Transportation Planning and Technology
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gtpt20

Effects of price promotions on potential consumers of high-speed rail

Yi-Wen Kuo[a], Cheng-Hsien Hsieh[b], Cheng-Min Feng[c] & Wen-Ya Yeh[c]

[a] Department of Logistics Management, Shu-Te University, Kaohsiung City, Taiwan

[b] Department of Marketing and Logistics Management, Chihlee Institute of Technology, New Taipei City, Taiwan

[c] Institute of Traffic and Transportation, National Chiao Tung University, Taipei City, Taiwan

Published online: 29 Oct 2013.

To cite this article: Yi-Wen Kuo, Cheng-Hsien Hsieh, Cheng-Min Feng & Wen-Ya Yeh (2013) Effects of price promotions on potential consumers of high-speed rail, Transportation Planning and Technology, 36:8, 722-738, DOI: 10.1080/03081060.2013.851508

To link to this article: http://dx.doi.org/10.1080/03081060.2013.851508

Transportation Planning and Technology, 2013
Vol. 36, No. 8, 722–738, http://dx.doi.org/10.1080/03081060.2013.851508

Effects of price promotions on potential consumers of high-speed rail

Yi-Wen Kuo[a], Cheng-Hsien Hsieh[b]*, Cheng-Min Feng[c] and Wen-Ya Yeh[c]

[a]*Department of Logistics Management, Shu-Te University, Kaohsiung City, Taiwan;* [b]*Department of Marketing and Logistics Management, Chihlee Institute of Technology, New Taipei City, Taiwan;* [c]*Institute of Traffic and Transportation, National Chiao Tung University, Taipei City, Taiwan*

(*Received 24 August 2011; accepted 31 July 2013*)

Effects of price promotions for high-speed rail (HSR) on the choice behaviours of potential consumers are analysed for public transit marketing purposes. A questionnaire survey, with 300 valid samples collected from private vehicle drivers with long-distance trips through freeways, is conducted. Factor analysis is employed to determine the constructs of service quality, while a discrete choice model considering individual heterogeneity, namely a mixed logit model, with stated preference is utilised to explore the diversion of passengers from private vehicle drivers due to price promotions. Analytical results reveal that service qualities, socio-economic characteristics and price promotions significantly affect choice behaviours. Finally, some strategies are developed from these analytical results to help a HSR operator increase its market share.

Keywords: service quality; price promotions; high-speed rail; mixed logit model; Taiwan

Introduction

Asian cities have experienced fundamental socio-economic changes resulting from rapid population growth and expansion in the use of private vehicles. The relationships between rising incomes, extensive car ownership and improvements in the road network have increased private vehicle use (Asensio 2002). The rapid growth of private vehicle ridership has had a negative impact on the quality of life through increases in accidents, travel times, natural resource consumption, congestion and environmental damage. Since promoting the sharing of public transport assists in mitigating pollution, reduces energy consumption and encourages sustainable transportation (Kim, Ulfarsson, and Hennessy 2007), it is essential to determine an efficient and effective approach to improve mobility, accessibility and environmental quality, by enhancing public transport design (Alterkawi 2006).

Taiwan is a narrow island stretching approximately 400 kilometres (km) from north to south with over 95% of the population living in the Western corridor. The increasing demand for intercity transportation in this corridor has attracted the attention of authorities who are striving to provide the best solution. Along with two freeways serving private vehicles, public transport services such as airways, freeway buses, the railway and high-speed rail (HSR) have served to intensify the competition among

*Corresponding author. Email: chhsieh@mail.chihlee.edu.tw

different modes of transportation (Yang and Sung 2010). Most authorities recognise bus-based systems as legitimate alternatives to rail systems (Wright and Hook 2006) owing to the lower associated financial risks, including less potential for cost overruns and greater responsiveness to forecast demand (Hensher 2007). However, previous studies have concluded that investment in rail offers the best overall solution to public transport problems (Hensher and Waters II 1994; Kain 1988).

Accordingly, an efficient high-speed mass transportation system is considered necessary in order to meet anticipated demand for intercity and regional daily commuting and business trips. The HSR linking the Western corridor of Taiwan with a total length of 345 km and eight stations commenced operation in January 2007. The THSR has cut travel time between north and south to 90 minutes, meaning that most residents of Taiwan can make one-day return trips. The substitutability between public transport modes has caused a significant decline (by more than 50%) in the ridership of domestic airlines, while freeway buses lost 13.2% of their passenger volume due to the HSR operations, as shown in Figure 1. The Taiwan Railway Administration (TRA) has improved local shuttle services to mitigate the effects of shifting passengers for long-distance trips. This has allowed the TRA to retain its ridership although the average travel distance per passenger has decreased by 16.4%, and revenues have fallen by 11.9%.

Private vehicles occupy about 65% of the mode share, largely because of the advantages of door-to-door accessibility, mobility, amount of private space in a passenger car (Anable 2005), inconvenience in transferring between modes of public transport, and last but not least, the focus on development of car-oriented transportation in Taiwan. Figure 1 illustrates that there was an insignificant decline of car users in 2009 whereas the average load factor of the HSR was only 46%. This indicates that the shifting of passengers from other modes of public transport is insufficient to assist the HSR in achieving break-even operation. How to promote the competitive advantage of the HSR over private vehicles rather than other forms of public transport becomes a crucial issue for developing a sustainable transportation system. However, previous researchers have focused on competition for the choice of modes (Hensher and Rose 2007; Román, Espino, and Martín 2007). This study begins by investigating the critical factors impacting the choice behaviour of potential HSR consumers (i.e. private vehicle users) and then develops appropriate strategies for improving the market share of the HSR.

Research framework

The major difference between this and previous studies is that the utility of the HSR is constructed by taking into account only private vehicle users rather than public transport riders when determining insufficient services of HSR. Several HSR marketing scenarios and alternatives are generated by means of a stated preference survey. Along with travel cost and travel time, this study investigates some essential factors impacting mode choice behaviour that have been omitted previously in the literature. According to the preliminary survey, private vehicle users choose not to use HSR services owing to problems with inaccessibility, cost, inconvenience, discomfort, time-consumption and unreliability. This study uncovers factors impacting choice behaviour for the HSR based on the literature review and extracts the principal components using factor analysis. Moreover, the discrete choice model, involving marketing alternatives, essential impact factors and socio-economic characteristics, is employed to examine the effect of marketing strategies on HSR ridership. Figure 2 shows the research framework.

