Exploring Economic Development Trends Through Entropy Analysis

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Abstract. This paper aims to explore the economic development trends by analyzing the potential information contained in entropy values. The study focuses on three industries and examines the timeline of entropy values to understand their development patterns. Initially, the GDP data of subsectors within the three industries are selected as the research objects. Entropy values for the GDP of these subsectors are then calculated for all available years, resulting in a time series of entropy values. The paper proceeds by analyzing the patterns of entropy values within a given year across different subsectors and within a given subsector across different years. The obtained results indicate the effectiveness of national economic policies, the narrowing differences within the first industry across regions, reflecting the determination to build a robust agricultural nation, and the increasing market competition in other industries. Additionally, the financial industry and wholesale and retail trade exhibit the highest market levels, indicating the continuous formation of strongholds in these two sectors.

Keywords: economy; entropy; industry; time-series

1 Introduction

Concern for economic development is at the core of both the Chinese people and the government. The level of economic development directly impacts the welfare of the people, and the Chinese government strives to develop the economy by estimating its developmental trends and adjusting strategies accordingly. Numerous scholars have conducted research on methods for estimating the national or local level of economic development. In particular, GDP has gained significant attention with the establishment of novel prediction models for GDP [1,2]. Additionally, spatial-temporal analysis methods have been employed to evaluate the spatial pattern evolution of GDP in different regions [3,4].

The Chinese economy is divided into three sectors: the primary sector, which involves the exploitation of natural resources; the secondary sector, with a focus on industry; and the tertiary sector, specialized in providing tertiary services [5]. The total GDP is composed of the GDP contributions from these three industries. In China, the proportion of the primary industry in GDP composition has rapidly decreased, while

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the proportions of the secondary and tertiary industries have significantly increased [6]. However, each industry within the three sectors holds importance. China is a country with a large agricultural sector, and rural revitalization is a fundamental long-term national policy. Industry serves as the core driver for the rapid development of the national economy and also plays a significant role in supporting the primary industry. Simultaneously, the goal of China's economic system reform is to establish a market economy, and the development level of the tertiary sector serves as a measure of the market economy's progress. Accordingly, evaluation methods for GDP pertaining to the three industries have been established.

China's regional agricultural economy mainly encompasses planting, animal husbandry, forestry, and fishery. Approximately 43% of the Chinese population is engaged in agriculture, and seeking integration between urban and rural areas while utilizing information platforms is a primary approach to development [6]. Currently, China's economic development aims to reduce dependence on the real estate and low-end export processing industries, emphasizing the vigorous development of the tertiary sector. The cultural tourism industry [7], knowledge economy [8], digital economy [9], and aviation economy [10] are of particular interest. Moreover, estimating economic resilience is also a crucial responsibility [11].

However, merely evaluating the developmental level and the advantages or disadvantages of the three industries is insufficient. It is more important to identify the potential and balance degree of these industries across different regions. This paper aims to explore the economic data obtained from China's National Bureau of Statistics to uncover the potential and balance degree of the three industries from a subsector's perspective and investigate the developmental trends of the economy.

The remainder of this paper is structured as follows: The "Literature Review" section discusses the methods employed for evaluating GDP's level of development. The "Data and Methodology" section describes the approach used to identify the economy's potential. The "Discussion" section examines the development trends within the subsectors of the three industries. Finally, the "Conclusion" section summarizes the findings of this research.

2 Literature review

This paper focuses on studying the development trends of subsectors within the Chinese economy. Specifically, the GDP of various industries is selected as the object of study. In the primary industry, the GDP of agriculture, forestry, animal husbandry, and fishery is examined. In the secondary industry, the focus is on the construction industry. In the tertiary sector, the GDPs of transportation, warehousing and postal services, the financial industry, wholesale and retail trade, and the accommodation and catering industry are analyzed.

While GDP in a district can be considered constant in a given year, spatial-temporal analysis methods are typically employed to evaluate its aggregation characteristics [1,2]. Spatial regression models are utilized to analyze the factors affecting GDP [12]. However, GDP across different districts or years is a random variable. According to the

literature [13], random variables can be evaluated using information measures. Information theory, which originated from Shannon's concept of entropy or differential entropy, has been extensively explored in various fields, such as mathematics, statistics, dynamical systems, and information theory [13]. Therefore, entropy serves as a scientific and applicable method for studying the distribution patterns of the three industries.

