Research on the Its Economy Based on TOPSIS Entropy Weight Method and Spearman Correlation Analysis

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Abstract. Its Economy refers mainly to the economy of the pet industry. In the process of social modernization, the role of Its Economy in constituting the main economy and promoting social development has become more and more obvious, and it is of great significance to study its future development. This paper adopts Spearman correlation analysis and TOPSIS entropy weight method for data analysis and research, and analyzes from both micro and macro perspectives to establish Its Economy Development Evaluation Model. This paper analyze the correlation between the economic indicators and social indicators affecting Its Economic development, and compare and rank the weights of the indicators affecting Its Economic development, so as to draw the correlation between the each influencing indicators, the weights of the indicators, and the ranking of the development of the pet industry in each province in China. These conclusions provide suggestions and references for the development and economic regulation of the Its Economy.

Keywords: EWM-TOPSIS, Spearman Correlation Analysis, Economy, Pet Industry.

1. Introduction

With the rapid development of economy and society and the improvement of people's living standard, pets have gradually become a part of many families '[1]. In 2023, China's pet industry and its affiliated industries have an economic scale of nearly 300 billion yuan [2]. This new type of economy is called the Its Economy. Under the influence of multiple social factors, such as the aging of society and the persistently low marriage rate, pets not only provide emotional value to human beings, but also play a unique role in society, bringing economic effects and social value [3]. Studying the development of the pet industry can help provide reliable power and advice for the future diversified economy and society, and promote the development of the Its Economy and the index of industry share [4] [5]. Wang *et al.* suggested that the number of pets in China has changed considerably over the past few years, maintaining an overall upward trend, and its influencing factors are complex and diversified [6]. Meanwhile, Song *et al.* argued that the influencing factors of the industry development can be analyzed from external aspects (such as SWOT analysis), internal aspects (such as Porter's Five Forces Model analysis), or other more aspects of the analysis, and that a comprehensive analysis of multiple factors tends to be more effective [7]. Jiang *et al.* further integrated and proposed multi-factor analysis of China's pet industry development on this basis [8]. Liu *et al.* and Wang *et al.* proposed that the analysis method of multi-factor correlation of irregularly distributed data can be Spearman correlation analysis, and the common influence of multi-faceted multi-factors can be determined by TOPSIS entropy weight method to determine the size of the indicator weights and sorting [9] [10]. Considering the factors affecting the change of the number of pets in China and the development of China's pet industry, and combining the analysis angles and suggestions put forward by previous scholars, the method of combining the micro-macro analysis and the correlation analysis of internal factors is more appropriate for the comprehensive analysis of multi-faceted and multi-factors. This paper searches for relevant information and literature, adopts Spearman correlation analysis and TOPSIS entropy weight method to comprehensively analyze the factors affecting China's pet industry, to better study the development of Its Economy.

(Data Resources: http://www.apmcm.org/)

2. Overview of pet industry development in each Chinese province

2.1. Data on the number of pets in each Chinese Province

According to the findings of Xu *et al.*, cats and dogs are currently the two most important types of pets in China, with the number of cats and dogs accounting for 87% and more of the country's pets, and it is representative to conduct research on cats and dogs separately [11]. According to the 2023 China Pet Industry White Paper, the number of domestic pet cats in China reached 69.8 million, and the number of domestic pet cats in China has reached 51.7 million.

In order To determine the change and rate of change of the number of pet cats in China in the past five years, let NC_i be the number of pet cats in China in the year i, and let RC_i be the growth rate of pet cats, then there is a formula for (1):

$$RC_i = \frac{NC_{i+1} - NC_i}{NC_i} \tag{1}$$

When RC_i is greater than 0, the number of pet cats in the $i+1$ year is greater than that of pet cats in the i year, which is the increasing trend. When RC_i is less than 0, the number of pet cats in the $i+1$ year is less than the number of pet cats in the i year, which is a decreasing trend. The greater the absolute value, the greater the growth or decrease, and the more obvious the trend.

