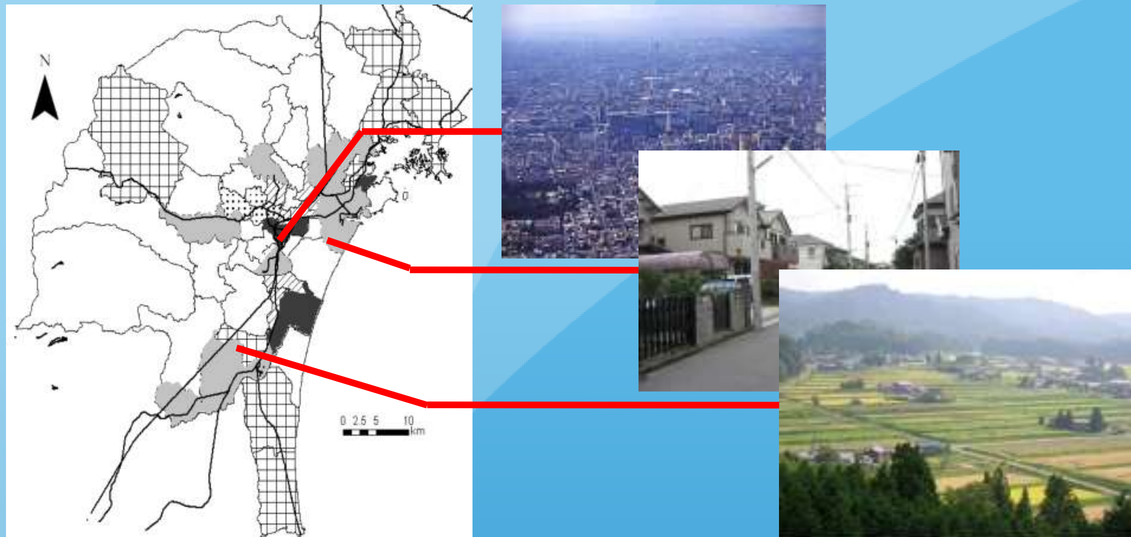

Qualitative Classification Based on Transportation Activities

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Demographical condition & Transportation services in Northeast Asia

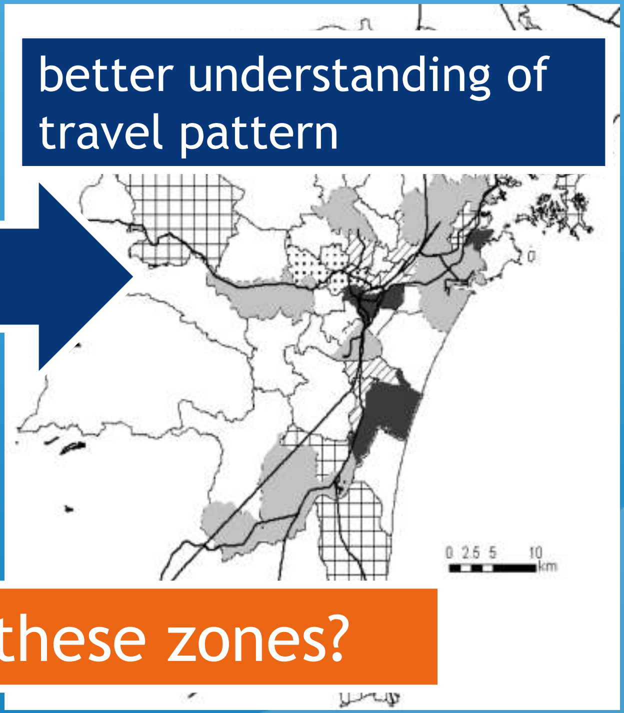
- Demographical conditions is changing rapidly
  - The habitation density is neither so sparse to permit the private automobile free from congestions, nor dense enough to support an expensive public transportation
- Public transportation policy must be harmonized with the difference in transport demand structure reflecting demographical characteristics of each area in a city
- Cities in this region have to carefully design an efficient transportation service network considering demographical characteristics

Purpose

- To propose a new qualitative classification method of urban zones, based on the present demographical conditions and transportation behaviors

Classification

better understanding of travel pattern



How we classified these zones?

