Identifying the Determinants of Light Rail Mode Choice for Medium- and Long-Distance Trips

Results from a Stated Preference Study

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The introduction of new public transport systems can influence society in a multitude of ways ranging from modal choices and the environment to economic growth. This paper examines the determinants of light rail mode choice for medium- and long-distance trips (10 to 40 km) for a new light rail system in Flanders, Belgium. To investigate these choices, the effects of various transport system–specific factors (i.e., travel cost, in-vehicle travel time, transit punctuality, waiting time, access and egress time, transfers, and availability of seats) as well as the travelers' personal traits were analyzed by using an alternating logistic regression model, which explicitly takes into account the correlated responses for binary data. The data used for the analysis stem from a stated preference survey conducted in Flanders. The modeling results are in line with literature: most transport system–specific factors as well as socioeconomic variables, attitudinal factors, perceptions, and the frequency of using public transport contribute significantly to the preference for light rail transit. In particular, the results indicate that the use of light rail is strongly influenced by travel cost and in-vehicle travel time and to a lesser extent by waiting and access–egress time. Seat availability appeared to play a more important role than did transfers in deciding to choose light rail transit. The findings of this paper can be used by policy makers as a frame of reference to make light rail transit more successful.

The importance of transport as one of the key prerequisites of any modern society cannot be downplayed. Transport enables people to reach services and to maintain contacts and social interactions. Unfortunately, transport also has many negative impacts such as safety problems (e.g., traffic casualties), environmental pressure (e.g., greenhouse gas emissions), and economic losses (e.g., time lost due to congestion) (*1*). To make transport more sustainable, transport systems that provide good alternatives to car use must be developed. In an attempt to alleviate the negative effects of car use and to achieve travel behavior that is more sustainable, the Flemish public transport company De Lijn is preparing an investment program to introduce a regional light rail network to provide adequate public transport at medium distances (10 to 40 km) (*2, 3*). Nevertheless, at this moment, the concept of light rail is still relatively unknown in Flanders (the Dutch-speaking northern region of Belgium), since this mode of transportation has not been implemented yet. Consequently, there is a clear need to assess the impact of a light rail system in Flanders.

The development of light rail systems may have many effects, as indicated in the literature. They may range from shifts in modal split and improved accessibility to urban development and economic growth. Billings (*4*) investigated the impact of a new light rail system on property values in Charlotte, North Carolina, and demonstrated an increase in real estate prices within 1.6 km of the stations. Light rail investments can therefore serve as an economic development tool. Senior (*5*) investigated the impacts of a light rail project in the Greater Manchester region (United Kingdom) on travel behavior and concluded that the light rail project contributed significantly to the declining share of bus trips and work trips by car. Mackett and Edwards (*6*) analyzed the impacts of 46 urban public transport systems around the world, including a series of light rail systems. In most instances, they found a reduction in car use after implementation of the transit systems. In addition to the impacts on modal split, they reported important environmental and accessibility effects. In general, these impacts were positive (e.g., a reduction in air pollution and improved access to the city center). However, in a few cases, negative effects occurred (e.g., an increase in noise pollution). Furthermore, they considered impacts on urban development and land use. Transit infrastructure stimulated industry and urban development around stations.

This paper examines the determinants of light rail mode choice for medium- and long-distance trips (10 to 40 km) for a new light rail system in Flanders. To investigate these choices, the effects of a multitude of transport system–specific factors, such as travel cost, in-vehicle travel time, transfers, availability of seats, access and egress time, waiting time, and transit punctuality, as well as the travelers' personal traits, are analyzed with an alternating regression model (*7, 8*).

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LITERATURE REVIEW

Key Determinants of Mode Choice in General

In this section, an overview of the factors that influence mode choice is given. The overview focuses on two categories: specific factors of public transport systems and personal traits and attitudes of the travelers.