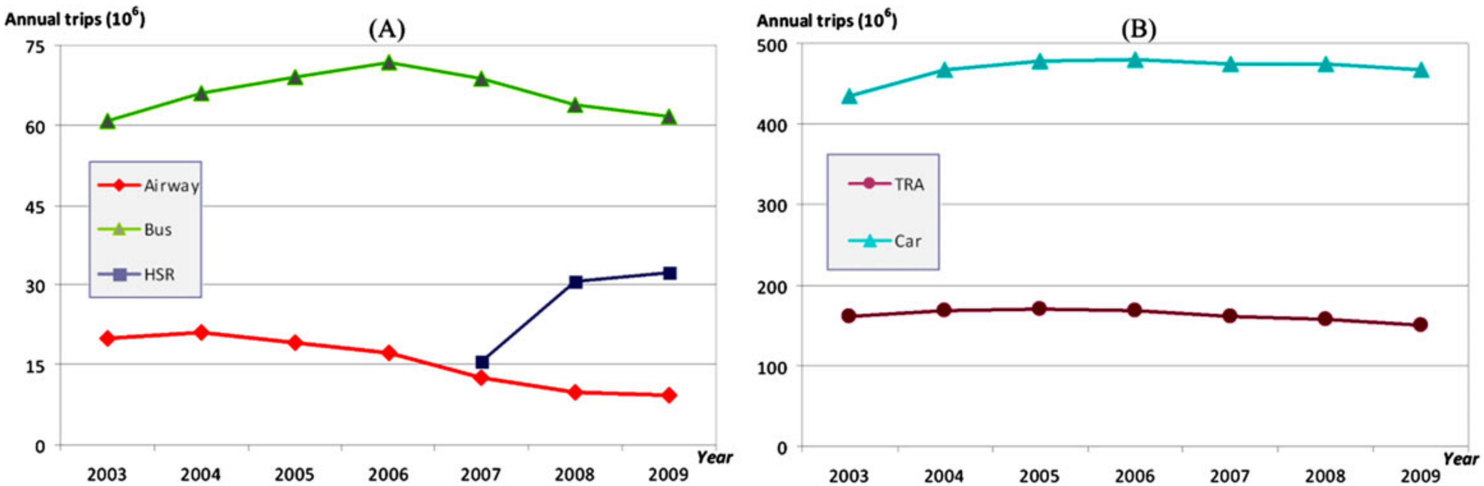

Figure 1. Trends in mode ridership.

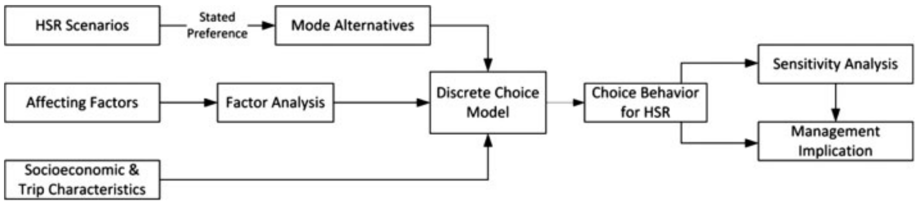

Figure 2. Research framework.

Alternatives

Hensher and Prioni (2003) examined the shift in potential demand due to the introduction of HSR services from Sydney to Canberra via a stated preference survey. The mode share of passenger cars, buses, HSR and chartered buses was predicted according to the preferences expressed by the respondents who comprise residents, domestic tourists and commuters in the corridor. González-Savignat (2004) also explored the mode choice behaviours of private vehicle drivers in Spain under the HSR operation scenario with a stated preference study. A multinomial logit (MNL) model involving the different distances and purposes of the trip was employed to estimate the critical variables impacting car users in changing their mode of transport. The analytical results revealed that most respondents are willing to shift to the HSR provided the impact factors are acceptable with monetary cost considered the most crucial.

Ortúzar and Simonetti (2008) investigated the competition between the HSR and domestic airways in Chile. They generated nine scenarios for various combinations of stated preference, revealed preference and critical impact factors. A nested logit (NL) model was applied to estimate parameters affecting choice behaviour of bus, railway and airway passengers, with reliability being deemed the most important variable. Respondents with a lower income level were more concerned with price than higher income respondents. Furthermore, Román, Espino, and Martín (2007) utilised a discrete choice model to assess the impact of HSR services on domestic airways in Spain. Stated preference questionnaires were delivered to car drivers along with users of intercity bus and railway services, whereas domestic airway users were asked to complete both stated and revealed preference questionnaires. The results showed that domestic airways were unable to regain remarkable consumer losses even after they significantly improved the monetary cost and travel time.

Accordingly, pricing is the most critical controllable factor for enhancing the competitiveness of the HSR. Sales promotion is a useful method for encouraging customers to increase consumption ahead of time, and for acquiring potential consumers in the short term. In fact, price is a major factor affecting both market share and profits. Price promotion as an economic incentive can thus be employed to increase sales (Kotler and Keller 2006). Wansink and Rohit (1998) concluded that price promotion assists customers to decide whether or how much to consume. The degree of discount significantly affects potential demand (Meyer and Assuncao 1990; Krishna 1994; Jedidi, Mela, and Gupta 1999). The THSR Corporation (THSRC) has offered a variety of price promotions including pricing discrimination, group tickets, ticking channels and horizontal alliances. However, these price promotion strategies have a significant attraction to consumers of modes of transport other than private vehicle drivers. To improve the willingness of car users to switch as well as to increase the HSR share of the transportation market, price promotion strategies need to be developed that have a wider appeal and are based on the demands/needs of private vehicle drivers. Although the HSR has been in operation for only the past four years, this study emphasises the HSR's weakness from the car users' perspective rather than simply determination of the mode share in the Western Taiwan corridor. The target consumers in this case are private vehicle drivers rather than existing HSR customers. Accordingly, this study proposes alternative price promotion strategies arrived at from stated preferences.

Influence factors

Numerous scholars have discussed issues related to HSR operations. Besides cost–benefit analysis (Bonnafous 1987; Coto-Millán, Inglada, and Rey 2007), discrete choice models, including MNL, NL as well as the mixed logit (ML) model, have been used to explore the behaviour of intercity travellers as shown in revealed or stated preference questionnaires (González-Savignat 2004; Park and Ha 2006; Román, Espino, and Martín 2007; Yang and Sung 2010). Generally, the exogenous variables utilised in econometric choice modelling of transportation systems include monetary cost, travel time, accessibility, frequency, safety, reliability and comfort (Asensio 2002; Hensher and Prioni 2003; Espino, Martín, and Román 2008; González-Savignat 2004; Ortúzar and Simonetti 2008; Román, Espino, and Martín 2007; Wang, Feng, and Hsieh 2010).

