside which has a proportional weight of 0.023 or 2.3%.

$$\Pr(\zeta') = \frac{\zeta'_X}{\sum_{X} \zeta'_X} = \frac{0.11}{4.86} = 0.023 \quad .....(4)$$

Finally, column 8 gives the parameter ratio (Z_X) of each attribute rating to the on-train time rating. Thus, for reliability, the ratio is 2.46, equation 5.

$$Z_X = \frac{\zeta'_X}{\zeta'_V} = \frac{1.23}{0.5} = 2.46 \quad .....(5)$$

where:

Z_X = ratio of attribute X rating parameter to on-train time rating parameter

ζ'_X = on-train time rating parameter

Table 4: Relative Attribute Rating Importance

October 2004 - February 2005 Survey

Model	Attribute	Model Estimates Parameter (ζ)	|t|	Final Parameters Weight	Parameter (ζ')	Percent of Total	On-Train Time Ratio (Zx)
Overall	Service Frequency	0.40	1.58	100.0%	0.40	8.2%	0.80
"	On Train Time	0.50	1.92	100.0%	0.50	10.3%	1.00
"	Reliability	1.23	5.20	100.0%	1.23	25.3%	2.46
"	Seat Availability	0.15	0.84	100.0%	0.15	3.1%	0.30
"	Train Day Safety	0.09	1.32	100.0%	0.09	1.9%	0.18
"	Train Night Safety	0.07		100.0%	0.07	1.4%	0.14
"	Station Day Safety	0.09		100.0%	0.09	1.9%	0.18
"	Station Night Safety	0.07		100.0%	0.07	1.4%	0.14
"	Train Quality	1.03	3.72	100.0%	1.03	21.2%	2.06
"	Station Quality	1.23	4.51	100.0%	1.23	25.3%	2.46
"	Total Rail Service	4.86	na	100.0%	4.86	100.0%	9.72
Train	Train Outside	0.45	2.51	24.9%	0.11	2.3%	0.22
"	Ease of Board & Alight	0.39	2.00	24.9%	0.10	2.1%	0.20
"	Seat Comfort	0.44	2.40	24.9%	0.11	2.3%	0.22
"	Smoothness	0.36	1.71	24.9%	0.09	1.9%	0.18
"	Quietness	0.43	2.10	24.9%	0.11	2.3%	0.22
"	Air Conditioning	0.55	3.40	24.9%	0.14	2.9%	0.28
"	Lighting	0.16	0.94	24.9%	0.04	0.8%	0.08
"	Train Grafitti	0.17	3.08	24.9%	0.04	0.8%	0.08
"	Train Cleanliness	0.42		24.9%	0.10	2.1%	0.20
"	Train Announcements	0.23	2.10	24.9%	0.06	1.2%	0.12
"	Layout	0.53	3.30	24.9%	0.13	2.7%	0.26
"	Total Train Attributes	4.13	na	24.9%	1.03	21.2%	2.06
Station	Platform Train On-Off	0.19	0.33	13.9%	0.03	0.6%	0.06
"	Weather Protection	0.24	0.55	13.9%	0.03	0.6%	0.06
"	Platform Seating	0.23	0.32	13.9%	0.03	0.6%	0.06
"	Platform Surface	0.15	0.22	13.9%	0.02	0.4%	0.04
"	Subway / Overbridge	0.52	1.52	13.9%	0.07	1.4%	0.14
"	Station Building	0.54	0.35	13.9%	0.08	1.6%	0.16
"	Lifts & Escalators	0.48	0.31	13.9%	0.07	1.4%	0.14
"	Information	0.35	1.64	13.9%	0.05	1.0%	0.10
"	Announcements	0.43		13.9%	0.06	1.2%	0.12
"	Signing	0.43		13.9%	0.06	1.2%	0.12
"	Lighting	0.42	0.54	13.9%	0.06	1.2%	0.12
"	Station Cleanliness	0.59	1.50	13.9%	0.08	1.6%	0.16
"	Station Grafitti	0.59		13.9%	0.08	1.6%	0.16
"	Toilets	0.30	0.41	13.9%	0.04	0.8%	0.08
"	Staff	1.05	2.03	13.9%	0.15	3.1%	0.30
"	Car Park	0.07	0.14	13.9%	0.01	0.2%	0.02
"	Car Drop Off	0.05		13.9%	0.01	0.2%	0.02
"	Taxi	0.16	0.18	13.9%	0.02	0.4%	0.04
"	Bus	0.71	0.96	13.9%	0.10	2.1%	0.20
"	Bike	0.07	0.12	13.9%	0.01	0.2%	0.02
"	Telephone	0.17	0.38	13.9%	0.02	0.4%	0.04
"	Retail	0.15		13.9%	0.02	0.4%	0.04
"	Ticketing	0.98	1.66	13.9%	0.14	2.9%	0.28
"	Total Station Attribute	8.86	na	13.9%	1.23	25.3%	2.46

