A Study of Coupling Coordination between Marine Economy and Land Economy Based on Gear Model

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Abstract Based on the construction of evaluation index system of marine-land economy system, this paper analyzes the coupling coordination between marine economy and land economy. The coupling coordinative model is used to analyze the coupling coordinative degree of the marine economy and land economy. The results show that from 2002 to 2012, the marine economy and land economy coupling degree was high and it achieved coordination from disorder gradually, resulting in mutual promotion and common development of marine economy and land economy.

Key words Coupling coordination model, Marine economy, Land economy

1 Introduction

Marine economic system as a complex regional economic development system is affected by the land economy and it shows the particularity of the marine economy. The marine economic system and land economic system are closely linked systems. The coupling coordinative analysis of marine and land economy has become a key topic, because the marine economy plays an important role, and has important practical significance to the realization of sustainable development of the national economy. In recent years, the coupling coordinative theory has been widely used. The coupling coordinative degree is simply used to describe the interaction between objects. Huang Ruifen (2011), William (2011) and other scholars applied this theory to the research of land and marine industry; Wu Yuming (2008), Liu Dinghui (2011), Zhang Hongchao (2013) and other scholars used it for the study of regional economic research; Huang Muyi (2012) used the theory to study the relationship between city and region economy; Zhang Chunyan (2014) used the theory to study the relationship between tourism industry and new urbanization; Fang Falin (2103) used gear model to improve the parameters, which makes the coupling coordinative model more applicable. However, the coupling coordinative model for the relationship between marine economy and land economy has not been researched widely and deeply enough. Using the method of quantitative analysis will help provide an effective method for the evaluation of marine economy and land economy system.

2 Establishment of coupling coordinative evaluation index system and research method

Based on the current situation of the marine economy, following the scientific, comprehensive and feasible guidance, we establish the evaluation index system of marine economy and land economy system (Table 1).

Table 1 shows that the evaluation index system is divided into the goal layer, function layer, criteria layer and index layer, and its purpose is to explore the marine economy system's internal structure, function and main characteristics. Among them, the goal layer is the evaluation index system of marine economy and land economy; function layer consists of marine economy and land economy sub-systems; criteria layer covers five standard systems, including system environment, system management, system structure, system performance and system of sustainable development capacity; the index layer is to realize the target refinement; the index type describes the index's positive or negative effects on economic system. Specifically, the system environment refers to the external environmental factors of the economic system; system management refers to the management and control of the economic system; system structure refers to the structure of the economic system; system performance refers to the utility output of economic system; system sustainable development capacity refers to the sustainable development of economy and the potential of the system. The degree of coupling is simply used to describe things' influence. From the perspective of synergies, the coupling coordinative degree determines the system from disorderly to orderly trends. The synergistic effect on the order parameter is the basis for the realization of the process, and the synergistic effect on system plays a very important role. And the coupling degree can measure this precisely synergistic effect. The degree of coupling is widely used in the evaluation of the two economic systems. However, in some cases, it is difficult to reflect the overall effectiveness of marine economy and land economy, so the coupling coordinative degree model is better. The ordinary coupling coordinative model's parameter is fixed. It can not reflect the dynamic changes of the two systems, so the introduction of gear model can solve this problem.

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Table 1 The evaluation index system of marine-land economy

