Reoptimization of the Food Supply System

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Abstract: The team develops a model to reprogram and prioritize food systems to strike the best balance between equity, ecological conservation and profitability, and provides practical recommendations based on our findings, with a focus on equity and sustainable development. First, we divided all countries and regions in the world into importers (food-deficit countries), exporters (food-rich countries), and food-subsistence countries, analyzed two indicators of per capita food availability and per capita GDP over the past 15 years, and built an agricultural system evaluation model. To ensure the accuracy of the model, our team collected ecological factors recognized by each country for analysis, including land salinization and land degradation. We concluded that the model optimizes both anthropogenic and non-anthropogenic factors for greater stability and resilience to adversity compared to the old model. This is expected to be achieved within five years. We simulated GDP per capita, achieved profitability, and analyzed and compared the economies of different countries. Based on the available data, we obtained the following results: the regions with a clear increasing trend in per capita food availability are mainly located in Northeast China, Southwest China and Eastern Europe. In contrast, per capita food availability will decline in northern and southern China, most countries in Southeast and South Asia, and Western Europe. Its main advantage lies in the rational distribution of food at the economic level of each country at the cost of idealism. Considering the profit and distribution issues, the model is again optimized to predict the probability of food mold in cross-country transportation using a probabilistic prediction method and correcting it by recalculating it into the cost, which is more realistic.

Keywords: Equity, Sustainability, Multivariate Analysis, Predict, Improvement

1 Introduction

Recent events have shown that the global food system is fragile, even in recognized well-served areas of the world.

These instabilities are in part the result of our current global system of large national and international food producers and distributors. This food system allows food to be produced and distributed relatively cheaply and efficiently, suggesting that the current model prioritizes efficiency and profitability.

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Despite the efficiency of this system and the fact that the world produces enough food to feed everyone, the United Nations estimates that 821 million people around the world [1].

Eight hundred and twenty-one million people worldwide still suffer from hunger. The food insecure, those who do not have access to enough nutritious food they can afford, live on every continent, in every country and in every community. And, even in rich countries, there are areas of food insecurity. In addition, the current food system leaves a huge environmental impact, accounting for 29% of greenhouse gas emissions [2].

In causing up to 80% of biodiversity loss, 80% of deforestation, and 70% of freshwater use. As our global population continues to grow, while the reckless use of the environment in recent decades has brought about penalties for humanity, the need to produce more food while maintaining and even improving the health of our environment has never been more urgent [3]. Therefore, a comprehensive assessment of our current food system seems reasonable and urgently needed.

Re-imagine and re-prioritize the food system by developing a model that Provide a sufficiently robust food system model that is capable of being adjusted to optimize for different levels of efficiency, profitability, sustainability, and equity [4~5].

2 Manuscript preparation

Develop a model to reimagine and prioritize the food system so that the model can be adjusted to optimize for different levels of efficiency, profitability, sustainability and equity.

Explain the benefits and costs of our team's model for changing food system priorities, and explain and predict when this will happen. Finally, data analysis is used to predict these differences in benefits and costs between developed and developing countries.

Discuss the scalability (for larger or smaller food systems) and adaptability (for other regions) of the established model. As shown in Figure 1.

2.1 Problem statement

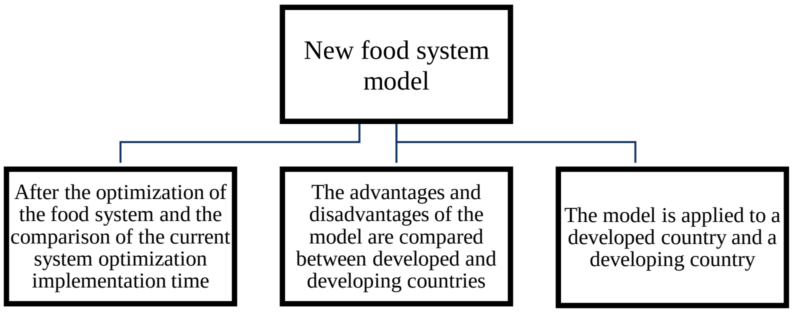

Figure 1. Thinking research paper figure

2.2 Symbols

Our team has set some necessary symbols and unit representations for the model building research, as shown in Table 1.

