

Study on the Coupling Relationship Between Rural E-Commerce and Rural Economy

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Abstract—In order to promote the coordinated development of both rural e-commerce and rural economy, and better solve the "three rural issues", we conducted an empirical analysis of the coupling development of the two systems. We selected the national rural e-commerce and rural economy in 2014-2020 as the research object, built an indicator system, and calculated the indicator weights of both e-commerce and economy in the countryside of China using the entropy method, and establish the evaluation model and coupling evaluation model for the development level of both e-commerce and economy in the countryside. The results show that the development level of e-commerce in the village and rural economy is basically in the same direction, showing an upward trend as a whole. There is a mutual influence relationship between the two systems, and the extent of coupling coordination is gradually increasing. By 2020, it will reach the level of high-quality coordination, and provide relevant suggestions for the sustainable and coordinated development of the two systems.

Keywords-Rural e-commerce; rural economy; Coupling analysis.

1. Introduction

Promoting the rural economy, improving farmers' lives, and achieving all-round prosperity are important tasks of the current "three rural" work in China, especially in the critical period when the current evolution of economy stepped into the new normal and the industrial structure is facing major adjustment. With the development of traditional rural industries in trouble, the era of e-commerce with "Internet+" as the leading force is coming, which effectively solves the space-time constraints of commodity trading, Become an important leader in pushing the countryside to the market front. Hence, the analysis of relations of both rural e-commerce and rural economy is crucial and promote their coordinated development to deal with the "three rural" problem.

Nowadays, a great deal of literatures on rural e-commerce and rural economy. Mu Yanhong et al. (2016) selected 15 e-commerce model regions of Heilongjiang Province as samples, measured the affecting elements of e-commerce in the countryside, using structure equal mode in the village, and believed that the circulation factor is one of the core factors affecting the evolution of rural e-commerce [1]. Fang Ziyang (2021) explored the case of four "Taobao villages" in Qixia District, Nanjing City, where e-commerce in the countryside helped rural revitalization. Starting from the current situation of e-commerce evolution in the countryside, he fo-

cused on analyzing four mature e-commerce models, and explored the specific reasons for their successful development^[2]. Wu Xiaoer (2021) studied the impact of fiscal expenditure on rural economic growth using multiple linear regression model, showing that education expenditure has heavy influence on the economic growth in the village. The improvement of residents' consumption level has a certain role in promoting the rural economy^[3]. Xie Xiuliang (2021) took Dongfeng Town, Fujian Province, as an example to discuss the path of rural economic development under the rural revitalization strategy^[4].

With limited analysis on the relations of both rural e-commerce and rural economy, and most of them are qualitative analysis. Liu Kai (2021), taking Shandong Province as an example, proposed that rural e-commerce model can further promote rural economic development by summarizing the obvious advantages brought by rural e-commerce model for rural economic development^[5]; Zhu Fangfang (2021) studied the effect on e-business on economy in the village under the context of new rural construction and proposed corresponding development measures^[6]. In this paper, the quantitative analyzing method is adopted to study the realtions of both e-commerce and economy in the village. The results are more scientific and objective. The entropy method is employed for determining the index weight of e-commerce and economy in the village in China, and the evaluation model and coupling evaluation mode of e-business and economic in the countryside are established. Finally, the suggestions for the coupling evolution of e-business and economy in the countryside are put forward to offer reference for solving the "three rural" problems.

2. Research Methods

2.1 Entropy method

Entropy method is a method to determine the index weight according to the number of message offered by the observation value of each indicator. This evaluation method is objective and can reduce the deviation caused by subjective factors. Let x_{ij} ($i=1, 2, \dots, n$; $j=1, 2, \dots, m$) be the observation data of index j in the i -th system (evaluated object). For a given j , the larger the distinction of x_{ij} , the larger the comparative effect of this indicator on the evaluated object. The calculation process of entropy method is as follows:

Data standardization. For the sake of eliminating the influence on units of each indicator and the huge difference between numerical magnitude, the range method is used to standardize the data, and the standardized data is recorded as p_{ij} .

$$p_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (1)$$

Calculate the entropy value of each index, e_j is information entropy, and k is the constant $k=1/\ln(n)$.

$$e_j = -k \sum_{i=1}^n p_{ij} \ln p_{ij} \quad (2)$$

Count the difference coefficient of each indication.

$$g_j = 1 - e_j \quad (3)$$

Determine weights.

$$w_j = g_j / \sum_{j=1}^m g_j \quad (4)$$

2.2 Rural E-commerce and Rural Economic Development Level Model

On the basis of the entropy method to determine the index weight, combined with the linear weighting method to calculate the rural e-commerce and rural economic development level, the particular equations are described in the following part:

$$f(x) = \sum_{j=1}^m w_j p_{ij} \quad (5)$$

$$g(y) = \sum_{j=1}^m v_j p_{ij} \quad (6)$$

$f(x)$ represents the development level of rural e-commerce, $g(y)$ represents the development level of rural economy, w_j and v_j are the weights of e-business and economy in the village indicators respectively, and p_{ij} is the standardized value of rural e-commerce or rural economy indicators.

