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Evaluating Sustainable Urbanization and Coordinated Development---A case study of Liaoning in China

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Abstract

Although urbanization can promote social and economic development, it can also cause various problems. How to evaluate urbanization performance and development coordination is a key problem for decision makers to find problems caused by urbanization and enhance the efficiency of urbanization performance. This paper introduces a hybrid combined weight method–McKinsey Matrix for evaluating the sustainable of urbanization. The values of development index and coordination index are calculated by combined weight method. The GE matrix can assist in assessing sustainable urbanization performance by locating the urbanization state point. A case study of urbanization in Liaoning in China demonstrates the process of using the evaluation method. The result indicates that the development of urbanization in Liaoning is better. The values of the coordination index between economic, environments, social, public service and livelihood is enhancing conspicuously. The case study reveals that the method is an effective tool in helping policy makers understand the performance and formulate suitable strategies for guiding urbanization towards better sustainability.

Keywords: *Sustainable urbanization, Coordinated development, Combined weight method, GE matrix, China*

1. Introduction

Urbanization is the movement of people from rural to urban areas with population growth equal to urban migration, which is shown in two forms, the increasing number of cities and the expanding population of cities. Urbanization is the core force of regional economic and social development, the development quality of which determined the regional economic capacity for sustainable development to a large extent. The level of urbanization, the number and size of large cities are unprecedented especially in developing countries [1]. According to United Nations and The World Bank, the world urbanization grew at an average rate of 2.6% per year and more than half 52.1% of the world population was living in urban areas by the end of 2011. Urbanization is these benefits that help upgrade market efficiency, jobs, education and health improvement and provide new opportunities to improve social services and promote economic development [2-3]. Others studies have recognized that the urbanization process helps upgrade industrial structure and increase per capita income.

On the other hand, recent studies have also indicated that the rapid pace of urbanization also caused a variety of problems such as global climate change, air and water pollution, traffic congestion, rising crime rates and increase of carbon emissions and CO_2 emissions [4-6]. Excessive urbanization in many countries has raised a major concern about the detrimental effects of urbanization on the environment [7]. These problems present barriers to achieving sustainable development. Along with the transition of economic development, the development of urbanization is also transformed from the traditional urbanization to conserve resources, environment-friendly, efficient and effective

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development of new-type urbanization. Consequently, with the global promotion of sustainable development, the problems created by urbanization have attracted efforts to find solutions from various sectors, including academics [8].

Urbanization is one of the major topics that have been studied focusing on socio-economic and environmental perspectives in urbanization [9], to economic perspectives in peri-urban areas [10], to the loss of vegetation and with respect to urban emissions. Increased urbanization has direct impact on the social and economic condition of the cities [11]. This phenomenon is particularly significant in developing countries, where the rural-urban areas become one of the very important places of urban growth. Meanwhile, urbanization must take into account such factors as development capacity, avoiding mega-city problems experienced by many countries, and balancing urban development and ecological protection [12].

2. Literature Review

Principles and methods for implementing sustainable urbanization have been introduced in various studies, such as developing indicators to guide policy makers to make adequate decisions to implement urban development towards the mission of sustainable development [13-14] and measuring sustainable urbanization performance which relates to social, economic, environmental, and governance dimensions [15-16]. Various conceptual frameworks or models were also introduced to guide the practice of selecting sustainable urbanization indicators. Zhao and Wu (2014) used scenario analysis to analyze the vulnerability of natural ecosystem [17]. Bannayan and Rezaei (2014) forecasted the climate change with scenario analysis [18]. Li and Tong (2009) evaluate the sustainable development capacity of a specific city using data envelopment analysis [19]. Other scholars used input–output design and neural networks prediction to evaluation the coordination between energy efficiency, environmental change and urban environment [20-21].

Most literature on China's urbanization has focused on the reform of the household registration system, the migration of the rural population into the cities, the correct account of urban population, welfare distribution problems amid the urban transformation process, and the mode of urban transformation. Much less, however, has been done to investigate the most recent government initiatives such as the Coordinated Development model, and even less attention has been paid to such development in China's inland cities that have much lower urbanization rate and thus can be impacted more significantly by the new initiatives. In recent years, scholars in China have paid more attention to the coordination between urbanization and sustainable [22].

