Study on the Evaluation Model of Coupling Effect between Higher Education and Creative Industries

Tianwei Huang, Wen Li*, Bozhen Chen

huangtianwei@wust.edu.cn

*2668055440@qq.com

1073528707@qq.com

School of Management, Wuhan University of Science and Technology, Wuhan, P. R. China

Abstract—In the era of knowledge economy, there is an interactive coupling relationship between higher education and creative economy. They have become a mutually reinforcing and mutually beneficial relationship. This study sorted out the sources of evaluation factors of coupling development effect between higher education and creative industries. In qualitative aspects, this paper makes an empirical analysis of 18 urban higher education coupling and development, innovation ability and economic growth with multidimensional indicators. It analyzes the coupling and coordination relationship between the development of higher education and technological innovation in high-tech industries by taking the panel data of 31 cities. Based on the system coupling theory, the evaluation indices system of the coupling effect is established with entropy method which proposes the evaluation intervals of the coupling degree, the evaluation model of the coupling coordination degree and the synchronous coordination degree. All these indicators make a deep analysis on the coupling relationship between higher education and creative economy and find channels to improve their coupling effect.

Keywords—Higher education, Creative industries, Coupling, System coupling theory, Entropy method

1. Introduction

In recent years, the global economy has undergone smooth transition to downward economic growth. How to transform development model is a big challenge facing all countries. In the era of information explosion, technological innovation and cultural economy, cultural creative economy is forming rapidly. It has become important components to national strength, which named ‘soft power of country’. Meanwhile, creative elites are the decisive element to the creative economy, especially in the advent of the knowledge-based economy. The development of creative industries must rely on innovative talents.

Many scholars have paid attention to the interaction between higher education and the creative industries [1]-[4]. The term "coupling" is adopted to describe this relationship and put forward corresponding suggestions for the future development. Hoareau, C (2013) discussed higher education policies and their contribution to economic innovation are used as comparison benchmarks to work out which indicators can affect educational performance and innovation potential.

BDEIM 2022, December 02-03, Zhengzhou, People's Republic of China

DOI 10.4108/eai.2-12-2022.2328769

Then, to build a benign coupling and coordination relationship between higher education and creative industries and make policy recommendations for European countries[5]. Therefore, this paper focuses on analyze the evaluation model of coupling effect, establish an evaluation index system to analyze the various influencing factors on the coupling degree, summarizes relevant conclusions and puts forward new opinions to promote the mutual development of higher education and creative industries.

2. Theories and Hypotheses

2.1 Units Literature Review

The term "coupling" originated in physics and refers to close cooperation and interaction between two or more systems[6]. In scope of education and economy, some research identified main factors affecting its coupling coordination degree from the perspectives of space and timeline[7], and built up the evaluation indices system of coordination degree[8]; Other studies demonstrated the relationship between talents cultivated by universities and regional innovation ability[9]. Higher education institutions are important component of regional innovation system[10]. Enterprises' innovation relies on the knowledge acquisition from universities. However, many entrepreneurial universities use knowledge and technological innovation to attract external funds, develop emerging industries and accelerate the transformation of scientific and technological achievements[11]. Finally it concluded that universities was indirectly reflected by communication and learning.

2.2 Hypothesis and Construction of the Coupling Effect Evaluation Model

Based on the interaction of system coupling theory, the construction of evaluation indices system refers to the nonlinear relations of the interaction between each system. This study constructs evaluation indices based on three principles respectively: scientific, maneuverability, data availability.

2.2.1 Synergy evaluation indices system for higher education development level

In the existed references, a series of indices have been chosen as the evaluation indices, which reflect the development level of higher education. This research selected ten indicators from three aspects: talents converging, input of higher education and output of higher education (shown in table 1 below).

Table 1 Synergy Evaluation Indices System for Higher Education

First-level indicators	Second-level indicators
Talents converging	The number of academic institutions
	The number of enrolled students
	The number of enrolled professors
Input of higher education	Regional Investment in higher education
	fund for internal expenditure
	Growth rate of internal expenditure
Output of higher education	Academic achievements produced
	Academic fund of development projects
	Number of granted patents by institutions

2.2.2 Synergy evaluation indices system for creative industries development level

Based on the principles of index system building, the synergy evaluation indices system is built from three aspects: input, output and effectiveness. R&D personnel is selected as input of manpower, capital investment is usually measured by R&D expenditure. The output index mainly includes the number of patent applications and effective invention patents. The sales revenue reflect the application value and reflect the innovative economic output. Evaluation indices are shown in table 2.

