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# *Research on Combating Illegal Wildlife Trade Based on an Integrated Regression and Enhanced Forecasting Model*

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***Abstract:*** Illegal wildlife trade, a significant threat to global biodiversity, is estimated at $26.5 billion annually. This research focuses on the development and application of a comprehensive data analysis framework to combat this illicit trade. We employed a weighted scoring model to assess potential clients for collaboration, utilizing a multidimensional evaluation system informed by extensive literature review. The model allocated weights to key criteria such as resource capacity, political support, and management capabilities, leading to the selection of INTERPOL as the optimal partner. Subsequently, a multiple linear regression model was established to explore the correlation between illegal wildlife trade and other criminal activities, revealing a positive relationship with drug, arms, and human trafficking. To forecast the project's impact, an enhanced forecasting model was developed, incorporating intelligence collection and analysis to predict a decline in illegal wildlife trade cases over a five-year period. The sensitivity of the model to various factors was evaluated using the Monte Carlo simulation, which underscored the importance of operational efficiency and international cooperation in the project's success. This research demonstrates the potential of data-driven approaches to significantly influence and reduce illegal wildlife trade, offering valuable insights for future conservation efforts.

## 1. Introduction

The rampant illegal wildlife trade not only undermines the integrity of our planet's ecosystems but also poses a significant threat to the survival of countless species, contributing to the ongoing crisis of global biodiversity loss[1, 2]. In response to this pressing issue, our research endeavors to develop and implement a strategic data-driven framework aimed at significantly reducing the scale of illegal wildlife trade activities [3].

Our primary objective is to employ advanced analytical methods to identify and engage with key stakeholders capable of supporting and advancing our mission. To this end, we have meticulously constructed a weighted scoring model to evaluate potential clients based on a set of critical criteria derived from extensive literature review. This model serves as a decision-making tool, enabling us to rank and select the most suitable partners for the project, with INTERPOL emerging as our top candidate due to its alignment with project objectives and available resources. Furthermore, we have developed a robust regression prediction model to simulate the impact of our strategies on curbing illegal wildlife trade[4, 5]. By integrating real-world influencing factors, this model forecasts the potential reduction in illegal activities and provides a quantitative basis for assessing the effectiveness of our interventions. Our commitment to data-driven solutions is underscored by the application of the Monte Carlo simulation[6], which allows for a thorough sensitivity analysis and enhances the reliability of our predictions.

## 2. Project Implementation and Client Selection

First of all, we establish a Weighted Average Score Model to identify the best clients for the project. This model assigns weights to each evaluation criterion ($K_i$), multiplies the score of each organization on each criterion by the corresponding weight ($W_i$), and then adds up these weighted scores to obtain the overall score ($Mark_i$) for each organization.

$$Mark_i = \sum W_i \times K_i \tag{1}$$

First, we establish the user evaluation criteria based on project requirements, including Resource Capability, Power and Political Support, Interest and Mission, Management Capability, Collaboration Potential, and Influence.

After reviewing literature and official websites of various organizations, we have preliminarily selected 6 potential clients. Then, by combining the disclosure documents and official information of the candidate organizations with third-party evaluations, we ranked and scored the 6 dimensions of the candidate organizations. The scoring range is from 0 to 10 points, resulting in the final evaluation data for the candidate organizations as shown in Table 1.

Table 1: Candidate organizations correspond to scores.

| Organization | Resource Capacity | Power and political support | Interests and Mission | Management Skills | Potential for cooperation | Influence |
|---|---|---|---|---|---|---|
| WWF | 9 | 8 | 8 | 8 | 9 | 8 |
| OIE | 6 | 7 | 8 | 7 | 7 | 6 |
| WCS | 7 | 6 | 9 | 8 | 7 | 7 |
| IUCN | 8 | 7 | 9 | 8 | 9 | 9 |
| INTERPOL | 8 | 9 | 8 | 9 | 8 | 9 |
| CITES | 8 | 8 | 7 | 9 | 7 | 9 |

After carefully assessing the project's implementation requirements and considering its long-term development, we meticulously assigned weights to six key indicators. The weight distribution is shown in Figure 1. For each potential client project, we meticulously calculated the final allocation results by multiplying and summing the weighted scores, as shown in Figure 2. Leveraging our robust evaluation model, we meticulously derived the client's final weighted score and ranking. As a result, the International Criminal Police Organization emerged as the top choice for our project, based on its exceptional score.