With regard to the first category, it was found that reliable travel times contribute significantly to public transport choice. Schramm et al. (*9*) and Van Loon et al. (*10*) indicated that more reliable travel times lead to an increase in transit ridership. In addition, Zhang et al. (*11*) and Outwater et al. (*12*) found that punctuality of transit systems adds significantly to the mode choice decision process. In contrast, only one study could be found in which the effect of reliable travel times on mode choice turned out to be not significant (*13*). In addition to reliable travel times, other transport system–specific factors, such as travel cost, in-vehicle travel time, waiting time, access and egress time, transfers, and availability of seats, affect mode choice. Mattson et al. (*14*), Outwater et al. (*12*), and Hensher and Rose (*15*) emphasized the importance of travel costs (i.e., transit fares). Ben-Akiva and Morikawa (*16*) illustrated that the various travel time components (i.e., access and egress time, in-vehicle time, and waiting time) all contribute significantly in explaining mode choice. Furthermore, they indicated that travelers prefer modes that offer sufficient comfort (heating, air-conditioning, sufficient legroom, etc.). Outwater et al. (*12*) emphasized the decreasing effect of transfers on transit choice. Finally, the importance of seat availability was stressed by Bierlaire et al. (*17*), who indicated that sufficient free seats increase transit use. In addition to factors specific to the transport system, various personal traits and attitudes of travelers significantly influence mode choice. Age, gender, car ownership, and income are often reported as factors influencing transit ridership (e.g., *18–20*). Personal attitudes have been cited as influencing the mode choice decision process (e.g., *21, 22*). These studies show that people with negative attitudes toward public transport and positive attitudes toward car use are less inclined to use public transit. Finally, Mattson et al. (*14*) found that individuals with at least some transit experience are more likely to choose public transit and other alternative modes.

Key Determinants of Light Rail Ridership

The driving characteristics for the specific case of light rail ridership are pinpointed in this section. They can be classified into four categories: system-specific, socioeconomic, policy-related, and regional characteristics. This paper focuses on the first and second categories. However, for successful implementation of the light rail system, the other factors must be taken into account as well.

With respect to the system-specific attributes, one of the most important factors is the service level, measured as the frequency or the time span covered. In general, the higher the level of service, the higher the light rail ridership (*19, 23–25*). Furthermore, travel costs have been cited as one of the key drivers: Kain and Liu (*25*) reported that ticket costs are negatively related to light rail ridership. Next, speed contributes to ridership: lower speed is related to higher ridership (*23, 26*). This negative relation appears to be illogical, but it can be explained by the fact that dwell times increase as loadings rise. Accordingly, routes with high ridership tend to be slower. In addition, Kuby et al. (*24*) found that high-quality connections (short walking distances between modes combined with coordinated and closely scheduled arrival and departure times) to other forms of public transport contribute to the success of the system. Ticket integration (a single ticket for various transport modes) between public transport modes is also cited as a success factor (*19, 23, 26*). With regard to socioeconomic characteristics, Mackett and Babalik-Sutcliffe (*19*) found that high car ownership and high incomes reduce light rail ridership. With regard to policy-related attributes, Mackett and Babalik-Sutcliffe (*19*) showed that offering (temporally) free travel for target groups increases ridership. Furthermore, they indicated that marketing campaigns enlarge the travelers' knowledge of the light rail system, which in turn augments ridership levels. Finally, with regard to regional characteristics, a number of studies emphasize the importance of land use features (e.g., *19, 23–25*). Areas with high employment and retail and residential densities generate more trips than do regions with low densities. Moreover, light rail systems are more likely to be successful when they serve areas with economic growth. In its turn, the development of a light rail system contributes to the economic and urban development of the region as it generates attractive locations for retail settlements (*19*).

DATA

A stated preference (SP) survey was conducted to identify the determinants of light rail mode choice for medium- and long-distance trips for a new light rail system in Flanders (the northern part of Belgium). In 2010, the region had about 6.2 million inhabitants. Flemish residents make 2.9 trips per day on average; the majority of the trips (66.8%) are carried out by car. Slow modes account for 26.4% of the trips, while public transport has a share of 5.3% (*27*).

In SP approaches, respondents indicate their preferences among a set of alternatives for various hypothetical situations (*28–30*). SP surveys are common in travel behavior research and have been extensively applied to the analysis of modal choices (*28*). SP approaches allow researchers to identify behavioral responses to new transport options and travel conditions that have not yet been experienced. Such responses are not (yet) revealed on the market (*30*). However, SP data have one major drawback. They describe only what an individual claims he or she would do in a given scenario, which does not always correspond to the actual or revealed behavior (*28, 30*). One reason for this mismatch is that respondents might give socially desirable answers. Despite this disadvantage, SP approaches have already proved successful in capturing individual preferences under new choice situations. Louviere et al. (*31*) showed that stated behavior is a good approximation of actual (revealed) behavior when socially desirable answers are controlled for. In the current research, socially desirable answers are mitigated by taking the frequency of public transit use and the attitudes toward the various transport modes as controls for inherent preferences.

