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Commuter dependence on expressways when travelling to work

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Traffic congestion is a serious problem in the Seoul metropolitan area in Korea, as the city has sprawled drastically over the past several decades. Although the area has a considerable length of expressways, commuters travelling on them ironically suffer from recurrent traffic congestion. The present study focused on the factors that lead commuters to depend on expressways regardless of the disadvantages in terms of travel costs and even travelling times. The impact of commuters' behavioural or attitudinal latent propensities on determination of their usual route for their commute to work was investigated based on a binary logit choice model. Route- and individual-specific variables, which have been widely adopted in conventional route choice studies, were also included in the model. A total of 522 commuters participated in the survey and provided actual information of the routes they used to travel to work. The results showed that behavioural or attitudinal latent determinants other than travel times and costs also contributed to commuters' dependence on expressways.

1. Introduction

Most residents on the outskirts of the Seoul metropolitan area in Korea commute toward the inner-city to employment centres such as the CBD, Yeouido and Gangnam and the majority of these commuters choose expressways as their routine commute. Consequently, expressways in the area suffer from recurrent congestion. There are 16 expressway lines in the area, with a total length of approximately 819·2 km (Figure 1), and all are operated by either public or private agencies with a relatively high toll charged to users. The Korean government has made considerable efforts to alleviate congestion through operational and constructional strategies, but the reality is that there has been little improvement thus far. Recently, the government instead focused on determining the potential causes associated with user characteristics. According to the survey carried out by the authors targeting commuters in the area, a quarter of the respondents who use expressways for their commute to work thought they would save travel times and costs if they switched to parallel arterials nearby. The present study thus addressed the question of why these commuters irrationally prefer expressways to urban arterials despite the disadvantage in both travel times and costs. To explain the phenomenon, this research examined the behavioural or attitudinal propensities associated with dependence on expressways.

Behavioural or attitudinal determinants other than travel times and costs that are associated with route choice are recognised as important. However, many researchers have considered these latent variables to represent little more than a route diversion or pre-trip planning rather than a rigorous modelling of route choice behaviour (Ben-Elia *et al.*, 2008; Bogers *et al.*, 2005; Madanat *et al.*, 1995; Papinski *et al.*, 2009; Parkany *et al.*, 2006; Polydoropoulou *et al.*, 1995). Recently, Prato *et al.* (2012) applied a mathematical model to accommodate these latent factors in a route choice modelling framework. The present study also handled latent variables, but with a significant difference from the previously cited studies. The previous works all concentrated on the impact of the provision of en-route information to determine route diversions. That is, dynamic changes in the behaviour of a driver behind the wheel when traffic information was provided were the main targets of investigation. Their results thus had to be derived from stated preference data within a synthesised experimental environment. However, the objective of the present study was to find the potential reasons for dependence on expressways when a person determines his/her long-term routine route for commuting to work.

Identifying the routine route for commuters required considerable effort, but was invaluable in determining the potential reasons for