The discussions above show studies have introduced various models to guide the practice of sustainable urbanization. However, the methods evaluate urbanization performance based on a single aspect such as speed or quality and lack of qualitative analysis of new-type urbanization. Few studies measure the new-type urbanization of the index system. By constructing the new-type urbanization evaluation index system, the level of urbanization by the quantitative method will be estimate. Therefore a tool to evaluate whether the new-type urbanization is sustainable is needed. This tool should be able to incorporate the principles of sustainable urbanization and evaluation the coordination of the development of new-type urbanization. This paper aims to develop such a tool for evaluating the sustainability of urbanization in China and help city decision-makers to select a suitable development strategy. This paper proposed a hybrid approach using combined weight method- GE matrix method for assessing the development of new-type urbanization and coordination. This research intends to fulfill two primary objectives. First, we construct a hybrid model using combined weight method and place value method to evaluate the development of new-type urbanization. Second, the coordination degree of new-type urbanization is analyzed based on the GE matrix method proposed by this paper. The hybrid method can not only evaluate the development performance of new-type urbanization, but also provide a method for improving coordination of new-type urbanization.

The rest of this paper is organized as follows: The steps for establishing the hybrid approach using place value method and GE matrix method for assessing the development of new-type urbanization and coordination are presented in Section 3. Following the application of the method in a case study of the new-type urbanization in Liaoning province of China is presented in Section 4. The results are analyzed and discussed and the conclusion is set out in the end.

3. The Hybrid Model for Evaluating the Development of New-type Urbanization and Assessing Coordination

3.1. Confirm the New-type Urbanization Evaluating Indicators

Indicators were identified from the following sources:

(1) An list of 115 sustainable urbanization indicators (Shen, 2011). The researchers obtained these indicators after examining indicator systems developed by six different international organizations including the UN, UN-Habitat, World Bank, and others [15].

(2) The Economic Forecasting Research Department of State Information Center in China presented 57 indicators with four dimensions including Economic and Structure, Population, Resource and environment, Public Service and People's Livelihood.

(3) China City Development Academy presented 35 indicators with three dimensions including Economic, Social and People's Livelihood. Institute of Urban Environment and Chinese Academy of Science presented 12 indicators including Economic, Social and Environmental. China’s 12th Five Year Plan showed 23 major indicators for promoting sustainable urbanization and sustainable development.

(4) A list of 259 indicators from 30 different cities in China such as Harbin, Qingdao, and Kunming was obtained after a comprehensive content analysis of redefinition, modification, combination, and deletion.

In this study, four dimensions of the new-type urbanization indicators are adopted, including environment, economy, social and public service and livelihood. Each dimension is categorized into many sections. After analyzing the above sources and researching from industry, governmental offices, the paper led to the selection of 23 indicators that are further grouped in the four dimensions, as shown in Table 1.

Table 1. Indicator System for Urbanization Development

First grade index	Second grade index	Properties
Economic (Ec)	Fixed assets investment of urban (Ec_1)	Positive
	Speed of urbanization (Ec_2)	Positive
	Per capita GDP of urban residents(Ec_3)	Positive
	Per capita disposable income of urban residents (Ec_4)	Positive
	Engel's Coefficient of urban residents (Ec_5)	Negative
	Energy consumption of per 10,000 output value of urban (Ec_6)	Negative
	Proportion of GDP accounted for by services of urban (Ec_7)	Positive
Public service and livelihood (Pu)	Employment ratio of urban residents (Pu_1)	Positive
	Urban road area per capita (Pu_2)	Positive