The SP survey was conducted on a person-based level from early December 2010 to late January 2011 and was completed by random individuals over 18 years of age. The majority of the questionnaires were distributed over the Internet. However, similar traditional paper-and-pencil questionnaires were handed out to counteract the sample bias arising when only web-based data are collected (*32, 33*). In total, the survey collected valuable information from 492 respondents.

The SP questionnaire consisted of three parts in which the respondents had to indicate their preference for, respectively, (*a*) car use versus light rail transit, (*b*) bus transit versus light rail transit, and (*c*) train transit versus light rail transit. Each part contained eight

You live in the center of a small city called ‘A’. You want to perform a work activity. For this, you need to travel to the center of a larger city called ‘B’. The towns are 30 km apart.

Which alternative do you prefer, given following trip characteristics?

	Alternative 1 Bus	Alternative 2 Light rail
Total Travel Time	43 min – 59 min	25 min – 35 min
Egress Time	5 min	5 min
Waiting Time	6 min	5 min
Cost	€2	€5
Transfers	No	Yes
Seats	Free seats	No free seats

O Bus O Light rail

FIGURE 1 Example of alternatives in a hypothetical situation.

hypothetical situations with varying trip characteristics. The trip characteristics included total travel time, access and egress time, waiting time, travel cost, transfers, and availability of seats. Access and egress times were defined as the necessary times for traveling to and from the station, respectively. In contrast to trip characteristics, trip distance and trip motive remained constant across the hypothetical situations. Trip distance was fixed at 30 km, since the goal of light rail transit is to provide transport at the regional level. Trip purpose was set as the most frequently performed purpose indicated by the respondent. This could be a work trip, a shopping trip, or a leisure trip. In total, each respondent was confronted with 24 (= 3 × 8) situations. Figure 1 shows an example of such a hypothetical situation in the survey.

For each hypothetical situation, the respondents had to choose between exactly two alternatives. This was a conscious choice, since research had shown that augmenting the number of alternatives in the experiment would enlarge the cognitive burden of the survey, and the respondents would ignore some of the information (*34*).

In addition to the SP questions, the survey queried some socioeconomic variables in a personal questionnaire (e.g., age, gender, income, household size, number of children, owned vehicles). Information about the frequency of using different transport modes was also obtained. Attitudes toward various transport modes were surveyed, as well as the importance that respondents attached to, respectively, a fast, a convenient, an inexpensive, an environmentally friendly, and a safe trip. Respondents’ perceptions of the various modes with regard to comfort, environment, safety, and speed were queried. The respondents’ expected values of travel time, waiting time, access and egress time, cost, and number of transfers in a trip of 30 km were surveyed and used as a basis for comparison of the values offered in the hypothetical situations. Finally, information was gathered about the importance that respondents attach to specific features of the station or stop locations, such as lighting, guarded bicycle parks, and dynamic information.

Table 1 gives an overview of the definitions and the corresponding measurement units of the variables that were collected in the survey. Because of the large number of variables, only the variables that are included in the final models (Tables 2 and 3 of the results section) are presented here.

To attain an optimal correspondence between the survey sample composition and the Flemish population, the observations in the sample were weighted. The weights were calculated by matching the marginal distributions of the sample with the marginal distributions of the population on the basis of the key person-level attributes age, sex, and marital status.

METHODOLOGY

As stated earlier, the main research objective of this paper is the assessment of the impact of various transport system–specific factors (such as travel cost, in-vehicle travel time, transfers, availability of seats, access and egress time, waiting time, and transit punctuality) and the travelers’ personal traits on modal choice in the presence of light rail transit. The previous section indicated that each respondent had to give the preferred mode (a binary choice) for a number of hypothetical situations. This implies that multiple answers for a single respondent were recorded and that correlation among these repeated observations cannot be disregarded. Therefore, a modeling approach that takes into account correlated responses for binary data is needed. The model adopted to fulfill this requirement is a generalized estimating equations (GEE) model for binary data with the logit link function. The mean response is modeled as a logistic regression model, which is defined as follows (*7*):

$$\log\left(\frac{\pi_i^*}{1-\pi_i^*}\right) = \theta^* + X_i'\beta^* \qquad (1)$$

where

$\left(\frac{\pi_i^*}{1-\pi_i^*}\right)$ = odds,
θ^* = intercept,
β^* = vector of model parameters to be estimated, and
X_i' = vector of explanatory variables.

