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Metrical Analyses on Population and Economic Growth and Urban "Quality Of Life" of Metropolitan Cities in China during the 00s

Toshiyuki Kaneda, Meiying Tian, Yang Wang, Mingji Cui, Renbao Jin

(Toshiyuki Kaneda, Prof., Graduate School of Engineering, Nagoya Institute of Technology, Doctor of Engineering, Gokiso-cho, Nagoya, Aichi, Japan, kaneda@nitech.ac.jp)
(Meiying Tian,Master Course Student, Graduate School of Engineering, Nagoya Institute of Technology, Gokiso-cho, Nagoya, Aichi, Japan, tianmeiying123@yahoo.co.jp)
(Yang Wang, Master Course Student, Graduate School of Engineering, Nagoya Institute of Technology, Gokiso-cho, Nagoya, Aichi, Japan, wangyang1982510@yahoo.co.jp)
(Mingji Cui, Post-Doctoral Fellow, Ritsumeikan University, Doctor of Engineering, Kinugasa, Kyoto, Japan, myunghee116@yahoo.co.jp)
(Renbao Jin , Doctor-Course Student, Graduate School of Engineering, Nagoya Institute of Technology, Doctor of Engineering, Gokiso-cho, Nagoya, Aichi, Japan, kinjinhoo@yahoo.co.jp)

1 ABSTRACT

In the first decade of the 21st century, along with rapid economic growth, China also experienced rapid urbanization, more specifically, the concentration of large populations from rural areas into urban areas. In 2005, the Chinese Government, in its Eleventh Five-Year Plan, had an attitude of promoting the sound development of urbanization, while also promoting cooperative development in regions. However, there has emerging some mass media reports on the shadow side of the rapid growth and the rapid concentration such as environmental problems e.g. pollution affairs since early of the 2010's. These are the same as Japan had already suffered from the 1960's to 70's, so it suggests that the new era has come when Chinese inquire their 'Quality Of Life (QOL)'.

This paper analyses 51 metropolitan cities (prefecture-level cities with over one million population in 2000). Firstly, mainly based on Population Census Reports data in 2000 and 2010, we examine the economic growth and the urban in-flow migration, and the relationship between these two kinds of the indicators in detail. We show a classification of 51 cities through cluster analysis and their geographical distributions, and then we summarize the dynamics of all over China economy and population during this decade.

Based on published statistical data in 2005 and 2010 such as China City Statistical Yearbooks, we propose an indicator-system on China urban QOL of the 51 metropolitan cities. This QOL system is consisted of five groups of indicators (Education/ Daily-Life Convenience/ Urban-Life Enivironment/ Consumer-Side Sustainability/ Indstry-Side Sustainability) of 23 elemental indicators. At one time-point, QOL value is defined as an average of the group indicators, each of which is an average of each standard scores of the elemental indicators. On the other hand, 'Change of QOL' value is defined as an average of each standard scores of the change ratios of the elemental indicators. Using these kinds of QOL indicators, we also show a classification of the metropolitan cities through cluster analysis and their geographical distributions in China.

Furthermore, we analyse correlations between the five group indicators of the QOL system and the economic level and its growth through MRA. As the results, there can be observed the negative values of correlation between GRP per capita and Consumer-Side Sustainability and so on statistical significantly.

2 RESEARCH BACKGROUND AND OBJECTIVES

The Chinese Government proclaimed that the Twelfth Five-Year Plan (2011 - 2015) would improve the life of citizens and establish equal basic social services throughout the basic national public service system. The basic public services cover such areas as education, employment, medical treatment and hygiene, transportation, communications, and environmental conservation, all of which are closely associated with every aspect of people's daily life. During the decade from 2000 to 2010, along with China's rapid economic growth, massive migration to metropolitan areas was seen, and such migration can be considered to have had both a positive and negative effect on the people's "Quality of Life"; for example, in recent years, increasing air pollution and traffic congestion in the metropolitan areas has been noted.

This paper examines population censuses, which are basically fact-finding surveys conducted once every ten years, and newly establishes a Quality of Life indicator system for the 51 metropolitan areas in China, and then analyzes these Quality of Life indicators from 2005 to 2010. Moreover, the paper explores three interwoven themes: the relations among migration, the economic level of each metropolitan area, and changes to the Quality of Life.

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3 EXPLANATION OF DATA USED IN THIS RESEARCH

