# Benefits on Sustainability of Ivory Trade Governance in Developed Countries Based on Grey Predictive Model

Shiqi Zheng[1,a,#], Fangchi Zhou[1,b*,#], Jiaxin Cheng[2,c,#]

[1]School of Mathematical Sciences, Dalian University of Technology, Dalian, Liaoning, China
[2]School of Software Technology, Dalian University of Technology, Dalian, Liaoning, China

[a]1227013101@mail.dlut.edu.cn;
[b*]2791516141@mail.dlut.edu.cn;
[c]chengjiaxin@mail.dlut.edu.cn
[#]These authors contributed equally to this work.

**Abstract.** In order to visualize the economic benefit analysis of national ivory trade governance, GDP and GNI were chosen as the indicators to measure the economic level of the country. Data processing based on gray prediction was used for data analysis and curve comparison. It is concluded that the governance of the ivory trade has a low impact on long-term economic trends and that the share of illegal wildlife trade is gradually declining, laying the foundation for sustainable economic development. Additionally, through data analysis of North American female African elephant population size based on Asian elephant data, it is concluded that managing the ivory trade has a beneficial effect on the environment.

**Keywords:** Grey Predictive Model; Ivory Trade Governance; Developed Countries; Sustainable Development

## 1  INTRODUCTION

The ivory trade has led to a dramatic decline in elephant populations. Meanwhile, with the development of computer network technology and e-commerce, cases of illegal ivory trade on the Internet have gradually increased, which has brought new difficulties to wildlife protection.[1] Enforcement is crucial for effective international environmental agreements.[2] However, the governance of the ivory trade requires human, material and financial resources. Therefore, some countries are reluctant to invest more energy in the governance of the ivory trade.

Actually, when the ivory trade is regulated, economic development is sustainable and the ecosystem is improved. The study aims to prove that regulating the ivory trade is profitable and discusses the economic and ecological benefits of regulating the ivory trade in developed countries as a reference for global sustainable development.

In order to study the economic benefits of developed countries' governance of the ivory trade, we select five developed countries with long-term and effective governance of the ivory trade in Table 1, namely the United States, France, Germany, Australia and

the New Zealand. By analyzing the economic and environmental benefits of these five countries, we will provide positive guidance for global ivory trade control efforts.

**Table 1.** Ivory Trade Governance Policies

| | |
|---|---|
| The US | During the visit to Kenya, Barack Obama announced that the U.S. would ban most interstate trade in African ivory and severely restrict commercial exports.[3] |
| France | The decree includes a ban on trade in ivory of any age and the use of ivory in the production of artifacts. |
| Germany | The European Commission's proposal ensures that the remaining limited legal ivory trade does not foment poaching or illegal trade.[4] |
| Australia | Contravention of Australia's wildlife laws is punishable by fines up to AUD210,000 for an individual and up to 10 years imprisonment.[5] |
| New Zealand | In 2020, Eugenie Sage, the Minister for Environmental Protection, announced a ban on the sale of any goods made from ivory from elephants killed after 1975 in New Zealand.[6] |

## 2      ECONOMIC BENEFITS OF IVORY TRADE

### 2.1      Data Sources and Collection

Ivory trade volumes are difficult to obtain due to illegal trade, incomplete data collection and reporting, complexity of trade routes, fluctuations in market demand, difficulties in valuation and pricing, and political and economic factors. Instead of ivory trade volumes, we use trade volumes for the five main ivory products. The volume of ivory trade is calculated from the volume of ivory trade and the price of ivory.

$$Tv = Pri \times m \tag{1}$$

Tv is the volume of ivory trade, Pri is the price of ivory, and m is the quality of the traded product.

we measure the country's economic level through GDP and GNI. GDP (Gross Domestic Product) and GNI (Gross National Income) are better measures of a country's economy mainly because they provide comprehensive and all-rounded economic indicators that reflect a country's economic activities and income levels over a certain period of time. In addition, GDP and GNI have a certain degree of international comparability, as they are statistically and methodologically calculated in accordance with internationally accepted standards and methods.

