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Passenger Preferences for Surface versus Underground Rail Travel

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Abstract

Mature city development has forced metropolitan rail line construction underground. Despite this trend, a review of the literature was unable to find any studies that have estimated the preference for surface versus underground travel amongst rail passengers.

This paper reports the results of a 2014 survey of 347 Sydney rail users using services with some underground track. The survey asked about preferences for surface versus underground travel and found that 46% preferred surface travel, 39% were indifferent and 16% preferred underground travel. Unsurprisingly, ‘window views’ was the most important factor that determined a preference for surface travel. Surface travel was also preferred, albeit less strongly, for smoothness/quietness and safety. These three ‘intrinsic’ factors accounted for two thirds of overall preference with the remaining third due to crowding, reliability and speed which were ‘route specific’ factors.

The survey included a set of Stated Preference questions that varied the travel time, fare and method of travel (underground v surface). A ‘penalty’ of 1.9 minutes was estimated for underground travel. Restricting the penalty to ‘intrinsic’ factors reduced the penalty to 1.25 minutes which worked out at 5% of rail travel time.

The survey also asked about on-train activities passengers and found that, unsurprisingly, that the underground penalty was greatest for respondents who ‘relaxed or looked out of the window’ followed by passengers who used the internet (possibly attributable to internet connection problems). The penalty was lowest for passengers who worked, read a book/magazine, talked to their travelling companions or used their electronic device but didn’t access the internet.

1. Introduction

Mature city development has forced metropolitan rail line construction underground. Despite this trend, a review of the literature was unable to find any studies that have attempted to estimate the public's preference for going underground.[1]

This paper attempts to address this knowledge gap by reporting the results of a 2014 survey of 347 Sydney rail users who used three rail services that involve some underground travel. The survey asked about preferences for surface versus underground travel and included a set of Stated Preference questions that aimed to estimate the size of any 'tunnel penalty' in equivalent rail time minutes.

Section 2 provides a review of the literature which is necessarily short because no studies were able to be found that attempted to estimate the preference for surface versus underground rail travel. Section 3 provides an overview of the survey and the profile of the sample. Section 4 describes passenger preferences for surface versus underground travel in terms of journey attributes and respondent characteristics. Section 5 summarises the Stated Preference component of the survey. Section 6 gives the conclusions of the study.

2. Literature Review

The literature review was unable to find any studies that had attempted to estimate the preference for surface versus underground rail travel.

Some studies have been undertaken into driver attitudes towards the design of road tunnels, see for example Wolstenholme (2014) but no quantified 'penalties' as such were found for driving in tunnel versus on the surface.

The patronage forecasting work for the underground Epping-Chatswood rail line in Sydney in the late 1990s and early 2000s did look at the patronage impacts of building a bridge over the Lane Cove river (with a station to serve a university campus at UTS) rather than remaining underground, PCIE (2001). To model the impacts, a disbenefit of 0.5 minutes was assumed for the tunnel option. The bridge option was later rejected on environmental grounds (Lane Cove being a National Park).

Other studies that have used Stated Preference (SP) market research techniques to forecast patronage for metro style rail services have tended not to mention the amount of time likely to be spent underground. As an example, Hensher (2011) undertook SP patronage research for a proposed Sydney Metro service which would have involved some underground running. Hensher included several variables in the survey such as access time, frequency and crowding, but did not mention underground travel to compare with the surface running of heavy rail and bus alternatives.

3. Survey Overview & Sample Profile

The survey used a self-completion questionnaire handed out and collected by surveyors onboard train. Three lines were surveyed which all had sections of underground track: Illawarra-Eastern Suburbs Railway (ESR), Airport Rail Line (ARL) and the Epping-Chatswood rail line (ECRL).

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[1] "*And the public gets what the public wants but I want nothing this society's got, I'm going underground (going underground)*" Weller (1982).

The ESR rail line from Central to Bondi Junction was opened in 1978 and largely runs underground from Redfern (2 minutes south of Central) to Bondi Junction (15 minutes). There are some short stretches where the line surfaces however.

The Airport Rail Line runs between Wolli Creek (where passenger can transfer to the Illawarra line) and Central via Sydney Airport International and Domestic terminals. The line which runs through to the East Hills line at Wolli Creek was opened in 2000 is all in tunnel and is 10 kilometres long. The trip takes 16 minutes between Wolli Creek and Central.