3.1 Spatial administration system in China and selection of cities for research

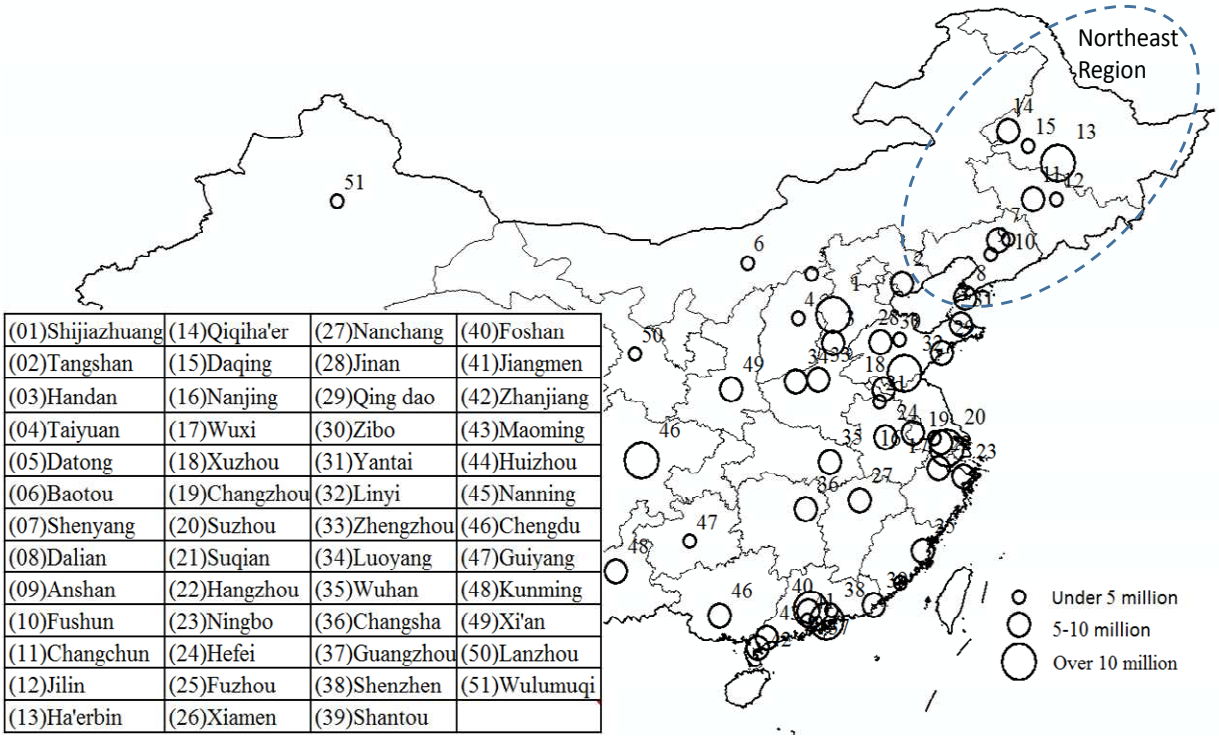
Historically, China had used three-layered spatial administrative systems: Province, Prefecture, and Township; however, to deal with urbanization, currently four-layers have been established: Province-level, Prefecture-level, County-level, and Township-level (Table 1).

3.2 Selection of cities for research

In this research, from among 333 prefecture-level administrative units, 51 prefecture-level cities with populations in excess of 1 million in 2000 were selected (Table 2 [1]). These prefecture-level cities generally include county-level cities and counties; therefore, in this paper they are referred to as metropolitan areas. In addition, Beijing, Shanghai, Tianjin, and Chongqing, the four Direct-Controlled Municipalities, were excluded from the research. In this research an entire city is referred to as a metropolitan area, and cities and wards are referred to as urban zones. Fig. 1 shows the sizes of the resident populations of the 51 target metropolitan areas according to the 2010 population census. The region encircled with a broken line indicates nine metropolitan areas in the Three Northeastern Provinces. The numbers 1 to 51 on the map correspond to the target metropolitan areas in the table.

Source Number	Source name	Years	Publisher
[1]	China City Statistical Yearbook	2000,2005,2010	National Bureau of Statistics of China
[2]	China Population Census	2000,2010	National Bureau of Statistics of China
[3]	China City Construction Statistical Yearbook	2005,2010	National Bureau of Statistics of China
[4]	China Regional Economics Statistical Yearbook	2005,2010	National Bureau of Statistics of China

Table 2: Data Sources



(01)Shijiazhuang	(14)Qiqiha'er	(27)Nanchang	(40)Foshan
(02)Tangshan	(15)Daqing	(28)Jinan	(41)Jiangmen
(03)Handan	(16)Nanjing	(29)Qing dao	(42)Zhanjiang
(04)Taiyuan	(17)Wuxi	(30)Zibo	(43)Maoming
(05)Datong	(18)Xuzhou	(31)Yantai	(44)Huizhou
(06)Baotou	(19)Changzhou	(32)Linyi	(45)Nanning
(07)Shenyang	(20)Suzhou	(33)Zhengzhou	(46)Chengdu
(08)Dalian	(21)Suqian	(34)Luoyang	(47)Guiyang
(09)Anshan	(22)Hangzhou	(35)Wuhan	(48)Kunming
(10)Fushun	(23)Ningbo	(36)Changsha	(49)Xi'an
(11)Changchun	(24)Hefei	(37)Guangzhou	(50)Lanzhou
(12)Jilin	(25)Fuzhou	(38)Shenzhen	(51)Wulumuqi
(13)Ha'erbin	(26)Xiamen	(39)Shantou	

Fig. 1: Selected 51 Prefecture-Level Citys (Metropolitan areas) in China.

3.3 Sources and explanation of the data

The sources for the research data are as follows: Section 3 is based upon two population censuses; and Section 4 is based upon the China City Statistical Yearbook, and in addition the China Urban Construction Statistical Yearbook and the China Statistical Yearbook for Regional Economy were also used as complementary materials in this section. The urban population data from the China City Statistical Yearbook [1] has an established reputation for use in comparing cities, but with a middle-level of accuracy.

The metropolitan area population recorded by the population census [2] is based on a survey of the actual state and has a correspondingly high-level of accuracy; however, very little detailed data has been officially announced.

