Dynamic Nature Reserve Project Effectiveness Assessment and Environmental Sensitivity Analysis Based on Genetic Algorithm

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Abstract. This study takes the dynamic nature reserve project as the research object, and utilizes genetic algorithm and other computer technologies to assess the effect of the project through horizontal comparison and vertical prediction, and to conduct environmental sensitivity analysis. Cross-sectional comparisons analyzed data from 28 regions and countries using COX regression to verify the effectiveness of the project's wildlife conservation interventions. Longitudinal prediction combined with legislation time and nature reserve area to infer the effectiveness of project implementation.The results of COX regression model analysis showed that factors such as nature reserve area, legislation time, and economic level had a significant impact on the project effectiveness.VAR analysis revealed the sustained contribution of the project implementation to the control of illegal wildlife trade. Likelihood analysis was conducted by genetic algorithm, and the maximum likelihood was 1.243 and the minimum likelihood was 0.983, which predicted that illegal wildlife trade is expected to be reduced by 20% after the project implementation. Sensitivity analysis showed that the model has good adaptability to environmental changes. The study provides theoretical support and decision-making reference for the effective implementation of the dynamic nature reserve project, and at the same time highlights the application value of computer technology in the field of environmental protection.

Keywords: Genetic algorithms, Ssensitivity analysis, Cox regression.

1. Introduction

The purpose of this paper is to explore the effects and possibilities of dynamic nature reserve projects, and to assess the implementation effects and impacts of the projects from different dimensions through comparative analysis and predictive modeling. At present, environmental protection and wildlife conservation on a global scale have become the focus of attention of governments and the international community. However, in response to these issues, there are challenges such as imperfect laws and regulations, ineffective supervision, and unbalanced allocation of resources, which make environmental protection face a severe test. Therefore, this paper selects the Dynamic Nature Reserve Program as the research object and aims to provide new ideas and methods for environmental protection through horizontal comparison and vertical prediction of its effects [1-2].

In terms of horizontal comparison, this paper collected data from 28 different regions and countries and used the increase in mammal protected species from 2011 to 2013 as the basis of judgment, and analyzed the information related to the basis of judgment by using proportional hazards regression (COX regression), so as to prove the good effect of the Dynamic Nature Reserve Program's intervention on wildlife protection. As for the longitudinal prediction, we speculated the effect of the program implementation by predicting the legislation time and combining the corresponding nature reserve domains [3]. Therefore, in this paper, we will analyze and discuss the effects of the project in detail in terms of both the COX regression model and the VAR model, with a view to providing useful reference and guidance for practical work in the field of environmental protection.

2. Effect Speculation

In order to reflect the role of the dynamic nature reserve project, we speculate on the effect of the project through horizontal comparison and vertical prediction. Horizontally, we collected data from 28 different regions and different countries, and used whether the protection species of mammals increased from 2011 to 2013 as the basis for judgment, and performed proportional hazard regression (COX regression) to analyze the information related to the judgment basis, and then proved that the dynamic nature reserve project has a good effect on the intervention of wildlife protection. Vertically, we predict the effect of implementing the project by predicting the legislative time and combining the corresponding nature reserve area[4].

2.1. COX Regression Model

To objectively speculate the biological protection ability of the project in legislation and nature reserve construction, we use the COX model for regression. The Cox model does not directly examine the relationship between the survival function S(t) and the independent variable, but uses the relationship between the survival function S(t) and the risk function h(t), and uses the risk function h(t) as the dependent variable to indirectly reflect the relationship between the independent variable and the survival function S(t). The regression coefficient reflects the effect of the independent variable, which can be estimated by the actual observation value of the sample.

Firstly, the data are analyzed. The higher the proportion of land reserve area to land area, the more attention the country pays to the construction of nature reserves. The larger the value of legislative time, the closer the legislative time is to the current time, that is, the shorter the time of law enforcement. Then the data of the national economic development level are coded as table 1:

Table 1: Encoding Countries' Economic Level

Economic Level	High	Middle-High	Low-Middle
Coded Data	1	2	3

A Cox proportional hazards regression model is established below

$$\mathrm{h}(t) = h_0(t)\exp\left(\beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p\right) \tag{1}$$

In the above formula, X1, X2, ..., Xp are independent variables (influencing factors) that may be related to survival time. The independent variables or influencing factors may be quantitative or qualitative, and do not change with time during the whole observation period. h(t) is the risk function of individuals with independent variables X1, X2, ..., Xp at time t ; h_0(t) is the risk function at time t when all the independent variables are 0, which is called baseline hazard function and is unknown. β1, β2,......, βp are the partial regression coefficients of their respective variables, which are a group of unknown parameters and need to be estimated according to the data.

The Omnibus global test is a statistical test used to evaluate whether the explanatory power of all independent variables in a statistical model to the dependent variable is significant. This test can be used to determine the overall fit of the model[5-6].

