Financial Engineering and Risk Management (2024)
Clausius Scientific Press, Canada
DOI: 10.23977/ferm.2024.070206
ISSN 2523-2576 Vol. 7 Num. 2

The Analysis of Wildlife Trade Based on Aggregate Analysis Model and Time Series Prediction

Kai Zhao[1,a], Hantao Zhang[1,b,*]

[1]School of Economics and Modern Finance, Gannan University of Science and Technology, Ganzhou, China
[a]zk3108289323wr@163.com, [b]z18017817980@163.com
[*]Corresponding author

Keywords: Wildlife Trade, Aggregate Analysis, Time Series, Illegal Trade, Biodiversity Conservation

Abstract: The ever-expanding global demand for wildlife consumption and related illegal trade is one of the major threats to biodiversity conservation. The recent outbreak of COVID-19 has drawn wide attention to the public health and safety of wildlife trade and consumption. In this paper, the correlation analysis of wildlife trade and its impact is conducted through time series prediction model. First, this paper adopted the method of aggregate analysis, classified the data in the attachment, and made bar contrast charts and pie charts. By analyzing and comparing, we found that this Primate was the most traded species when divided by groups in Macaca fascicularis and by species. This paper choice the time sequence model to analyze the dates. This study analyzes the annual data from several aspects, such as the species of main trading animals, main trading purposes and trading volume. This study provides a comparative analysis of trends and a visual analysis of this primate. In the end, we find that Primates occupies a very large proportion in the trade every year, and wild animals are used for commerce almost every year.

1. Introduction

The novel coronavirus pneumonia outbreak, deemed the largest global epidemic in centuries, poses a significant threat to human life and health. Scientists attribute the outbreak to wildlife, particularly bats, and possibly Malayan pangolins, as carriers or vectors of the virus. Chen Huanchun, an academician at the Chinese Academy of Engineering, highlights that 78% of emerging human infectious diseases are linked to wild animals. Factors such as environmental changes, close human-animal contact, and agricultural behaviors contribute to the spread of zoonotic diseases. Despite global calls to ban wild animal trade and consumption, existing laws have loopholes, allowing for the hunting and trade of animals without proper regulations. Illegal channels exacerbate the issue, making supervision challenging. This trade accelerates virus transmission by increasing contact between wild animals and humans. Urgent actions include banning wild animals, strict trade restrictions, and minimizing contact with wildlife.

2. Related Works

In recent years, many scholars have made research on the illegal trade of wildlife. Hughes pointed out that in ancient Greece and Rome, Europe served as a consumer of exotic biodiversity, providing important historical references for landscape research [1]. Van Uhm delved into the internal workings of illegal wildlife trade in his work, uncovering the realities of smuggling, trafficking, and trading [2]. Milner-Gulland reviewed the literature and practices of illegal wildlife trade over the past 40 years, emphasizing the importance of documenting and addressing this issue [3]. Warchol discussed the scale and impact of transnational illegal wildlife trade, highlighting the challenges in combating such trade [4]. Nijman provided an overview of international wildlife trade in Southeast Asia, highlighting the characteristics and issues of trade in the region [5]. Beastall et al. focused on the trade of the Helmeted Hornbill, emphasizing the value of its ivory-like casque and the challenges it poses to conservation efforts [6]. The United Nations Office on Drugs and Crime (UNODC) released the World Wildlife Crime Report, detailing the global situation of wildlife crime [7]. Broad et al. introduced the nature and extent of legal and illegal wildlife trade in their work [8]. Cooney et al. proposed a framework to improve biodiversity and livelihood outcomes in wildlife trade, providing theoretical support for promoting trade and conservation [9]. Hutton and Dickson comprehensively reviewed the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), discussing its past, present, and future developments [10]. Weber et al. discussed the unintended conservation outcomes of wildlife trade bans and the emerging challenges faced by stakeholders [11]. These research articles provide valuable theoretical support and practical experience for understanding and addressing the issue of illegal wildlife trade.