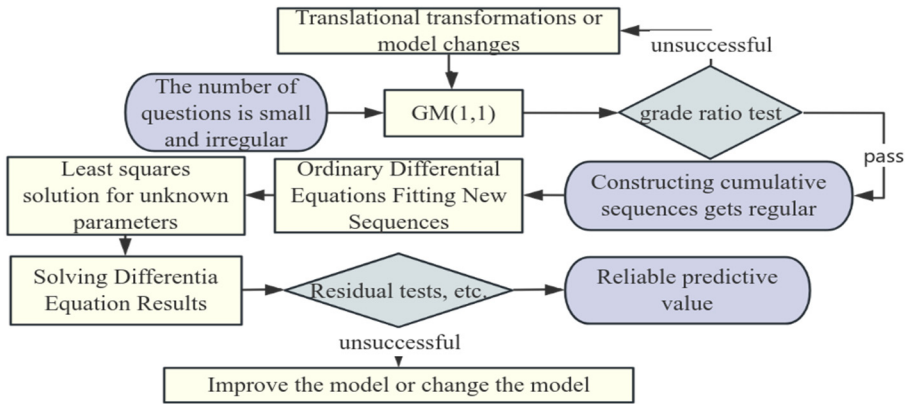## 2.2    Accounting for Ivory Trade Based on a Grey Prediction Model



**Fig. 1.** Grey Prediction Process

There is less data on ivory prices, so we use Grey prediction model presented in Figure 1 to predict ivory prices from known data. GM (1,1) is the simplest Grey prediction model. It uses the original discrete non-negative data columns and generates new, more regular discrete data columns that weaken randomness by accumulation.

$$x^{(0)} = \left(x^{(0)}(1), x^{(0)}(2), \dots, x^{(0)}(n)\right), x^{(1)}(m) = \sum_{i=1}^{m} x^{(0)}(i), m = 1,2,\dots,n \qquad (2)$$

$$z^{(1)}(m) = \delta x^{(1)}(m) + (1 - \delta)x^{(1)}(m - 1), m = 2,3,\dots,n, \delta = 0.5 \qquad (3)$$

We call the equation the basic form of the GM(1,1) model (k=2,3,...,n). b denotes the amount of Grey interaction. c denotes the amount of Grey interaction. d denotes the amount of Grey interaction. e denotes the amount of Grey interaction. a denotes the development coefficient. We transform the formula into matrix form and then use least squares regression to finally obtain the estimates of $\hat{a}$ and $\hat{b}$.

$$x^{(0)}(k) + az^{(1)}(k) = b, u = (a, b)^{T}, Y = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(n) \end{bmatrix}, B = \begin{bmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \vdots & \vdots \\ -z^{(1)}(n) & 1 \end{bmatrix} \qquad (4)$$

Integrating the regression results by Newton's Leibniz formula with definite integrals yields the integral formula, which further yields the Grey differential equation and the white differential equation.

$$\int_{k-1}^{k} \frac{dx^{(1)}(t)}{dt} dt \approx \hat{a} \int_{k-1}^{k} x(1)dt + \int_{k-1}^{k} \hat{b} \, dt = \int_{k-1}^{k} \left[-\hat{a}x^{(1)}(t) + \hat{b}\right] dt \qquad (5)$$

Finally, we determine the suitability of the model through many ways. Examples include a posteriori difference tests for model accuracy, find the residual mean, finding the residual variance, finding the a posteriori difference ratio and the probability of

small errors. However, it is only suitable for short to medium term forecasts and only approximates exponential growth.

