An Impact Analysis of the Taiwan Taoyuan International Airport Access MRT System – Considering the interaction between land use and transportation behavior

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ABSTRACT
The Taiwan Taoyuan International Airport Access MRT System, a large scale transportation project, is under construction in Taiwan and expected be partially in service from 2015. However, the official report of the impact analysis of the project is based on traditional mechanisms for project evaluation and doesn’t consider the interaction between land use and transportation behaviors. Furthermore, the official report includes some inappropriate indexes for project evaluation.

This study establishes a framework of an interaction model of land use and transportation model, called the computable urban economic (CUE) model and uses it to review the original cost-benefit analysis of the Airport MRT project. In addition, the CUE model explicitly considers the usage of scooters, which plays an important role in commuting, private and business trips in Taiwan and other Asian developing countries, as a mode of transport.

KEYWORDS
Computable Urban Economic Model, Impact analysis, Taoyuan International Airport Access MRT System

1. INTRODUCTION

Traditionally, transportation policies are mainly established to satisfy present demand derived from economic and social activities in cities. However, the social and economic shifts such as population redistribution which result from the variation of transportation accessibility are always ignored because of the difficulty in estimating them. And the neglect often leads to improper transportation policies. Therefore, in recent years, the establishment of transportation policies with consideration of the interaction between social and economic activities and transportation are considered more important (Figure1) so land-use transportation interaction models are created and applied on urban planning in developed countries. (Table 1)

However, almost all project evaluation cases in Taiwan are still processed by traditional transportation forecast mechanism. Under such a background, applying the CUE model (Computable Urban Economics model), one of land use transportation interaction models, which is never put into practice for impact analysis on transportation projects will be valuable and it also can be thought helpful to improve the accuracy of project evaluation in Taiwan.

A large scale transportation project in recent years in Taiwan, namely the *Taiwan Taoyuan International Airport Access MRT System*, has been construction and will be partially in service from 2015. Because the project will affect the greatest metropolis with a population of almost 9 million for sure, it will be worthy and significant to apply the CUE model to this region and analyze impacts that the project will bring. Furthermore, the result of the cost benefit analysis of this study can be also compared with that from the official report of the project to help judge if the old result is reliable and find possible problems or mistakes of it. According to the table 2, it can be observed that some indexes for project evaluation in Taiwan are actually not appropriate and the effect of those inappropriate indexes can be also reviewed through this study.

Besides, the CUE model is still applied in Japan mostly so applying the CUE model through this study will make it possible to discover possible problems while trying to operate the CUE model with Taiwanese database.

This study establishes a framework of a CUE model and uses it to review the original cost-benefit analysis of the Airport MRT project. In addition, the CUE model explicitly considers the usage of scooters, which plays an important role in commuting, private and business trips in Taiwan and other Asian developing countries, as a mode of transport.

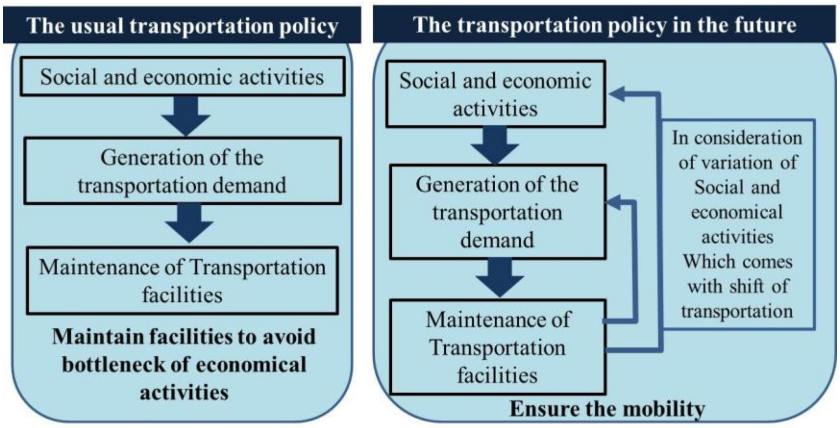


Figure 1 The future transportation policy

Table 1 The classification of recent land use transportation models

Type of the model	Contents	Cases
METEROPLUS family (ex: Putman(2001))	1. Introduce the entropy concept to the Lowry model. 2. Be established by econometrical methods.	MPO in U.S.
MEPLAN family (ex: Hunt and Mcmillan (1995))	1. Introduce economic theories to the Lowry model. 2. Introduce concepts of the I-O model. 3. Introduce concepts of the price function and the random utility theory.	SPARTACUS, PROPOLIS and so on in Europe
METROSIM family (ex: Anas (2002))	1. Introduce base of microeconomics. 2. Be able to reflect the equal utility principle and the general equilibrium theory.	New York metropolis
URBANSIM family (ex: Waddel(1998))	1. A microsimulation model consists of disaggregation models. 2. Emphasize on action theory more than delicate theoretical bases.	Oregon state and so on

Table 2 A comparison between indexes of project evaluation manuals of different countries

Index \ Manual	**STEAM (U.S.A)**	**TJRI (Japan)**	**HETCO (E.U)**	**CEPD (Taiwan)**
Travel time savings	V	V	V	V
Travel cost savings	V	V	V	V
Road accident cost savings	V	V	V	V
Noise	V	V	V	--
Air pollution	V	V	V	V
Greenhouse gas	V	V	V	--
Value-added of lands	--	--	--	V
Employment opportunities	V	--	--	V
Economic development	--	--	V	--
Other externalities	V	--	V	--

Source: *Economic Evaluation Software for Transport Projects (textbook, 2009)*

2. TAIWAN TAOYUAN INTERNATIONAL AIRPORT ACCESS MRT SYSTEM PROJECT

2.1 Project Overview

Because of the growth in the volume of traffic between Taipei City and the Taiwan Taoyuan International Airport and the establishment of a second terminal at the airport, accessibility to the airport has become an urgent issue. Meanwhile, in an effort to decrease CO2 emission level, limiting vehicle traffic has become a long-term target for Taiwan. One solution is a railway project that will connect downtown Taipei City and the economic center of the Taoyuan prefecture via the Taoyuan International Airport. This project has been named the "*Taiwan Taoyuan International Airport Access MRT System"*-- (hereafter, "Airport MRT")

The total length of the Airport MRT project is 53.7 km (including the extension part to Zhongli station), and there will be 24 stations on route (see Figure 2). Other details of the project are as follows:

(1)Shortest time from Taipei City to Taoyuan International Airport: 35 minutes (by express trains).

(2)It will take about 70 minutes from Zhongli station to Taipei station using normal trains, which are mainly for commuting.