3. Theory and Method

3.1 Establishment of Aggregation Analysis Model

The comparison and evaluation of the trade of wild animal groups and species involve many factors, such as year, scientific name, order, family, genus, importer and exporter, origin, etc., and the relationship among these factors is complicated, so it is not easy to conduct systematic analysis and evaluation. Firstly, a more complex index evaluation system should be established and a more comprehensive framework system should be constructed. Then, according to the correlation between the factors contained in the data, purposeful screening is carried out to reduce some less important indicators and gradually screen out the indicators with clear meaning and appropriate quantity. The known data were divided into 17 groups according to their orders and several species according to all the scientific names in the data, and the trade quantity data of each type was used as the analysis basis to study the quantity of wildlife trade. By following the data completeness and independence, science and feasibility, dynamic and stability, combined with the classification of population and species in this paper, a complex index system is established.

Suppose the set of transaction times in group decision-making is $E = \{e_1, e_2, \dots, e_m\}$, the set of alternative times to be considered is $A = \{a_1, a_2, \dots, a_r\}$, and the evaluation criterion or index set of alternative times is $C = \{c_1, c_2, \dots, c_n\}$. Next, the intuition fuzzy set distance will be used to study the degree of consistency between the number of transactions and the group and species in group decision making

If the effects of population and species on transaction i are identical, the intuition fuzzy distance is equal to 0;

If the effects of population and species on transaction i are completely opposite, the intuitionistic fuzzy distance is equal to 1;

If the effects of the population and species on transaction i are inconsistent to some extent, the intuitionistic fuzzy distance is a value in $[0,1]$.

According to the actual situation after data processing, combined with the classification of the population and the relationship between the species, the intuitive fuzzy evaluation made by the k population or species on the j valuation criterion or index of transaction i is

$$P_{ij}^{k} = \left(\begin{matrix} k \\ -ij \end{matrix}, \ v_{ij}^{k}, \ c_{ij}^{k} \right) \tag{1}$$

Then the intuitive fuzzy evaluation influence matrix of the k population or species on scheme set A can be obtained:

$$P^{k} = \begin{vmatrix} \left({}^{k}_{-11}, & v_{11}^{k}, & c_{11}^{k} \right), & \left({}^{k}_{-12}, & v_{12}^{k}, & c_{12}^{k} \right), & \left({}^{k}_{-1n}, & v_{1n}^{k}, & c_{1n}^{k} \right) \\ \left({}^{k}_{-21}, & v_{21}^{k}, & c_{21}^{k} \right), & \left({}^{k}_{-22}, & v_{22}^{k}, & c_{22}^{k} \right), & \left({}^{k}_{-2n}, & v_{2n}^{k}, & c_{2n}^{k} \right) \\ \left({}^{k}_{-r1}, & v_{r1}^{k}, & c_{r1}^{k} \right), & \left({}^{k}_{-r2}, & v_{r2}^{k}, & c_{r2}^{k} \right), & \left({}^{k}_{-rn}, & v_{rn}^{k}, & c_{rn}^{k} \right) \end{vmatrix} \tag{2}$$

Among them $i = 1,2,\dots,r$; $j = 1,2,\dots,n$; $k = 1,2,\dots,m$. If the weights of evaluation criterion $(c_1, c_2, \dots, c_n)$, are $w = (w_1, w_2, \dots w_n)$

$$\sum_{j=1}^{n} k_j = 1 \tag{3}$$

Respectively, the intuition fuzzy distance between (k,t) of each pair of population or species and alternative is:

$$e_i^{k,t} = \sqrt{\frac{1}{3n}\sum_{j=1}^{n} \left[w_j \left(\left(\begin{matrix} k-ij-ti \\ i-1 \end{matrix} \right)^2 + \left(v_{ij}^{k} - v_{ij}^{t}\right)^2 + \left(c_{ij}^{k} - c_{ij}^{t}\right)^2 \right) \right]} \tag{4}$$

This distance reflects the degree of agreement between (k,t) of each pair of populations or species on the trade i. If the agreement between all groups and species is measured, then alternative $i(i = 1,2,\dots,r)$ can be constructed. The average agreement of $k(k = 1,2,\dots,m)$ between groups or species is:

$$A\left(e_i^{k}\right) = \frac{1}{m-1}\sum_{\substack{j=1 \\ j\neq k}}^{m} e^{kj} \tag{5}$$