Table 1: Symbol table of grain model

Symbols	*Definition*	*Units*
effective irrigation area	(X1n)	J
fertilizer application amount	(X2n)	J
electricity consumption	(X3n)	K
total power of agricultural machinery	(X4n)	m
number of agricultural labor force	(Y1n)	m
sown area of grain crops	(Y2n)	m
disaster area	(Y3n)	/
total grain output	(Y4n)	/

2.3 Establishment of grey prediction model

Present the question in the following way: Now assume that the following assumptions are consistent with the fact that we are fully aware of:

All the factors, including driving forces and environmental factors, that have influenced or will affect global food production.

To define the status of all parameters required for the initial conditions of the global food production system. In this case, we can think that the prediction problem we are concerned with can be treated as a standard initial value problem. However, we should also recognize that experience from similar but much less complex prediction problems has shown that the error weakens the prediction of the outcome, but in the actual model, we default to the feasible model except for the necessary checks in the sensitivity analysis [6].

This model does not include unpredictable political factors, such as war, trade fortress, etc., and it defaults to an ideal economic and trade basis.

Modeling process: Firstly, we found enough data, including basic data such as food production in each country, food production per hectare in each country, arable land per ca-pita in each country, and taking into account the differences between developed and developing countries. In different countries, such as developed and developing countries, the cost of food production is different. Intensive agriculture in developed countries is naturally adaptable to the production of some crops, but the labor cost in developed countries is also relatively high. Some high-yield crops are expensive to produce, but they are necessary in countries where there is not enough arable land.

At the same time, we started with three types of models for defining, importer (food shortage countries), exporter (food abundant countries), grain self-sufficiency, respectively chose Japan, Malaysia and the United States as the basic model of architectural design, using grey prediction model to analysis the production of the next year. Based on the above consideration, this study chose the per ca-pita grain new products after system optimization system model compared with the current system optimization implementation time model and analysis of the comparison between developed and developing countries will model is applied to a developed country and a developing country GDP per ca-pita occupancy of grain and two indicators to describe food life situation. The per ca-pita availability of grain can describe the situation of food supply and stability, while the per ca-pita GDP can reflect the situation of food availability. The two factors together comprehensively determine the food security situation of a country or region [7].

Secondly, consider the reality: a profit-making food system is one in which a few large countries or companies dominate the world's food production. This profit-making system results in unfair and unsustainable food production and consumption globally or within a single country.

Finally, our model needs to consider the ecological problems. Our team listed most of the influencing factors.

Model influencing factors: There is still an opportunity to increase grain yield by expanding the irrigated land area. But because of fierce competition for water, increasing food production in this way will surely be slower than in the past. In developing countries, the annual growth rate of irrigated land for irrigation was reported to be only 7 per cent between 2005 and 2020, compared with 1.7 per cent in the 1982-1993 period. In addition, the problem that irrigation means a significant loss of land, since it can lead to soil salinization and water depletion, should also be considered.

A considerable amount of agricultural land is lost every year due to the degradation of various forms of soil. In addition, meeting other demands for land results in the loss of large amounts of agricultural land each year. The question, however, is how severe the loss of food production due to these causes is before it is necessary to use LPAs to compensate for the loss (the quality and availability of LPAs, of course).

If our interest is limited to assessing the sensitivity of the current climate to changes in influencing factors, it is reasonable to believe that the current CGCM models are capable of simulating such changes and that the results are quite realistic. But we should recognize that natural climate change and human-induced climate change can happen together.

All we have to do is distinguish natural and human-induced climate change as best we can, and try to identify the observed climate change. Because of the food demand forecasting, food demand is affected by many factors, and impact factors is difficult to determine, and grey interval prediction can use data volatility-based prediction of upper and lower boundary, have certain reference significance for the forecast of demand for food, so this research use grey interval can be used to predict the total demand of the main grain varieties [8].Since grain production is affected by factors such as the total power of agricultural machinery and the sown area of grain, and the process of obtaining data is gray to a certain extent, and the grey GM (1,

N) model fully considers the influence of the influencing factors of grain, so the grey GM (1, N) model is used to predict the yield of the main grain varieties.

