For office use only	Team Control Number	For office use only
T1 ________________	**55869**	F1 ________________
T2 ________________		F2 ________________
T3 ________________	Problem Chosen	F3 ________________
T4 ________________	**E**	F4 ________________

2019
MCM/ICM
Summary Sheet

Summary

In recent years, with the rapid development in economy and explosive growth in population, environment pollution and depletion of resources have been aggravated day by day. Smart Growth was then put forward. Lots of cities have drawn up the development plans on basis of the combination of ten principles for Smart Growth and their own conditions. Our work is to evaluate the success of each city in Smart Growth and provide a guidance for plan making.Meanwhile, we need to measure the success of our smart growth plan. Therefore, we define the "Smart Growth Index" (SGI) to measure the success of smart growth and development plans of a city.

Our model establishes a detailed group of 52 indictors, which reflects the ten principles for smart growth and the three E's of sustainability. On basis of this, we can assess the success of smart growth of a city. In the construction of SGI model, we use linear aggregation to combine individual variables into the theme scores. Compensability of linear aggregation ensures fair assessment of different cities which have different emphasis in urban development. Then we use geometric aggregation to combine theme scores into SGI. Low compensability of geometric aggregation requires a city to develop evenly in all themes. We use entropy method to determine weights of indictors or themes, which avoid subjectivity. SGI model has an all-round and objective assessment of the success of smart growth of a city.

With the completion of these, we respectively select a city in China and America (Zhenjiang and Columbia.SC). We assess the success of city development and their smart growth on basis of SGI model. Finally, we proved the reasonability and applicability of our model.

Keywords: **Geometric and linear aggregation ; entropy method**

Smart Growth Index ; PCA

Contents

1 Introduction

1.1 Background

As is projected by 2050, 66 percent of the world's population will be urban, which means 2.5 billion people will be added to the urban population. Consequently, many communities are carrying out smart growth measures, which focus on the three E's of sustainability–Economically prosperous, socially Equitable, and Environmentally Sustainable, to ensure that people have access to equitable and sustainable homes, resources and jobs.

1.2 Our work

Smart growth is an urban planning theory that originated in 1990's as a means to curb continued urban expansion and reduce the loss of farmland surrounding urban centers. To meet the requirements of ICM, we need to complete the following tasks:
(1) Develop a metric model to measure the success of smart growth of a city based on the three E's of sustainability.
(2) Use our model to measure and discuss whether the chosen two cities are successful in the current growth plans or meet the smart growth principles.
(3) Develop a growth plan for both cities using smart growth principles, and explain why we chose these components and initiatives of plan from based on the geography, expected growth rates, and economic opportunities of the two cities. Assess whether our plans is successful or not by way of our model.
(4) Use our models to rank the individual initiatives within our redesigned smart growth plan as the most potential to the least potential. Compare and contrast the initiatives and their ranking between the two cities.
(5) Assess the applicability of our plans by supposing that the population of each city will increase by an additional 50% by 2050.

To further our solutions, we arrange our paper as follow:
In section 2, we make some reliable assumptions to simplify our metric model.
In section 3, we develop a model to measure the success of smart growth of a city.
In section 4, we develop a plan analysis model to assess smart growth plan. And, develop a metric to assess the importance of each initiative in a plan.
In section 5, solutions for tasks.
In section 6, sensitivity analysis.
In section 7, strengths and weaknesses

2 Assumptions

(1) The real change of indictors corresponds to policies.
(2) Each indictor will not have abrupt and rapid changes.
(3) The relationship between initiative and indictor is one to one.
(4) Indictors are mutually dependent.

3 The Smart Growth Index Metric Model

3.1 Theoretical framework

3.1.1 framework

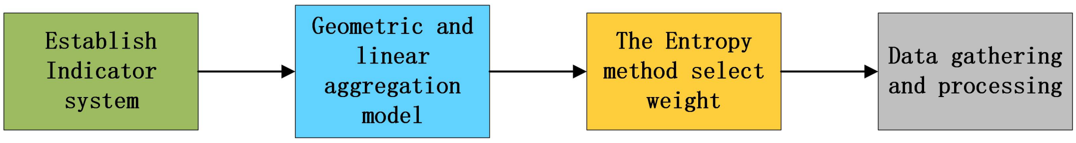

Figure1:Flow diagram

To meet ICM group's requirements, we establish a model to access the smart growth of a city. Thus, we define an index as the criterion to measure the success of smart growth of a city, represented as SGI (Smart Growth Index).
Referring to literature and research [1], we choose 52 indictors (including positive indictors and negative indictors), which have effects on SGI in degrees, based on the ten principles for smart growth and the three E's of sustainability. Through analysis, we further boil these indictors down to 4 themes. Finally, we aggregate the 4 themes as the SGI.