Likewise, let ND_i be the number of pet dogs in China in the year i, and let RD_i be the growth rate of pet dogs, then there is a formula for (2):

$$RD_i = \frac{ND_{i+1} - ND_i}{ND_i} \tag{2}$$

When RD_i is greater than 0, the number of pet dogs in the $i+1$ year is greater than that of pet dogs in the i year, which is the increasing trend. When RD_i is less than 0, the number of pet dogs in the $i+1$ year is less than the number of pet dogs in the i year, which is a decreasing trend. The greater the absolute value, the greater the growth or decrease, and the more obvious the trend.

Visualize the *NC*, *ND*, *RC* and *RD* values of each year to see the trend and characteristics of the pet cat and dog number in China. Meanwhile, visualize the number of pets in each province in China. It will show the geographical distribution characteristics of the pet number in China. The trend of the number of pets and the characteristics of the geographical distribution are shown in the Fig 1-5.

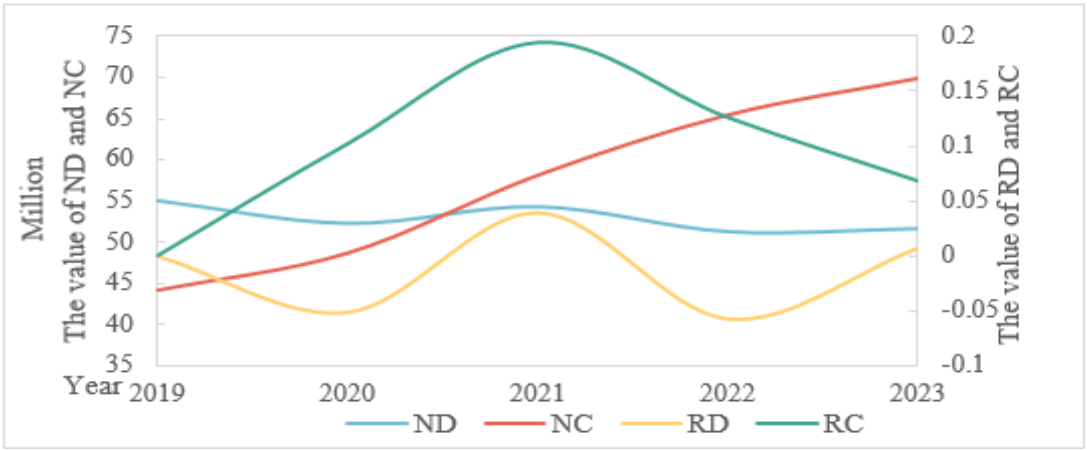

Fig 1. Smooth Line Chart of Chinese Pet Number and Growing Index.

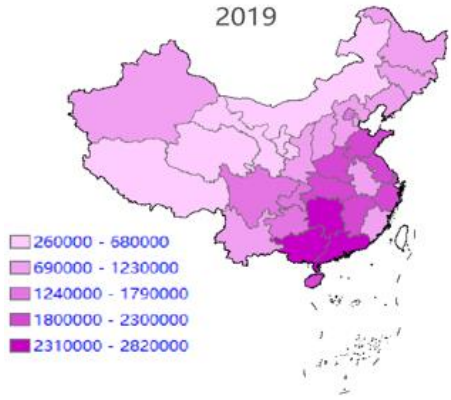

Fig 2. Map of the Number of Pet cat in each Province in 2019.

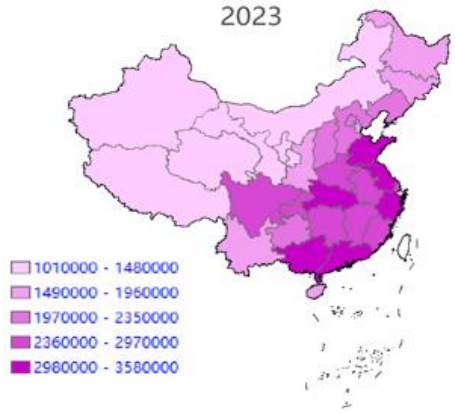

Fig 3. Map of the Number of Pet cat in each Province in 2023.

