MODE CHAINING CHOICE ANALYSIS OF HIGH SPEED RAIL SYSTEM AND ITS FEEDER SYSTEM

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abstract: The effectiveness of a High Speed Rail (HSR) system is strongly dependent on its feeder system and station location. That means a trip using High Speed Rail has a trip chaining characteristic i.e., mode chaining. So we developed a joint mode chaining choice model to describe this characteristic. According to the research results we found the best location of a HSR station is to be integrated with the traditional railway station and combined with Mass Rapid Transit system. The effectiveness of a feeder system will influence the mode choice of the main transport systems significantly.

1.INTRODUCTION

In order to balance the area development of Taiwan, the High Speed Rail (HSR) project, one of the National Six Years Construction Projects in Taiwan, selected its stations to be developed as new towns. As shown in Fig.1, present planning HSR system in this country has high mobility, with travel speed reaches 200 km/hr[1]. However, the 7 stations on the route with the average spacing 57km only make its accessibility very low. Therefore, the connecting transit system around the station becomes the key factor to ensure the integral efficiency of the HSR. The planning of HSR must also consider the connection issues among transit systems. Therefore, in this paper, the Mode-chaining concept is developed to set up basic idea for HSR planning methodologies. Through analysis of the travel behaviors under consideration of the mode-transferring process between trip origin and destination, it is anticipated that the HSR and its connecting transport system could be correctly planned.

Travel behavior study is quite a complicated subject. Traditionally, it divides travel process into some independent stages and then analyzes them separately, as A, B, C shown in Fig. 2. It analyzes the travel demands of origin (A), destination (C) and main travel mode (B) individually, especially, when analyzing the travel demand of main mode (B) such as HSR system in this study, it assumes (A) and (C) are given. Such method may simplify the travel model, but it distorts the nature of travel model in explaining the real phenomenum. Actually, as shown in Fig.3, the whole travel behavior should include the transfer process before and after main travel mode. The concept that a trip may use multiple modes to perform its travel purpose is Trip-Chaining. The idea of Trip-Chaining includes two different concepts based on trip purpose chain and mode chain separately. The trip purpose chain means a trip consists a series of different travel purposes. On the other hand, the mode chain means a trip consists a series of different travel modes in its whole travel process. Since a person must transfer in order to perform his travel purpose when using the HSR system, the study uses the concept of mode-chaining to analyze the travel demand of the HSR system. The Fig.4 shows the modeling concept of mode-chaining in this study. It basically concerns the mode choice model with the aspect of mode chaining. We use the travel behavior feature between Taipei and Tai-Chung (Wu-Zu) of the planed HSR in Taiwan as a case to analyze the mode chaining characteristic and to generate the theoretical structure of the travel demand model.

