Combating Illegal Wildlife Trade through Big Data Monitoring and Management

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Abstract. Illegal wildlife trade is a persistent global issue that threatens biodiversity and ecological stability. Addressing this challenge requires innovative approaches, including leveraging big data for management solutions. This paper conducts a comprehensive evaluation and analysis of a management project aimed at combating illegal wildlife trade, with a focus on utilizing big data technology. Through the PRI-AHP model, economic analysis tools, and system dynamics modeling, the study identifies TRAFFIC as the optimal project management client, assesses financial feasibility and risk and predicts positive impacts on illegal trade activities, law enforcement, and monitoring system efficiency. This research provides valuable insights for decision-makers and emphasizes the potential of big data in wildlife conservation projects.

Keywords: Illegal wildlife trade, big data monitoring, and management, PRI-AHP model, economic analysis, system dynamics modeling.

1 INTRODUCTION

Illegal wildlife trade has evolved into a serious transnational issue globally, posing a significant threat to biodiversity, ecological balance, and the sustainable development of human society. This illicit trade encompasses various wildlife species and their derivatives, including but not limited to rhinoceros' horns, ivory, tiger bones, corals, snake skins, and parrots.

Although many countries and international organizations have taken a series of measures to address illegal wildlife trade, including strengthening law enforcement, enhancing international cooperation, and intensifying public awareness and education, the challenges remain daunting. Traditional regulatory methods and approaches often prove inefficient in effectively combating illegal trade activities [1]-[3]. Additionally, with the advancement of globalization and technology, illicit traders continually adapt and employ more covert and efficient methods of operation.

To tackle this serious issue, there is an urgent need for innovative and efficient measures. The utilization of big data technology has emerged as a highly promising approach[4]. Big data technology possesses the capability to rapidly and accurately

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process large-scale data, enabling regulatory agencies to better understand and discern patterns and trends in illegal trade, thereby facilitating timely detection and crackdown on illicit trafficking activities[5]. In this regard, this paper proposes a method utilizing artificial intelligence monitoring technology to assist in the global management of illegal wildlife trade. The project management plan aims to develop a highly intelligent data-driven market monitoring system that utilizes big data and machine learning technologies to automatically identify and track global illegal wildlife trade activities. It will enable real-time monitoring, automated alerts, comprehensive analysis of data from multiple sources, and detailed reporting, providing a powerful tool for relevant agencies to tackle illegal wildlife trade and protect wildlife and ecological balance. Its significance to global ecological conservation and the long-term survival of wildlife populations cannot be overstated.

2 ESTABLISHMENT OF THE PRI-AHP MODEL

This paper first utilizes the PRI-AHP model to select the optimal target client for the project management scheme, aiming to apply the management plan proposed in this paper for utilizing artificial intelligence to monitor illegal wildlife trade to this client.

2.1 Establishment of Target Client Evaluation Indicator System

To select suitable clients, this paper proposes a comprehensive evaluation indicator system through extensive research on the websites of relevant organizations and literature on related projects, ensuring the comprehensiveness and effectiveness of the method. These indicators are divided into three main indicators and eight sub-indicators, aimed at thoroughly analyzing various factors influencing the reduction of illegal wildlife trade. The detailed descriptions of these indicators are as follows:

1. Power: This indicator reflects the strength and efficiency of different actors in combating illegal wildlife trade. Subsequently, we divided power into three sub-indicators: partners, policy influence, and legal capacity.

2. Resources: The adequacy of resources directly impacts the effectiveness of wildlife conservation areas. We divided resources into two sub-indicators: financial and human resources.

3. Interest: Interest refers to the level of attention and involvement of the public, related industries, and decision-makers in wildlife conservation. We divided interest into three sub-indicators: past achievements, current priorities, and goals and missions.

2.2 Construction of the PRI-AHP Model

After completing the preliminary preparation work, we constructed a PRI-AHP model, which is a decision support tool designed specifically for the optimal client selection problem, based on the principles of the Analytic Hierarchy Process (AHP), with targeted improvements and expansions[6]. AHP is a method for analyzing complex decision problems by decomposing them into smaller parts and assessing the relative importance of each part to prioritize options. The main process consists of five steps: defining decision objectives and hierarchy structure, constructing judgment matrices, calculating maximum eigenvalues and eigenvectors, standardizing the process, and consistency testing[7]. Through the aforementioned calculation process, the weights of the first and second-level indicators are as shown in Table 1.