Proposed Classification Method

1. Independent Component Analysis (ICA)
   - Extracting remarkable demographical characteristics of each zones from the multivariate zone data
2. Clustering Analysis (CLA)
   - Classifying zones by age distribution of trip maker and trip timing distribution

- We confirm the performance of this method by applying to some case

Case setting

- A person trip (PT) database gathered by the questionnaire survey in Sendai City in year 2002.
  - The analysis is tested for the 35 zones including one or more railway/subway stations in Sendai City area.
- We focus on these as qualitative characteristics of each zone.
  - the age configuration of trip makers
  - the departure time distribution of trips
- We see only the first trip of each trip maker, in order to avoid the mixture of going trips and returning trips.

1.Independent Component Analysis

- The age distribution of generated trips in each zone is considered as a mixture of the different age distribution corresponding to the different trip purpose, with certain mixture rate
- It does not assume the normality in the age distribution of each factor

Estimate

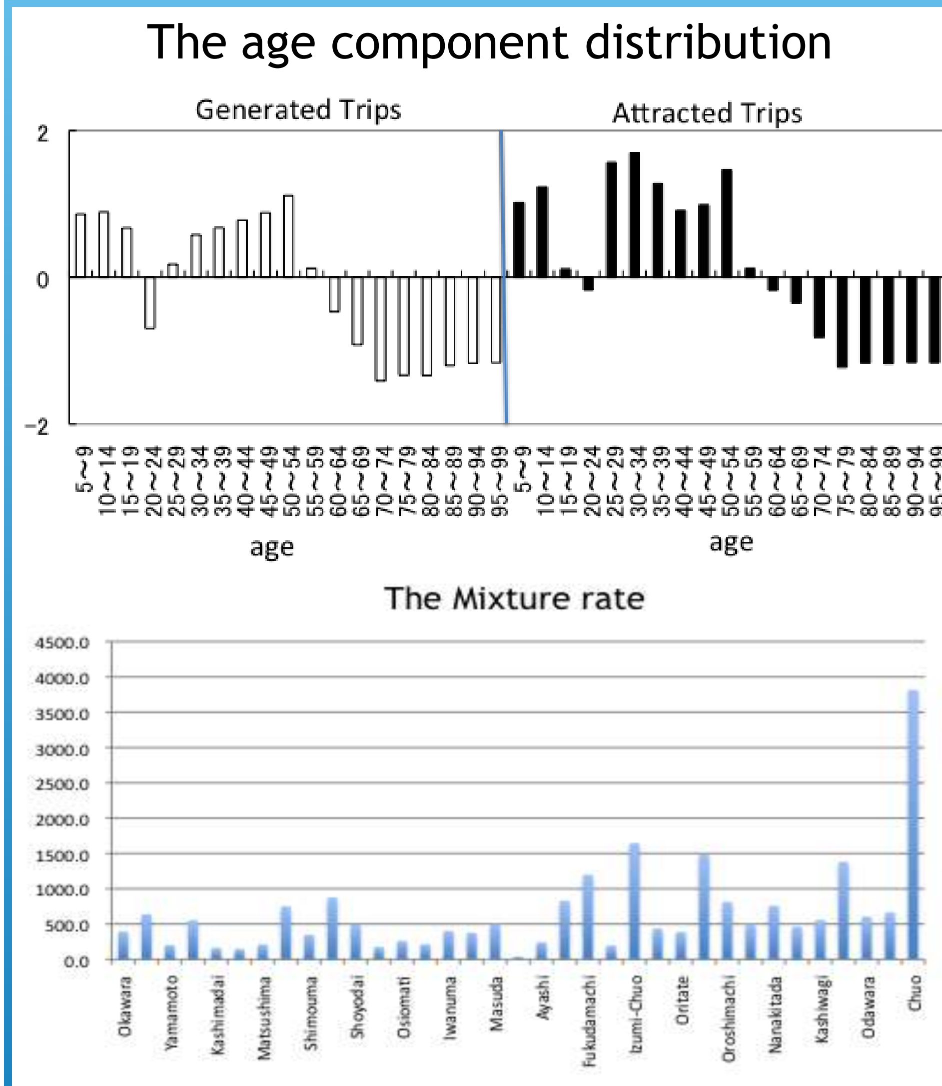
$$\mathbf{x} = \mathbf{A}\mathbf{s}$$

$\mathbf{x} = (x_1, \cdots, x_i, \cdots x_m)^T$:the age distribution vector for each zone

$\mathbf{A}$: the mixture rate of trip types in each zone (m×n matrix)

$\mathbf{s} = (s_1, \cdots, s_j, \cdots s_n)^T$:n types of trips corresponding to age compenent distribution

