Data Statistics Applications in Regulating the Balance of the Wildlife Trade

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Abstract. The global wildlife trade is a massive industry, with over 36,000 protected species and profits exceeding $20 billion. While this trade brings huge profits to those involved, it also increases the risk of zoonotic diseases. To analyse the wildlife trade, we used the CITES trade database, which contains over 20 million records of trade. After data pre-processing, we got the result of the most traded wildlife species, Primates, and analysed the purpose of trade through Pareto Analysis Model. We also conducted an Augmented Dickey-Fuller Unit Root (ADF) test model to compare import and export quantities, finding that the import quantity was gentle, while the export quantity had fluctuations. We also created a line chart and a bubble map indicating unstable trade during a certain period. To determine if the wildlife trade is related to major infectious disease epidemics, we conducted a qualitative analysis, and a quantitative analysis as well as created two flow direction maps. Using the Kendall consistency test, our quantitative analysis found that the wildlife trade is indeed related to the epidemic of major infectious diseases. Afterward, we investigated the impact of the wildlife trade on the economy and society, building a hypothetical-deductive model. We found that while the volume of trade is not directly related to the economy, it does partially affect GDP growth. The Kendall consistency test showed a high degree of correlation between the economy, society, and trade. Eventually, we proposed some urgently needed measurements to regulate the balance of wildlife trade.

Keywords: Data Statistics Applications; Wildlife trade; Pareto Analysis; ADF test; Kendall consistency test

1 INTRODUCTION

With the process of globalization, countries around the world are increasingly opening their trade doors, including the trade of wildlife. This trade brings economic benefits to

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both importing and exporting countries. However, the expansion of wildlife trade, particularly on a large scale, has given rise to numerous environmental challenges. One of the significant concerns is the reduction and potential extinction of various species. Additionally, the illegal wildlife trade has facilitated the transmission of diseases through contact with virus-carrying species, as exemplified by the COVID-19 pandemic. These factors prompt us to contemplate whether wildlife trade should be banned for an extended period. It also necessitates careful consideration of how to determine the scale of wildlife trade and establish corresponding regulations based on the prevailing circumstances.

In this paper, we apply the knowledge of statistics to find the most traded species and groups in terms of live animals taken from the wild. We also dive deeply into the dataset to explore the reasons behind trades by using Pareto Analysis. Additionally, we plot a line chart and a bubble map to visualize how the trade changed over the past two decades. Afterward, by first assuming and then illustrating as well as analyzing from two aspects, which is a comprehensive model-building process, we investigate whether the wildlife trade is related to the epidemic situation of major infectious diseases. Apart from that, we also find that though wildlife trade has an impact on the economy and society due to the increase in the unemployment rate, incidence, and death rate as well as the decrease of GDP and its growth rate during epidemic prevalence, we still keep an open mind on the wildlife trade in the long run rather than banning it forever! Based on that, we put forward some advisable suggestions to maintain a balance between the two of them. We also make some assumptions to make the analysis more convenient. We default that all null values are filled with "W" (wild). And we suppose that each virus is caused only by the trade of the most typical animal host. What's more, to facilitate the analysis, it is assumed that the outbreak of a certain virus is only related to the animal trade within 5 years before the outbreak, and those beyond 5 years will not be considered.

2 DATA PROCESSING, QUALITATIVE AND QUANTITATIVE ANALYSIS

2.1 The relationship between species and trade

2.1.1. Preprocessing: Eliminate the irrelevant variable "U" (unknown)

According to the Trade Database Using Guide, we determine "Live" in column "Term" and "W" in column "Source" as the retrieval objects. We eliminate the irrelevant data and update the original dataset. In addition, for those null values in "Live", the probability of "W" is much greater than the probability of "U" according to a probability distribution. So, we denote all these values as "W". We also find units including kilograms, grams, and liters. etc. To simplify our analysis, we make a unit conversion which is shown in Table 1.

Table 1. Unit conversion.