In the Cox proportional hazard model, the Omnibus test is usually performed after the model fitting is completed to evaluate whether the independent variable as a whole has a significant effect on the survival time risk ratio. If the P value of the global test is small, it usually means that one of the following situations exists :

1. At least one independent variable has a significant effect on the risk of survival time.
2. The model as a whole is effective in explaining the relationship between survival time and independent variables.
3. Through the Ominbus global test, the regression coefficients are summarized as table 2 :

Table 2: Regression coefficients of variables

Variable	P	HR	Variable	P	HR
proportion of nature reserve area in land	-0.097	0.908	national economic situation	0.084	1.088
proportion of nature reserve area in ocean	-0.01	0.99	legislative time	0.358	1.431
number of illegal trade	0.353	1.401	high plant plants	0.005	1.005

In the complex system of analyzing the number of illegal wild trade and the protection of animal species, the establishment of nature reserves and the efficiency of legislation are the key to the discovery and protection of endangered species, and the determinants of the survival and extinction risk of endangered species. The level of national development also reflects the intensity of its propaganda on species protection from the side. The lower the level of development, the greater the resistance, and the smaller the propaganda. The more the number of illegal wildlife trade, the greater the hindrance to the number of protected animal species. On the contrary, strengthening the crackdown on illegal wildlife trade can increase the number of protected species.

2.2. Vector Auto-regression

Because in considering the legislative time, the proportion of the protection of the number of species, also need to consider the development of a country, and the government execution of the project, so the use of VAR in explore their influence at the same time, to increase the number of protection of the indicator.

Using the method of VAR, the results obtained are shown in the following table 3:

Table 3: VAR of Effect Speculation

Stage	legislative%	Decision-making%	Execution%	number of illegal trade%
1	18.326	3.576	0.385	77.713
2	11.602	4.154	39.846	44.398
3	10.222	3.982	55.258	30.538
4	9.902	3.777	61.85	24.471
5	9.753	3.665	65.432	21.15

From the results of variance decomposition, it can be inferred that with the implementation of the project, the construction of nature reserves has a continuous contribution to the control of the number of illegal trade wildlife cases. With the improvement of the management of illegal trade wildlife, the resources and legal control that need to be invested can also be gradually reduced, and as the project progresses, the impact of the three aspects on the number of illegal trade wildlife cases is far greater than its own adjustment[7].

3. Possibility and Sensitivity

3.1. Possibility Analysis Based on a Genetic Algorithm

In order to analyze the possibility of the project, that is, the possible effect after the implementation of the project, we use the genetic algorithm to solve it. Firstly, we establish the optimization model and hope to get the maximum and minimum values of the possibility.

Objective function: The purpose is to find the maximum and minimum project implementation possibilities. Set Z to represent the ratio of the prediction result of one year after the project execution to the one year before the project execution. We hope to find the maximum $\mathrm{Max}\,(\mathrm{Z})$ and the minimum $\mathrm{Min}\,(\mathrm{Z})$, that is:

$$Z = \frac{\delta}{Y} \tag{2}$$

Decision variable:

Y : It predicted the number of illegal trade wildlife cases after next year

Other variables:

N_i $(1 \le i \le 4)$: They indicates the number of illegal trade wildlife cases, the effect of law enforcement, land management ability and decision-making effect as of this year.

P_j $(1 \le j \le 8)$: They respectively expressed quantification of the number of illegal trade wildlife cases as of last year, law enforcement, promotion, land management ability, decision-making effect, scientific and technological ability, funds and cooperation ability quantification.

Constraints:

$$N i(t) = \sum_{i=1}^{4} m_i N_i(t-1) + ai$$

$$Pj(t) = \sum_{j=1}^{8} n_j P_j(t-1) + b \tag{3}$$

Let δ = 5000, P_1= 5200, we have:

$$Max(Min)Z = \frac{5000}{Y} \Rightarrow s.t.\begin{cases} N_2 = -0.069P_2 - 0.748P_5 + 5.971P_4 - 5.259 \\ N_1 = 21.82P_2 + 17.064P_5 + 28786.336P_4 + 0.539P_1 - 26192.996 \\ N_3 = 0.041P_2 - 0.13P_5 + 6.666P_4 - 5.9966 \\ N_3 = 0.192P_3 + 0.564P_5 + 3.27P_4 + 0.102P_7 + 0.101P_8 - 0.282P_6 - 2.948 \\ N_4 = 0.002P_2 + 0.007P_5 + 0.569P_4 + 0.405 \\ N_4 = 0.026P_3 - 0.015P_5 - 0.121P_4 + 0.008P_7 + 0.028P_8 - 0.005P_6 + 1 \\ N_i and P_j \in (0,1) \\ P_1 = 5200 \end{cases} \tag{4}$$

Here we introduce genetic algorithms to solve this problem. Genetic algorithm is a search algorithm for non-deterministic polynomial time classes. If violent retrieval is used, the computation will be exponential, and this algorithm optimizes the time complexity to the polynomial level, greatly reducing the computation[8-9].