(3)The whole project will be put into service in three stages. (see Figure 3)
(Stage 1: station A2 to station A21- ; Stage 2: station A1 to station A2 ; Stage 3: station A21 to station A23)

(4)The expected ticket price from Taipei station (station A1) to the Taoyuan International Airport (stations A12, A13, and A14) is about 90 NT dollars. (by normal trains)

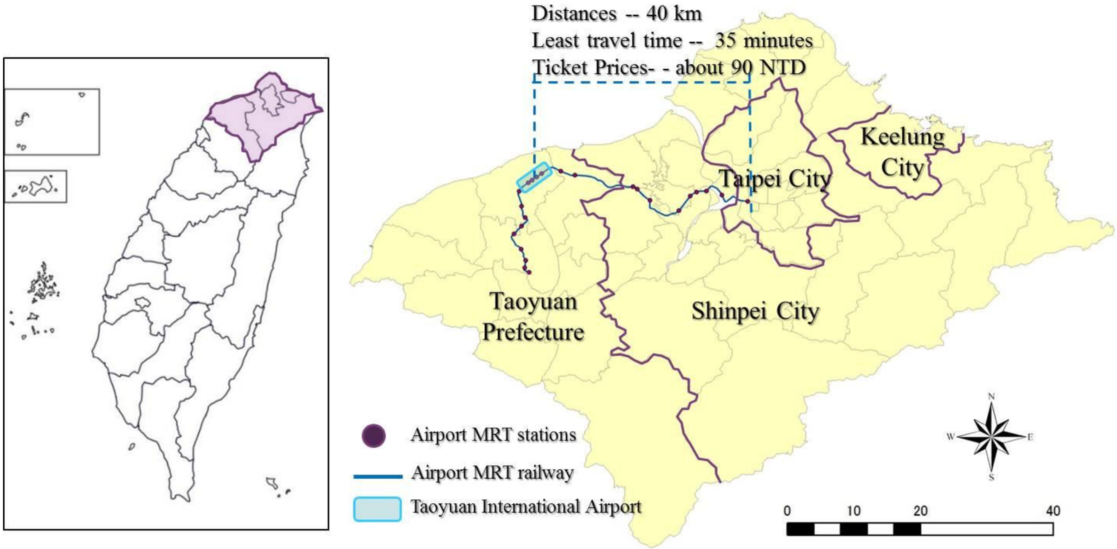
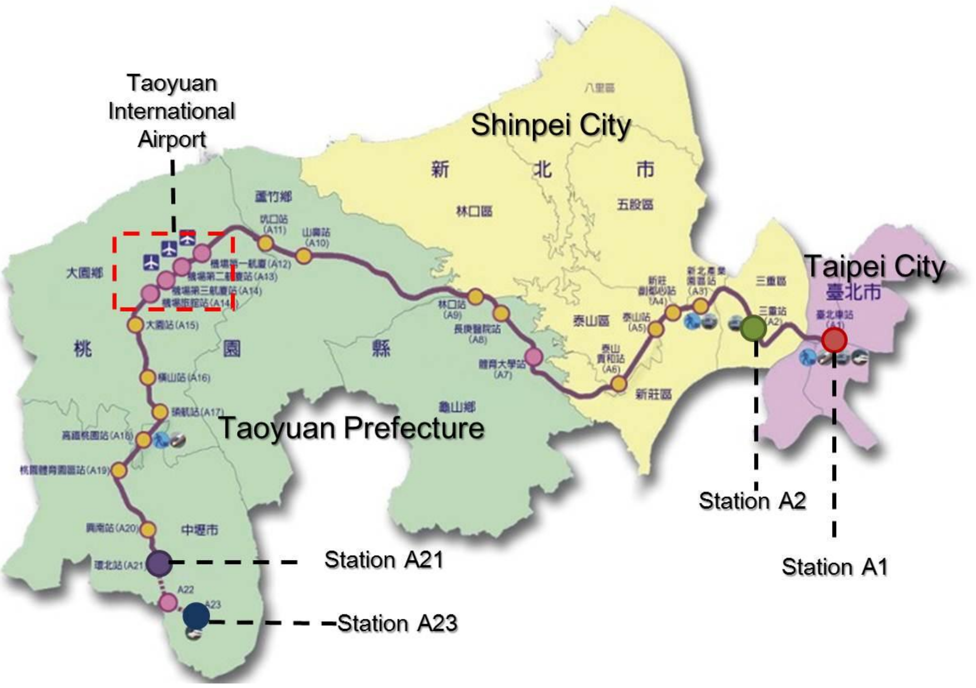


Figure 2 Contents of the objective project



Source: http://220.128.208.14/MRT/ProjectInfo.aspx; modified by the author

Figure 3 The line and the stations of the Airport MRT

2.2 The Affected Region: An Introduction

The objective region of this study includes three cities (--Taipei, Shinpei, and Keelung) and one prefecture (--Taoyuan). The total areas of the region is about 3643 km^2. In addition, the overall objective region is divided into 55 traffic zones, which match the smallest official wards in this study.

3. IMPACT ANALYSIS FRAMEWORK

3.1 The Computable Urban Economic Model

3.1.1 Premise conditions of the CUE model

The CUE model, a land-use transportation interaction model with a microeconomic theoretical base, is a statics equilibrium model proposed by Ueda (1991), Ueda (1992), and Takagi, Muto, and Ueda (1999). Its basic framework is applied generally in Japan. The model in this study which is especially suitable for the analysis of a metropolitan region, is derived from the framework of the above model and the model proposed in Yamazaki et al. (2008).

The structure of the CUE model is shown in Figure 4. In the model, there are three agents, namely households, firms, and absentee landowners. All the agents attempt to maximize their utility or revenues by changing their location. The consumption and investment in the trip and land will keep changing until the land market and transportation market in each zone reaches a state of equilibrium. Values such as rent and generalized transportation costs also reach a state of equilibrium, which means that locators cannot enjoy a higher level of utility or revenue in zones other than the present one.

The premise conditions are as follows:

(1) The three agents are households, firms, and absentee landowners where each household is presumed to be a person with the same preference and each firm is presumed to be an employee without industry classification.

(2) The metropolis is divided into several zones and each zone has homogeneous geographical and economic features.

(3) The metropolis is a closed region which means there is no interaction between the subject metropolis and any outside region. In addition, the population and the employee are regarded as exogenous variables.

(4) The overall model reaches a state of equilibrium when the land market and the transportation market reach equilibrium. The equilibrium state in the land market and transportation market are based on the equal utility principle and equal travel time principle, respectively.

(5) Households and firms allocate themselves by maximizing their utilities and profits. However, any additional costs owing to relocation behavior are not considered.