Table 1. Indicator weights

1 Level	**Power**			**Resource**		**Interest**		
	0.37			0.16		0.47		
2 Level	**Coopera-tive part-ner**	**Policy imoact**	**Lagel ca-pacity**	**Fiances**	**Manpower**	**Past achieve-ment**	**Presnet achieve-ment**	**Objectives and mission**
	0.20	0.47	0.33	0.58	0.42	0.45	0.27	0.27

By multiplying the score of each indicator for every potential target client with its corresponding weight, we obtained the score for each potential client. TRAFFIC scored the highest, with a score of 8.57. Therefore, we have chosen TRAFFIC as the client for our management project.

3 FUNDING FORECAST AND RISK ASSESSMENT FOR IMPLEMENTATION OF MANAGEMENT PLAN

To comprehensively assess our client's economic resilience in applying this management plan, we have established the Panoramic Insight Analysis (PIA) model.

3.1 Utilizing Forecast Models for Future Management Fund Forecast

First, in the study, two models, Random Forest, and Linear Regression, were used to predict the future funding status of the TRAFFIC project. As shown in Fig.1, due to the insufficient sample size, the predictions of the random forest model are excessively consistent and cannot effectively fit the data, indicating its limited applicability in this situation. Therefore, we turned to the results of the linear regression model, which showed that the TRAFFIC project would have sufficient funding in the future.

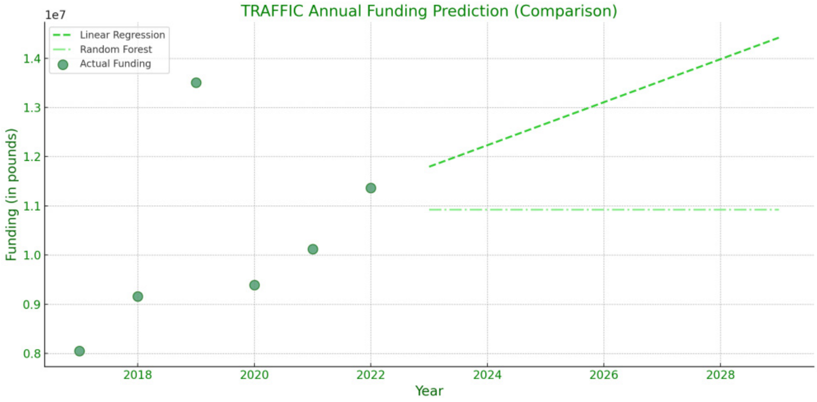

Fig. 1. Future Funding Forecast Chart for TRAFFIC

3.2 Risk Assessment for Economic Management

Based on the projections, we can conclude that TRAFFIC's funding will be sufficient to support the start-up of the project. Next, we use the risk prediction model to analyze the funding of the project[8].

Initial investment cost: \$300,000 is expected to be needed (e.g., for software development, hardware purchase, personnel training, etc.). Operating Costs: Annual operating costs are expected to be \$80,000.

Expected Revenue: Expected annual revenue growth from year two is \$200,000. Project Life: 5 years.

Discount rate: Assuming a base discount rate of 5%, we add a risk premium of 2% to account for project risk, resulting in a total discount rate of 7%.

Next, we will evaluate the project using Net Present Value (NPV) and Internal Rate of Return (IRR) and briefly explain how Monte Carlo simulation can be applied to analyze the risks.

Combined with the results you provided, we can describe it like this:

- **Net Present Value (NPV)**: the NPV is calculated using the formula

$$\mathrm{NPV} = \sum_{t=0}^{T} \frac{R_t}{(1+d)^t} - C_0 \tag{1}$$

Where R_t is the net cash inflow in period t, d is the discount rate, and C_0 is the initial investment cost. With a discount rate of 7%, the NPV is about \$542,830, indicating that the expected return of the project, after taking into account the value of time, far exceeds the initial investment.

- **Internal Rate of Return (IRR)**: IRR is the discount rate that makes the NPV equal to zero, and the calculation formula is implied in the definition of NPV, which needs to be solved by an iterative method. the IRR is about 38.5%, which is much higher than the original discount rate of 7%.