The Epping Chatswood rail line linking the Main North line with the North Shore line was opened in 2008. The line is all ‘in tunnel’ and is 13 kms long taking 17 minutes between Epping and Chatswood.

Figure 1: Surveyed Rail Lines

The survey was undertaken in February-March 2014 and surveyed 347 passengers.

The survey asked questions about the preference for surface versus underground travel and presented a set of pair-wise Stated Preference choices in which the travel time, fare and whether the trip was on the surface or underground varied. To help explain passenger preferences, respondents were asked what activities they did whilst travelling on the train.

The sample was reasonably well balanced across the three lines with 151 questionnaires (44%) completed on ARL services, 102 (29%) on ECRL services and 84 on (27%) ESR services. The sample was however skewed towards the off-peak with two-thirds of completed questionnaires compared to a third on peak trains.

The sample was described in terms of journey purpose, gender, age group, employment status, income and fare concession entitlement. Table 1 summarises the sample profile.

Passengers were asked how long they would spend on the train. The average time was 42 minutes, varying between 34 on ECRL services to 45 minutes on Illawarra and ARL services.

Passengers were also asked their board and alight stations. Based on the stations given, the time spent underground was calculated at 14 minutes for ECRL and ARL respondents. For ESR respondents the underground time was shorter at 4 minutes.

Table 1: Sample Profile

Statistic	ESR	ARL	ECRL	All
Peak (%)	31%	30%	50%	36%
Off-Peak (%)	69%	70%	50%	64%
To/from work (%)	37%	31%	20%	29%
To/from education (%)	31%	20%	62%	35%
Other trip purpose (%)	32%	49%	18%	35%
Employed (%)	50%	52%	31%	45%
Student (%)	34%	35%	64%	43%
Other (%)	16%	12%	5%	11%
Fare Concession (%)	45%	42%	44%	44%
Av income ($k p.a.)	45	39	36	40
Average Age (Years)	35	32	30	32
Female (%)	65%	58%	52%	58%
Time Underground (mins)	4	13	14	11
Total Rail Time (mins)	45	45	34	42
Percent Underground (%)	9%	30%	42%	27%
Sample	94	151	102	347

The profile was compared with that of a larger system-wide survey to estimate values of service level quality. Based on the comparison, a set of weights were created to adjust the sample in terms of trip purpose and concession use.

Passengers were asked what activities they did whilst travelling on the train with response considered likely to affect preferences for surface versus underground travel. For instance, passengers who 'relaxed and looked at the view' were considered more likely to prefer surface travel than passengers who read a book or did work or talked to their travelling companions.

The questionnaire allowed for passengers to tick more than one activity which meant that the response percentages summed to over 100%. A set of 'activity shares' were calculated by dividing the number 'ticking' an activity by the total number of activities ticked.

Table 2: Passenger Activities whilst Travelling on Train

Activity	Number			Percent	Activity
	Yes	No	Response*	Yes	Share %
Read a book/magazine	140	183	323	43%	19%
Did some work/thought about work	87	236	323	27%	12%
Used Internet on electronic device^	183	140	323	57%	25%
Electronic Device but not internet^^	76	247	323	24%	10%
Talked to my travelling companions	62	261	323	19%	9%
Relaxed and looked at the view	148	175	323	46%	20%
Something else	30	293	323	9%	4%
Total Activities	726	na	323	225%	100%

^ Used the internet on my smart phone/tablet/laptop ^^Used my smart phone/tablet/laptop but not the internet. * Total sample was 332 with 9 not answering the activity question

The most common activity was electronic devices (smart phones, tablets or laptops) with 57% using the internet and 24% not using the internet. Second on 46% was to 'relax and look at the view' with reading a book/magazine third on 43%. Around a quarter did some work or thought about work and a fifth talked to their travelling companions.

The activity shares in the right hand column assume that equal time was spent on each activity where more than one was given indicate that 25% of time was spent on the internet and 20% relaxing and looking at the view with 19% spent reading a book/magazine.

4. Preference for Surface versus Underground Travel

Passengers were asked their preference for travelling 'on the surface' versus 'in tunnel'. The questions were tailored to each rail line. Figure 2 presents the question shown to passengers surveyed on the ARL.