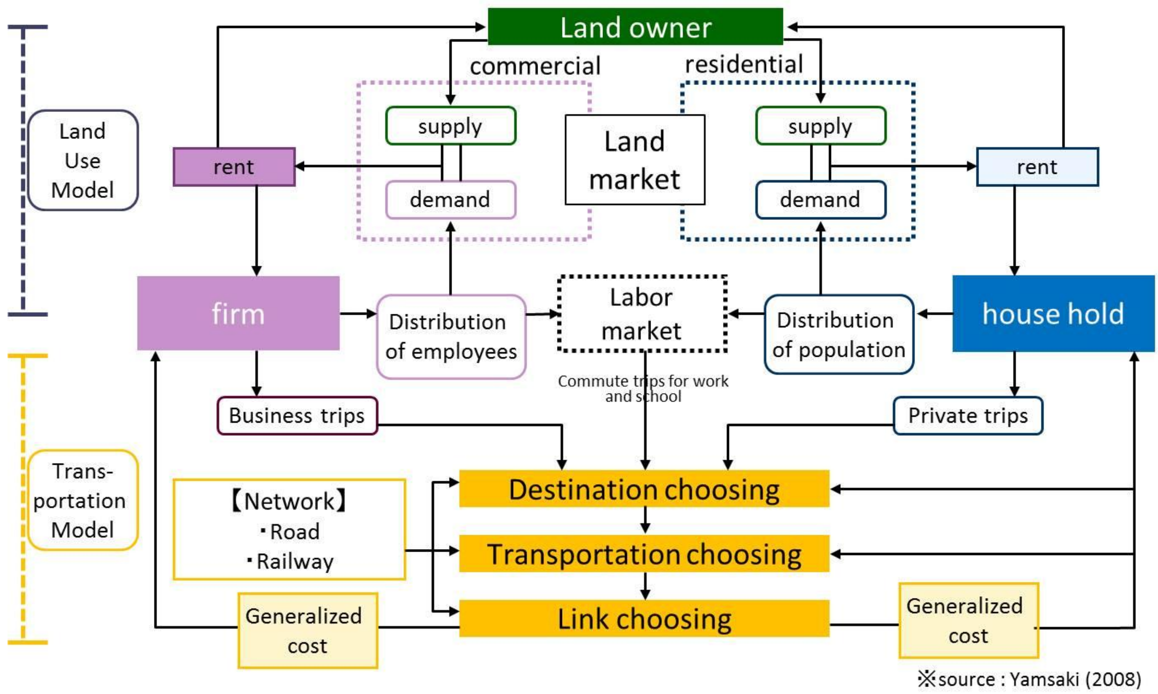


Figure 4 The overall structure of the CUE model

3.1.2 Agents' behavior models

The structures of the household behavior model, the firm behavior model, and the absentee landowner behavior model have been shown in existing studies such as Yamasaki et al. (2008). Therefore, no elaborate explanation about functions and solutions of equations of the land use model is presented in this study.

The household's behavior model is essentially based on maximizing of its utilities, which are controlled by the consumption of residential lands, private trips and composite commodities. The firm's behavior model is based on maximizing its revenues, which is controlled by inputting lands (commercial lands), business trips, and freight trips under production technologies. The absentee landowner behavior model is based on the land market equilibrium.

3.1.3 Transportation behavior models

The transportation behavior model consists of two agents, namely, the household and the firm, which can choose their destination, transportation mode, and path to accomplish trips for different travel purposes. The structure of the nested logit model, which is used in the CUE model, is shown in figure 5.

In the transportation model, commuting trips (to school) and private purpose trips are dealt with as shown in Figure 5. The behavior is modeled individually as a generation of trips, a destination choice, and mode choice phases. However, the traffic assignment to each link is not operated by a different purpose. In addition, freight trips are treated as an exogenous OD (Origin-Destination) value and assigned individually.

As mentioned earlier, elaborate explanations on the solutions of equations for the transportation models are not presented here.

