

Urban Growth Evaluation Model

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Abstract. Nowadays, smart growth is popular around the world. This paper establishes an evaluation model for urban smart growth and a optimal decision model to provide the developing plan with the best strategy to develop cities meet the standards of three E's and ten principles. We build a three-layer evaluation model considering comprehensive factors of smart growth. We define smart growth as the first layer, the three E's as the second layer, and two trend parameters indexes for each E's as the third layer. The trend parameters are defined as the growth ratio of two factors (the ratio of GRDP growth rate and population growth rate, the ratio of population growth rate and urban area growth rate, the ratio of GRDP growth rate and urban area growth rate, the ratio of education funding growth rate and population growth rate, the ratio of public traffic capacity growth rate and population growth rate), which show the relative change speed of two factors. With the three E's indexes and standards we make, the smart growth rank table is obtained, which can rank a city's level of smart growth as "Utterly", "Nearly", "Transitionally", "Informally" and "Badly". In conclusion, urban smart growth is a brilliant method that balances economy, environment and human well.

Introduction

Context. Urbanization is the inevitable trend of the development of human society. However, attendant with rapid urban expansion, public facilities, municipal facilities and environmental facilities put forward higher requirements. Smart growth is one of the most popular planning theory in academic circle in the US, originated at the end of 1990s. [1] Aiming at curbing continued urban sprawl and reducing the loss of farmland surrounding urban centers, it emphasizes the need to establish a link between urban growth and quality of life. Smart growth has ten principles:

Actually, only full consideration of the demographics, growth needs, and geographical conditions of a city as well as the goal to adhere to the three E's ensures the city's optimization method.

Our Work

Aiming at contemporary urban development mode of smart growth theory combine with three E's and ten principles, using the methods of trend variable definitions and analytic hierarchy process (AHP)错误!未找到引用源。 ,we formulated the evaluation system of comprehensive evaluation of urban development, with the method of rating table designated rating range.[2]

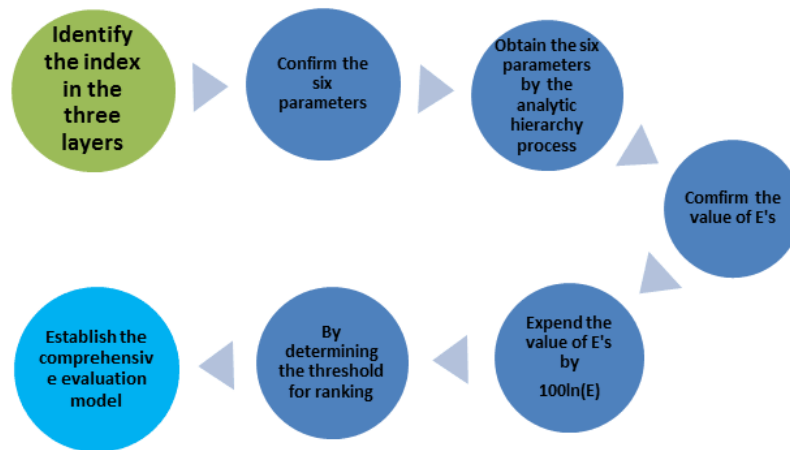


Figure 1. The process of the evaluation model building.

Assumptions

All of our models are based on a series of key assumptions that simplify the problem within rational extent. The following are assumptions used in every model. Each individual model's additional assumptions will be illustrated along with the description of that model.

According to the various indicators (GDP, population, urban area, etc.), every cities have many trends of development within the scope of international. Because these relationships are generally correct, we think Malmo and Yucheng city will follow the trend[3]. This makes based on the relationship between the international data of several indexes of quantitative can predict the growth of the two cities according to the current value of each index of the initial values.

Ignore the out-sync factor in the development of each region in the same city and the complex relationship between urban internal mixing factors, i.e., according to the city as a whole as the basic unit.[4]

Additional assumptions which are made to simplify analysis for individual part will be discussed at the appropriate portion.