4 EFFECT OF ECONOMIC GROWTH AND MIGRATION ON CHINESE METROPOLITAN AREAS FROM 2000 TO 2010

4.1 Analysis of metropolitan area populations from 2000 to 2010 found in the population census

Population growth in metropolitan areas consists of a natural increase, which is the difference between births and deaths, and migration, which is the difference between the recorded inflow and outflow of people. In this research, the migration figures were calculated by subtracting the natural increase of population from the total increase of population in the metropolitan areas and urban zones. In a metropolitan area, migration is an increase due to drift from outside the area, whereas in an urban zone, it is an increase due to both drift from outside and from the suburbs within the metropolitan area. To examine the population growth composition in each metropolitan area, the following indicators were established (Table 3). The natural increase ratios in the population census were calculated by assuming that they were the same as in the City Statistical Yearbook.

(1) Natural increase ratio for 10 years in a metropolitan area: $E = (\prod_{t=01}^{t=10}(Q_{t-1}\,E_t))^{1/10}/Q_{t-1}$

(2) Urbanization ratio (Table 3): $C_t = P_t/Q_t$

Fundamental statistics	2010 Metropolitan area population (10thousands person)	2000 Metropolitan area population (10thousands person)	Population increase in metropolitan area (10thousands person)	2010 Urban zone population (10thousands person)	2000 Urban zone population (10thousands person)	Population increase in urban zone (10thousands person)	Population of natural increase in an area (10thousands person)	Population of natural increase in urban zone (10thousands person)	Population of net social migration in metropolitan area (10thousands person)	Population of net social migration in urban zone (10thousands person)	Net social migration ratio in metropolitan area (%)	Net social migration ratio in urban zone (%)
Calculation formula	Q_{10}	Q_{00}	$\Delta Q = Q_{10} - Q_{00}$	P_{10}	P_{00}	$\Delta P = P_{10} - P_{00}$	$\Delta NQ = Q_{00}$ E	$\Delta NP = P_{00}$ F	$\Delta SQ = \Delta Q - \Delta NQ$	$\Delta SP = \Delta P - \Delta NP$	$\alpha = \Delta SQ/Q_{00}$	$\beta = \Delta SP/P_{00}$
Average	671.2	569.3	101.9	392.4	238.9	143.7	26.8	12.4	75.0	128.5	15%	86%
Standard deviation	261.9	222.0	91.9	235.2	172.0	140.9	24.1	16.2	87.6	136.8	18%	141%
Maximum value	1,404.8	1,110.9	367.4	1,107.1	852.5	642.6	136.9	116.0	362.0	624.5	90%	812%
Minimum value	213.8	205.3	-34.6	121.8	24.5	-135.1	-0.1	-0.3	-67.7	-147.4	-13%	-109%

Table 3: Basic Statistics in 51 Metropolitan Areas.

The natural increase ratio of an urban zone for 10 years is , and the calculation method is the same as E. In the formula, t represents a year, and is an annual natural increase ratio from the year t-1 to the year t.

From Table 3 it can be seen that the natural increase of population in the metropolitan areas is higher than in the urban zones, but the difference is small. Regarding the migration population, however, the figure of the urban zones is double that of the metropolitan areas. Based on this finding, it can be considered that the migration population from outside a metropolitan area drifts into the urban zone, and there is also a considerably large migration population from the suburbs within the metropolitan area.

4.2 Factor analysis of the migration in the metropolitan areas

Concerning the 51 metropolitan areas at two points of time, the years 2000 and 2010, regression analysis was conducted to explain the urbanization ratios by using the GRP growth, and the results were compared. The cities shown in Fig. 2 are nine metropolitan areas in the Three Northeastern Provinces. As can be seen, in both years, the urbanization ratio and GRP per capita have a positive correlation, and as the economic levels improved, urbanization progressed. Moreover, compared with the year 2000, the year 2010 shows increased economic discrepancies, and over the period, in the nine metropolitan areas of the Northeast region these became considerably larger.

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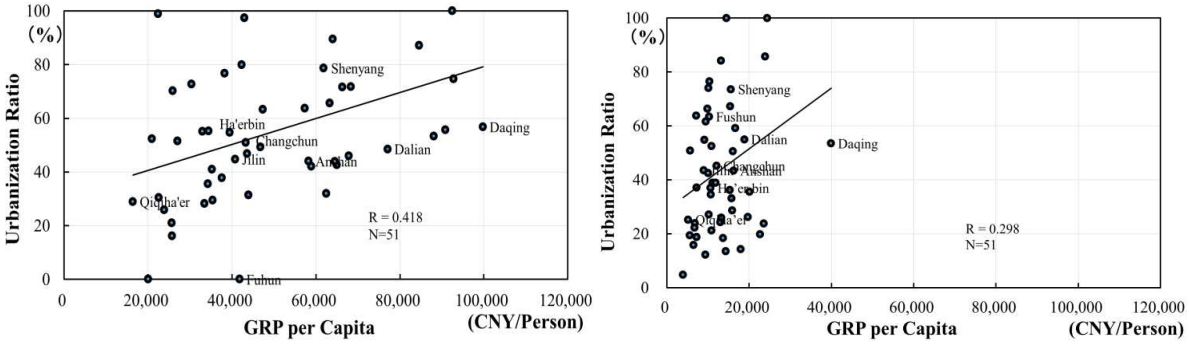


Fig. 2: Correlation between Urbanization Ratio and GRP per Capita, 2000(Left), 2010(Right).