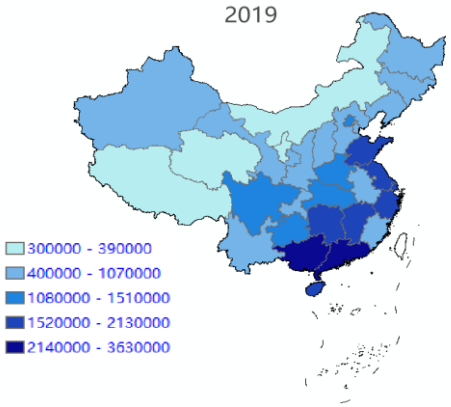

Fig 4. Map of the Number of Pet dog in each Province in 2019.

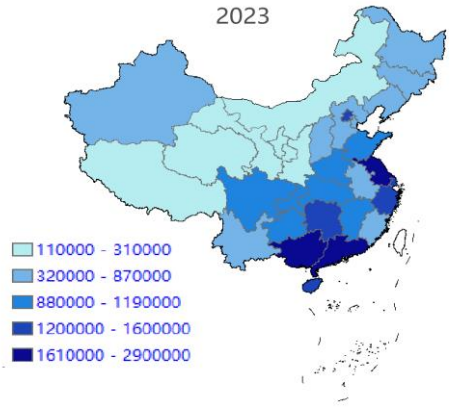

Fig 5. Map of the Number of Pet dog in each Province in 2023.

Based on Fig 1, it can be drawn that in China, from 2019 to 2023, the number of pet cats kept rising, and the number of pet dogs fluctuated and decreased. The growth rate of pet cats changed from fast to slow and peaked in 2021. The growth rate of pet dogs was sometimes positive and sometimes negative, with an overall decreasing trend.

Based on Fig 2-3, it can be drawing that in the past five years, most provinces of the number of pet cats rose, and the number of pet cat in eastern and southern China is denser.

Based on Fig 4-5, it can be drawing that in the past five years, the number of pet dogs in some provinces has risen (such as Chongqing, Beijing), the number of pet dogs in most provinces has declined, and the number of pet dogs in some provinces has remained relatively stable.

Comparing the industry development of pet cats and pet dogs, it can be understood that the number of pet cats in the eastern part of China grows faster and in higher numbers, which may be related to factors such as population size, urbanization, and the concept of pet ownership , and it is also understood that there are fluctuations and reductions in the number of pet dogs, which may be related to the impact of epidemics and the policy of dog ownership. To better analyze the future trend of the number of pet dogs and cats, and to forecast the size of Its Economy with high precision, it is necessary to use high correlation indicators as the factor to research on the development of the industry in China.

2.2. Selection of factors affecting pet industry

Lu suggested that there are three main factors affecting the development of the pet industry: economic aspects, social aspects and pet-related aspects [12]. The main factors selected are shown in the below Table 1 and Fig 6:

Table 1. Three Aspects of the Selected Factors affecting Pet Industry and Their Specific Factors.

	Economic aspect	Social aspect	Pet-related aspect
1	Gross Domestic Product	Single Population	The Number of Cat or Dog
2	Gross National Income	Education Attainment	Online Searching of Cat or Dog
3	Disposable Personal Income	Aging Population Ratio	Pet Store Count
4	/	/	Pet Hospital Count
5	/	/	Pet Literature Count

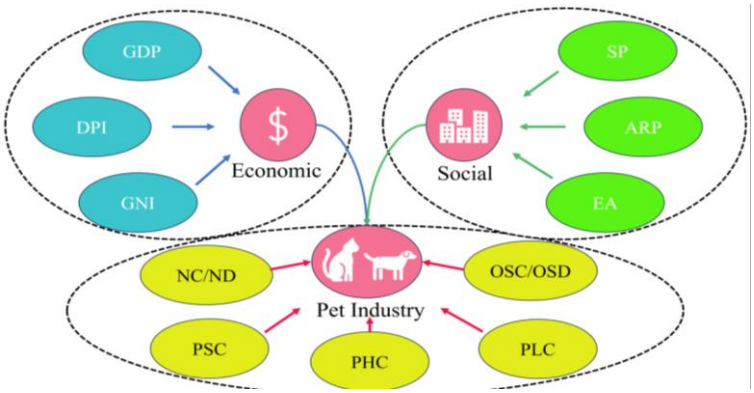

Fig 6. The Chart of Composition and Relationship between the Factors of Three Aspects.