Taxon	Reference	Original Unit	New Unit

Odobenus rosmarus	19 kg	1	Standard weight
Panthera tigris	650 kg	4	Standard weight
Moschus spp	1800 g	1	Cub weight
Loxodonta africana	21 kg	1	Cub weight
Loxodonta africana	10 g	0	Scientific research
Mustela sibirica	23.724 kg	39	Each 600g
Globicephala melas	230 kg	3	Each pub has 100kg

2.1.2. Classification and analysis

To obtain a comprehensive view of the wildlife trade, the data needs to be classified and analyzed from multiple aspects, including the frequency and the number of transactions. The number of imports and exports can be regarded as the level of trade. The frequency and quantity statistics of the Order and the CITES Appendix of the taxon concerned (App.) are shown in Table 2 and Table 3. From Table 2, we can easily get the result that Primates are the most traded order, followed by Carnivora. For endangered species in the App., the number of level II endangered species trade is higher than levels I and III. We also sum up the results after the classification. There appears to be no change from the results of the App. and the Order.

2.1.3. The main purpose of the trade

To analyze both primary and secondary purposes, Pareto Analysis is utilized. Pareto Analysis Model, also known as ABC (Activity Based Classification), focuses on the principal contradiction and solving core issues, stating that 80% of problems are caused by 20% of the causes [1]. We classify trade purposes and count the frequency of each purpose using the same method. Firstly, the frequency is arranged in descending order, and then the cumulative percentage is calculated. The research objects are then divided into three groups based on the grouping situation.

Results are shown in Table 4. From the table, it is clearly can be seen that 37% T (Commercial) is the main object, while 22% Z (Zoo) produces the secondary object, and so on. Pareto Analysis aims to screen out 80% of the frequencies, a process using tried addition to get the results. T, Z, and P account for 80% of the four purposes, so they are also regarded as the key purposes (which cannot be ignored). To recap, the main purpose of trade is Commercial, followed by Zoo, Circus, or traveling exhibition. There, we can deduce that animal trade is mainly used in the service industry.

Table 2. Frequency and quantity statistics of the Order.

Order	Frequency	Import Quantity	Export Quantity
Carnivora	3830	15539.0	22659.0
Cetecea	840	2047.0	3158.0
Diprotodontia	16	354.0	66.0
Perissodactyla	548	1849.0	1966.0
Pholidota	103	906.0	1785.0
Primatea	5240	174924.0	255403.0
Sirenia	39	120.0	27.0

Table 3. Frequency and quantity of the App.

App.	Frequency	Import Quantity	Export Quantity
I	2588.0	5026.0	4715.0
II	8813.0	197069.0	280844.0
III	1075.0	5392.0	14796.0
N	8.0	98.0	13.0

2.2 Changes in trade

Over time, everything tends to change, and this is particularly true in the case of the wildlife trade. We have analyzed changes in the trafficking of wild species over the past 20 years, focusing on both the time dimension and the purpose of trafficking. We collect data about the import and export quantities of wildlife trade from 2004 to 2021 and create a line chart shown in Figure 1 to visualize the trends. From the chart, we can see that while the volume of trade remained relatively stable from 2007 to 2017, there were fluctuations in the number of trades after 2017. Overall, the trade has a certain level of stability. To further study the data, we conduct an Augmented Dickey-Fuller Unit Root (ADF) test model on the import and export quantities, frequently employed for testing a time series stationarity [2]. We choose two random years denoted as t and s, X_t is a random variable at any time. Our goal is to

Table 4. The ratio of possession for different purposes.

Purpose	Ratio (%)	Purpose	Ratio (%)
T[a]	37.02	N[g]	2.97
Z[b]	22.35	M[h]	2.13
Q[c]	15.77	E[i]	1.46
P[d]	6.11	H[j]	0.67
S[e]	6.07	L[k]	0.24
B[f]	5.15	G[l]	0.008

a-l means Commercial, Zoo, Circus or travelling exhibition, Personal, Scientific, Breeding in captivity or artificial propagation, Reintroduction or introduction into the wild, Medical (including biomedical research), Educational, Hunting trophy, Law enforcement / judicial / forensic and Botanical garden.