Figure 2: Preference for Surface v Underground Travel Question

8. Your rail trip involves travelling on two rail lines:
(1) The East Hills Line between Campbelltown and Wolli Creek which is *'on the surface'*
(2) The Airport Line between Central and Wolli Creek which is *'in tunnel'*.

For each of the seven factors listed below, please tick the box which describes your preference for travelling *'on the surface'* on the East Hills Line or *'in tunnel'* on the Airport Line.

Factor	Strongly Prefer East Hills Line	Weakly Prefer East Hills Line	No Preference	Weakly Prefer Airport Line	Strongly Prefer Airport Line
a) Reliability - Service Delays					
b) Smoothness /Noise of Train					
c) Window Views					
d) Feeling of Personal Safety					
e) Number of Stops & Speed of Train					
f) Crowding on the Train					
g) Your Overall Preference					

In terms of the overall preference, surface travel was preferred to underground travel with 29% having a strong preference and 17% a weak preference. 39% had no overall preference with 9% strongly and 7% weakly preferring underground travel.

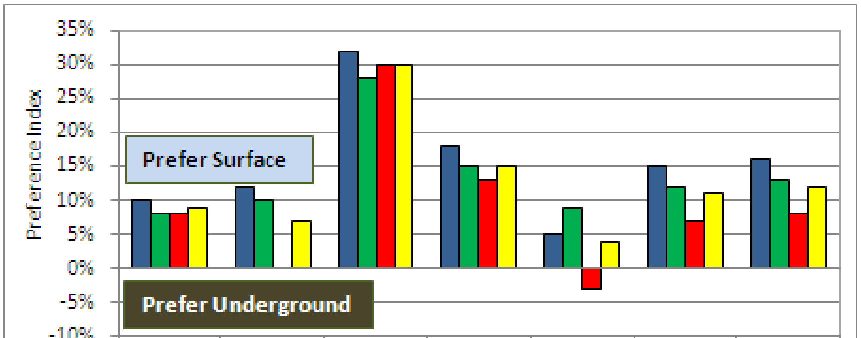
Table 3: Preference for Surface versus Underground Travel

Strength of Preference	Rel-iability	Smooth-ness	View	Safety	Speed	Crowd-ing	Overall
Strongly Prefer Surface	25%	24%	56%	29%	24%	27%	29%
Weakly Prefer Surface	9%	14%	12%	12%	8%	10%	17%
No Preference	51%	41%	29%	52%	44%	52%	39%
Weakly Prefer Underground	7%	10%	1%	4%	10%	5%	7%
Strongly Prefer Underground	9%	11%	2%	3%	14%	6%	9%

Unsurprisingly, the strongest preference for surface travel was 'views' with 56% having a strong preference and 12% a weak preference which contrasted with a negligible preference for underground travel. The next strongest preference for surface travel was safety. For speed, the preference for surface travel was weaker and for reliability and crowding one half of respondents had no preference either way.

A 'preference index' was calculated which weighted 'strongly prefer surface travel' at 50%, 'weakly prefer' at 25%, 'no preference' at 0%, 'weakly prefer underground' at -25% and 'strongly prefer underground' at -50%. Overall, there was a 12% point preference for surface travel with the strongest preference for 'views' (30%) followed by safety (15%). Smoothness/noise was also favoured surface travel by 7% points. There was also a preference in terms of crowding (11%) and reliability (9%) which are more ‘route specific’ than ‘intrinsic’ factors distinguishing surface from underground travel. In terms of speed, which is also a route specific factor, the preference for surface travel was weakest at 4%.

Figure 3: Preference Index for Surface v Underground Travel



	Reliab	Smooth	View	Safety	Speed	Crowding	Overall
ESR	10%	12%	32%	18%	5%	15%	16%
ARL	8%	10%	28%	15%	9%	12%	13%
ECRL	8%	0%	30%	13%	-3%	7%	8%
ALL	9%	7%	30%	15%	4%	11%	12%

The relative importance of each individual factor was estimated by regression using the surface v tunnel preference index but without subtracting 0.5, equation 1. The model was fitted without a constant and was constrained so that the six parameters summed to 1.

$P_{ALL} = \sum \beta_x P_X$ subject to $\sum \beta_x = 1$ ......(1)

Where:

P_{ALL} = the overall preference for surface travel (1= 100%)
P_X = the preference for each factor and
β_X = the parameter governing the relative importance of each factor.