The relative agreement degree of $k(k = 1,2,\dots,m)$ between populations or species is :

$$RAD\left(e_j^{k}\right) = \frac{A\left(e_j^{k}\right)}{\sum_{k=1}^{m} A\left(e_j^{k}\right)} \tag{6}$$

In some cases, the percentage of the total population varies from group to group and from species to species, and some groups or species are more representative than others or animals, so it is necessary to consider the percentage weight of each group or species. The relative importance weights of groups or species are determined as follows:

First, this paper selects the population or species with the largest percentage from the whole population or species, and assigns its weight equal to 1. Then, the k group or species is compared with the group or species with the largest percentage to obtain the relative comparative weight n of the k group or species $r_k, k = 1,2,\dots,m$. Finally, the relative important weight w_k of each group or species is defined as follows:

$$w_k = \frac{r_k}{\sum_{i=1}^{m} r_k}, \ k = 1,2,\dots,m \tag{7}$$

If each population or species has an equal percentage, then

$$w_1 = w_2 = \cdots = w_m = \frac{1}{m} \tag{8}$$

By synthesizing the percentage weight of each group and species and the relative consistency degree of alternative number, the final comprehensive consistency degree of all groups and species for alternative number $i(i = 1,2, \dots, r)$ can be obtained:

$$e_i = \sum_{k=I}^{m} w_k \cdot RAD\left(e_i^k\right) \tag{9}$$

The values of e are arranged in the order from small to large. The transaction number with the smallest value indicates that the group or species has a higher degree of agreement on the transaction number, and there is little difference between the groups or species.

3.2 The Establishment of Time Series Model

According to the changes of wildlife trade in the past 20 years, the known data are divided into species category, trade purpose, source and trade volume, and the data of changes in each category is used as the basis for the study of wildlife trade changes. In describing the changes of wildlife trade in the past, a time series model can be established to solve the changes in time. Time series analysis is based on the continuous laws of the development of objective things, using the past historical data, through statistical analysis, to further speculate the future development trend. The assumption that the past continues into the future has two implications; First, there is no sudden change of jump, but a relatively small pace of progress; Second, past and present phenomena may indicate trends in the development and change of current and future activities.

Time series analysis is a theory and method to build a mathematical model by curve fitting and parameter estimation based on the time series data obtained from systematic observation. Generally using curve fitting and parameter estimation methods such as: nonlinear least square method to carry out. In the stationary time series model, the stationary refers to the wide stationary, whose characteristic is that the statistical properties of the series do not change with the translation of time, that is, the mean and covariance do not change with the translation of time. The general formula for the general moving average model MA(q) is as follows:

$$Y_t = e_t - \theta e_{t-1} - \theta_2 e_{t-2} - \cdots - \theta_q e_{t-q} \tag{10}$$

The above equation is a moving average process of order q, recorded as MA(q). The general formula for the general auto regressive model AR(p) is as follows:

$$Y_t = \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \cdots \phi_p Y_{t-p} + e_t \tag{11}$$

The above equation is an auto regressive process of order p, recorded as AR(p); Therefore, the general formula of auto regressive moving average mixed model ARMA(p, q) is as follows:

$$Y_t = \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \cdots \phi_p Y_{t-p} + e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2} - \cdots - \theta_q e_{t-q} \tag{12}$$

The above equation is an auto regressive moving average mixing process, with orders of p and q respectively, recorded as ARMA(p, q), It can be seen from the general formula, Model ARMA is a combination of model AR and model MA, It has both properties. For normal model ARMA (p, q), the general prediction form is:

$$\begin{aligned} \hat{Y}_t(\zeta) = \quad & \phi_1 \hat{Y}_t(\zeta - 1) + \phi_2 \hat{Y}_t(\zeta - 2) + \cdots + \phi_p \hat{Y}_t(\zeta - p) + \theta_0 \\ & -\theta_1 E\left(e_{t+\zeta-1} \mid Y_1, Y_2, \dots, Y_t\right) - \theta_2 E\left(e_{t+\zeta-2} \mid Y_1, Y_2, \dots, Y_t\right) \\ & -\theta_q E\left(e_{t+\zeta-q} \mid Y_1, Y_2, \dots, Y_t\right) \end{aligned} \tag{13}$$

In the above formula, ζ represents the lag time unit, that :

$$\hat{Y}_t(0) = Y_t, E\left(e_{t+j} \mid Y_l, Y_2, \dots, Y_t\right) = \begin{cases} 0 & j > 0 \\ e_{t+j} & j < 0 \end{cases} \tag{14}$$

The variables involved in this question and the data collected are more consistent with this model. Temperature is a nonlinear variable, so this traditional model is selected.

