Research on wildlife trade based on comprehensive evaluation and correlation analysis

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Abstract. The outbreak of the COVID-19 in 2019 has again attracted people's attention to wildlife trade market transactions. To find out the correlation between wildlife trade and major infectious diseases,we classify and count according to countries, and then take the COVID-19 epidemic that is sweeping the world as the representative of major infectious diseases, and make correlation analysis by Pearson correlation coefficient model. In order to judge whether wildlife trade should be banned, this paper establishes an economic and social evaluation model through TOPSIS evaluation model based on both banned and unbanned aspects, and corrects it by using entropy weight method, and the results indicate that wildlife trade should be banned.

Keywords: Wildlife trade, Pearson correlation coefficient method, Entropy method, Topsis method.

1. Introduction

In natural ecosystems, wildlife is an important component that maintains the global ecological balance, and the rational use and development of its resources by people can promote the stable development of human society. In the current society, human beings have the vice of pursuing game, and in the past decades, due to the expanding demand for wild animals, there has been indiscriminate hunting of wild animals and illegal sale of wild animals[1-2]. Illegal trade and over-exploitation not only threaten ecosystem diversity and endangered species conservation, but also may cause biological invasions and spread new diseases to humans, resulting in a public health crisis[3].

The increasing incidence of emerging infectious diseases in recent years, the outbreak of the novel coronavirus（COVID-19）and the SARS epidemic in 2002 have caused significant global economic losses and reduced quality of life for people, while raising concerns about the possibility of a link between wildlife trade and infectious diseases[4-5]. When new infectious diseases occur, the relevant state agencies attach great importance to the supervision of illegal trade in wildlife markets, crack down and manage animal trading markets according to the law, and formulate relevant laws and regulations to prohibit the illegal trade of wild animals[6-7]. To find out the correlation between wildlife trade and major infectious diseases,we classify and count according to countries, and then take the COVID-19 epidemic that is sweeping the world as the representative of major infectious diseases, and make correlation analysis by Pearson correlation coefficient model[8]. In order to judge whether wildlife trade should be banned, this paper establishes an economic and social evaluation model through TOPSIS evaluation model based on both banning and not banning, and corrects it by using entropy weight method.

2. Model building and solving

2.1. Analysis of the correlation between wildlife trade and disease transmission

we use Pearson algorithm to continue the correlation. Pearson correlation coefficient is a method to measure the degree of correlation between two variables. It is a value between 1 and -1, where 1 represents variable perfect positive correlation, 0 represents wireless correlation, and -1 represents complete negative correlation. We use the following formula here:

$$\rho_{x,y} = \frac{\operatorname{cov}(x,y)}{\sigma_x \sigma_y} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}} \tag{1}$$

Where $cov(x,y)$ represents the covariance of two groups of data, and $\sigma_x \sigma_y$ represents the standard deviation of x,y.

To solve this problem, we first crawled the data of the COVID-19 epidemic so far from the Internet[9], recorded the number of infected people in some countries in a table, and drew a heat map of the world epidemic situation with Python, as shown in the following Figure 1. The color depth can intuitively reflect the distribution relationship between the current severe infectious diseases and countries and regions.

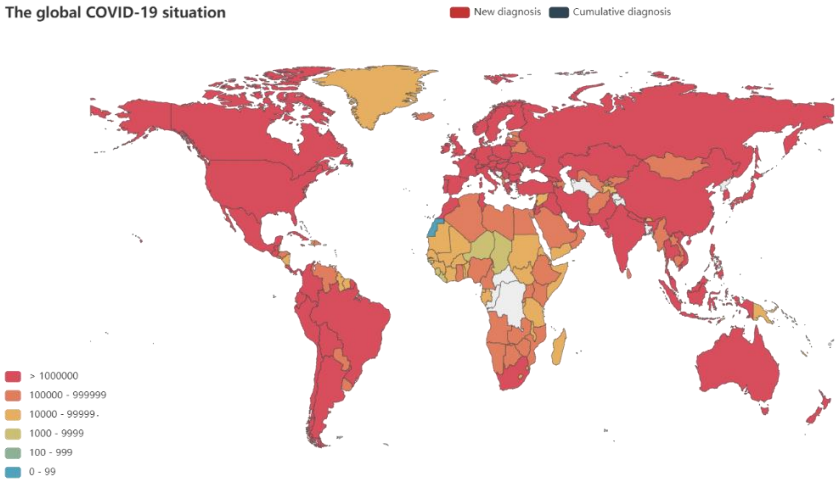


Figure 1. World epidemic situation

It can be seen from the epidemic map that the epidemic situation in COVID-19 is serious, and most countries are fighting against infectious diseases fiercely. Then, we classify the given data by country and count the trade volume of wildlife in each country, as shown in Figure 2 below.