Naive Bayes algorithm was used to calculate the probability of rice mildew occurrence under the conditions of given water content, temperature and storage time of grain, and the classification and prediction were made to form a probability prediction model of rice mildew, which could be applied to the judgment of grain situation.

NARX neural network model: Seven data including effective irrigation area (X1), fertilizer application amount (X2), electricity consumption (X3), total power of agricultural machinery (X4), number of agricultural labor force (Y1), sown area of grain crops (Y2), disaster area (Y3) and total grain output (Y4) were selected for correlation analysis. Before building the model, the data is preprocessed and the data values are mapped to the interval of (-1, 1), that is, the data is standardized, and then the dimensionless data can be transformed into dimensionless data to eliminate the impact of dimensionality on the final regression results.

In this study, the results of operation are mapped to the interval of (-1, 1) by using the maxima and minima normalization methods. Canonical correlation analysis is a method of using comprehensive variable analysis, through the comprehensive variables reflect the relationship between the overall correlation between 2 groups of indicators of the multivariate statistical method, the original 2 set of variables in the research of extracting two representative variables (X and Y is 2 to examine the meaning of a linear combination of the variable group), the use of these two variables reflect the relationship between the 2 groups indicators[9].

The simple derivation is as follows: Let the vectors X and Y, where:

$$(XR,\ YR),\ w = aTX,\ v = bTY \tag{1}$$

$$\text{I.e.,}\ w = a1x1 + a2x2 + \dots akxk; \tag{2}$$

$$v = b1y1 + b2y2 + \dots blyl \tag{3}$$

Among them, a1~ak and b1~bl are standardized typical coefficients. Then the correlation coefficient is used to measure the relationship between w and v:

$$\rho wv = Cov(w,\ v)/\sigma w \sigma v \tag{4}$$

In this case, the optimal solution of a group of a and b is sought so that ρ wv is maximized. The obtained a and b after this treatment are the typical coefficients that make w and v have the maximum correlation. Then the correlation between X and Y can be replaced by ρ wv, so as to achieve the purpose of dimensionality reduction. a and b can be solved by MATLAB software. Time series is a group of data arranged in time sequence [10].

Analyzing time series is a quantitative prediction method for curve fitting and parameter estimation based on the data of time series. Its basic principles include: first, admitting that things are continuous in the process of development, that is, using the past data can master the law of development of things; Secondly, considering the randomness of the development of things, the development of anything is affected by accidental factors, so the data are further processed by statistical principles. The data used in the prediction model of grain yield in this study are time series, so the statistical method of time series can be used to build the time series model.

Data Processing: Can be found by the existing literature, in the study of grain supply and demand, existing in the study of the global food supply and demand balance is under the condition of food demand structure must be more, from food and feed grains, industrial usage and the loss trend with low demand growth trend prediction, forecast supply few considering various factors affecting food production, the overall forecasting and using time series prediction period is longer than the other. In the application of the grey system in grain production, the grey GM (1,1) or grey combination model is used to predict the global total grain yield, and the influence of the influencing factors of grain production on the grain yield of various varieties is rarely considered.

Therefore, this study uses grey interval prediction and grey GM (1, N) model to analyze the structural balance of global grain supply and demand. Considering the amount of grain supply and demand of the people's eating habits, the influence of national policy and other aspects, this study based on the analysis on the current situation of grain supply and demand in China, as a whole to consider the total demand, changes in people's diet structure, the total demand fluctuates up and down, using the grey interval prediction to the future of wheat, soybean, corn, rice total four major food demand forecast; in consideration of many factors affecting grain production, the production of main grains in China in recent 15 years was classified and predicted by using grey GM(1, N), and the balance of supply and demand structure was discussed in the final forecast results, and the reasonable suggestions were put forward. As shown in Figure 2.