In order to explore the main factors of migration, multiple regression analysis was conducted to explain migration to the metropolitan areas (Y=ΔSQ) by using two variables, economic growth (X1= GRP10/GRP00) and area population size (X2=Q_{00}). Here, an objective variable Y and explanatory variables X1 and X2 are all a log-log model using logarithms.

Linear model: $y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \varepsilon_i$

Log-log model: $\log y_i = \beta_0 + \beta_1 \log x_{i1} + \beta_2 \log x_{i2} + \varepsilon_i$

When both sides are positioned at the upper right of e, the following is obtained:

The results of the analysis demonstrated that the population size factor had little effect on migration, but the economic factor had a significant impact (Table 4).

response variable logY(Y=ΔSQ) / predictor variable	Partial regression coefficient	t- Value	p- value	Statistical significance test
$\log X_1$ (X_1=GRP_{10}/GRP_{00})	1.615	2.878	0.006	1%- significant difference
$\log X_2$ (X_2= Q_{00})	0.583	1.691	0.097	
Constant	-0.937	-0.916	0.364	

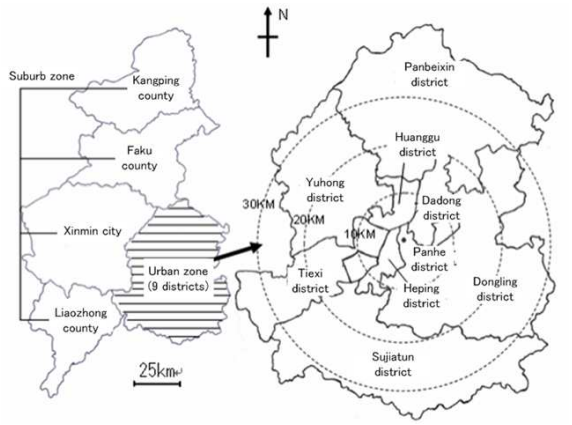
Table 4: Results of MRA on Population Increase in Metropolitan Areas.

5 ANALYSIS OF POPULATION INCREASE: CASE STUDY OF SHENYANG METROPOLITAN AREA

5.1 Summary of Shenyang metropolitan area

To understand the composition of population increase in the metropolitan areas from 2000 to 2010, this section takes Shenyang metropolitan area as a case study and analyses the actual state of population increase using Source C. The Shenyang metropolitan area is located in the central part of the Liaoning Province, the southern part of the Northeast region (Figure 3). It is the capital of the Liaoning Province, and the metropolitan area population in 2010 was 8.106 million, which is the largest population in the Northeast region.

The Shenyang metropolitan area is composed of 9 districts as the intra-urban area, 1 county-level city, and 3 counties (total area: 12,942 km²). The Shenyang urban zone with 9 districts covers 3,464 km², with a population of 6.381 million and includes Heping, Shenhe, Huanggu, Dadong, Tiexi, Sujiatun, Dongling, and Yuhong Districts and the Shenbei New District; the Shenyang suburban zone includes the one county-level city, Xinmin and the 3 counties, Liaozhong, Kangping, and Faku and covers 9,478 km² with a population of 1.726 million.



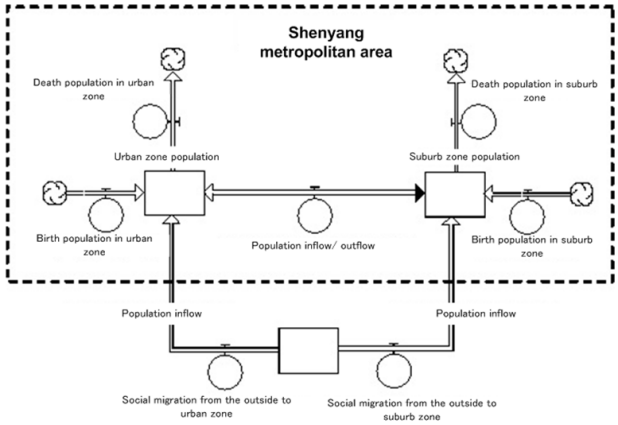


Fig. 3: Shenyang prefectural-level city (metropolitan area), Fig. 4: Diagram among the inflow/ outflow of metropolitan population.

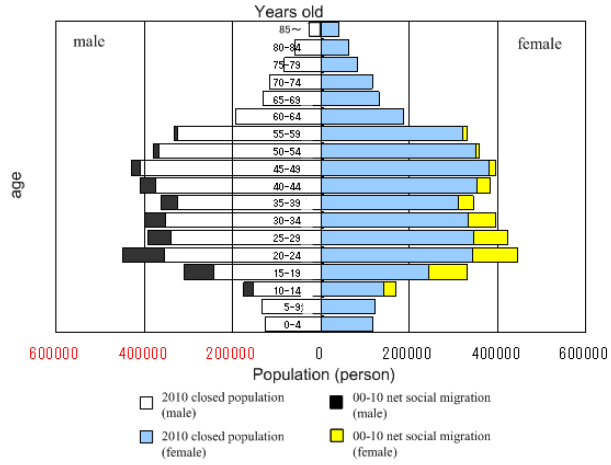
5.2 Estimation of social migration population using the cohort method

In accordance with the framework shown in Figure 4, the Shenyang metropolitan area and the surrounding were aggregated into three zones: an urban zone, the suburb zone, and the outside, and using the cohort method the population move between these three zones was estimated.