Table 2 Synergy Evaluation Indices System for Creative Industries

First-level indicators	Second-level indicators
Input of creative industries	R&D personnel
	Enterprises in creative industries
	Expenditure on scientific and technological projects
Output of creative industries	Internal expenditure of R&D
	Number of domestic patent applications
	Number of domestic patents authorized
Effectiveness of creative industries	Market turnover of creative industries
	Added value of creative industries
	Growth of creative industries

2.3 Selection of Evaluation Method

Entropy mainly refers to the uncertainty of the measurement system, and the information determines the uncertainty of the system. The more information in the system, the lower the uncertainty, the lower the entropy. In order to make the research scientific and rigorous, avoid subjectivity of indices system, entropy method is adopted to determine the weights of indicators, defining exact influence degree of different indicators.

2.3.1 Evaluation steps of entropy method

the collected and statistical data are now processed:

a) Building initial data matrix: According to the evaluation indices system in the table, the following initial data matrix is constructed:

$$X = (X_{ij})_{m\times n} \qquad (1)$$

Thereinto, X_{ij} represents the J index value of the i^{th} year.

b) Standardizing values of indices: Each indicator needs to be standardized. Non-negative processing is carried out in order to avoid nonsense in the calculation process of entropy value:

$$X'_{ij} = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)} + 0.01 \qquad (2)$$

$$X'_{ij} = \frac{\max(x_j) - x_{ij}}{\max(x_j) - \min(x_j)} + 0.01 \qquad (3)$$

(i=1, 2, L, m, j=1, 2, L, n)

In the above equation, if X '$_{ij}$ is a positive indicator, select equation (2); if it is a negative indicator, select equation (3) for calculation. thereinto, Max (X_j) is the maximum value in the Jth index, and min (X_j) is its minimum value.

c) Calculating the proportion of item j in year i in this index:

$$P_{ij} = \frac{X_{ij}}{\sum_{i=1}^{m} X_{ij}} (i = 1,2, \dots, n) \quad (4)$$

d) Calculating the entropy value of item j:

$$e_j = -k \sum_{i=1}^{m} p_{ij} \ln(p_{ij}) \quad (5)$$

Thereinto，k>0 ej≥0。Generally, k=1 /lnm，mis the number of years for comparison, then $0 \leq e_j \leq 1$.

e) Calculating difference coefficient of the Jth index:

$$g_j = 1 - e_j \quad (6)$$

The difference coefficient directly affects the weight. The larger its value, the smaller its entropy value; the larger its weight, the greater its impact on the comprehensive evaluation.

f) Calculating the weight of index j:

$$W_j = \frac{g_j}{\sum_{j=1}^{n} g_j}, j = 1,2, \dots, n \quad (7)$$

g) Calculating the comprehensive score of development level

$$S_i = \sum_{j=1}^{n} W_j \times X'_{ij}, i = 1,2, \dots, m \quad (8)$$

3. Evaluation model of coupling effect

3.1 Evaluation Intervals of the Coupling Degree

Based on the coupling model in physics, this research establishes the evaluation model for the coupling development effect, and calculates the interaction degree between the two industries. The greater the coupling degree is, the more stable relationship between the factors is. The evaluation model of coupling effect is:

$$c = 2 \sqrt{\frac{f(x) \times g(x)}{[f(x) + g(x)]^2}} \quad (9)$$

f(x) represents the score of comprehensive development level with the dimensionless indicators of higher education, and g(x) represents the score of comprehensive development level with the dimensionless indicators of creative industries, $0 \leq C \leq 1$. The coupling degree intervals are shown in table 3:

Table 3 Intervals of The Coupling Degree

C	[0,0.3]	(0.3,0.5]	(0.5,0.8]	(0.8,1.0]
Coupling level	Low-level	Lower-level	Higher-level	High-level

3.2 Evaluation Model of the Coupling Coordination Degree

According to the theory of coupling system, the virtuous interaction process between systems or among internal elements of systems are called the 'coordination degree'. It is necessary to further build an evaluation model to calculate the coordination degree. The evaluation model is as follows:

$$D = \sqrt{C \times T} \quad (10)$$

$$T = \alpha F(x) + \beta G(y) \quad (11)$$

Thereinto, D represents the degree of coupling coordination, C represents the degree of coupling, and T represents the harmonic index, reflecting their synergies. α+β=1, α and β respectively represent the weights of higher education and creative industries, namely the contribution coefficient. This research assumes that the importance of two industries is the same, so it makes α=β=0.5.