Calculate the autocovariance function and autocorrelation coefficient X_t, as is shown in equations (1) and (2), describing the degree to which the same event is correlated between two different periods (time t and time s). The results indicate a gentle time series for the import quantity due to equal values for $\gamma(t,s)$ and $\rho(t,s)$, while a certain fluctuation for the export quantity, possibly caused by policy changes.

$$\gamma(t,s) = E[(X_t - \mu_t)(X_s - \mu_s)] \tag{1}$$

$$\rho(t,s) = \frac{Conv(X_t, X_s)}{\sigma_t, \sigma_s} \tag{2}$$

We also plot a bubble map shown in Figure 2 of the trade data and find that most of the bubbles are concentrated in the red box area. By tracking the path of bubble changes year by year, we discover that the import and export data for 2004, 2005, 2006, 2009, and 2010 were outside the box area, while the bubbles returned to the region in 2021. This indicates that trade was unstable during this period, with the number of trades increasing. Finally, we conduct a differential analysis of the data and find the different levels in the App. are significant in both import and export quantities. Specifically, the center of gravity (quantity) of the trade is always placed on the area, but the quantity and frequency of trade are decreasing.

3 THE ASSOCIATION BETWEEN WILDLIFE TRADE AND INFECTION

3.1 Hypothesis and illustration

Firstly, let's give a guess: The wildlife trade is greatly related to the epidemic situation of major infectious diseases. By consulting the Internet, mainly based on a paper titled "Wildlife Trade, COVID-19, and Other Zoonotic Diseases" [3], published by the US Congressional Research Service (CRS) in 2021, we have compiled some of the four major infectious diseases that have occurred around the world from 1990 to 2022:

2002-2003: SARS-COV (SARS) virus was prevalent in China;

2004-2014: Simian Foamy virus and Herpesvirus, which was a high incidence in some tropical rainforest areas in central and western Africa;

2014-2016 and 2018-2020: The Ebola virus with a high mortality rate occurring in Africa;

2019 up to now: COVID-19.

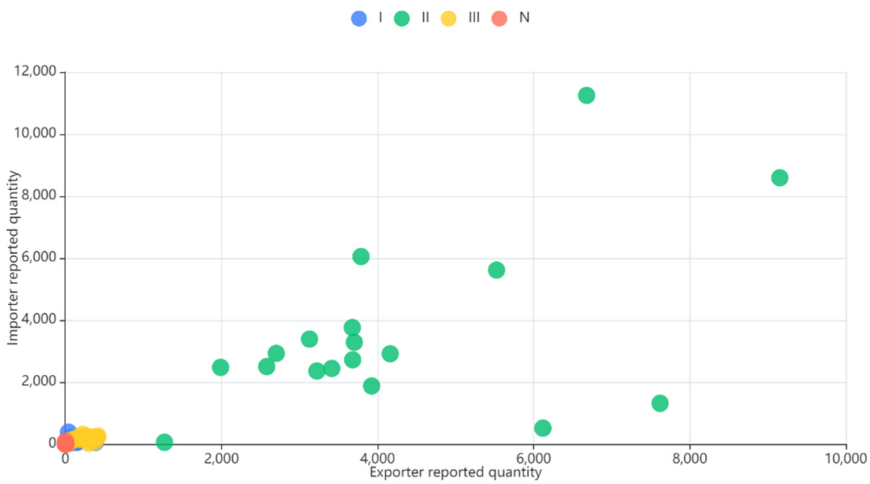

Fig. 1. Overall Import and Export quantities from 2004 to 2021.