The steps of the cohort analysis are as follows: (1) Calculation of survival ratio for 5 years: Multiply the arithmetic average between the 2000 and 2010 values of each 5-year age cohort annual survival ratio by itself 5 times; (2) Calculation of closed population: A closed population is an estimated population on the assumption that there is no social move. Multiply each 5-year age cohort population by the survival ratio for 5 years 2 times to obtain the closed population in 2010; (3) Calculation of net social migration: Find the difference between each 5-year age cohort population in 2010 and the closed population to obtain the net social migration.

5.3 Analysis of social migration in the Shenyang metropolitan area

Figure. 5 show the population pyramid in 2010 in the urban zones of the Shenyang metropolitan area, overlapped by social population change found by cohort analysis. Due to the nature of the cohort method, it was not possible to estimate all age cohorts; however, for these 10 years, in each of the metropolitan area and urban zone, the social migration of population is observed in each age group. When these figures are summed up, it can be estimated that the population increase for 10 years were 902,000 for the metropolitan area and 548,000 for the urban zone, and the social migration were 565,000 and 875,000 respectively.



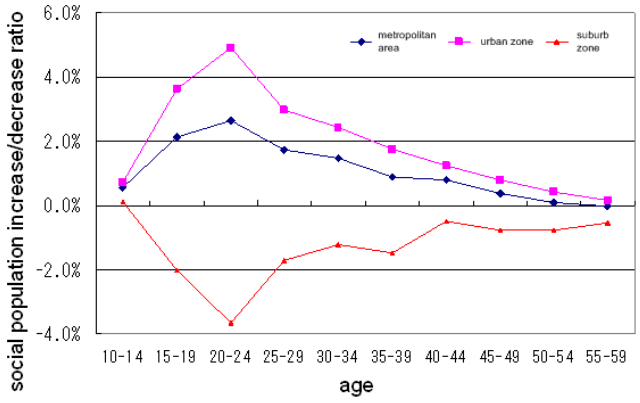


Fig. 5 (Left): Estimation of net social migration in Shenyang metropolitan area using the cohort method（2000-2010), Fig. 6 (Right): Social migration ratio in urban zone in Shenyang metropolitan area (2000-2010).

Figure 6 shows the net social migration ratios of each cohort (10-54 years olds) in Shenyang. For each of the urban zone and the suburbs, using the urban zone population, and suburbs population in 2000 as denominators, the net social migration ratios were estimated. In the entire metropolitan area all cohorts showed the positive values, which was caused by the population inflow from the outside. Inflow excess from the suburbs to the urban zone can be seen mainly in the 15 to 29 cohorts; employment or entering a higher-

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level educational institution can be considered as the main factors. When the urban zone is focused on, inflow from the suburbs can be estimated as 308,000, and inflow from the outside 567,000. When these figures are compared with the indicators of the Shenyang metropolitan area, found in Section 3, a difference of 46.4% is found, which suggests that population increase with no change of household registration is included.

6 ANALYSIS OF THE QUALITY OF LIFE IN CHINESE METROPOLITAN AREAS

6.1 Establishment of a Quality of Life indicator system

6.1.1 Method to select indicators for evaluating the Quality of Life

By employing data [1], [3], and [4] from the two points of time, 2005 and 2010, this section establishes indicators to evaluate the Quality of Life (excluding economy-related indicators), and attempts an analysis (see Table 4).

the Structure of "quality of life" indicator System			
First-level index	The second level index	Third level index	data
(EC) Education and Culture	a)Primary education	①Number of primary school per capita(School / 10thousands person)	[1]
		②Number of primary school teacher per pupil(Person / 10thousands person)	[1]
	b) Secondary education	①Number of Junior high school per capita (School / 10thousands person)	[1]
		②Number of Junior high school teacher per pupil(Person / people)	[1]
	c) High education	①Number of high education student per population(People / 10thousands person)	[1]
	d) Public library	①Number of public library per capita (Thousand books / 10thousands person)	[1]
(DC) Daily-life Convenience	a) Communication	①Number of household use of internet per capita(household/10thousands person)	[1]
		②Number of set-up phone per capita (household/people)	[1]
		③Number of mobile phone per capita(household/people)	[1]
	b) Movie theater, post office	①Number of movie theater per capita(a movie/10thousands person)	[1]
		②Number of post office per capita(a post office/10thousands person)	[1]
	c) Transportation cost	①Area amounts of city road per capita(㎡/person)	[1]
		②Number of public bus per capita(a bus/10thousands person)	[1]
		③Number of annual bus passengers per capita (time/person・Year)	[1]
	d) Electricity	①Number of Electricity Consumption of household per capita (Ten thousand kWh / million people)	[1]
(UE) Urban Environment	a) Housing price	①Average house price/annual citizen income (Year/People/100㎡・person) [Metropolitan area]	[4]
	b) Open space	①Area amounts of public park per capita(㎡/person)	[3]
	c) Medical care	①Number of hospitals per capita(a hospitals/10thousands person)	[1]
		②Number of medical doctor per capita(People / 10thousands person)	[1]
		③Total number of bed in hospital(a bed/10thousands person)	[1]
	d) Water-supply	①Water-supply coverage(%) covered pop./total pop.	[3]
		②Total amounts of water-supply per capita(Ton/person) total amounts of water-supply /total pop.	[3]
(CS) Consumption Sustainability	a) Household garbage	①Treatment ratio of household garbage(%) amounts of treatment of garbage/total household garbage	[3]
		②total household garbage per capita(Ton/person) total household garbage/total pop.	[3]
	b) Household sewage	①Treatment ratio of household sewage (%) [Metropolitan area]	[1]
(IS) Industrial Sustainability	a) Industrial recycling	①Rcycle ratio of Industrial garbage(%) [Metropolitan area]	[1]
	b) Industrial wastewater	①Capita per industrial wastewater without the treatment [Metropolitan area]	[1]
	c) SO2	① Industrial SO2 treatment ratio (%) Industrial SO2 removal amounts /the total industrial SO2 emission [Metropolitan area]	[1]
		②Capita per industrial SO2 emission without the treatment(10thousands person/Ton) total pop./the total industrial SO2 emission [Metropolitan area]	[1]
	d) Smoke	①Industrial smoke treatment ratio (%) industrial smoke removal amounts/the total industrial smoke emission[Metropolitan area]	[1]
		②Capita per industrial smoke emission without the treatment(10thousands person/Ton) total pop./the total industrial smoke emission[Metropolitan area]	[1]