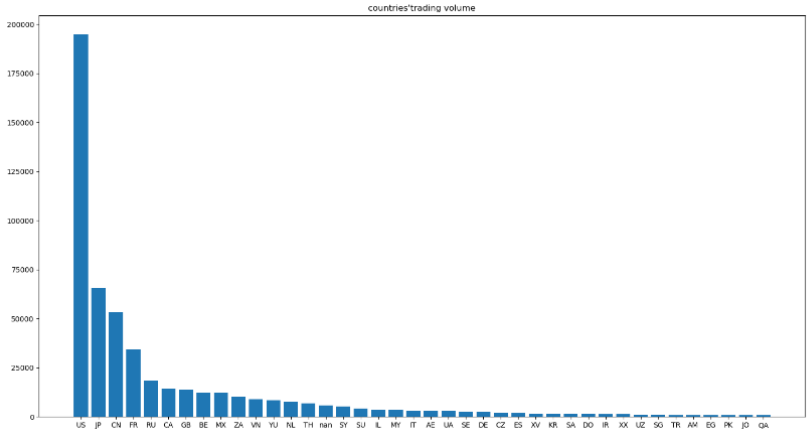


Figure 2. The trade volume of wildlife in each country

As can be seen from the figure, there is a big difference in wildlife trade between the first few countries. We selected 40 countries with a large number of transactions as representatives, and tested Pearson correlation by their transaction volume and epidemic situation. We only explore the relationship between trading volume and national epidemic situation[10], so we use 40 countries with obvious fluctuations to test the correlation, which can roughly reflect the relationship between trading volume and national infectious diseases:

$$\rho = 0.82903953 \tag{2}$$

With the result close to 1, we can conclude that the wildlife trade in each country is closely related to the infectious disease situation in the country. Factor correlation matrix is shown in figure 3.

	GDP	Employment	Medical and health expenditure	Ecological and environmental benefits	Export	Import
GDP	1.0000	-0.0091	0.9735	0.9866	0.4667	-0.1709
Employment	-0.0091	1.0000	-0.1780	0.0259	-0.0840	0.3306
Medical and health expenditure	0.9735	-0.1780	1.0000	0.9706	0.5072	-0.2576
Ecological and environmental benefits	0.9866	0.0259	0.9706	1.0000	0.5423	-0.1656
Export	0.4667	-0.0840	0.5072	0.5423	1.0000	-0.3853
Import	-0.1709	0.3306	-0.2576	-0.1656	-0.3853	1.0000

Figure 3. Factor correlation matrix

For the above results, we conducted another T-test:

$$t = \rho\sqrt{\frac{n-2}{1-\rho^2}} \tag{3}$$

Where n is the number of samples and follows the T-distribution with n-2 degrees of freedom. In this case, the critical value of n=40 and 38 degrees of freedom is 2.7633, resulting in the following results:

$$t = 9.139886 > 2.7633 \tag{4}$$

This allows us to determine whether wildlife trade is linked to major infectious disease outbreaks.

2.2. Analysis of the economic feasibility of banning wildlife trade

2.2.1 Entropy Method

Based on the explanation of the basic principles of information theory, information is a measure of the order degree of the system, and entropy is a measure of the disorder degree of the system. According to the definition of information entropy, for an index, the entropy value can be used to judge the degree of dispersion of an index. The smaller the information entropy value is, the greater the degree of dispersion of the index will be, and the greater the influence (i.e., weight) of the index on the comprehensive evaluation. If all the values of an index are equal, then the index has no role in the comprehensive evaluation. Therefore, the tool of information entropy can be used to calculate the weight of each indicator and provide a basis for the comprehensive evaluation of multiple indicators.