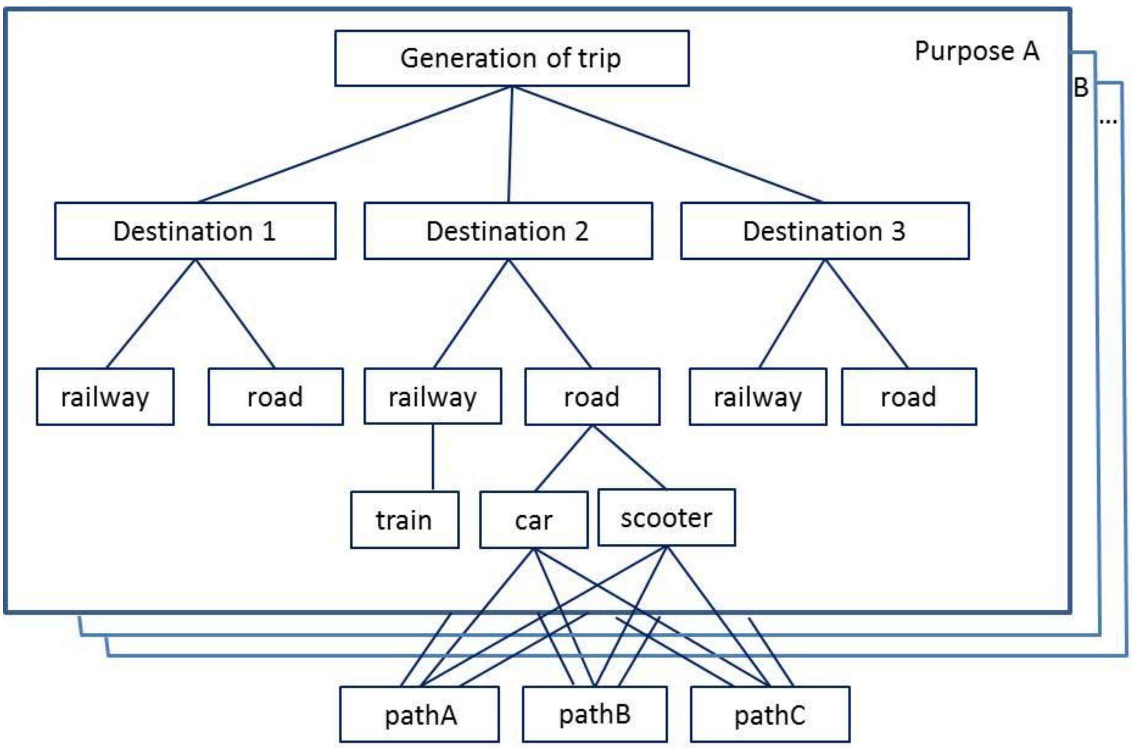


Figure 5　The choice structure of the nested logit model

3.2 Data Set For The Cue Model

3.2.1 The population and numbers of employees

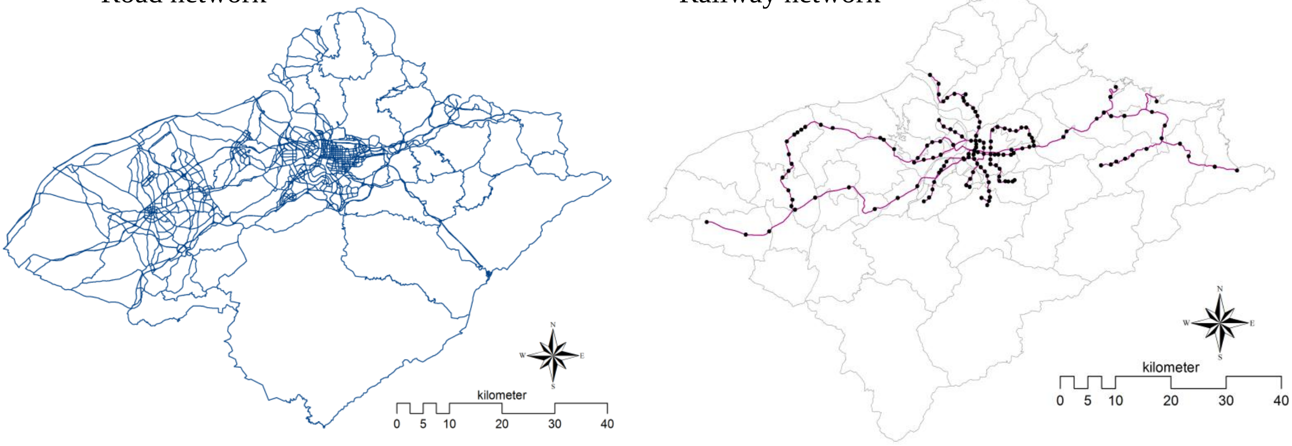
The entire objective region in 2009 had a population of about 8.9 million, and approximately 3.7 million were employees. More than a third of the population of Taiwan is concentrated in this region.

3.2.2 The network of the objective region

The road network was downloaded from *http://download.geofabrik.de/*. In addition, the railway network, made with the assistance of Google Maps, consists of both railway and subway systems. However, the road network needs to be modified to match the needs of this study. All roads higher than tertiary roads are retained in the road network.

Figure 6 The road and railway networks of objective region

Road network Railway network



3.2.3 Other essential data

In addition to the population data, numbers of employees, and the network file, the other data essential to operating the CUE model are shown in Table 3. There were no problems in compiling essential data for the CUE model in Taiwan.

Table 3 Essential data for applying the CUE model

Variables			Sources
Land Use Models	Population	J[1]	National Census
		T[2]	Statistical Abstract of City/Prefecture
	Employees	J	National Census
		T	Industry, Commerce and Service Census in Taiwan
	Areas of residential lands	J	Fixed Property Tax Cadaster
		T	Master Plan Reports of Urban Planning Areas
	Areas of Commercial Lands	J	Fixed Property Tax Cadaster
		T	Master Plan Reports of Urban Planning Areas
	Land Prices	J	Land Market Value Publication
		T	Urban Land Price Indexes Reports
	Wages	J	Explanation of Monthly Labor Survey
		T	Report on the Survey of Family Income -- The Survey of Vehicle Operation Costs and Promotion of Training Program for Economic Evaluation of Transport Projects
	GRP (Gross Regional Product)	J	Statistics of the Ministry of Agriculture / Ministry of Economy, Trade and Industry
		T	Industry, Commerce, and Service Census
Transportation Models	Personal Trips	J	Personal Trip Census for Tokyo Metropolis
		T	Traffic Census for Metropolis / Prefecture
	OD data for Vehicles and Transits	J	Road Traffic Census
		T	Traffic Census for Metropolis / Prefecture
	Network File	J	Ministry of Land, Infrastructure, Transport and Tourism
		T	Institute of Transportation, MOTC (only main avenues)
	Freight Trips	J	Road Traffic Census
		T	Survey report on motor vehicle freight traffic Taiwan area R.O.C. [3]

※[1] [2] “J” means “Japan” and “T” means “Taiwan”
[3] The survey offers only weights of freight data. Therefore, OD trips need extra estimation.

3.3 Modifications Of Transportation Models

The importance of scooters for transportation in Taiwan is illustrated by the following information:

(1) According to Figure 7, it is easy to tell that road congestion occur in many links when scooter trips are considered in traffic assignment. Therefore, it is acceptable to conclude that scooter trips do affect road congestion in Taiwan and the traffic assignment result will be more reliable by considering scooter trips.

(2) According to Figure 8, scooter trips form a large proportion of all modes of transportation. For most travel purposes, scooters are the main transportation mode in Taiwan.

(3) According to Figure 9, the tendency to own a scooter did not disappear with GDP growth, as might have been expected. It is clear that scooter ownership rates in the Taipei metropolis have been growing steadily and continuously over the last decade.

Based on this statistical data and the result of the traffic assignment mentioned above, it is undoubtedly necessary to consider scooter trips when processing transportation forecasting or establishing transportation models with such transportation behavior.