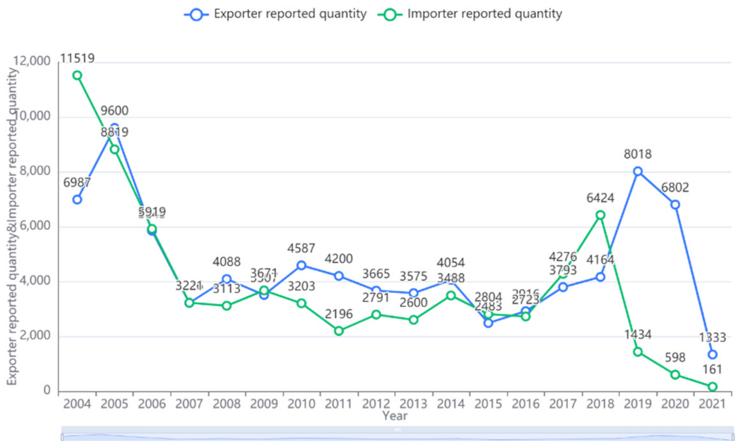

Fig. 2. App. Import and Export quantities from 2004 to 2021.

Scientific research has shown that there is a significant relationship between the production of viruses and wildlife trade. For instance, COVID-19 has been found in bats and other species, including mink and pangolin. Scientists speculate that a possible intermediate host species in the wildlife trade may have spread the virus to humans. Similarly, the SARS coronavirus outbreak during 2002 and 2003 was discovered by scientists in civets, horseshoe bats and other epidemical animals sold on Chinese wildlife markets, and it is widely believed that these animals transmitted the virus to humans. Ebola outbreaks in humans from 2014 to 2016 and from 2018 to 2020 have also been linked to the processing and consumption of infected wildlife carcasses, especially the vast relation with apes. A series of scientific studies and data suggest that the wildlife trade is closely linked to the outbreak of major infectious diseases.

For reference, we have presented a map of infectious disease outbreaks in Asia from 1900-2020 shown in Figure 3. At the same time, we found that all four types of viruses have one in common: they are all zoonotic viruses. By checking Wikipedia, zoonoses are diseases and infectious diseases that are naturally transmitted between human and human-raised livestock and poultry, so many factors promote zoonoses, such as land reclamation, close contact between human and animal beings (such as in live animal markets), hunting and consumption of wildlife, and wildlife trade. Meanwhile, an EU study showed that nearly three-quarters of new human infectious diseases are caused by zoonotic pathogens [5]. Most of these originate from wildlife. Human activities such as the wildlife trade increase the opportunities for animals to interact with humans and promote the spread of zoonotic diseases. This progress confirms the correctness of our guess.

3.2 Qualitative analysis: the propagation path of trade

When it comes to analyzing the relationship between two things, there are typically two methods: a qualitative and quantitative analysis. In this paper, we will explore both approaches. For the qualitative analysis, we take the global outbreak of the COVID-19 virus in late 2019 and the present, and the animal trade flow of the SARS can be obtained in the same way. Based on our hypothesis, we screen out the trade data of pangolins representing the typical animal hosts for the COVID-19 virus for 5 years from 2015-2019. We draw the flow direction map and the results are shown in Figure 4. From Figure 4, it is not difficult to find that from 2015 to 2019, the worldwide trade of pangolin exists in Asian countries, the most importers and exporters, and the current scientific research shows that COVID-19 host animals may be pangolin. And using the same method, the flows of animal host namely Paguma larvata trade for SARS are shown in Figure 5.

The direction of the arrow indicates the direction of trade, and the dots of different colors represent the number of traded animals. A red color indicates more trade, and a blue color indicates less trade. Hence, by analyzing the animal trade visual flow direction diagram of the above two viruses and reading the related literature, we believe that the wildlife trade is related to the epidemic situation of major infectious diseases.