These results show that our project is financially viable under current conditions and will show a profit, indicating that TRAFFIC does not need **additional funding.**

4 ANALYZING THE IMPACT OF PROJECT IMPLEMENTATION

This question will use a system dynamics model to analyze the possible impacts of the project.

4.1 Analysis of interrelationships and development of corresponding equations

In this paper, to create a specific system dynamics model to analyze the impact of the AI Big Data project on the illegal wildlife trade, we need to define some basic mathematical equations to describe the dynamics between the key variables in the system. This model will focus on 3 main components: illegal trade activities, enforcement efforts, and AI monitoring system efficiency[9].

• The dynamics of the illegal trade activity (I)

It can be modeled by considering the combined efficiency of illegal capture, transport, sale, etc. activities. This can be expressed as follows.

$$\frac{dI}{dt} = r_I \cdot I \cdot \left(1 - \frac{I}{K}\right) - (E_{AI} + E_L) \cdot I \tag{2}$$

• Changes in enforcement effort (EL)

It can be modelled by taking into account the efficiency of resource allocation, training of law enforcement officials and international cooperation.

$$\frac{dE_L}{dt} = r_E \cdot (B - E_L) \tag{3}$$

• Al Monitoring System Efficiency (EAI)

Technological advances and improved data analysis capabilities can be considered.

$$\frac{dE_{AI}}{dt} = r_E \cdot (B - E_L) \tag{4}$$

Based on the data we collected and references, calculations as well as reasonable assumptions led to the initial data:

Incorporating data, calculations, and reasonable assumptions, the initial values are as follows: Growth rates - Illegal trade activities: 0.07, Enforcement efficiency and AI monitoring efficiency: 0.02 each. Constants - Market saturation point (K): 1000, Maximum achievable enforcement efficiency (B), and monitoring efficiency (T): 0.8 and 0.9, respectively. Initial values - Illegal Trading Activity (I0): 100, Law Enforcement Efficiency and AI monitoring efficiency: 0.1 each.

4.2 Solving and analyzing the model

The model was solved to obtain the trends of the variables illegal trade activities (I), enforcement efforts (EL), and the efficiency of the AI monitoring system (EAI) over time over five years, as shown in Fig.2 below:

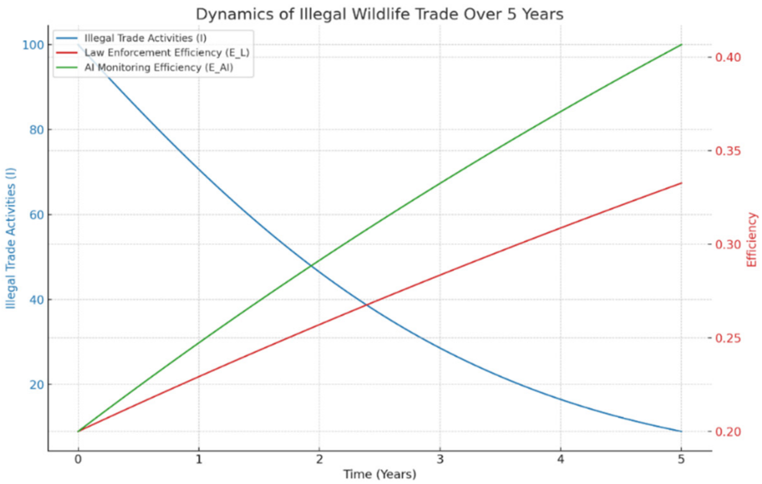

Fig. 2. Future trend curve

The blue curve shows the change in illegal trade activity (I), measured by the vertical coordinate on the left. The red curve shows the change in enforcement efforts (EL), while the green curve represents the change in the efficiency of the AI monitoring system (EAI), which are both measured through the vertical coordinate on the right.

The value for illegal trade activities (I) has decreased by about 64.51% The value of Enforcement Effort (EL) increased by about 67.6%. The value of AI monitoring system efficiency (EAI). it was increased by about 75%.

In summary, the results analyzed above show that the implementation of the project will in- increase the efficiency of law enforcement and AI monitoring systems and will be effective in reducing illegal wildlife trade activities.

4.3 Sensitivity Analysis

In our system dynamics model, we acknowledge some subjectivity in parameter settings derived from literature reviews or independent choices. Parameter changes can impact model results.