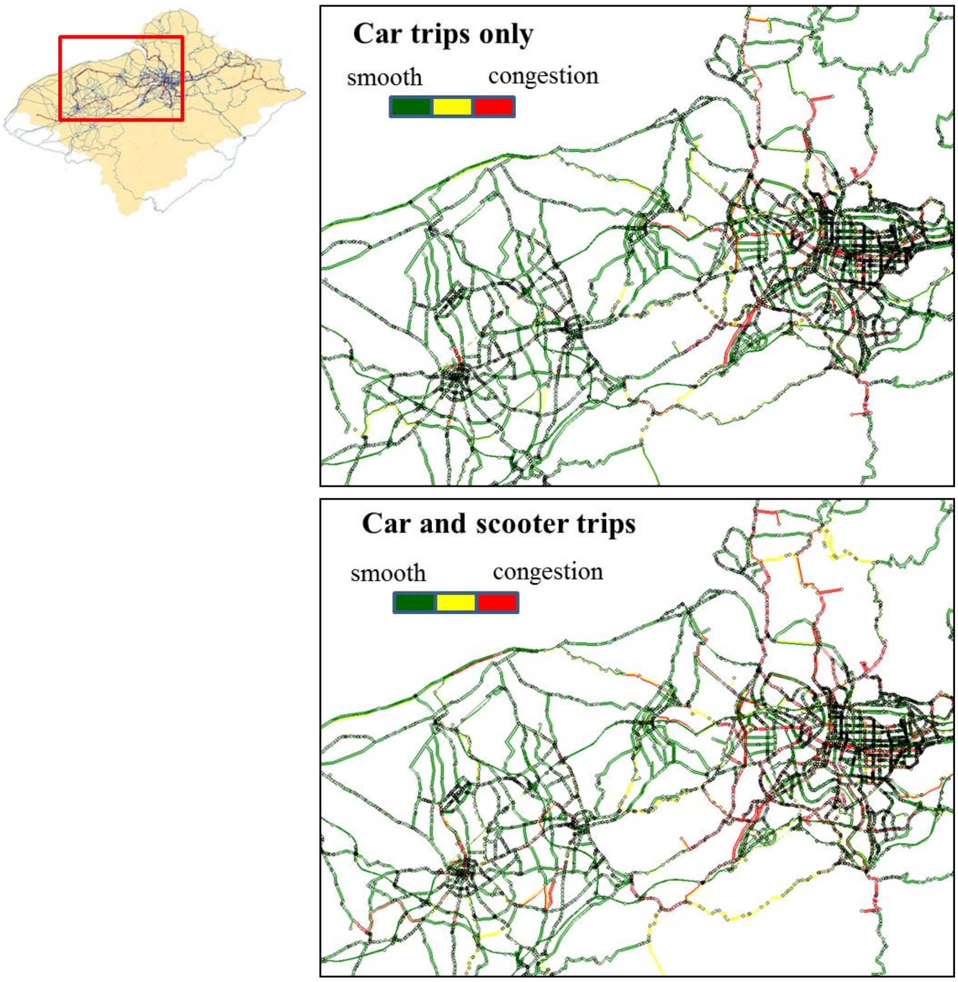


Figure 7 A comparison between the results of traffic assignment with and without scooters

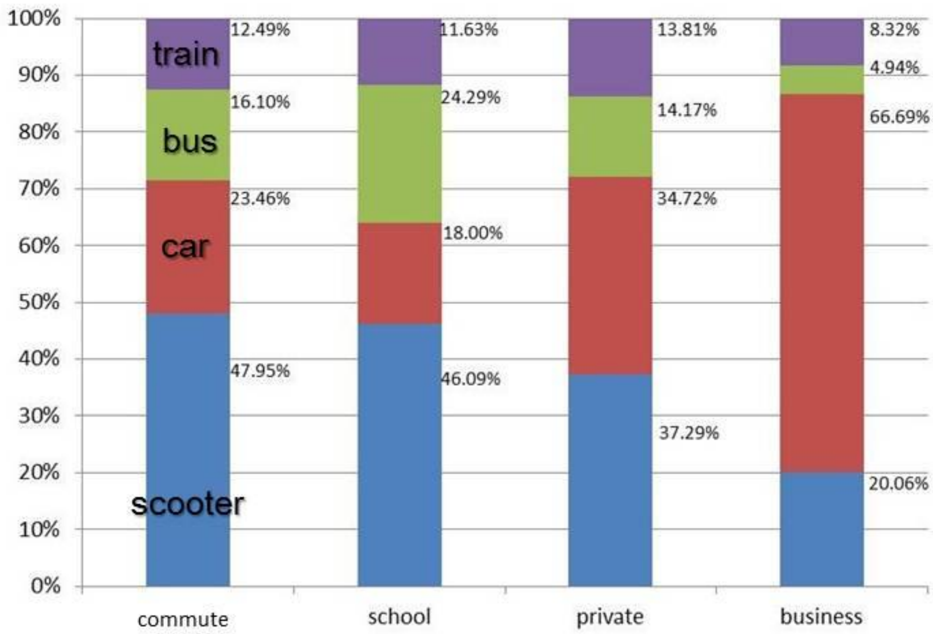


Figure 8 Proportions of each mode for different travel purposes

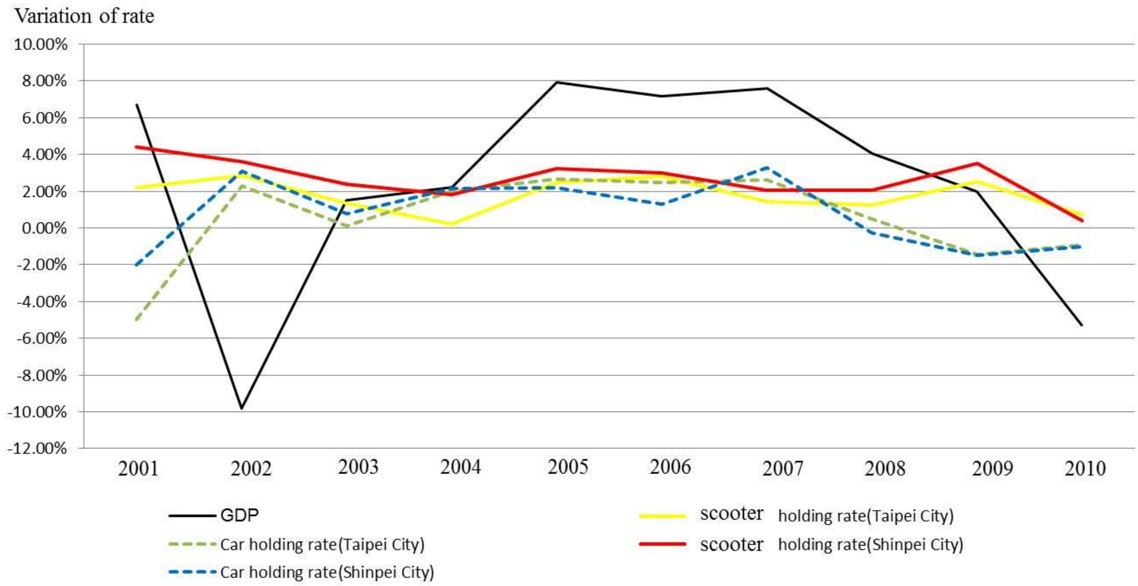


Figure 9 Variations of car and scooter holding rate and GDP growth

4. RESULTS

4.1 Results Of Parameter Estimations

4.1.1 The land use model section

Households

The distribution parameters of the household utility function and the firm production function are all estimated using the ordinary least squares method. The results of the parameters for the household section are shown in Table 4.

Table 4 Results of estimation of parameters for the household utility function

	Consumption of residential lands (αa)	Generation trips for private purpose (αx)	Consumption of residential lands (αz)
parameter	1.07×10^{-2}	26.93×10^{-2}	0.72
t-statistics	4.2	16.2	-- (derived from 1-αa-αx)
R-squared	0.24	0.83	--

Firms

The necessary premise assumption here is that all products, which are manufactured under the condition that all firms have maximized their profits, will be purchased. The parameters here are also estimated using the ordinary least squares method. The results of parameters for the firm section are shown in Table 5.

Table 5 Results of estimation of parameters for the firm production function

	Consumption of commercial lands (βa)	Generation trips for business purpose (βb)	Generation trips for freight purpose (βf)
parameter	0.37×10^{-2}	6.80×10^{-2}	1.30×10^{-2}
t-statistics	3.6	5.5	3.5
R-squared	0.19	0.36	0.18

4.1.2 The transportation model section

According to the personal trip census data, it seems clear that the numbers of scooter- users would decline sharply when the travel distance is too long. The results of the commute distance survey (see Table 6) support this notion, showing that the distance traveled by most scooter users when commuting is less than 10km, with an average travel distance of 8km. Therefore, to increase the accuracy and explanatory ability of the model, the variable that represents such a tendency should be used to estimate the parameters in the mode choice model. In this study, the distance dummy variable and the accident variable are considered. The values of the distance dummy variable when traveling by car and train are both 1, which means the choice between using a car or train will not be affected by the travel distance. For scooter trips, the average travel distance (8 km) is taken to represent the distance factor that might affect the choice of whether to use a scooter. In other words, if the travel distance is more than 8km, the values of the dummy variable will be 0, or else, will be 1.