	Penetration rate of water of urban residents (Pu_3)	Positive
	Penetration rate of gas of urban residents (Pu_4)	Positive
	Per capita Housing space of urban residents (Pu_5)	Positive
Environment (En)	Percentage of good air quality of urban resident s(En_1)	Positive
	Waste water emissions ratio of urban residents (En_2)	Positive
	Total Disposes of living garbage harmless of urban residents (En_3)	Positive
	Green area per capita of urban residents (En_4)	Positive
	Total Industrial dust emissions of urban residents (En_5)	Positive
	Comprehensive utilization ratio of Industrial solids waste of urban residents (En_6)	Positive
Social (So)	Registered urban unemployment ratio (So_1)	Negative
	Number of hospital beds per 10,000 population of urban residents (So_2)	Positive
	Number of health workers per 10,000 population of urban residents (So_3)	Positive
	Per capita employment-burden coefficient of urban residents (So_4)	Negative
	Social insurance coverage of urban residents (So_5)	Positive

3.2. Calculate the Value of Development Index

3.2.1. Standardize the Indicator

$$X_{ij} = \begin{cases} X_{ij} = \dfrac{a_{ij} - \min a_{ij}}{\max a_{ij} - \min a_{ij}}, & a_{ij} \text{ for positive indicator} \\ X_{ij} = \dfrac{\max a_{ij} - a_{ij}}{\max a_{ij} - \min a_{ij}}, & a_{ij} \text{ for negative indicator} \end{cases}$$

Where a_{ij} is the original value of the j th indicator that is accounted for at the i th year.

3.2.2. Determine the Combined Weight: Using the principles to calculate the weight of new-type indicators among Entropy method, AHP and Deviation weight method. The combined weight method is as follows:

$$w_j = \frac{w_1^j \cdot w_2^j \cdot w_3^j}{\sum_{i=1}^{4} w_1^j \cdot w_2^j \cdot w_3^j}$$

Where w_1^j is the weight calculated by Entropy Method, w_2^j is the weight calculated by AHP, w_3^j is the weight calculated by Deviation Weight Method. Thus the combined weight of new-type indicators is presented.

3.2.3. Calculate the Value of Development Index: Using the place value method, the normalized value of index is calculated.

$$p_{ij} = \begin{cases} 0.01 + 0.99 \times \dfrac{a_{ij} - \min a_{ij}}{\max a_{ij} - \min a_{ij}}, a_{ij} \in p_{ij}^{+} \\ 0.01 + 0.99 \times \dfrac{\max a_{ij} - a_{ij}}{\max a_{ij} - \min a_{ij}}, a_{ij} \in p_{ij}^{-} \end{cases}$$

a_{ij} is the original value of index, p_{ij} is the place value of a_{ij} calculated by the place value method, p_{ij}^{+} indicates forward index, p_{ij}^{-} indicates backward index. Then the value of development index for each year is calculated by the following method:

$$f_j = \sum_{j=1}^{n} w_j p_{ij}, i = 1, 2, \cdots, m$$

3.3. Calculate the Value of Coordinating Index of New-type Urbanization Process

The GE Matrix is an extension of the Boston Consulting Group matrix. The matrix is a research tool for product portfolio analysis; this tool is used mainly in the fields of strategic business analysis for companies and strategic selection of products, and resource allocation. The GE Matrix evaluates the performance of two dimensions of a company or product: Competitiveness and attractiveness, as shown in Figure 1.

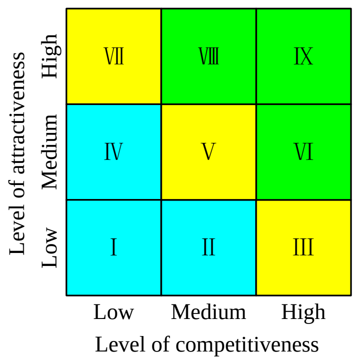

Figure 1. The GE Matrix model

The method adopted for analyzing the market attractiveness and competitiveness of company performance can be used for analyzing the development and coordination of urbanization performance. Therefore, the GE Matrix can be applied in the context of urbanization based on the two dimensions of development index (speed) and coordination index (quality). The decision-makers at the city level can select appropriate strategies by using the GE Matrix analysis.

The GE Matrix model modified is shown in Figure 2. The degree of urbanization development and coordination can be divided into three levels respectively (High, Medium, and Weak). In this hybrid matrix, the axis of coordination index presents the degree of coordination between economic, public service and livelihood, environment and social, whereas the axis of development index shows the development speed of urbanization.