To ensure model stability and accuracy, we conducted a sensitivity analysis, as depicted in Fig.3 and Fig.4 with varying values. Despite data volatility, our model consistently predicts a decreasing trend in illegal wildlife trade volume over the project's next five years, confirming the model's stability.

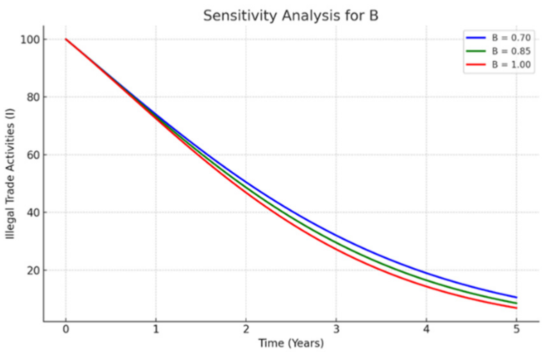

Fig. 3. Sensitivity analysis graph of parameter B

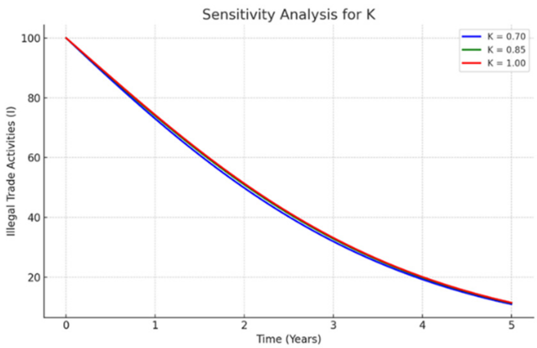

Fig. 4. Sensitivity analysis graph of parameter K

Based on these charts, we can draw the conclusion that despite fluctuations in the data, our management plan consistently yields similar results from a fixed perspective. In other words, the volume of illegal wildlife trade is projected to continue declining over the next five years, thereby maintaining the same relative relationships reflected. This validates the stability of the model and the correctness of our management plan.

5 PROJECT SUCCESS RATE JUDGEMENT - LRBD MODEL

This study combines the number of wildlife trade incidents, the efficiency value of the monitoring system, and the value of enforcement effort, using the LRBD model for analysis. In line with the results of the previous question, our goal is to reduce the volume of illegal wildlife trade by 64.51%.

5.1 Predictive modeling

Since this paper is a five-year project, it was decided to use a linear regression model to predict values from 2023 to 2029 regarding the number of wildlife trade incidents, the efficiency of the AI monitoring system, and the strength of enforcement.

The formula for the linear regression model:

$$Y = \beta_0 + \beta_1 X + \epsilon \tag{5}$$

Using data collected from 2012 to 2022, we can make predictions for illegal wildlife trade volume, AI monitoring system efficiency, and law enforcement work value from 2023 to 2029.

5.2 Modelling project effects based on projections

In the first place, we establish a model, with the project's impact factor defined as βi, and the degree to which various factors of the project are affected is defined as:

$$Y_i' = Y_i(1 + \beta_i) \tag{6}$$

Based on extensive literature, this study defines $\beta 1$ as -0.25 for illegal wildlife trade volume, and both $\beta 2$ and $\beta 3$, representing AI monitoring system and law enforcement efficiency, as 0.20, derived from the results of the third question.

Continuing to delve deeper into the study, we will conduct a detailed analysis of the relationship between the forecast data and the project's objectives to obtain the probability of successfully achieving the objectives between 2023 and 2029.The predicted values of the relevant variables compared to the actual values are shown in Fig. 5, Fig.6 and Fig.7.