Based on the Fig 6, it can be drawing that economic factors and social factors firstly affect the pet-related factors, and all three work together to influence the development of the pet industry, ultimately affect the development of Its Economy.

3. The construction of Its Economy Development Evaluation Model

3.1. Spearman correlation analysis

Collect the data of all the indicators mentioned in 2.2 for Spearman correlation analysis, and to make the indicators more current, it would be more appropriate to use indicators from 2019 to 2023.Since the development of the pet cat and dog industries are different, Spearman correlation analyses of pet cats and dogs should be conducted separately to better study the development of its economies under different pet types. The correlation analysis is shown in the formula (3)-(4).

$$\rho = \frac{\frac{1}{n}\sum_{i=1}^{n}\left(R(x_i)-\overline{R(x)}\right)\cdot\left(R(y_i)-\overline{R(y)}\right)}{\sqrt{\left(\frac{1}{n}\sum_{i=1}^{n}\left(R(x_i)-\overline{R(x)}\right)^2\right)\cdot\left(\frac{1}{n}\sum_{i=1}^{n}\left(R(y_i)-\overline{R(y)}\right)^2\right)}} \tag{3}$$

x,y corresponds to the values of the two types of data, where formula (3) can be simplified into formula (4).

$$\rho = 1-\frac{6\sum_{i=1}^{n} d_i^2}{n\left(n^2-1\right)} \tag{4}$$

Where d_i is the rank difference between x_i and y_i.

The Spearman correlation coefficient heat maps of the pet cat industry and the pet dog industry and their corresponding 11 indicators data were derived after analyzing the Spearman correlation coefficients of the pet cat industry and the pet dog industry, respectively, which is shown in the Fig 7-8.