Models

Evaluation Model for Smart Growth. Under varies academic discussion on smart growth, we focus on the E's of sustainability—Economically prosperous, socially Equitable, and Environmentally Sustainable in this paper. In order to state brief and clear. We define Economically prosperous index as EPI, socially Equitable index as SEI, Environmentally Sustainable index as ESI.

Notations.

Table 1 Notations

Symbol	Meaning
P	urban population
PT	public traffic capacity
A	urban area
G	GRDP
LG	low income group's gross revenue
E	basic education funding cost

Table 2 Abbreviations

Abbreviation	Meaning
EPI	Economically prosperous index
SEI	Socially Equitable index
ESI	Environmentally Sustainable index
PRA	The growth multiple of population relative to urban area
PRP	The growth multiple of public traffic capacity relative to urban population
GRP	The growth multiple of GRDP relative to population
GRA	The growth multiple of GRDP relative to urban area
GRG	The growth multiple of low income group's gross revenue relative to GRDP
ERP	The growth multiple of education funding relative to population

Above are the main parameters we choose while specific define of those parameters will be given later. The additional symbols used in models will be attached with the relevant formula. And detailed symbol instructions will be given in the text.

Model Building. We consider smart growth on the three E's. And if we define smart growth city as the first layer of metric, the three E's the second. In order to clarify the third layer of metric, some explanation is listed below.

The growth multiple of population relative to urban area (PRA)

We define the growth multiple of population relative to urban area as PRA. It represents the ratio of the multiple of population growth and the multiple of urban area. The formula can be expressed as

$$PRA = \frac{1 + \frac{P_2 - P_1}{P_1}}{1 + \frac{A_2 - A_1}{A_1}} \quad (1)$$

Where P represents urban population, and a represents urban area. P_1 and A_1 stand for initial status, P_2 and A_2 stand for the state of termination. Adding one both in the numerator and denominator makes our model away from the effect of negative growth.

The growth multiple of public traffic capacity relative to urban (PRP)

We define the growth multiple of public traffic capacity relative to urban as PRP. It represents the ratio of the multiple of the growth of population in public transport and the multiple of urban population growth. The formula can be expressed as

$$PRP = \frac{1 + \frac{PT_2 - PT_1}{PT_1}}{1 + \frac{P_2 - P_1}{P_1}} \quad (2)$$

Where P represents urban population, and PT represents population in public transport. P_1 and PT_1 stand for initial status, P_2 and PT_2 stand for the state of termination. Adding one both in the numerator and denominator makes our model away from the effect of negative growth.

The growth multiple of GRDP relative to population (GRP)

We define the growth multiple of GRDP relative to population as GRP. It represents the ratio of the multiple of GDRP growth and the multiple of urban population growth. The formula can be expressed as

$$GRP = \frac{1 + \frac{G_2 - G_1}{G_1}}{1 + \frac{P_2 - P_1}{P_1}} \quad (3)$$

Where P represents urban population, and G represents GRDP. P_1 and G_1 stand for initial status, P_2 and G_2 stand for the state of termination. Adding one both in the numerator and denominator makes our model away from the effect of negative growth.

The growth multiple of GRDP relative to urban area (GRA)

We define the growth multiple of GRDP relative to urban area as GRA. It represents the ratio of the multiple of GDRP growth and the multiple of urban population growth. The formula can be expressed as

$$GRA = \frac{1 + \frac{G_2 - G_1}{G_1}}{1 + \frac{A_2 - A_1}{A_1}} \quad (4)$$

Where A represents urban area, and G represents GRDP. A_1 and G_1 stand for initial status, A_2 and G_2 stand for the state of termination. Adding one both in the numerator and denominator makes our model away from the effect of negative growth.

The growth multiple of low income group's gross revenue relative to GRDP. (GRG)

We define the growth multiple of low income group's gross revenue relative to GRDP as GRG. It represents the ratio of the multiple of low income group's gross revenue growth and the multiple of GDRP growth. The formula can be expressed as

$$GRG = \frac{1 + \frac{LG_2 - LG_1}{LG_1}}{1 + \frac{G_2 - G_1}{G_1}} \quad (5)$$

Where LG represents low income group's gross revenue, and G represents GRDP. LG_1 and G_1 stand for initial status, LG_2 and G_2 stand for the state of termination. Adding one both in the numerator and denominator makes our model away from the effect of negative growth.