The above equation can be rewritten as the well-known likelihood function of a binary logit model:

$$\pi_i^* = \frac{\exp\left(\theta^* + X_i'\beta^*\right)}{1+\exp\left(\theta^* + X_i'\beta^*\right)} \qquad (2)$$

TABLE 1 Overview of Variables Collected in the Survey

Variable	Definition	Measurement Unit
Transport System–Specific Variables		
Cost	Total cost for the traveler when using LRT (include access and egress mode costs)	€
Access–egress time	Necessary time to travel to and from LRT station	Minutes
Seat availability	Availability of sufficient free seats on LRT–vehicle	Yes/no
Transfers	Need to make transfers during the trip	Yes/no
In-vehicle travel time	Total travel time on LRT–vehicle	Minutes
Transit punctuality	Variation in travel times (e.g., due to delays)	Minutes
Waiting time	The total time spent waiting at boarding station	Minutes
Socioeconomic Variables		
Age	Years passed since birth	Years
Sex	Gender	Man or woman
Number of cars	The number of cars in the household	Absolute values
Frequency of using public transport	Regularity of public transport use	Daily, weekly, monthly, several times a year, never
Attitudinal Variables		
Attitude toward car	Feelings or mind-set toward the car	7-point Likert scale (1 = very positive, . . . , 7 = very negative)
Attitude toward train	Feelings or mind-set toward the train	7-point Likert scale (1 = very positive, . . . , 7 = very negative)
Attitude toward tram	Feelings or mind-set toward the tram	7-point Likert scale (1 = very positive, . . . , 7 = very negative)
Perception of bus, tram, or metro with regard to comfort	To what extent do people find a bus, tram, or metro trip comfortable?	7-point Likert scale (1 = very comfortable, . . . , 7 = not comfortable at all)
Perception of train with regard to cost	To what extent do people find a train trip inexpensive?	7-point Likert scale (1 = very cheap, . . . , 7 = not cheap at all)
Importance of fast traveling	How important is fast traveling to the traveler?	7-point Likert scale (1 = very important, . . . , 7 = not important at all)
Importance of inexpensive traveling	How important is inexpensive traveling to the traveler?	7-point Likert scale (1 = very important, . . . , 7 = not important at all)
Expected waiting time of a 30-km trip (relative)	Expected waiting time of an imaginary 30-km trip	Relative values (difference in expected waiting times between bus and LRT)

NOTE: LRT = light rail transit.

Equation 1 shows that the estimated parameters must be interpreted as the change in the predicted logged odds for a one-unit change in the corresponding explanatory variable. The odds can be defined as the probability of an event divided by the probability of no event. In this paper, the probability of an event equals the likelihood of choosing light rail transit. The most common way to interpret the parameter estimates is according to the odds ratios (ORs). An OR can be obtained by taking the exponent of the parameter estimate (e^{β}). If the OR is smaller (greater) than 1, it represents a decrease (increase) in the odds of an event (i.e., choosing light rail). This implies that the probability decreases (increases) significantly for every unit increase in the corresponding explanatory variable. Parameter estimates can also be construed by examining their signs. A positive (negative) sign implies an increase (decrease) in the likelihood of an event for every increase in the corresponding explanatory variable.