Fig.1. Taiwan HSR system

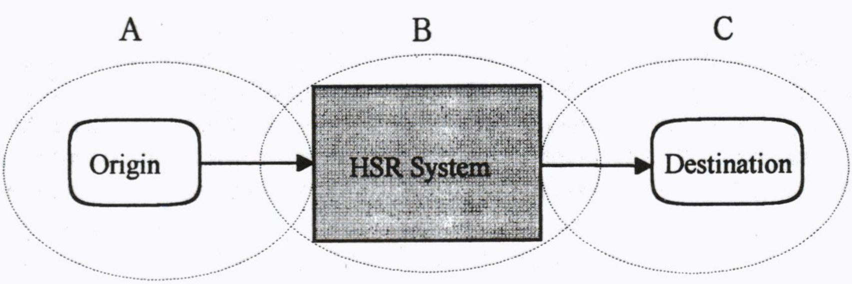


Fig.2. Traditional transportation planning concept

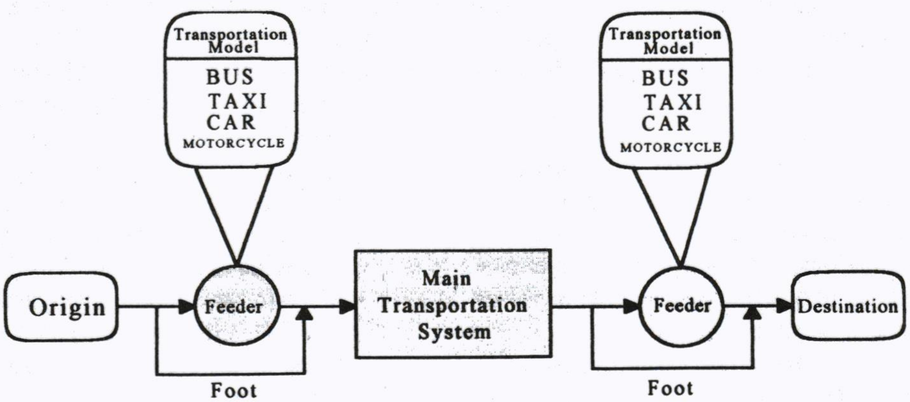


Fig.3. Intercity travel behavior

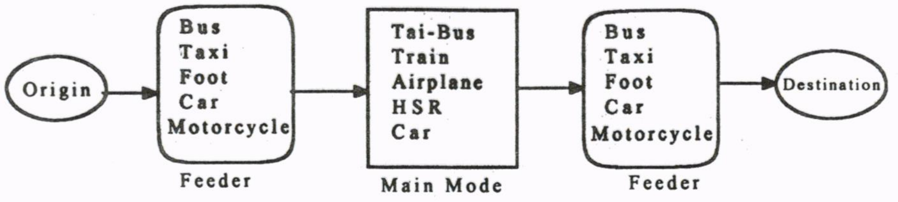


Fig.4. Modeling conception of trip-chaining mode choice

2.ANALYSIS OF CURRENT MODE-CHAINING SELECTION BEHAVIOR

2.1 Data Collection

The necessary data for this study are mainly got from questionnaires. The items in the questionnaires include four parts: basic individual trip information, the usage of the traffic mode, survey of the preference toward HSR and personal data. They are described more detail in the following:

(1)basic individual trip information: including trip objective, starting time, expected travel time, and the travel modes ever used for the same destination.

(2)the usage of travel mode: the modes includes main mode and feeder modes. The feeder modes are further divided into the modes used before and after using the main mode. The collected data include the travel times in and out of the mode, out-of-pocket cost and the alternative modes.

(3)the survey of the preference toward HSR: focusing on the preference to use HSR by the inter-city passengers at different level of variables including the importance of connecting system, transfer time, number of transferring, and fares.

(4)personal data: including traveler's age, sex, education, personal income, household income and car ownership.

Choice-based sampling is adopted for the survey. Basically, when using choice-based sampling the parameter estimation may have some errors because the occupant rate in the sample is different from that in the population. However, in the saturated model, the errors of the parameter estimation can be escaped by some specific dummy variables in the alternatives. Therefore, there is no significant influence towards policy analysis. Furthermore, the specific dummy variables can be adjusted by using the occupancy ratio (Qi/H_i) in the sample and population of the alternatives:

$$\beta_i^* = \hat{\beta}_i + \ln[Q_i/H_i] \quad \text{.......(2-1)}$$

where β_i^* is the non-error estimated value of the specific dummy variable in alternative i and $\hat{\beta}_i$ is the unadjusted estimated value of the parameter.

In order to get the enough samples, we collected the samples on the trains, buses, airports, freeway toll stations since this study focuses on the travel characteristics of the inter-city travelers. The results of the questionnaires are shown in Table.1.

Table.1. Questionnaire statistics

	delivered	returned	returned ratio	effective	ineffectiv	effective ratio
Train*	221	221	100%	128	93	58%
Tai-Bus*	362	362	100%	250	112	69%
Airplane*	115	115	100%	96	19	83%
Car**	2,500	206	8.02%	99	107	48%
Total	3,198	904	28.89%	573	331	63%

* : direct interview, ** : mail return

2.2 Mode Chaining Behavior Analysis

Basically, an inter-city trip can be performed only through the connection of multiple modes. Therefore, this section used the idea of mode chaining to analyze the travel behavior of inter-city traffic in Taiwan according to the results of questionnaires survey.

(1)Using train as the main mode: As indicated in Fig.5, when using train as the main mode the percentages of mode-chain are 17.79% of bus-train-bus, 10.6% of bus-train-taxi, 14.84% of taxi-train-taxi and 13.28% of car-train-taxi. These four mode-chains occupy 66.41% of the total train passengers. In addition, taxi works as an important transfer mode, there are 50% of the total passengers taking taxi from the train station to their destination.

(2)Using Tai-bus as the main mode (Tai-bus is a main inter-city bus company in Taiwan): As shown in Fig.6, for those passengers taking Tai-bus as their main mode, more people prefer the following mode chains: 25.20% of bus-Taibus -bus, 9.6% of bus-Taibus-taxi and 14.4% of taxi-Taibus-taxi. Its main transfer modes are bus and taxi. Next, deserving attention, there are 6.4% of the total travelers choose bus-Taibus-foot. This may be due to the fact that Taibus drops its passengers at the stations along the route. Finally, another 6.4% of the passengers select the motorcycle-Taibus-motorcycle mode. This also is a special characteristic in Taiwan. Taiwan has more than ten million motorcycles now.