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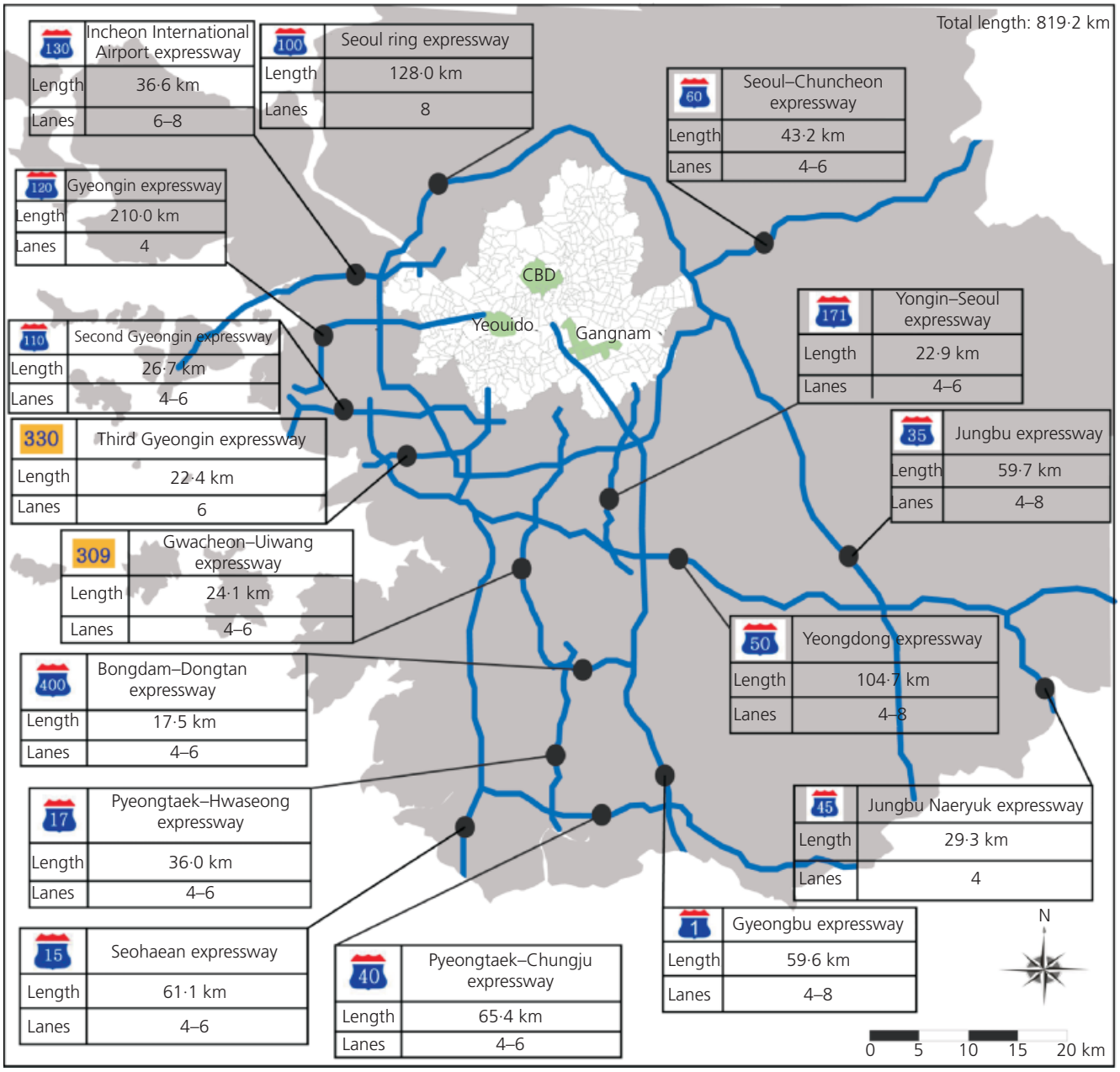

Figure 1. Expressway network in the Seoul metropolitan area

commuters insisting on expressways for their journey to work despite the disadvantages in travel times and costs. Some researchers have studied the difference between commuter groups with and without alternative routes, but it is not easy to identify those differences without surveying commuters' actual route-use patterns. Only a few studies have surveyed such data and identified the possession of alternative routes for each respondent. Khattak and Khattak (1998) collected data through handout/mailbox questionnaires targeting car commuters, and proposed a hierarchical structure of commute route choices to accommodate the choices of whether a commuter acknowledges alternative routes in the upper level, or whether he/she diverts en-route in the lower level. For the upper-level choice, factors such as residence tenure, location characteristics and commuters' behavioural or attitudinal latent propensities were found to significantly affect the decision to use alternative routes. According to the survey conducted by Abdel-Aty *et al.* (1994), no less than 87·5% of commuters had only one route to work. More recently, Li *et al.* (2005) reported that around 40% of respondents used only one route for their commute during a 10-day survey period. The latter proportion seemed too small to provide a rationale for confining the present investigation to commuters who use a routine route.

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However, it is certain that the figure was somewhat distorted. When recalculated on an individual trip basis, 84% of the total morning commute trips were along primary routes, with only 16% along alternative routes. This means that route diversion is not a frequent event, even for commuters who do have alternative routes to work.

The present study was not undertaken to identify drivers' route-switching behaviours or to determine discerning available routes from all possible alternative routes, which was dealt with in the conventional route choice analysis. Instead, the research focused on commuters' potential motives in determining their routine route. What follows deals more with long-term decision-making for the choice of a routine commuting route. It is thus important to recognise that a commuter with their own routine route can switch to any other route when he/she perceives a short-term advantage. In this study, a commuter's routine route for their home to work trip was defined as a route being used constantly for more than 4 days per week. About 74·6% of respondents participating in the survey conducted for the present study had a single routine route for their morning commute trip. To target these people, data necessary for analysing the dependence on expressways were collected.