Liu and Jiang et al. employ the entropy method to measure the quality of the marine environment and marine-fishery-economic quality. They calculate the weights of evaluation indices based on entropy and derive a comprehensive evaluation score for the target [14]. Ma and Zhang et al. use the entropy method to analyze the influencing factors of high-quality development in the open economy of the Yangtze River Delta area [15]. Wang and Yuan et al. assess sustainable development capacity using the entropy weight coefficient method [16]. Scholars continuously improve the entropy method, such as Wang and He combining the analytic hierarchy process (AHP) with entropy weighting to measure the development level of China's digital economy [9]. Xu and Huang apply the entropy weight coupling model to measure the coupling and coordinated development level of two systems [17]. Additionally, scholars combine the entropy method [18], TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method [19], and entropy weighted TOPSIS method to evaluate economic growth in China [20]. Moreover, the entropy method and an improved TOPSIS method are used to assess the sustainability of the marine economy in China's coastal areas [19].

Based on the aforementioned research, it is evident that entropy, as a quantitative measure of information, has been widely applied to evaluate economic development. However, its potential capacity is often limited to serving as weights for indices, and its deeper implications have not been fully explored. This paper aims to uncover the profound implications of entropy in economic indices to analyze the development trends of the economy.

3 Data and Methodology

This paper utilizes original GDP data obtained from the National Bureau of Statistics of China. The data include the GDPs of agriculture, forestry, animal husbandry, and fishery; the GDP of the construction industry; and the GDPs of transportation, warehousing and postal services, the financial industry, wholesale and retail trade, and the accommodation and catering industry. The data span from 2013 to 2022 and encompass 31 provinces, autonomous regions, and municipalities in China. As the data are readily available for download from the website of the National Bureau of Statistics of China, this paper provides an example in Table 1 showcasing the GDP of the construction industry. However, for the sake of brevity, the data for other subsectors within the three industries are omitted.

Table 1. GDP of the construction industry (Unit: 100 million yuan)

Regions	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Beijing	872	952.7	1002.6	1074.5	1210.9	1387.8	1477.4	1528.2	1591.5	1614.2
Tianjin	625	677.2	695.6	710.8	704	674.1	693.8	714.3	745.9	724.7
Hebei province	1361	1452	1524.4	1610.1	1796.8	2007.9	2118.9	2135.8	2263.7	2413.6
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The methodology is as follows:

Step 1. For one subsector of the three industries, calculate the sum of GDP of a given year for different regions, as shown in equation (1).

$$R_j = \sum_{i=1}^{n} r_{ij} \quad (i = 1,2 \ldots n, j = 1,2 \ldots m) \tag{1}$$

Where R_j is the sum of GDP in a given year; r_{ij} is the value of GDP of a region in a given year; i is the province; and j is the year.

Step 2. Calculate the proportion p_{ij} of the GDP of i province in j year based on equation (2).

$$p_{ij} = r_{ij}/R_j \tag{2}$$

Step 3. Calculate the entropy value of this subsector in a given year on the basis of equation (3).

$$E_j = -1/\ln(m).\sum_{j=1}^{m} p_{ij} ln(p_{ij}) \quad (i = 1,2 \ldots n, j = 1,2 \ldots m) \tag{3}$$

Step 4. Calculate the entropy value of the other subsectors.

The entropies of subsectors selected in this paper are shown in Table 2.