The above requirements are solved using a genetic algorithm, as shown in the table 4:

Table 4: Genetic Algorithm

Algorithm: GA Process
Input: Year 1 to 5, Set Z as random $X_{year} = \{x_i \mid i \in Z, 0 < i \le p\}$ $x_i = \{a_j \mid a_j \in R, 0 < j \le q\}$ **Output:** (Max F(x), Min F(x)) **Initialize:** Eliminate influence of dimension of formula **(21)** to N and P; Define suitability function F(x)=S(a_j) and storage matrix of $(F_1(x_i),\ F_2(x_i))$ **Run:** **for**: **year** **Selection:** $X_{year} \rightarrow X_{year+1}$ by (Max $S(a_j)_{x_i} \rightarrow F_1(x_i)$, Min $S(a_j)_{x_i} \rightarrow F_2(x_i)$) ; **Crossover:** Crossing Calculation: N $\times$ X_{year} and P $\times$ X_{year} ; **Mutation:** Randomly change 0.01% of the value of a_j ; **Return** $(F_1(x_i),\ F_2(x_i))$.

Finally, the maximum and minimum values of the possibility are obtained, and in two cases, the data of last year, the maximum possibility is 1.243, indicating that after the implementation of the project, the local illegal wildlife trade will be reduced by 20 % compared with last year, and the minimum possibility is 0.983, indicating that the number of illegal trades may increase by 1 %. Among them, the difference in data last year has a greater impact on the possibility of promotion indicator. As the table 5:

Table 5: Possibility Analysis

Indicators	Max	Min	Gap
Possibility	1.243	0.983	0.26
Legislation	0.788	0.147	0.641
Decision-making	0.39	0.052	0.338
Land Management	0.675	0.787	-0.112
Promotion	0.147	0.908	-0.761
Funds	0.012	0.262	-0.25
Cooperation	0.187	0.504	-0.317
Scientific and Technological Strength	0.63	0.437	0.193

3.2. Sensitivity Analysis

In order to study the model in different environments, sensitivity analysis was performed on the objective function in 3.1：

Based on the Y value in the GA algorithm, it can be expressed as follows:

$$Y = 214.82N_1 + 17.064N_2 + 28786.336N_3 + 0.539N_4 \tag{5}$$

In the sensitivity analysis, when the parameters fluctuate, for example, the reserve area increases, the environmental protection expenditure becomes more, and the legislation time becomes later, the model results will have relative changes [10].

Hint: Divide the two sides of the function by an independent variable, observe the function perturbation

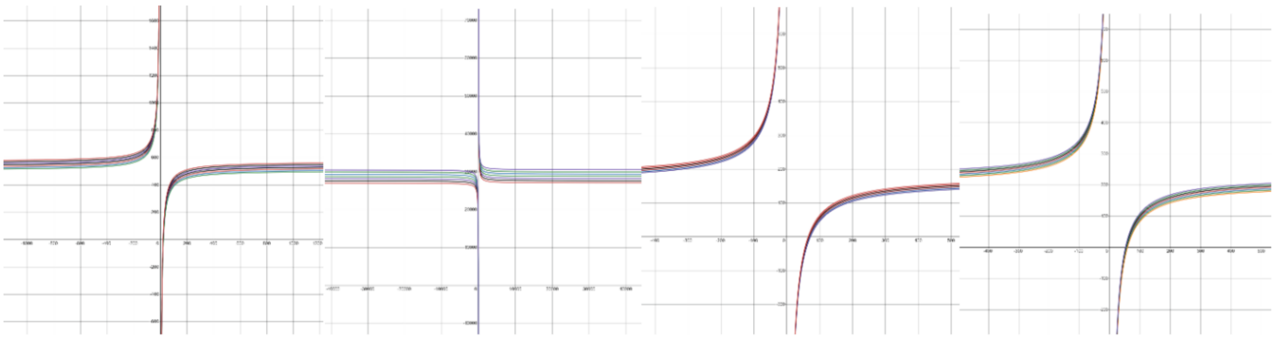

Figure 1: Sensitivity analysis based on function perturbation observations

The above figure 1 can be seen that it is very stable, can adapt to most of the changes in the environment, to maintain the accuracy of the model.

4. Conclusions

Through in-depth research and analysis of the effects and possibilities of the dynamic nature reserve project, this paper has achieved the following main results and findings:

First, in terms of the COX regression model, by comparing and analyzing the data from different regions and countries, we found the good effects of the dynamic nature reserve program in terms of wildlife conservation interventions. In particular, the implementation of the project has a positive impact on the protection of species and control of illegal trade in terms of the timing of legislation, the construction of nature reserve areas and illegal wildlife trade.

Second, in terms of the VAR model, we predicted the effects after project implementation and further verified the stability and accuracy of the model through sensitivity analysis. The results show that the implementation of the project may lead to a reduction in illegal wildlife trade and have a positive impact on national legislation, decision-making and enforcement.

In summary, the research results of this paper provide important theoretical support and practical experience for the implementation of dynamic nature reserve projects and environmental protection. We believe that under the guidance of further research and practice, the Dynamic Nature Reserve Project will make greater contributions to the cause of wildlife conservation and environmental protection and promote the construction of global ecological civilization to a new level.

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