Journal of the Korea Academia-Industrial cooperation Society
Vol. 23, No. 1 pp. 679-688, 2022

https://doi.org/10.5762/KAIS.2022.23.1.679
ISSN 1975-4701 / eISSN 2288-4688

Manufacturing Enterprise, Tourism Industry and Economic Development Coupling Coordinative in Jilin Province, China

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중국 길림성 제조업, 관광업과 지역경제 협조발전에 관한 연구

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Abstract This study aims to promote the coordinated development of manufacturing, tourism, and regional economy in Jilin Province. Based on the inferences from previous studies, this research first constructed an evaluation system of 16 indicators for the three subsystems of manufacturing, tourism, and regional economy. Next, it used the entropy method to evaluate the comprehensive evaluation level of the three subsystems in Jilin Province from 2009 to 2019. Then, the coupling coordination model was used to evaluate the coupling and coordination development level of manufacturing, tourism, and regional economy in Jilin Province from 2009 to 2019. The research results show a high coupling coordination degree between the manufacturing industry, tourism industry, and regional economy in Jilin Province. Although the evaluation indexes of the manufacturing and tourism industries have a certain downward trend, they still have a great development potential. Based on the analysis results, this study puts forward relevant suggestions to strengthen the support and guidance for the manufacturing industry relying on Jilin Province's industrial development advantages. This study also provides suggestions to promote the development and upgrading of tourism in Jilin Province through tourism development.

요 약 본 연구에서는 중국 길림성 제조업, 관광업 및 지역경제의 조화로운 발전을 촉진하기 위하여, 중국 길림성의 제조업, 관광업, 지역경제의 3개 서브 시스템(subsystem) 평가체계과 16개 평가지표를 구축하였다. 본 연구에서는 엔트로피 방법(entropy method)을 이용하여 2009년~2019년 길림성 3개 서브 시스템의 종합수준을 평가하였다. 또한 2009년~2019년 길림성의 제조업, 관광업, 지역경제의 결합 균형발전 수준을 coupling coordination model를 통해 평가하였다. 분석결과에 따르면 길림성의 제조업, 관광업 및 지역경제의 coupling coordination degree는 비교적 높은 것으로 나타났다. 제조업과 관광업의 평가지표는 하락하는 추세를 보이고 있지만, 성장할 잠재력은 큰 것으로 분석되었다. 이에 따라 길림성의 제조업에 대한 지지와 인도를 강화시켜야 한다. 또한 관광업에 대한 발전을 통해 산업을 업그레이드를 해야한다.

Keywords : Tourism, Manufacturing Enterprise, Regional Economy, Coupling and Coordination, Jilin Province

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Received September 24, 2021 Revised October 18, 2021
Accepted January 7, 2022 Published January 31, 2022

1. Introduction

China's regional economy has experienced three stages of balanced development, unbalanced development, and unbalanced coordinated development, and is developing to the stage of overall regional planning. Exploring the coupling coordination degree between industrial systems is becoming a breakthrough of new economic growth points[1]. Meantime, Industrial development, tourism development, and regional economic growth have always been important issues concerned by Chinese academic circles[2]. In the 1990s, Yang introduced the concept of a coordination degree in physics to economic research for the first time to discuss the coordinated development of the environment and economy. Since then, many scholars have conducted an in-depth study on the analysis between different systems, especially the development of the manufacturing industry closely related to the regional economy, the coupling relationship of the manufacturing industry, and its coordinated development. This study is judged from the existing studies, and there are few studies on the correlation between the three systems, including manufacturing, tourism, and economic development at the same level[2]. The three subsystems of manufacturing, tourism, and regional economy are in the same temporal and spatial environment. The development of manufacturing is an essential determinant of regional economic growth, and it also provides a source of funds and tourists for the development of tourism. Tourism is one of the vital sources of regional economic development. The income from tourism can provide necessary funds for the manufacturing industry, improve residents' income and employment status, and drive local economic growth[3]. The manufacturing, tourism, and regional economic systems are open systems with high complexity, uncertainty, and multiple levels. The three subsystems promote and restrict each other, so it is worthy of in-depth study and discussion.