For the all observation model, speed was the most important factor explaining 32% of overall preference; crowding was second on 23% with views third on 21%. Smoothness explained 14%. Neither reliability (8%) nor safety (3%) was statistically significant at the 95% confidence level.

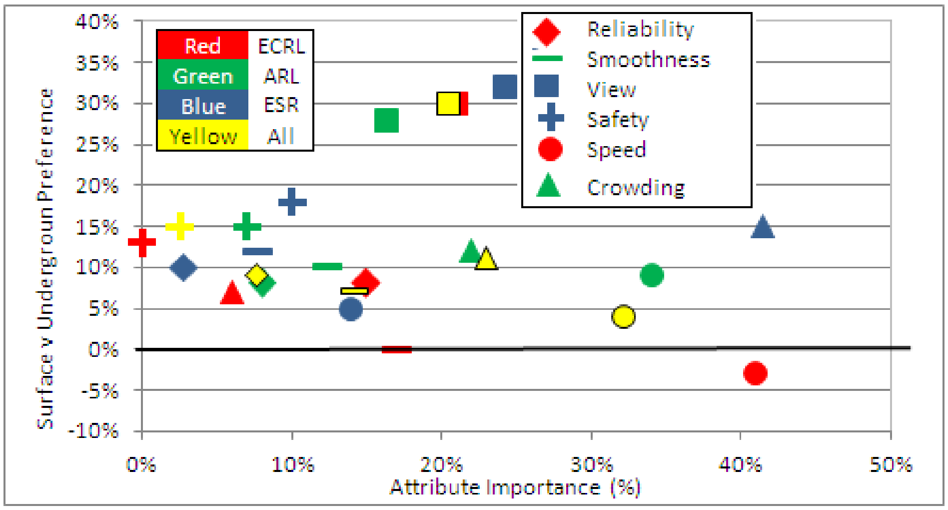
Table 4: Attribute Importance for Surface v Underground Travel

Attribute	ESR		ARL		ECRL		ALL	
	β	|t|	β	|t|	β	|t|	β	|t|
Reliability	3%	0.3	8%	1.0	15%	1.7	8%	1.5
Smoothness/Noise	8%	0.9	12%	1.5	17%	2.3	14%	3.0
Window Views	24%	3.5	16%	2.6	21%	3.4	21%	5.4
Safety	10%	1.2	7%	0.9	-	-	3%	0.5
Speed	14%	1.8	34%	5.3	41%	5.2	32%	7.6
Crowding	41%	5.5	22%	2.7	6%	0.7	23%	4.7
Total	100%	-	100%	-	100%	-	100%	-
Observations	90		142		100		332	

The relative importance varied by rail line. For the ARL and ECRL, speed was the most important factor accounting for 34% and 41% respectively but for the ESR speed only explained 14% with crowding (41%) the most important factor. There was less variation in the importance of 'views' which ranged from 16% to 24%

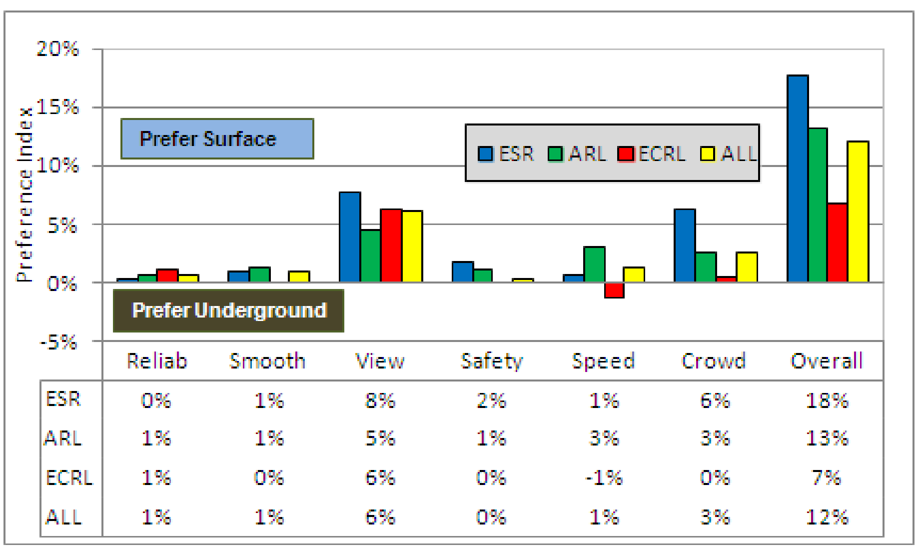
Figure 4 plots attribute preferences against attribute importance. Views had the highest surface preference (30%) and explained 20% of overall preference. Speed had a much weaker surface preference but was a more important attribute. The other attributes had generally weaker preferences and lower preferences.