Briefly, we can develop a three-layer model (outer: indictors; middle: themes; inner: SGI) based on the analysis above. Below are the figure reflecting the relationships:

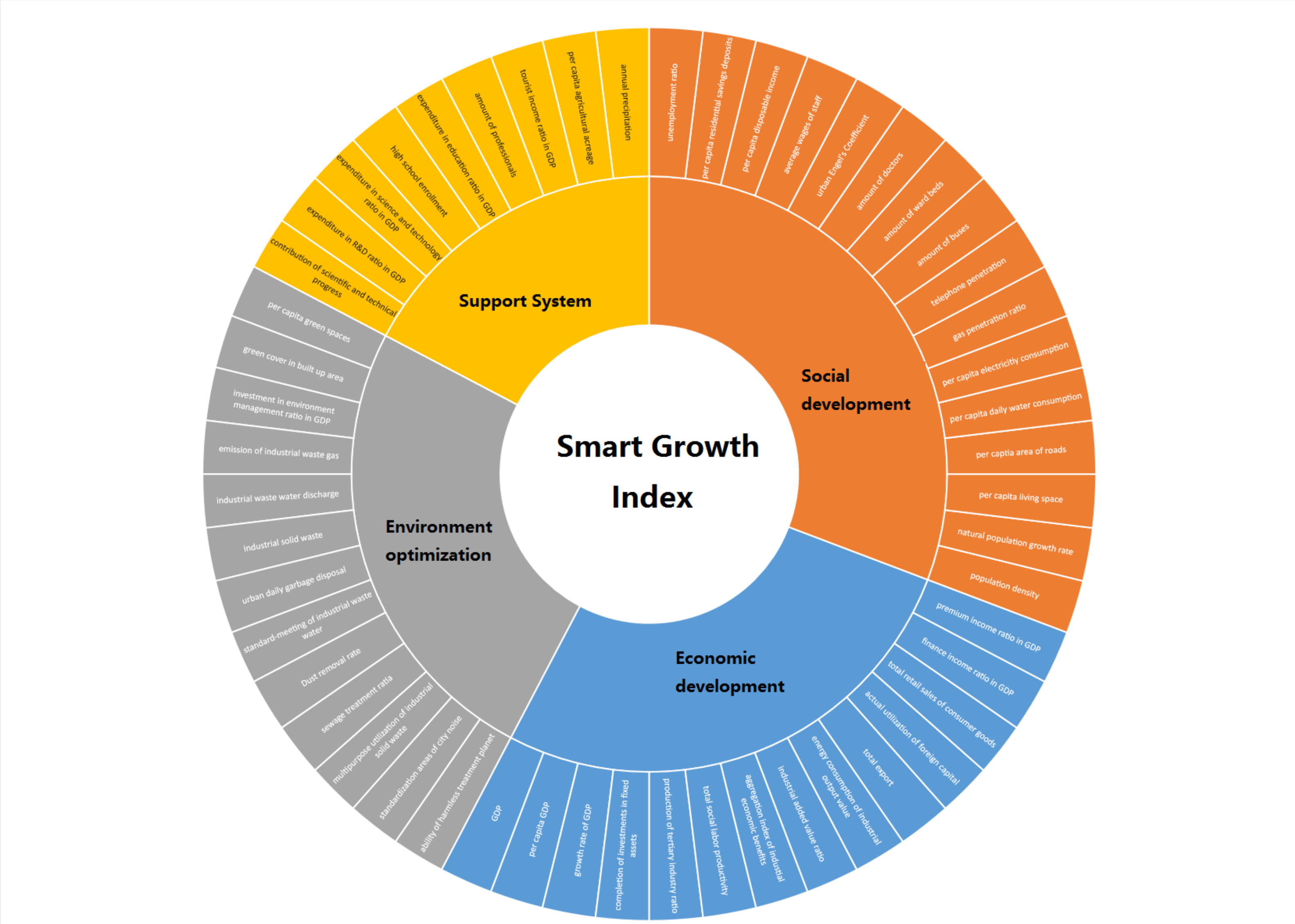

Figure2:The relationship of the model

3.1.2 Multivariate Analysis by PCA

After selecting indicators,we try to assess between-variable correlation by Principle Compomnents Analysis(PCA).
the results of the PCA fitted less closely with our conceptual framework for the Environment theme. However ,because we think it's indicators we selecteed are importent , we left them unchanged.