The growth multiple of education funding relative to population. (ERP)

We define the growth multiple of education funding relative to population as ERP. It represents the ratio of the multiple of the growth of basic education finished group and the multiple of urban population growth. The formula can be expressed as

$$ERP = \frac{1 + \frac{E_2 - E_1}{E_1}}{1 + \frac{P_2 - P_1}{P_1}} \quad (6)$$

Where E represents basic education finished group, and P represents urban population. P_1 and E_1 stand for initial status, P_2 and E_2 stand for the state of termination. Adding one both in the numerator and denominator makes our model away from the effect of negative growth.

Having fitted a great deal ratios in these 6 aspects, we discover that the ratios' main range is from 0.96 to 1.04.[5,6] We define these 6 indexes as the third layer of metric and the relationship among these three layers is plot in Figure 2 below.

The flow chart shows that smart growth is the first layer, the three E's the second and the remaining the third. These three layers form the metric of smart growth.

The Relationship among the Three Metric Layers.

The relationship between the second layer and the third layer.

ESI is evaluated by PRA and PRP. The growth of population density and the increase of the multiple of population in public transport relative to urban population would better ESP.[7] On the contrary, the opposite result is obtained. Referring to the authoritative information, PRA and PRP take the important degree as 3:1 for ESI evaluation.

EPI is evaluated by GRP and GRA. The growth multiple of GRDP relative to population and the increase of the multiple of GRDP relative to urban area would better EPI. On the contrary, the opposite result is obtained. Referring to the authoritative information, GRP and GRA take the important degree as 1:1 for EPI evaluation.

SEI is evaluated by GRG and ERP. The growth multiple of low income group's gross revenue relative to GRDP and the increase of the multiple of basic education finished group relative to population would better SEI. On the contrary, the opposite result is obtained.[8,9] Referring to the authoritative information, GRG and ERP take the important degree as 2:1 for SEI evaluation.[10,11]

The relationship between the first layer and the second layer.

From the relationship between the third layer and the second layer, each second layer could get an evaluating parameter. We distinguish the parameters' range into three section, and classify them as good, medium, weak. Based on the third layer's main range is from 0.96 to 1.04, we define a critical parameter as $\pm 3.92 (\pm 100 \ln 1.04)$ to amplify small differences, by the method of Micro amplification. And all ratios would be disposed as 1.04.

When the second layer's parameters is in the range of $[-\infty, -3.92]$, the relative aspect would be support as weak. When the second layer's parameters is in the range of $[-3.92, 3.92]$, the relative aspect would be support as medium. When the second layer's parameters is in the range of $[3.92, +\infty]$, the relative aspect would be support as good. The method is summarized in Table 2.

Table 3 The distribution of smart growth evaluation

	EPI+	EPI+	EPI=	EPI=	EPI+	EPI-	EPI=	EPI-	EPI-
	SEI+	SEI=	SEI+	SEI=	SEI-	SEI+	SEI-	SEI=	SEI-
ESI+	***	**	**	*	○	○	○○	○○	×
ESI=	**	*	*	○○	○○	○○	×	×	×
ESI-	○	○○	○○	○	×	×	×	×	×

Utterly SG
 Nearly SG
 Transitionally SG
 Informally SG
 Badly Growth

In this table, * represents good, O represents medium, × represents weak. Green is the symbol of great smart growth, yellow is the symbol of intermediate smart growth, red is the symbol of weak smart growth. Besides, great smart growth can be distinguished into utter and basic, weak smart growth can be distinguished into informal and bad.

With the foundation of our metric, the evaluation of any cities' degree of smart growth would be obtained basing on its data base. What's more, its forecasting ability is also available.

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- [3] <http://baike.baidu.com/link?url=5W6w6WjwJErX6ZqszoYXsPtINg1leKq8BaVAdAtpz9oTeOhzm3EzMVMCtTg4qkCi6d6Hc4ZdTCkO8adntSXWrqQgg1FP7mSTJ63TFVwAcUZJrIwIhOSLHk0SOeONK8Ds>
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