The next section introduces a modelling framework for analysing dependence on expressways. The variables used in the model and a description of data collection are presented in Section 3. The results are presented and discussed in Section 4. The final section of the paper draws conclusions and suggests possible policies that would be effective in overcoming irrational dependence on expressways.

2. Modelling framework

A conventional route choice structure was used to analyse commuter dependence on expressways based on a binary logit model. As mentioned earlier, determination of a routine route for commuting was regarded as a long-term choice. Prior to presenting the model framework, the setting up of the choice structure had to be addressed.

Only two options were hypothesised to be available for each respondent when determining a routine route. Although constituting a choice set for each respondent was a big challenge in conventional route choice analysis, a commuter's long-term choice for his/her routine route to work was assumed to be binary: an expressway-dominated route or an arterial-only route. For convenience, a route that includes any of the expressway sections will be referred to as an expressway-dominated route hereafter. It was also necessary to ensure that a respondent's alternative route should represent a route that he/she knew exactly or had used at least once at the early stage of determining their routine route. Car commuters who live in the suburbs of the Seoul metropolitan area have no other options but these two routes when determining their routine route to work. Moreover, other researchers who have dealt with pre-trip route choices or en-route choices have depended on only two alternatives (Abdel-Aty *et al.*, 1995; Ben-Elia *et al.*, 2008; Bogers *et al.*, 2005).

As already noted, data for the route choice model were collected from only commuters who had a routine route. A single alternative route other than the routine route was identified for each respondent. Subjects who had any expressway section in their routine route were asked, in a face-to-face interview, what their most plausible arterial-only route was. Subjects who had an arterial-only routine route for their commute to work were asked to present an alternative route, which could include any expressway sections. Of course, those who had no knowledge of an alternative route or no experience using the stated alternative route were excluded from the sample. This survey was extremely time-consuming as long debate between an interviewer and a respondent was inevitable in order to determine an alternative route that the respondent knew exactly or had experienced at least once during the initial stages of determining a routine route for their commute. This was the main reason for the relatively small size of the sample (522). The proportion of expressways was recorded for each respondent's expressway-dominated route, regardless of whether it was used or unused. For each respondent, an expressway-dominated route and an arterial-only route for their commute were finally identified, one of which must have been the respondent's routine chosen route.

Modelling for the commuter route choices in the present study was carried out to identify dependence on expressways. Aside from both route-specific impedances and individual-specific characteristics, behavioural or attitudinal latent propensities were added to feed a route choice model under the expectation that they might be potential causes of the dependence. As mentioned earlier, many researchers have dealt with latent factors in a systematic manner within a route choice or mode choice framework (Ben-Akiva *et al.*, 2002; Johansson *et al.*, 2006; Lee *et al.*, 2012; Morikawa *et al.*, 2002; Sohn and Yun, 2009; Walker, 2001). Those studies combined a choice model and a latent variable model, as shown in Figure 2. Each latent variable was incorporated into the choice utility as a new element. Walker (2001) presented a rigorous estimation methodology to the combined model based on maximum simulated likelihood. Prior to this, a simple sequential approach was used by Prashker (1979) and Madanat *et al.* (1995) to reduce the computational burden. Previous studies by Sohn and Yun (2009) and Lee *et al.* (2012), on which the present study was based, also identified the impact of latent variables on transport choices by using a simpler approach. Even though the simple approach used contained statistical inconsistency, the impact of latent variables on car dependence was successfully identified. In the first step, a principal component analysis (PCA) on indicators that represent behavioural or attitudinal latent variables was performed and the fitted factor scores for each of the respondents were derived. In the next step, the factor scores were used as additional variables to constitute travel utilities.

