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Does Individual Capability Influence Travel Time Expenditure? A Mediation Modeling Approach

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Travel time saving has been thought as the major benefit of transport investment in cost-benefit analysis in many developing cities. However, it has been criticized that the transport project evaluation based on travel time saving can lead to unequitable results. For example, a positive association between individual capability and travel time expenditure indicates that travel time saving might be benefical mainly for those who are more capable. In this study, we empirically examine the association between individual capability and travel time expenditure in 17 developing cities by using person trip survey data collected by JICA. We further explore the mechanism how the capability affects travel time expenditure with a particular focus on mediation and moderation effects through residential location choice. As an initial step to understand the mechanism, mediation and moderation models are developed by using the person trip survey data collected in Hanoi (Vietnam) in 2004. The results indicate that controlling residential location choice in identifying the association between individual capability and travel time expenditure is crucial.

Key Words : *capability, developing cities, SEM, mediation and moderation*

1. INTRODUCTION

Cost-benefit analysis is widely used before implementing infrastructure development such as roads, railways, harbors, and so on. It is widely known that the results of cost-benefit analysis depend highly on which benefits are taken into consideration. Recently, in developed countries, in addition to the existing basic benefits such as travel time saving, the social benefits such as improvement of education, health, and welfare have been discussed. On the other hand, such social benefits have been little discussed in developing countries. Given that improvement of transportation infrastructure leads to better occupation and access to educational opportunities, it is desirable for developing countries to evaluate social benefits as well. One possible starting point is to consider the role of capability introduced by Sen (1987) [(2)] in quantifying benefits from infrastructure investment. Capability is an approach focusing on living standards, which is an attractive approach in temrs of considering actual social welfare evaluation. In this regard, Chikaraishi *et al.* (2017) [(1)] considered the influence of capability on traffic behavior theoretically and empirically in Mumbai, India, and pointed out the problem of existing ex ante assessment focusing on travel time saving from the viewpoint of fairness through showing the positive correlation between capability and travel time expenditure. This indicates that the higher the capability is, the individual travel time expenditure tends to become larger, indicating that those who are more capable could obtain the greater benefit from travel time saving. On the other

hand, it is pointed out that cost benefit analysis focusing only on travel time saving makes it difficult to take enough benefits for low capability group. Karel et al.(2017)[3] identified five equity effects to analyze the fairness of the results of the cost-benefit analysis and each of them showed that transport projects serving the high capability people are highly likely to perform better in CBA than low capability people. However, the analysis in Chikaraishi *et al.* (2017) [1] only focuses on a limited situation where sufficient activity opportunities (jobs, educational institutions, etc.) exist in surrounding areas in the slum of Mumbai. In addition, only the correlation between capability and travel time expenditure is analyzed, and the mechanism of the correlation is not considered. Therefore, this study firstly analyzes the association between capability and travel time expenditure in 17 developing cities using the data of person trip survey which are conducted by JICA to confirm whether the the correlation between capability and travel time expenditure exists in a more general setting. Then, the mechanisms how capability affect travel time expenditure with considering indirect (moderation) effects is analyzed with the aim at improving the hypothesis stated in Chikaraishi *et al*. (2017) [1].

2.DATA OVERVIEW AND PRELIMINARY ANALYSIS

In this analysis, the person trip survey data in 17 developing cities collected by JICA (Japan International Cooperation Agency) are used. Table1 shows basic information of the data.

Table 1 Basic information of data

City	Year	No. of Sample	No. of Trip	No. of Population
Tripoli	2000	3,608	7,615	330,900
Phnom Penh	2000	18,664	40,369	1,152,000
Damascus	1998	38,490	81,698	3,078,190
Manila	1996	231,889	471,035	9,454,000
Chengdu	2000	31,188	70,199	3,090,000
Managua	1998	24,854	54,138	1,200,000
Belem	2000	24,043	59,529	1,782,394
Bucharest	1998	87,792	169,069	2,150,000
Cairo	2000	136,070	268,360	14,400,000
Jakarta	2000	423,237	1,083,280	20,964,000
Kuala Lumpur	1997	80,560	218,460	1,390,800
Ho Chi Minh	2002	27,412	71,890	7,785,000
Hanoi	2004	63,716	188,949	2,355,000
Lima	2004	115,728	270,384	7,995,000
Dar es Salaam	2008	11,200	22,950	2,487,000
Da Nang	2010	18,171	52,694	890,000
Ulan Bator	2009	16,196	40,995	885,000

For a preliminary analysis, poor people and wealthy people are defined by the seven indicators (car ownership, motorcycle ownership, household income, education standards, occupation, housing possession and license hold) which are used to quantify the capability. Table 2 compare travel time expenditure between poor and wealthy people. Downward arrows indicate that the travel time expenditure of the wealthy people is more than that of the poor at the 5 percent significant level, and bold-type allows indicate the difference of travel time expenditure is 10 minutes or more. Generally speaking, significant differences of travel time expenditure between poor people and wealthy people are confirmed in most of the cities through almost of all indicators, and wealthy people tend to travel more compared to poor people.