Along with monetary cost and travel time, the analytical results of such studies reveal that service quality is becoming ever more crucial in the transportation industry. Qualitative studies of bus users suggest that it is necessary to improve the understanding of traveller attitudes regarding public transport and explore perceptions of bus service quality (Hensher and Prioni 2003; Hensher, Stopher, and Bullock 2003; Wall and McDonald 2007). Moreover, much work has been done in the literature to assess the service quality of airlines. Various constructs and measures have been used to analyse the relationships amongst performance, competition, critical factors and customer satisfaction (Liou and Tzeng 2007; Wang 2007; Espino, Martín, and Román 2008; Balcombe, Fraser, and Harris 2009). Ortúzar and Simonetti (2008) made a comparison of competitiveness between the HSR and domestic airways using NL, in which the revealed and stated preference methods were considered simultaneously. Travel time and service quality were found to be the most significant factors influencing consumer choice behaviours.

Nathanail (2008) addressed the importance of service quality for railway passengers. Brons, Givoni, and Rietveld (2009) discussed the relationship between service quality and railway ridership in the Netherlands and estimated the effects of customer satisfaction on consumer behaviour intentions. Moreover, the socio-economic characteristics including age, income level and number of children play an essential role as service quality for mode choice behaviour (Dissanayake and Morikawa 2010). This study thus considers the effects of quantitative cost and time, as well as qualitative service quality and socio-economic characteristics for determining the selection of HSR services. Identifying the demands of potential consumers and ranking them in terms of importance in the consumption decision is critical to expanding market share (Chikweche and Fletcher 2010). To attract private vehicle users as HSR consumers, it is necessary to understand their expectations of HSR services based on the demand perspective. This understanding assists in analysing the mode choice behaviours of private vehicle users, developing marketing strategies and improving operational processes.

Research approaches

Discrete choice model

The discrete choice model has been extensively adopted to analyse the selection of one among a set of alternatives by a decision maker, a household or an organisation – such as a firm or government agency (Schmöcker et al. 2006; García and Hernández 2007; Frenkel 2007; Wong, Wong, and Sze 2008). The principle of utility maximisation assumes that an individual facing multiple discrete choices from a universal but finite number of alternatives will select the alternative with the highest utility. The discrete choice model may not be a newly advanced methodology; however, it is an appropriate approach to easily determine the user behaviours through economic rationality (Si et al. 2010).

The utility of each alternative consists of an observable component and a random error term. Let subscripts n and j represent individual $n = 1, 2, \ldots, N$ and alternative $j = 1, 2, \ldots, J$, respectively. The utility function of alternative j for individual n can be expressed as.

$$U_{jn} = V_{jn} + \varepsilon_{jn}, \tag{1}$$

where U_{jn} indicates the marginal utility associated with alternative j for individual n which comprises an observable component of utility, V_{jn}, related to each alternative j for individual n, as well as a random component ε_{jn}. Linear-in-parameter utility functions are usually employed due to their computational simplicity and ease of interpretation in parameter estimates. Equation (2) shows the observable component of utility involving a vector of exogenous variables x_{jnk} associated with different attributes $k = 1, 2, \ldots, K_j$ for each alternative j and the parameter estimate β_{jk}.

$$V_{jn} = \sum_{k=1}^{K_j} \beta_{jk} \times x_{jnk}. \tag{2}$$

Moreover, the random components of utility are assumed to possess an independently and identically extreme value type I distribution. In the decision process, individual n ranks combination i higher than non-i if $U_{in} > U_{i'n}$. Equation (3) defines the logit probability of individual n choosing alternative i, $P_n(i)$.

$$P_n(i) = \Pr(U_{in} \geq U_{i'n}) = \frac{\exp(V_{in})}{\sum_{j=1}^{J} \exp(V_{jn})}. \tag{3}$$

Equation (3) shows that the independence of irrelevant alternatives (IIA) property is inadequate when alternatives are correlated. The ML model allows parameters associated with each observed variable to vary randomly across individuals, enabling heterogeneity among individuals recognition. ML was introduced to bridge the gap between logit and probit models by combining the advantages of both techniques. Equation (4) indicates the ML probability of individual n choosing alternative i under the taste parameter vector B specified according to a taste distribution function f(B), making the ML probability a weighted average of the logit formula evaluated at different values of with the weights given by the density f(B).

$$P_n(i) = \int \frac{\exp(\mathrm{B}x_{in})}{\sum_{j=1}^{j} \exp(\mathrm{B}x_{jn})} f(\mathrm{B}) d\mathrm{B}. \tag{4}$$

The model can significantly improve the explanatory power and the precision of parameter estimates simultaneously (Bhat 2000). The ML method is being implemented in a growing number of empirical studies (Termansen, Zandersen, and McClean 2008; Yagi and Mohammadian 2008).

Questionnaire design

Revealed preference and stated preference data possess their own strengths and weaknesses. In fact, revealed preference data are cognitively congruent with actual behaviour (Walker and Ben-Akiva 2002) whereas stated preference surveys could present reasonable and valid combinations of situational alternatives to the subjects and allow them to evaluate the alternatives according to their own preferences. The strengths of both data sources could be exploited and weaknesses ameliorated by pooling both data sources in a joint model (Louviere, Hensher, and Swait 2000). Additionally, the data enrichment process should provide more robust parameter estimates as well as increase the confidence and accuracy of the predictions. A combined revealed preference and stated preference questionnaire was thus designed to determine the choice behaviour for the HSR from the private vehicle drivers' perspective. Five alternatives related to HSR services – namely, discount on a second ticket, round trip tickets, non-peak hour fares, coupon tickets and THSRC e-tickets – were included in the discount scenarios.

THSRC provided a 'buy four and get one free' promotion in July 2009. However, this offer which required four people to use the same origin–destination (O–D) pair on the same train led to insignificant effects. Discount on a second ticket gives an average of 40% off for each ticket. Moreover, the THSRC also intends to provide 25% off round trip tickets with horizontal alliances. The round trip ticket is thus a considered alternative. Non-peak hour discounts (15% and 35%) were offered from November 2008 to June 2010. To simplify the set of choices, this study proposes using only a third alternative (25% off) during non-peak hours. The fourth alternative is the offering of 45% off coupon tickets for attracting frequent travellers with the same O–D pair. The last alternative, the e-ticket, is useful to improve customer loyalty, providing 30% off each trip.

Regarding the individual characteristics influencing modal choice, the developed questionnaire inquires about respondent demographics, including gender, age, personal income, education, the number of children, household vehicles, driving experience and trip purpose besides monetary cost and travel time. Determining attribute levels to compose hypothetical alternatives is important in experimental design. Each variable is defined on three variation levels to test whether the individual response is linear with regard to variables of interest. The monetary costs of HSR alternatives are estimated by the product of list price and discount of each alternative. For private vehicles, the gas prices and energy efficiency from the Bureau of Energy, Ministry of Economic Affairs (2009) are considered simultaneously along with average tolls to calculate the monetary costs, whereas the travel time is defined in terms of the values declared by the individual in the pilot revealed preference survey. The final values assigned to each level are shown in Table 1.