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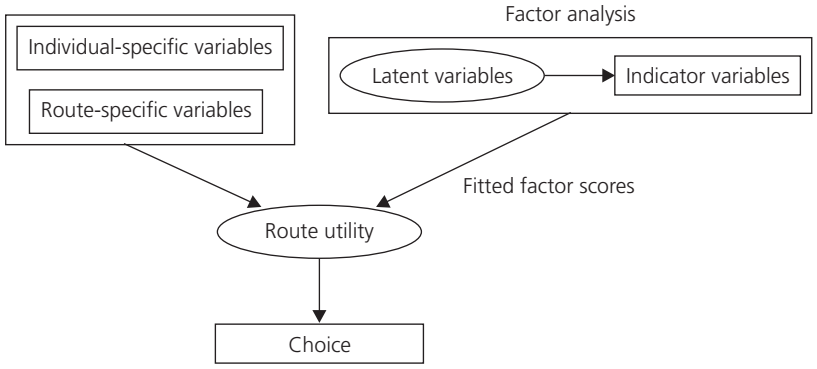

Figure 2. Structure of the combined model

3. Variable selection and data acquisition

Based on intuition and the knowledge accumulated thus far in the field of route choice studies, 17 variables that were expected to affect commuter dependence on expressways were chosen (Table 1). These variables were then categorised into individual-specific and route-specific variables. While these factors could be easily ascertained through straightforward questions to respondents, there was no direct way of identifying a respondent's behavioural

Variable		Mean	Standard deviation	Minimum	Maximum
Individual-specific variables					
Age		39·050	7·602	21	64
Gender (male: 1; female: 0)		0·807	0·395	0	1
Car ownership		1·347	0·541	1	3
Marital status (married: 1; unmarried: 0)		0·751	0·433	0	1
Number of children		0·665	0·473	0	1
Education (college-graduated: 1; otherwise: 0)		0·900	0·300	0	1
Family members		3·397	1·072	1	8
Family members doing economic activities		1·847	0·798	1	6
Dwelling type (apartment: 1; otherwise: 0)		0·713	0·453	0	1
Occupation (white collar: 1; blue collar: 0)		0·157	0·380	0	2
Dwelling location I (Gangnam: 1; otherwise: 0)		0·207	0·405	0	1
Dwelling location II (inner-city: 1; suburb: 0)		0·475	0·500	0	1
Residence tenure: years		4·45	3·67	0·17	20·67
Route-specific variables: expressway-dominated route users					
Routine route (expressway)	Travel time: min	60·47	24·79	15·00	190·00
	Travel distance: km	35·47	17·12	5·00	100·00
	Share of expressways: %	63·46	20·09	2·00	98·00
	Toll: Won	1991	1568	800	10000
Alternative route (arterial)	Travel time: min	76·74	29·71	5·00	180·00
	Travel distance: km	38·41	21·37	3·00	130·00
Route-specific variables: arterial-only route users					
Routine route (arterial)	Travel time: min	44·52	21·22	5·00	100·00
	Travel distance: km	21·80	12·72	8·00	74·00
Alternative (expressway)	Travel time: min	38·06	21·81	0·00	110·00
	Travel distance: km	23·43	15·28	0·00	94·00
	Share of expressways: %	39·36	29·12	1·00	90·00
	Toll: Won	1160	1216	0	10000

Table 1. Descriptive statistics for individual-specific and route-specific variables

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or attitudinal latent propensities. Respondents were thus asked 43 indirect questions on a simple form in order to extract latent variables, each of which indicated a respondent's attitude or behaviour towards the choice of a routine route for commuting. The questions (indicators) were basically selected from previous studies associated with transport choices based on latent variables (Ellaway *et al.*, 2003; Eriksson *et al.*, 2008; Johansson *et al.*, 2006; Prato *et al.*, 2012; Sohn and Yun, 2009; Steg, 2005; Steg *et al.*, 2001). The questionnaire was designed so that the questions could be randomly shuffled to avert bias. For convenience, available answers to the questions were confined to a five-point Likert scale that ranged from strongly negative to strongly positive.

Table 2 shows the resultant 14 variables (factors) and their respective indicators, after completing a PCA. The PCA grouped indictors together when they shared a large part of a factor. A factor must be linked to every indicator theoretically, but only links with a factor loading value larger than 0·5 were taken into account. This often failed to confer the proper title to a factor that the PCA had produced. The seemingly irrational titles were inevitable because they were determined based on the authors' insights. For some factors, the title was determined based on an indicator with the largest factor loading value. Thus, an attempt was made to interpret the results based on individual indicator questions rather than on the titles. Fortunately, the factors with problematic titles were all statistically insignificant when adopted in the choice model for determining a routine route.