Based on the computational results of the model, we ultimately identified the International Criminal Police Organization as the target client for our project. This organization can match well with all six indicators we obtained, and through the modeling process and analysis of the data of potential clients, we can also verify that the target client selected by our model fits well with the needs of our project, enabling the smooth implementation and effectiveness of our project.

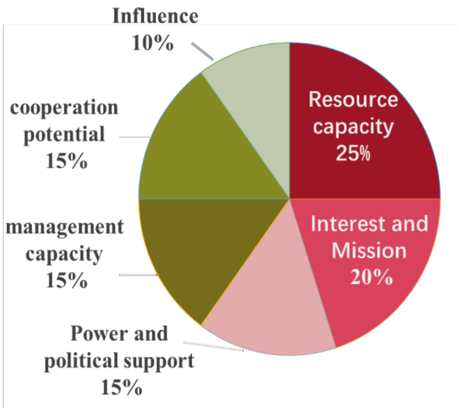


Figure 1: Weight.

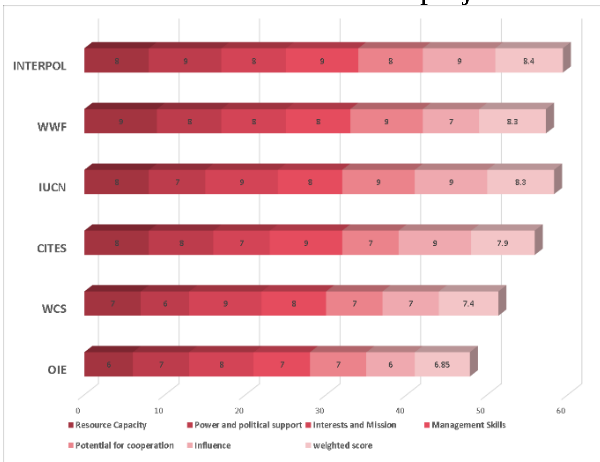


Figure 2: Final score and ranking.

## 3. Construction of the Integrated Model

### 3.1. Multiple Linear Regression Model

Because illegal wildlife trade is often conducted through smuggling, which is often associated with drug trafficking, arms trafficking, and human trafficking, we speculate that illegal wildlife trade is related to smuggling crimes such as drugs, arms, and human trafficking. We have obtained evidence of this from relevant literature.

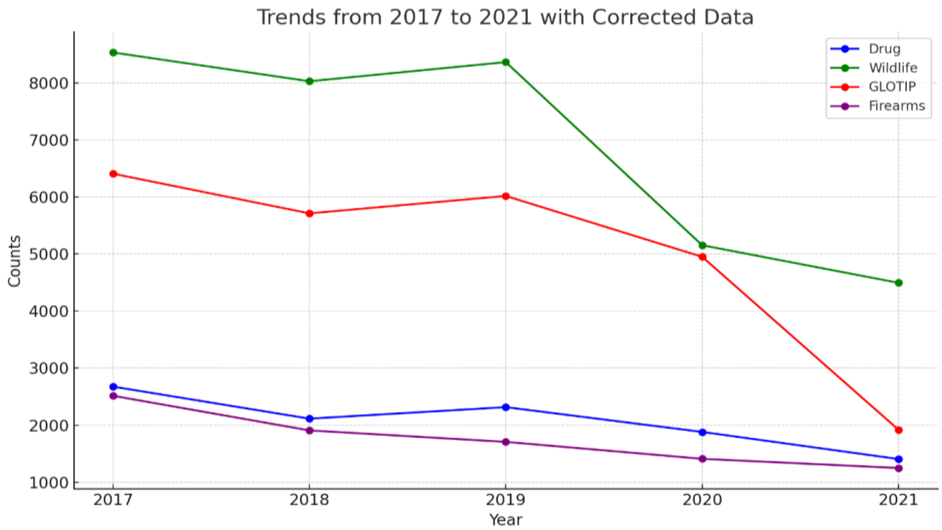


Figure 3: Number of various types of crime cases from 2017 to 2021.