3.2 Construction of SGI Model

3.2.1 Geometric and linear aggregation model

We decide to use GLA to obtain the relationship between SGI and the 4 themes along with 52 indictors.
Geometric and linear aggregations (GLA) each have their own benefits, while in a linear aggregation, the compensability is constant, with geometric aggregations, compensability is lower for the composite indictor or themes with low values. This means that when using a geometric aggregation, a city with a low score for one indictor or theme will need a much higher score on the others to improve its score.
Thus, it's relatively reasonable to use GLA to obtain the SGI. From indictors to themes, we use liner aggregation model. And, from themes to SGI, we use geometric aggregation model.
This captures the non-compensability across themes without making the Index too sensitive to individual variables for which the importance, robustness and compensability is less clear.The figure as follow:

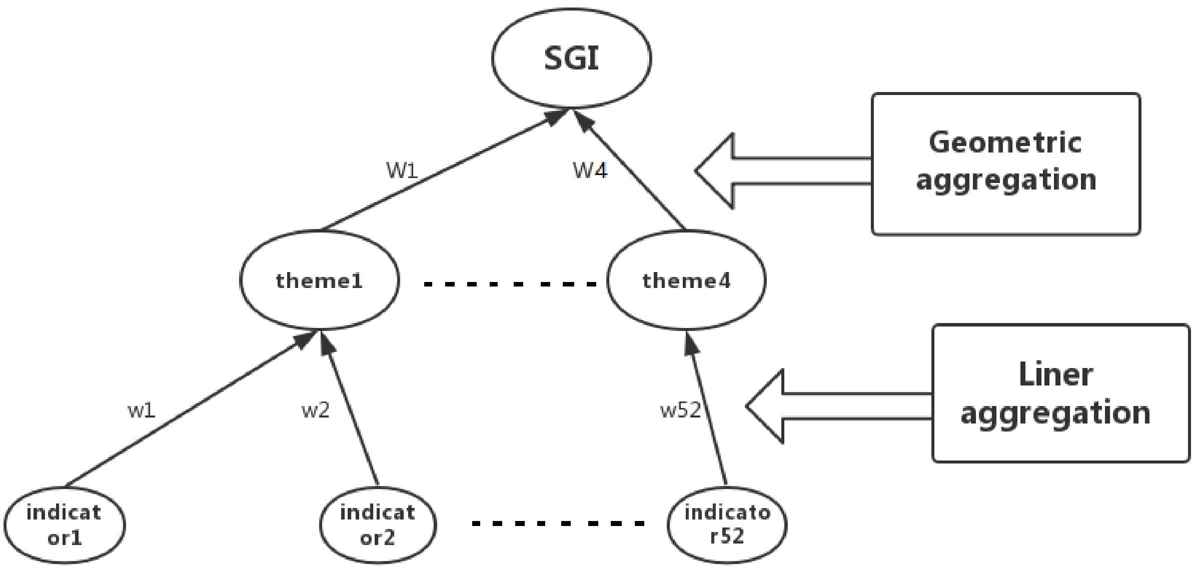

Figure3:GLA model

(1) Liner aggregation equation for the score of theme

$$\mathbf{T_i} = \frac{\sum_{j=1}^{J} \mathbf{w_j z_j}}{\sum_{j=1}^{J} \mathbf{w_j}}$$

where $\mathbf{T_i}$is the aggrregated theme score for theme i of chosen city
$\mathbf{w_j}$ is the weight given to indicator
$\mathbf{z_j}$ is the normalised value for indicator j

(2) Geometric aggregation equation for the score of SGI

$$\mathbf{SGI} = (\prod_{i=1}^{I} \mathbf{T_i}^{\mathbf{W_i}})^{\frac{1}{\sum_{i=1}^{I} \mathbf{W_i}}}$$

where **SGI** is the aggregated Index score for the chosen city .
$\mathbf{W_i}$ is the weight given to theme .
$\mathbf{T_i}$ is the aggregated theme score for the theme.
In consideration of the different measurement of these indictors, we decide to normalize the data of indictors to a certain extent, in order to apply to the basic model above.