As candidates for the first interview, 700 commuters living in the vicinity of expressway interchanges in the Seoul metropolitan area were randomly selected. To conduct the route choice analysis, 522 of the commuters who had a routine route for their commute to work were asked further questions. The results showed that 75·3% had an expressway-dominated routine route for their commute, while the remaining respondents used arterial-only routine routes. The questionnaire comprised three parts.

- The first part contained questions regarding a respondent's individual-specific characteristics.
- The second part was allotted to collect data for route-specific impedance variables. A respondent's route travel time was recorded depending on his/her perceived experiences. In particular, to precisely obtain the travel time for a respondent's alternative route, interviewers let respondents assess the travel time change relative to their routine route. As mentioned in Section 1, a quarter of the respondents who had an expressway-dominated route for their commute answered that travel time would be saved if they switched to an arterial-only route. Although the figure was calculated based on perceived travel times, the relative difference between both travel times on chosen and alternative routes remained fairly consistent even after validating the perceived travel times with estimated network travel times.
- The last part of the questionnaire contained questions to derive respondents' latent propensities. The survey was conducted by a commercial company with expertise in collecting individual information by interview. The company first selected candidates by randomly telephoning residents who lived in the vicinity of expressway interchanges. They finally interviewed 522 respondents face-to-face with a detailed atlas covering possible paths connecting their home to their workplace. It took more than 3 months to complete the survey and a further month to validate the travel time data.

4. Results and discussion

Prior to analysing the choice of a routine route, a preliminary test identified the difference in individual-specific and latent variables according to whether a commuter had an expressway-dominated routine route or an arterial-only routine route (Table 3). The mean of 14 variables was found to be significantly different between the two groups. Regarding individual-specific variables, it was found that young white-collar male commuters, who were unmarried, lived in Gangnam and had more than one car were more likely to choose expressways for their commute to work. Regarding latent propensities, commuters who had extensive spatial knowledge and familiarity with portable electronic devices preferred expressways to arterials, while those who had tendencies to depend on habits and a preference for suburban houses more often used arterial-only routes. It was not surprising that commuters who depended on the use of a car, and who also lacked patience, showed a preference for expressways. The results from these simple tests also confirmed that commuters with good health preferred expressways and adventure-seeking people were committed to arterial-only routes. The results were compared with those from the binary logit choice model wherein each variable's net effect was identified with other influences that could be controlled for.

The estimated results of the two binary logit models are shown in Table 4. Model I took the form of a conventional route choice model including individual- and route-specific variables. Model II added behavioural or attitudinal latent variables to model I and then showed a more promising goodness-of-fit. Accommodating latent variables thus proved to enhance the explanation power of the model. To guarantee model identification, coefficients of individual-specific and latent variables were attached only to the utility of an expressway-dominated route. The estimated results are discussed with respect to model II as follows.

Among individual-specific variables, only two were statistically significant at the 0·05 level. Age was found to negatively affect the utility of an expressway-dominated route. Special care had to be taken with respect to the residence tenure. It was found that a long period of residence reduced the utility of an expressway-dominated route. This can be interpreted as a learning effect, reflecting the possibility that commuters might realise their irrational preference for expressways after a certain amount of experience. The reason that individual-specific variables did not fully account for a preference for expressways might be due to

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Variable	Indicator
1. Ability to remember	I can remember the layout of a shopping mall where I usually shop
	I can easily find things used at home
	I can remember transit routes well
	I can remember birthdays of my friends
	I seldom forget the road I have travelled on
	I can remember most parking places that I have used
	I can easily find things in the dark
2. Spatial knowledge	I can describe well the path to reach home
	I always arrive at the expected time
	I can describe well a path I know
	I usually search for an available path when I visit somewhere unfamiliar
	I prefer a road with a spectacular landscape nearby
3. Preference for electronic devices	I like a smartphone
	I am an early adapter for IT products
4. Reluctance for use of a car	Driving is a burden for me
	I am or have been suffering from adult disease
	A limousine does not suit me
5. Car dependence	My car is like my foot
	I am going to drive even for a 10-minute trip
	I am OK even though my home-to-work distance increases
6. Early-bird propensity	I am a morning person
	I can't understand those who are late for work frequently
	I am more vigorous in the morning than in the evening
7. Too many concerns	I worry about traffic accidents when driving
	I have hypochondria
8. Habitual behaviour	I always use a familiar road
	I usually shop near home
	I use the same route when commuting to work or returning home
9. Adventure-seeking propensity	I enjoy driving
	I should visit a newly opened shopping centre
	Speed makes me happy
10. Lack of patience	I am irritated when stuck in a traffic jam
	I feel uncomfortable because of traffic signals
	I really want to avoid irksome things even though they're in my charge
11. Health conditions	I am in good physical condition
	I enjoy exercise
12. Preference for the use of portable devices	I think navigator information is reliable
	I prefer a notebook to a desktop computer
	I am accustomed to searching for something with a smartphone
13. Work environment	I work in a liberal environment
	There is little flexibility for work hours in my workplace
	I am stressful while working
14. Preference for suburban houses	I want to live in a single-detached house in a suburb, other conditions being equal