Compared with the coupling degree, the coupling coordination degree is more sensitive to compare the development level of higher education and the creative industries in different periods. It seems that when the coupling coordination degree is proportional to the synergistic development effect, the higher the score is, the better the synergistic development effect is. It is necessary to grade the coupling degree value of two industries, so as to judge the coupling development effect. Based on the relative research results, this research divides the coupling coordination degree into ten levels and three levels, which is shown in table 4:

Table 4 The Levels of The Coupling Coordination Degree

Intervals	levels of coordination
[0.00,0.10)	Extremely imbalance
[0.10,0.20)	High-level imbalance
[0.20,0.30)	Middle-level imbalance
[0.30,0.40)	Mild imbalance
[0.40,0.50)	Verge of imbalance
[0.50,0.60)	Mild balance
[0.60,0.70)	Primary balance
[0.70,0.80)	Middle-level balance
[0.80,0.90)	High-level balance
[0.90,1.00]	Extremely balance

3.3 Evaluation Model of the Synchronous Coordination Degree

The relative relationship between their coupling development is obtained through the following synchrony evaluation model formula, which is expressed by synchrony P.

$$P = Y/X \quad (12)$$

Among them, X is the development level index of higher education after coupled development, and Y is the development level index of creative industries after coupled evelopment.

According to the P value of synchronicity calculated by equation above, the synchronization types of the coupling development are classified, as shown in table 5 below:

Table 5 The types of the synchronous coordination degree

P	**P<0.9**
Types of synchronous coordination	Creative industries-lagging type
0.9≤P≤1.1	**P>1.1**
Synchronous coordination	Higher education-lagging type

4. Case analysis of Evaluation

4.1 Sample Selection and Data Source

This research selects data from the statistical yearbook of H province in China in 2015, 2017, 2019 and 2021: science and technology statistical data collection of higher education, Chinese education statistical yearbook, Chinese statistical yearbook of science and technology. H province is one district with high-level development both in higher education industry and creative industries, it is a representative district that the government paid lots of attention on their coupling coordination in different development stages. All relative data were selected for intertemporal dynamic analysis.

4.2 Data Calculation and Processing

4.2.1 Weighting of the evaluation indices

Based on the specific data collected in the evaluation system of H province from 2015 to 2021, the weight of each evaluation index of higher education and creative industries development level is calculated with the entropy method calculation process:

Table 6 Synergy Evaluation Indices for Higher Education

Second-level indicators	**weight**
The number of academic institutions	0.021
The number of enrolled students	0.026
The number of enrolled professors	0.030
Regional Investment in higher education	0.034
Science and technological fund for internal expenditure	0.040
Growth rate of internal expenditure	0.045
Academic achievements produced by higher education	0.041
Academic fund of research and development projects	0.045
Number of granted patents by institutions	0.042

4.2.2 Calculation of the comprehensive score of development level

According to the formula 2.1 to 2.8, the comprehensive score of development process of 2015, 2017, 2019 and 2021 in H province can be calculated (shown in table 7).

Table 7 Synergy Evaluation Indices for Creative Indusries

Second-level indicators	weight
R&D personnel	0.024
Enterprises in creative industries	0.037
Expenditure on scientific and technological projects	0.039
Internal expenditure of R&D	0.021
Number of domestic patent applications	0.035
Number of domestic patents authorized	0.031
Market turnover of creative industries	0.035
Added value of creative industries	0.035
Growth of creative industries	0.037

Evaluation of the Coupling Effect

4.2.3 Calculation of the coupling degree

According to the calculation formula of coupling degree, the coupling degree between higher education and creative industries in H province from 2015 to 2021 is calculated, and the result is shown in table 8:

Table 8 Synergy Evaluation Indices for Creative industries

Year	2021	2019	2017	2015
Comprehensive score of higher education	0.2891	0.1955	0.1122	0.0497
Comprehensive score of creative industries	0.2599	0.1722	0.0901	0.0399

Table 9 The Coupling Degree of H Province In 2015-2021

Year	2021	2019	2017	2015
coupling degree C	0.9846	0.9850	0.9936	0.9958

It says that the coupling degree in H province from 2015 to 2021 stays high-level steadily. The coupling degree is in a higher-level coupled stage. However, the value of coupling degree C decreased slightly.

4.2.4 Calculation of the coupling coordination degree

According to the calculation formula of coupling coordination degree, the coupling coordination degree between higher education and creative industries in H province from 2015 to 2021 is calculated and results shown as follows:

Table 10 The Coupling Coordination Degree of H Province

Year	2021	2019	2017	2015
coupling coordination degree D	0.5339	0.4362	0.3255	0.2261
levels of coordination	mild balance	Verge of imbalance	mild imbalance	Middle-level imbalance
levels of the degree	Middle-level balance	Middle-level balance	primary balance	primary balance

It can be concluded that the value of coupling coordination degree between higher education and creative industries in H province from 2015 to 2021 is growing steadily, from the mild imbalance in 2015 to mild balance in 2021, the coupling coordination is getting better stably.