Table 2. Entropies of subsectors selected in this paper

Subsectors	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
A	0.9217	0.9226	0.9222	0.9228	0.9226	0.9237	0.9242	0.9253	0.9263	0.9271
B	0.9316	0.9307	0.9280	0.9284	0.9240	0.9198	0.9192	0.9206	0.9197	0.9169
C	0.9255	0.9256	0.9275	0.9279	0.9270	0.9282	0.9259	0.9265	0.9240	0.9235
D	0.8982	0.9029	0.9024	0.9042	0.9042	0.9037	0.9013	0.8966	0.8939	0.8921
E	0.8887	0.8887	0.8861	0.8851	0.8874	0.8862	0.8862	0.8851	0.8846	0.8841
F	0.9160	0.9159	0.9158	0.9141	0.9138	0.9138	0.9123	0.9094	0.9088	0.9044

Annotations: A: agriculture, forestry, animal husbandry and fishery; B: construction industry; C: transportation, warehousing and postal services; D: financial industry; E: wholesale and retail trade; F: accommodation and catering industry.

4 Discussion

Entropy is a measure of the uncertainty associated with possible events. A higher entropy signifies greater uncertainty, while an entropy of 1 indicates a balanced state among all events.

By analyzing Table 1, we can extract valuable information. Across all subsectors, the entropies of the construction industry from 2013 to 2016 are consistently the highest. This indicates that the construction industry flourished in all provinces of China during this period, demonstrating a high degree of equilibrium within the industry. Conversely, the entropies of the transportation industry reached their peak from 2017 to 2020. This can be attributed to real estate policies that led to a contraction in the construction industry and rapid development of the transportation industry. The entropies of agriculture, forestry, animal husbandry, and fishery are among the highest across all subsectors, which can be attributed to the nationwide policy of rural revitalization.

Examining the entropy of a specific subsector from 2013 to 2022, we observe that the entropies of agriculture, forestry, animal husbandry, and fishery consistently increase. This trend indicates that the development of the agricultural industry is valued in all regions of China, leading to reduced regional disparities and a move toward more balanced development. In contrast, the entropies of the construction industry continuously decrease, indicating an increasing imbalance among different regions. This reflects the reality where developed regions witness massive investments in the construction industry, while undeveloped regions experience lower investment levels. The entropies of the transportation industry exhibit fluctuations, particularly a continuous decrease from 2020 to 2022 due to the impact of the COVID-19 pandemic.

Regarding the financial industry, there is a peak in entropies in 2016 and 2017, followed by a slight decrease. This reflects the concentration of the financial industry, particularly the presence of financial centers in the Yangtze River Delta and Greater Bay Area. The entropies of wholesale and retail trade are the lowest among all subsectors, indicating significant regional disparities in purchasing power and an imbalance in economic development. The entropies of the accommodation and catering industry steadily decrease, indicating the gradual formation of a hierarchical structure within this industry.

Table 2 also highlights the significant role played by national policies. The rural revitalization policy promotes balanced development across different regions in the agriculture, forestry, animal husbandry, and fishery sectors. The market economy policy drives competition in mature markets and fosters the development of intensive industries.

5 Conclusions

Monitoring and evaluating the trend of economic development is crucial because it aids in estimating the effectiveness of policies and provides data support for formulating new policies. Various methods, including assigning scores to evaluation indices, are employed to assess the level of economic development. One such method is the entropy

model, which calculates index weights. However, this approach often overlooks the valuable information embedded within the entropy values. In reality, entropy serves as a useful tool for reflecting changes in GDP.

This paper explores the development trend of the economy by analyzing the potential information contained in entropy values. The findings indicate that the GDP development of subsectors within the three industries aligns with the actual situations. By combining entropy values with the timeline, we can easily calculate and uncover the patterns of economic development. Several key observations emerge from this analysis. First, economic development trends are influenced by economic policies, highlighting the efficiency of national macro control measures. Second, the development levels of the primary industry in different regions are progressively converging, reflecting the commitment to building a strong agricultural sector. Third, the market levels of other industries gradually increase, showcasing the power of market competition. Fourth, the financial industry and wholesale and retail trade exhibit the highest market levels, signifying the formation of prominent centers within these industries and their role as leaders in financial and retail trade activities.

The author acknowledges that this study discusses the economic development trend by analyzing the entropy values of GDP subsectors within the three industries and presents certain results. However, these findings represent the overall trend and are primarily suited for macro control purposes. Furthermore, this research is based on official data, and the specific conditions of different regions are not deeply explored. For relevant policy-making, further in-depth studies should be conducted to account for regional variations and specific circumstances.

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