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Integrated sustainable development evaluation based on human well-being indices and pressure indices: A case study of the South China Sea Neighboring Countries

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ABSTRACT

To overcome the inherent shortcomings of the human development index (HDI) and to improve the comparability of evaluation results, in this study, an evaluation indicator system of regional sustainable development pressures was constructed based on catastrophe theory. An improved catastrophe model was used to calculate the sustainable development pressure index (SPI), which was combined with the human development index (HDI) proposed by the United Nations Development Program (UNDP) to explore the human welfare and sustainable development pressures in 9 countries bordering the South China Sea in the period 2003–2015 based on statistical data provided by the World Bank. It was found that during the period of investigation, the level of human welfare in the region gradually increased and the HDI steadily rose, with an average annual growth rate between 0.29% and 2.50%. The sustainable development pressures in the South China Sea neighboring region were very high, and the development models in this region can be divided into 4 types: very high level human welfare with very high sustainable development pressures; high level human welfare with very high sustainable development pressures; medium level human welfare with very high sustainable development pressures; and low level human welfare with very high sustainable development pressures. It is recommended that a country should explore its own development path based on the actual situation in the country to reduce sustainable development obstacles. Moreover, bilateral or multilateral cooperation should be actively pursued to solve the bottleneck problems that restrict regional sustainable development.

1. Introduction

With the rapid economic and social development in countries all over the world, the correlated environmental problems have become increasingly prominent (Ryder & Hall, 2016; Song & Zheng, 2016), and humanity's dichotomous relationship with resources and the environment has become a great concern (Gunderson, 2014a, 2014b). Thus, a broad consensus on sustainable development has been reached across the world (Hák, Janousková, & Moldan, 2016; Song & Zheng, 2016): synergistic progress among people (including among generations) and the harmonious coexistence between humanity and nature have become 2 basic fundamentals of sustainable development (World Commission on Environment Development, 1987). At present, an increasing number of people realize the fol-

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lowing concepts: economic and social development cannot be over-dependent on resource consumption, and damage to the natural environment not only harms current human welfare but also threatens the survival and development of future generations (Tran, 2016).

Due to the need for large amounts of supportive data (McLaren & Simonovic, 1999), the measurement of developmental sustainability has become a complex and difficult problem. Due to data constraints, researchers attempt to use a series of simplified indexes and focus on different perspectives to explore the sustainable development of human society: at the macroeconomic level, the index of sustainable economic welfare (ISEW) and the Sustainable Net Benefits Index (SNBI) have been proposed (Daly & Cobb, 1989; Lawn & Sanders, 1999), and the former has been practiced and applied in many countries (Bleys, 2008; Castaneda, 1999; Gigliarano, Balducci, Ciommi, & Chelli, 2014). At the social development level, the United Nations (United Nations Development Program, 2015) has proposed the human development index (HDI) and used the arithmetic mean or geometric mean of the indexes of 3 dimensions – life expectancy, education level, and gross national income (GNI) – to measure human welfare in different countries and different regions (Harttgen & Klasen, 2012).

Relatively speaking, human development indexes only use a few indicators, and therefore, they are easy to operate in practice and have been widely used, tested, and validated in different countries and regions (Kaivo-oja, Panula-Ontto, Vehmas, & Luukkanen, 2014; Morse, 2014; Willems, 2015; Yakunina & Bychkov, 2015). Although using the HDI can give simple and clear evaluation results, these results are only a rough characterization of the economic and social indicators. To explore the relationship between humanity and nature, researchers attempt to study issues related to the sustainable utilization of natural resources or sustainable development from the perspective of environmental changes, resource development, and energy utilization. For example, using factor analysis and a multivariate regression model, Knight and Messer (2012) found that, from a cross-national perspective, the binary relations between environmental concerns and the levels of environmental degradation, affluence, and world society were positively correlated, not correlated, and non-significantly correlated, respectively. Horsley, Prout, Tonts, and Ali (2015) construct the sustainable livelihoods framework to evaluate the correlation between mining and development based on 5 aspects: financial capital, human capital, social capital, natural capital, and material capital. Goldrath, Ayalon, and Shechter (2015) construct a multi-standard composite sustainability index based on 5 predefined indexes: the economy, the environment, technology, society, and politics, to explore measures to improve energy efficiency, providing supplementary information for energy policy-making. Iddrisu and Bhattacharyya (2015) find that the Sustainable Energy Development Index (SEDI) is positively correlated with the HDI, providing theoretical guidance for measuring inter-regional or inter-generational variance in the degree of sustainable development.

The South China Sea is located in the southwest Pacific Ocean, neighboring 9 countries. The South China Sea neighboring countries (SCSNC) include China (CHN), Cambodia (KHM), Vietnam (VNM), Thailand (THA), the Philippines (PHL), Malaysia (MYS), Indonesia (IDN), Singapore (SGP), and Brunei Darussalam (BRU). With growing global imbalances, the resource-related and environmental issues caused by economic and social development have continued to grow in the SCSNC (Cui, Hens, Zhu, & Zhao, 2004; Jarzebski, Tumilba, & Yamamoto, 2016). In both rural and urban areas (Duangjai, Ngamniyom, Silprasit, & Kroeksakul, 2013; Fan & Qi, 2010), at the regional and the national levels (Polnyotee & Thadaniti, 2015), sustainable development is facing continuously increasing pressure (Hara, Uwasu, Yabar, & Zhang, 2009). The essence of sustainable development suggests that on one hand, resources and the environment support regional economic and social development; on the other hand, economic and social development will cause greater pressure on resources and the environment. Indicators may play an important role in the continuous process of the redefinition of concepts (Rinne, Lyytimäki, & Kautto, 2013). Given that the HDI and other macroscopic indexes fail to consider natural resource-related and ecological-environmental issues (Bravo, 2014), in addition to the fact that the SEDI and other medium-scope or microscopic evaluation indexes have limitations in evaluating the overall situation, in this paper, we attempt to build a comprehensive evaluation framework based on the interactions among the economy, society, and resources and the environment. This framework is validated using the SCSNC case: First, the evaluation index system is established, and the pressure faced by regional sustainable development is measured using the catastrophe progression method. Then, the human welfare status during regional development is evaluated using the HDI proposed by the United Nations Development Program (United Nations Development Program, 2015). Finally, the correlation factors driving or constraining human welfare in this region are analyzed using statistical methods (Partial Least Squares Model).

2. Methods

2.1. Evaluation index (system)

2.1.1. Human welfare evaluation methods

In this paper, human welfare is characterized by economic and social achievements and evaluated using the HDI proposed by the United Nations Development Program (2015). The model is as follows:

$$HDI = \sqrt[3]{LEI \cdot EI \cdot GNII} \tag{1}$$

$$LEI = (LE - LE_{\min})/(LE_{\max} - LE_{\min}) \tag{2}$$

$$EI = \sqrt{MYSI \cdot EYSI} \tag{3}$$

$$GNII = (\ln PCGNI - \ln PCGNI_{\min})/(\ln PCGNI_{\max} - \ln PCGNI_{\min}) \tag{4}$$

where *LEI*, *EI*, and *GNII* represent the indexes of life expectancy, education level, and GNI, respectively, and are represented by 4 indicators: life expectancy at birth, expected years of schooling, mean years of schooling, and

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