Source: RailCorp Surveys, Douglas Economics Analysis DEL Valuation06_5.xls!Model

The parameter ratio is the equivalent improvement in on-train time rating required to achieve the same overall rating as a one rating point improvement in attribute X. For reliability, a 2.46 rating improvement in on-train time would achieve the same improvement in the overall rating as a one rating point improvement in reliability.

The equivalent change in on-train rating required to produce the same overall change in rating is calculated by equation 6. For a 10% improvement in the rating of reliability for peak medium distance trips, the equivalent change in on-train rating would be 1.02 (with 0.38 calculated as 10% of the base reliability rating for peak medium trips of 3.8 as given in Table 3).

$\Delta R_V = Z_X \{\Delta R_X\} = 2.46.\{0.38\} = 0.93$ …..(6)

where:

ΔR_V = Equivalent change in on-train time rating

ΔR_X = Change in attribute rating

ΔR_V = Equivalent change in on-train time rating

Z_X = Rating explanation parameter (see Table 4) for attribute X in terms of on-board rail time

5. Valuing the On-board Rail Time Rating in Minutes

The 2004-05 Rating Survey asked respondents to estimate the time they would spend onboard the train, how they rated the speed of their train service on a one to nine scale and how short the travel time would have to be for them to rate the speed as excellent.

12. How long will you spend on the train from boarding to alighting? *…………. minutes*
(Please include any time on trains you may have transferred from or may transfer to)

13. Please rate the speed of your train service on a 1-9 scale *Very Poor Average Excellent*
Please circle your rating with 1 being very poor & 9 being excellent 1 2 3 4 5 6 7 8 9

14. To have rated your rail speed as excellent, how short would your train trip have had to be?
My on-train trip would have to take me……….minutes for me to rate it excellent and score it 9

The three questions enabled the equivalent change in onboard train rating to be converted into an equivalent change in onboard rail time.

Individual response was analysed to determine the reduction in on-board travel time necessary to produce an excellent rating. The model took into account the current rating and the current on-board travel time. The estimation model is shown in equation 7. If an individual already rated on-board time as excellent (9), (i.e ΔR = 0 for an excellent rating) the required reduction in on-board travel time would be zero (∂V = 0). The function was therefore constrained to pass through the origin (i.e. had no constant term).

$\partial V = V^{\alpha} \beta \{\Delta R\}^{\gamma}$ …..(7)

where:

∂V = Change in on-board train time required by respondent to rate it excellent (9)
V = Current on-board train time estimated by respondent
ΔR = Change in rating from current to excellent (9 – current rating)
α,β,γ = Parameters to be estimated

Theoretically, as the current rating declines (ΔR increases) the required reduction in onboard time should increase. Parameter (β) should therefore be positive. However the relationship need not be proportional. A functional form parameter (γ) was introduced to determine the shape of the relationship. The model also allowed for the on-train reduction to be a function of the current on-train time by including the current on-train time (V) as an explanatory variable.

Peak, off-peak and overall models were estimated. The best fit model was determined by searching over a grid of possible values of α and γ and minimising the standard error of the required onboard time reduction. Ordinary Least Squares was used to estimate the standard error of the estimate (S.E.) and estimate β.