2.3 Rural E-commerce and Rural Economy Coupling Coordination Model

Coupling indicates the degree of coordination of interaction and coupling between two or more systems. The value range of coupling degree C is 0-1. The value range of coupling degree C is 0-1. The larger the C , the greater the coupling degree between systems; When C tends to 0, the coupling degree is getting smaller and smaller, and each parameters are in a disorder state and independent development. The calculation formula is as follows:

$$C = \sqrt{\frac{f(x)g(x)}{[(f(x) + g(x)) / 2]^2}} \quad (7)$$

Since the coupling extent can only describe the interaction of the system, it cannot reflect the level of coupling coordination, which should be measured by the coupling coordination extent. The calculation formula of coupling compatibility is as follows:

$$D = \sqrt{CT} \quad (8)$$

$$T = \alpha f(x) + \beta g(x) \quad (9)$$

D is coupling coordination degree of e-business and economy in the countryside, the comprehensive evaluation index of e-business and economy in the countryside is T, α and β are constants.

3. Empirical Analysis

3.1 Establishment of indicator system

For the sake of analyzing the coupling relations both e-commerce and economy in the rural areas, establish an assessment mechanism of e-commerce and economy in the countryside, and refer to the research contents of Wang Qigou^[7] and Xie Tiancheng^[8], select five indicators as the development level indicators of rural e-commerce in China: rural online retail sales, agricultural product online retail sales, number of Taobao villages, rural Internet users, and rural Internet penetration rate. The level of rural economic development is comprehensively measured by four indicators just as Wang Yue^[9], namely, the total value of agriculture, forestry, animal husbandry and fishery, the total power of agricultural machinery, the disposable income of rural residents, and the personal Consumption cost of people in the countryside. The specific indicator system is presented as table 1.

Table 1 Indicator System of Rural E-commerce and Rural Economy

| item | index |
|------------------------------------|---|
| Rural e-commerce development level | Rural online retail sales (trillion yuan) |
| | Online retail sales of agricultural products (100 million yuan) |
| | Number of Taobao villages |
| | Rural Internet users (100 million) |
| | Rural Internet penetration rate (%) |
| Rural economic development level | Total cost of agriculture, forestry, animal husbandry and fishery (RMB 0.1 billion) |
| | Total power of agricultural machinery (10000 kW) |
| | Disposable revenue of people in the countryside (RMB) |
| | Personal Consumption of people in the countryside (yuan) |

3.2 Data source

The data of rural online retail sales and online retail sales of agricultural products are from the Research Report on China's Rural E-commerce Market in 2020 by AIMEDIA Data Center (data. iimedia. cn); The relevant data on the scale of rural Internet users and the rural Internet penetration rate are from the China Information Yearbook and the statistics of the Ministry of Industry and Information Technology from 2015 to 2020; The four indicators of rural economic level are from the China Statistical Yearbook 2015-2020. The raw data of each indicator is provided in table 2.

Table 2 Original Data of Rural E-commerce and Rural Economy

| year | E-commerce in the countryside | | | | |
|------|---|---|---|---|---------------------------------|
| | Rural online retail sales (trillion yuan) | Online retail sales of agricultural products (100 million yuan) | Number of Taobao Village | Rural Internet users (100 million) | Rural Internet penetration rate |
| 2014 | 0.18 | 1000 | 212 | 1.78 | 28.8 |
| 2015 | 0.35 | 1456 | 779 | 1.95 | 31.6 |
| 2016 | 0.89 | 1588.7 | 1311 | 2.01 | 33.1 |
| 2017 | 1.24 | 1723 | 2118 | 2.09 | 35.4 |
| 2018 | 1.4 | 2305 | 3202 | 2.22 | 38.4 |
| 2019 | 1.7 | 4168.6 | 4310 | 2.5 | 46.2 |
| year | rural economy | | | | |
| | Total value of agriculture, forestry, animal husbandry and fishery (1 billion yuan) | Total power of agricultural machinery (10000 kW) | Disposable income of rural residents (yuan) | Personal consumption cost of people in the countryside (yuan) | |
| 2014 | 97822.5 | 108056.6 | 10448.9 | 8382.6 | |
| 2015 | 101893.5 | 111728.1 | 11421.7 | 9222.6 | |
| 2016 | 106478.7 | 97245.6 | 12363.4 | 10129.8 | |
| 2017 | 109331.7 | 98783.3 | 13432.4 | 10954.5 | |
| 2018 | 113579.5 | 100371.7 | 14617 | 12124.3 | |
| 2019 | 123967.9 | 102758.3 | 16020.7 | 13327.7 | |