4. Results and Discussions

4.1 Results of Aggregation Analysis Model

The known data in this paper is analyzed and substituted into the above, and the comprehensive agreement degree of alternative number set scheme i is calculated to determine which wild animal groups and species are traded the most. The calculated data set is shown in Table 1 and Table 2.

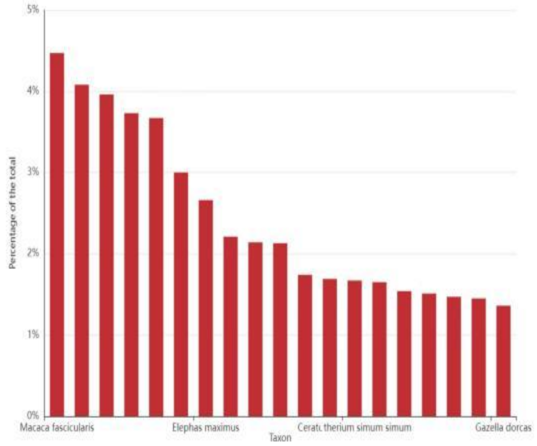
Table 1: Classification by species

Taxon	Occurrence number	Percentage	Importer reported quantity	Exporter reported quantity
Acerodon Celebensis	1	0.00741125	4	0
Acerodon humilis	3	0.022233751	0	45
Nycticebus Coucang	32	0.237160009	136	64
Nycticebus Pygmaeus	26	0.192692507	14	29
Vulpes zerda	208	1.541540058	2816	4365
Zaglossus bruijni	1	0.00741125	0	3

Table 2: Classification by category

Taxon	Occurrence number	Percentage
Artiodactyla	697	5.165641444
Carnivora	4151	30.7640999
Cetacea	813	6.025346476
Rodentia	170	1.259912547
Scandentia	33	0.244571259
Sirenia	39	0.289038761

Finally, the calculated$w_k$was made into a tree chart and pie chart, and the transaction maximum value of each model was obtained through observation, analysis and multiple classification processing.



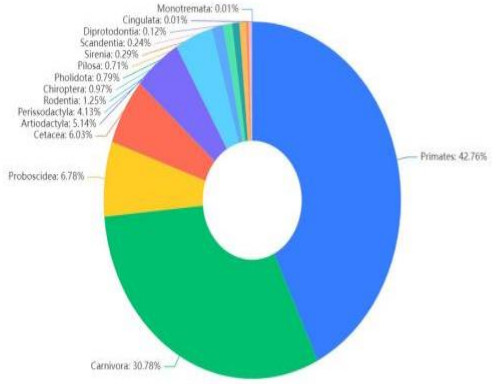


Figure 1: Classification by species(left) and category(right)

As can be seen from Table 1-2 and Figure 1, the maximum values obtained by aggregation analysis are respectively: The maximum value by species was Macaca fascicularis, which appeared 603 times in the trade data; This Primates is the largest classification by category, which comes into 5762 cases in the trade data. According to the data and images obtained from Table 1-2 and Figure 1 above, it is not difficult to get the maximum value of which category, that is, there are the largest transactions of wild animal groups and species. Therefore, in this paper, Macaca fascicularis and Primates species have the largest transactions.

4.2 Results of Time Series Model

After sorting out the data given by the topic and the data collected in this paper, the annual trade data of wildlife trade can be obtained. After time series analysis, MATLAB software is used to solve the data, and the following data can be obtained, as shown in Table 3.