An on-board travel time parameter (α) close to one minimised the S.E. of V implying the required reduction was roughly proportional to the current onboard train time. The parameter was estimated at 0.95 for the peak model and 0.85 for the off-peak model. The rating parameter (γ) however was noticeably lower than one implying a proportionally smaller on-board travel time reduction the lower the current rating. The peak parameter (γ) was estimated at 0.3 and the off-peak parameter at 0.4. Table 5 presents the estimated parameters for the minimum error functional forms. The β parameters were estimated with precision with |t| values ranging from 33.8 to 62.8.

Table 5: Estimated On-Train Time – Rating Model Parameters

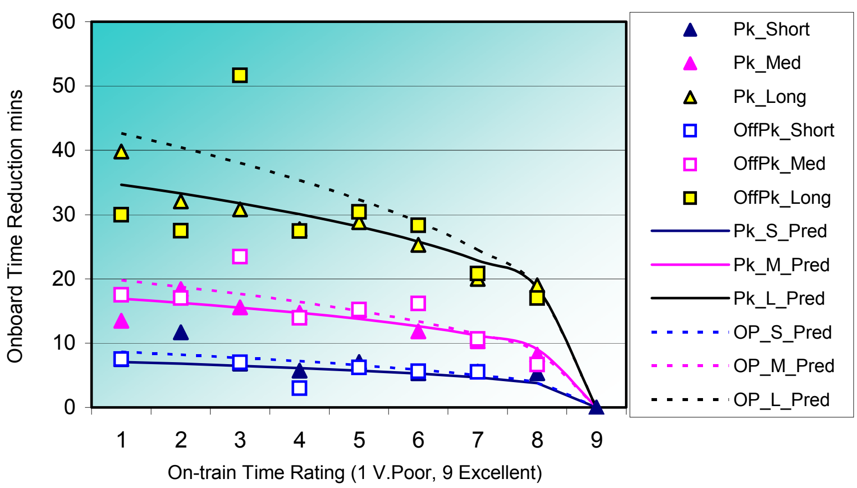
	Parameter Estimates			Goodness of Fit			Number of
Period	α	γ	β	S.E. β	|t| for β	S.E. δV	Observations
Peak	0.95	0.3	0.271	0.0052	52.4	8.87	577
Off-Peak	0.85	0.4	0.374	0.0079	33.8	8.87	185
All	0.9	0.3	0.339	0.0054	62.8	8.88	762

RailCorp Surveys, Douglas Economics Analysis DEL QSF06_Analysis_4.xls!ONTT

Figure 3 shows the predicted on-board rail time reduction. Also shown is the observed average response for each current rating.

Figure 3: Required Reduction in On-Train Time

Required Reduction in On-Board Rail Time in minutes for Excellent Rating



RailCorp Surveys, Douglas Economics Analysis QSF06_analysis_4.xls!ONT

No reduction in on-train time was required for passengers who already rated on-train time as excellent (9). The required on-train time reduction then began to increase, the lower the rating. The reduction in on-board time was not proportional however. A larger proportional reduction was required for passengers who rated on-train time as ‘very good’ (8) than for passengers who rating it as average (5).

The on-board time reduction also increased with the respondent’s current on-train time. Thus, peak passengers travelling 15 minutes who rated on-train time as average (5) required six minutes reduction. Passengers travelling 40 minutes required 15 minutes reduction. In percentage terms, the two reductions were 40% and 37.5% respectively. The reduction was therefore just less than proportional to the current on-train time. There was relatively little difference between peak and off-peak passengers.

It is recommended that the estimated models are applied individually to the six market segments, given the non-linear functional form. The peak, off-peak and overall valuations should then be calculated from the trip weighted market segment valuations.

In order to apply the models, an estimate of the onboard rail time is required for each market segment. Table 6 presents an estimate based on the three surveys.