Table 3 Weights of indicators of rural e-commerce and rural economy

| item | index | Entroy | Weight |
|------------------------------------|--|--------|--------|
| Rural e-commerce development level | Rural online retail sales (trillion yuan) | 0.6085 | 0.3130 |
| | Online retail sales of agricultural products (100 million yuan) | 0.7407 | 0.2074 |
| | Number of Taobao villages | 0.7664 | 0.1868 |
| | Rural Internet users (100 million) | 0.8276 | 0.1379 |
| | Rural Internet penetration rate (%) | 0.8062 | 0.1550 |
| Rural economic development level | Total number of agriculture, plants and animal husbandry and fish (¥1 billion) | 0.8290 | 0.1860 |
| | The sum of power of machines for agriculture (10000 kW) | 0.7799 | 0.2393 |
| | Disposable revenue of people in the countryside (RMB) | 0.7661 | 0.2544 |
| | Personal consumption cost of people in the countryside (RMB) | 0.7054 | 0.3204 |

Substitute the standardized data and corresponding weights into Formula (5) - (9). Since the development of rural economy is mainly motivated by the development of rural e-commerce, the values α , β are 0.6 and 0.4 respectively. The comprehensive development level, coupling degree and coupling coordination degree of e-business and economy in the village are shown in Table 4 and Table 5, The variation tendency can be seen in the following chart1 and Figure 2.

3.3 Empirical results

The data in Table 2 are standardized using Formula (1) to facilitate subsequent data calculation. Take 0.01 as the value of 0. Substitute the standardized data into Formula (2) - (4) to obtain the entropy value and percentage of every index, which is presented in the following chart 3.

Table 4 Comprehensive Development Level of Rural E-commerce and Rural Economy

| year | f(x) | g(x) | T | F (x) vs. g (x) | Comprehensive development type |
|------|--------|--------|--------|-----------------|--------------------------------|
| 2014 | 0.0100 | 0.1862 | 0.0805 | f(x)<g(x) | Rural e-commerce lag |
| 2015 | 0.0969 | 0.3457 | 0.1964 | f(x)<g(x) | Rural e-commerce lag |
| 2016 | 0.2280 | 0.2306 | 0.2301 | f(x)<g(x) | Rural e-commerce lag |
| 2017 | 0.3475 | 0.3521 | 0.3534 | f(x)<g(x) | Rural e-commerce lag |
| 2018 | 0.4758 | 0.5085 | 0.4889 | f(x)<g(x) | Rural e-commerce lag |
| 2019 | 0.7123 | 0.7220 | 0.7162 | f(x)<g(x) | Rural e-commerce lag |
| 2020 | 0.9206 | 0.8991 | 0.9120 | f(x)>g(x) | Rural economy lag |

Table 5 Types of Coupling and Coordinated Development of Rural E-commerce and Rural Economy

| year | Coupling degree | Coupling coordination | Coupling and coordinated development type |
|------|-----------------|-----------------------|---|
| 2014 | 0.4398 | 0.2256 | Moderately disordered |
| 2015 | 0.8269 | 0.4512 | on the verge of dysregulation |
| 2016 | 0.9993 | 0.4768 | on the verge of dysregulation |
| 2017 | 0.9999 | 0.5926 | Barely coordinated |
| 2018 | 0.9994 | 0.7037 | Intermediate Coordinator |
| 2019 | 0.9999 | 0.8474 | well coordinated |
| 2020 | 0.9999 | 0.9527 | Quality coordination |