(3)Using airplane as the main mode: As you can see in Fig.7, 91.66% of the airplane passenger choose the following mode chains: 64.58% of taxi-airplane-taxi, 10.42% of taxi-airplane-car, 8.33% of car-airplane-taxi and 8.33% of car-airplane-car. Apparently, taxi is the main transfer mode in this case.

The following conclusions are got from the analysis :

- The transfer mode choice before taking the main mode is more uniform according to the social-economic characteristic of the passengers. On the contrary, there are significant difference for the transfer mode after taking the main mode, e.g., students prefer to taking bus, but workers like to take taxi.
- the usage of taxi somewhat is higher than expected before. Except the special characteristics of the mode, this may be due to some implicated issues, such as the

non-integrity of the public transit system and the passengers are not so familiar with the environment.

- Passengers who select Tai-bus for their main mode and transfer on foot are higher than by the other main modes. Because the Tai-bus stops, not only at the bus terminal, but also at the stations along the route in the destination city , so passenger can easily reach the destination on foot.
- For those taking train as their main mode, travelers prefer to using taxi as the transfer mode. This may be arisen by the non-integrity with the connecting transit system.

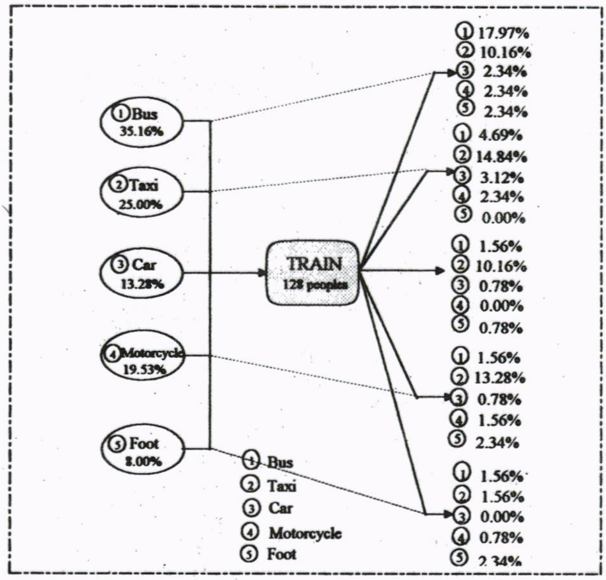


Fig.5. Mode-chaining behavior analysis (using train as the main mode)

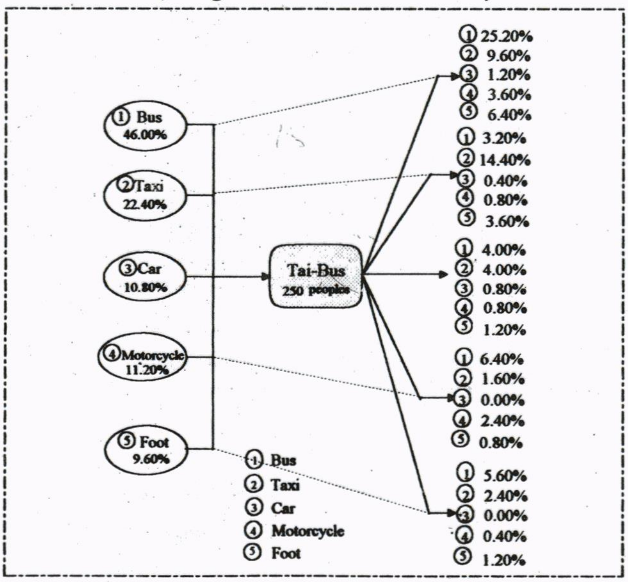


Fig.6. Mode-chaining behavior analysis (using Tai-bus as the main mode)