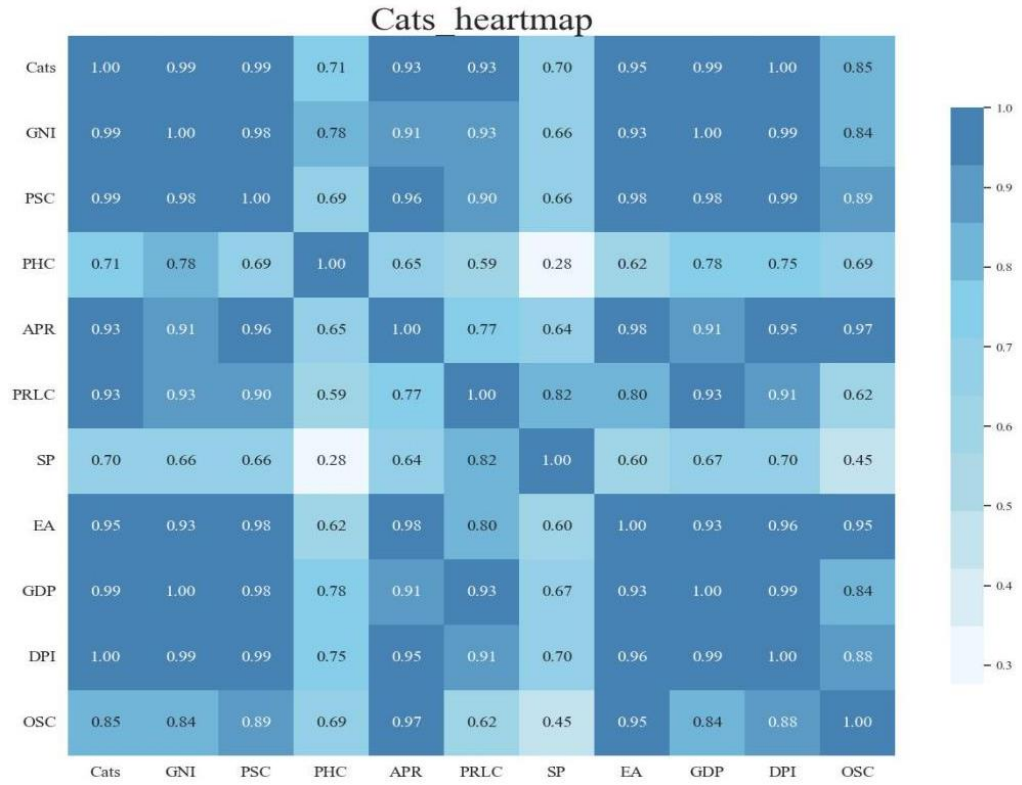

Fig 7. Heat Map of the Correlation between the Development of the Pet Industry (cats) and the Corresponding Factors.

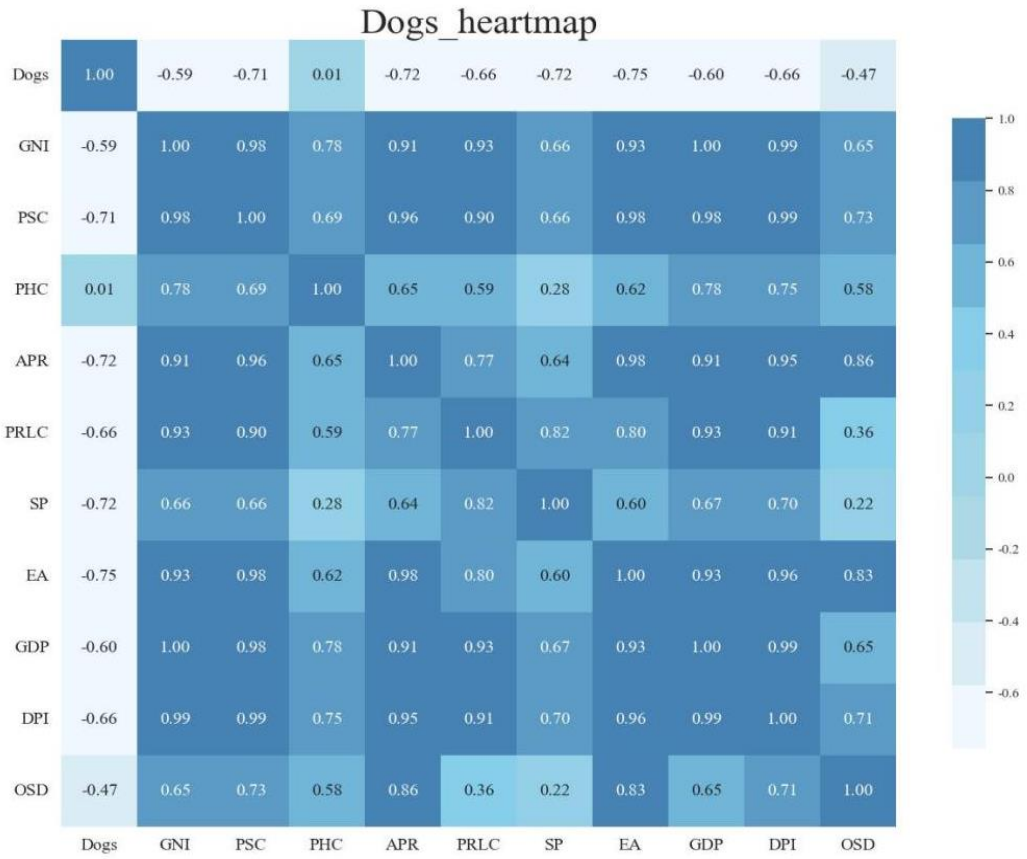

Fig 8. Heat Map of the Correlation between the Development of the Pet Industry (dogs) and the Corresponding Factors.

Based on the Fig 7-8, it can be concluded that the correlation between the five pet industry indicators and the six influencing factors are compared:

The number of pet cats or dogs shows a high correlation with PSC, PHC, PLC, OSC, which indicates that the indicators within the pet industry are closely linked.