Table 3: Annual exports of each species

	2003	2004	2011	2012	2020	2021
Pholidota	2	13	24	524	350	0
Sirenia	1	3	0	0	0	0
Cetacea	97	82	126	117	48	2
Primates	10737	6185	2912	2044	5608	1138
Rodentia	30	13	29	20	70	0
Pilosa	5	1	0	17	0	0
Perissodactyla	65	41	89	108	27	0
Carnivora	361	277	768	594	305	192
Cingulata	8	0	0	0	0	0
Proboscidea	86	43	24	56	0	1
Artiodactyla	493	182	62	88	360	0
Chiroptera	0	147	154	94	34	0
Scandentia	0	0	12	3	0	0
Diprotodontia	0	0	0	0	0	0
All	11885	6987	4200	3665	6802	1333

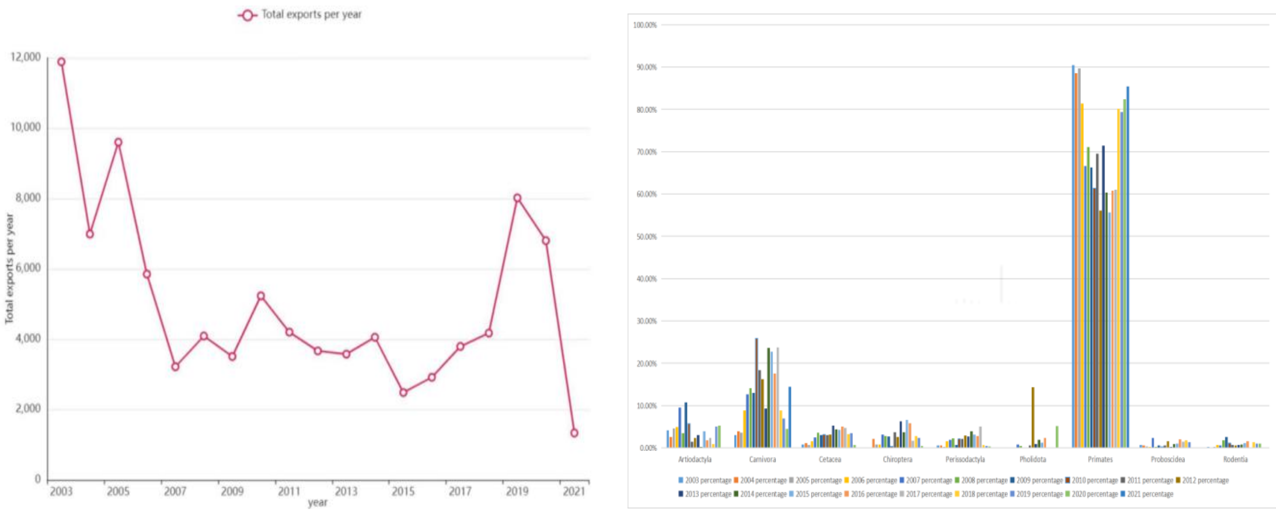


Figure 2: Total number of wild animals exported each year (left) and the proportion of different wildlife exports each year (right)

Figure 2 shows the change trend of the number of wildlife traded each year, and the proportion of different wildlife traded each year.