3.2.2 Normalization

Due to indictors measured in different counting units, we adopt a min-max normalization method which normalizes the 52 indicators within an identical [0,1] range.
Normalization equations
For positive indictors

$$z_j = \frac{x_j - min(x_j)}{max(x_j) - min(x_j)}$$

For negative indictors

$$z_j = \frac{max(x_j) - x_j}{max(x_j) - min(x_j)}$$

$\mathbf{x_j}$ represents the data of indictor j.
$\mathbf{z_j}$ represents the data of indictor j after normalization.

3.2.3 Weigh indictors and themes by Entropy method

We adopt the Entropy method to determine the weight of each indictor or theme.
Entropy is originally a physical theory in thermodynamics. In information system, entropy weight, known as information entropy, reflects the disorder of information. The smaller the information entropy is, the lower the disorder of information is, which means the availing value of information is great. And, the problem of weight allocation is solved.
Compared with other methods like AHP and so on, this way is more objective and more reliable to reflect the relationship between indictors or themes in the model. Below are the steps to determine the weight:
Step 1: Choose n cities and m indictors. And x_{ij} represents the data of indictor j of city i (i=1,2,3...n, j=1,2,3...m).
Step 2: Normalize indictors using the method in 3.2.2.$\mathbf{z_j}$ represents the data of indictor j after normalization
Step 3: Calculate the proportion $\mathbf{p_{ij}}$ of $\mathbf{z_{ij}}$

$$p_{ij} = \frac{z_{ij}}{\sum_{i=1}^{n} z_{ij}}, i = 1, ..., n, j = 1, ..., m$$

Step 4: Calculate the entropy $\mathbf{e_j}$ of variable j

$$e_j = -k \sum_{i=1}^{n} p_{ij} ln(p_{ij})$$

$k = 1/ln(n) > 0, e_j \geq 0$
Step 5: Calculate the availing value $\mathbf{d_j}$ of variable j

$$d_j = 1 - e_j$$

Step 6: Calculate the weight $\mathbf{w_j}$ of variable j

$$w_j = \frac{d_j}{\sum_{j=1}^{m} d_j}$$

Step 7: Calculate the weight $\mathbf{W_k}$
According to Entropy's additivity, we can obtain the weight of theme(middle) on the basis of the availing value of variable(bottom).
Summarize the availing value of indictors, which correspond to theme k, and we obtain the availing value of theme k denoted by $D_k(k = 1, 2, 3, 4)$.then we obtain

$$D = \sum_{k=1}^{4} D_k$$

therefore

$$W_k = \frac{D_k}{D}$$

Based on the data of several cities over 10 years[2] ,we obtain the weight of each variable by the way of the entropy method

Table 1:City Smart Growth indicator system weight

I	Indictors	entropy	availing value	weight (%)
	Group of indictors for ecnomic development			22.925
1	GDP(100 million yuan)	0.99001	0.00999	7.59925
2	per capita GDP(yuan/person)	0.99044	0.00956	7.27817
3	growth rate of GDP(%)	0.99723	0.00277	2.11033
4	completion of investments in fixed assets(%)	0.99512	0.00488	3.71549
5	production of tertiary industry ratio(%)	0.99908	0.00092	0.70123
6	total social labor productivity(yuan)	0.98483	0.01517	11.5444
7	aggregation index of industial economic benefits	0.99766	0.00234	1.7815
8	industrial added value ratio(%)	0.99892	0.00108	0.8213
9	energy consumption of industrial output value (tce)	0.99687	0.00313	2.37957
10	total export(100 million dollars)	0.98463	0.01537	11.6974
11	actual utilization of foreign capital(100 million dollars)	0.97431	0.02569	19.5481
12	total retail sales of consumer goods(yuan)	0.99087	0.00913	6.9475
13	finance income ratio in GDP(%)	0.98757	0.01243	9.46227
14	premium income ratio in GDP(%)	0.98106	0.01894	14.4136
	SUM		0.1314	100
	Group of indictors for social development			32.8844
15	population density(person/km^2)	0.99998	0.000021	0.01095
16	natural population growth rate(%)	0.98577	0.01432	7.54951
17	per capita living space(urban,m^2)	0.99927	0.00073	0.38819
18	per captia area of roads(urban,m^2)	0.99469	0.00531	2.81685
19	per capita daily water consumption(urban,L)	0.99739	0.00261	1.38275
20	per capita electricitiy consumption(W)	0.983176	0.016824	8.926287
21	gas penetration ratio(urban,%)	0.99829	0.00171	0.90891
22	telephone penetration(set/hundred person)	0.941254	0.058746	31.16803
23	amount of buses (per ten thousand)	0.981269	0.01873	9.938145
24	amount of ward beds(per ten thousand)	0.99656	0.00344	1.82491
25	amount of doctors (per ten thousand)	0.99507	0.00493	2.61773
26	urban Engel's Coefficient(%)	0.99754	0.00246	1.30663
27	average wages of staff(yuan)	0.98371	0.01629	8.64347
28	per capita disposable income(urban, yuan)	0.99453	0.00547	2.89988
29	per capita residential savings deposits(urban,yuan)	0.972096	0.027904	14.8049
30	unemployment ratio(urabn,%)	0.990929	0.009071	4.812845
	SUM		0.188481	100