Table 6: Average Market Segment On-Train Times

	Peak			Off-Peak					
	Short	Medium	Long	Short	Medium	Long	Peak	Off-Peak	ALL
	<25	25-59	>59	<25	25-59	>59	All	All	All
Rating 0405	21	43	95	19	44	109	40	41	40
Rating 0405	16	40	86	15	40	99	35	36	35
VOT 03	14	41	94	14	40	90	35	34	35
Average	16	42	93	16	42	98	37	38	38

Segment average is sample size weighted; peak & off-peak average weighted by CityRail segment %
RailCorp Surveys, Douglas Economics Analysis Valuation06_5.xls!Sample

A difference equation was used (equation 8) to estimate the on-train time increase that would exactly compensate respondents for the 10% rail service level improvements.

$$\Delta V = V^{\alpha}\beta\left[\{9 - R_V\}^{\gamma} - Max\left[0, \{9 - (R_V + \Delta R_V)\}\right]^{\gamma}\right] \quad .....(8)$$

where:
ΔV = Change in on-board time in minutes associated with the change in on-board rating
V = Current on-board train travel time (see Table 6)
ΔR_V = Predicted change in on-board time rating equivalent to the rating change for attribute X
R_V = Base on-board time rating (see Table 3)
α,β,γ= Estimated parameters

Equation 10 was applied to each service level attribute for each market segment. The peak, off-peak and overall estimates were determined by the weighted sum of the market segment estimates. As an example, a 1.013 minute increase in on-board rail time would exactly compensate peak respondents travelling medium distances for a 10% improvement in reliability rating (equation 9).

$$\Delta V = 42^{0.95}0.271\left[\{9 - 4.6\}^{0.3} - Max\left[0, \{9 - (4.6 + 0.93)\}\right]^{0.3}\right] = 1..013 \quad .....(9)$$

Table 7 presents the estimated ‘willingness to pay' for a 10% improvement in rating. The WTP increased with trip length reflecting the proportional model. Overall, an increase of 1.29 minutes of onboard rail time compensated a 10% improvement in reliability rating.

The compensating increase in on-board rail time was greater at 1.83 minutes for a 10% improvement in the overall station rating whilst a 10% rating improvement in service interval was valued at 0.44 minutes.

7. Willingness to Pay Higher Fares

The compensating on-board rail times (Table 7) were translated into ‘willingness to pay' (WTP) higher fares (cents per trip) by applying values of time to the on-train travel time benefit measures, equation 10.

$$\Delta F = \frac{100}{60} VOT.\Delta V \quad .....(10)$$

where:
ΔF = Willingness to pay higher fares in cents per trip
ΔV = Change in on-board rail time (mins) associated with the on-train time rating change
VOT = Value of onboard rail time in dollars per hour

Table 7: On-Train Time Benefit for 10% Attribute Improvement

Change in On-Train Time (mins/trip) for a 10% Rating Point Improvement in Attribute Rating