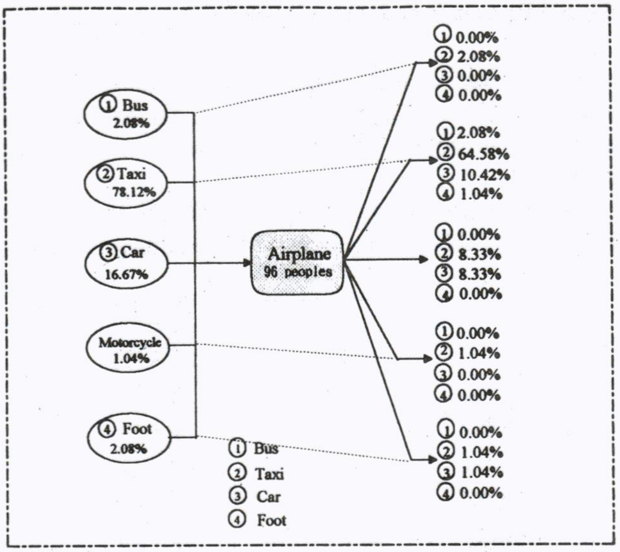
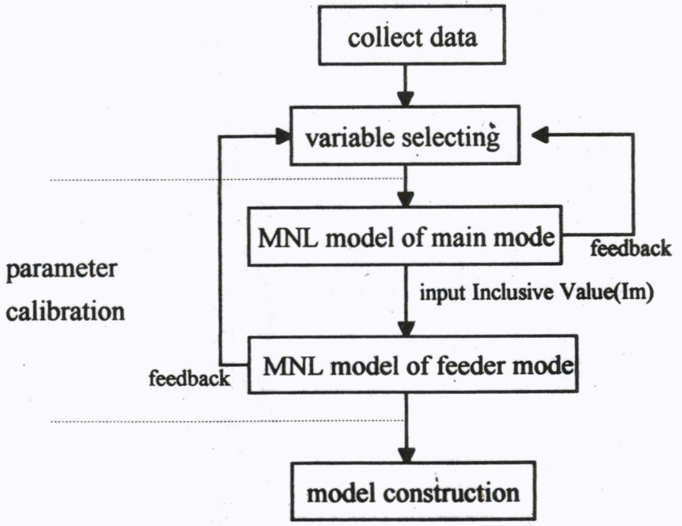


Fig.7. Mode-chaining behavior analysis
(using airplane as the main mode)

3.MODEL CONSTRUCTION AND APPLICATION

3.1 Parameter Calibration Method

The calibration method of model parameter is Multi-Step Estimation Method, i.e., Limited Information Maximum Likelihood Method (LIML). The process of parameter calibration is shown in Fig.8.



*MNL: Multinomial Logit Model

Fig.8. Process of parameter calibration

3.2 Variable Selecting

The choice of variable can be separated into two parts. They are Main Mode Choice Model and Mode-Chaining Choice Model, as described in the following:

3.2.1 Main Mode Choice Model

The variables of model consists of the variables to indicate the service level of transportation system and the variables of personal social economic characteristic. The variables are described in the following:

1. Travel time:

(1)'total travel time' generic variable: If traveler has same travel time by different modes, then the coefficient value of travel time is the same in utility function for different modes.

$TT = BT + WT + DT + AT$ TT: total travel time
BT: from origin to main mode station time
WT: waiting time of main mode
DT: in-vehicle travel time of main mode
AT: the duration time from station to destination

(2)'total travel time' alternative specific variable: If traveler has different travel time among different modes, then the coefficient value of travel time is different among utility functions of different modes. TT_T means the train specific variable, and TT_B 、TT_A 、TT_C 、TT_H means the bus 、 the airplane 、the car 、the HSR specific variables.

(3)'origin to boarding station time' and 'landing station to destination' generic variables: If traveler has different travel time evaluation among different time section, then the total travel time can be separated into 'origin to boarding station travel time(SET)'and 'landing station to destination travel time (AT)'.

where $SET = BT + WT + DT$

(4)'origin to boarding station time' specific variable and 'landing station to destination time' generic variable: If traveler has different evaluation of SET, then we can set up the specific variable of airplane (SETA)、 Tai-bus (SETB)、 car (SETC)、 train (SETT)、HSR (SETH).

2. Travel cost

(1)'total travel cost' generic variable: If traveler has same travel cost evaluation among different modes, then set up total travel cost (TC) as generic variable.

(2) union of the total travel cost and the social economic characteristic.

$TC_{PC} = TC/PC$

$TC_{HC} = TC/HC$

where PC is the personal income, HC is the household income.

(3)'total travel cost of car' specific variable:

$TC_{NUM} = TC/(PC \times NUM)$

where NUM is the people in the same car.

3. Personal social economic characteristic :

All variables for personal social economic characteristics of must use specific variable style, because they can not input utility function using generic variable.