GEE models take into account the correlation between different observations of the same subject (i.e., repeated answers by the same respondent) by explicitly modeling the correlation structure of the repeated observations. Correlation structures specify how observations within a subject or cluster are correlated with each other. For binary data, the correlation between the *j*th and the *k*th response is by definition the following (*18*):

$$\text{Corr}\left(Y_{ij}, Y_{ik}\right) = \frac{\Pr\left(Y_{ij} = 1, Y_{ik} = 1\right) - \mu_{ij}\mu_{ik}}{\sqrt{\mu_{ij}\left(1-\mu_{ij}\right)\mu_{ik}\left(1-\mu_{ik}\right)}} \tag{3}$$

However, the above formula has one important disadvantage. The correlation is constrained to be within limits that depend in a complicated way on the means of the data. In contrast, the OR is not constrained by the means and is therefore preferred. The OR is defined as follows (*8*):

$$\text{OR}\left(Y_{ij}, Y_{ik}\right) = \frac{\Pr\left(Y_{ij} = 1, Y_{ik} = 1\right)\Pr\left(Y_{ij} = 0, Y_{ik} = 0\right)}{\Pr\left(Y_{ij} = 1, Y_{ik} = 0\right)\Pr\left(Y_{ij} = 0, Y_{ik} = 1\right)} \tag{4}$$

The latter implementation of GEE is called alternating logistic regression (ALR). In general, ALR models the association between responses with log ORs instead of with correlations, as do ordinary GEE (*8*).

TABLE 2 Results of Overall Significance Type III Test of Travel Mode Choice Model

		Car Versus Light Rail			Bus Versus Light Rail			Train Versus Light Rail		
Parameter	DF	χ^2	*P*-Value	Sgn.	χ^2	*P*-Value	Sgn.	χ^2	*P*-Value	Sgn.
Transport System–Specific Variables										
Cost	1	120.04	<.0001	***	133.76	<.0001	***	90.42	<.0001	***
Access–egress time	1	31.90	<.0001	***	99.31	<.0001	***	5.57	0.0183	*
Seat availability	1	65.34	<.0001	***	66.46	<.0001	***	64.09	<.0001	***
Transfers	1	33.09	<.0001	***	1.96	0.1615	NS	27.37	<.0001	***
In-vehicle travel time	1	76.47	<.0001	***	140.69	<.0001	***	17.36	<.0001	***
Transit punctuality	1	2.29	0.1306	NS	3.04	0.0814	NS	0.25	0.6169	NS
Waiting time	1	33.64	<.0001	***	44.93	<.0001	***	13.45	0.0002	***
Socioeconomic Variables										
Age	1	2.63	0.1047	NS	2.85	0.0915	NS	1.46	0.2276	NS
Sex	1	0.07	0.7871	NS	6.70	0.0096	**	4.50	0.0340	*
Frequency of using public transport	4	13.42	0.0094	**	/	/	/	/	/	/
Number of cars	1	3.86	0.0496	*	/	/	/	/	/	/
Attitudinal Variables										
Attitude toward car	1	38.85	<.0001	***	/	/	/	/	/	/
Attitude toward tram	1	9.83	0.0017	**	5.28	0.0216	*	/	/	/
Attitude toward train	1	/	/	/	/	/	/	3.64	0.0565	*
Importance of inexpensive traveling	1	/	/	/	12.46	0.0004	***	/	/	/
Importance of fast traveling	1	/	/	/	4.08	0.0433	*	/	/	/
Perception of train with regard to cost	1	/	/	/	/	/	/	9.39	0.0022	**
Perception of bus, tram, or metro with regard to comfort	1	6.94	0.0084	**	/	/	/	5.23	0.0222	*
Expected waiting time of a 30-km trip (relative)	1	/	/	/	5.10	0.0240	*	/	/	/

NOTE: DF = degrees of freedom; sgn. = significance; / = not applicable.
* *P*-value <.05, ** *P*-value < .01, *** *P*-value < 0.001, NS = not significant.

Three models were estimated to assess the impact of various transport system–specific factors: the binary choice between car use and light rail transit (Model 1), between bus transit and light rail transit (Model 2), and between train transit and light rail transit (Model 3). Since transport system–specific attributes may not explain mode choice fully, other variables (such as personal traits and attitudes) that may have an influence were added as control variables. When the models were built, forward selection was used to find the most relevant variables in the model. Forward selection adds variables to the model one at a time. At each step, each variable that was not already in the model is tested for inclusion. The most significant variable is then added to the model as long as its *P*-value remains below the significance level of .05. The final models were assessed for multicollinearity by using tolerance and variance inflation factor values, but no problems occurred. The results of the model estimations are presented below.