Figure 4: Strength of Preference versus Attribute Importance



The overall preference can be predicted by multiplying the individual attribute preferences by their respective importance and then summing the scores. Figure 5 shows the composition of the overall preference index with views dominating the result. At 12%, the predicted preference index for surface travel was the same as the observed response (Figure 2).

Figure 5: Composition of Overall Surface Travel Preference



	Reliab	Smooth	View	Safety	Speed	Crowd	Overall
ESR	0%	1%	8%	2%	1%	6%	18%
ARL	1%	1%	5%	1%	3%	3%	13%
ECRL	1%	0%	6%	0%	-1%	0%	7%
ALL	1%	1%	6%	0%	1%	3%	12%

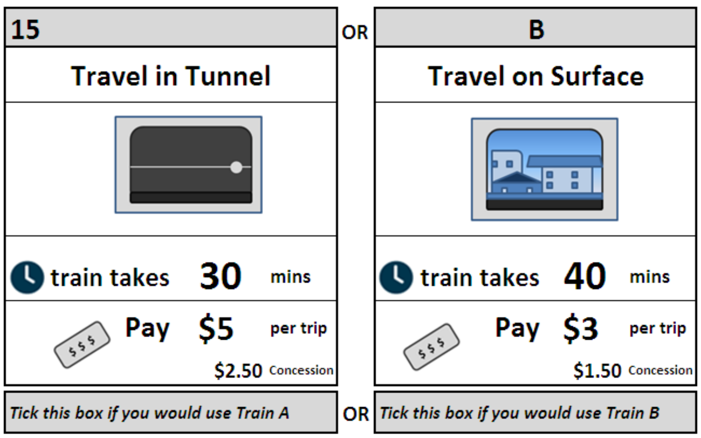
The preference for surface v tunnel travel was also assessed by passenger activity. Preferences were reasonably constant across the activities apart from passengers who relaxed and looked at the view to have a stronger preference for surface travel (17% points compared to 12% overall).

Splitting the preference into ‘intrinsic’ attributes (smoothness/noise, view and safety) and ‘route specific’ attributes (reliability, speed and crowding) results in 63% of the total preference being ‘intrinsic’ and 37% being ‘route specific’.

5. Stated Preference Survey

The survey included a set of pair-wise choices in which respondents ‘traded-off’ time against cost. Confounding the choice was whether travel was on the surface or underground tunnel. Figure 6 presents an example choice.

Figure 6: Example Stated Preference Show Card



There were therefore three variables featured in the show cards, each of which could take one of three levels. The fare differences were $1, $2 and $3 (halved for concession users). Travel time (IVT) was either 10 minutes or 15 minutes quicker by train A with two ten minute differences specified from a base of either 20 or 40 minutes to see whether the length of travel time affected preferences. The ‘method’ of travel was either surface v surface; tunnel v tunnel or tunnel v surface. Given that A was always quicker than B, the tunnel option was always quicker than the surface option.

A full factorial design was used which required 27 choices (3^3). The questions were split into four sets with each respondent completing 7 choices (one pair-wise choice was repeated). The ordering of the show cards was randomised and half the cards were swapped so that the quicker mode was sometimes on the right and sometimes on the left.

Altogether, a sample of 2,107 responses was obtained. Response varied across the 27 questions from 65 to 137 which reflected the omission of response to pilot surveys where the levels differed from the final questionnaire and including one question twice (which balanced the numbers of questions across the four sets shown to respondents).

The lowest percentage choosing A was 25% for question 27 which featured 30 minutes travel in tunnel costing $6 versus 40 minutes of surface travel costing $3. The highest percentage choosing A was 81% for question 13 where travel was by tunnel for both A and B and where A was 15 minutes shorter than B and cost $1 more.