As one of the essential industrial bases in China, Jilin Province has an excellent industrial development foundation and has formed a complete and well-based manufacturing system of automobile manufacturing, instrumentation, and special equipment, and is an essential national production base. At the same time, Jilin Province is located in the middle of the Northeast region. The excellent location conditions, beautiful ecological environment, profound cultural heritage, and long history and culture make Jilin Province an essential position in the tourism industry of the Northeast region. In 2019, the province received 248 million domestic and foreign tourists, including 247 million domestic and 100 million inbound tourists. The annual tourism revenue was 492.038 billion yuan, of which domestic tourism revenue was 487.789 billion yuan, and tourism foreign exchange income was 615 million yuan. Therefore, relying on the development advantages of manufacturing and tourism resources in Jilin Province to achieve the coordinated development of manufacturing, tourism, and regional economy is an important issue facing the high-quality development of the regional economy in Jilin Province. Therefore, this article takes Jilin Province as the research object. Based on the measurement of the coupling degree of the three subsystems of Jilin Province's manufacturing, tourism, and regional economy, this paper analyzes the coupling and coordination level of the three subsystems, aiming to promote the manufacturing and tourism industry in Jilin Province, thereby promoting economic growth.

2. Literature review

Before the 2008 international financial crisis, there was a general bias in Chinese society,

believing that the development of manufacturing enterprises mostly meant high input, high energy consumption, and high pollution. It also emphasized the role of the service sector in economic growth, believing that the service industry had less input, less energy consumption, and less pollution. Meantime, the tourism industry as a major component of the service industry, government departments had issued various policies to vigorously support the development of the tourism industry and strive to make the tourism industry a pillar industry for local economic development. Related research in academia also emphasized promoting tourism development to economic development. When Khan, Phang & Toh, and Lee & Kwon studied the relationship between the tourism industry and economic growth, They used the co-integration theory to verify the positive role of tourism development in driving the growth of the national economy[4,5]. Jacint et al. proposed the Tourism-Led Economic Growth Hypothesis, and Drisakis et al. presented this point of view through empirical analysis of Spain and other places[6,7]. About the impact of regional economic growth on the tourism industry, Chi-Ok Oh combined the co-integration analysis and Granger causality test method to empirically study the equilibrium relationship between tourism income and economic development in South Korea and concluded that economic growth has a one-way driving effect on tourism[8].

In recent years, some studies have pointed out that tourism development had a limited driving effect on regional economic growth, such as the research by Andrew[9], Ashworth & Page[10]. Through research, some scholars had discovered that the development of tourism had a crowding-out effect on manufacturing, similar to the "Dutch Disease" caused by the curse of natural resources, which was not conducive to long-term economic development. After the 2008 international financial crisis, with the re-emphasis on manufacturing at home and abroad, similar studies had also emerged in China. Through the overall research on 40 tourist cities in China, Zhong Wei found that the expansion of tourism in most cities was conducive to urban economic growth, but the effect was not very significant. After categorizing cities and adopting a fixed-effect model, it was found that the development of tourism had a different degree of substitution effect on the manufacturing, labor power capital, and technological progress, and tourism had a crowding-out impact on the manufacturing industry[11]. Deng took China's Huangshan, Tai'an, Leshan, and Nanping as case studies and found that, on the one hand, the capital and labor power capital brought about by the development of tourism will positively impact the local economy. On the other hand, in cities that rely too much on tourism, the phenomenon of Dutch disease appears[12]. Zuo Bing used VAR cointegration analysis, Granger causality test, impulse response function, and variance decomposition analysis methods to conduct empirical research on the relationship between tourism development and the change in the proportion of industrial added value in Guangxi province. The results of the study showed that the economy was free from any intervention. The expansion of tourism will squeeze out industrial investment capital, transfer industrial labor, cause a decline in industrial growth, and bring de-industrialization effects to destinations[13].

The academic circles do not have a unified view on whether tourism and the manufacturing industry are mutually conflicting or mutually promoting. This study establishes a coupling coordination model based on the coupling theory, including manufacturing, regional economy, and tourism. It takes the economic development of Jilin Province in China as an example to analyze the relationship and

coordination degree among manufacturing, regional economy, and tourism, to evaluate tourism more objectively and comprehensively. It references the mutual relationship between the manufacturing industry and regional economic development and provides theoretical support and a decision-making basis for Jilin Province and other regions.