With regard to accident variable, it is known that the incidence of road (or railway) accidents rises as the travel distance increase, as shown in the existing research. In addition, because the probability of being injured in a road accident when traveling by scooter is much higher than in the case of the other two travel modes, it is also reasonable to use the expected value of the accident cost as an accident variable to explain the real scooter use behavior in Taiwan.

Furthermore, personal trip census data show that Taiwanese people tend to choose car for business trips rather than other modes. Therefore, it would be more reliable if the variable that represents such a preference could be used to estimate the parameters of the mode choice models for business purpose. The values of the preference dummy variable are set to 1 for each OD pair by car and 0 for each OD pair by scooter and train.

After several estimation tests, the most suitable for estimating the parameters of the transportation models in this study were chosen and shown in Tables 7 and 8.

Table 6 Results of the survey of move distances for commute by scooter

	Total	**Below 1 km**	**1 km-5 km**	**5 km-10 km**	**Over 10 km**	**Average move distance on 1 trip**
Taipei Metropolis	100%	8.9%	36.9%	25.5%	28.7%	8.1km
Taiwan	100%	11.4%	40.9%	23.5%	24.1%	7.7km

Table 7 Results of the estimation of parameters in the mode choice model

Trip purpose	**Commute and school**	**Private**	**Business**
Variable	**parameter (z-statistics)**	**parameter (z-statistics)**	**parameter (z-statistics)**
Generalized costs	-0.0058 (-16.1)*** [4]	-0.0049 (-11.6)***	-0.0026 (-10.9)***
Distance dummy	-0.2926 (-9.8)***	-0.1192 (-3.9)***	--
Accident variable	--	--	-0.1725 (-3.2)***
Preference dummy	--	--	-0.8051 (-36.8)***
Car constant term	-1.2196 (-45.0)***	-0.3398 (-12.7)***	0.4843 (19.9)***
Train constant term	-1.4830 (-73.3)***	-1.1130 (-47.9)***	-1.5628 (-65.7)***
Likelihood-ration Index (ρ^2)[5]	0.48	0.27	0.83

[4] ***P<0.001

[5] According to McFadden (1970), the model could be effective if the likelihood-ratio index is over 0.2.

Table 8 Results of the estimation of parameters in the destination choice model

Trip purpose	Commute and school	Private	Business	Freight
Variable	parameter (t-statistics) [6]	parameter (t-statistics)	parameter (t-statistics)	parameter (t-statistics)
Generalized costs	-0.0088 (-24.2)***	-0.0099 (-23.5)***	-0.0045 (-22.4)***	-0.0170 (-18.3)***
Density of employee	10.8169 (9.6)***	10.8865 (9.7)***	14.2815 (15.4)***	-30.0200 (-5.9)***
Constant term	-2.4204 (-28.4)***	-1.5071 (-12.4)***	-2.0373 (-18.5)***	--
Likelihood-ration Index (ρ^2)	0.36	0.36	0.34	0.95

[6]: Parameters of the destination choice are estimated by glm code in this study. Therefore the t-statistics are substituted for the z-statistics here.

4.2 Impact Analysis

4.2.1 The impact analysis framework

The timeframe of the model estimation is based on 2009 data which means all the exogenous values for the population, such as numbers of employees, and the network are fixed. The simulations are based on two conditions for the Airport MRT project, namely **without (Case A)** and **with (Case B)**.

4.2.2 Simulation Results

The population distribution

According to the variation in the simulation results of Case A and Case B, the impact on the population distribution of the airport MRT project is not obvious (see figure 10). However, the tendency of the population to concentrate in the Taoyuan prefecture does match the expectation of the effect of the Airport MRT project. In addition, the attraction of locating to Shinpei also rises because of the project. However, the effect of the project on Shinpei is not as strong as it is in the Taoyuan prefecture.

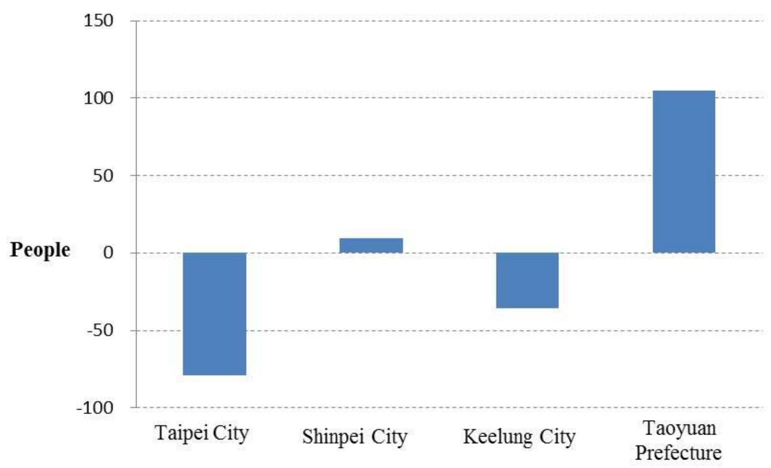


Figure 10 Shifts in population for the objective cities and the prefecture (Case B – Case A)

The employee distribution

The tendency of a shift in the employee distribution is similar to that for the population. However, the commercial location attraction of the Taoyuan prefecture is particularly strong. Therefore, even employees in Shinpei City are attracted to the Taoyuan prefecture.

Nevertheless, the subtle shifts of employees can be seen in Figure 11. Therefore, it can be concluded that the project will not influence the commercial location choice behavior in this study.