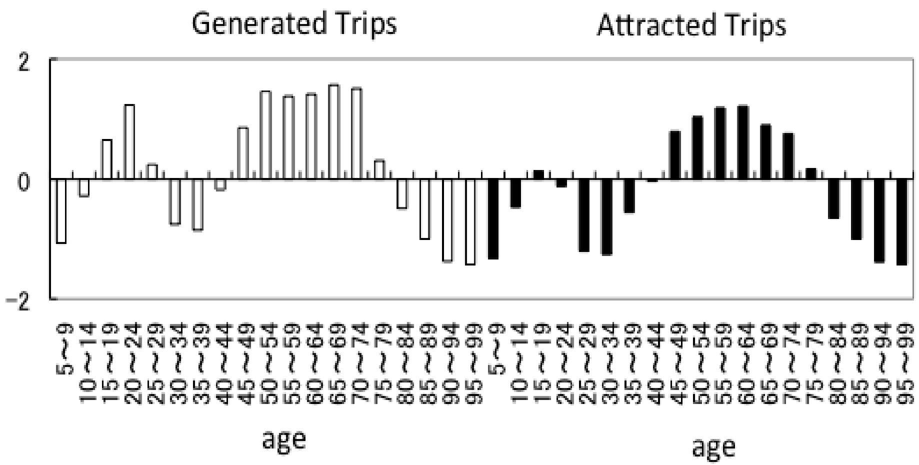
The extracted age component distribution

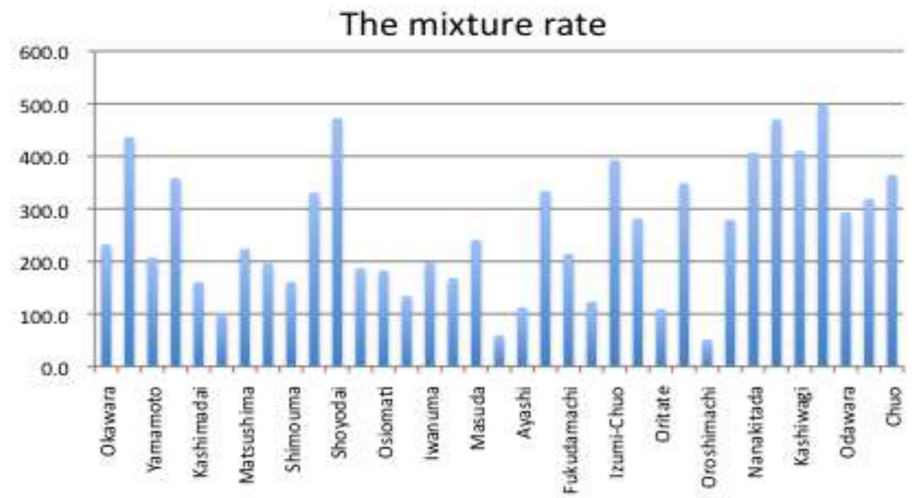


- *S_1*:A general age distribution Component
  - Many trips are occurred on the age between 5 and 59 years old except for 20-24 years old.
  - All mixture rates are positive and their average ratio is high for almost all zones.