(1)'personal income (PC)' specific variables: set HSR as the reference alternative, then the PC specific variables are PC_T 、 PC_B 、 PC_A 、 PC_C that can inflect the PC influence of mode choice.
(2)'household income (HC)' specific variables: set HSR as the reference alternative, then the HC specific variables are HC_T 、 HC_B 、 HC_A 、 HC_C that can inflect the HC influence of mode choice.
(3)'car ownership' specific variable: set CAR_C as the specific variable of car ownership that can inflect the car ownership influence of mode choice.

4. Specific alternative dummy variable (DUM)

In order to reflect the influence of variables on mode choice and to delete the errors, three dummy variables are put in the model.

3.2.2 Mode-Chaining choice model

For building mode-chaining choice model the main mode choice behavior and the feeder mode choice behavior of inter-city would be considered together. The feeder time can influence the inter-city mode choice and it also is an important utility indices of a feeder mode. Therefore, it needs a model to combine two mode choice behaviors. In the decision process of travel behavior, the inter-city mode is the main influence element. The variables of feeder mode choice model are following:
(1)'bus dummy variable' alternative specific dummy variable: 1, while the mode is bus and 0, while other modes.
(2)'car dummy variable' alternative specific dummy variable: 1, while the mode is car and 0, while other modes.
(3)'motorcycle dummy variable' alternative specific dummy variable: 1, while the mode is motorcycle and 0, while other modes.
(4)'feeder time' generic variable: the value is travel time of feeder modes.
(5)'feeder cost' generic variable: the value is travel cost of feeder modes.
(6)'inclusive value of mode' (I_m) generic variable.

3.3 Building and Analysis of Model

3.3.1 Main mode choice model (P_m)

There are 7 models analyzed in this research, as presented in Table.2 and Table.3.
(1) In model 1, the coefficient value of TT generic variable is reasonable and its t-value is -4.124. The coefficient value of TC/PC generic variable is also reasonable and its t-value is -3.407. They are very significant and have influences of the mode choice.
(2) In model 2, let SET and AT be generic variables of TT. All coefficient values of variables are reasonable same with model 1.The t-value of SET is -4.387 which shows significant.
(3) In model 3, let TT_A 、 TT_H 、 TT_{TBC} be specific variables of TT. The parameter quantity of result of calibration are reasonable. The t-value of TT_{TBC} is -4.457, of TT_A is -1.188, and of TT_H is 1.648.

(4) In model 4, let SET_{TBC} 、 SET_A 、 SET_H be specific variables of SET. The most of parameter value are similar with model 3. The t-value of SET_H is -2.006 which is significant. So the traveler of HSR can be influenced by SET_H.
(5) In model 5 and model 6, let the generic variable of TT and SET be specific variables of alternatives. All the values of parameters seem reasonable.

We set the choice behavior of traveler is rational and unchangeable in the future after the HSR constructed. Then, we can modify the specific dummy variable using equation (2-1) in order to estimate the expected new main mode choice percentage after HSR constructed. The result is presented in Table.4.

3.3.2 Mode-Chaining Choice Model (P_{md})

Table 5 presents three mode-chaining choice models developed in this paper. The method for calibrating the parameters is Multi-Step Estimation Method. The model 1 is similar with nested multinomial logit model which set the uncontrollable and unmeasurable effects of the utility of mode choice behavior are correlated. The model 2 is similar with multinomial logit model which set the uncontrollable and unmeasurable effects of the utility of mode choice behavior are independent and its inclusive value (Im) is 1. The model 3 is the independent model of mode choice that doesn't consider inclusive value.

Table.2. Alternative model of main mode choice(1)

	model 1	model 2	model 3	model 4
TT	-0.0117(**-4.124**)			
TT_{TBC}			-0.0131(**-4.457**)	
TT_A			-0.01232(-1.188)	
TT_T				
TT_B				
TT_C				
TT_H			-0.01176(-1.648)	
SET		-0.0133(**-4.387**)		
SET_{TBC}				-0.0147(**-4.662**)
SET_A				-0.0161(-1.172)
SET_T				
SET_B				
SET_C				
SET_H				-0.01502(**-2.006**)
AT		-0.016(-1.775)		-0.01819(**-1.990**)
TC/PC	-0.013(**-3.407**)	-0.012(**-3.163**)	-0.0121(**-3.144**)	-0.01184(**-3.095**)
PC_T	-0.144(-1.487)	-0.0898(-0.933)	-0.039(-0.412)	-0.0606(-0.63)
PC_B	-0.074(-0.887)	-0.031(-0.0367)	0.2578(0.307)	0.0297(0.358)
PC_A	-0.010(-0.065)	-0.0105(-0.073)	0.0047(0.0324)	-0.0029(-0.02)
PC_C	-0.164(-1.432)	-0.115(-1.017)	-0.0535(-0.487)	-0.081(-0.725)
DUM_T	-0.0433(-0.082)	-0.023(-0.043)	-0.0096(-0.0097)	-0.0149(-0.018)
DUM_B	0.092(0.171)	0.042(0.07589)	0.0207(0.021)	0.0297(0.035)
DUM_A	0.007(0.0087)	0.0008(0.0011)	0.002(0.0012)	0.00113(0.0007)
DUM_C	-0.080(-0.153)	-0.041(-0.077)	-0.016(-0.016)	-0.0246(-0.0296)
CAR_C	0.0305(0.079)	0.00085(0.0022)	0.00153(0.004)	0.0026(0.0068)
L(0)	-381.87	-383.97	-388.11	-385.52
σ^2(EQ)	**0.11**	**0.11**	**0.1**	**0.1**