I	Indictors	entropy	availing value	weight (%)
	Group of indictiors for environment optimization			22.6476
31	per capita green spaces(m^2)	0.9962	0.0038	2.927595
32	green cover in built up area(%)	0.994739	0.005261	4.052684
33	investment in environment management ratio in GDP	0.946798	0.053202	40.98544
34	emission of industrial waste gas(billion cubic meters)	0.997865	0.002135	1.645014
35	industrial waste water discharge(ten thousand ton)	0.99866	0.00134	1.032296
36	industrial solid waste(ten thousand ton)	0.997948	0.002052	1.580738
37	urban daily garbage disposal(ten thousand ton)	0.996143	0.003857	2.971568
38	standard-meeting of industrial waste water(%)	0.980095	0.019905	15.33443
39	Dust removal rate(%)	0.997501	0.002499	1.924922
40	sewage treatment ratia(%)	0.99454	0.00546	4.205913
41	multipurpose utilization of industrial solid waste(%)	0.995567	0.004433	3.414808
42	standardization areas of city noise(km^2)	0.983896	0.016104	12.40645
43	ability of harmless treatment planet(ton)	0.990241	0.009759	7.518134
	SUM		0.129807	100
	Group of indictors for support system			21543
44	annual precipitation(mm)	0.991201	0.008799	7.126399
45	per capita agricultural acreage(acre)	0.999253	0.000747	0.604674
46	tourist income ratio in GDP(%)	0.962193	0.037807	30.61872
47	amount of professionals(ten thousand, person)	0.995093	0.004907	3.974089
48	expenditure in education ratio in GDP	0.995912	0.004088	3.31051
49	high school enrollment(ten thousand,person)	0.973031	0.026969	21.84158
50	expenditure in three charges of science and technology ratio in GDP(%)	0.985541	0.014459	11.70999
51	expenditure in R&D ratio in GDP(%)	0.975452	0.024548	19.88107
52	contribution of scientific and technical progress(%)	0.998848	0.001152	0.932972
	SUM		0.123476	100

4 Analysis of chosen cities' smart growth

4.1 Construction of plan analysis model(PAM)

We develop a metric model to assess the effects of a plan or policy on the SGI. Also, we can analysis the potential of indictors in a plan(policy) by the way of the model.

4.1.1 Assumptions for PAM

(1) Due to the established detailed group of indictors, we assume that the relationship between plan(policy) and indictor is one to one, even though the existence of the situation of n to one, we can also simplify the relationship as one to one on the basis of SGI model.
(2) We assume that the relationship between plan(policy) and indictor is linear to simplify our model.
(3) Quantification of plan(policy) is directly reflected in the data of indictors of a city. The relationship between plan(policy) and indictor is reflected in data of years in a city.

4.1.2 Plan's impacts on SGI

According to the researches on urban planning of a city, we know of its plans(policies), we can boil plans(policies) down to indictors or themes on the basis of assumptions above and linear aggregation model.
Thus, we can further analyze these plans'(or policies') impacts on SGI by the way of geometric aggregation model.
Below are the method
(1) According to the plans or policies, we update data of relative indictors.
(2) Using SGI model on the basis of new data of indictors, we can obtain a new smart growth index, represented as SGI'.
(3) We can further obtain the change in SGI based on the original SGI of city(plans or policies not carried out).

$$\Delta SGI = SGI' - SGI$$

(4) Through the analysis of ΔSGI_i , we can see the impacts of plans or policies on SGI.