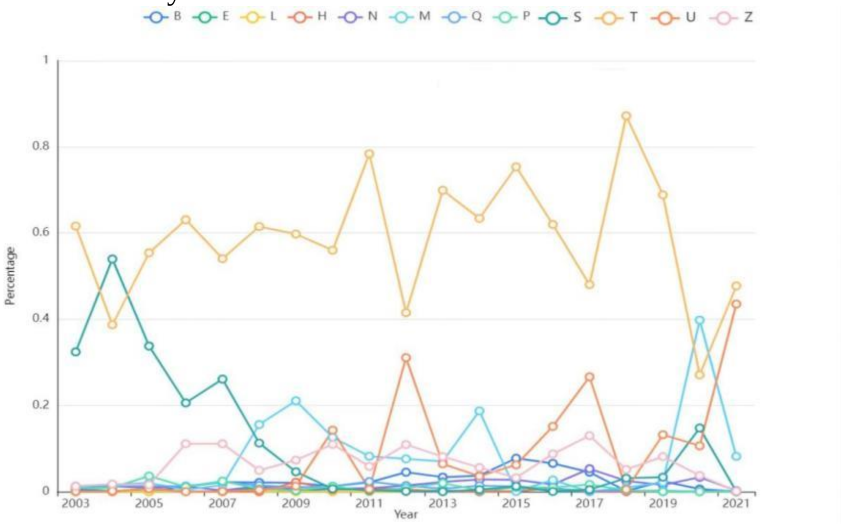


Figure 3: Changing trend of the proportion of wildlife trade each year

Figure 3 shows the trend and proportion of wildlife traded each year. As can be seen from Figure 2, the quantity of wildlife trade is on the decline in general, but it increases sharply in 2019, decreases slowly in 2020, and decreases sharply in 2021. In addition, Primates is a very large Primates in trade every year, but it presents a trend of first decreasing and then increasing between 2003 and 2021. Besides Camivora Primates, this Primates is the largest Primates in terms of average proportion each year, which shows a trend of first rising and then declining in general. It is worth mentioning that Pholidota saw explosive growth in 2012 compared to previous years, although it still does not account for very much of the total trade volume.

5. Conclusion

In general, the number of wildlife trade is on a downward trend, but there was a sharp increase in 2019, a slight decline in 2020, and a sharp decline in 2021. In addition, primates are a group of animals with a very large annual trade volume, but showed a trend of decreasing first and then increasing between 2003 and 2021. In addition to the carnivorous primates, this type of animal is also the largest in terms of the average proportion of each year, showing a trend of rising first and then falling. It is worth mentioning that compared with previous years, the trade volume of pangolins increased explosively in 2012, although its proportion in the total trade volume was still not high. In addition, it can be seen from Figure that wild animals are used for T purposes almost every year. In addition, the use of S shows a downward trend, while the use of U shows an upward trend. In addition, the maximum values obtained by the polymerization analysis are: the maximum value obtained by species classification is the long-tailed monkey, which appears 603 times; the maximum value obtained by category classification is primates, which appears 5762 times. Based on the above tables and image data, it is not difficult to draw the maximum value is which category, that is, there is the largest trading volume in wildlife groups and species. Therefore, in this paper, the long-tailed monkey and primate species are the largest trading volume.

References

[1] Hughes J. D. (2003). Europe as consumer of exotic biodiversity: Greek and Roman times. Landscape Research, 28(1), 21–31.

[2] Vanuhm D. P. (2016). The Illegal Wildlife Trade: Inside the World of Poachers, Smugglers and Traders. Springer International Publishing, 6(2), 37–46
[3] Milner-Gulland E. J. (2018). Documenting and tackling the illegal wildlife trade: change and continuity over 40 years. Oryx, 52(4), 597–598.
[4] Warchol G. L. (2004). The transnational illegal wildlife trade. Criminal Justice Studies, 17(1), 57–73.
[5] Nijman V. (2010). An overview of international wildlife trade from Southeast Asia. Biodiversity and Conservation, 19(4), 1101–1114.
[6] Beastall C, Shepherd C. R, Hadiprakarsa Y, & Martyr D. (2016). Trade in the Helmeted Hornbill Rhinoplax vigil: the 'ivory hornbill'. Bird Conservation International, 26(2), 137–146.
[7] United Nations Office on Drugs and Crime (UNODC). (2016). World Wildlife Crime Report: Trafficking in Protected Species. New York: United Nations.
[8] Broad S, Mulliken T, & Roe D. (2003). The nature and extent of legal and illegal trade in wildlife. In S. Oldfield (Ed.), The Trade in Wildlife: Regulation for Conservation. London: Earthscan. (pp. 3–22)
[9] Cooney R, Kasterine A, MacMillan D, Milledge S, Nossal K, et al. (2015). The Trade in Wildlife: A Framework to Improve Biodiversity and Livelihood Outcomes. Geneva: International Trade Centre, 1(1), 5–7.
[10] Hutton J, & Dickson B. (2000). Endangered Species, Threatened Convention: The Past, Present and Future of CITES, the Convention on International Trade in Endangered Species of Wild Fauna and Flora. London: Earthscan, 7(1), 50–56
[11] Weber D. S, Mandler T, Dyck M, Van Coeverden De Groot P. J, Lee D.S, & Clark D.A. (2015). Unexpected and undesired conservation outcomes of wildlife trade bans—An emerging problem for stakeholders. Global Ecology and Conservation, 3, 389–400.