Table. 3. Alternative model of main mode choice(2)

	model 5	model 6	model 7
TT			-0.011(**-3.916**)
TT_{TBC}			
TT_A	-0.0131(**-2.949**)		
TT_T	-0.0102(**-2.585**)		
TT_B	-0.0133(-1.292)		
TT_C	-0.0151(**-2.986**)		
TT_H	-0.0117(-1.598)		
SET			
SET_{TBC}			
SET_A		-0.0135(**-3.097**)	
SET_T		-0.0102(**-2.062**)	
SET_B		-0.0138(-1.035)	
SET_C		-0.0157(**-3.265**)	
SET_H		-0.0111(-1.423)	
AT		-0.0207(**-2.292**)	
TC/PC	-0.0079(**-2.231**)	-0.0087(**-2.444**)	-0.0137(**-3.56**)
PC_T			-0.148(-1.556)
PC_B			-0.154(-1.820)
PC_A			
PC_C			-0.159(-1.552)
DUM_T	-0.00009(-0.00008)	-0.0007(-0.00069)	-0.068(-0.128)
DUM_B	-0.00009(-0.00008)	0.00005(0.00005)	0.189(0.353)
DUM_A	0.00012(0.000078)	0.000067(0.00005)	0.0047(0.0178)
DUM_C	-0.00013(-0.0011)	-0.00054(-0.00053)	-0.1424(-0.28)
CAR_C	0.00095(0.0026)	0.002256(0.0062)	
L(0)	-384.04	-381.03	-381.15
σ^2(EQ)	**0.11**	**0.11**	**0.11**

Table.4. Percentage analysis of main mode choice after modified

	occupancy ratio(Q_i/H_i)	model 1	model 2	model 5	model 6	model 7
Train	0.06	0.07	0.07	0.07	0.07	0.08
Tai-bus	0.18	0.16	0.16	0.19	0.19	0.15
Airplane	0.01	0.02	0.02	0.02	0.02	0.02
Car	0.33	0.36	0.38	0.33	0.33	0.36
HSR	0.41	0.39	0.37	0.39	0.38	0.39

Table.5. Joint choice model of mode-chaining

	model 1	**model 2**	**model 3**
DUM_T	-0.018(-0.079)	-0.018(-0.079)	-0.018(-0.079)
DUM_B	0.062(0.232)	0.062(0.232)	0.062(0.232)
DUM_A	0.033(0.101)	0.033(0.101)	0.033(0.101)
SET	-0.011(**-3.025**)	-0.011(**-3.025**)	-0.011(**-3.025**)
TC/PC	-0.0019(-1.788)	-0.0019(-1.788)	-0.0019(-1.788)
AT	-0.0747(**-6.558**)	-0.0747(**-6.558**)	-0.0747(**-6.558**)
CAR_C	0.0002(0.00013)	0.0002(0.00013)	0.0002(0.00013)
I_m	**0.16**(--)	1(-)	--
D_{BUS}	0.672(**2.357**)	0.7346(**2.46**)	0.8696(**2.886**)
D_M	-0.53(-1.794)	-0.5773(-1.841)	-0.673(**-2.16**)
D_{CAR}	-0.299(-1.705)	-0.331(-1.727)	-0.415(**-2.155**)
FT	-0.0591(**-7.357**)	-0.035(**-4.719**)	-0.076(**-8.882**)
FC	-0.00935(**-3.615**)	-0.0104(**-3.66**)	-0.0135(**-4.71**)
L(0)	-428.83	-426.81	-410.15
σ^2(EQ)	**0.26**	**0.26**	**0.29**
σ^2(MS)	**0.03**	**0.04**	**0.07**