RESULTS

Overall Results

The overall significance tests for the final models are given in Table 2. The table indicates that, in all three models, almost all transport system–specific factors significantly affect the choice of light rail transit (*P*-values are below .05). An exception is the punctuality of light rail transit, which appears not to be significant in any of the three models. In addition, the variable transfers shows no significant effect when the choice between bus transit and light rail transit is modeled.

Other factors that influence mode choice were taken into account in the models as well. Table 2 indicates that various socioeconomic variables, attitudinal factors, and perceptions, as well as the frequency of using public transport (only Model 1), significantly influence the preference for light rail transit. Sex and age are not always significant but were kept in the final models to control for Type I errors (also known as false positives) (*35*). It was also found that the expected waiting time for light rail transit for a 30-km trip was significant when the choice between bus transit and light rail transit was modeled. The expected waiting time is relative: it is the difference between the expected waiting time for bus and the expected waiting time for light rail. If the value is greater than zero, the waiting time for bus transit is larger than the waiting time for light rail transit for the same trip and vice versa.

Parameter Estimates

The parameter estimates for the binary mode choice models are shown in Table 3. As stated earlier, the most common way to interpret these

TABLE 3 Parameter Estimates for Binary Travel Mode Choice Model

	Model 1. Car (0) Versus Light Rail (1)			Model 2. Bus (0) Versus Light Rail (1)			Model 3. Train (0) Versus Light Rail (1)		
Parameter	Estimate	SE	OR	Estimate	SE	OR	Estimate	SE	OR
Intercept	3.6237	0.6729	/	5.6812	0.4734	/	4.6443	0.5884	/
Transport System–Specific Variables									
Cost	–0.4528	0.0336	0.63582	–0.3784	0.0274	0.68502	–0.3545	0.0409	0.70152
Access–egress time	–0.0776	0.0131	0.92532	–0.1721	0.0152	0.8419	–0.0620	0.0220	0.93992
Free seats									
Yes	0.5316	0.0526	1.70171	0.8812	0.0933	2.41381	1.6582	0.1623	5.24991
No	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Transfers									
Yes	–0.3137	0.0468	0.73072	0.1110[a]	0.0790	1.11741	–0.5463	0.1275	0.57912
No	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
In-vehicle travel time	–0.0567	0.0059	0.94492	–0.0851	0.0058	0.9184	–0.0693	0.0065	0.93302
Transit punctuality	–0.0551[a]	0.0362	0.94642	–0.0589[a]	0.0332	0.9428	–0.0281[a]	0.0550	0.97232
Waiting time	–0.0816	0.0143	0.92162	–0.1056	0.0143	0.8998	–0.0663	0.0150	0.93592
Socioeconomic Variables									
Age	–0.0086[a]	0.0053	0.99142	–0.0074[a]	0.0043	0.9926	–0.0057[a]	0.0048	0.99432
Sex									
Man	–0.0241[a]	0.0897	0.97622	0.3837	0.1457	1.46771	0.3660	0.1712	1.44201
Woman	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Frequency of using public Transport									
Daily	1.3893	0.3907	4.01201	/	/	/	/	/	/
Weekly	0.6559[a]	0.3402	1.92691	/	/	/	/	/	/
Monthly	0.4820[a]	0.3466	1.61931	/	/	/	/	/	/
Several times a year	0.3888[a]	0.2941	1.47521	/	/	/	/	/	/
Never	Ref.	Ref.	Ref.	/	/	/	/	/	/
Number of cars	–0.2537	0.1279	0.77592	/	/	/	/	/	/
Attitudinal Variables									
Attitude toward car	0.5872	0.0817	1.79891	/	/	/	/	/	/
Attitude toward tram	–0.2305	0.0743	0.79412	–0.1344	0.0580	0.87422	/	/	/
Attitude toward train	/	/	/	/	/	/	0.1258	0.0671	1.13411
Perception of bus, tram, or metro with regard to comfort	–0.1731	0.0649	0.84111	/	/	/	–0.1560	0.0660	0.85562
Perception of train with regard to cost	/	/	/	/	/	/	0.1799	0.0578	1.19711
Importance of inexpensive traveling	/	/	/	0.2545	0.0721	1.28981	/	/	/
Importance of fast traveling	/	/	/	–0.1583	0.0746	0.85362	/	/	/
Expected waiting time of a 30-km trip (relative)	/	/	/	0.0301	0.0129	1.03061	/	/	/