According to the definition and principle of entropy, when the system may be in several different states, the probability of each state is $p_i(i = 1,2\ldots,m)$, then the entropy of the system can be defined:

$$e = x = -\frac{1}{lnm}\sum_{i=1}^{m} p_i lnp_i \tag{5}$$

The steps to obtain weight based on Entropy weight method are as follows:

Step1: We take each year of the ten-year data of the United States as the evaluation object, and the impact of ***GDP***, ***employment rate***, ***medical and health care***, and ***ecological environment*** (**GEP**) on economic life as the evaluation index. A total of ***n=10*** evaluation objects, ***m=4*** evaluation index variables, and the value of the ***i-evaluation*** object about the ***j*** index variable were obtained: $a_{ij}(i = 1,2,..,n;\ j = 1,2,..,m)$.

Step2: Construct the data Matrix $A = (a_{ij})_{n\times m}$

Step3: Use the raw data Matrix $A = (a_{ij})_{n\times m}$ calculate the proportion of P_{ij}, that is the ***i-evaluation*** object with respect to the ***j*** index:

$$p_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}, i = 1,2,...,n;\ j = 1,2,...,m \tag{6}$$

Step4: Calculate the entropy of the ***j*** index:

$$e_j = -\frac{1}{lnn}\sum_{i=1}^{1} p_{ij} lnp_{ij}, j = 1,2,...,m \tag{7}$$

Step5: Calculate the coefficient of variation of the ***j*** index:

$$g_i = 1 - e_i, j = 1,2,...,m \tag{8}$$

Step6: Calculate the weight of the ***j*** index**:**

$$W_j = \frac{g_j}{\sum_{j=1}^{m} g_j}, j = 1,2,...,m \tag{9}$$

Finally, the weights of our four indexes are:

$$W = [0.29512396,0.00807525,0.48842295,0.20837784] \tag{10}$$

2.2.2 TOPSIS Method

TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) method was first proposed by C.L. Wang and K. Yoon in 1981. TOPSIS method is a method to rank a limited number of evaluation objects according to their proximity to the idealized target, which is to evaluate the relative advantages and disadvantages of existing objects. TOPSIS method is a commonly used and effective method in multi-objective decision analysis, also known as the superior and inferior distance solution method.

The steps to establish of TOPSIS comprehensive evaluation model are as follows:

Step1: The influence of whether to ban wildlife trade or not are compared and showed in the following **table 1**. According to these data, we construct the initial matrix ***A***, ***m=2*** evaluation objects and ***n=4*** evaluation indexes:

Table 1. Comparison of results of wildlife trade ban and no ban

	GDP (**Contribution**)	Employment (**Contribution**)	Medical and health care (**Cost**)	Ecological environment (**GEP**) (**Contribution**)
Prohibition	0	0	73950**w**	1(**Yes**)
Permission	500 **billion**	100**w** employer	65195.9 **billion**	0 (**No**)

Since the ecological and environmental benefits brought by the wildlife trade ban to the economy and society cannot be expressed quantitatively in a short time, we choose to use 1 and 0 to express qualitatively, where 1 means there are ecological and environmental benefits, and 0 means no.

$$A=\begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{bmatrix} \tag{11}$$

In the formula a_{ij} represents the **j** index value of the **i** object.

Step2: Normalize the initial matrix:

$$A^{*}=\begin{bmatrix} a^{*}_{11} & \cdots & a^{*}_{1n} \\ \vdots & \ddots & \vdots \\ a^{*}_{m1} & \cdots & a^{*}_{mm} \end{bmatrix} \tag{12}$$

$$a_{ij}=\frac{a_{ij}}{\sqrt{\sum_{i=1}^{m} a_{ij}^{2}}} \tag{13}$$

Step3: Construct weighted standardization processing:

$$\mathrm{Z}=\mathrm{A}^{*}\mathrm{W}=\begin{bmatrix} \mathrm{a}^{*}_{11} & \cdots & \mathrm{a}^{*}_{1n} \\ \vdots & \ddots & \vdots \\ \mathrm{a}^{*}_{m1} & \cdots & \mathrm{a}^{*}_{mn} \end{bmatrix}\begin{bmatrix} \mathrm{w}_{1} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \mathrm{w}_{n} \end{bmatrix}=\begin{bmatrix} \mathrm{z}_{11} & \cdots & \mathrm{z}_{1n} \\ \vdots & \ddots & \vdots \\ \mathrm{z}_{m1} & \cdots & \mathrm{z}_{mn} \end{bmatrix} \tag{14}$$

