The Evaluation System of Sustainable Development Country Based on Multiple Target

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Abstract. This paper has divided a country into two systems: economic system, environmental system. On the basis of Development evaluation system from United Nations and our analysis, we determined first grade metrics of sub-systems. Then, based on first metrics, we specified second grade metrics and defined the method of calculating first grade metrics to make first grade metrics is positive to sustainable development of sub-systems. After getting specific metrics, we built Linear Evaluation Model for each sub-system. Then based on data from World Bank, we chose 130 countries who have complete data set to calculate the weight of each first grade metric by using entropy method and MATLAB. The specific weights we got are (0.2449,0.1331,0.1175,0.0998,0.2625,0.1422),(0.2566,0.1615,0.2292,0.1165,0.2362). The Static Comprehensive Evaluation Model is the sum of the Linear Evaluation Model of each sub-system. Based on the definition of sustainable development and our metrics, we get overall evaluation model, we can easily find the difference between different developing countries, so ,it can be used give one country advice to become more sustainable by the metric system.

1. Build overall model

1.1 The evaluation equation to whole system

In this paper, one country involve three part: economic sub-system, environmental sub-system, it is obvious that every sub-system is important for one country's development, environmental sub-system represents the potential development and competitiveness in future, economic sub-system represents one country's immaterial influence in different areas now. So we can use these three sub-system analyze one country's sustainable development.

$$P = PE + PO \qquad \qquad ①$$

Where, P denotes National Sustainable Development Index, PE denotes Economic Sustainable Development Index, PO denotes Environmental Sustainable Development Index

1.2 Determine influence of different sub-system

Step1: calculate Standardized matrix
We use Standard-Deviation Method to construct Standardized matrix:

$$P_{ij} = \frac{A_{ij} - A_{j(\max)}}{A_{j(\max)} + A_{j(\min)}} \qquad \qquad ②$$

Where, A_{ij} denotes ith system index of the country, $A_{j(\min)}$ denotes the minimum index of all countries. $A_{j(\max)}$ denotes the maximum index of all countries.

Step2: calculate entropy of each sub-system index

$$E_j = -\frac{1}{\ln(N)} \sum_{i=1}^{n} p_{ij} \ln(p_{ij}) \qquad \text{③}$$

Step3: calculate the sub-system index redundancy

$$g_j = 1 - e_j \qquad \text{④}$$

Step4: Determine the weights of each sub-system

$$\alpha_j = \frac{g_j}{\sum_{i=1}^{n} g_j} \qquad \text{⑤}$$

2. Determine Metrics system

For metrics related to economic influence are too many, we divide economic metrics into different first grade metrics, however, the first grade metrics can involve irrelevant metrics, so we divide the first grade metrics into different second metrics, then the total economic influence of the countries can be calculated step by step.

2.1 Calculate first grade metrics

2.1.1 analyze economic system

＊ Meaning of second grade metrics:

symbol	meaning
E_{11}	value of per capita GDP
E_{12}	the growth rates of per capita GDP
G_e	Exports of goods and services
G_i	Imports of goods and services
E_{31}	Central government debt
E_{32}	ODA
R	Alternative and nuclear energy
E_{output}	Energy production
E_{in}	Energy use
E_{51}	Strength of energy production
E_{52}	Energy consumption per unit GDP
E_{53}	Energy use (kg of oil equivalent per capita)
E_{61}	Rate of waste recycling
E_{62}	harmful waste management(not including solid waste)
E_{63}	solid waste management

＊Calculate first grade metrics

we can calculate first grade metrics as follow:

symbol	equation
Economic performance	$P_{E1} = a_1 \dfrac{G}{G_{max}} + a_2 G_i$
Trade	$P_{E2} = a_1 \dfrac{G_e}{G_{i-1}}$
Finance	$P_{E3} = -(a_5 F_1 + a_6 F_2)$
Resource consumption	$P_{E1} = -(a_{31} \dfrac{E_{31}}{E_{32(max)}} + a_{32} \dfrac{E_{32}}{E_{32(max)}})$
Trade	$E_{51} = \dfrac{E_{output}}{E_{in}}$ $P_{E5} = -(a_{51} \dfrac{E_{51}}{E_{51(max)}} + a_{52} \dfrac{E_{52}}{E_{52(max)}} + a_{53} \dfrac{E_{53}}{E_{53(max)}}$
Waste emission	$P_{E5} = -(a_{61} \dfrac{E_{61}}{E_{61(max)}} + a_{62} \dfrac{E_{62}}{E_{62(max)}} + a_{63} \dfrac{E_{63}}{E_{63(max)}}$
Energy consumption	$P_{S6} = C_r$