Table 2 Difference of travel time expenditure

	Car	Motorbike	Income	Education	Occupation	House	Driving Licence
Tripoli	→	→					↓
Phnom Penh	→	→	→				
Damascus	↓	→	→		→		→
Manila	↓	→	↓		↓	↓	
Chengdu	↓	↓	→		→		↓
Managua	→		↓				
Belem	→	→	↓	↓		→	
Bucharest		↓	↓		↓		
Cairo	→	↑	↓		↓	→	↓
Jakarta	↓	→	↓		→		
Kuala Lumpur	↓	↑	↓		↓	↓	↓
Ho Chi Minh	→	↓	↑	↓	↓	↓	↓
Hanoi	→	↓	↓	↓	↓	→	↓
Rima	↑	→	↓	↓	↓	↓	↓
Dar es Salaam	→	→	→		↓		↓
Da Nang	↓	↓	↓	↓	↓	→	↓
Ulan Bator	→	→	↓		→	→	

↓: Wealthy＞Poor（Significant）
↑: Wealthy ＜Poor（Significant）
→: No significant difference

3. ANALYSIS OF RELATIONSHIP BETWEEN CAPABILTIY AND TRAVEL TIME EXPENDITURE

In order to analyze the relationship between capability and travel time expenditure in 17 developing cities, the capability index is constructed through principal component analysis of seven indicators used in preliminary analysis with reference to the concept of capability indicated by Sen (1987) [2] as an index for living standards. Table 3 shows the analysis result of relationship between capability and travel time expenditure in 17 cities. The horizontal axis is capability and the vertical axis is travel time expenditure, and the correlation between these two indices is expressed using correlation coefficients. When the correlation efficient is 0.2 or more, it is indicated by a yellow marker as a mark showing a significant difference between travel time expenditure and capability. As a result, it is found that significant correlations between the two indicater are confirmed only for four

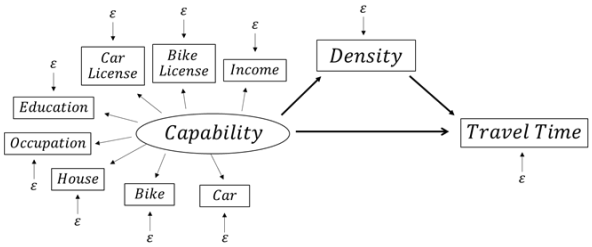
cities (Managua, Bucharest, Hanoi and Ulan Bator). The result shows that the association between capability and travel time expenditure are not really clear, indicating that the mechanism causing the association may not be so simple as Chikaraishi *et al.* (2017) [(1)] explain. The following section attempts to provide more richer explanation on the association by considering a number of potential indirect effects.

4. STRUCTUAL EQUATION MODELING

In order to consider the mechanism how the capability influences the travel time expenditure, we employ the path diagrams with considering indirect effects, and check the performance of each model by using a structural equation model. As an initial step, mediation and moderation models are developed by using the person trip survey data collected in Hanoi in 2004. We used 17 cities data in the past analyzes, but in this analysis, we use only the data in Hanoi due to data constraints. It is hypothesized that the capability does not only have a direct effect on travel time expenditure, but also have an indirect effect - population density of residential location. The hypothesis of path diagram among capability, density and travel time is as shown in Fig. 1 and Fig. 2.