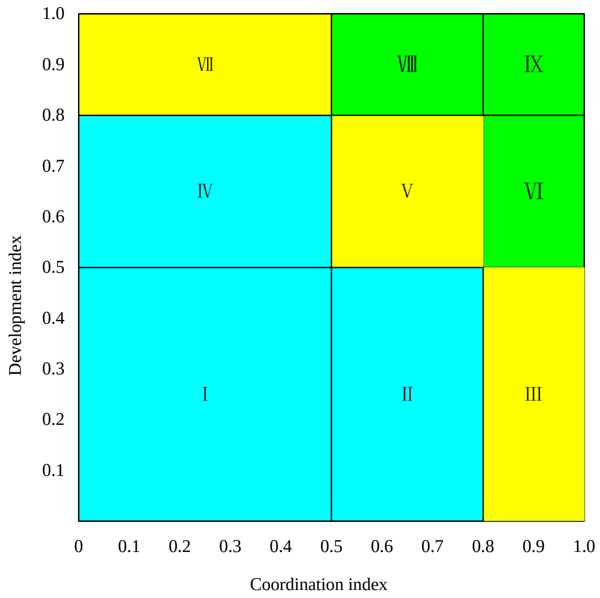

Figure 2. Sustainable Urbanization GE Matrix

The strategies for each area were proposed, as listed in Table 2.

Table 2. Different Strategies in Sustainable Urbanization GE Matrix

Stage	Performance of sustainability	Strategies to be selected
Ⅰ	Weak development / Weak coordination	Speed up the urbanization process to improve the function of urban areas
Ⅱ	Weak development / Medium coordination	Perfect infrastructure construction
Ⅲ	Weak development / Strong coordination	Make full use of land resources in return
Ⅳ	Medium development / Weak coordination	Improve population urbanization Take measures to protect environment Promote social harmony and stability
Ⅴ	Medium development / Medium coordination	Continue to increase the level of urbanization Develop high-tech industry
Ⅵ	Medium development / Strong coordination	Establish modern industrial system and promote comprehensive development
Ⅶ	High development / Weak coordination	Structural adjustment, promote urbanization of rural areas Improve the social security system
Ⅷ	High development / Medium coordination	Promote urbanization of rural areas and realize transition from spillover-echo model to leap-type model
Ⅸ	High development/ Strong coordination	Strengthen innovation development and realize leap-type urbanization model for urban and rural integrity

The development index can be calculated by the place value method mentioned above, using the indicators weight presented by the combined weight method. The value of coordination index is defined as:

$$C_j = 1 - \frac{F_j}{\overline{F}}$$

$$F_j = \sqrt{\frac{1}{4}\sum_{i=1}^{4}\left(F_{ij} - \bar{F}\right)^2}$$

$$\bar{F} = \sqrt[n]{F_{j1} \cdot F_{j2} \cdot F_{j3} \cdot F_{j4}}$$

In which F_{j1} , F_{j2} , F_{j3} , F_{j4} is the value of development index for economic, public service and livelihood environment and social dimensions, $\bar{F}$ is the geometric mean value of F_{j1} , F_{j2} , F_{j3} , F_{j4} . The development trance and coordination level can be presented by Table 3.

Table 3. Sustainability Classification Criteria for Urban Development

Development index	0-0.5	0.5-0.8	0.8-1
Development level	Weak development	Medium development	High development
Coordination index	0-0.5	0.5-0.8	0.8-1
Coordination level	Weak coordination	Medium coordination	High coordination

By applying the information presented in Table 3, the development trance and the coordination trance of urbanization process is clarified.

4. A case Study

In this paper, we present whether the urbanization is coordinate with the development of economy and society in Liaoning. We hope to provide insights into sustainable management in the process of urbanization.

In recent years, the urbanization trance in Liaoning is faster due to the growing population, rapid industrial development and exploitation of mineral resources. The urbanization level in Liaoning increased from 34% in 2000 to 66% in 2013 (Figure 3). According to Northam urbanization curve [23], urbanization in Liaoning entered the stage of acceleration stage.