We obtained relevant data on drug trafficking, arms trafficking, human trafficking, and wildlife trafficking from the UNODC website. From the data, we extracted the number of various types of crime cases from 2017 to 2021, and plotted a line graph as shown in Figure 3. By establishing a multiple linear regression model, we found that the number of wildlife trafficking cases is positively correlated with the number of drug trafficking, arms trafficking, and human trafficking cases. The original form of a regression model with the coefficients set as unknowns and the inclusion of a residual term would be as follows.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon \quad (2)$$

Here, $Y$ represents the dependent variable, $\beta_0$ is the intercept term, $\beta_1$ , $\beta_2$ and $\beta_3$ are the coefficients of the independent variables $X_1$, $X_2$ and $X_3$ respectively, and  is the residual or error term that captures the deviation of the observed values from the line of best fit.

For our specific regression model related to Wildlife, the formula would be as follows.

$$\text{Wildlife} = 222.6819 + 1.7882 \times \text{Drug} + 0.3383 \times \text{GLOTIP} + 0.7310 \times \text{Firearms} + \varepsilon \quad (3)$$

The estimated regression equation represents the result of fitting the original model to the data. We assess the model's fitting effect through regression fit goodness-of-fit tests and validation with values, and present the validation results as Figure 4. By fixing the values of three explanatory variables separately to test the other two estimated parameters, we determine that the model fitted to the processed data can provide a good explanatory effect.

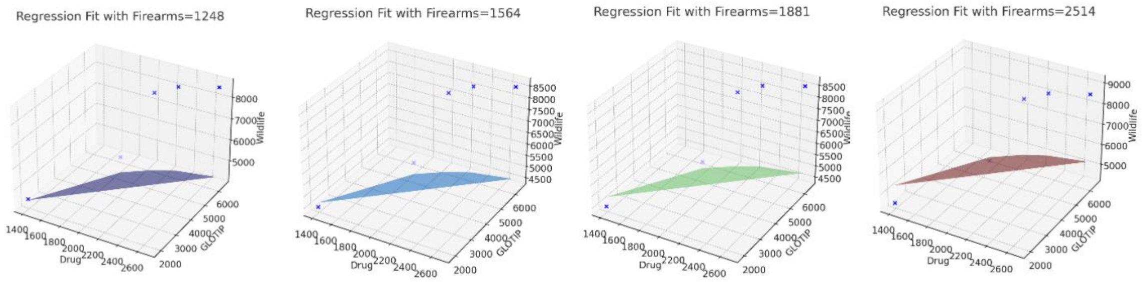


Figure 4: Good fit test graphs.

## 3.2. Enhanced Forecasting Model

For the effect of the project, we designed an enhanced model to predict the number of illegal animal smuggling cases in the next five years, and in our enhanced model, we chose the "Intelligence Collection and Analysis" action in the project to make the prediction. The project design of this action can significantly improve the efficiency of the police in identifying and combating the illegal wildlife trade, by collecting cases of illegal and criminal offenses around the world, establishing a global intelligence sharing platform, and collecting intelligence about the illegal trade, including the trafficking routes, criminal groups involved, and commonly used smuggling methods. Big data and artificial intelligence technologies are used to analyze intelligence and identify crime patterns and potential risk points.

We assume that over the next 5 years, with the efforts of Interpol, the implementation of the project will meet the expected goals and the efficiency of the police in identifying and combating cases will increase by 15% per year. In order to make the projections clearer, we assume that the number of illegal wildlife trade cases that the police are able to identify and crack down on is 100 per year prior to the implementation of the project, and that the global illegal wildlife trade incidents are 1,000 unrecognized cases that are still going on.

We let Pt be the number of illegal wildlife trade cases identified and cracked down by the police in year t, and Ut be the number of cases that were not identified and continued. t be the year after the implementation of intelligence collection and analysis (t=1,2,3,…). We obtain the following model.

$$\begin{cases} P_t = P_{t-1} \times (1 + r + e) \times (1 + c) \\ U_t = (U_{t-1} + U_{t-1} \times g) \times (1 - k) - P_t \\ P_0 = 100 \\ U_0 = 1000 - P_0 \end{cases} \quad (4)$$

In these formulas, Pt is positively influenced not only by the number of cases identified in the previous year, but also by the operational efficiency improvement factor e and the international cooperation impact factor c. On the other hand, Ut is driven by the growth rate of trade activity g and the dampening effect of the correlation between other criminal activities and the illegal wildlife trade k.