3. The indicator system and method

3.1 The construction of indicator system

This study aims to measure the coupling coordination degree among manufacturing enterprises, regional economy, and tourism industry in Jilin Province. It is necessary to analyze and evaluate several indicators. Based on the existing evaluation indicators and according to the principles of correlation, representativeness, and availability of indicators, A total of 16 evaluation indexes, including manufacturing subsystem (MS), tourism subsystem (TS), and regional economic subsystem (ES), have been established[2,14,15]. The evaluation index system is as shown in Table 1. The research period is from 2009 to 2019, and the basic data are obtained from the China Statistical Yearbook (2010-2010) and Jilin province Statistical Yearbook (2010-2020).

Table 1. Evaluation index system of coupling and coordination degree

The first indicators	The secondary indicators	Sign	Weight
Manufacturing subsystem	Gross industrial output value	X_1	0.2012
	Total profit	X_2	0.2008
	Number of enterprises	X_3	0.2030
	Number of employees	X_4	0.1976
	Average wage of workers	X_5	0.1974
Tourism subsystem	Domestic tourism revenue	X_6	0.1942
	International tourism revenue	X_7	0.2019
	Domestic visitor numbers	X_8	0.1965
	Inbound visitor numbers	X_9	0.2029
	Star-rated hotels	X_{10}	0.2044
Economic subsystem	Gross regional production	X_{11}	0.1558
	General budget revenue	X_{12}	0.1474
	Total imports and exports	X_{13}	0.1234
	Per capita GDP	X_{14}	0.1591
	Per capita income of urban residents	X_{15}	0.1937
	Per capita income of rural residents	X_{16}	0.2207

3.2 Research method

3.2.1 The choice of weighting methods

Based on the previous studies about the evaluation research, various methods need to be widely used. The weighting methods can be summarized into three categories: subjective weighting methods, objective weighting methods, and combination weighting methods. The subjective weighting methods mostly adopt qualitative methods to determine the weights, mainly obtained by experts in related fields based on their experience and subjective judgments. For example, the Delphi method, the decision evaluation system, the analytical hierarchy process, etc. The research on these methods starts early, and the use is mature. Still, the evaluation results are very subjective and arbitrary and are greatly affected by subjective factors, so they lack certain scientific and objective characteristics. The objective weighting methods include the coefficient of variation method, the principal components analysis, entropy method, etc[16]. It determines the weight according to the variation degree of each index value, which reduces the influence of human factors, so it has higher accuracy, reliability, and objectivity. A comprehensive comparison of the merits and demerits of each weighting method, considering the relationship between the evaluation index system and the evaluation target

of this study, so this study will use the entropy weight method to calculate the index weight of each system.

3.2.2 The basic theory of the entropy method

Assuming that there are n evaluation indexes, m years. Then the matrix $R=(X_{ij})_{m\times n}$ can be obtained according to the original data, X_{ij} means the original value of index j in year i.

① Data preprocessing:

Standardization of data processing, because units of the index in the evaluation system are different, this study first carries out data processing to compare different indicators and determine the weights for each data normalized. In data processing, each indicator is converted by using the extremum method[2]. The calculation processes are expressed in Eqs. (1) and (2).

$$Z_{ij}=\frac{X_{ij}-\min(X_{ij})}{\max(X_{ij})-\min(X_{ij})}, \quad (1)$$

i is the positive indicator.

$$Z_{ij}=\frac{\max(X_{ij})-X_{ij}}{\max(X_{ij})-\min(X_{ij})}, \quad (2)$$

i is the negative indicator.

$$Z'_{ij}=Z_{ij}+0.0001 \quad (3)$$

Where Z_{ij} is the value of indicator X_{ij} processed by the extremum method, X_{ij} is the actual value of indicator i in the year j, $\max(X_{ij})$ is the maximum actual value of indicator i in the year j, and $\min(X_{ij})$ is the minimum actual value of indicator i in the year j.