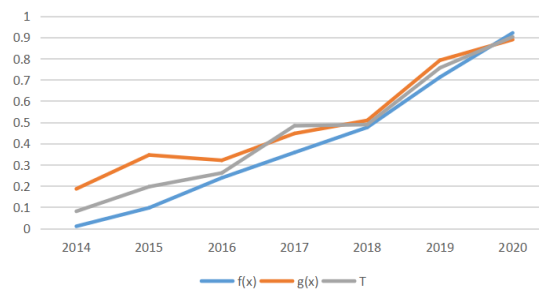


Figure 1 Rural E-commerce and Rural Economic Development Level

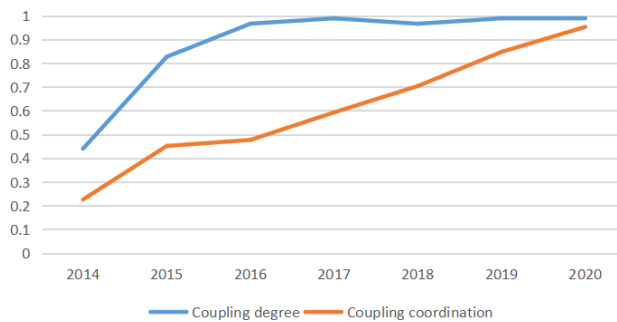


Figure 2 Coupling degree and coupling coordination degree of Rural E-commerce and Rural Economic Development Level

3.4 Analysis of results

3.4.1 Analysis on the comprehensive development level of rural e-commerce and rural economy

(a) development level of e-business in the countryside

From the weights in Table 3, it can be seen that rural online retail sales can best reflect the development level of e-business in the countryside, with a weight of 0.313, followed by Online

trading volume of agricultural products, and the smallest weight is the scale of rural netizens, with a weight of 0.1379.

The data presented in figure 1 that the comprehensive development level of rural e-business during the period of 2014 to 2020 shows a gradual upward development trend. The data from the table can be found that the comprehensive development level score of the rural e-commerce industry has risen from 0.01 in 2014 to 0.92 in 2020. The development of e-business is very fast, especially in 2019. The e-commerce development level score has increased the most, from 0.4758 in 2018 to 2019. of 0.7123. The reason is that 2019 is a critical year for poverty alleviation, and e-commerce poverty alleviation as an industrial poverty alleviation welcomes more policies or support. The first paperwork of the Central Committee of the Communist Party of China in 2019 pointed out: continue to carry out comprehensive demonstration of e-commerce into rural areas, and implement the "Internet +" project of agricultural products going outside the rural areas and entering into the urban areas. This is the sixth time since 2014 that the No. 1 document of the Central Committee of the Communist Party of China has focused on rural e-commerce.

(b) The level of development of rural economy

On the basis of the table, the fact can be known that the consumption expenditure of rural residents can best reflect the development of the rural economy, with a weight of 0.3204. The smallest weight is the whole output cost of agriculture, forestry, fishery and animal husbandry, with a weight of 0.186. The whole power of agricultural machinery is in the middle, indicating the level of agricultural mechanization. It also has a great impact on the rural economy, and improving the level of rural mechanization will help develop the rural economy.

It can be seen from figure 1 that the overall level of rural economic development from 2014 to 2020 showed an upward trend, slightly decreased in 2016, and then gradually increased. The forth chart could provide the comprehensive development level score of the rural economy in 2014 was 0.1862, the lowest in 2014-2020; The overall score of the rural economy in 2020 is 0.8991, which is the highest in 2014-2020. The comprehensive economic development level score in 2020 is 4.83 times that of 2016. In recent years, the rural economy has achieved good development.

(c) Comprehensive development level

From the perspective of the development level of the two systems, the comprehensive coordination function T of the e-business industry and the economy in the village from 2014 to 2020 shows a gradual upward trend. The comprehensive coordination function of e-business industry and economy in the village the year of 2020 is the highest level of development in 2014-2020, and the comprehensive coordination function value is 0.912, which is 10.7 times that of 2014, the lowest level of comprehensive development. From 2014 to 2019, $f(x) > g(y)$, the evolution of e-business in the countryside is slower than that of rural economy, which is manifested as lagging of rural e-commerce. In 2020, the development of rural economy is slower than that of rural e-commerce, which is manifested as lagging rural economy.

3.4.2 Coupling and coordination analysis of e-business and economy in the village

It can be seen from Table 5 and figure2 that there is a mutual influence lies in both the rural e-business industry and the rural economy, which will grow to the highest level in 2020 and

reach a high-level coordination stage. From this point of view, the sustainable and stable evolution of the rural e-commerce industry can improve the evolution of the rural economy in a sense. Similarly, the sustainable and stable development of rural e-commerce industry can promote the development of rural economy to a certain extent, and the development of rural economy will also promote the development of rural e-commerce industry in turn, becoming one of the driving forces to promote the good development of rural e-commerce.