Goal layer	Functional layer	Criteria layer	Index layer	Index type
The evaluation index system of marine economy and land economy	x marine economy system	x_1 system environment	x_{11} area of marine aquaculture	positive
			x_{12} industrial wastewater into the sea	negative
			x_{13} number of hotels	positive
		x_2 system management	x_{21} comprehensive utilization rate of industrial solid waste	positive
			x_{22} number of coastal observation station	positive
			x_{23} area of nature reserves	positive
		x_3 structure of the system	x_{31} primary industry	positive
			x_{32} secondary industry	positive
			x_{33} tertiary industry	positive
		x_4 system performance	x_{41} gross ocean product	positive
			x_{42} added value of primary industry	positive
			x_{43} total seawater aquatic products	positive
			x_{44} added value of secondary industry	positive
			x_{45} added value of tertiary industry	positive
			x_{46} international standardized containers handled at coastal seaports	positive
		x_5 system of sustainable development capacity	x_{51} personnel engaged in scientific activities	positive
			x_{52} number of institutions	positive
			x_{53} number of research subjects	Positive
			x_{54} employed population	positive
			x_{55} proportion of the gross ocean product in GDP	positive
	y land economy system	y_1 system environment	y_{11} industrial wastewater	negative
			y_{12} industrial solid waste	negative
			y_{13} annual production water	negative
		y_1 system management	y_{21} industrial pollution control investment completed	positive
			y_{22} comprehensive utilization rate of industrial solid waste	positive
			y_{23} total investment in environmental pollution control	positive
		y_3 structure of the system	y_{31} primary industry	Positive
			y_{32} secondary industry	positive
			y_{33} tertiary industry	positive
		y_4 system performance	y_{41} land output value	positive
			y_{42} added value of primary industry	positive
			y_{43} added value of secondary industry	positive
			y_{44} added value of tertiary industry	positive
			y_{45} total investment in fixed assets	positive
			y_{46} CPI	negative
		y_5 system of sustainable development capacity	y_{51} education funds	positive
			y_{52} total output value of high-tech enterprise	positive
			y_{53} proportion of the third industry professionals	positive
			y_{54} patent authorization	positive
			y_{55} technology market turnover	positive

In order to avoid the influence of the dimension difference, the normalization method is used for the data at first. Then the standard formula can be made.

$$x_{ij} = \frac{v_{ij} - \min\limits_{1 \leqslant j \leqslant m}(v_{ij})}{\max\limits_{1 \leqslant j \leqslant m}(v_{ij}) - \min\limits_{1 \leqslant j \leqslant m}(v_{ij})} \tag{1}$$

$$x_{ij} = \frac{\max\limits_{1 \leqslant j \leqslant m}(v_{ij}) - v_{ij}}{\max\limits_{1 \leqslant j \leqslant m}(v_{ij}) - \min\limits_{1 \leqslant j \leqslant m}(v_{ij})} \tag{2}$$

where v_{ij} is the ith index value in year j ; x_{ij} is the ith standard index value in year j.

In order to reduce the influence of subjective factors, the information entropy e_i is used to determine the weight of index q_i.

$$e_i = -\frac{1}{\ln m}\sum_{j=1}^{m}\left(\frac{v_{ij}}{v_i}\ln\frac{v_{ij}}{v_i}\right),\ v_i = \sum_{j=1}^{m} v_{ij} \tag{3}$$

$$q_i = -\frac{1 - e_i}{n - \sum\limits_{i=1}^{n} e_i} \tag{4}$$

The comprehensive evaluation function is used to calculate the comprehensive development level of marine economy and land economy system, respectively.

$$f(x) = \sum_{j=1}^{5}\sum_{i=1}^{n_j} q_{ji}x_{ji},\ g(y) = \sum_{j=1}^{5}\sum_{k=1}^{n_j} y_{jk}q_{jk} \quad (5)$$

where $f(x)$ and $f(y)$ are the level of comprehensive development of marine economy and land economy system, respectively; q_{ij} is the ith criterion and the j th index weight.

By capacity coupling concept and capacity coupling coefficient model in physics, we can draw the coupling degree C of marine economy and land economy.

$$C = 2\left\{\frac{f(x)g(y)}{[f(x)+g(y)]^2}\right\}^{\frac{1}{2}} \quad (6)$$

With the help of the coupling degree, we can draw the coupling coordinative degree D. T is comprehensive evaluation index of marine economy and land economy system.

$$D = (CT)^{\theta} \quad (7)$$

$$T = \alpha f(x) + \beta g(y) \quad (8)$$

Based on the coupling coordination model with the values of α and β, we use the principle of mechanical gear to analyze the subsystem of marine-land economy. We regard the two subsystems as connected gears: gear 1 is for the marine economy and gear 2 is for land economy. When gear 1 works, it will inevitably make gear 2 rotate, and *vice versa*. This relationship is similar to the relationship of the marine economy and land economy promoting each other. According to the principle of system dynamics, gear ratio is the speed ratio of the driving wheel and the wheel.

$$i = \frac{\omega_1}{\omega_2} = \frac{z_2}{z_1} \quad (9)$$

where ω_1 is the angular velocity of gear 1 and means the rate of marine economy growth; ω_2 is the angular velocity of gear 2 and means the rate of land economy growth; z_1 is the number of gear 1; z_2 is the number of gear 2.