2.1.2 Analyze environmental system

* Meaning of second grade metrics

symbol	meaning
O_{11}	CO2 emissions
O_{12}	Hydroxide emissions
O_{13}	PM2.5
O_{21}	Percentage of arable land
O_{22}	Agriculture, value added
O_{31}	Forest area
O_{32}	Forest rent
O_{41}	Annual freshwater withdrawals
O_{42}	Improved water source, urban
O_{43}	Improved water source, rural
O_{51}	Energy use (kg of oil equivalent per capita)
O_{52}	Nature Reserve
O_{53}	GEF benefits index for biodiversity

* Calculate first grade metrics

We can calculate the first grade metrics as follow:

symbol	equation
Air Quality	$P_{O1} = -(b_{11}\dfrac{O_{11}}{O_{11(max)}} + b_{12}\dfrac{O_{12}}{O_{12(max)}} + b_{13}\dfrac{O_{13}}{O_{13(max)}})$
Agriculture	$P_{O2} = -(b_{21}\dfrac{O_{21}}{O_{21(max)}} + b_{22}\dfrac{O_{22}}{O_{22(max)}})$
Forest	$P_{O3} = -(b_{31}\dfrac{O_{31}}{O_{31(max)}} + b_{32}\dfrac{O_{32}}{O_{32(max)}})$
Fresh water	$P_{O4} = -(b_{41}\dfrac{O_{41}}{O_{41(max)}} + b_{42}\dfrac{O_{42}}{O_{42(max)}} + b_{43}\dfrac{O_{43}}{O_{43(max)}})$
Natural ecological system	$P_{O5} = -(b_{51}\dfrac{O_{51}}{O_{51(max)}} + b_{52}\dfrac{O_{52}}{O_{52(max)}} + b_{53}\dfrac{O_{53}}{O_{53(max)}})$

2.2 weight of economic sub-system

Based on data from World Bank and above equation, we can get the first metrics and second metrics of different sub-system, three sub-system are ayalyzed as follows:

2.2.1 the analysis of economic system

– **weight of economic system**

* *Calculate weight of first grade metrics*

$$[\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6] = [0.2449, 0.1331, 0.1175, 0.0998, 0.2625, 0.1422]$$

Where, α_i denotes coefficient of ith first grade metric in economic system.

* *Calculate weight of second grade metrics:*

$$[a_{11}, a_{12}] = [0.4055, 0.5945]$$
$$[a_{31}, a_{32}] = [0.3821, 0.6179]$$
$$[a_{51}\ a_{52}, a_{53}] = [0.2929, 0.2641, 0.4430]$$
$$[a_{61}, a_{62}, a_{63}] = [0.0582, 0.025, 0.9167]$$

where, a_{ij} denotes coefficient of jth second grade metric in ith first grade metric.

Conclusion

• Energy assumption and economic performance play an important in first grade metrics, these two factors can conspicuously affect economic development.

• The weight of most metrics is close, only resource consumption have a lower weight, it proves that most metrics are representative.

2.2.2 The analysis of environmental system

– **weight of environmental system**

* *Calculate weight of first grade metrics*

$$[\beta_1, \beta_2, \beta_3, \beta_4, \beta_5] = [0.2566, 0.1615, 0.2292, 0.1165, 0.2362]$$

Where, α_i denotes coefficient of ith first grade metric in environmental system.

* *Calculate weight of second grade metrics:*

$$[b_{11}, b_{12}, b_{13}] = [0.0464, 0.1231, 0.8304]$$
$$[b_{21}, b_{22}, b_{23}] = [0.4941, 0.0393, 0.4666]$$
$$[b_{31}, b_{32}] = [0.7466, 0.2534]$$
$$[b_{41}, b_{42}] = [0.0504, 0.0702, 0.8754]$$
$$[b_{51}, b_{52}, b_{53}] = [0.2362, 0.5828, 0.1810]$$

where, aij denotes coefficient of jth second grade metric in ith first grade metric.

Conclusion

Atmosphere, biology and forest have a larger weight in first metrics, they represent environmental and ecological capacity, respectively. So, the three factors have an obvious influence on ecological development.

As we can see, every first grade metric have close weight, so, these factors are representative.

References

[1]Samiha Tahseen, Moinul Hossain, *Towards City Sustainability: An Updated Framework, IPCBEE, vo1.32(2012)@(2012), IACSIT Press, Singapore*

[2] Jack. *How to determine regional sustainable development evaluation index, Progress in geography, 1998.6.*

[3] World Commission on Environment and Development (WCED).*Our Common Future, New York: Oxford University Press,* 1987, 8.

[4] Bell, Simon and Stephen Morse. *Sustainability Indicators: measuring the immeasurable, Earth scan, London, 2008.*

[5] Daly, Herman, *Towards some operational principles of sustainable development, Ecological Economics, 2(1990) 1-6.*

[6] *http://www.nisd.cass.cn/news/602697.htm*

[7] *http://wenku.baidu.com/view/08eb6f659b6648d7c1c74639.html*