The extracted age component distribution

The age component distribution

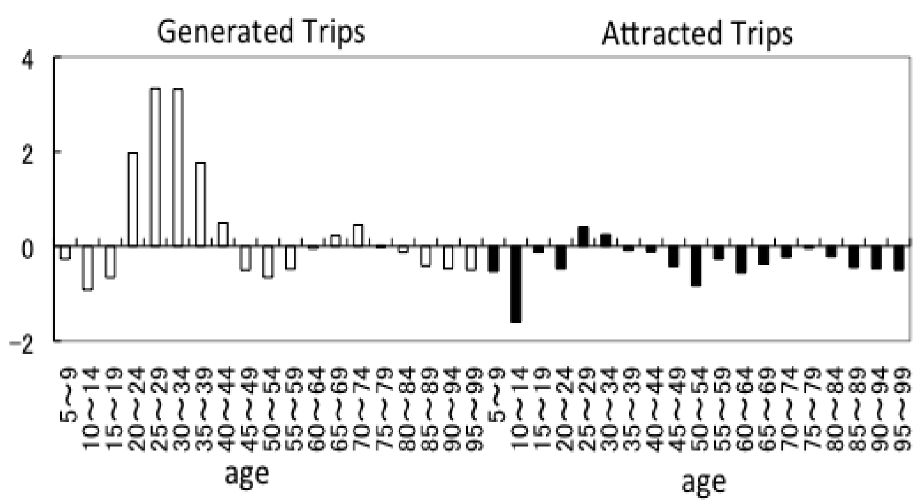


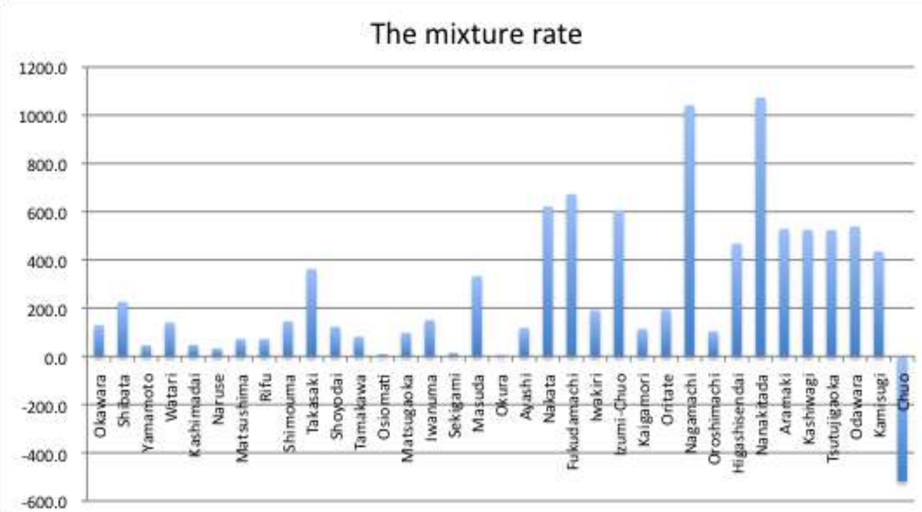


- S_2 :A suburban component
  - Many departure and arrival of middle and elderly generation, which is between 45 and 79 years old.
  - Its mixture ratio takes high positive value in the suburban zones, while low positive value in CBD

The extracted age component distribution

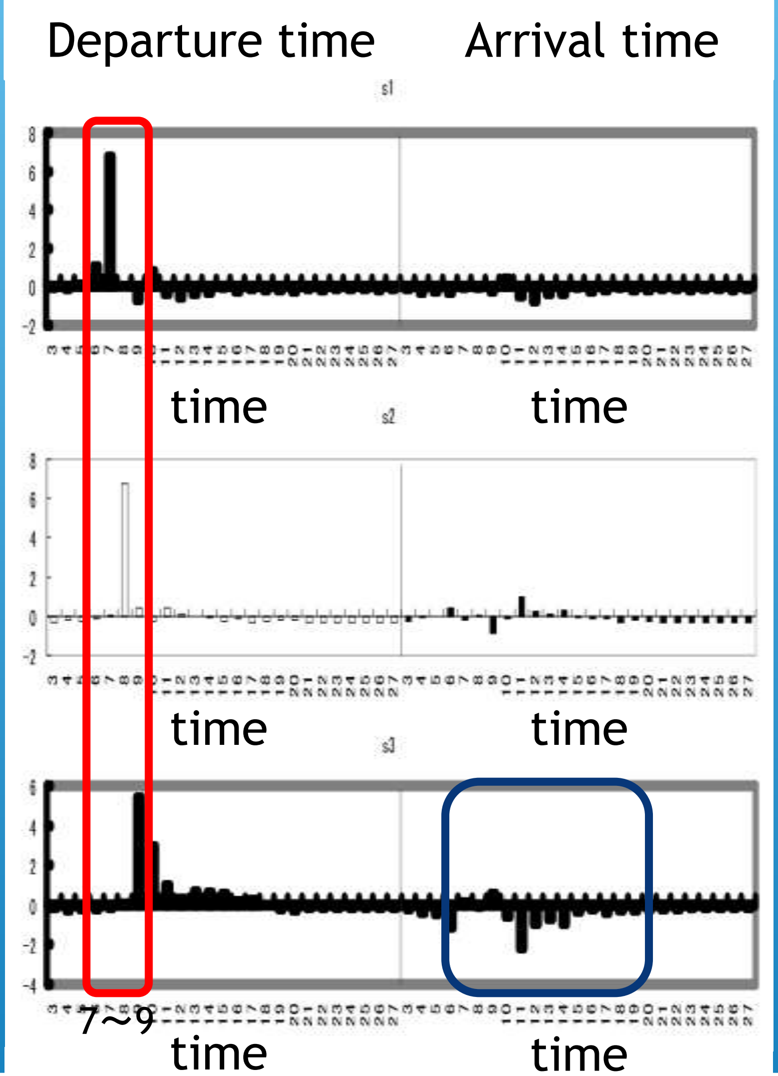
The age component distribution





- S_3 : A component of single families residence
  - many trips are generated on the age between 20 and 44 years old.
  - Its mixture coefficients are small in the CBD and large in the SBD