By checking ivory data over the years, we get a small number of accurate results in Figure 2. Ivory prices are predicted from the limited data.
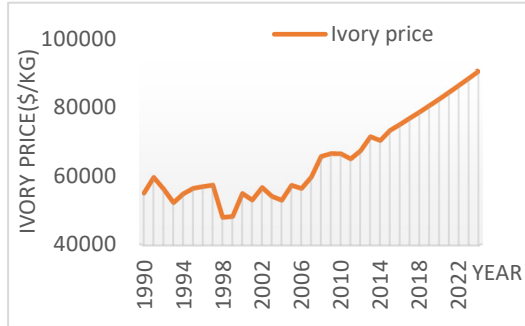


**Fig. 2.** Ivory Price

Estimation of unknown trade volumes through Grey prediction models from a small number of known trade volumes[7] is shown in Figure 3.
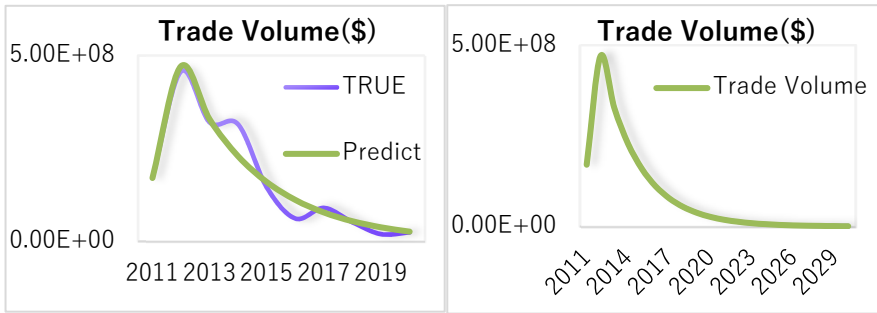


**Fig. 3.** Trade Volume

## 3    ANALYSIS

### 3.1    Economic Efficiency

We calculate the average economy for the United States, Germany, France, New Zealand and Australia and then analyze the trends. Besides, we calculate the average GDP and GNI of all countries whose economies is similar to the five countries and compare it with the average economy of the five countries.[8] Our results are shown in Figure 4.
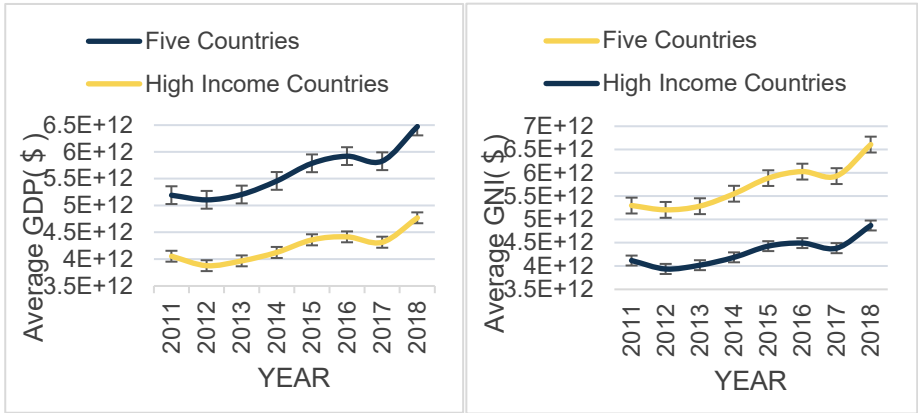
**Fig. 4.** Average GDP & GNI

The line graph shows that the average GDP and GNI of the five countries is not significantly different from the average GDP and GNI of all countries with similar economies. It suggests that longer period of commercial illegal wildlife trade have a smaller impact on long-term GDP and GNI. Analyzing the data, it is concluded that regulating illegal wildlife trade has little impact on long-term economic trends. This reflects the synchronization of economic development.