4.2 Assess the importance of initiatives in a plan

A plan has many initiatives, which has different emphasis on various fields. Thus, we develop a metric to assess the importance of each initiatives. Below is the metric:
(1) On the basis of APM, we can obtain SGI' after a plan is implemented.
(2) Then we adopt qualitative analysis, only implement an initiative of a plan(e.g. initiative i), therefore, we can obtain a new index SGI_i'.
(3) We can get the change in SGI

$$\Delta SGI_i{}' = SGI' - SGI_i{}'$$

Through the qualitative analysis of each initiative, we obtain the change in SGI of each initiative.
(4) Compare the relative change$|\frac{\Delta SGI'}{SGI'}|$ on the basis of original SGI', and we can analyze the importance of each initiative.

5 Solutions for tasks

5.1 Task 1

We have developed our models in the section 3(SGI model) and section 4(PAM).

5.2 Task 2

According to the current researches on urban planning of our chosen cities (Columbia.SC and Zhenjiang), we adopt quantization analysis of plans or policies. Then we obtain the following policy conclusion:

Table 2:Current Plan

Zhenjiang 5 years	**change**	**Columbia 5 years**	**change**
per capita GDP(yuan/person)	+8%	per capita disposable income(yuan)	+5%
production of tertiary industry ratio(%)	to 50%	per capita green spaces(m^2)	+4%
per capita disposable income(yuan)	+8.5%	average wages of staff(yuan)	+5%
tourist income ratio in GDP(%)	+100%	sewage treatment ratia(%)	to 99%
total export(100 million dollars)	+50%	high school enrollment(10000 person)	+8%
amount of doctors (per ten thousand)	+10%	per capita living space(m^2)	+7%
per captia area of roads(urban,m^2)	+10%	green cover in built up area(%)	+5%

Using SGI model, we can obtain SGI of two cities after implementing the current plan. Also, we can obtain original SGI on the basis of original data. Based on the method in section 4, we can get the following result by way of matlab.

Table 3:SGI of Current Plan

City	SGI_0 (2014)	SGI (2020)	ΔSGI
Zhenjiang	12.5126	14.3771	1.8645
columbia	13.962	14.1089	0.1469

Through the analysis of the relative change in SGI of two cities, we can assess the success of the growth plan.
Apparently, SGI of two cities both increases after implementing their own current growth plan.
Thus, their current growth plan is both successful.

5.3 Task 3

5.3.1 Our growth plans

Combining the current plans of two cities and ten principles of smart growth, we make the following growth plans for our cities over few decades.

Table 4:Our Plan

Zhenjiang 10 years	**change**	**Columbia 10 years**	**change**
per capita GDP(yuan/person)	+100%	per captia area of roads(urban,m^2)	+15%
production of tertiary industry ratio(%)	to 55%	ability of harmless treatment planet(ton)	+100%
total export(100 million dollars)	+100%	tourist income ratio in GDP(%)	+100%
per capita disposable income(yuan)	+100%	amount of professionals(10000 person)	+50%
per capita green spaces(m^2)	+20%	expenditure in education ratio in GDP	to 10%
high school enrollment(10000 person)	+100%	high school enrollment(10000 person)	+50%
total social labor productivity(yuan)	+200%	amount of ward beds(per ten thousand)	+30%
amount of ward beds(per ten thousand)	+20%	per capita green spaces(m^2)	+10%

5.3.2 Reasons for choosing these initiatives

Ten principles of smart growth can be reflected in the detailed of indictors. Thus, in the process of making our smart growth plans, we just need to choose appropriate indictors supported by policies on basis of geography and economic development.

For Zhenjiang, as manufacturing industry basement in middle and lower reaches of Yangtze River in China, adept in manufacturing and export, we can stimulate its export in our plan, which can accelerate the development of city. Even though economic development is on the agenda, the environment and medical level is as important as economic development. Thus, we also give priority to relative indictors of these elements in our smart growth plan.
For Columbia.SC, its economy and livelihood have higher level, thus we put its emphasis on education, technology and protection of environment. In the meanwhile, tertiary industry should be developed rapidly, which plays important role in urban development.
Therefore, we make these smart growth plans above for both cities.

5.3.3 Assessment of the success of our smart growth plans

Based on the method in task 2, we can obtain the changes in SGI of two cities by way of matlab after implementing our growth plans.

Table 5:SGI of Our Plan

City	SGI_0 (2014)	SGI (2025)	ΔSGI
Zhenjiang	12.5126	15.4329	2.9023
columbia	13.962	15.092	1.13

Apparently, SGI of two cities both increases after implementing our smart growth plan. Therefore, our smart growth plans are successful in the chosen cities through analysis.