Table 5: Tunnel v Surface SP Response by Question

#	Time	Fare	Mode	% A	N	#	Time	Fare	Mode	% A	N	#	Time	Fare	Mode	% A	N
1	10v20	5v4	SvS	67%	76	10	10v20	5v4	TvT	76%	78	19	10v20	5v4	TvS	67%	69
2	10v20	5v3	SvS	49%	81	11	10v20	5v3	TvT	51%	77	20	10v20	5v3	TvS	58%	69
3	10v20	6v3	SvS	46%	79	12	10v20	6v3	TvT	43%	80	21	10v20	6v3	TvS	28%	69
4	17v32	5v4	SvS	85%	81	13	17v32	5v4	TvT	81%	77	22	17v32	5v4	TvS	74%	65
5	17v32	5v3	SvS	64%	86	14	17v32	5v3	TvT	78%	79	23	17v32	5v3	TvS	69%	67
6	17v32	6v3	SvS	46%	79	15	17v32	6v3	TvT	45%	80	24	17v32	6v3	TvS	44%	68
7	30v40	5v4	SvS	55%	77	16	30v40	5v4	TvT	61%	79	25	30v40	5v4	TvS	46%	69
8	30v40	5v3	SvS	44%	81	17	30v40	5v3	TvT	59%	80	26	30v40	5v3	TvS	46%	137
9	30v40	6v3	SvS	32%	79	18	30v40	6v3	TvT	32%	76	27	30v40	6v3	TvS	25%	69

A logistic function was fitted to explain the individual responses. Response either a value of one if service A was selected or zero if B was selected. Maximum likelihood estimation was used to find the parameter values most likely to have produced the observed responses. The model is shown in equation 2.

$Pa = \dfrac{\exp Z}{1 + \exp Z}$ where:

$$Z = \alpha + \beta_f \Delta F + \beta_{fc} \Delta F.C + \beta_t \Delta IVT + \beta_{ts} TvS + \beta_{tt} TvT \; ....(2)$$

$F =$ fare difference (A-B) in dollars (taking account fare concession (½ΔF) where appropriate)
$C =$ concession entitlement taking a value of 1 if entitled to a concession else zero
IVT difference in train time (A-B) in minutes
$TvS =$ dummy variable taking a value of 1 if service A was by tunnel and service B was by surface travel else 0
$TvT =$ dummy variable taking a value of 1 if both service A were by tunnel else 0.
$\alpha, \beta_i =$ parameters to be estimated (note given TvS and TvT dummy variables α denotes travel by surface for both services A and B.

Although a constant (α) and variable for the Tunnel v Tunnel choice are shown in equation 2, both parameters were statistically insignificant and were therefore omitted. Thus the tunnel v surface penalty was measured against the average of tunnel v tunnel and surface v surface travel.

Two sets of weights were applied to the response data. The first set balanced the SP response so that each question was equally represented. The second set matched the sample profile in terms of trip purpose and concession entitlement to the standard Sydney rail profile. Table 6 presents the SP weighted model on the left and the SP and trip/concession weighted on the right. All the parameters were statistical significant.

The tunnel penalty, which was calculated as the ratio of the tunnel dummy variable parameter over the IVT parameter, was 1.9 minutes. Given that the average trip in the design was 15 minutes, the tunnel penalty represented 8% of travel time. Thus, the travel time multiplier for time spent underground was 1.08. In relation to fare, the penalty was worth 34 cents (9% of the average fare in the design).

The results of the surface v tunnel preference questions (section 4) were used to restrict the tunnel penalty to only 'intrinsic' factors (i.e. views, safety and quietness/noise) which collectively were worth 63% of the total preference. This reduced the tunnel penalty to 1.25 minutes and the travel time multiplier to 1.05.

Table 6: Estimated Surface v Underground SP Model

Parameter	SP Weighted		SP & Purp/Conc Weighted	
	β	*t*	β	*t*
IVT Dif	-0.137	-15.2	-0.14	-14.5
Fare Dif	-0.654	-11.7	-0.66	-12.2
Conc Fare Dif	-0.685	-8.3	-0.76	-8.3
Tunnel v Surface	-0.245	-2.6	-0.27	-2.8
Tunnel Penalty (mins)	1.8	2.5	1.9	2.8
Tunnel Penalty ($)	0.37	2.5	0.41	2.8
Tunnel Penalty Conc ($)	0.18	2.5	0.19	2.7
Tunnel Penalty Av ($)	0.29	3.2	0.34	3.3
Value of Time $/hr	12.57	9.3	13.05	9.3
Value of Time (Conc) $/hr	6.14	9.3	6.06	9.1
Value of Time Av $/hr	9.74	12.0	10.81	11.1
Concession Share (%)	44%	-	32%	-
Observations	2,108	-	2,108	-

The value of time for non concession passengers was $12.57/hr and $6.14/hr for concession passengers. The values were slightly lower than the figure of $13.49/hr estimated by Legaspi and Douglas (2015) for Sydney rail passengers using similar Stated Preference surveys undertaken reasonably contemporaneously.