Based on the transmission principle of the gear, gear 1 and gear 2 will increase its speed through whole system running. We assume the growth rate to be $\Delta\omega_1$ and $\Delta\omega_2$. So we can get the final speed for gear 1 and gear 2, namely $V_1 = \omega_1 + \Delta\omega_1$, $V_2 = \frac{z_1}{z_2}(\omega_1 + \Delta\omega_1)$.

$$\frac{z_2}{z_1} = \frac{\Delta\omega_1}{\Delta\omega_2} = \frac{\omega_1}{\omega_2} \quad (10)$$

where ω_1 is the marine economy growth rate; ω_2 is the land economy growth rate.

We use the gear model to calculate α and β.

$$\frac{\alpha}{\beta} = \frac{\omega_1}{\omega_2},\ \alpha + \beta = 1 \quad (11)$$

where α and β are undetermined parameters.

3 Empirical results

According to the above formula, the comprehensive score can be derived on 2002 – 2012 marine economy and land economy system. We can also get the coupling degree and coupling coordinative degree of marine economy and land economy system.

Table 2 The comprehensive score of marine economy and land economy system

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
$f(x)$	0.036	0.047	0.051	0.074	0.189	0.230	0.293	0.385	0.867	0.536	0.036
$f(y)$	0.055	0.091	0.134	0.184	0.234	0.338	0.417	0.493	0.633	0.759	0.055

According to Table 2, we can evaluate the overall development of the system of marine economy and land economy over 11 years. Specifically, marine economy experienced sustainable development from 2002 to 2010, and reached a peak in 2010. Then it declined, but its growth was basically unchanged, while land economy underwent a significant increase.

Table 3 Coupling coordinative degree of the marine-land economy system

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
D	0.211	0.256	0.287	0.341	0.459	0.528	0.591	0.66	0.861	0.799	0.862

According to Table 3, the simple calculation of coupling degree has some problems. The results show that the marine economy and land economy of China gradually changed from imbalance to coupling coordination from 2002 to 2012.

4 Conclusions

The land economy and marine economy system is a complex system, so it is not a simple matter to evaluate the interaction between the marine economy and land economy. The information entropy is used to determine the index weight coefficient and improve parameters based on gear model. So we can build a coupling coordinative model, which provides an effective evaluation method for the research of the interaction between marine economy and land economy. And we can draw the conclusion that the marine economy and land economy in China has realized a gradual process from the disorder to the coupling coordination. The results of this research can provide a method to evaluate the relationship between the system of marine economy and land economy in theory. And it provides a reference for the construction of the coupling coordinative degree evaluation system between marine economy and land economy.

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(To page 26)

formation exchange platform, these new agricultural business entities will actively participate in these activities from a long-term perspective and will be inclined to establish reciprocal win-win cooperation with suppliers.

5.2 Recommendations

(i) Developing low toxic pesticides. In value equity driving factors, low toxicity has the most significant influence on value equity. And the trend and policy inclination are increasingly clear from ecological agriculture and biological pesticide demands from high toxic and efficient pesticide demands. Farmers demand that pesticide should ensure bumper harvest and more important guarantee safety. Therefore, pesticide enterprises should increase research and development input, produce pesticides with low toxicity and low residue, and effectively inhibiting plant diseases and insect pests, so as to obtain sustained competitive edge and sustainable development.

(ii) Establishing stable cooperative relation with new agricultural business entities. For new agricultural business entities, establishing stable cooperative relation is of utmost importance. Since order-oriented vegetable purchasing enterprises have certain requirements for vegetable production and vegetable quality, pesticide enterprises can consider cooperation with them as intermediaries, reach agreement with vegetable purchasing enterprises, while pesticide enterprises play vegetable production supervisors to guarantee vegetable quality.

(iii) Vegetable enterprises should strengthen brand construction, because good brand reputation plays a great role in increasing value equity and improving relation equity. Market environment is constantly changing. Enterprises need to drive businesses through brands, establish brand awareness through appropriate way, and guarantee high quality and excellent technical service and after-sale guarantee to ensure benefits of vegetable planting farmers, and cultivate a good many domestic brands with high quality and reputation to compete with foreign famous brands and expand the influence power of national brands. Advertisement propaganda may be placed in professional magazines, such as China Vegetables, China Pesticide, and some agricultural sci-tech newspapers.

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(From page 20)

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