	Peak			Off-Peak			Weighted		
Attribute	Short	Medium	Long	Short	Medium	Long	Peak	Off-Peak	ALL
Service Frequency	0.18	0.36	0.84	0.27	0.60	1.47	0.34	0.56	0.44
On-Train Time	0.24	0.48	1.11	0.37	0.78	1.94	0.45	0.75	0.58
Reliability	0.51	1.02	2.44	0.79	1.64	4.84	0.98	1.71	1.29
Seat Availability	0.08	0.18	0.40	0.13	0.29	0.67	0.16	0.26	0.21
Train Security Day	0.05	0.10	0.23	0.07	0.17	0.38	0.10	0.15	0.12
Train Security Night	0.03	0.06	0.13	0.05	0.10	0.22	0.06	0.09	0.07
Station Security Day	0.05	0.11	0.24	0.08	0.17	0.39	0.10	0.16	0.12
Station Security Night	0.03	0.06	0.13	0.04	0.09	0.21	0.05	0.09	0.07
Train Overall	0.60	1.28	2.95	0.91	2.07	4.95	1.19	1.92	1.50
Station Overall	0.74	1.54	3.69	1.07	2.58	5.97	1.46	2.32	1.83
Total Rail Service	na	na	na	na	na	na	na	na	na
Train Outside	0.05	0.12	0.27	0.08	0.19	0.43	0.11	0.17	0.13
Ease of Boarding	0.06	0.13	0.28	0.09	0.21	0.47	0.11	0.18	0.14
Seat Comfort	0.05	0.12	0.27	0.09	0.20	0.48	0.11	0.19	0.14
Smoothness of Ride	0.04	0.10	0.23	0.07	0.16	0.38	0.09	0.15	0.12
Quietness	0.05	0.12	0.28	0.09	0.19	0.46	0.11	0.18	0.14
Air Conditioning	0.07	0.15	0.35	0.11	0.24	0.56	0.14	0.22	0.17
Lighting	0.02	0.05	0.11	0.04	0.08	0.19	0.05	0.07	0.06
Graffiti	0.02	0.05	0.11	0.03	0.07	0.17	0.04	0.07	0.05
Cleanliness	0.05	0.12	0.26	0.08	0.19	0.43	0.11	0.17	0.13
Announcements	0.03	0.06	0.13	0.05	0.10	0.24	0.06	0.09	0.07
Layout	0.07	0.15	0.34	0.10	0.24	0.54	0.14	0.22	0.17
Train Overall	0.60	1.28	2.95	0.91	2.07	4.95	1.19	1.92	1.50
Station On-Off	0.02	0.04	0.08	0.03	0.06	0.13	0.03	0.05	0.04
Weather Protection	0.02	0.03	0.07	0.02	0.06	0.13	0.03	0.05	0.04
Platform Seating	0.01	0.03	0.06	0.02	0.05	0.11	0.03	0.04	0.03
Platform Surface	0.01	0.02	0.05	0.02	0.04	0.08	0.02	0.03	0.03
Subway-OverBridge	0.03	0.08	0.18	0.05	0.12	0.28	0.07	0.11	0.09
Station Building	0.04	0.09	0.21	0.06	0.15	0.34	0.08	0.13	0.10
Lifts & Escalators	0.03	0.07	0.18	0.05	0.12	0.28	0.07	0.11	0.09
Signing	0.03	0.06	0.13	0.04	0.09	0.21	0.05	0.08	0.06
Announcements	0.03	0.06	0.14	0.05	0.10	0.24	0.06	0.09	0.07
Information	0.03	0.06	0.14	0.04	0.10	0.24	0.06	0.09	0.07
Lighting	0.03	0.07	0.16	0.05	0.11	0.26	0.06	0.10	0.08
Cleanliness	0.04	0.09	0.22	0.07	0.15	0.35	0.09	0.14	0.11
Graffiti	0.04	0.09	0.22	0.06	0.15	0.34	0.09	0.13	0.11
Toilets	0.02	0.03	0.09	0.03	0.05	0.14	0.03	0.05	0.04
Staff	0.08	0.16	0.36	0.12	0.26	0.61	0.15	0.24	0.19
Car Park	0.01	0.01	0.03	0.01	0.02	0.04	0.01	0.02	0.01
Car Drop Off	0.00	0.01	0.02	0.01	0.01	0.04	0.01	0.01	0.01
Taxi	0.01	0.02	0.05	0.01	0.03	0.07	0.02	0.03	0.02
Bus	0.05	0.10	0.24	0.07	0.16	0.37	0.09	0.15	0.12
Bicycle	0.01	0.01	0.02	0.01	0.02	0.04	0.01	0.02	0.01
Telephone	0.01	0.02	0.04	0.01	0.03	0.07	0.02	0.03	0.02
Retail	0.01	0.02	0.04	0.01	0.03	0.08	0.02	0.03	0.02
Ticketing	0.07	0.14	0.30	0.10	0.23	0.50	0.13	0.20	0.16
Station Overall	0.74	1.54	3.69	1.07	2.58	5.97	1.46	2.32	1.83

Source: RailCorp Surveys, Douglas Economics Analysis   DEL Valuation06_6.xls!Model

Table 8 presents the estimated values of time and average fares. The WTP increased with trip length reflecting the higher compensating onboard rail time increases. For a 10% increase in reliability rating, the WTP per peak medium distance trips was 15.8 cents per medium distance peak trip; this was just over twice as much as a 10% improvement in onboard rail time (7.5 cents) and just under three times as much as a 10% improvement in service frequency (5.6 cents).