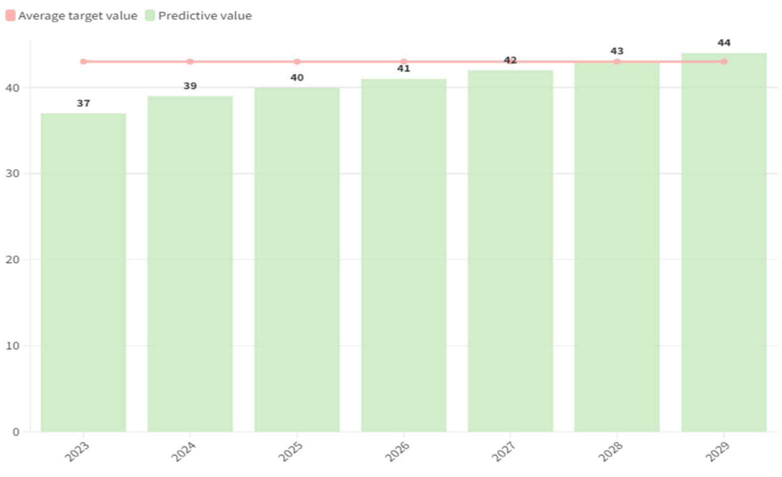

Fig. 5. Comparison chart of actual values and predicted values of related laws and regulations

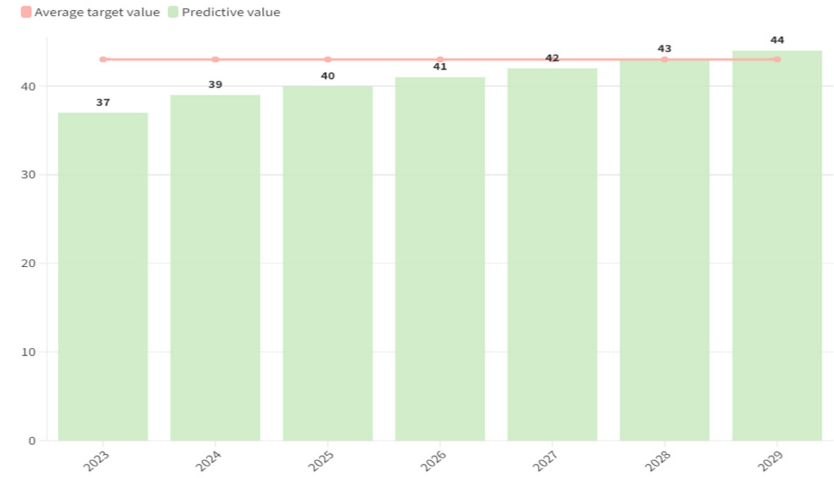

Fig. 6. Comparison chart of actual values and predicted values of AI technical literature

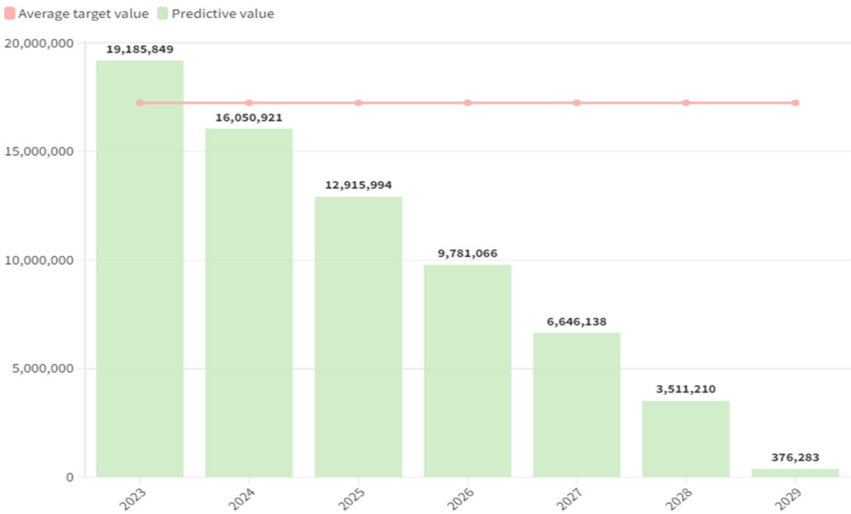

Fig. 7. Comparison chart of actual values and predicted values of illegal trade in wildlife

To get a more complete picture of the distribution of the probability of success, we will use the binomial distribution, which is a commonly used probability distribution that describes the probability of a successful event (e.g., project success) occurring a given number of times in multiple independent trials. Its mathematical formula is as follows:

$$P(X = k) = \binom{n}{k} \cdot p^k \cdot (1 - p)^{n-k} \tag{7}$$

Next, we will calculate the probability of success at least once in seven years based on the formula for the binomial distribution.