With 44% of respondents in the sample entitled to a concession, the overall average was $9.74/hr. Weighted to the Sydney system-wide trip and concession profile (32% concessions) increased the value of time to $10.81/hr.

Table 7: Tunnel v Surface Travel Preference SP Models by Passenger Activity

	Parameter Value							
Parameter:	Read	Work	Wifi	EDEV	Talk	View	Other	ALL
IVT Dif	-0.15	-0.21	-0.19	-0.22	-0.16	-0.16	-0.14	-0.14
Fare Dif	-0.66	-0.92	-0.90	-0.86	-0.68	-0.82	-0.88	-0.66
Conc Fare Dif	-0.98	-1.21	-0.77	-1.67	-1.56	-0.98	-0.68	-0.76
Tunnel v Surface	-0.07	0.06	-0.32	-0.14	-0.18	-0.44	-0.69	-0.27
Tunnel Penalty (mins)	0.49	-0.31	1.67	0.62	1.16	2.82	4.94	1.90
Tunnel Penalty ($)	0.11	-0.07	0.36	0.16	0.27	0.54	0.79	0.41
Tunnel Penalty Conc ($)	0.04	-0.03	0.19	0.06	0.08	0.25	0.45	0.19
Tunnel Penalty ($)	0.09	-0.06	0.31	0.13	0.21	0.44	0.63	0.34
Value of Time $/hr	13.55	13.41	12.79	15.62	13.87	11.48	9.60	13.05
Value of Time (Conc) $/hr	5.47	5.79	6.86	5.31	4.21	5.22	5.41	6.06
Value of Time $/hr Av	11.21	11.50	11.19	12.53	10.83	9.41	7.67	10.81
Concession Share	29%	25%	27%	30%	32%	33%	46%	32%
Observations	939	561	1,175	539	413	927	927	2,108
	t Value							
Parameter:	Read	Work	Wifi	EDEV	Talk	View	Other	ALL
IVT Dif	-10.7	-9.4	-13.6	-9.6	-7.1	-9.8	-4.5	-14.5
Fare Dif	-8.5	-8.1	-11.6	-7.2	-5.6	-9.2	-4.5	-12.2
Conc Fare Dif	-7.0	-5.9	-6.0	-7.4	-6.8	-6.7	-2.4	-8.3
Tunnel v Surface	-0.5	0.3	-2.4	-0.7	-0.8	-2.8	-2.1	-2.8
Tunnel Penalty (mins)	0.5	-0.3	2.4	0.7	0.8	2.7	1.9	2.8
Tunnel Penalty ($)	0.5	-0.3	2.3	0.7	0.8	2.7	1.9	2.7
Tunnel Penalty Conc ($)	0.5	-0.3	2.3	0.7	0.8	2.7	1.9	2.7
Tunnel Penalty Conc ($)	0.6	-0.4	2.8	0.8	0.9	3.2	2.5	3.3
Value of Time $/hr	6.6	6.1	8.9	5.8	4.4	6.7	3.2	9.3
Value of Time (Conc) $/hr	6.9	6.0	7.9	6.4	5.2	6.7	3.0	9.1
Value of Time $/hr Av	7.6	6.9	10.4	6.6	5.0	8.0	4.2	11.1