5.4 Task 4

5.4.1 Assessment of the importance of each initiative

In this task, we need to rank our chosen initiatives of our smart growth plan. Thus, we can compare the importance of each initiative to complete this task.
On basis of the method mentioned in 4.2 of section 4 and SGI model, we can obtain the following ranking of each city by way of matlab.

Table 6:Ranking of initiatives

Columbia				
rank	**initiatives**		**SGI**	ΔSGI
1	tourist income ratio in GDP(%)	+100%	14.3194	0.3574
2	high school enrollment(10000 person)	+50%	14.2334	0.2714
3	ability of harmless treatment planet(ton)	+100%	14.1711	0.2090
4	amount of professionals(10000 person)	+50%	14.0586	0.0966
5	expenditure in education ratio in GDP	to 10%	13.9929	0.0309
6	amount of ward beds(per ten thousand)	+30%	13.9838	0.0218
7	per capita green spaces(m^2)	+10%	13.9811	0.0190
8	per captia area of roads(urban,m^2)	+15%	13.9726	0.0106
Zhenjiang				
rank	**initiatives**		**SGI**	ΔSGI
1	total export(100 million dollars)	+100%	14.4935	1.9809
2	high school enrollment(10000 person)	+100%	13.0236	0.5109
3	per capita disposable income(yuan)	+100%	12.6755	0.1628
4	total social labor productivity(yuan)	+200%	12.6102	0.0975
5	per capita GDP(yuan/person)	+100%	12.5504	0.0377
6	amount of ward beds(per ten thousand)	+20%	12.5304	0.0177
7	per capita green spaces(m^2)	+20%	12.5288	0.0161
8	production of tertiary industry ratio(%)	to 55%	12.5128	0.0002

5.4.2 Analysis of the ranking

Evidently, the ranking proves the reasonability of our plans' emphasis.
The ranking of the same initiatives of both cities is the same (education, medical level and green spaces). Thus, each of these indictors play the same role in urban development. Giving thought to national conditions of both cities, Zhenjiang's emphasis is economic development while Columbia's is soft strength of society like education, as well as technology and tertiary industry. The ranking of each city's initiatives is correspond to our reasons for choosing these initiatives.

5.5 Task 5

In the case of that the population of city will increase 50% by 2050, we analyze our group of indictors. We find that the increase of population has negative effects on population

density, per capita green spaces and per capita living space so on.
Due to population density and per capita living space not under the control of governmental policies or plans, we neglect these indictors in our smart growth plan.
For Columbia.SC and Zhenjiang there are several initiatives like $per\ capita\ green\ spaces$ and $amount\ of\ ward\ beds(per\ ten\ thousand)$
These implements all can effectively curb the negative impacts of the increase of population.

6 Sensitivity analysis

6.1 Selection of indictors

The aim of this analysis is to determine whether a single variable had an unduly large impact on the overall ranking. To test this, we randomly exclude variables/themes from the index several times. The rest of variables/themes can use the same method to aggregation smart growth index (SGI). Observe and analyze the distribution of SGI of two cities.