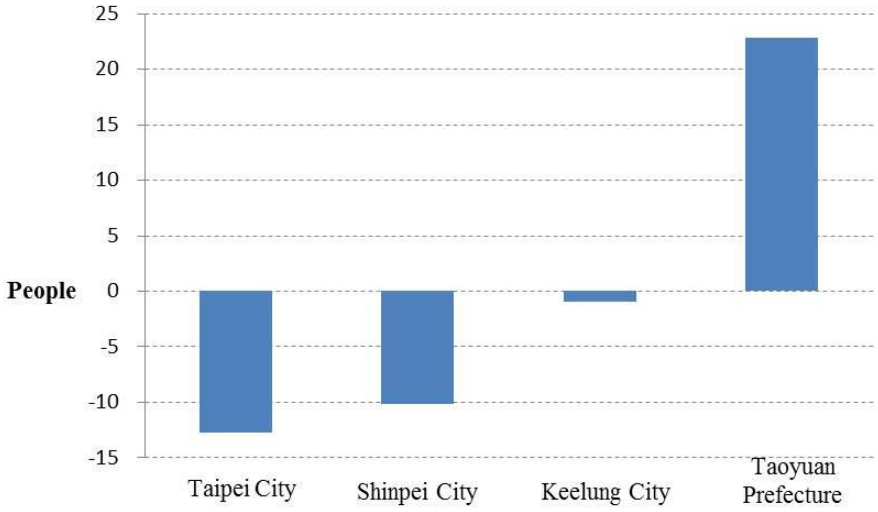


Figure 11 Shifts of the numbers of employees of the objective cities and the prefecture (Case B – Case A)

4.3 Discussions

4.3.1 Impacts of the project on CO_2 emissions

After the Kyoto Protocol was enacted, methods of decreasing the amount of CO_2 emissions have become an important index in transportation infrastructure project evaluations. In this study, we use equation (1) to calculate the amount of CO_2 emissions and observe how much of the CO_2 emissions can be decreased through the airport MRT project.

The emission parameters for each kind of vehicle are obtained from *The Survey of Vehicle Operation Cost and Promotion of Training Program for Economic Evaluation of Transport Projects* and the values of the parameters are expressed in Table 9.

$E_{ij} = D_{ij} \cdot e_{ij}$ (1) where

i :zone, j :mode of vehicle, E_{ij} :the total amount of emissions, D_{ij} :travel distances of per vehicle, e_{ij} :the emission parameter

Table 9 The emission parameters for each vehicle type

Mode	Car	Scooter	Truck
Parameter (g- CO_2/Kilometer)	231.801	44.334	45.974

The results of the shifts in the amount of CO2 emissions in the objective region are shown in Figure 12. Apparently, the Airport MRT project would effectively reduce the amount of CO2 emissions in the Taoyuan prefecture. However, the reduction of CO2 emissions from cars in Shinpei is not obvious, even if approximately a quarter of the MRT system is set up there. Therefore, the numbers of car users and transferring car trips to train trips an important consideration in the strategy to reduce CO2 emissions in Shinpei.

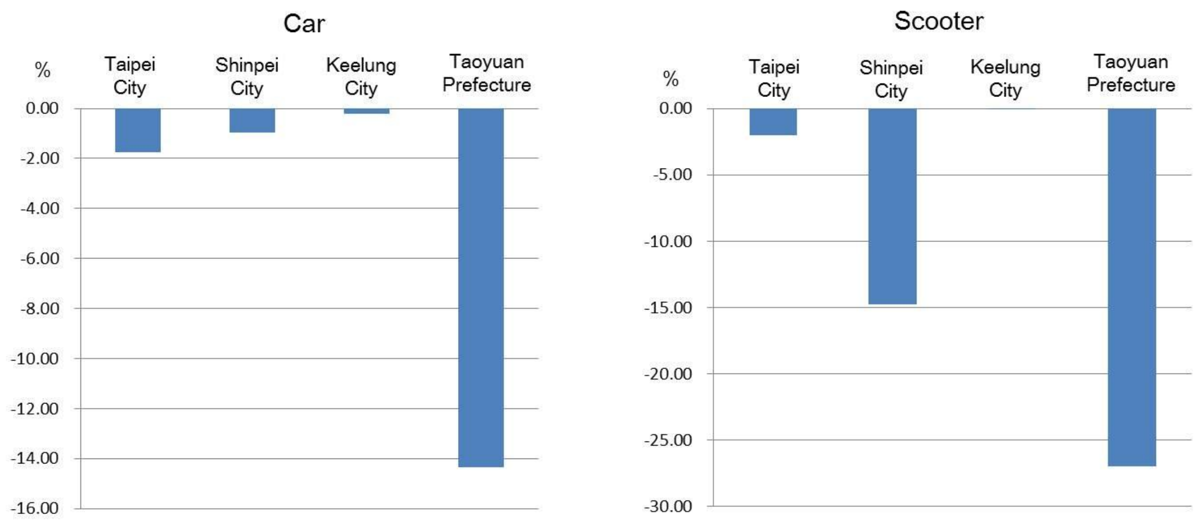


Figure 12 Shifts of CO_2 emissions of objective cities and prefecture (Case B – Case A)

4.3.2 Benefits of the project

Shifts to trips by train

Although the impact of the project on distribution of the population and employees are not obvious, the project will increase the number of train trips by 135,236 per day, representing a growth of 1.39%. (see Figures13, and 14)

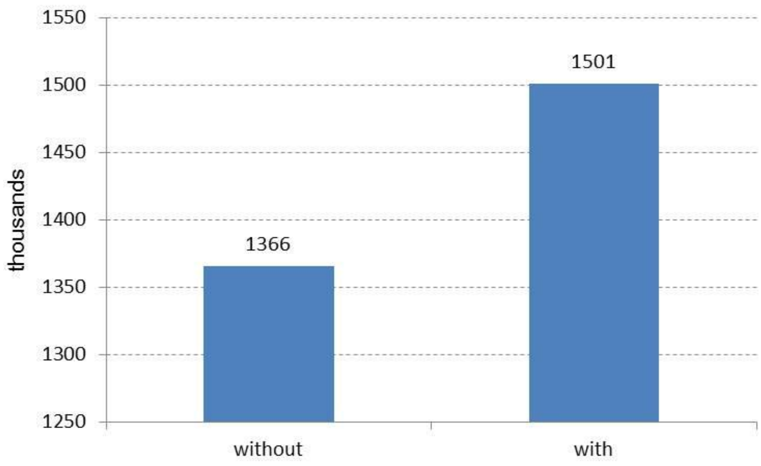


Figure 13 The shift of numbers of trips by train per day

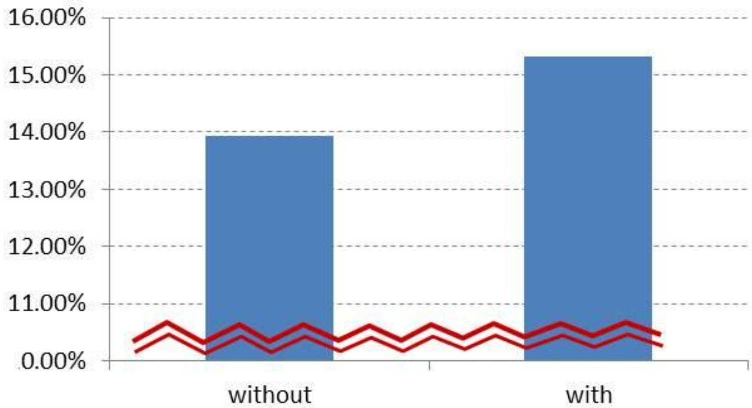


Figure 14 The shift of proportion of trips by train

Cost benefit analysis

According to Table 10, the B/C (Benefits over Costs) value of the project in this study is less than 1, which means the project is not a worthwhile investment. Furthermore, although the B/C value in the official report is 1.45, it is evident that inappropriate benefit indexes, such as tax increases, have been included to make the result of the cost-benefit analysis profitable. Therefore, the cost-benefit analysis results of this study and the official report are not that different.