The number of pet cats shows a high positive correlation with GDP, GNI, DPI, which indicates that the number of pet cats and economic indicators are closely related.

The number of pet dogs is highly negatively correlated with EA, SP and APR, which indicates that the number of pet dogs is closely related to social indicators.

3.2. Research on Its Economy Based on EMW-TOPSIS

After determining the relationship between pet-related factors and economic and social factors, the study of Its Economy requires the elimination of self-influencing factors within the economy, i.e., pet-related factors. To better explore its economy, two social aspects are added at the same time:

Pet Industry Investment Risk (PIIR): For investors, the pet industry investment risk can be used to determine the investment risk of a country's pet market, which is obtained from formula (5):

$$PIIR = \frac{IC - IR}{IC} \tag{5}$$

Where *IC* is the cost of investment and *IR* is the return on investment.

Pet Fatality Rate (PFR): It is the rate of pets dying at the young adult stage, and large numbers of pets dying at this stage means that there is a lack of safeguarding development in the pet industry.

As the indicators come from three different aspects, there are certain differences among them. Additionally, there is a certain degree of correlation between the indicators. Given the differences and correlations among the indicators, it is suitable to employ the EWM method to determine the weights of each indicator.

Firstly, this paper categorizes all the indicators. Based on experience, and then classify the indicators into positive type and negative type according to their impact on Its Economy.

Then, normalize each indicator based on quantity, use Formula 6 for positive indicators and 7 for negative indicators.

$$Z_{ij} = \frac{X_{ij} - X_{\min}}{X_{\max} - X_{\min}} \tag{6}$$

$$Z_{ij} = \frac{X_{\max} - X_{ij}}{X_{\max} - X_{\min}} \tag{7}$$

Where X_{ij} represents the *j* th data of the *i* th indicator.

Subsequently, calculate the entropy value of each indicator's *j* th data using the following formula to determine the information content of the indicators.

$$e_j = -k \sum_{i=1}^{n} p_{ij} \ln(p_{ij}),\ j = 1, \cdots, m \tag{8}$$

Where $k=1/\ln(n) > 0$ and $e_j > 0$.

To identify and eliminate indicators with the least impact on decision outcomes, ensuring a more balanced and rational distribution of weights, Formula 8 is widely used to calculate information entropy redundancy.

$$d_j = 1 - e_j,\ j = 1, \cdots, m \tag{9}$$

$$w_j = \frac{d_j}{\sum_{j=1}^{m} d_j}, j = 1, \cdots, m \tag{10}$$

Finally, use Formula 10 to calculate the weights of each indicator. The results are shown in the Table 2 and Fig 9.

Table 2. Weight of each Indicator.

Primary Indicators	Secondary Indicators	Weight(%)
Economic Indicator	*GDP*	27.12
	GNI	13.33
	DPI	17.77
	PIIR	7.91
	PFR	3.13
Social Indicator	*EA*	5.15
	SP	9.66
	APR	4.18
	NC	7.39
	ND	4.33

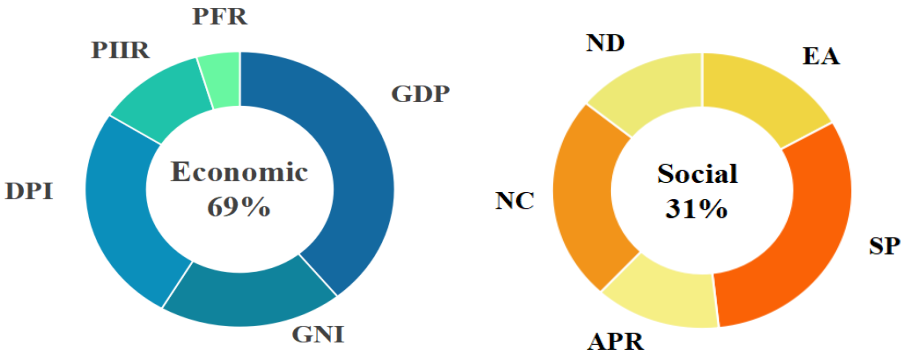

Fig 9. Pie Chart of Weight of Two Primary Indicator and Corresponding Secondary Indicator.