Table 4: The Structure of "quality of life" indicator System.

Firstly, from among 53 indicators for which data was available at both points of time, 38 indicators were selected using the KJ method, and then, missing data and correlation analysis were confirmed, and finally 31 indicators were selected as element indicators (third-level indicators). By combining several indicators second-level indicators were created; and the second-level indicators were further combined to establish the five Quality of Life indicators, each of which cosists of a number of element indicators as follows:

(1) Education and Culture (EC): 6 element indicators

(2) Daily-life Convenience (DC): 9

(3) Urban Environment (UE): 7

(4) Consumption Sustainability (CS): 3

(5) Industrial Sustainability (IS): 6

6.1.2 Quality of Life indicators and Change to Quality of Life indicators

To combine the Quality of Life indicators at each point of time, the deviation value was first found for each element indicator, and each higher level indicator was obtained by successively calculating the mean value of the deviation values.

In addition, to combine the Change to Quality of Life indicators between the two points of time, the deviation value was found for the ratio between the two points of time of each element indicator, and each higher level indicator, in the same manner as above, was obtained by successively calculating the mean value of the deviation values.

When creating indicators, histograms for original data and indicators at each level were created to confirm the existence of outliers, and the outliers were treated as missing data. Many outliers were found for Shenzhen; this would appear to be a consequence of the city being designated as a Special Economic Zone, and its ranking immediately under the Direct-Controlled Municipalities.

6.2 Analysis of Chinese metropolitan areas employing the Quality of Life indicator system

6.2.1 Classification of metropolitan areas according to the Quality of Life indicators in the years 2005 and 2010

Using these five Quality of Life indicators, 51 metropolitan areas in the years 2005 and 2010 were classified according to type. After applying cluster analysis (Ward's method) the metropolitan areas were divided into five groups (Fig. 7), and similarities were found in classification for both years; therefore, the two points of time were overlapped and any movement between the metropolitan area groups was added as shown in Fig.8.