4. ALTERNATIVES GENERATING AND COMPARING ANALYSIS

4.1 Alternatives Generating

For analyzing the mode-chaining choice behavior, we use the data got from questionnaire survey to develop the joint choice model of a mode-chaining. Using the joint choice model, the alternatives of station location combining with the feeder system can be compared and analyzed. We selected a typical station, Wu-Zu station in Taichung, in middle Taiwan, as the case to generate different alternatives. According to the site of station and the structure of feeder system, four alternatives are worked out and stated as follow:

(1) alternative 1, as shown in Fig.9: it only connects with major cities under consideration of the present demand characteristic of inter-city passengers.

(2) alternative 2, as shown in Fig.10: associating with new town development concept and using Wu-Zu as the transportation center, more densely connecting networks are built for better feeder service.

(3) alternative 3, as shown in Fig.11: the same connecting concept as alternative 1, but rapid transit system will be built additionally as a feeder mode.

(4) alternative 4, as shown in Fig.12: the HSR station is not located in Wu-Zu, but located in Taichung city center using present railway station and the existing connecting network to proceed transfer.

There are advantages and disadvantages of each alternative. The travel time and cost calculated for each alternative are shown in Table.6.

Table.6. Time and cost analysis of different feeder system

mode \ alternative / sample		Alternative 1		Alternative 2		Alternative 3		Alternative 4	
		Time	Cost	Time	Cost	Time	Cost	Time	Cost
Transit	94	60.28	48.68	30.28	23.68	45.28	53.68	24.13	20.52
Taxi	196	20.79	104.77	20.79	104.77	20.79	104.77	16.38	88.93
Motorcycle	10	25.13	16.5	25.13	16.5	25.13	16.5	20.65	15.39
Car	37	22.5	82.12	22.5	82.12	22.5	82.12	18.57	77.46
Average	--	32.12	84.02	23.75	77.05	27.93	85.41	18.91	66.41

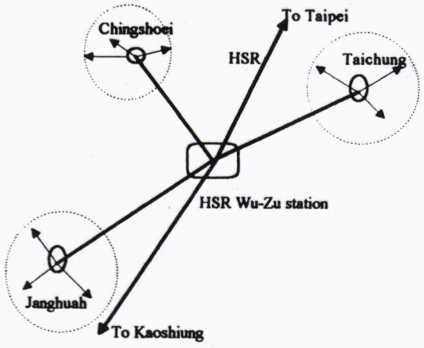


Fig.9. Two-stage feeder style at HSR station (Alternative 1)

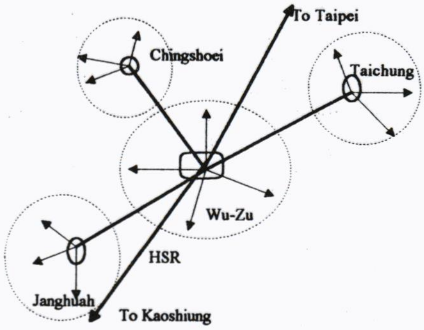


Fig.10. Direct radial feeder system HSR station (Alternative 2)

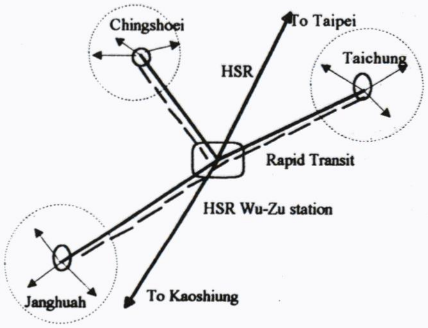


Fig.11. Two-stage feeder associated with rapid transit system (Alternative 3)

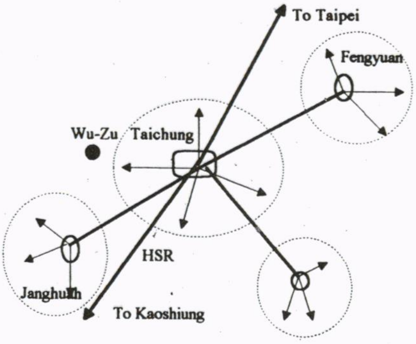


Fig.12. Direct radial feeder style at HSR station located Taichung center (Alternative 4)

4.2 The Comparison Analysis for Feeder Concept

Because the difference between alternative 1, 2 and 3 concerns about the connecting concept mainly, so we use the best model 6 in the main mode models to compare these three alternatives. The results of main mode choice probability are shown in Table.7. The highest ratio of using HSR is by alternative 2, that is direct radial style. The result shows that the connecting feeder style has certain degree of influence on HSR riderships.