Table 2. Behavioural or attitudinal latent propensity variables derived from PCA

the interdependence on latent variables that cannot be accommodated by the simple estimation approach adopted in the present study. In the future, this should be resolved with a fully integrated estimation method.

Regarding route-specific variables, the coefficients for travel times were statistically significant and intuitively accountable for both route options. The travel time of arterial-only routes had a stronger negative impact on utility than that of expressway-

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Variable	Group	Mean	Standard deviation	*t*-statistic	*p*-value
Individual-specific variables					
Age	EWD	38·478	7·521	−3·021[a]	0·001
	AO	40·791	7·613		
Gender (male: 1; female: 0)	EWD	0·824	0·381	1·811[a]	0·035
	AO	0·752	0·434		
Car ownership	EWD	1·382	0·569	2·591[a]	0·005
	AO	1·240	0·429		
Marital status (married: 1; unmarried: 0)	EWD	0·728	0·446	−2·147[a]	0·016
	AO	0·822	0·384		
Number of children	EWD	0·646	0·479	−1·558	0·060
	AO	0·721	0·450		
Education (college-graduated: 1; otherwise: 0)	EWD	0·919	0·274	2·431[a]	0·008
	AO	0·845	0·363		
Family members	EWD	3·402	1·072	0·204	0·419
	AO	3·379	1·077		
Family members engaging in economic activities	EWD	1·849	0·808	0·156	0·438
	AO	1·837	0·768		
Dwelling type (apartment: 1; otherwise: 0)	EWD	0·718	0·451	0·432	0·332
	AO	0·698	0·461		
Occupation (white collar: 1; blue collar: 0)	EWD	0·142	0·364	−1·534	0·063
	AO	0·202	0·422		
Residence location I (Gangnam: 1; otherwise: 0)	EWD	0·250	0·434	2·665[a]	0·004
	AO	0·116	0·322		
Residence location II (inner-city: 1; suburb: 0)	EWD	0·483	0·500	0·503	0·308
	AO	0·453	0·501		
Residence tenure: year	EWD	—	—		
	AO	—	—		
Latent variables					
Ability to remember	EWD	0·021	1·023	0·450	0·327
	AO	−0·025	0·962		
Spatial knowledge	EWD	0·099	0·970	2·150[a]	0·016
	AO	−0·116	1·034		
Car dependence	EWD	0·097	0·986	3·681[a]	0·000
	AO	−0·281	1·090		
Reluctance to use a car	EWD	0·001	1·024	1·538	0·062
	AO	−0·154	0·885		
Preference for the use of a car	EWD	0·091	0·952	−0·107	0·457
	AO	0·102	1·064		
Early-bird propensity	EWD	0·013	1·026	−0·426	0·335
	AO	0·057	0·934		
Too many concerns	EWD	−0·030	0·989	−0·291	0·386
	AO	0·000	1·036		
Habitual behaviour	EWD	−0·083	0·966	−3·257[a]	0·001
	AO	0·239	1·003		
Adventure-seeking propensity	EWD	−0·066	1·037	−2·550[a]	0·005
	AO	0·196	0·931		
Lack of patience	EWD	0·081	1·013	1·958[a]	0·025
	AO	−0·119	0·993		

Table 3. Comparison of variables according to both groups by routine route, expressway-dominated (EWD) or arterial-only (AO)
(continued on next page)

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Variable	Group	Mean	Standard deviation	*t*-statistic	*p*-value
Latent variables					
Health conditions	EWD	0·130	1·013	4·544[a]	0·000
	AO	−0·325	0·898		
Preference for use of portable devices	EWD	0·074	0·998	1·839[a]	0·033
	AO	−0·114	1·050		
Work environment	EWD	−0·003	0·985	−0·091	0·464
	AO	0·007	1·042		
Preference for suburban house	EWD	−0·102	0·953	−2·243[a]	0·013
	AO	0·119	1·016		