We've figured out by the entropy weight that the weight of a factor is W:

$$W = [0.29512396,0.00807525,0.48842295,0.20837784] \tag{15}$$

Step4: Judge the positive and negative ideal solutions respectively according to weighting matrix.

$$\mathrm{Z}_{j}^{+}=\begin{cases} \max(Z_{ij}),\ j\in J^{*} \\ \min(Z_{ij}),\ j\in J^{'} \end{cases},Z_{j}^{-}=\begin{cases} \min(Z_{ij}),\ j\in J^{*} \\ \max(Z_{ij}),\ j\in J^{'} \end{cases} \tag{16}$$

*In the above formula, **J*** is a **contribution** index and **J'** is a **cost** index.*

Step5: Calculate the distance from each scheme to the ***positive*** and ***negative*** ideal points:
the ***positive*** ideal points:

$$\mathrm{S}_{I}^{+}=\sqrt{\sum_{j=1}^{n}(Z_{ij}-Z_{j}^{+})^{2}},i=1,2,...,m \tag{17}$$

the negative ideal points:

$$\mathrm{S}_{I}^{-}=\sqrt{\sum_{j=1}^{n}(Z_{ij}-Z_{j}^{-})^{2}},i=1,2,...,m \tag{18}$$

Step6: Calculate the relative closeness C_i of each scheme:

$$\mathrm{C}_{i}=\frac{S_{i}^{-}}{(S_{I}^{+}+S_{I}^{-})},i=1,2,...,m \tag{19}$$

There are different evaluation criteria for indicators with different properties:
To a contribution index:

$$a_{ij}^{'} = \begin{cases} (a_{ij} - a_{j\min}) / (a_{j\max} - a_{j\min}), a_{j\max} \neq a_{j\min} \\ 1, a_{j\max} = a_{j\min} \end{cases} \quad (20)$$

To a cost index:

$$a_{ij}^{'} = \begin{cases} (a_{j\max} - a_{ij}) / (a_{j\max} - a_{j\min}), a_{j\max} \neq a_{j\min} \\ 1, a_{j\max} = a_{j\min} \end{cases} \quad (21)$$

Step7: Arrange the schemes in order of advantages and disadvantages of C_i from ***large*** to ***small***.

Outcome of Topsis is shown in figure 4.We finally get that:

[1. 0.57482][2.0.42518]

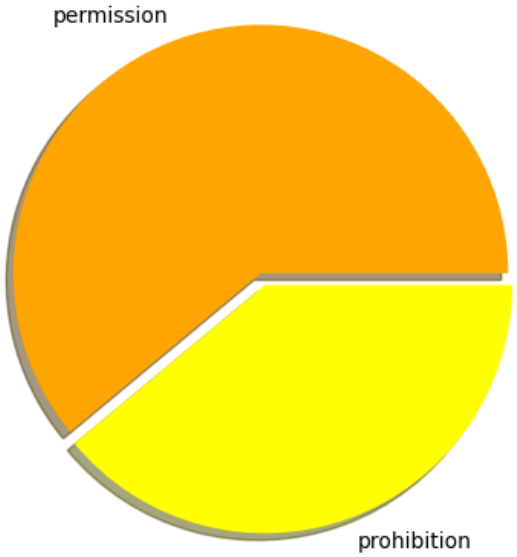


Figure 4. Outcome of Topsis

which means Scheme 1(Prohibition) gets higher score, so ban on wildlife trade for long term will not affect economic and social development.

3. Conclusions

The outbreak of the COVID-19 in 2019 has again attracted people's attention to wildlife trade market transactions. According to research, 78% of new infectious diseases of human beings are related to wildlife. The occurrence of major infectious diseases will cause global economic and social turmoil, its harm and influence, and crisis the safety of mankind. At present, there are two opposing views on whether wildlife trade should be banned. To answer thie question, our team analyzed and visualized CITES database, and then established models to solve each question. Our team's understanding of statistics affecting the economy and society is not comprehensive enough. Here, we will show our analysis of "whether wildlife trade should be banned" by classifying, processing, analyzing and visualizing wildlife data. The results suggest that wildlife trade should be banned.

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