The Extracted departure time component distribution



- The departure time and arrival component distribution
  - Many departure trips in an hour after 7, 8 and 9 o'clock respectively.
  - Many arrival trips which were generated in an hour after 7,8 and 9 o'clock respectively.

2. Clustering Analysis

The mixture rate matrix **A**

Name	a1	a2	a3	a4	a4	a5
Izumi-Chuo	985.3	2494.7	788.1	687.2	2280.0	1395.3
Kaigamori	390.0	1122.9	454.8	128.0	707.3	542.2
Oritate	332.7	810.6	297.8	246.8	591.7	210.7
Shoyodai	666.4	1369.4	481.1	426.4	884.1	290.3
Oroshi-machi	150.3	455.2	161.8	1222.9	1266.7	246.8
Higashi-sendai	416.0	1387.1	642.5	191.8	666.0	384.6
Kashiwagi	260.3	1191.1	931.1	575.1	1375.6	901.1
Tsutsujigaoka	255.9	1703.7	1126.2	1175.6	3538.0	1552.7
Odawara	312.3	1479.7	730.0	381.6	775.8	563.8
Kamisugi	251.5	1299.4	831.7	584.0	1555.6	733.2
Chuo	-209.4	302.4	109.0	3560.5	9498.8	4712.6
:	:					

Clustering Analysis

Central Business District(CBD)

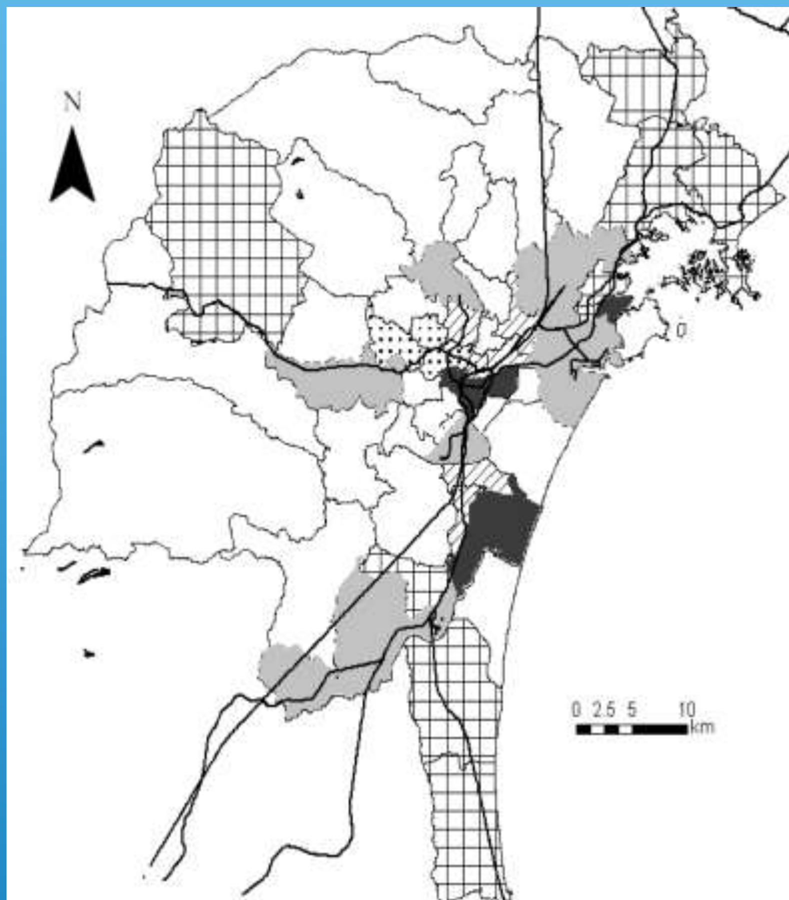
Secondary Business District(SBD)

Neighbor Residential District(NRD)

Neighbor Residential District of Universty

Suburban Residential District(SRD)