After making assumptions about the required data, we simulated the model using Python and ended up with predicted data for the next 5 years under ideal conditions, as shown in Figure 5.

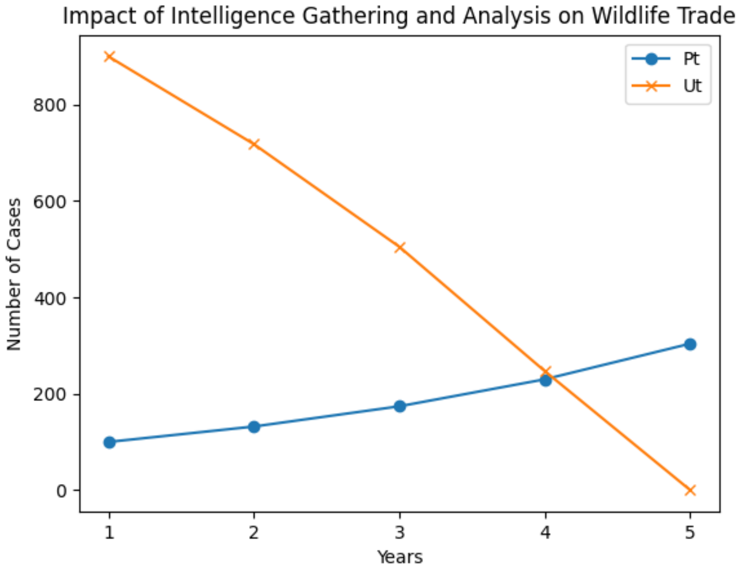


Figure 5: Projected caseload over the next 5 years.

By simulating the effect of the project before and after the implementation, we finally obtained the predicted results of the number of illegal smuggling cases in the next five years under the ideal state, and it can be clearly found that, through the implementation of our project, the probability of detecting illegal cases of the Interpol has been improved, and the number of illegal smuggling cases per year has been gradually reduced, and thus we can see the concrete impact effect of the project.

### 3.3. Sensitivity Analysis

For sensitivity analysis and situational analysis, we can use Monte Carlo Simulation to build a suitable mathematical model. Monte Carlo Simulation is able to model uncertainty and complexity by generating a large number of random samples, which makes it suitable for sensitivity analysis and situational analysis.

Table 2: Selected range of data.

| factor dimension | Selected reasonable ranges |
| --- | --- |
| Operational efficiency improvement factor(e) | 2%-5% |
| Coefficient of influence of international cooperation(c) | 3%-8% |
| Growth rate of trade activities(g) | 1%-7% |
| Correlation with other criminal activities(k) | 5%-15% |

After bringing the combined dataset into the original model for Monte Carlo simulation, we got the corresponding simulation results, which we divided into four dimensions and showed the results of the impact of the data selection on the model according to the level of data selection as shown in Table 2.

In conducting sensitivity analysis, we particularly focused on the impact of the operational efficiency improvement factor (e) and the international cooperation impact factor (c) on the number of undetected cases. The results indicate that when the operational efficiency improvement factor is relatively low, for example, at 3%, it is projected that the number of undetected cases of illegal wildlife trade will be reduced to approximately 500 by the fifth year. However, if the operational efficiency improvement factor significantly increases, such as to 8%, it is hopeful that the number of undetected cases could be reduced to zero within five years, demonstrating the substantial positive effect that increased efficiency can have on combating illegal trade.

Similarly, the international cooperation impact factor also plays a crucial role in the rate of case detection. When this factor is low, such as at 1%, the reduction in undetected cases is slower. In contrast, when the international cooperation impact factor is elevated, for instance, at 7%, the number of undetected cases decreases significantly at an accelerated rate, underscoring the key role of international cooperation in combating illegal wildlife trade.