Table 8: Value of Time & Average Fares

Value of Onboard Rail Time ($/hr) and Average Fare per Trip ($/trip)

	Peak			Off-Peak				Off	
	Short	Med	Long	Short	Med	Long	Peak	Peak	All
Value of Time $/trip	9.51	9.35	9.53	8.14	7.83	7.40	9.46	7.93	8.80
Average Fare $/trip	2.13	2.96	5.32	1.87	2.19	3.60	2.90	2.25	2.62

Values include GST and take account of concession entitlement Valuation06_5.xls!VOT

Source: "Value of Rail Time Survey", Douglas Economics 2004

8. Relative Valuation of Service Interval and Reliability

The 2004-05 Rating Survey asked respondents to estimate the frequency of their train service by giving the number of minutes between departures. Respondents were then asked to rate their train service frequency on a 1-9 scale. Finally, they were asked how frequent the trains would have had to be for them to have rated train frequency as excellent.

For reliability, respondents were asked to estimate how many of their last ten CityRail trips were (i) over 5 minutes late and (ii) over 10 minutes late. Passengers were then asked to rate the reliability of their rail service on a 1-9 scale.

Equations 11 and 12 show the estimation models for service frequency and reliability:

$\Delta SI = SI^{\alpha} \beta \{9 - R_{SI}\}^{\gamma}$ .....(11)

$\Delta E(L) = V^{\alpha} \beta \{9 - R_{REL}\}^{\gamma}$ .....(12)

where:

ΔSI = Reduction in service interval (SI) required for excellent rating (R_{SF}=9)
SI = Current service interval as estimated by respondent
R_{SI} = Service frequency rating
ΔSI = Reduction in service interval (SI) required for excellent rating (R_{SF}=9)
$\Delta E(L)$ = Reduction in expected lateness required for excellent rating (R_{REL}=9)
R_{REL} = Reliability rating
$E(L)$ = Current expected lateness based on passenger estimation of trains late
V = On-train time in minutes
α,β,γ = Parameters to be estimated

The required service interval reduction was roughly proportional to the base service interval but was non-proportional to the service interval rating, Table 9. For reliability, the reduction in expected lateness was approximately proportional to the reliability rating (γ=0.92 for the all observation model) and increased only slightly with trip length for peak respondents (α=0.05 for peak trips).

The two models were used to calculate the change in service interval and reliability associated with a 10% rating point improvement in rating. The changes were then compared with the predicted equivalent change in onboard rail time to derive relative valuations of service interval and expected lateness.

Table 11: Estimated On-Train Time – Rating Model Parameters

Market Segment	SI Parameters			SI Estimation Accuracy			OBS
	α	γ	β	S.E. β	|t| β	S.E. SI	N
Peak	0.95	0.3	0.397	0.006	69.2	4.92	598
Off-Peak	1.05	0.2	0.340	0.007	47.3	5.95	202
ALL	1	0.3	0.340	0.004	83.7	5.27	800
Market Segment	**Reliability Estimates**			**E(L) Estimation Accuracy**			**OBS**
	α	γ	β	S.E. β	|t| for β	S.E. E(L)	N
Peak	0.05	0.96	0.93	0.0212	43.9	2.51	642
Off-Peak	0	0.83	1.36	0.0079	26.6	2.42	230
ALL	0.02	0.92	1.1	0.0054	51.2	2.49	873

Source:RailCorp Surveys, Douglas Economics Analysis QSF06_Analysis_4.xls!PNF2

The relative overall valuation of service interval was 1.15 with a peak value of 0.87 and off-peak value of 1.56, Table 12. The valuation increased with trip length reflecting the relationship between on-board time and rating.