Overall, the coupling coordination degree between the e-business industry and the economy in the village is separated two phases. The period from 2014 to 2016 is the imbalance stage, and the value range of the coupling coordination degree is [0.2256, 0.4768]. The evolution of e-business in the village is relatively Lag, during this period, farmers were relatively unfamiliar with the emerging economic development format of e-commerce, and lacked relevant business experience. It is in the coordination stage from 2016 to 2020, and the value scope of coupling coordination degree is [0.5926, 0.9527]. Among them, it has reached a good coordination level in 2019, and achieved high-quality coordination in 2020. The coupling coordination degree is 0.9527, which is the highest coupling coordination degree in 2014-2020. At this stage, the government proposes to vigorously develop rural e-commerce, create various policies that benefit farmers, increase policy support, and strengthen the building of e-business in the village for the development of rural e-commerce, so that more and more farmers will see the advantages of developing rural e-commerce, an emerging industry type, and prompting more and more farmers to join the ranks of developing e-business in the countryside, promoting the relatively coordinated development of rural e-commerce and rural economy, and finally in 2020 It has achieved high-quality cooperative evolution of e-business and economy in the village.

4. Conclusions and Recommendations

4.1 Conclusion

According to constructing the assessment indicator system and coupling assessment mode of the two systems of e-business industry and economy in the village, the coupling and coordinated evolution of e-business and economy in the countryside is analyzed through time series, and the following three conclusions are drawn.

- 1) The development status between the two systems of e-business industry and economy in the village is in a state of development in the same direction. When the comprehensive development level score of rural e-commerce increases, the comprehensive development level score of rural economy generally also increases.
- 2) From the perspective of the comprehensive development level of rural e-commerce industry and rural economy, from 2014 to 2019, the development of rural economy continued to be higher than that of rural e-commerce. This shows that the contribution of rural economy to rural e-commerce is greater than the contribution of e-business evolution to the development in the village, which belongs to the rural economy-led coupling coordination. After 2019, the rapid evolution of e-business, which is higher than the development of rural economy, and it has changed into the rural e-business-led coupling coordination.
- 3) The coupling degree of e-business and economic development in the village is on the rise as a whole. The two systems gradually transition from the antagonistic stage to the running-in

coupling, and finally reach the high-level coupling stage. The two have a mutually reinforcing effect. The degree of coupling of both two systems is divided into 6 categories: moderate disorder, at the edge of disorder, hardly coordinated, intermediate adjustment, good coordination, and high-quality coordination, indicating that the interaction between the two systems continues to increase, gradually moving towards a healthy and orderly direction develop.

However, it is limited to public data, and the research object of this paper is national data, without considering the differences between provinces, cities and counties. With the expansion of public data, panel data of provinces, cities and counties can be used for more in-depth exploration.

4.2 Recommendations

At present, the level of coupling and coordinated development between e-commerce and economy in the village is good, but for the sake of maintaining the high-quality coupling and coordinated development between the two, there are some tips are raised as follows:

1)*To optimize the layout of rural e-commerce*: it is necessary to tap the local rural economic potential and create a commercialized and branded rural e-commerce model. For example, areas with good ecological agriculture can focus on the evolution of characteristic rural e-commerce, with the theme of ecological rural economy and characteristic rural economy, provide rural economic products, make up for the vacancy in the rural economic market, and increase investment in logistics and other infrastructure to achieve development breakthroughs. In other areas, the merits of traditional rural economy should be comprehensively made use, and then strengthen the planting of cash crops, increase capital investment in weak links such as e-commerce talents, and transfer the advantages of rural economy to e-commerce to form a joint development force.

2)*Improve the coordinated development of the industry*: For one perspective, the coordination of e-business in the village needs to grasp the characteristics of the rural economy. Agricultural products are typical fresh products. my country's long-distance logistics cold chain construction level is relatively low, and it is still not enough to ensure the freshness of agricultural products. Therefore, in major regions the completion of particular and efficient distribution according to the characteristics of agricultural yield to achieve the efficient transportation of agricultural yield is especially crucial; Collaboration between businesses.

3)*Under the new normal, the rural sector can use e-commerce to optimize supply and innovate rural business models in combination with the demand side*: Using two-way circulation channels to integrate logistics resources and information could accelerate the deep integration of e-business as well as rural agriculture. Through the establishment and improvement of two-way circulation channels, the integration of the e-commerce in the city and village will be realized, the rural consumer market will be expanded, the consumption potential of rural residents will be stimulated, and the re-development of the rural economy will be promoted.

Acknowledgement

This paper get the help from Guangdong Provincial Department of Education General Colleges and Universities Young Innovative Talents Project: Research on the formation mechanism and development path of rural e-business field agglomeration under the rural revitalization strategy (2019GWQNCX118) and Analysis of the integration path of rural industries in the

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