Furthermore, the growth rate of trade activities (g) and the correlation with other criminal activities (k) also influence the number of undetected cases. When g is high or k is low, implying that illegal trade activities grow rapidly or have weak associations with other criminal activities, the decline in undetected cases is slow. Conversely, when g is low or k is high, indicating that illegal trade activities grow slowly or are strongly correlated with other criminal activities, the number of undetected cases declines rapidly. These findings highlight the importance of considering a combination of factors when devising strategies to combat illegal wildlife trade.

For a more in-depth sensitivity and contextual analysis, we will use Monte Carlo simulations combined with visualization results to show an in-depth analysis of the impact of different parameter variations on the impact of projects to combat illegal wildlife trade. The visualization results are shown in Figure 6. We will explore the following core parameters: operational efficiency improvement factor e, international cooperation impact coefficient c, growth rate of trade activities g, and correlation with other criminal activities k.

The sensitivity analysis in Figure 6 shows that the operational efficiency improvement factor (e) and the international cooperation impact factor (c) have (a) significant impact on project success. Increased operational efficiency and international cooperation can significantly improve the effectiveness of combating illegal wildlife trade. The growth rate of trade activities (g) and the correlation with other criminal activities (k) also affect the effectiveness of the project, but their impacts are slightly less significant compared to e and c. The impacts of the two factors on the effectiveness of the project are also significant, although the impacts of the two factors are more significant. Through this contextual and sensitivity analysis, the project team can better understand the impact of different factors on project outcomes, which can inform implementation strategies and resource allocation. It also helps to prepare for potential risks and capitalize on opportunities to increase the likelihood that the project will meet its desired objectives.

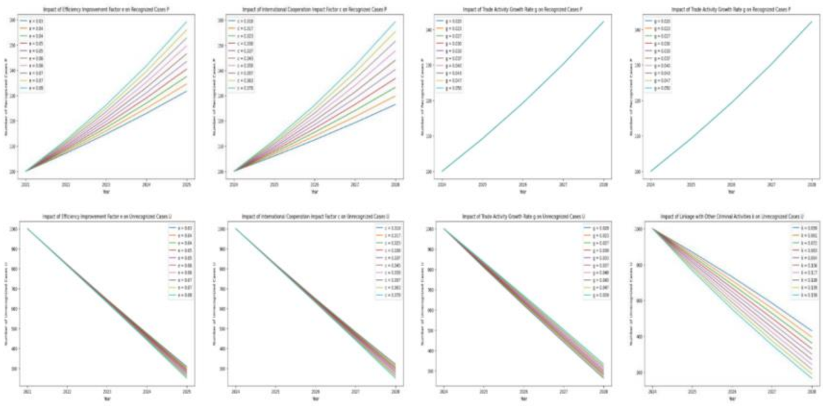

Figure 6: Monte Carlo simulation.

## 4. Conclusions

In conclusion, this research has meticulously evaluated the efficacy of two pivotal models within the context of combating illegal wildlife trade. The Weighted Scoring Model and the Enhanced Forecasting Model have been central to our analytical framework. The Weighted Scoring Model has proven to be a robust tool for client selection, providing a systematic and quantitative approach to assessing the suitability of potential partners. By assigning weights to various dimensions such as resource capability, political support, and collaboration potential, the model has facilitated the identification of INTERPOL as our strategic partner. This model's strength lies in its ability to synthesize complex data into actionable insights, thereby streamlining the decision-making process.Our Enhanced Forecasting Model, on the other hand, has been instrumental in simulating the projected impact of our interventions on illegal wildlife trade. By incorporating variables such as operational efficiency and international cooperation, the model has forecasted a significant decline in illegal activities over the five-year span of our project. The model's predictive capabilities have been validated through sensitivity analysis, underscoring its reliability in estimating the long-term effects of our strategies.

Despite the strengths of these models, they are not without limitations. The Weighted Scoring Model's reliance on accurate data and the potential for subjective interpretation in assigning weights to criteria are areas that require careful consideration. Similarly, the Enhanced Forecasting Model's projections are contingent on the assumption that current trends will continue, which may not account for unforeseen changes in the landscape of illegal wildlife trade. In future iterations, it will be crucial to refine these models with ongoing data collection and incorporate emerging trends and variables to enhance their predictive accuracy.

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