[a] Statistically significant at the 0·05 level

Table 3. (continued)

dominated routes, which means that commuters tended to underestimate the travel time on expressway-dominated routes. In the same context, the coefficient for travel distance was statistically significant for expressway-dominated routes, and it had a positive effect on the utility. That is, a longer distance equated to a larger utility for an expressway-dominated route. These results confirmed the prior hypothesis that latent motivations might have expedited the use of expressways. Another counterintuitive result was that the impact of tolls charged to expressway users did not significantly affect the route utility. This might have been due in part to the existence of toll-free expressway segments, but could also be a phenomenon whereby the preference for expressways takes precedence over travel costs. Also, when an expressway-dominated route contained a longer segment of expressway, the route was more likely to be chosen as a commuter's routine route.

Several behavioural or attitudinal latent propensities were found to have a significant influence on commuters' dependence on expressways (see Table 4). Coefficients for two factors (or variables) were statistically significant at the normal level (0·05) and four were significant at the marginal level (0·10). Data for the latent variables were not observed directly but were derived through a post-process (i.e. PCA). Accordingly, the significance criterion was relaxed for the variables that were apt to be contaminated. Adventure-seeking commuters were not likely to use expressways as their routine route for commuting to work. These results imply that commuters who enjoy driving tend to choose arterials that entail more turns and more geometry changes, while those who enjoy exercise preferred to simply drive on expressways. Another finding was that those in good health preferred to use expressways, which was somehow hard to interpret. Commuters caught in daily routines turned out to prefer arterial-only routes. It was, however, contradictory to prior expectations that commuters experiencing habitual use of a certain route would mainly concentrate on expressways. The reason behind this finding might be that the irrational preference for expressways did not stem from a simple habitual behaviour but from a complicated emotion associated with other symbolic advantages of expressways. Unfortunately, the emotional causes were not explicitly confirmed in the present study, even though many latent factors, which were expected to impact them, were tested in the model. This modelling limitation will be left for future research to resolve.

Dependence on car use was positively associated with a dependence on expressways – commuters who evaluated their car highly were more likely to use expressways when commuting to work. Familiarity with portable electronic devices was also strongly linked to dependence on expressways. These two results could provide policy makers with a helpful tip to counter the irrational dependence on expressways. Policies to alleviate car dependence should also address dependence on expressways, and promotional campaigns to accomplish that would be more effective if they were implemented through portable electronic devices. How to reduce car dependence by controlling latent propensities has been discussed extensively by Sohn and Yun (2009) and these goals are also applicable to reducing dependence on expressways.

Several latent variables were expected to greatly impact the dependence on expressways: the ability to remember, spatial knowledge, the early-bird propensity, too many concerns, lack of patience and the work environment. Unfortunately, these variables were either statistically insignificant or intuitively unaccountable. In particular, there was no statistical significance regarding variables for spatial knowledge or lack of patience, but they were found to positively affect the utility of expressway-dominated routes in the simple statistical comparison shown in Table 3. The impact of these two variables could be absorbed into other individual-specific and latent variables, which could also be determined by using a fully integrated estimation method