Factor analysis

Additionally, this study takes qualitative variables, for example, service quality, into consideration in the choice behaviour model. This is helpful for determining precisely the importance of HSR service quality from the car users' perspective and for improving the explanatory ability of the model. Factor analysis is employed to extract principal components, investigate the item factor structure for identifying HSR service quality characteristics and confirm the measurement fitness of the developed model. The purpose

Table 1. Values of each attribute level.

Attributes	Levels	Price promotions of THSRC					
		Discount on second ticket	Round trip ticket	Discount in non-peak hours	Coupon tickets	THSRC e-tickets	Private vehicles
Monetary cost (NTD[a])	0	845	920	1070	770	995	1320
	1	895	970	1120	820	1045	1370
	2	995	1070	1220	920	1145	1470
Travel time (minutes)	0	100	100	100	100	100	255
	1	120	120	120	120	120	285
	2	140	140	140	140	140	315

[a]New Taiwan dollar (NTD) 1 is approximately equivalent to USD 0.032.

of factor analysis is to simplify the item factor structure by extracting the least constructs with the greatest explanatory ability. These observed variables function as indicators of their respective underlying latent constructs (Byrne 2009). An error term is associated with each observed variables. The relationships leading from the construct to each of the observed variables suggest that these score values are influenced by their respective underlying constructs. As such, these path coefficients, also called factor loadings, represent the magnitude of expected change in the observed variables for every change in the related latent construct. The multi-item scales drawn from previous work are shown in Table 2. All the constructs were measured with items previously used in the literature. In some cases, the items were modified to adapt them to this research context. Respondents were asked to indicate their perception of each attribute on a five-point Likert scale anchored from 'strongly disagree' to 'strongly agree'. Finally, the reliability and validity were statistically tested to confirm the consistency and representability of the instrument.

Results and discussion

Questionnaires were distributed at freeway service areas nearby HSR stations to 350 private vehicle drivers travelling distances exceeding 200 km and 300 effective responses

Table 2. Description of the research variables and basic statistics.

Items for service quality		Mean	SD	Min	Max
SQ_1	The monetary cost for the trip is reasonable	2.69	1.07	1	5
SQ_2	The travel time of the vehicle is acceptable	3.26	1.13	1	5
SQ_3	You can easily arrive at your destinations with this vehicle	2.68	1.05	1	5
SQ_4	It is convenient for you to transfer to other modes of transport	2.62	1.01	1	5
SQ_5	You can easily access the vehicle anytime	2.32	0.93	1	5
SQ_6	The seats are comfortable	2.28	0.81	1	5
SQ_7	The air-conditioning systems are appropriate	2.19	0.75	1	5
SQ_8	It is rare to have an accident on trips with this vehicle	2.29	0.78	1	5
SQ_9	The vehicle rarely fails	2.26	0.75	1	5
SQ_{10}	The vehicle takes you to your destinations on schedule	2.21	0.77	1	5
SQ_{11}	The response in case of an accident is immediate	2.43	0.74	1	5

being obtained, yielding an 86% response rate. About 57% of the drivers in the sample were aged 25–44 and 59.7% were male. About 79% of the respondents had more than three years of driving experience of which 36.7% had more than 10 years. The trip purpose revealed the following: business (23.0%), recreation (20.7%) and return hometown (20.3%), followed by visiting (12.0%), whereas 10.7% were commuters and 9.0% of trips were for purposes of health care.

Factor analysis

Besides monetary cost and travel time, the quality of the HSR service has an influence on traveller demand choice in the developed model. However, numerous correlated indicators in the choice models may lead to a multi-collinear problem. A common approach to dealing with this type of problem is factor analysis where a few latent constructs are used to represent a large number of observable indicators. Following orthogonal rotation with the maximum variance method, those components with eigenvalues exceeding 1 (Kaiser 1960) are adopted. Table 3 lists the four components for the factor analysis. The first principal component explains 27.32% of the total variance, with four items having positive loadings ranging from 0.76 to 0.92. Since all items express the aspects of reliability, the construct is named 'Reliability'. The second component, consisting of three items, explains 18.73% of the total variance, and has factor loadings ranging from 0.71 to 0.81. This construct is termed 'Accessibility' because its strong loading items express the convenience of access of the mode. Additionally, the third component explains 16.35% of the total variance, with two items whose loadings range from 0.90 to 0.91. Since all items express the perception of comfortable trips, the construct is labelled 'Comfort'. The final component, comprising two items, explains 15.55% of the total variance, and has factor loadings ranging from 0.65 to 0.89. It is labelled 'Efficiency' according to the features of stronger loading items.

First of all, the reliability and validity of the measurement must be tested. Cronbach's (1951) alpha values for all constructs are above 0.70, indicating strong scale reliability. Moreover, the measures adopted with factor loading, ranging from 0.65 to 0.92, exceed the suggested threshold of 0.4 (Cortina 1993). The content validity is measured by considering the relationship between the semantic meaning of the measures and the constitutive definitions of the constructs (Bagozzi, Yi, and Phillips 1991). The items were adapted from the previous literatures as well as from an in-depth interview process then validated by exploratory factor analysis (EFA) to infer content validity.

Table 3. Results of factor analysis.

Component	Percentage of variance	Cumulative percentage	Items (factor loading)	Cronbach's alpha
1	27.32	27.32	SQ_8 (0.762), SQ_9 (0.916), SQ_{10} (0.888) and SQ_{11} (0.783)	0.882
2	18.73	46.05	SQ_3 (0.784), SQ_4 (0.805) and SQ_5 (0.709)	0.763
3	16.06	62.11	SQ_6 (0.911) and SQ_7 (0.895)	0.875
4	12.39	74.50	SQ_1 (0.653) and SQ_2 (0.885)	0.702

The 11 items used to measure four latent constructs are subjected to confirmatory factor analysis to verify reliability and validity. Reliability can reflect the internal consistency of the indicators used to measure given factors. Internal consistency is assessed using the average variance extracted (AVE) and composite reliability (CR), as shown in Table 4. In this study, all standardised factor loadings ranging from 0.51 to 0.98 exceed the 0.5 threshold value (Rivard and Huff 1998). Moreover, the CR of each construct significantly exceeds the 0.7 minimum value suggested by Nunnally (1978), and AVE is higher than the benchmark of 0.5 recommended by Fornell and Larcker (1981), respectively. This study thus infers that the four constructs are internally consistent and have strong scale reliability. Besides, convergent validity is achieved if strongly correlated scores are obtained when using various indicators to measure the same construct. The structural equation model can assess convergent validity by reviewing the *t*-tests for the factor loadings (Hatcher 1994). The *t*-values in Table 4 reveal statistical significance for all factor loadings for indicators measuring the same construct, indicating that all indicators effectively measure their corresponding constructs and exhibit good convergent validity. Additionally, the values of the conventional model fit indices – such as the goodness-of-fit index (GFI) (0.92), the normed fit index (NFI) (0.91), the non-normed fit index (NNFI) (0.91) and the comparative fit index (CFI) (0.93) – exceed the threshold value of 0.9. The parsimony goodness-of-fit index (PGFI) (0.53) also exceeds the value of 0.5 suggested by Mulaik et al. (1989), referring to the model's excellent fit to the data.