Table 10 A comparison of the cost-benefit analysis between the official report and this study

Unit: billion NT dollars

	Evaluation Index	Results of the official report	Results of this study
Costs (30 years)	Construction costs	79.69	
	Operating costs	26.91	
	Renewal costs	8.09	
	Supplement costs	1.75	
	Total amount	**116.44**	
Benefits (30 years)	Travel time cost savings	77.15	76.80
	Operating cost savings (Private vehicles)	5.90	16.93
	Operating cost savings (shuttle bus)	14.03	--
	Accident cost savings	0.62	3.53
	Taxes increase	66.97	--
	Land values increase	4.08	--
	CO2 emissions mitigation	0.01	0.19
	Noise mitigation	0.01	--
	Total amount	**168.85**	**97.45**
	B/C	**1.45**	**0.84**

※Discount rate = 5.5% (source: *Planning report of Taiwan Taoyuan International Airport Access MRT System)*

4.3.3 Limitation of the current analysis

It can be assumed that variations in the redistribution of households and firms are not obvious, because of the following limitations in the obtained data:

(1)The data used to estimate the parameters of the transportation models are not sufficiently precise. In this study, the average traffic OD data per day are used to estimate the parameters. However, the average data clearly cannot reflect the road congestion in rush hour conditions. Therefore, the generalized costs of vehicles might be f significantly under-estimated.

(2)The data used in this study are not specialized. Therefore, the same utility function is used to represent all the people who actually belong to different age groups and have different characteristics.

(3)Accurate household income figures for the different zones are difficult to obtain.

(4)Accurate data on residential lands and commercial lands are difficult to obtain because of the common occurrence of mixed land use in Taiwan.

5. CONCLUSIONS AND FUTURE CHALLENGES

5.1 Conclusions

In this study, the CUE model was applied to evaluate the benefits of the Airport MRT project. It also established the way to construct a database and essential adjustments for the estimation of the parameters. On the basis of the parameter estimation for the transportation models, there are several points that need to be noted:

(1)Scooters undoubtedly need to be considered because of their importance to the transportation behavior in Taiwan when establishing the mode choice model with Taiwanese data.

(2)To estimate more precise and useful parameters for transportation models with Taiwanese data, the distance factor, the mode preference, and the possibility of accidents should be considered.

(3)Although the ordinary least squares method is used to estimate the parameters for the transportation models in most existing studies that apply the CUE model, the parameters can also be estimated using the maximum likelihood method, as shown in this study.

In addition, there is a notable difference in the results of the potential impacts of the project between the analysis using traditional mechanisms and that of the CUE model. Although the impact on the redistribution of households and firms is not obvious in this study, the simulation results matches the expectations of the project. In other words, it is expected that people will concentrate in the northern Taoyuan prefecture and that the amount of CO_2 emissions will decrease because of the project.

5.2 Future Challenges

The zoning laws in Taiwan have been in place since 1970. However, the laws do not strictly restrain the behavior of mixed land use. In addition, to achieve higher floor area ratio, it has become common to build apartments in commercial area. Therefore, since residential lands and commercial lands are considered separately when constructing the utility function of the households and the production function of firms in the CUE model, the accuracy of these land use models might be defective because of inaccurate land use data. A possible way to obtain highly accurate data is to establish a model that estimates the level of mixed land use behavior. In addition, another possible solution is to use the latest land use data being surveyed by the National Land Surveying and Mapping Center of Taiwan. However, a similar problem is likely to occur if floor areas are used instead of land areas. Thus, estimating the mixed land use behavior of floor areas is still an important issue that needs to be resolved.

REFERENCES

1. Wegener M (2003) Overview of land-use transport models, Proceedings of CUPUM '03 Sendai (conference brochure of CUPUM '03 Sendai), 20–40.

2. Institute of Transportation R.O.C. (2009) *Economic Evaluation Software for transport Projects (textbook)*, 1.1-3.8. (in Chinese)

3. Yamasaki K, Ueda T, Muto S (2007) The evaluation of the Tokyo-metropolitan area policy by computable urban economic model (CUE), *Selected Proceedings of the 11th World Conference on Transport Research*, University of California, Berkeley, CD-ROM, 734.

4. Muto, S., Akiyama, T. and Takagi, A. (2000) Economic Evaluation of an Urban Road Network Project Considering the Spatial Structure Change, *Traffic Engineering*, 44, 205-214.(in Japanese)

5. Ueda, T. (1991) A model analysis on the impact of transport improvement on household locations through increase in opportunities for life activities, *Infrastructure Planning Review*, 9, 237-244. (in Japanese)

6. Ueda, T. (1992) A General Equilibrium Model with re-defined Location Surplus, *Infrastructure Planning Review*, no.10, pp.183-190. (in Japanese)

7.. Muto S, Ueda T, Yamaguchi K, Yamasaki K (2004) Evaluation of environmental pollutions occurred by transport infrastructure project at Tokyo metropolitan area, *Selected Proceedings of the 10th World Conference on Transport Research*, CD-ROM, No. 1152.

9. Ueda, T., Tsutsumi M., Muto S., and Yamasaki K., (2013) Unified computable urban economic model, The Annals of Regional Science, 50(1), 341-362.

10. Bureau of High Speed Rail, M.O.T.C. (2005) Planning report of Taiwan Taoyuan International Airport Access MRT System. (in Chinese)

11. Chiang, Y., Wen, T.,and Lu, J. (2006) The study of multi-vehicle household mix demand model on auto/motorcycle ownership and use in Taiwan area, *Journal of the Chinese Institute of Transportation*, .35(3), 309-335.

12. Yeh, C-F (2011) Modeling the full trip costs of urban intermodal passenger transport development of urban full trip cost models, *Transportation Research Board Annual Meeting 2011 Paper*, No.11-1914

13. Chang, S.K. and Guo, Y.J. (2007) Effects of motorcycle management strategies on external costs, *Proceedings of the 86th Transportation Research Board Annual Meeting*, CD-ROM 07-1978.

14. Feng, C. and Wang, S. (2007) Integrated cost–benefit analysis with environmental factors for a transportation project: case of Pinglin Interchange in Taiwan, Journal of Urban Planning and Development, 133(3), 172–178.

15. McFadden, D. (1974) Conditional logit analysis of qualitative choice behavior, In Zarembka P. (ed.) *Frontiers in Econometrics*, New York .