Result of the clustering



- A Standard clustering analysis
  - classified 35 zones into 5 groups

A. Central Business District(CBD)

B. Secondary Business District(SBD)

C. Neighbor Residential District(NRD)

D. Neighbor Residential District of Universty(NRD Univ.)

E. Suburban Residential District(SRD)

The proposed gravity model

- Estimation model of the number of inter-zonal trips
  - The number of trips is explained by the number of generated trips attracted trips and the travel time

$$T_{rs} = \frac{O_r^{\alpha_1} D_s^{\alpha_2}}{d_{rs}^{\beta}} \prod \exp(\gamma^{kl} \delta_{rs}^{kl}) \exp(\varepsilon^k \phi_{rs}^k \sigma_{rs})$$

Applying the result of our method

T_{rs} :The number of trips from zone *r* to zone *s*

O_r :The number of generated trips from zone *r*

D_s :The number of attracted trips into zone *s*

d_{rs} :The average travel time between zone *r* and *s*

$\alpha_1, \alpha_2, \beta$: Estimation parameter

The proposed gravity model

- The model can evaluate the effect of zone type combination
  - e.g) there are many trips between a residential zone and school zone

$$T_{rs} = \frac{O_r^{\alpha_1} D_s^{\alpha_2}}{d_{rs}^{\beta}} \prod \exp(\gamma^{kl} \delta_{rs}^{kl}) \exp(\varepsilon^k \phi_{rs}^k \sigma_{rs})$$

Applying the result of our method

k :The type of the generated zone

l :The type of Arrival zone

δ_{rs}^{kl} :Dummy variable (which shows the combination of the type k and l)

ϕ_{rs}^{k} :Dummy variable (which shows the intra-zonal trip of zone k)

$\alpha_1, \alpha_2, \beta, \sigma_{ij}, \gamma^{kl}, \varepsilon^k$:Estimation parameter

A Standard gravity model

- Estimation model of the number of inter-zonal trips
  - The number of trips is explained by the number of generated trips, attracted trips and the travel time
  - It does not use the result of our method

$$T_{rs} = \frac{{O_r}^{\alpha_1} {D_s}^{\alpha_2}}{{d_{rs}}^{\beta}} \prod \exp(\lambda \sigma)$$

T_{rs}:The total number of daily trips from zone *r* to zone *s*

O_r:The total number of generated trips from zone *r*

D_s:The total number of attracted trips into zone *s*

d_{rs}:The average travel time between zone *r* and *s*

σ : Dummy variable which represents intra-zone trips

$\alpha_1, \alpha_2, \beta, \lambda$:Estimation parameter

The estimation result of the gravity models

	The Proposed Gravity Model			The Standard Gravity Model		
	Unstandardized coefficient	Standardized coefficient	t value	Unstandardized coefficient	Standardized coefficient	t value
constant	-5.804			-5.452		
$\log(O_i)$	0.954	0.344	17.842	0.922	0.332	17.482
$\log(D_j)$	0.916	0.328	16.964	0.883	0.316	16.621
$\log(d_{ij})$	-2.293	-0.535	-25.573	-2.198	-0.513	-23.81
σ	-	-	-	1.744	0.152	7.082
δ^{AE}	0.793	0.076	3.945			
δ^{EA}	0.632	0.061	3.176			
δ^{BA}	0.358	0.038	2.022			
δ^{BC}	-0.317	-0.037	-1.966			
δ^{CC}	-0.629	-0.056	-2.711			
φ^{C}	2.148	0.079	3.823			
φ^{B}	1.344	0.066	3.422			
φ^{D}	1.338	0.040	2.115	-	-	-
δ^{E}	2.781	0.125	6.409	-	-	-
Adj. R^2		0.610			0.595	

Many generated and arrival trips between (A) CBD and (E) Suburban

Many trips generated from (B) SBD and attracted into (A) CBD

Less trips generated from (C) NRD to the similar zone, but attracted into the same zone

Improved

Conclusions

- This research proposed an urban zone classification method based on quantitative characteristics.
- ICA was efficiently applied to pick up the zonal characteristics in term of the mixture rate of the several types of trips.
- Clustering Analysis extracts 35 zones into 5 zones.
- The combinations of the obtained classification of zones were successfully used to improve the goodness of fit of gravity model for the inter-zonal trips.
- Through the above application, the importance and effectiveness of the proposed method would be understood. Further application works in many cities in Northeast Asia will be required to prove the applicability of the proposed method and to find the points to be improved.