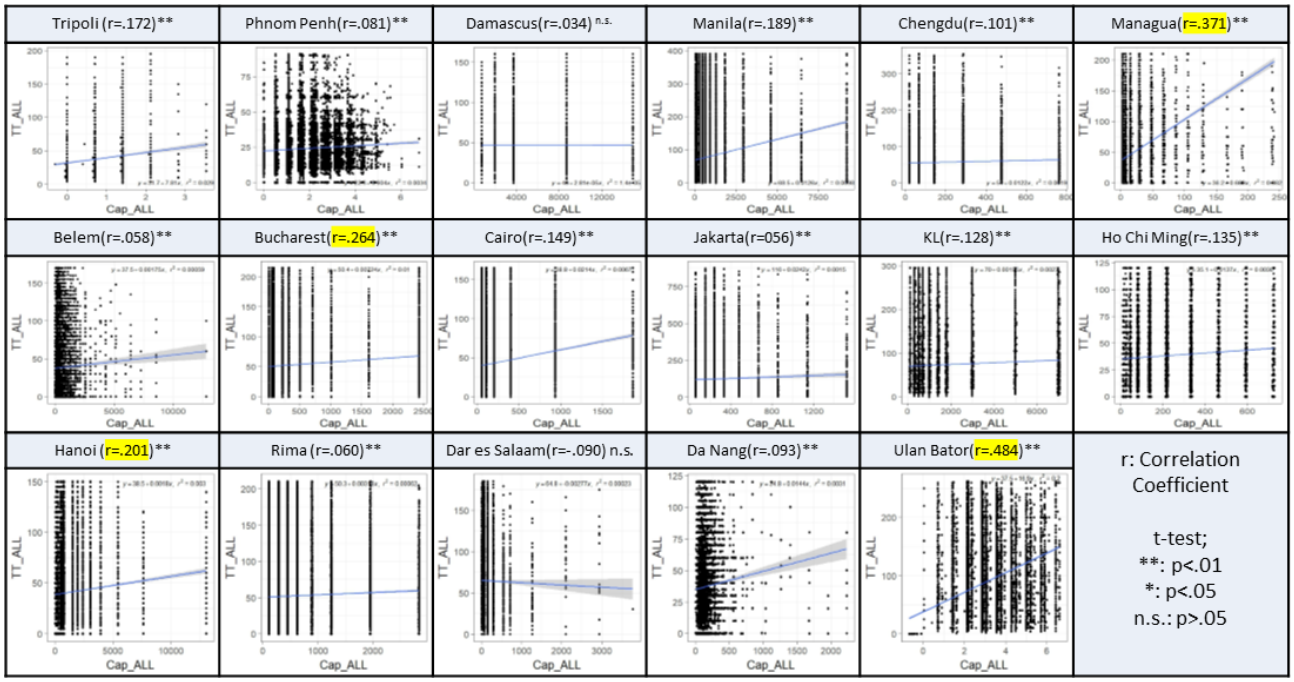
In the mediation model shown in Fig.1, we assume that the population density of residential location is a proxy variable of activity opportunities which exist in the surrounding area. The greater the population density of the residential location, the more various functions for living will be there. The area with various opportunities are attractive for many people, while the living cost may be higher than the other area ingeneral, making the place mainly for the rich. Thus, residential sorting would happen by the level of capability. This would be one of the potential reasons why we could not observe the clear association between capability and travel time expenditure.

Also, since the population density is linked with various functions and activity opportunities in the surrounding area, the number of trips and travel distance would be affected by the population density. If there are sufficient activity opportunities around the residential area including occupation and educational institutions, the travel time from home to the activity place will be short, and vice versa. Hence, there would be the association between the population density and travel time expenditure. Based on these considerations, we hypothesize that the association between capability and travel time expenditure is mediated by population density.

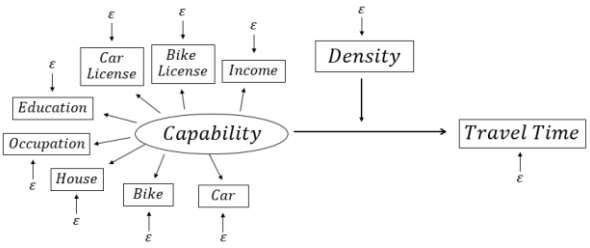


Figue 1 Path diagram of mediation model

Table 3 Result of relationship between capability and travel time expenditure in 17 cities



Another possible hyposthesis on the role of population density is that the population density moderates the association between capability and travel time expenditure. Fig.2 illustrates such a situation. In the moderation case, we assume that less capable people basically want to reduce travel time as much as possible to allocate more time to income-generating activities. This indicates that, the amount of activity opportunities in the surrounding area would be a crucial factor determing travel time: they may be able to reduce travel time dramatically if they live in the urban core, while it would be very long if they live in the place with less job/education opportunities. On the other hand, since the rich may have more non-income-generating (e.g., leisure) activities, their travel time may depend less on population density.



Figue 2 Path diagram of moderation model

Based on the above considerations, we develop mediation and moderation models based on structural equation modeling (SEM). In the analysis, we consider capability as a latent variable explqained by observation variables such as car ownership, and occupation and educational level.