Table.7. Mode choice probability of main mode

ridership % / alternative / main mode	Two-stage Feeder (Alternative 1)	Direct Radial Feeder (Alternative 2)	Two-stage Feeder Associated with Rapid Transit (Alternative 3)
Train	0.08	0.07	0.08
Tai-bus	0.21	0.19	0.2
Airplane	0.02	0.02	0.02
Car	0.36	0.33	0.35
HSR (new mode)	**0.33**	**0.38**	**0.36**

4.3 Analysis of the Joint Choice of Main Mode and Its Feeder System

The choice ratio of each feeder mode connected with main mode can be obtained from the result of joint choice model analysis. The results of the joint choice of main mode and its feeder system are shown in Table.8.

Table.8. Probability analysis of mode-chaining choice

	Feeder mode choice ($P_{d/m}$)	Ridership of HSR (P_m)	Union of feeder and HSR (P_{md})
Bus	0.38	0.33 (two-stage feeder, alternative 1)	0.13
Automobile	0.12		0.04
Car	0.17		0.06
Taxi	0.33		0.11
Mass Rapid Transit	--		--
Bus	0.38	0.38 (direct radial feeder, alternative 2)	0.14
Automobile	0.12		0.05
Car	0.17		0.06
Taxi	0.33		0.13
Mass Rapid Transit	--		--
Bus	0.26	0.36 (two-stage feeder associated with rapid transit system, alternative 3)	0.09
Automobile	0.08		0.03
Car	0.12		0.04
Taxi	0.23		0.08
Mass Rapid Transit	0.31		0.11

4.4 The Analysis of HSR Station Location

Different locations of HSR station may incur different riderships of HSR. Two different station locations are analyzed in this study to investigate the influence of station location on the HSR riderships. They are the alternative 2 and 4 described in section 4.1. In alternative 2, the HSR station is located in Wu-Zu, near metropolitan Taichung. In alternative 4, the HSR station is located in Taichung city center and sited together with the Taichung railway station. The result shows that the convenient feeder system is the main reason for passenger to take HSR. That means if the HSR station locates at Taichung rail station, its connecting system will be more convenient for the passenger, so HSR gets more ridership, as shown in Table.9.

Table.9. The percentage of ridership at different station locations

	Wu-Zu station Direct radial feeder (alternative 2)	Taichung rail station Direct radial feeder (alternative 4)
Train	0.07	0.06
Tai-bus	0.19	0.18
Airplane	0.02	0.02
Car	0.33	0.31
HSR	**0.38**	**0.43**

5. CONCLUSIONS AND SUGGESTIONS

5.1 Conclusions

HSR possesses the role of trunk route in inter-city travel in terms of its high comfort, high speed and high mobility. But, its accessibility is low due to the limitation of the number of stations. Therefore, the efficiency of HSR must strongly depend on integral connection transit system. Most of the present inter-city travel demand studies neglect the transfer behavior along the travel path. The idea of mode-chaining can remedy such deficiency. The following findings are resulted from the analysis of mode-chaining in Taiwan regarding HSR planning:

(1) taxi occupied 50% of the passengers who take the train as main inter-city mode. It responses a unreasonable supply situation of the transport system.

(2) Most Tai-bus passengers take bus and taxi as the main transfer equipment. Students will use the bus as main feeder mode. In addition, a lot of Tai-bus passengers will be on foot to reach the destination.

(3) 90% of the airplane passengers use cars and taxis as feeder mode. That means that we neglected the developing of mass transit for the feeder traffic to connect air traffic. If we had used mode chaining concept to plan the inter-city transport system, this deficiency can be avoided in advance.

(4) Apparently, the feeder system has highly influence on the mode choice of HSR. In addition, the location of station also affect the passenger volume of HSR significantly.

5.2 Suggestions

Trip-chaining is more suitable for describing travel behavior in view of the nature of travel demand. Therefore, it is worthwhile to do further studies in this field. For promoting the integrity among the traffic modes and the transfer performance, using the idea of trip-chaining to establish transportation planning method is deserved in the future. Although the joint mode choice model could analyze some of the features of mode-chaining, however it should consider using the Monte-Carlo simulation method to analyze the trip chaining characteristics in view of the extension of the amount of modes within every trip. Since feeder transit system has significant influence on the performance of the riderships of HSR, the planning of a HSR should take the integration of the feeder transit system with the main mode into consideration.

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