Based on the Table 2 and Fig 9 of each indicator's weights, the following conclusions can be intuitively drawn.In the two main categories of indicators, the weights are economic and social in descending order, accounting for 69% and 31% respectively.

In the economic aspect, GDP has the greatest impact on the development of the pet industry with about 27.12%, followed by DPI with about 17.767%, and PFR with the smallest share of 3.13%.In the social aspect, SP has the greatest influence on the development of pet industry, accounting for about 9.66%; followed by NC, accounting for about 7.39%; and APR has the smallest influence on the development of pet industry, accounting for only 4.18%. And the impact weight of each indicator of the social aspect is not more than 10%.

This indicates that for the development of Its Economy in the past 5 years, the economic aspects of the indicators occupy the dominant factors, and the GDP has the greatest impact. The social aspect of the policy, the national situation and other factors affect the development of the pet industry is more volatile, the impact is not prominent.

Based on the given data, calculate the optimal solution and the worst-case solution. Subsequently, the gaps between each evaluation indicator and the optimal and worst vectors are calculated using Formula 11.

$$D_i^+ = \sqrt{\sum_{j=1}^{m} w_j \left(Z_j^+ - Z_{ij}\right)^2}, D_i^- = \sqrt{\sum_{j=1}^{m} w_j \left(Z_j^- - Z_{ij}\right)^2} \tag{11}$$

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \tag{12}$$

Where w_j is the weight of the j th indicator.

Calculate and visualize the rank of the Its Economy development of each Chinese province by using Formula 12.

Table 3. Ranking of Its Economic Development in each Province.

Rank	Its Economy Development
1	Guangdong Province
2	Jiangsu Province
3	Shanghai Municipality
4	Beijing Municipality
5	Shandong Province
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According to the entropy weighting method and Table 3, Guangdong Province ranks first in terms of Its Economic development, followed by Jiangsu Province, Shanghai Municipality, Beijing Municipality, and Shandong Province. The top five provincial administrations all have the highest GDPs, and are also among the best or highest in the country in terms of social indicators (e.g., average educational attainment, urbanization, number of pets, and aging population). This is a better fit with the weight shares of the indicators obtained from the entropy weighting method. In the future, these provinces will have to take more responsibility for the development of their economies, and macro-regulate the fit of their economies with the overall economic structure in the future development, to strengthen their mutual promotion of other economic systems.

4. Conclusions

The trend of combination of micro and macro analysis to analyze complex and dynamically changing industry is developing rapidly in academic circle. This paper combines Spearman correlation analysis and the TOPSIS entropy weighting method to analyze the pet industry and the development of the Its Economy.

From a micro perspective within the industry, by analyzing Spearman correlation between several indicators of the pet industry, it is possible to obtain the relationship between changes in the number of pet cats and dogs and the social factors or economic factors. Spearman correlation analysis indicated that the number of pet cats and economic indicators (GDP, GNP, DPI) are closely related and the number of pet dogs is closely related to social indicators (EA, ARP, SP). After identifying the important influences within the pet industry, the next step is to determine the specific relationships and weightings between the pet industry-based Its Economy and the important influences to better study the economy. From a macro perspective, the TOPSIS entropy weighting method was used to determine the weighting of the economic and social impact indicators on the economy, and the TOPSIS entropy weighting method resulted in the following results: GDP has the greatest impact on the economy, followed by GNI, DPI, SP and so on. The weight of economic factors on Its Economy reaches 69%, which indicates that economic prosperity is the main reason for the development of Its Economy, but the social factors cannot be ignored, the combined effect of economic factors and social factors. It is the combined effect of economic and social factors that Its Economy can develop healthily.

Against the background of the development of Its Economy, the reasonable measures should be correctly taken to regulate Its Economy and then to strengthen their mutual promotion of other economic systems so that their economic structure is reasonable. At the same time, a series of policies should be introduced to enable Its Economy and pet industry to serve society and to enhance people's trust and satisfaction.

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