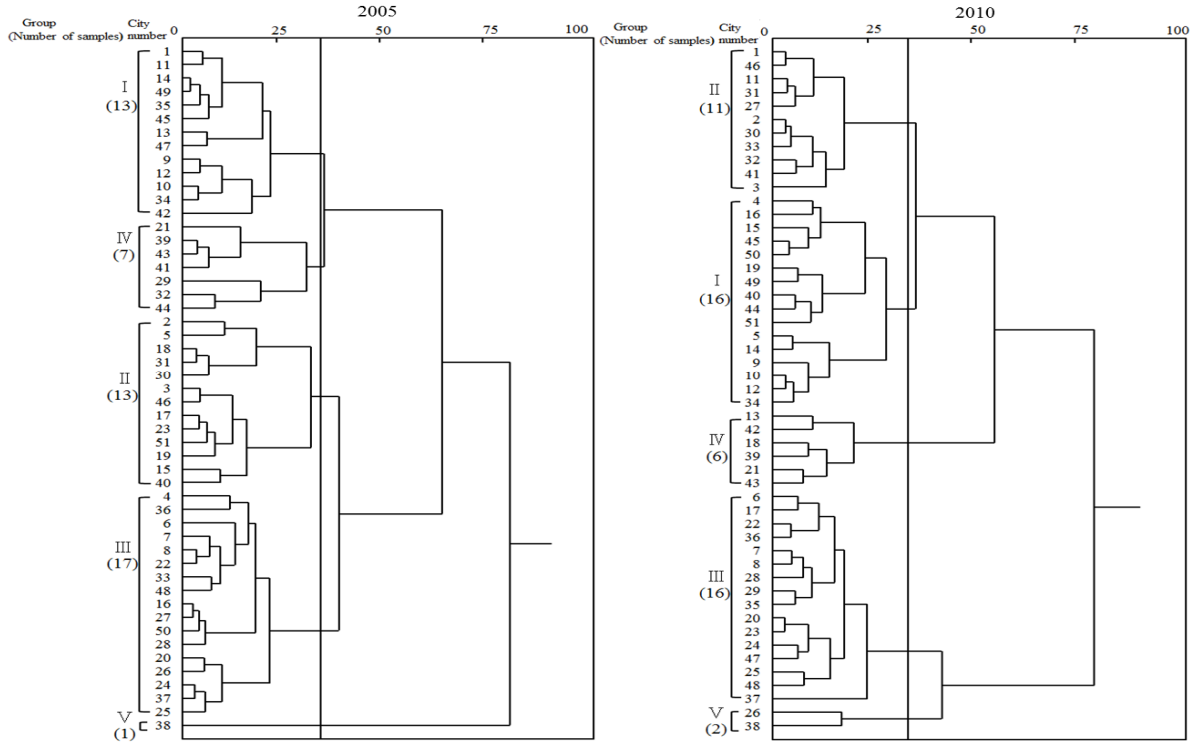

Fig. 7: Dendrogram of the metropolitan areas as.

The characteristics of each group are as follows (the figure within brackets indicates the number of metropilitan areas in 2010):

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Group I (16): The Education and Culture indicator is close to the mean value, and the other four indicators are lower than the mean value.

Group II (11): The Daily-life Convenience indictator is close to the mean value, along with the particularly-high Consumption Sustainability indicator, and the remaining three indicators are lower than the mean value.

Group III (16): The four indicators other than the Industrial Sustainability indicator are almost uniformly higher than the mean value.

Group IV (6): Among the five groups, the Industrial Sustainability indicator is the highest, but the other four indicators are all the lowerst.

Group Ⅴ (2): This group shows the highest overall in all five Quality of Life indicators (Fig. 8).

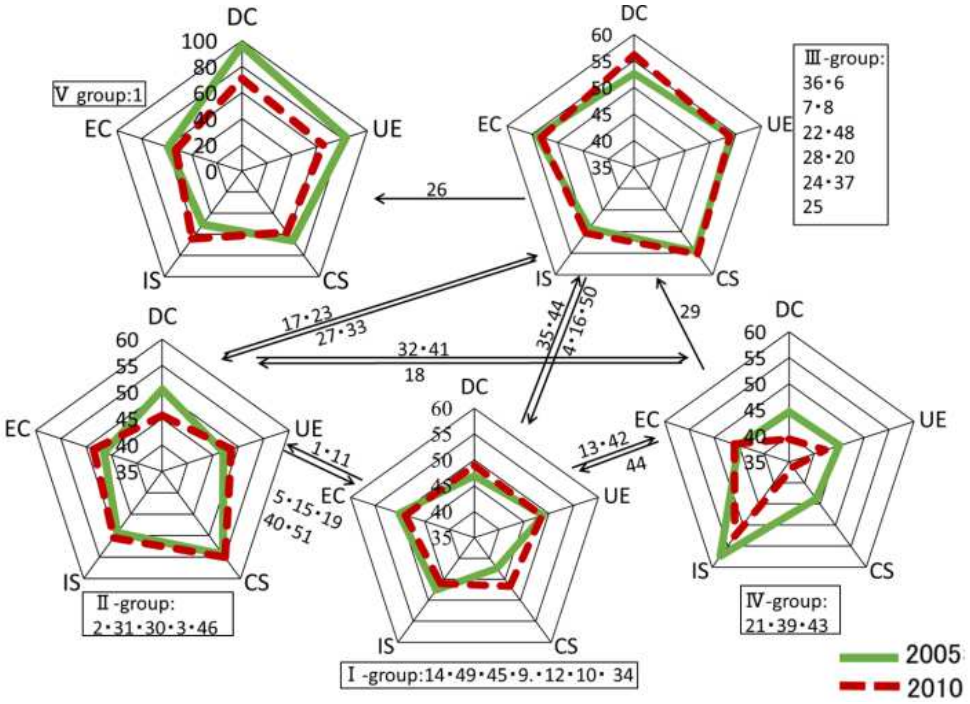

Fig. 8: Types of metropolitan areas as measured by the index "quality of life" index('10 And '05).

Next, for the five groups classified according to the Quality of Life, their ranking order was determined by the Pareto superiority/inferiority method, and in order of the highest Quality of Life they were arranged as V III (II IV I). Among three groups II, IV, and I, it was difficult to definitively judge superiority/inferiority. Over the five years, 24 cities moved between the groups, and six metropolitan areas moved to a group with a higher Quality of Life: Xiamen (26) moved from Group III to Group V; Wuxi (17) and Ningbo (23) moved from Group II to Group III; Wuhan (35) and Huizhou (44) moved from Group I to Group III; and Qing dao (29) moved from Group IV to Group III. It can be considered that these metropolitan areas developed their Quality of Life more quickly than other areas, and by 2010 the Quality of Life level had improved. These 6 metropolitan areas are mainly located on the coast and showed remarkable economic growth.

6.2.2 Linkage analysis of economic growth, migration, and area population size with the Change to Quality of Life indicators

Stepwise multiple regression analysis (method of decreasing the variables) was conducted and the results are shown in Fig. 9 as a linkage diagram. The following three elements were used as objective variables: GRP per capita in 2010 (Y_1) , migration to the urban zones from 2000 to 2010 (Y_2=ΔSP), and the area population size in 2010 (Y_3=P_{10}). The following five Change to Quality of Life indicators from 2005 to 2010 were used as explanatory variables: ECc(X1), DCc(X2), UEc(X3), CSc(X4), and ISc(X5).