Discrete choice model

The initial utility function specification includes alternative specific constants, generic variables and alternative specific variables. The average values of the latent constructs utilised in the choice model are calculated from the sum of each involved item score multiplied by its standardised factor loading. Analogous to the *t*-test in linear regression,

Table 4. Construct validation.

Construct Items	Standardised factor loading	*t*-Value	Measurement error	CR	AVE
Efficiency				0.755	0.621
SQ_1	0.59	8.43	0.75		
SQ_2	0.98	11.25	0.05		
Accessibility				0.750	0.510
SQ_3	0.80	14.58	0.40		
SQ_4	0.51	8.27	0.88		
SQ_5	0.84	15.53	0.26		
Comfort				0.917	0.847
SQ_6	0.89	17.42	0.14		
SQ_7	0.87	16.97	0.14		
Reliability				0.926	0.759
SQ_8	0.69	13.09	0.32		
SQ_9	0.89	19.04	0.11		
SQ_{10}	0.84	17.24	0.18		
SQ_{11}	0.78	15.55	0.21		

the asymptotic *t*-test (valid only for large samples) is used to test whether a particular parameter differs from zero. The likelihood ratio test can provide joint tests of several parameters and allow assessment of overall goodness-of-fit of the model. The likelihood ratio index (rho-squared), a goodness-of-fit measure similar to R^2 in linear regression, is employed to compare different model specifications. The estimation results of the MNL and ML are indicated in Table 5.

Based on Table 5, it can be seen that all parameter estimates are robust, statistically significant and of the right sign. Monetary cost and travel time have a significantly

Table 5. Estimation results of the choice models.

	Parameter estimates (*t*-value)			
Attribute	MNL		ML	
Alternative specific constant				
Discount on second ticket	−6.819		−7.585	
Discount on second ticket (standard deviation)	–		1.623	(3.71)
Round trip ticket	−8.826		−10.165	
Discount in non-peak hours	−5.492		−6.384	
Coupon tickets	−11.552		−13.303	
THSRC e-tickets	−9.116		−10.447	
Private vehicles (baseline)	–		–	
Generic variables				
Monetary cost	−1.688	(−19.79)	−1.929	(−14.39)
Monetary cost (standard deviation)	–		0.212	(2.90)
Travel time	−2.424	(−7.97)	−2.851	(−7.73)
Efficiency	0.389	(3.20)	0.310	(2.05)
Accessibility	0.320	(3.80)	0.334	(3.20)
Comfort	0.278	(2.55)	0.376	(2.92)
Reliability	0.202	(2.18)	0.218	(2.03)
Alternative specific variables				
Age – specific to round trip ticket	0.835	(3.42)	0.928	(3.42)
Education – specific to coupon tickets	0.946	(2.27)	1.030	(2.25)
Children – specific to round trip ticket	−1.163	(−5.13)	−1.354	(−5.16)
Children – specific to non-peak hours	−1.977	(−5.63)	−2.221	(−5.80)
Children – specific to e-tickets	−1.025	(−3.26)	−1.147	(−3.26)
Household cars – specific to second ticket	−0.883	(−4.39)	−1.186	(−4.19)
Household cars – specific to non-peak hours	−0.697	(−2.91)	−0.785	(−3.14)
Household cars – specific to coupon tickets	−1.065	(−4.48)	−1.242	(−4.55)
Driving experience – specific to second ticket	−0.710	(−2.57)	−0.714	(−1.96)
Driving experience – specific to coupon tickets	−1.306	(−3.92)	−1.427	(−3.80)
Driving experience – specific to e-tickets	−1.050	(−3.53)	−1.184	(−3.66)
Observable heterogeneity				
Efficiency × purpose – back home	–		1.007	(2.53)
Log-likelihood at zero	−1605.416		−1605.416	
Log-likelihood at convergence	−862.627		−812.759	
Likelihood ratio index (rho-squared)	0.463		0.469	
Sample size	300		300	

negative impact on utility. This implies that the probability of choosing modes to finish a trip is reduced with increasing travel cost or time. In contrast, all the constructs of service quality possess a significantly positive influence on choice behaviours. In fact, most car drivers are concerned with the accessibility of HSR stations, which are located in suburban areas, so must depend on the provision of feeder buses. Older respondents are more likely to choose the HSR if round trip tickets are available, whereas respondents with higher education are more likely to utilise HSR services if coupon tickets are provided.

The number of children significantly decreases the willingness to select the HSR even with the round trip ticket, THSRC e-tickets and non-peak hour discount price promotion strategies, whereas the group discount alternative is insignificantly negatively affected by children. Furthermore, the user utility is negatively correlated to those with more available cars per household and more driving experience. As expected, such users are more accustomed to driving rather than taking the HSR to make a trip.

The ML improves the accuracy of the simulation of individual log-likelihood functions and reduces simulation variance of the maximum simulated log-likelihood estimator. Random parameters for this ML model are estimated as normally distributed parameters. This is done in order to allow parameters to both negative and positive values. Both observed attributes associated with the mode alternative, and individual along with the unobserved attributes were tested by introducing random parameters. The significant cross relationship between efficiency and the back home trip indicates the observable heterogeneity. Most back home trips occur during vacations and entail more monetary cost and travel time regardless of whether the HSR or a private vehicle is used. Such travellers thus attach more importance to efficiency than other trip purposes.

The results of the estimated ML model are shown in Table 5. The likelihood ratio index is 0.469, indicating a good model fit with statistically significant parameters. Furthermore, estimated standard deviations of the random parameters of the variable representing the monetary cost and the constant specific to the discount on the second ticket are statistically significant in the model at the 95% confidence level. The significant *t*-statistics for these standard deviations indicate that these are likely to be statistically different from zero, confirming that parameters indeed vary across individuals. Features of the other variables and the implications are generally similar to those in the MNL model.