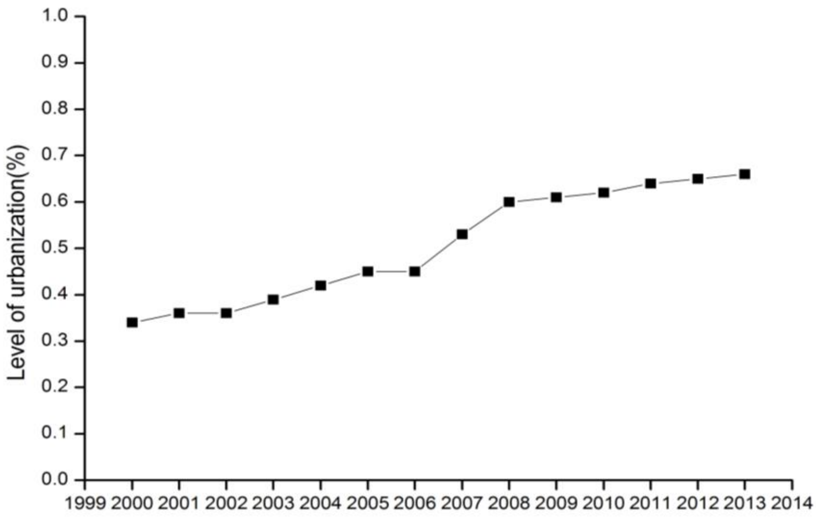

Figure 3. Urbanization Level Curve in Liaoning from the Year 2000 to 2013

4.1. Data Collection

The data source of this statistics is from Liaoning Statistics Annual, Official Journal of Liaoning National Economy and Social Development Statistics (2004-2013), Official Journal of Liaoning Environment Statistics (2004-2013), some individual data is from website such as Liaoning Statistics Bureau, Liaoning Environmental Protection Ministry, small and medium enterprise bureau of Liaoning, Liaoning National Land Bureau, Liaoning Coal Industry Management Bureau etc. It adopts portable average method to make supplementary and get the final original data of shortage.

4.2. Data Analysis

The indicator weight is calculated using the combined weighted method and shown in Table 4.

Table 4. The Indicator Weight of Urbanization

Level 1	EM	AHP	DM	CW	Level 2	EM	AHP	DM	CW
Ec	0.1614	0.2265	0.1772	0.1007	Ec_1	0.0478	0.1103	0.1311	0.0964
					Ec_2	0.0432	0.1551	0.1703	0.1229
					Ec_3	0.0459	0.1488	0.1343	0.1097
					Ec_4	0.0443	0.1651	0.1421	0.1172
					Ec_5	0.0428	0.1435	0.1503	0.1122
					Ec_6	0.0434	0.1116	0.1730	0.1093
					Ec_7	0.0429	0.1656	0.0989	0.1025
Pu	0.2385	0.2227	0.3531	0.2916	Pu_1	0.0429	0.2289	0.2256	0.1658
					Pu_2	0.0429	0.1953	0.1629	0.1337
					Pu_3	0.0428	0.1743	0.2103	0.1425
					Pu_4	0.0429	0.1849	0.2083	0.1454
					Pu_5	0.0440	0.2166	0.1929	0.1512
En	0.3207	0.2993	0.2363	0.3527	En_1	0.0442	0.1646	0.2588	0.1559
					En_2	0.0428	0.1498	0.1368	0.1098
					En_3	0.0429	0.1635	0.0955	0.1006
					En_4	0.0432	0.1396	0.2216	0.1348
					En_5	0.0434	0.1891	0.1305	0.1210
					En_6	0.0429	0.1934	0.1568	0.1310
So	0.2794	0.2515	0.2334	0.2550	So_1	0.0432	0.1403	0.1954	0.1263
					So_2	0.0429	0.2364	0.2508	0.1767
					So_3	0.0429	0.2151	0.1766	0.1449
					So_4	0.0428	0.1988	0.1869	0.1428
					So_5	0.0430	0.2094	0.1904	0.1476

Note: EM is the weight calculated by the Entropy method
AHP is the weight calculated by AHP
DM is the weight calculated by Deviation weight method
CW the weight calculated by the combined weight method mentioned

The values of development index (F_j) and coordination index (C_j) are calculated by using the Combined weight method and place value method, and the relevant calculations are shown in Table 5.