From the number of wildlife trade incidents, the average success rate per year is 85.71 percent, and the probability of at least one success after the binomial distribution is 99.99 percent. In terms of the value of the efficiency of the AI monitoring system, the average success rate per year is 100 percent, and the probability of success at least once after the binomial distribution is 100 percent. In terms of the value of the enforcement effort, the average success rate per year is 28.51 percent, and the probability of success at least once after the binomial distribution is 90.51 percent.

Finally, by averaging the data over the last three years, we will obtain the probability of the project's ultimate success. An average success rate of 71.42 percent per year was obtained, and an average success rate of 96.84 percent for at least one success was obtained.

6 CONCLUSIONS

This study conducted a comprehensive assessment and analysis of the management project for combating illegal wildlife trade through the utilization of the PRI-AHP model, economic analysis tools, and system dynamics model. Firstly, it successfully identified TRAFFIC as the optimal project management client, emphasizing its leadership position in the field of wildlife conservation. Secondly, through financial forecasting and risk assessment, the economic feasibility of the project and its future funding status were confirmed, highlighting the importance of the project's self-sustainability without the need for additional financial support. Lastly, through the system dynamics model, the potential impacts of project implementation on illegal wildlife trade were revealed, predicting its positive effects on illegal trading activities, law enforcement efforts, and the efficiency of monitoring systems.

In summary, this study provides a comprehensive evaluation and analysis of wildlife conservation projects, offering important reference points for decision-makers. Future research can further refine the model, consider the influence of additional factors, and utilize more refined data for validation, thereby better guiding practical efforts and promoting the sustainable development of wildlife conservation initiatives.

REFERENCES

1. Uddin, Nasir, Sam Enoch, Abishek Harihar, Rob SA Pickles, Tasnim Ara, and Alice C. Hughes. "Learning from perpetrator replacement to remove crime opportunities and prevent poaching of the Sundarbans tiger." Conservation Biology 37, no. 2 (2023): e13997.
2. Oyanedel, Rodrigo, Stefan Gelcich, Emile Mathieu, and E. J. Milner-Gulland. "A dynamic simulation model to support reduction in illegal trade within legal wildlife markets." Conservation Biology 36, no. 2 (2022): e13814.

3. Nuno, A., J. M. Blumenthal, T. J. Austin, J. Bothwell, G. Ebanks-Petrie, B. J. Godley, and A. C. Broderick. "Understanding implications of consumer behavior for wildlife farming and sustainable wildlife trade." Conservation Biology 32, no. 2 (2018): 390-400.
4. S. Sisodia, S. Dhyani, S. Kathuria, S. Pandey, G. Chhabra and R. Pandey, "AI Technologies, Innovations and Possibilities in Wildlife Conservation," *2023 International Conference on Innovative Data Communication Technologies and Application (ICIDCA)*, Uttarakhand, India, 2023, pp. 1090-1095, doi: 10.1109/ICIDCA56705.2023.10099721.
5. Aarju, R. Bahuguna, S. Pandey, R. Singh, H. Kaur and G. Chhabra, "Enabling Technologies for Wildlife Conservation," *2023 IEEE Devices for Integrated Circuit (DevIC), Kalyani, India, 2023, pp. 217-220, doi: 10.1109/DevIC57758.2023.10134561.*
6. Khan, Amin Ullah, and Yousaf Ali. "Analytical hierarchy process (AHP) and analytic network process methods and their applications: a twenty-year review from 2000-2019: AHP & ANP techniques and their applications: Twenty years review from 2000 to 2019." International Journal of the Analytic Hierarchy Process 12, no. 3 (2020).
7. Canco, Irina, Drita Kruja, and Tiberiu Iancu. "AHP, a reliable method for quality decision making: A case study in business." Sustainability 13,no.24(2021):13932.
8. B. Singh, S. B S and R. K, "Opportunity-Constrained Programming Model and Algorithm of Enterprise Risk," *2023 Second International Conference On Smart Technologies For Smart Nation (SmartTechCon)*, Singapore, Singapore, 2023, pp. 843-847, doi: 10.1109/SmartTechCon57526.2023.10391387.
9. Feiyue, D. E. N. G., W. A. N. G. Hongli, G. A. O. Ruiyang, and L. I. Hao. "Vibration characteristics analysis of the inner race fault of axlebox bearing under wheel-rail excitation." Journal of Hebei University (Natural Science Edition) 43, no. 6(2023):5