NOTE: / = not applicable; ref. = reference category, no parameter estimated.
[a]Not significant at the .05 level.

parameter estimates is according to the OR. The OR of travel cost in the car versus light rail model is 0.63582. This represents a decrease in the odds for light rail use of 36% for every €1 increase in ticket price and implies that the probability of choosing the light rail option decreases significantly for every increase in ticket price and that people will be more likely to take the car. Similar conclusions can be drawn for the remaining two models. When ticket prices rise, people are less likely to choose the light rail option and are more likely to choose the bus or train alternative. Next, the OR for the variable access–egress time shows that a 1-min increase in access–egress time will decrease the odds for light rail by 7.5%, 16%, and 6% for the car, bus, and train models, respectively. Thus, every increase in light rail's access–egress time significantly lowers the likelihood of using light rail. Similar conclusions can be drawn for light rail's in-vehicle travel time and waiting time. The OR implies that an increase in these time components leads to a significantly lower probability of light rail use. Furthermore, when light rail vehicles have sufficient seats available, people's probability of opting for light rail increases in all three models. The odds of using light rail when seats are available are 1.7, 2.4, and 5.2 times the odds when no seats are available for the car, bus, and train models, respectively. The opposite holds for the variable transfers. An interpretation of the OR indicates that the likelihood of using light rail decreases significantly when one has to make transfers. This is not the case in the bus versus light rail model, where the reverse is true. However, as mentioned above, this effect is not significant.

A number of attitudinal factors and perceptions contributed significantly to the choice of light rail transit. The OR indicates that a positive attitude toward the car (Model 1) will decrease the likelihood of light rail use and will increase the probability of car use. Similar conclusions can be drawn for the attitude toward train (Model 3), whereas the opposite is true for the attitude toward tram (Model 1 and Model 2). A positive attitude toward tram will enhance the likelihood of using light rail. Moreover, people who believe that traveling by bus, tram, or metro is not comfortable (Model 1 and Model 3) are less likely to travel by light rail. People who believe that train is expensive (Model 3) are more likely to use light rail, while people who attach great importance to inexpensive traveling (Model 2) are more likely to take the bus and are less inclined to use light rail. People who attach great importance to fast travel (Model 2) have higher probabilities of using light rail.

With regard to socioeconomic factors, it appears that men are more inclined to use light rail than women (Models 2 and 3) and that a high number of cars in the household (Model 1) will lower the probability of using light rail. Finally, it appears that current frequent public transport users (Model 1) are more inclined to choose light rail and have a lower probability of choosing the car.

DISCUSSION OF RESULTS

In the preceding section, the relationship between transit punctuality and mode choice was shown not to be significant at the .05 level. This was surprising since the majority of studies in the literature indicated the opposite. The insignificance of transit punctuality in the current study can be accounted for by the fact that the deviations of the travel times in the survey were small (3 to 5 min) in comparison with the overall travel time of the 30-km trips. The effect of larger deviations on light rail mode choice is not explored in this paper. Thus, the conclusion is confined to the fact that small deviations in travel times have no significant influence on light rail mode choice for medium- and long-distance trips.

The results of the other transport system–specific factors (i.e., travel cost, in-vehicle travel time, waiting time, access and egress time, transfers, and availability of seats) are in line with the literature: these factors all affect mode choice significantly in the way one would expect. Only the variable transfers shows no significant effect when the choice between bus transit and light rail transit is modeled. A possible reason is that people may implicitly assume that if a transfer for light rail is required, one would also be required for using the bus, which would negate the overall effect of transfers. Moreover, Table 2 indicates that travelers are strongly influenced by the cost of light rail (large χ^2-values, same number of degrees of freedom). Travel cost is the most important factor when the choices between car use and light rail transit and between train transit and light rail transit are modeled. From the χ^2-values of the time components, it can be inferred that people are most influenced by in-vehicle travel time and are influenced to a lesser extent by waiting and access and egress times (although the influence of those times is still highly significant). Furthermore, it appears that travelers pay more attention to the availability of seats than to transfers (larger χ^2-values, same number of degrees of freedom). The latter findings can be explained by the fact that the corresponding in-vehicle travel time is large compared with the total travel time and by the fact that for medium- and long-distance trips a lack of empty seats is perceived as unfavorable.