Different levels of monetary cost and travel time are simulated by offering a range of behaviour choices from 10% to 10%, respectively. Figure 3 shows the result of a sensitivity analysis of travel costs for car drivers. The variations in mode share for the car vary from 16.46% to 9.80%. The mode share for a car is slightly inversely proportional to travel time, since most drivers consider cost and accessibility to be more crucial than travel time. Notably, the increasing monetary cost for car use essentially leads to the switching of trips from private vehicles to HSR services. In comparison, choice behaviour insignificantly varies with reduction in car use cost, suggesting that push strategies for private vehicles might be more effective than pull strategies from the HSR.

Management implications

From the HSR operator's perspective, understanding the demands of potential consumers helps in the development of marketing strategies and thus increases their market share.

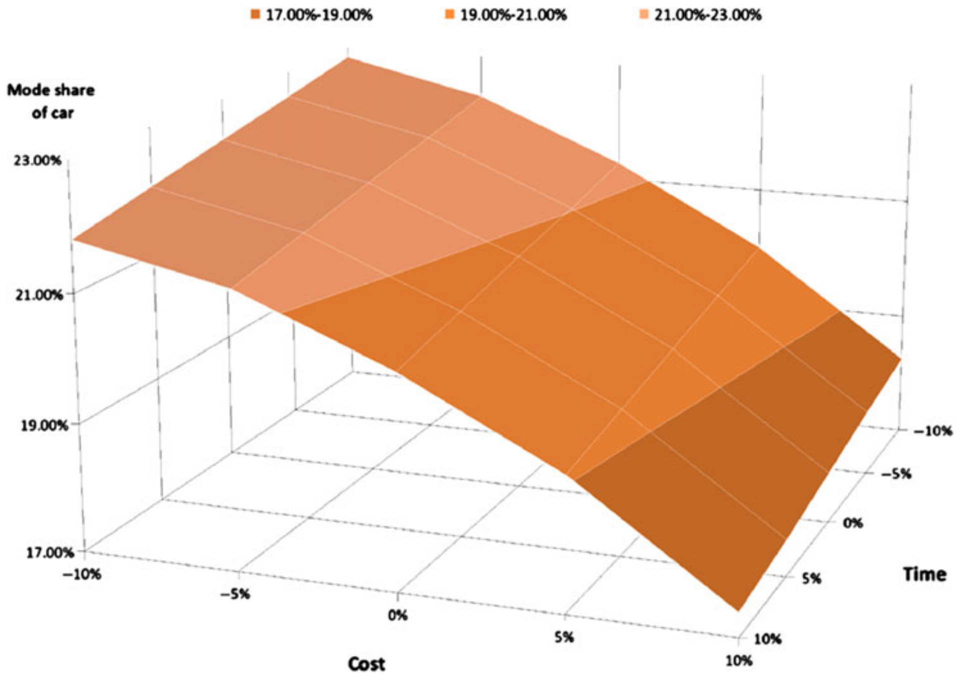

Figure 3. Sensitivity analysis of travel costs.

Based on the analytical results, some marketing implications are suggested given the diverse characteristics, strengths and weaknesses that affect competition.

According to the results of the sensitivity analyses of the proposed discrete choice model, to achieve a reduction of car trips, customers would prefer a discount on the second ticket and round trip ticket to other HSR alternatives. The discount on a second ticket releases a higher threshold of participants than for the previous 'buy four and get one free' offer. The next most effective at interesting car drivers in HSR services is the round trip ticket without limitations and departure time. Discounts on non-peak hour tickets, such as has been provided in the past, possess insignificant influence on attracting people to change their mode of transport on long-distance trips. Except for inelastic business demands, that is, peak hours, trips are usually made during vacations, so such discounts attract less attention from car drivers.

Because most respondents consider HSR services to be inaccessible and unreliable, operators should improve the quality of accessibility and reliability immediately. High speed is the major advantage of HSR services. However, delayed passenger arrival due to unreliability caused by failure of infrastructure is unacceptable. The THSRC should construct effective redundancies and comprehensive emergency response plans for improving the flexibility and mitigating the impact of external factors on HSR operations. Furthermore, the THSRC should also cooperate with local transit operators to provide efficient shuttle services along appropriate routes at sufficient frequencies for tackling the essential inaccessibility issues.

Due to the differences between the preference of travellers with various socio-economic and trip characteristics, various price promotion strategies are suggested for market segmentation. For instance, the THSRC could adopt miles earned e-tickets for business class upgrade or free tickets to retain the loyalty of both enterprise members and frequent consumers. Moreover, a HSR package tour deal could be provided through horizontal alliances with travel agencies, operators of recreation areas and hotels, as well as local government tourism activities. For passengers with accompanying children, strategies could include park and ride discounts or alliances with car rental firms to bridge the gaps of inaccessibility along with the inconvenience of HSR services. From the authority perspective, subsidies are infeasible because the THSRC is based on the 'build-operate-transfer' mechanism of ownership. However, releasing the road rights of shuttle services would be helpful to mitigate inaccessibility problems and encourage sustainable transportation. Additionally, it could be effective to levy congestion charges along the HSR corridor as a push strategy to encourage private vehicle users to switch.

Conclusions

This study has discussed the influence of HSR price promotion strategies and market structure on mode choice behaviour. The joint stated preference and revealed preference methods were utilised to collect data on intercity travellers and validate the proposed mode choice behaviour of potential consumers with heterogeneity. This study has suggested the most effective marketing strategy choices for HSR operators, determining the impact of the qualitative service qualities, including efficiency, accessibility, comfort and reliability, extracted from 11 items to determine the mode choice behaviour of long-distance travelling in the Western Taiwan corridor.

MNL and ML models were employed to discuss the relative advantages and weaknesses of the HSR's price promotion alternatives from the perspective of private vehicle drivers. The logit model, which may not be the most advanced choice of modelling method, has become a favourite research tool, and was used here. Whereas monetary costs and travel time significantly negatively impacted utility, the service quality constructs as the generic variables significantly influenced the mode choice preference. Based on the estimated parameters, the critical barriers causing private vehicle drivers shifting to HSR service were inaccessibility and high monetary cost.

The possible interactions of demographics and operational characteristics with the sensitivity measures were identified by market segmentation analysis. Age, educational level, number of children, number of cars per household and driving experience are noticeably associated with driver perceptions of the increase in penalty level for shifting to HSR services. For example, the number of children significantly decreases the willingness to select the HSR due to the insufficient facilities and lack of shuttle services. The utility was also negatively correlated with more available cars per household and more driving experience.