4.2.5 Calculation of the synchronous coordination degree

According to the calculation formula, the synchrony between higher education and creative industries in H province from 2015 to 2021 is calculated and analyzed in table 11:

Table 11 Synchronous Coordination Degree In H Province

Year	2021	2019	2017	2015
P	0.8989	0.8807	0.8031	0.8041
types	Creative industries-lagging type			

Combined with table 4.3, although the overall score of the comprehensive development level of creative industries is high and the growth rate is large, the higher education level still has superiority. The P value of synchronism has been gradually improved from 2015 to 2021, and reached 0.8989 in 2021, which is close to $0.9 \leq P \leq 1$, indicating that if the creative industries further develops, higher education and creative industries will gradually achieve synchronous development.

4.3 Results of Case Analysis

From 2015 to 2021, higher education and creative industries in H province has been in the stage of highly coupled but slightly declining. The level of coupling coordination degree has gradually changed from medium imbalance to mild balance, they are coupled development, which is interactive and mutually promoting. Meanwhile, the coupling coordination degree still at low level of coordination until 2019, and now it only has reached the mild balance state. Whereas, the results of synchronization evaluation, higher education and creative industries in H province did not reach the same development level. As a province which has strong advantage over higher education, creative industries are not mature enough. It hasn't used the opportunities fully to develop the coordination development.

5. Discussion and Conclusion

In the context of the coordinative development between high education and creative industries, this paper makes unique contributions. Firstly, to the best of our knowledge and the literature in hand, this study pioneers in studying the evaluation methods from different perspectives. Traditionally, it is known high education and creative industries are mutual benefit and reciprocity. Therefore, we realize it is important to get mutual coupled development. Thus, this study provides a new indices system to evaluate the coupling effect between high education and creative industries. Secondly, in the building of evaluation indices system, we found how to find the problems existed in their coupled coordination processes. All the evaluation indices also can be used as the channels to improve their coupling effect.

Acknowledgment

This study was supported by 'Humanities and Social Science Research Project of Hubei Provincial Department of Education' (Grant No. 18D007); 'The General Project of Center for Industrial Policy and Management Research Center of Wuhan University of Science and Technology'(17CYY06);

References

[1] Junting Chen, Arunkumar N,"Quantified comparative analysis of innovation and innovation based on multi orientation from the perspective of education and culture," Cluster Computing, vol. 22, pp. 4711-4718, March 2019.

[2] Esther Delesalle, "The effect of the Universal Primary Education program on consumption and on the employment sector: Evidence from Tanzania," World Development, vol.142, 105345, June 2021. (references)

[3] Thompson, B., Sanchez, C., Tklich, "P. A high-resolution atmosphere-ocean coupled model for the western Maritime Continent: development and preliminary assessment," Climate Dynamics, vol. 52, pp. 3951-3981, 2019.

[4] Rajappan Nair, K.P., Herbers, S., Lesarri, "Molecular systems with nearly-free internal rotation and nuclear quadrupole coupling: Meta-chlorotoluene," Journal of Molecular Spectroscopy, 2019. (references)

[5] Pranav Dharmani, Satyasiba Das, Sanjeev Prashar, "A bibliometric analysis of creative industries: Current trends and future directions," Journal of Business Research, vol. 135, pp. 252-267, October 2021. (references)

[6] Leticia Castillo Longoria, Ignacio López-Forniés, David Cortés Sáenz, Jorge Sierra-Pérez, "Promoting sustainable consumption in Higher Education Institutions through integrative co-creative processes involving relevant stakeholders," Sustainable Production and Consumption, vol. 28, pp. 445-458, October 2021. (references)

[7] Wenjing Yang, Adam E. Green, Qunlin Chen, Yoed N. Kenett, Jiangzhou Sun, Dongtao Wei, Jiang Qiu,"Creative problem solving in knowledge-rich contexts," Trends in Cognitive Sciences, vol. 26(10), pp. 849-859, October 2022. (references)

[8] Aekaterini Mavri, Andri Ioannou, Fernando Loizides, "Cross-organisational Communities of Practice: enhancing creativity and epistemic cognition in higher education," The Internet and Higher Education, vol. 49, 100792, April 2021. (references)

[9] Aurélie Hemonnet-Goujot, Björn Sven Ivens, “Catherine Pardo, Network creativity: A conceptual lens for inter- and intra-organizational creative processes,” Industrial Marketing Management, vol. 102, pp. 503-513, April 2022.
[10] Mavri Aekaterini, Ioannou Andri, Loizides Fernando, “Cross-organisational Communities of Practice: enhancing creativity and epistemic cognition in higher education,” Internet and Higher Education, vol. 49, April 2021.
[11] Tang Y.M., Au K.M., Lau, H.C.W., Ho, G.T.S., Wu, C.H, “Evaluating the effectiveness of learning design with mixed reality (MR) in higher education,” Virtual Reality, vol. 24(4), pp. 797-807, December 2020. (references)