From the perspective of economic structure, the lower the proportion of illegal wild-life trade in the national economy, the smaller the impact on biodiversity. The impact on environmental will be smaller as well. Therefore, economic sustainability can be analyzed from the environmental perspective through the change of Per over time.
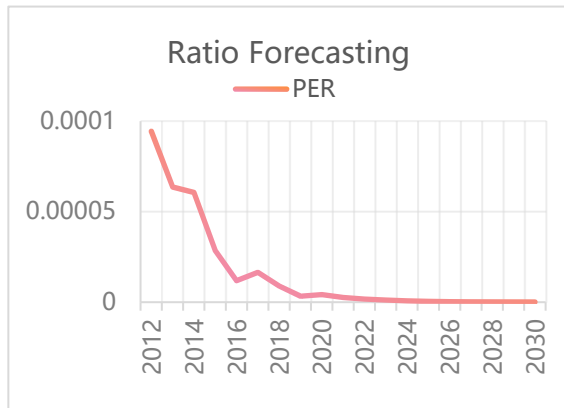
$$Per = \frac{Tv}{GDP} \tag{6}$$



**Fig. 5.** Ratio Forecasting

These five countries show a clear cyclical growth trend compared to other countries. As pioneer countries, their growth is largely due to the gradual improvement of environmental policies. The test results of Figure 5 shows a gradual decrease in the share of illegal wildlife trade. Illegal wildlife trade often involves damage to the natural environment and disturbance of the ecological balance, banning such trade helps to protect the ecological environment and maintain the ecological balance, thereby providing for sustainable economic development.

## 3.2    Environmental Efficiency

The ivory trade has had a significant impact on biodiversity, mainly in terms of its effect on elephant populations. This hunting behavior poses a significant threat to elephant populations, leading to sharp declines and even putting certain elephant populations at risk of extinction.
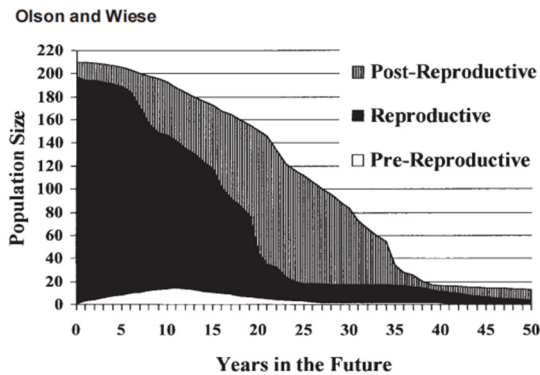


**Fig. 6.** Current Asian Elephant Mortality and Fecundity Curves[9]

A 50-year projection of female African elephant populations in North America, based on current mortality and fecundity curves for Asian elephants in Figure 6, shows that African elephant populations are declining rapidly.[9]

The ivory trade has serious negative impacts on biodiversity. In order to protect elephant populations and maintain the balance and stability of ecosystems, effective measures must be taken to combat the illegal ivory trade and promote sustainable wildlife conservation measures. This includes strengthening law enforcement, raising public awareness and promoting the development of alternative industries to ensure that biodiversity is effectively protected.

## 4    CONCLUSIONS

Firstly, according to the ivory trade quantity data of five selected developed countries and based on the gray prediction model to account for the ivory trade, and at the same

time to predict the ivory price to get the ivory trade volume of each country. After the governance, the share of ivory trade of the five countries gradually decreases.

Secondly, by comparing the GDP and GNI of the five countries, it can be concluded that the governance of ivory trade will not have a big impact on the long-term economic development trend, and provide a guarantee for the sustainable development of the economy.

Thirdly, the data on Asian elephants are used to predict the population size of female African elephants in North America. By controlling the ivory trade, the population can be increased, and the forest cover will increase, and the fight against ivory trade is favorable to the maintenance of the ecological environment.

Based on the above research, the ivory trade governance deserves to be encouraged and promoted. Countries can combat the ivory trade while preserving the ecology and developing the economy by improving the construction of laws and regulations, strengthening regulation and law enforcement, and developing the tourism industry on the basis of ecological protection. All this lays a solid foundation for global sustainable development.

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