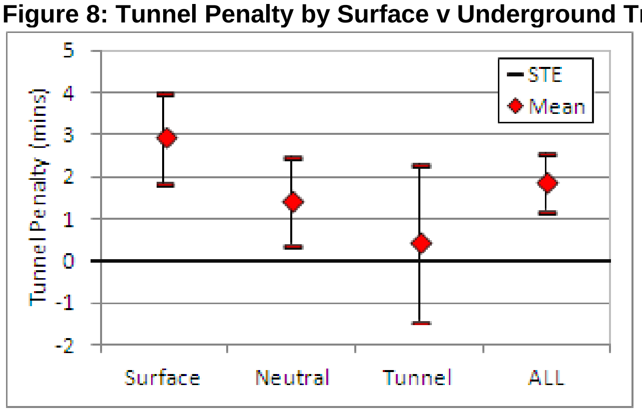
The response to the SP was analysed by passenger activity. Unsurprisingly, the tunnel penalty was strongest (excluding 'other' activities), at 2.8 minutes, for passengers relaxing or looking out of the window (View). The penalty was slightly lower at 2.4 minutes for passengers using an electronic device and accessing the internet (wifi) which may reflect poorer reception in tunnels than on the surface. For passengers 'working' (work) or reading a book (read) the penalty was not significantly different from zero. The value of time tended to decline as the tunnel penalty increased. Passengers relaxing or looking out of the window valued time at $9.41/hr compared to passengers working at $11.50/hr.

Those respondents who preferred surface travel also tended to have the highest tunnel penalty which averaged 2.9 minutes. Those respondents who were indifferent (neutral), had a penalty of around 1.4 minutes and for those who preferred tunnel travel, the penalty was in significantly different from zero.

Table 8: Tunnel v Surface Models by Tunnel v Surface Preference

	Parameter Estimate				t Value			
Value of Time $/hr	Surface	Neutral	Tunnel	ALL	Surface	Neutral	Tunnel	ALL
IVT Dif	-0.14	-0.15	-0.13	-0.14	-9.5	-9.6	-5.1	-14.5
Fare Dif	-0.69	-0.65	-0.64	-0.66	-8.4	-7.4	-4.8	-12.2
Conc Fare Dif	-0.68	-0.76	-0.97	-0.76	-4.9	-5.0	-4.4	-8.3
Tunnel v Surface	-0.42	-0.22	-0.06	-0.27	-2.9	-1.4	-0.2	-2.8
Tunnel Penalty (mins)	2.94	1.44	0.44	1.90	2.8	1.4	0.2	2.8
Tunnel Penalty ($)	0.61	0.34	0.09	0.41	2.7	1.4	0.2	2.7
Tunnel Penalty Conc ($)	0.31	0.16	0.04	0.19	2.7	1.4	0.2	2.7
Tunnel Penalty ($)	0.51	0.29	0.07	0.34	3.3	1.6	0.3	3.3
Value of Time $/hr	12.38	14.33	12.06	13.05	6.3	5.9	3.5	9.3
Value of Time (Conc) $/hr	6.24	6.58	4.79	6.06	5.9	5.7	3.8	9.1
Value of Time $/hr Av	10.48	11.92	9.51	10.81	7.5	6.9	4.1	11.1
Concession Share	31%	31%	35%	32%	-	-	-	-
Observations	952	806	352	2,108	-	-	-	-

Figure 8: Tunnel Penalty by Surface v Underground Travel Preference



6. Conclusions

Despite the construction of underground rail lines, no studies were able to be found that had attempted to estimate the preference for surface versus underground rail travel. To attempt to fill the knowledge gap, a survey of 347 Sydney rail passengers who used services where part of the trip was underground was undertaken. The survey asked questions about the preference for surface versus underground travel and included a set of pair-wise Stated Preference choices to quantify any tunnel penalty. To help explain the observed preferences, respondents were asked what activities they did whilst travelling on the train.

The survey established that 46% of rail passengers preferred surface to underground travel, 39% were indifferent and 16% preferred underground travel. 'Window views' was the most important attribute in preferring surface travel. Surface travel was also preferred, albeit less strongly, for reasons of smoothness and quietness and also safety. These three ‘intrinsic’ attributes accounted for two thirds of the overall preference for surface travel. The remaining third was explained by crowding, reliability and speed which were considered ‘route specific’ rather than ‘intrinsic’ attributes.

The survey estimated a tunnel penalty worth 1.9 minutes of rail travel time. When restricted to ‘intrinsic’ underground attributes (views, safety and smoothness and noise), the penalty reduced to 1.25 minutes. Expressed as a travel time multiplier, underground travel added 5% to travel time.

The estimated tunnel penalty, which is considered relevant for trips of 10 minutes or longer, could be used in forecasting route assignment and mode share.

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