② Calculate the proportion of the indicators:

$$p_{ij}=\frac{X_{ij}}{\sum_{i=1}^{m}X_{ij}} \quad (4)$$

③ The weight of each indicator is determined based on entropy method:

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

$$w_j=\frac{1-e_j}{\sum_{i=1}^{m}(1-e_j)} \quad (6)$$

Where e is the entropy for each indicator, m is the number of samples, and w refers to the indicator weight. The weights of each indicator in Table 1 are determined by the entropy weight method (EWM) in this study.

④ The comprehensive evaluation value of three subsystems:

$$u_1=\sum_{j=1}^{m}a_jx_j, u_2=\sum_{j=1}^{n}b_jy_j, u_3=\sum_{j=1}^{k}c_jz_j \quad (7)$$

Where u_1, u_2, u_3 is the comprehensive evaluation value of manufacturing subsystem, tourism subsystem, and social economic subsystem, respectively. a_j, b_j, c_j are the index weight of each indicator.

3.2.3 Coupling coordination model

The degree of coupling coordination model can truly reflect the synergistic effect and the coupling degree between the different systems, and it has been widely used.

$$C_n=n\left\{\frac{(u_1\cdot\ u_2\cdot\ \cdots\cdot\ u_n)}{\prod(u_i+u_j)}\right\}^{1/n} \quad (8)$$

This paper uses the model to study the coordination between the tourism industry, manufacturing enterprise, and economic development. The manufacturing enterprise, tourism industry, and economic development are three independent systems with coupling relations.

$$C_3 = \frac{3\sqrt[3]{u_1 \cdot u_2 \cdot u_3}}{u_1 + u_2 + u_3} \quad (9)$$

Where C_3 is the coordination degree of the three systems, $C_3 \in [0,1]$, u_1 is the comprehensive index of manufacturing subsystem, u_2 is the comprehensive index of tourism subsystem, u_3 is the comprehensive index of economic subsystem.

However, when the value of u_1, u_2, u_3 are very small, the coupling degree will be very high. Therefore, to avoid the phenomenon of high coupling degree at a low level, it reflects the synergistic effect and the coupling degree between the three systems objectively.

Coordination is a benign interrelated between two or more systems and guarantees healthy development among the systems. The formula of the coordination degree is:

$$T = \alpha u_1 + \beta u_2 + \gamma u_3 \quad (10)$$

$$D = \sqrt{C \cdot T} \quad (11)$$

Where T is for the comprehensive evaluation index among the tourism industry, manufacturing enterprise, and economic development, respectively. D refers to the coordinated development coefficient, C is for the coordination degree between (0, 1). α, β, γ is for the undetermined coefficients. Based on the previous studies[17,18], so the undetermined coefficients of α, β, γ is 0.3, 0.5, and 0.2. Therefore, the comprehensive evaluation index is as shown in Eq. (7).

$$T = 0.3u_1 + 0.5u_2 + 0.2u_3 \quad (12)$$

In order to reflect the coupling coordination degree of the tourism industry, manufacturing enterprise, and economic development, based on the previous study[19], this study divided the coupling coordination degree into ten levels.

Table 2. Levels and corresponding criteria of the coupling coordination degree

Coupling coordination type	Value	Coupling coordination level
Low coupling coordination	$0.00 < D \leq 0.09$	Extreme imbalance
	$0.10 \leq D \leq 0.19$	Serious imbalance
	$0.20 \leq D \leq 0.29$	Moderate imbalance
	$0.30 \leq D \leq 0.39$	Mild imbalance
Moderate coupling coordination	$0.40 \leq D \leq 0.49$	Imbalance
	$0.50 \leq D \leq 0.59$	Coordinate
Good coupling coordination	$0.60 \leq D \leq 0.69$	Basic coordinate
	$0.70 \leq D \leq 0.79$	Moderate coordinate
High quality coupling coordination	$0.80 \leq D \leq 0.89$	Good coordinate
	$0.90 \leq D < 0.1$	High quality coordinate

4. The results of empirical analysis

4.1 The comprehensive index analysis of three subsystems in Jilin province

According to the above steps, the data

Table 3. Statistics of Jilin manufacturing, tourism, economic evaluation index from 2009 to 2019