$$\text{Q(demand)} = \text{Q(production)} + \text{Q(import)} - \text{Q(export)} + \Delta\,\text{Q(inventory)} \tag{5}$$

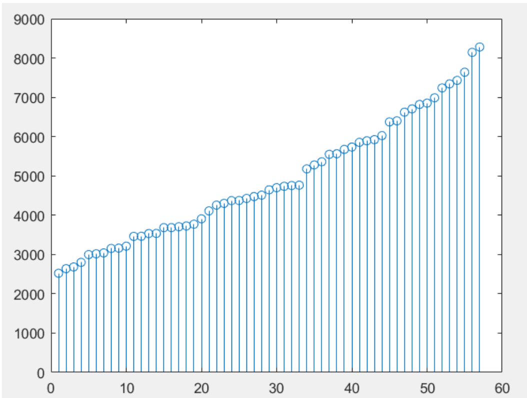

Figure 2. Grey correlation analysis diagram

Ten influencing factors of the model: According to the existing literature and Delphi method to select the 10 factors affecting the main varieties of grain production, seeding area (a1), yield per unit area (a2), effective irrigation area (a3), rural electricity consumption (a4), refraction of fertilizer application (a5), agricultural machinery total power (b6), inundated area (b7), primary industry employment figure (b8), the price index of agricultural production (b9), food commodities retail price index (b10). Grey correlation analysis was used to calculate the correlation degree of wheat, soybean, corn, rice and their influencing factors [11].

System sequence: Through the calculation of grey correlation degree of influencing factors, the sequence of factors with large influencing factors on grain production was brought into the GM (1, N) model. Let the behavior characteristic sequence of the system be:

$$X0 = [x\,0\,(1), x\,0\,(2)\,, \cdots, x\,0\,(n)] \tag{6}$$

The sequence of influencing factors with large correlation degree is:

$$Xi = [Xi\,(1), Xi\,(2) \ldots Xi\,(n)]\;(m\; = 1, 2 \ldots, n) \tag{7}$$

Let X (1)i be the sequence generated after one summation of X (0)i, X(1)i be the 1 AGO sequence of X (0) I, where:

$$X(1)i(k) = \sum ki\, = 1X(0)`(I), k = 1, 2 \ldots, n \tag{8}$$

The differential equation can be established by studying the accumulation of variables and influencing factor variables to generate variables:

$$dx1dt{+}\alpha x\;(1)1{=}\;b1x(1)2{+}\;b2x(1)3{+}...{+}\;bn{-}1x \tag{9}$$

2.4 The NARX prediction model

The data of the grain yield prediction model includes two parts, namely, the input time series data of the model (x1n ~ x5n) and the output time series data (the total grain yield y over the years), and the input delay is 2. In this study, MATLAB was used for programming to establish the NARX prediction model.

The NARX prediction model: The model changes parameters such as gradient during the training process. The effect of grain yield prediction model can be analyzed by error graph, error autocorrelation graph, input and error correlation graph. In the observation error graph, the yellow line represents the error line, that is, the error between the actual value and the predicted value. The smaller the error, the better the prediction effect of the model.

In the error autocorrelation, the error reaches its maximum value when the input delay (LAG) is 0, and the other LAG values are best when they are in the confidence interval. In order to further verify the accuracy and precision of the model, the same data were used to build the multiple linear regression equation to establish the multiple linear regression model. According to the data fitting, the regression equation was obtained. The two models were verified. As shown in Figure 3.

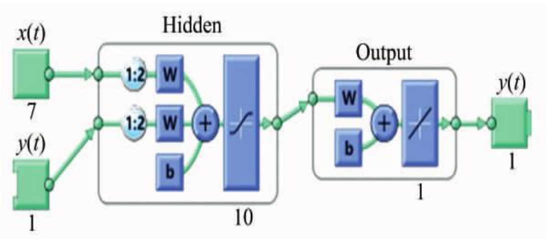

Figure 3. Schematic diagram of neural network model

Subsection Titles: The research shows that food security is the result of multiple factors such as nature, society and economy, and the shortage of food supply and poverty are the most important factors affecting and endangering food security. Therefore, to evaluate the food security of a country or region requires comprehensive consideration of many factors, and the previous food security evaluation focusing on food production capacity obviously has certain limitations.