Table 5. Analysis results on development index and coordination index

Year	Ec	Pu	En	So	$\bar{F}$	F_j	C_j
2000	0.2764	0.0738	0.0745	0.3160	0.2862	0.1552	0.3578
2001	0.2537	0.1655	0.1768	0.2861	0.3854	0.2081	0.4851
2002	0.2440	0.2125	0.2233	0.2604	0.4133	0.2311	0.5387
2003	0.2146	0.2991	0.2779	0.2817	0.4578	0.2748	0.5887
2004	0.2424	0.3284	0.3016	0.2701	0.4818	0.2934	0.6162
2005	0.2263	0.4601	0.3420	0.2451	0.5112	0.3368	0.6683
2006	0.2580	0.5025	0.4134	0.2339	0.5496	0.3771	0.7010

2007	0.3225	0.5519	0.4964	0.2283	0.6045	0.4297	0.7428
2008	0.3493	0.5734	0.5265	0.2496	0.6375	0.4551	0.7476
2009	0.2795	0.6105	0.5516	0.2841	0.6395	0.4708	0.7085
2010	0.4262	0.6518	0.5898	0.3198	0.7316	0.5261	0.7573
2011	0.3944	0.6717	0.6491	0.3710	0.7610	0.5587	0.7349
2012	0.5062	0.7123	0.6967	0.4069	0.8362	0.6119	0.7615
2013	0.5709	0.7384	0.7451	0.4692	0.8997	0.6595	0.7616

Based on the results by allocating development index (F_j) and coordination index (C_j) respectively in Table 5, the GE Matrix can be obtained respectively as shown in Figure 4.

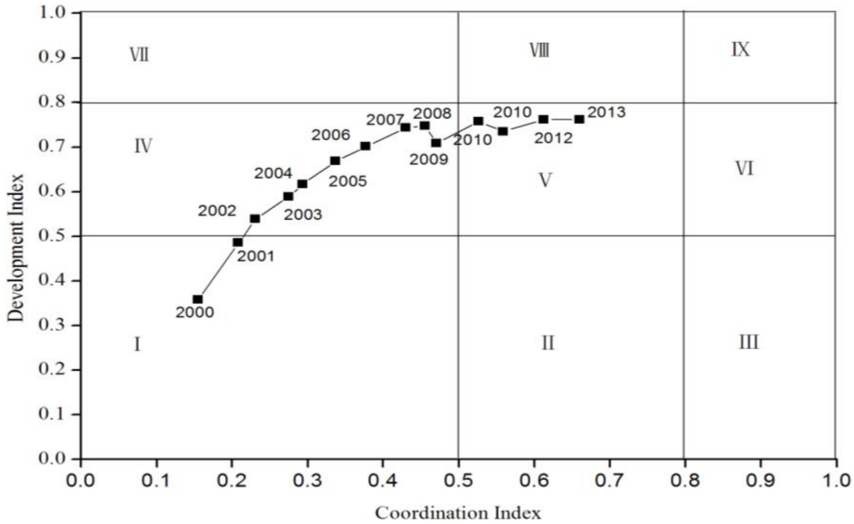

Figure 4. The GE Matrix of Urban Sustainability of Liaoning from 2000 to 2013

As can be seen in Figure 4, the development index located in a weak level (area Ⅰ) from 2000 to 2001 and the coordination degree was observed in a weak level (area Ⅰ). This result represents a weak development speed and a weak quality performance (coordination). In fact, the urbanization in Liaoning was in a lower acceleration stage from 2000. The government took many measures to speed up the urbanization process such as improve the function of urban areas, perfect infrastructure construction and make full use of land resources in return for capital. As a result, from 2002 to 2009, Liaoning had entered the stage of rapid development with the development index located in a medium level (area Ⅳ) till 2009. And the coordination degree was observed in a weak level (area Ⅳ). Among this period, the government continued to improve the population urbanization and protect the environment as well as promote social harmony and stability. After 2009, the coordination degree between economic, public service and livelihood, environment and social dimensions was observed in a medium level. Meanwhile, the development index is located in the same area (area Ⅴ). The role of urbanization for economic growth and modernization was emphasized further by the Chinese government in 2014. The government of Liaoning continued to expand the space for further development and drive the transition from a spill over-echo model to a leap-type model. More importantly, the local government was advised to take measures to improve rural–urban integration and the coordination performance between economic, social, and environmental interests, with particular efforts allocated to public service and livelihood.