Year	u_1	u_2	u_3
2009	0.2305	0.2045	0.0001
2010	0.3850	0.2617	0.1625
2011	0.4698	0.3259	0.3755
2012	0.5357	0.4623	0.5336
2013	0.7268	0.5296	0.6006
2014	0.7939	0.6154	0.6861
2015	0.7656	0.6919	0.6600
2016	0.7642	0.7658	0.7326
2017	0.7305	0.7557	0.7959
2018	0.6522	0.7334	0.8775
2019	0.4493	0.6767	0.9238

processing results can be obtained in Table 3. u_1 means the comprehensive index of manufacturing subsystem, u_2 means the comprehensive index of tourism subsystem, u_3 means the comprehensive index of the social-economic subsystem.

In order to see the development and change more intuitively, the evaluation index is drawn as Fig. 1. Combining Table 3 and Fig. 1, we can see the overall development of Jilin Province's tourism, manufacturing, regional economic comprehensive development level index from 2009 to 2019. It can be seen from the results that the regional economic development level is the lowest, the manufacturing industry evaluation index is the highest, and the tourism industry is somewhere in between. Before 2016, the development trends of the three systems remained the same. After 2016, the economic level was still upward, but the manufacturing and tourism industries had shown a downward trend. The economic level had developed the fastest among the three systems, increasing from 0.0001 in 2009 to 0.9238 in 2019.

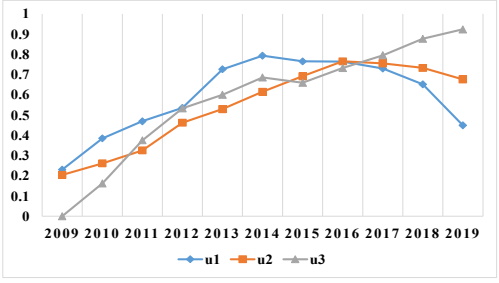

Fig. 1. Manufacturing, tourism, economic comprehensive development level trend from 2009 to 2019 in Jilin province

4.2 Coordination degree analysis between three subsystems in Jilin

The coupling degree and coupling coordination degree are calculated according to Eq. (9), Eq. (10), and Eq. (11). The coupling coordination levels of manufacturing, tourism industry, and regional economy in Jilin Province from 2009 to 2019 are classified according to the classification standards of coupling coordination levels in Table 2. The specific results are shown in Table 4 and Fig. 2.

Table 4. Statistics of Jilin manufacturing, tourism, economic evaluation index from 2009 to 2019

Year	C	D	Coupling coordination level
2009	0.1156	0.1408	Serious imbalance
2010	0.9414	0.5124	Coordinate
2011	0.9886	0.6121	Basic coordinate
2012	0.9977	0.7053	Moderate coordinate
2013	0.9915	0.7732	Moderate coordinate
2014	0.9945	0.8242	Good coordinate
2015	0.9981	0.8404	Good coordinate
2016	0.9997	0.8709	Good coordinate
2017	0.9994	0.8693	Good coordinate
2018	0.9925	0.8558	Good coordinate
2019	0.9585	0.7941	Moderate coordinate

Note: C means the coordination degree, D means the coordinated development coefficient.

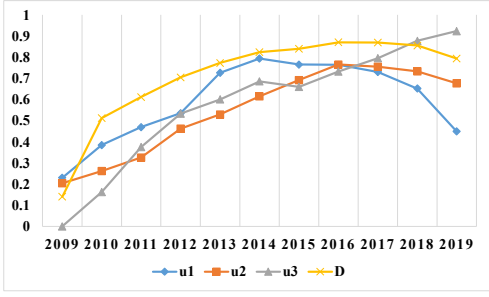

Fig. 2. Coordinated development trend of Manufacturing, tourism and economic development from 2009 to 2019 in Jilin province

Table 4 shows that the coupling coordination degree among the three subsystems of manufacturing, tourism, and regional economy in Jilin Province from 2009 to 2019 had steadily improved and declined. The coupling coordination degree has also changed from imbalance to coordination. In 2009, the evaluation indexes of the three subsystems were all low, and the coupling coordination degree was also in the low coupling coordination stage. From 2010 to 2013, the coupling coordination degree began to shift to the coordination stage,

and the three subsystems turned from the moderate coupling coordination stage to the good coupling coordination stage. From 2014 to 2018, The coupling coordination degree of the three subsystems rose to a new stage from 0.8242 to 0.8558. In 2019, the coupling coordination degree decreased slightly and was still in a good coupling coordination stage.