Firstly, Table 4 shows the estimation result of the mediation model. Table 4 shows that the influence of population density on travel time expenditure is negative, while the influence of capability on the population density is positive.

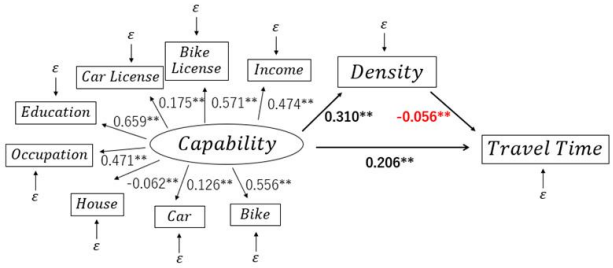
Secondly, Table 5 shows the estimation result of moderation model. Figue 4 illustrates the path diagram of the model. We confirm the positive moderating effects of population density.

As a results of SEM, the model using the population density of the residential location indicated that all passes are significant, and it was confirmed that the population density can be used as both moderator and mediator which affects the relationship between capability and travel time expenditure.

Table 4 Result of SEM (Mediation model)

	Capability		
Explanatory Variables	Parameter	z-Value	p
Number of Car	0.126	25.910	**
Number of Motorbike	0.556	130.227	**
Income	0.474	105.954	**
Education Level	0.659	169.999	**
Occupation	0.471	109.864	**
Ownership of House	-0.062	-12.708	**
Car License	0.175	36.668	**
Motorbike License	0.574	151.549	**
Path	Parameter	z-Value	p
Capability → Density	0.310	68.125	**
Capability → Travel Time	0.206	40.439	**
Density → Travel Time	-0.056	-12.810	**
Sample Size n = 59674			
Initial Loglikelihood = -1,612,674.18			
AIC = 3,225,410.35			

※*p<0. 05, **p<0. 01

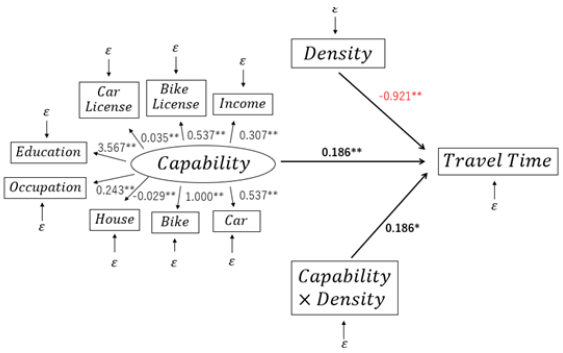


Figue 3 Result of Path diagram (Mediation model)

Table 5 Result of SEM (Moderation model)

	Capability		
Explanatory Variables	Parameter	S. E.	p
Number of Motorbike	1. 000	0. 000	**
Number of Car	0. 035	0. 001	**
Income	0. 307	0. 004	**
Education Level	3. 567	0. 044	**
Occupation	0. 243	0. 004	**
Ownership of House	-0. 029	0. 002	**
Car License	0. 035	0. 002	**
Motorbike License	0. 537	0. 006	**
Path	Parameter	S. E.	p
Capability → Travel Time	0. 186	0. 007	**
Density → Travel Time	-0. 921	0. 097	**
Capability×Density → Travel Time	0. 186	0. 210	*
Sample Size n = 59674			
Log likelihood = -268, 083. 70			
AIC = 536, 225. 40			

※*p<0. 05, **p<0. 01



Figue 4 Result of Path diagram (Moderation model

5. CONCLUSION

In this research, we first analyzed the association between the capability and travel time expenditure in 17 developing cities by using JICA person trip data. We then explored the mechanism how the capability affects travel time expenditure with a particular focus on mediation and moderation effects through residential location choice. As the estimation result of the moderation model, the influence of population density on travel time expenditure is negative, while the influence of capability on the population density is positive. In addition, as the estimation result of moderation model, the positive moderating effects of population density was proved. Thus, the developed mediation and moderation models by using Hanoi person trip data indicate that controlling residential location choice in identifying the association between individual capability and travel time expenditure is crucial.

REFERENCES

1) Chikaraishi, M., Arnab, J., Ronita, B., Varun, V., Fujiwara, A.: A framework to analyze capability and travel in formal and informal urban settings: A case from Mumbai, Journal of Transport Geography 65 (2017) 101–110
2) Sen, A., Commodities and Capabilities, Oxford India Paperbacks, (1987)
3) Karel, M., and Floridea, D.C.: Travel time savings, accessibility gains and equity effects in cost-benefit analysis, Transport Reviews, 37:2, 152-169, (2017)