The values of the development index for economic, public service and livelihood, environment and social dimensions are also shown in Table 5. Based on the four sets of data shown in Table 5, the changing trends of development index for each dimension during the period from 2000 to 2013 are simulated, as shown in Figure 5.

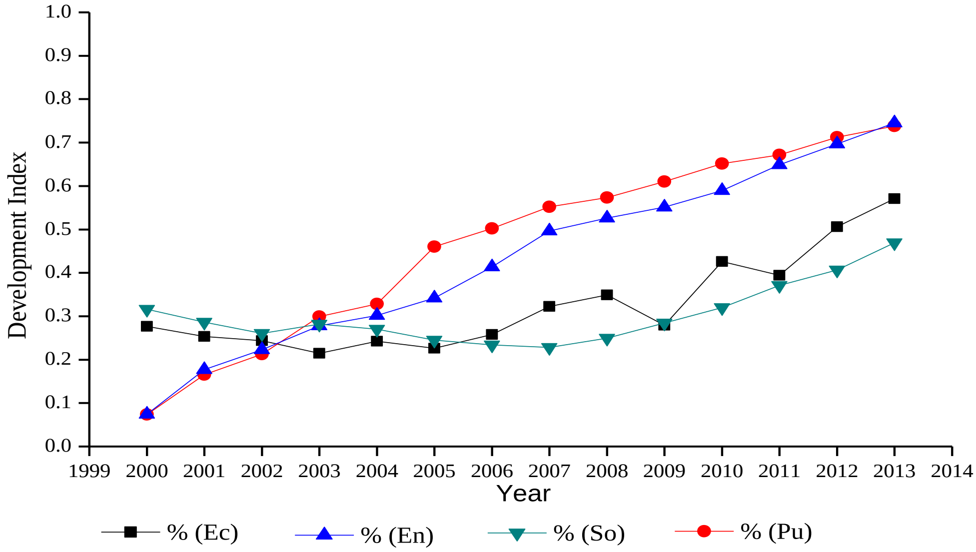

Figure 5. The Variation Trend of Development Index in Economic, Public Service and Livelihood, Environment and Social

The changing trends of development index illustrate that the improvement on the social performance of Liaoning Province is comparatively small during the year 2000-2013. The trend of development index of economy is unsteady but improved overall. On the contrary, the development of environment and public service and livelihood dimensions has improved greatly. As a result, the coordination index demonstrates up-ward trend in recent years. Therefore, government should strive to improve its social and economy performance in the urbanization process. First, the government should establish modern industrial system and promote comprehensive development to dealing with the unsteady of economy development. Also the structure of economy should be adjusted such as optimize industrial layout and greatly develop ecological industry by industry combination and transition, improve the social security system and promote urbanization of rural areas. Meanwhile, government should promote urbanization of rural areas and realize transition from spillover-echo model to leap-type model, also strengthen innovation development and realize leap-type urbanization model for urban and rural integrity.

5. Conclusions

In order to evaluate the performance of urbanization sustainability, a comprehensive indicator system and an effective method are necessary. This present research proposes a hybrid combined weight–GE Matrix and place value method to calculate the development and coordination index for such purpose. The case study presented in this study shows that the hybrid method model is an effective tool to evaluate the changing trace and the performance of urbanization sustainability in urban areas. The combined weight method assisting in determining the weights of indicators can help reduce subjectivity. Second, the GE Matrix method examines both development and coordination dimensions collectively when evaluating urbanization sustainability, which provides a balanced view on sustainable urbanization such as economic, public service and livelihood, environment and social. The hybrid methods can display the overall status of urbanization sustainability based on both development and coordination indexes, which allows managers to determine the level of urban development and develop suitable strategies for improving the performance of sustainable urbanization. The results of this research add value to the development of methodology for further studies on the sustainability of urbanization.

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