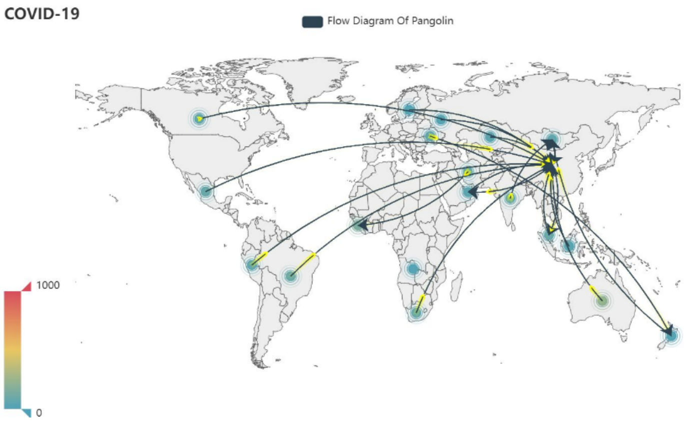

Fig. 3. Flow diagram of Pangolin for COVID-19.

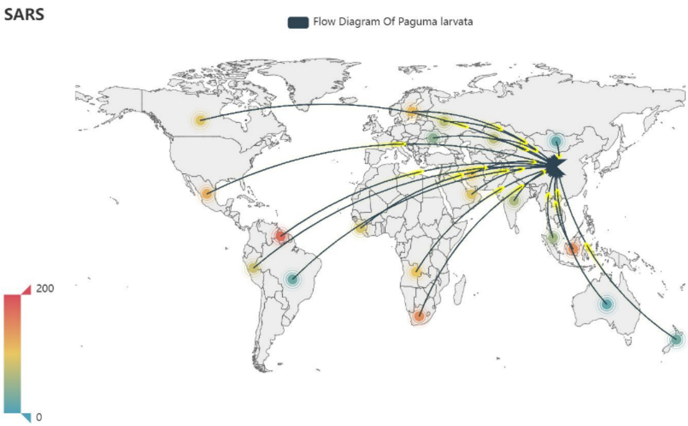

Fig. 4. Flow diagram of Paguma larvata for SARS.

3.3 Quantitative analysis: Correlation between Trade and Disease

For the quantitative analysis, we find that the dataset lacks an indicator to quantify the infectious virus (such as morbidity, mortality, etc.), and missing this indicator would bring great inconvenience to the correlation analysis. Therefore, we collect and analyze a dataset that provides information on the incidence and death rates of major infectious diseases in China from 2005 to 2020. We select five characteristics (year, importing country, exporting country, morbidity, and mortality) for correlation analysis. Through the intuitive observation of data, we find that any two variables between are not linear correlations. At the same time, there is no obvious normal distribution or close to normal unimodal distribution law, considering the above two factors, we abandon the Pearson correlation coefficient analysis and turn to the Kendall consistency test model, a method of analyzing the correlation between multiple pieces of data, as is shown in equation (3), where, S is the sum of squares of the difference between the rank sum and its mean value, K is the number of groups for rank evaluation, and N is the number of objects for rank evaluation. The results are shown in Table 5.

$$W = \frac{12S}{K^2(N^3 - N)} \tag{3}$$

Table 5. Kendall's Analytic result I.

Name	Rank average	Median
Year	2.750	2012.5
Importer	2.118	930.5
Exporter	1.062	8.5
Count_diseases	5.0	3130856.5
Count_death	4.0	16178

After analyzing the data, we have found that the results of the Kendall coefficient consistency test show a significant P-value of 0.000***, indicating a high level of significance and rejecting the original hypothesis. This means that the data present consistency. Furthermore, the model's Kendall concordance coefficient W-value is calculated to be 0.948, indicating almost complete consistency in the degree of correlation. Based on quantitative analysis, we can conclude that there is a significant relationship between wildlife trade and the epidemic situation of major infectious diseases.

4 THE IMPACT OF BANNING AND SUGGESTIONS

Trade bans have different effects on the economy. Studies have shown that the ban may promote the development of designated industries and curb the breeding of bad industries and grey industries. But there is also clear evidence that the ban will lead to a certain downward trend in economic growth [6], thus curbing economic development in some countries.

4.1 Correlation analysis

Studying the economic and social impact of banning wildlife trade, we choose to quantify the evaluation criteria. For example, we use GDP to measure the pace of economic growth and use unemployment to measure the impact on society.