Y_1 has a positive correlation with EC (Education and Culture), and a negative correlation with CS (Consumption Sustainability).

Y_2 has a positive correlation with UE (Urban Environment).

For Y_3, all explanatory variables were rejected, which indicates it had a weak correlation with the change to the Quality of Life.

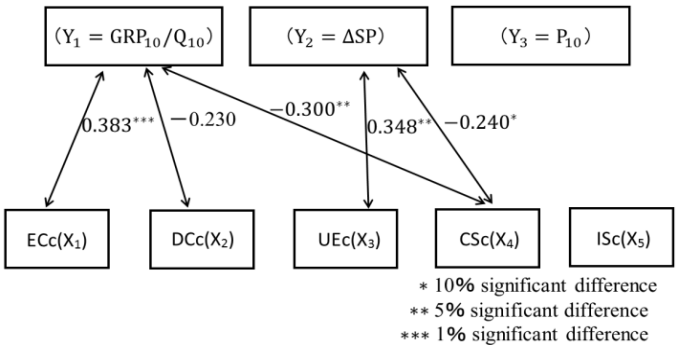

Fig. 9: Correlation diagram of each of "change in quality of life" indicators and the economic level, population influx and urban scale.

6.2.3 Relation between economic growth and the Change to Quality of Life indicators: Examining the Northeast region as a case study

For each of the nine metropolitan areas in the Northeast region, a radar chart was created to show the five Change to Quality of Life indicators and the indicator of the GRP per capita ratio between two points of time as shown in Fig. 10. The nine metropolitan area charts show that the Change to Quality of Life indicators and the indicator of the change to GRP per capita are close to the mean values, which demonstrates both the levels of economic growth and change to Quality of Life hold a middle-ranking position in the Chinese 51 metropolitan areas. Moreover, among the nine metropolitan areas Shenyang and Dalian belong to the second highest ranked Group III. The other seven metropolitan areas remain in Group I, II, or IV.

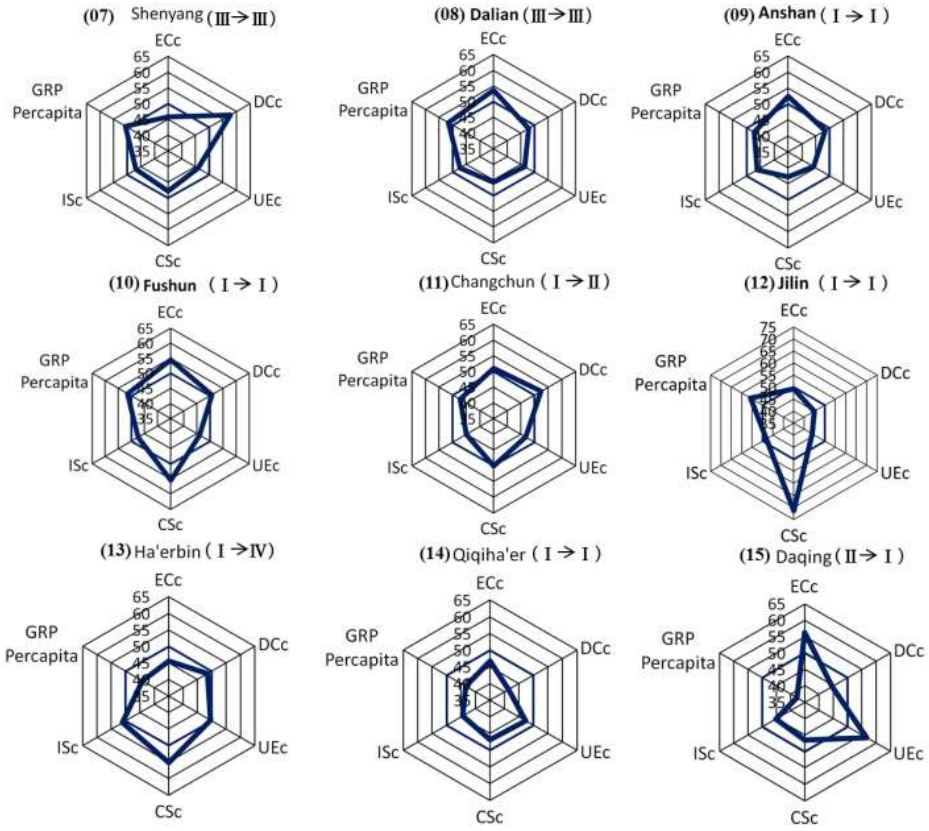

Fig. 10: The change index chart in each metropolitan area in the Northeast Region.

7 CONCLUSION

(1) The main factor of migration to each metropolitan area from 2000 through to 2010 is economic growth, rather than area population size.

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(2) According to the Quality of Life indicators established for 2005 and 2010, Chinese metropolitan areas were examined and classified into five groups, and a trend was seen that a metropolitan area with an overall growing economy also had a higher level of Quality of Life. However, depedning on the economic growth level of each metropolitan area, the Change to the Quality of Life differed.

(3) The linkage of economic level, migration, and area population size with the Change to Quality of Life indicators was analyzed. The economic level had a positive correlation with EC (Education and Culture), and a negative correlation with CS (Consumption Sustainability). In addition, migration had a positive correlation with UE (Urban Environment).

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