Various personal traits of the travelers contributed significantly to the choice for light rail transit. This again is in accordance with the general literature concerning transit mode choice. The literature has demonstrated that, in addition to age, gender, and car ownership, income is a main determinant of public transit mode choice. Nevertheless, income was not included in the final models presented in this paper. Income and number of cars are closely correlated, which implies that higher incomes make owning a car more feasible. As a result, the income effect is indirectly included in the models by means of the number of cars variable.

The findings with regard to attitudes are also confirmed by the literature. Table 3 indicates that a positive attitude toward the car (Model 1) will decrease the likelihood of using light rail, whereas a positive attitude toward the tram (Models 1 and 2) will enhance the likelihood of using light rail. This can be explained by the fact that a tram is also a public transport mode that might be viewed as a good approximation to light rail.

The results indicated that persons who attach great importance to fast traveling are more inclined to use light rail transit than to use bus service. This is confirmed by Scherer (*36*), who found that travelers are more attracted to light rail transit than to bus transit, even if both services offer the same level of service. Scherer explains the difference in ridership by suggesting that light rail transit is considered to be faster than bus service because it has its own right-of-way. In addition, the results indicated that travelers who regard trains as expensive (Model 3) are more likely to use light rail, while travelers who attach great importance to inexpensive traveling (Model 2) are more likely to take the bus and are less inclined to use light rail. These results may indicate that people see light rail as an expensive but fast public transportation mode.

POLICY RECOMMENDATIONS

The findings in this paper provide insight into the success factors of a (new) light rail system for medium- and long-distance trips and can be helpful to policy makers in making light rail more successful. Travel cost and in-vehicle travel time were identified as the most important factors for travelers in choosing to use light rail.

On the basis of the assumption that policy makers will primarily aim at shifting car users to light rail transit for trips of moderate length (10 to 40 km) with urban or suburban destinations, the findings of this research suggest that their flanking measures during introduction of the light rail network should be oriented toward the cost-effectiveness and immunity to congestion of this travel mode. Travelers can be convinced to exchange their cars for a light rail train by drawing their attention to the low travel cost per kilometer compared with the real cost of driving (including fixed costs such as insurance and depreciation). To this end, subsidizing (perhaps temporarily) light rail trips for particular target groups (e.g., commuters, large families, persons with low incomes) can help increase the chances of successful introduction of a light rail system (*19*). Regional authorities can play a major role in this respect through intensive promotional campaigns and by encouraging destination cities to participate in a system of third-party payers (*37*). In addition to the policy measures above, accompanying the introduction of a light rail network with a car restraint policy may help increase the success of the introduction (*19*). Road pricing and higher road taxes may be part of such a policy. The bundling of road pricing with improved public transportation alternatives increases the acceptability and consequently the effectiveness of road pricing (*38*).

Constraining in-vehicle travel time is important to policy makers in making light rail transit more successful. Limiting the number of stops to the absolute minimum and careful consideration of stop locations can make important contributions. In addition, reducing dwell time at stops by eliminating onboard ticket sales by the driver can significantly lessen total run time (*39*). Onboard ticket vending machines, vending machines at stations, and ticket sales by new technologies such as short message service, radio frequency identification, and electronic cash systems can be good alternatives.

CONCLUSIONS AND FURTHER RESEARCH

The impact of various transport system–related factors as well as sociodemographic variables on the use of light rail transit for medium- and long-distance trips in Flanders, Belgium, was investigated. Results from an ALR model confirm that most of these factors significantly influence the use of light rail. The results are in line with international literature. Hence, the key variables for light rail mode choice appear to be stable across different contexts, which implies that best-practice examples might be applicable across different geographical contexts.

The research findings can be used by policy makers in making the implementation of light rail transit more successful. The results of the paper indicate that there would be a shift toward light rail, but whether the shift can be characterized as major is uncertain unless the additional policies that were discussed in the policy recommendations section are also implemented. The effects of these measures are not analyzed in this paper and are an area for further research. In addition, important changes in land use and urban development around the stations can be expected. Hence, construction of a model integrating travel impacts with these land use and urban developments could be intriguing.

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