According to the different comprehensive development levels of the three subsystems of manufacturing, tourism and regional economy in Jilin Province, these three subsystems are divided into different types: $u_1 > u_2, u_3$, the stage of manufacturing development ahead of time. $u_2 > u_1, u_3$, the stage of tourism development ahead of time. $u_3 > u_1, u_2$, the stage of tourism development ahead of time. From 2009 to 2015, the evaluation index of manufacturing was higher than that of tourism and regional economy. The coupling and coordination of the three systems had also changed from an imbalanced level to a moderate coordinate level. It shows that the manufacturing development ahead of time can well drive the overall growth of the tourism industry and the regional economy. In 2016, the evaluation index of tourism was higher than that of manufacturing and regional economy. However, the development of tourism did not drive manufacturing development but had a driving effect on the regional economy, and the evaluation index of the tourism industry had exceeded that of manufacturing since 2016. From 2016 to 2019, the three subsystems were in a good coupling coordination stage.

5. Conclusions and suggestions

This paper uses the coupling coordination degree model to measure the coordinated development of the three subsystems of manufacturing, tourism, the regional economy in Jilin Province to distinguish the coupling and coordination relationship of the three subsystems. The research results can provide a decision-making reference for the collaborative development of the manufacturing-tourism-regional economy in Jilin Province. The conclusions can also be used for reference for similar research methods. The main conclusions of this study are as follows: (1) From 2009 to 2019, Jilin province's manufacturing, tourism, and regional economic comprehensive development index changed differently. The economic level maintained an upward trend, while the manufacturing and tourism industries showed a trend of first rising and then slowly falling. The economic level index has an enormous difference among them, and the growth is the most obvious. (2) The coupling coordination degree between manufacturing, tourism, and regional economy in Jilin Province has changed significantly during the study period, increasing from 0.1408 in 2009 to 0.7941 in 2019, changing from a serious imbalance state to a moderate coordinate state. As a whole, Jilin Province's manufacturing, tourism, and regional economy have a relatively high level of coupling and coordination and are in a state of good coupling coordination. (3) The coupling coordination degree of manufacturing, tourism, and regional economy in Jilin Province from 2009 to 2019 showed an overall upward trend in 2009-2016 and a downward trend in 2017-2019. The result is consistent with the overall trend of the comprehensive evaluation index of the manufacturing, tourism, and regional economy of Jilin Province from 2009 to 2019. When the comprehensive evaluation index of the three subsystems of manufacturing, tourism, and regional economy is low, and the difference is large, the value of the coupling and coordination of the three subsystems is low. When the comprehensive development index of the three subsystems grows at a constant speed, the

coupling coordination degree also shows the same growth trend and reaches a moderate coordinate state.

In the future, Jilin province will propose optimization measures based on resource endowments, regional conditions, and tourism upgrade methods to build a coordinated development pattern of efficient manufacturing, tourism, and economic development. Therefore, relying on Jilin Province's industrial development advantages, the government should further strengthen the support and guidance for the manufacturing industry. Promote the transformation of the manufacturing industry, eliminate outdated production capacity, further deepen system reform, and actively develop high-end equipment manufacturing, intelligent manufacturing, and green manufacturing. At the same time, enhance technological innovation and promote the manufacturing industry in Jilin Province to the high-end industrial value chain, high-end equipment manufacturing industry cluster, to support tourism and economic development. At this stage, the high-quality economic development of Jilin Province is also inseparable from the sustainable development of tourism. Based on ecological environment protection, the government should promote the development and upgrading of tourism through tourism development to optimize and upgrade other industries in Jilin Province to promote regional economic development. Moreover, innovate tourism development methods, and create diversified tourism methods to attract tourists in order to realize the coordinated development of manufacturing, tourism, and regional economy.

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