The overall valuation of expected lateness was 3.57 with a peak valuation of 2.8 and an off-peak valuation of 4.72. As with service interval, the relative valuation rose steeply with on-train time.

Table 12: Relative Valuation of Service Interval & Reliability in Onboard Time

Relative Valuation	Peak Short	Peak Medium	Peak Long	Off-Peak Short	Off-Peak Medium	Off-Peak Long	Weighted Peak	Weighted Off-Peak	Weighted All
SI Rating 1-9 Scale	4.8	4.4	4.6	4.7	4.7	5.2	4.7	4.8	4.7
SI Rating + 1 Rating Point	5.8	5.4	5.6	5.7	5.7	6.2	5.7	5.8	5.7
Implied Reduction in SI mins	0.80	0.79	1.11	0.66	0.69	1.13	0.85	0.75	0.80
Compensating Change in Onboard Time mins	0.38	0.83	1.74	0.57	1.26	2.96	0.74	1.17	0.92
Service Interval Valuation mins	0.48	1.04	1.57	0.86	1.83	2.61	0.87	1.56	1.15
Reliability Rating 1-9 Scale	4.20	3.80	4.12	4.20	4.04	5.08	4.04	4.28	4.20
Reliability Rating + 1 Rating Point	5.20	4.80	5.12	5.20	5.04	6.08	5.04	5.28	5.20
Implied Reduction in Expected Lateness mins	0.97	1.01	1.05	0.88	0.88	0.92	0.99	0.89	0.95
Compensating Change in Onboard Time mins	1.49	3.07	6.54	2.49	4.67	8.79	2.79	4.17	3.38
Expected Lateness Valuation mins	1.54	3.04	6.22	2.83	5.33	9.60	2.80	4.72	3.57

RailCorp Surveys, Douglas Economics Analysis DEL QSF06_Analysis_4.xls!ONF2

9. Valuing a Timetable Change

RailCorp introduced a new timetable in 2005 to improve reliability. Some services were slowed and the stopping pattern of some services was altered. The 2004-5 and 2005-6 surveys provide a 'before and after' comparison. The rating evaluation model was able to derive a dollar benefit measure for the 2005 timetable taking account the perceived changes in service frequency, onboard rail time, reliability and seat availability. A four-step procedure was used:

1. Prediction of the change in overall rating
2. Calculation of the change in onboard time rating due to the overall change in rating
3. Valuation of the change in onboard train time rating in equivalent onboard minutes
4. Conversion of the travel time into dollars by applying values of time

Step1: The rating valuation model was used to predict the overall change in rating based on the change in reliability, on-train rail time, service frequency and seat availability (note there was no overall rating in 2005-6).

In terms of individual attributes, the rating of reliability improved from 4.2 in the 2004-05 Survey to 5.5 in the 2005-06 Survey. However, the ratings of on-train time and seat availability decreased slightly with on-train time falling from 5 to 4.5 whilst seat availability fell from 6 to 5.6. Service frequency remained largely unchanged at just under 5.

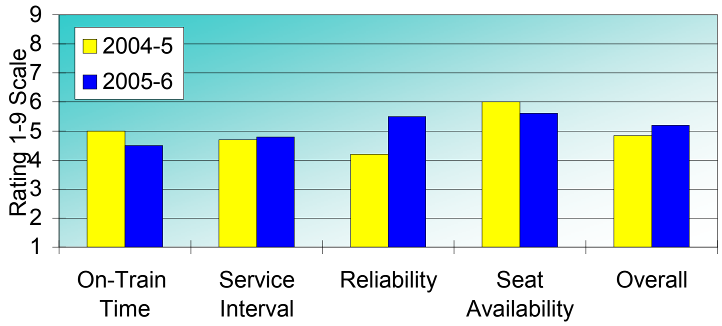
Table 13: Service Ratings Before & After 2005 Timetable Change