Granted, grain production capacity is important, which is the most basic factor affecting the grain supply of a country or region. However, in addition to being met through the country or region's self-sufficiency in food production, growing food needs can also be met through external purchases or food imports. Singapore and Hong Kong, for example, do not have their own advantages in grain production, and their internal grain supply capacity is often unable to meet the food needs of their populations.

But because these regions have sufficient purchasing capacity, their food supply can be met from outside or through international trade to achieve food security for their populations. Another example is the South Asian country India, although its own food production capacity is very good, but its domestic food supply capacity is still unable to meet the food demand of its rapidly growing population. At the same time, its relatively weak purchasing ability restricts the adjustment of grain supply through the external market.

Error correction and data detection: Wherein, [Y]_t is an m-dimensional nonstationary 1(1) sequence, Xt is a d-dimensional deterministic variable, and ε_t is a novel vector. After the transformation, available:

$$yt = \sum p - 1i = 1 \Gamma 1yt - i + \Pi yt - 1 + Bxt + \varepsilon t \tag{10}$$

Among them

$$\Pi = \sum pi = 1Ai - Im, \Gamma i = -\sum pj = i + 1Aj, (i = 1,2,\cdots,p-1) \tag{11}$$

If there is a co-integration relationship between variables of yt, so only a Πyt - 1 of each variable is the I(0), to ensure that the new rate is a smooth process. Therefore, available coefficient matrix Π rank meet 0< R (Π) at this point, there are two alpha and beta, m * r order matrix makes Π = alpha beta, among them, both decomposition of matrix rank is R. Where, α is called the adjustment parameter matrix, or correction coefficient matrix. Each element in α represents the rate at which the corresponding error correction term adjusts the explained variable of the difference.

And β is called the cointegration parameter matrix, each column of which is a cointegration vector, β=(β1, β2..., βr), and there are r co-integration vectors. β'yt -1 ~ I(0), it contains r error correction term (ECT), that is, each row is made variable y1, t-1, y2, t-1,···,ym,t-1 A linear combination with a cointegration relation. Therefore, the matrix β determines the number and form of the co-integration relation, and its rank R is the number of linearly independent co-integration vectors, and each row of it constitutes a co-integration vector [12].

Study on uncertainty of model: In addition to the basic predictions, our team also believes that food contamination must be considered in cross-border transport and world redistribution. The probabilistic prediction model of grain mildew based on Bayesian algorithm was established. Mildew is an important cause of grain loss [13]. In order to reduce the loss and control the damage in the bud, it is of great significance to forecast and forewarn in advance. Naive Bayes algorithm was used to calculate the probability of rice mildew under the given water content, temperature and storage time of grain, and then the probability prediction model of rice mildew was formed, which could be applied to the judgment of grain condition.

3 Conclusions

The model established by our team regards the random quantity as a grey quantity that changes within a certain range, and the random process as a grey process that changes within a certain range and time zone. After the irregular historical data series are accumulated, they are changed into a rising shape sequence with exponential growth law. Since the solution form of the first-order differential equation is exponential growth form, the differential equation model can be established for the generated sequence. So the grey model is actually a model built by generating the sequence. And the obtained data must go through the reverse growth, that is what the gradual generation requires to do the reduction after the application.

From the results of static simulation, it can be seen that the model describes the short-term fluctuations of each variable in a more detailed way and can accurately reflect the subtle changes of variables. The dynamic simulation results can also better reflect the variation trend of the variable sequence and can be applied to medium and long-term prediction. It is proved that the overall simulation effect of the model is relatively good, which effectively overcomes the problem of poor prediction stability and trend in the traditional structured modeling method. It proves the superiority of our model from an empirical point of view, and at the same time fills in the blank of the world food cost-benefit modeling research.

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