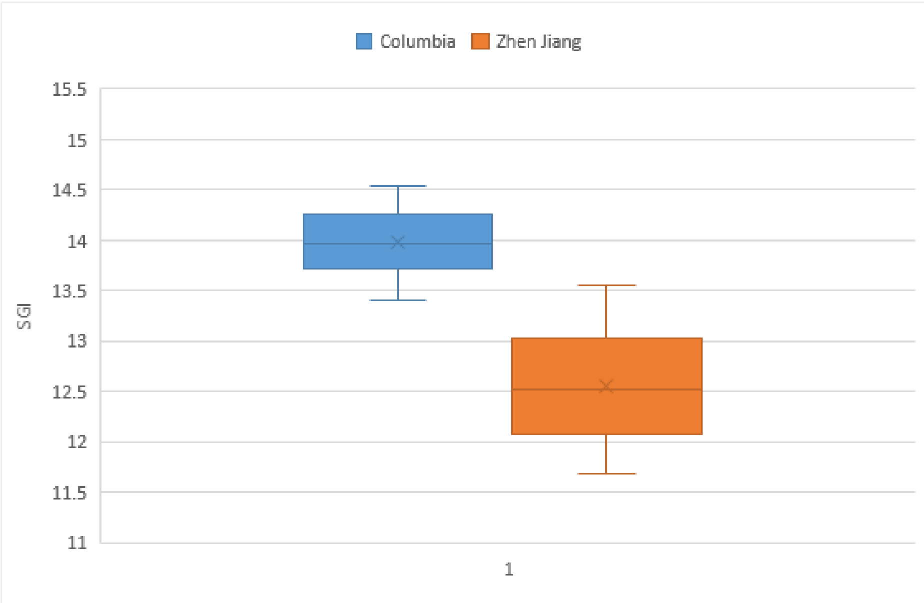

Figure2:boxplot

As is shown in the figure of statistics, the SGI of Columbia.SC is generally higher than that of Zhenjiang. The SGI of Zhenjiang is more sensitive to that of Columbia.SC. The result proves that SGI of Zhenjiang benefits from some indictors in degrees. In other words, the development of Columbia.SC is more balanced than that of Zhenjiang.

6.2 Selection of aggregation method

In Task 1, we compare linear aggregation with geometric aggregation in advantages. For that reason, we finally decided to use linear aggregation to combine individual variables into the theme scores and geometric aggregation to combine theme scores into SGI.
We tried to use geometric aggregation to combine individual variables into the theme scores. And we observe that the calculated SGI using different data may varies in difference.
Our model is sensitive to the selection of aggregation method.

7 Strengths and weaknesses

7.1 Strengths

- Our model establishes a detailed group of 52 indictors, which reflects the ten principles for smart growth and the three E's of sustainability. On basis of this, we can assess the success of smart growth of a city.
- In the construction of SGI model, we use linear aggregation to combine individual variables into the theme scores. Compensability of linear aggregation ensures fair assessment of different cities which have different emphasis in urban development. Then we use geometric aggregation to combine theme scores into SGI.Low compensability of geometric aggregation requires a city to develop evenly in all themes.
- We use entropy method to determine weights of indictors or themes, which avoid subjectivity.
- SGI model has an all-round and objective assessment of the success of smart growth of a city.

7.2 Weakness

- In our model, we regard the relationship between initiative and indictor as one to one. In reality, a plan can result in the change in other indictors(not included in plan) because of correlation between indictors. The real SGI may be different with our calculated SGI.
- In our model, we neglect the government's executive force.

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Appendices

Here are programmes we used in our model as follow.

calculation of SGI matlab source:

```
function [SGI]=model(X,Y)
A=[7.59925 7.27817 2.11033 3.71549 0.70123 11.5444 1.7815
   0.8213 2.37957 11.6974 19.5481 6.9475 9.46227 14.4136];
B=[0.01095 7.54951 0.38819 2.81685 1.38275 8.926287 0.90891 31.16803
   9.938145 1.82491 2.61773 1.30663 8.64347 2.89988 14.8049 4.812845];
C=[2.927595 4.052684 40.98544 1.645014 1.032296 1.580738
   2.971568 15.33443 1.924922 4.205913 3.414808 12.40645 7.518134];
D=[7.126399 0.604674 30.61872 3.974089 3.31051
   21.84158 11.70999 19.88107 0.932972];
E=[22.925 32.8844 22.6476 21,543];
H=X(1,1:14);
I=X(1,15:30);
J=X(1,31:43);
K=X(1,44:52);
L=Y(1,1:14);
M=Y(1,15:30);
N=Y(1,31:43);
O=Y(1,44:52);
AA=A./H;
BB=B./I;
CC=C./J;
DD=D./K;
a=sum(AA.*L)./sum(AA);
b=sum(BB.*M)./sum(BB);
c=sum(CC.*N)./sum(CC);
d=sum(DD.*O)./sum(DD);
SGI=a^(E(1)/100)*b^(E(2)/100)*c^(E(3)/100)*d^(E(4)/100);
```

calculation of weight by the entropy method matlab source:

```
function [s,w]=shang(x)
[n,m]=size(x);
[X,ps]=mapminmax(x');
ps.ymin=0.002; -
ps.ymax=0.996;
ps.yrange=ps.ymax-ps.ymin;
X=mapminmax(x',ps);
X=X';
for i=1:n
    for j=1:m
        p(i,j)=X(i,j)/sum(X(:,j));
    end
end
k=1/log(n);
```

```
for j=1:m
    e(j)=-k*sum(p(:,j).*log(p(:,j)));
end
d=ones(1,m)-e; -
w=d./sum(d);
```