The results of sensitivity analyses indicated that the mode share of cars is slightly inversely proportional to travel time since most drivers consider that cost and accessibility is much more crucial than travel time. Accordingly, some management implications such as the formation of horizontal alliances, taking advantage of market segments and improvement of service quality were suggested as mean for HSR operators and authorities to effectively attract car users from private vehicles.

In future, longitudinal studies should be considered to enrich the results and illustrate the complexity of the direction in the links between the variables and take into account the dynamics. In addition, the actual mode share effect should involve calibration of the behaviour of the transportation infrastructure and services in competition with each other.

Acknowledgement

The authors would like to express the gratitude to the National Science Council of the Republic of China, Taiwan for financially supporting this research under Contract number NSC 99-2415-H-366-014-SSS.

References

Alterkawi, M. M. 2006. "A Computer Simulation Analysis for Optimizing Bus Stops Spacing: The Case of Riyadh, Saudi Arabia." *Habitat International* 30 (3): 500–508. doi:10.1016/j.habitatint.2004.12.005.

Anable, J. 2005. "'Complacent Car Addicts' or 'Aspiring Environmentalists'? Identifying Travel Behaviour Segments Using Attitude Theory." *Transport Policy* 12 (1): 65–78. doi:10.1016/j.tranpol.2004.11.004.

Asensio, J. 2002. "Transport Mode Choice by Commuters to Barcelona's CBD." *Urban Studies* 39 (10): 1881–1895. doi:10.1080/0042098022000003000.

Bagozzi, R. P., Y. Yi, and L. W. Phillips. 1991. "Assessing Construct Validity in Organizational Research." *Administrative Science Quarterly* 36 (3): 421–458. doi:10.2307/2393203.

Balcombe, K., I. Fraser, and L. Harris. 2009. "Consumer Willingness to Pay for In-flight Service and Comfort Levels: A Choice Experiment." *Journal of Air Transport Management* 15 (5): 221–226. doi:10.1016/j.jairtraman.2008.12.005.

Bhat, C. R. 2000. "Incorporating Observed and Unobserved Heterogeneity in Urban Work Travel Mode Choice Modelling." *Transportation Science* 34 (2): 228–238. doi:10.1287/trsc.34.2.228.12306.

Bonnafous, A. 1987. "The Regional Impact of the TGV." *Transportation* 14 (2): 127–137. doi:10.1007/BF00837589.

Brons, M., M. Givoni, and P. Rietveld. 2009. "Access to Railway Stations and Its Potential in Increasing Rail Use." *Transportation Research Part A: Policy and Practice* 43 (2): 136–149. doi:10.1016/j.tra.2008.08.002.

Bureau of Energy, Ministry of Economic Affairs. 2009. *Gas Price Information Management and Analysis System* [Online]. Taipei: Bureau of Energy, Ministry of Economic Affairs. http://www.moeaboe.gov.tw:80/oil102/ [in Chinese].

Byrne, B. M. 2009. *Structure Equation Modelling with AMOS: Basic Conception, Application, and Programming*. 2nd ed. New York: Routledge Taylor & Francis.

Chikweche, T., and R. Fletcher. 2010. "Understanding Factors that Influence Purchases in Subsistence Markets." *Journal of Business Research* 63 (6): 643–650. doi:10.1016/j.jbusres.2009.04.024.

Cortina, J. M. 1993. "What Is the Coefficient Alpha? An Examination of the Theory and Applications." *Journal of Applied Psychology* 78 (1): 98–104. doi:10.1037/0021-9010.78.1.98.

Coto-Millán, P., V. Inglada, and B. Rey. 2007. "Effects of Network Economies in High-speed Rail: The Spain Case." *The Annals of Regional Science* 11 (4): 911–925. doi:10.1007/s00168-007-0134-6.

Cronbach, L. J. 1951. "Coefficient Alpha and the Internal Structure of Tests." *Psychometrika* 16 (3): 297–334. doi:10.1007/BF02310555.

Dissanayake, D., and T. Morikawa. 2010. "Investigating Household Vehicle Ownership, Mode Choice and Trip Sharing Decisions Using a Combined Revealed Preference/Stated Preference Nested Logit Model: Case Study in Bangkok Metropolitan Region." *Journal of Transport Geography* 18 (3): 402–410. doi:10.1016/j.jtrangeo.2009.07.003.

Espino, R., J. C. Martín, and C. Román. 2008. "Analyzing the Effect of Preference Heterogeneity on Willingness to Pay for Improving Service Quality in an Airline Choice Context." *Transportation Research Part E: Logistics and Transportation Review* 44 (4): 593–606. doi:10.1016/j.tre.2007.05.007.

Fornell, C., and D. F. Larcker. 1981. "Evaluating Structural Equation Models with Unobservable Variables and Measurement Error." *Journal of Marketing Research* 18 (1): 39–50.

Frenkel, A. 2007. "Spatial Distribution of High-rise Buildings within Urban Areas: The Case of the Tel-Aviv Metropolitan Region." *Urban Studies* 44 (10): 1973–1996. doi:10.1080/00420980701560059.

García, J. A. B., and J. E. R. Hernández. 2007. "Housing and Urban Location Decisions in Spain: An Econometric Analysis with Unobserved Heterogeneity." *Urban Studies* 44 (9): 1657–1676. doi:10.1080/00420980701426624.

González-Savignat, M. 2004. "Will the High-speed Train Compete Against the Private Vehicle?" *Transport Reviews* 24 (3): 293–316. doi:10.1080/0144164032000083103.

Hatcher, L. 1994. *A Step-by-step Approach to Using the SAS System for Factor Analysis and Structural Equation Modelling*. Cary, NC: SAS Institute.

Hensher, D. A. 2007. "Bus Transport: Economics, Policy and Planning." *Research in Transportation Economics* 18: 1–507. doi:10.1016/S0739-8859(06)18001-4.

Hensher, D. A., and P. Prioni. 2003. "A Service Quality Index for Area-wide Contract Performance Assessment." *Journal of Transport Economic and Policy*, 36 (1): 93–113.

Hensher, D. A., and J. M. Rose. 2007. "Development of Commuter and Non-commuter Mode Choice Models for the Assessment of New Public Transport Infrastructure Projects: A Case Study." *Transportation Research Part A: Policy and Practice* 41 (5): 428–443. doi:10.1016/j.tra.2006.09.006.

Hensher, D. A., P. Stopher, and P. Bullock. 2003. "Service Quality – Developing a Service Quality Index in the Provision of Commercial Bus Contracts." *Transportation Research Part A: Policy and Practice* 37 (6): 499–517. doi:10.1016/S0965-8564(02)00075-7.