Attribute	1-9 Rating Oct04-Feb05	Oct05-Jan06	Change
On-train Time	5.0	4.5	-0.5
Service Frequency	4.7	4.8	0.1
Reliability	4.2	5.5	1.3
Seat Availability	6.0	5.6	-0.4
Overall Rating	4.8	5.2	0.4

(1) Overall for 2005-06 Predicted

RailCorp Surveys, Douglas Economics

DEL QSF06_Analysis_4.xls!CF



To predict the 2005-6 overall rating, the rating explanation model was specified incrementally, 'pivoting' on the 2004-5 overall service rating of 4.8, equation 13. The overall rating for 2005-6 was predicted to increase from 4.8 to 5.2, an increase of 0.4 rating points or 8.3%.

$$R\%_{ALL0506} = \frac{\exp\left(\sum_{1-4} \zeta_i \Delta R\%_i\right) . R\%_{ALL0405}}{\exp\left(\sum_{1-4} \zeta_i \Delta R\%_i\right) R\%_{ALL0405} + \{1 - R\%_{ALL0405}\}} \quad .....(13)$$

where:

ζ_i = importance parameter in explaining the overall service rating for rail service attribute i

$\Delta R\%_i$ = change in rating on probability scale (0 very poor -1 excellent) for attribute i

$R\%_{ALL}$ = overall rating in 04- 05 or predicted for the October 05-February 06 survey

Step 2: The change in overall rating was then converted into the implied change in onboard rail time rating using equation 14:

$$\Delta R\%_{ALLV} = \frac{\ln\left[\frac{R\%_{ALL0506}}{1 - R\%_{ALL0506}}\right] - \ln\left[\frac{R\%_{ALL0405}}{1 - R\%_{ALL0405}}\right]}{\zeta_V} \quad .....(14)$$

where:

$\Delta R\%_{ALLV}$ = change in onboard train time rating required to give the overall rail rating change

ζ_V =parameter for onboard rail time rating in explaining the overall rating (0.5 in Table 8.3)

Step 3 The equivalent change in onboard rail time was predicted using equation 9 then in Step 4, equation 10 was used to calculate the fare benefit measure in cents per trip.

On average, passengers benefited by 4.5 cents per trip, Table 14. Peak passengers benefited by 5.2 cents and off-peak passengers by 3.5 cents per trip.[1] Thus in total, an annual passenger benefit of $12.3 million was predicted to have resulted from the 2005 Timetable change based on 273.4 million rail trips per year, RailCorp (2003). Peak trips benefited by $8.2 million and off-peak trips by $4.1 million.

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[1] It should be noted that the peak, off-peak and overall benefit measures were calculated by trip weighting the six market segment estimates.

Table 14: Change in Rating & Predicted Service Level

Predicted Change	Weighted Peak	Off-Pk	ALL
Equivalent Change On-train Time Rating	-0.4	-0.3	-0.3
Change On-train Time mins/trip	-0.3	-0.3	-0.3
Value of Time $/hr	9.5	7.9	8.8
Benefit Cents/trip	5.2	3.5	4.5
Annual Trips million	156	118	273
Annual Benefit $ million	8	4	12

RailCorp Surveys, Douglas Economics :L QSF06_Analysis_4.xls!CF

8. Conclusions

A rating valuation model was developed to convert changes in passenger ratings, for attributes such as reliability, seat availability and train quality, into an equivalent change in the rating of onboard rail time. A model was then developed to convert the change in onboard rail time rating into on-train time minutes. Finally, by applying values of rail travel time, the 'willingness to pay' for changes in service quality measured through passenger ratings was established.

As a case example, the rating valuation approach was used to value the passenger benefit from the introduction of the 2005 CityRail timetable. Based on the survey ratings, the 2005 timetable noticeably improved reliability although the rating of on-train time and seat availability declined slightly. The valuation model was able to determine the net passenger impact as an overall rating improvement of just over 8% that in turn was worth $12 million per year in passenger benefit.

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Acknowledgments

The authors would like to acknowledge the assistance of Atiqur Rahman and Kerrie Tandy of RailCorp and Greg Baker of 'Counting on Us' who managed the survey fieldwork and data processing.