Firstly, let's guess that the volume of trade is related to the economy, but in fact, their linear correlation is almost 0. The possible reason is that with the development of time, the level of productivity continues to improve, driving economic development, and this rapid development offset the reduction in GDP is caused by the decrease in wildlife trade. After making a first-order difference in GDP values, we find that there is a partial effect of trade on GDP growth. Furthermore, our data analysis reveals that the results of the Kendall coefficient consistency test show a significant P-value of 0.000*** which is under 0.05, indicating a significant correlation. We also draw a thermal map (refer to Figure 5) to display the results. This high level of significance indicates that the original hypothesis can be rejected with confidence. This means that the data present consistency. And the Kendall concordance coefficient W-value of 0.736 shows the degree of correlation is highly consistent. Kendall's Analytic result is shown in Table 6.

4.2 Pros & Cons of the ban

While implementation costs may be high, it is believed that effective monitoring of trade can greatly save on the costs incurred by a potential pandemic. High-income countries with the greatest demand for wildlife can support this effort so that the countries of wildlife origin can gain the necessary support to prevent the spread of zoonotic diseases [7]. But some experts believe that banning the trade of endangered species may not be an effective tool for their protection. In fact, it has been argued that such bans may increase the value of the species in question, leading to an increase in poaching. For species in East Asia with a high value and a threat, demand appears to be price-inelastic, meaning that even as the price increases, consumption remains relatively stable. This growing demand for wildlife in East and Southeast Asia could further expand the consumer base. Therefore, trade control measures may lead to significant price increases, but have little effect on demand in price-inelastic situations.

4.3 Regulations for wildlife trade

Sustainable utilization and conservation: Ensuring that the scale of wildlife trade remains within sustainable limits is essential for safeguarding species and ecosystem health. It requires the establishment and reinforcement of policies and measures for protected areas, wildlife conservation, and management. Legality and traceability: Establishing robust legal frameworks and regulatory mechanisms is crucial for combating illegal wildlife trade. Strengthening law enforcement and imposing stricter penalties for illegal activities are necessary. Additionally, enhancing international cooperation to combat transnational illegal trade is vital. Alternatives and sustainable development: Encouraging and supporting alternative options, such as the development of sustainable substitutes and alternative markets, can help reduce the demand for wildlife trade. Simultaneously, promoting the sustainable conservation of wildlife and protected areas provides economic opportunities for local communities while raising awareness and involvement in wildlife conservation efforts. International cooperation and coordination: Wildlife trade is a transnational issue that requires collective efforts from the international community. Countries should enhance cooperation, share information and experiences, establish unified standards and regulations, and collectively address the challenges posed by wildlife trade.

Fig. 5. Thermal map of the correlation coefficient.

Table 6. Kendall's Analytic result II.

Name	Rank average	Median
Year	4.81	2021
Importer	3.333	418
Exporter	2.381	13
GDP	6	6087164035072
GDP Growth Rate	2.714	8.49
Jobless Rate	1.762	4.1

5 CONCLUSIONS

In conclusion, after analyzing the trade data, we find that Primates are the most traded species, and level II endangered animals are highly involved in the trade. Commercial and Zoo demanding purposes are the main reasons for trading. The trade volume has remained stable from 2003 to 2022. Unfortunately, the wildlife trade is related to the epidemic situation of major infectious diseases. And wildlife trade has a significant impact on the economy and society. It leads to an increase in the unemployment rate, incidence, and death rate during epidemic prevalence, and a decrease in GDP and its growth rate. Therefore, we suggest maintaining a balance in wildlife trade in the long run. Rather than directly banning them, international collaboration should be strengthened to reduce wildlife trade and trafficking. By addressing the underlying drivers of trade, promoting sustainable alternatives, and implementing robust regulations, we can strive for a future where the trade of wildlife is conducted responsibly, ensuring the well-being of both ecosystems and societies.

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