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Variable	Model I			Model II		
	Coefficient	Standard error	*t*-statistic	Coefficient	Standard error	*t*-statistic
Individual-specific variables						
Age	−0·069[a]	0·025	−2·813	−0·094[a]	0·029	−3·249
Gender (male: 1; female: 0)	0·716	0·392	1·829	0·365	0·469	0·779
Car ownership	0·591	0·340	1·740	0·437	0·382	1·144
Marital status (married: 1; unmarried: 0)	−0·617	0·470	−1·312	−0·596	0·503	−1·184
Number of children	−0·025	0·392	−0·065	−0·128	0·418	−0·307
Education (college-graduated: 1; otherwise: 0)	0·348	0·470	0·741	0·005	0·514	0·010
Family members	0·239	0·167	1·430	0·272	0·183	1·484
Family members engaging in economic activities	−0·407	0·219	−1·861	−0·322	0·248	−1·299
Dwelling type (apartment: 1; otherwise: 0)	0·038	0·347	0·109	0·210	0·383	0·549
Occupation (white collar: 1; blue collar: 0)	−0·140	0·405	−0·346	−0·101	0·434	−0·232
Dwelling location I (Gangnam: 1; otherwise: 0)	0·793	0·521	1·521	0·748	0·551	1·358
Dwelling location II (inner-city: 1; suburb: 0)	0·814	0·346	2·355	0·732	0·381	1·920
Residence tenure: year	−0·070[a]	0·034	−2·061	−0·091[a]	0·038	−2·377
Latent propensities						
Ability to remember	—	—	—	−0·004	0·155	−0·024
Spatial knowledge	—	—	—	0·274	0·175	1·562
Preference for electronic devices	—	—	—	0·143	0·163	0·876
Reluctance for the use of a car	—	—	—	0·179	0·170	1·055
Car dependence	—	—	—	0·278[b]	0·165	1·686
Early-bird propensity	—	—	—	0·210	0·176	1·192
Too many concerns	—	—	—	0·082	0·166	0·496
Habitual behaviour	—	—	—	−0·331[b]	0·183	−1·807
Adventure-seeking propensity	—	—	—	−0·352[a]	0·173	−2·029
Lack of patience	—	—	—	0·044	0·156	0·281
Health conditions	—	—	—	0·552[a]	0·175	3·147
Preference for use of portable devices	—	—	—	0·300[b]	0·160	1·882
Work environment	—	—	—	−0·093	0·166	−0·561
Preference for suburban house	—	—	—	−0·149	0·165	−0·906
Route-specific variables: expressway-dominated route						
Travel time: min	−0·083[a]	0·013	−6·422	−0·088[a]	0·015	−5·984
Travel distance: km	0·096[a]	0·025	3·762	0·100[a]	0·028	3·554
Share of expressways: %	0·035[a]	0·006	5·698	0·035[a]	0·007	5·108
Toll: Won	0·000	0·000	−0·239	0·000	0·000	−0·041
Route-specific variables: arterial-only route						
Travel time: min	−0·086[a]	0·010	−8·251	−0·093[a]	0·012	−7·691
Travel distance: km	0·024	0·020	1·230	0·025	0·021	1·181
Goodness-of-fit	Log-likelihood −150·7636 $\bar{\rho}^2 = 0{\cdot}56672$, $\chi^2 = 282{\cdot}23178$			Log-likelihood = −134·6317 $\bar{\rho}^2 = 0{\cdot}60198$, $\chi^2 = 314{\cdot}4956$		

[a] Statistically significant at the 0·05 level
[b] Statistically significant at the 0·10 level

Table 4. Estimation results from the binary logit model

in the future. It can be inferred that the impact of the former variable was accountable by the residence tenure and the impact of the latter variable overlapped that of the adventure-seeking propensity.

5. Conclusion

The dependence of commuters on expressways in the Seoul metropolitan area was investigated with respect to the long-term choice structure of a routine route for the commute to work.

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Some 25% of respondents persisted in using an expressway-dominated routine route even though they acknowledged that they could reduce their travel time by switching to an alternative. This irrational dependence was manifested through estimated coefficients corresponding to the route-specific variables. That is, the travel time for an expressway-dominated route was less influential than that for an arterial-only route when choosing a routine route for commuting. There was a positive correlation between distance and use of expressway-dominated routes. When an expressway-dominated route contained a longer segment of expressway, the route was more likely to be chosen as a commuter's routine route. Moreover, several behavioural or attitudinal latent factors were found to be responsible for the dependence, while individual-specific variables offered few clues to account for this.

Unfortunately, the influences of several latent factors were either statistically insignificant or intuitively unaccountable, and this should be addressed with more samples and a more rigorous estimation approach in further research. Nonetheless, some policies could be formed from the use of behavioural or attitudinal latent propensities. The dependence of motorists on expressways should be understood in the same context as car dependence. It can be inferred that a motorist with a strong dependence on a car for various purposes will also have a strong preference for expressways when commuting to work. Consequently, controlling car dependence could be a key to reducing irrational use of expressways. The study of latent propensities also showed that the use of portable electronic devices could be effective in conducting a promotional campaign to persuade commuters to give up cars along with their irrational use of expressways.

The simple estimation approach used led to a lack of statistical significance regarding the individual-specific variables and several counter-intuitive results from the latent variables. To overcome this problem in the future, an integrated estimation method should be adopted to derive more statistically consistent results. This might, however, entail computational burdens.

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