Hensher, D. A., and W. G. Waters II. 1994. "Light Rail and Bus Priority Systems: Choice or Blind Commitment?" *Research in Transportation Economics* 3: 139–162. doi:10.1016/S0739-8859(09)80008-5.

Jedidi, K., C. F. Mela, and S. Gupta. 1999. "Managing Advertising and Promotion for Long-term Profitability." *Marketing Science* 18 (1): 1–22. doi:10.1287/mksc.18.1.1.

Kain, J. F. 1988. "Choosing the Wrong Technology: Or How to Spend Billions and Reduce Transit Use." *Journal of Advanced Transportation* 21 (3): 197–213. doi:10.1002/atr.5670210303.

Kaiser, H. F. 1960. "The Application of Electronic Computers to Factor Analysis." *Educational and Psychological Measurement* 20 (1): 141–151. doi:10.1177/001316446002000116.

Kim, S., G. F. Ulfarsson, and J. T. Hennessy. 2007. "Analysis of Light Rail Rider Travel Behavior: Impacts of Individual, Built Environment, and Crime Characteristics on Transit Access." *Transportation Research Part A: Policy and Practice* 41 (6): 511–522. doi:10.1016/j.tra.2006.11.001.

Kotler, P., and K. L. Keller. 2006. *Marketing Management*. 12th ed. Upper Saddle River, NJ: Prentice Hall.

Krishna, A. 1994. "The Impact of Dealing Patterns on Purchase Behaviour." *Marketing Science* 13 (4): 351–373. doi:10.1287/mksc.13.4.351.

Liou, J. H., and G. H. Tzeng. 2007. "A Non-additive Model for Evaluating Airlines Service Quality." *Journal of Air Transport Management* 13 (3): 131–138. doi:10.1016/j.jairtraman.2006.12.002.

Louviere, J. J., D. A. Hensher, and J. D. Swait. 2000. *Stated Choice Methods: Analysis and Application*. Cambridge: Cambridge University Press.

Meyer, R. J., and K. Assuncao. 1990. "The Optimality of Consumer Stockpiling." *Marketing Science* 9 (1): 18–41. doi:10.1287/mksc.9.1.18.

Mulaik, S. A., L. R. James, J. van Alstine, N. Bennett, S. Lind, and C. D. Stilwell. 1989. "Evaluation of Goodness-of-fit Indices for Structural Equation Models." *Psychological Bulletin* 105 (3): 430–445. doi:10.1037/0033-2909.105.3.430.

Nathanail, E. 2008. "Measuring the Quality of Service for Passengers on the Hellenic Railways." *Transportation Research Part A: Policy and Practice* 42 (1): 48–66. doi:10.1016/j.tra.2007.06.006.

Nunnally, J. C. 1978. *Psychometric Theory*. 2nd ed. New York: McGraw-Hill.

Ortúzar, J. D., and C. Simonetti. 2008. "Modelling the Demand for Medium Distance Air Travel with the Mixed Data Estimation Method." *Journal of Air Transport Management* 14 (6): 297–303. doi:10.1016/j.jairtraman.2008.08.002.

Park, Y., and H. K. Ha. 2006. "Analysis of the Impact of High-speed Railroad Service on Air Transport Demand." *Transportation Research Part E: Logistics and Transportation Review* 42 (2): 95–104. doi:10.1016/j.tre.2005.09.003.

Rivard, S., and S. L. Huff. 1988. "Factors of Success for End-user Computing." *Communications of the ACM* 31 (5): 552–561. doi:10.1145/42411.42418.

Román, C., R. Espino, and J. C. Martín. 2007. "Competition of High-speed Train with Air Transport: The Case of Madrid–Barcelona." *Journal of Air Transport Management* 13 (5): 277–284. doi:10.1016/j.jairtraman.2007.04.009.

Schmöcker, J. D., A. Fonzone, M. Quddus, and M. G. H. Bell. 2006. "Changes in the Frequency of Shopping Trips in Response to a Congestion Charge." *Transport Policy* 13 (3): 217–228. doi:10.1016/j.tranpol.2005.09.005.

Si, B. F., M. Zhong, H. Z. Zhang, and W. L. Jin. 2010. "An Improved Dial's Algorithm for Logit-based Traffic Assignment within a Directed Acyclic Network." *Transportation Planning and Technology* 33 (2): 123–137. doi:10.1080/03081061003643705.

Termansen, M., M. Zandersen, and C. J. McClean. 2008. "Spatial Substitution Patterns in Forest Recreation." *Regional Science and Urban Economics* 38 (1): 81–97. doi:10.1016/j.regsciurbeco.2008.01.006.

Walker, J., and M. Ben-Akiva. 2002. "Generalized Random Utility Model." *Mathematical Social Sciences* 43 (3): 303–343. doi:10.1016/S0165-4896(02)00023-9.

Wall, G., and M. McDonald. 2007. "Improving Bus Service Quality and Information in Winchester." *Transport Policy* 14 (2): 165–179. doi:10.1016/j.tranpol.2006.12.001.

Wang, R. T. 2007. "Improving Service Quality Using Quality Function Deployment: The Air Cargo Sector of China Airlines." *Journal of Air Transport Management* 13 (4): 221–228. doi:10.1016/j.jairtraman.2007.03.005.

Wang, S. M., C. M. Feng, and C. H. Hsieh. 2010. "Stakeholder Perspective on Urban Transport System Service Quality." *Total Quality Management & Business Excellence* 21 (11): 1109–1121.

Wansink, B., and D. Rohit. 1998. "Out of Sight, Out of Mind: Pantry Stockpiling and Brand Usage Frequency." *Marketing Letters* 5 (7): 91–100.

Wong, S. C., C. W. Wong, and N. N. Sze. 2008. "Attitudes of Public Light Bus Drivers to Penalties to Combat Red Light Violations in Hong Kong." *Transport Policy* 15 (1): 43–54. doi:10.1016/j.tranpol.2007.10.009.

Wright, L., and W. Hook. 2006. *Bus Rapid Transit Planning Guide*. New York: Institute for Transportation and Development Policy.

Yagi, S., and A. Mohammadian. 2008. "Policy Simulation for New BRT and Area Pricing Alternatives Using an Opinion Survey in Jakarta." *Transportation Planning and Technology* 31 (5): 589–612. doi:10.1080/03081060802087676.

Yang, C. W., and Y. C. Sung. 2010. "Constructing a Mixed-logit Model with Market Positioning to Analyze the Effects of New Mode Introduction." *Journal of Transport Geography* 18 (1): 175–182. doi:10.1016/j.jtrangeo.2009.01.005.