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Sustainable Food System for No-Hunger

Mingquan Wang, Yuting Du, Daolong Zhang

Nanjing University of Information Science and Technology, School of Mathematics and Statistics, Applied Statistics, Nanjing Jiangsu, 210044, China

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Abstract: Poverty and hunger have been a hard nut to crack throughout the world even in sections that developed well. What's worse, environment abuse makes tackling the problem of hunger more challenging and demanding for certain countries. Therefore, it is high time for us to take Sustainability and Equity into account and change the current food system. In task 1, for the sake of numeric measurement of the food system change in response to the priority of Sustainability and Equity, we introduce the RAP-RFS coupling model including the stability estimation based on the reprioritized food system (RFS) evaluation model, and the reprioritization of the food system agricultural time-varying autoregression with stochastic volatility was introduced to calculate the impulse response to the agricultural policy (RAP) which could evaluate the efficiency of the optimized food system. The result shows, the mid-term impulse response show results inferior to the long-term response, and the longer the policy period lasts, the more negative impulse response to the agricultural policy, that is, the optimized food system works under the influence of agricultural policy. As for the RAP model, first, 6 indicators concerning 4 aspects are selected primarily to build the food system. Then entropy weighted method (EWM) is used to calculate the weight of each indicators and identify the stability. Finally, we select the GHG indicator which has high correlation with sustainability to calculate the comprehensive score, when it reaches the sustainable level 90, it will cost 3 years to achieve in 2024.

1. Introduction

1.1 Background

Poverty and hunger have been a hard nut to crack throughout the world even in sections that developed well. The United Nations have estimated that more than 700 million people, or 10 per cent of the world population, still live in extreme poverty [1]. However, what makes things worse is that, under the greenhouse gas footprints and other environment abuse, tackling the problem of hunger will be more challenging and demanding for certain countries.

As the current food system is prioritized for *Efficiency* and *Proficiency*, qualified food may give way to the not expensive storage or transportation, resulting in the stale meals in the dustbin. In consequence, the food loss in these communities would aggravate hunger in poor areas. Moreover, people living in diverse countries own various diets, malnutrition is another food insecure problem. Fortunately, the shift to a more vegetarian diet really counts as plant-based food would primarily improve nutrition situation and reduce carbon emissions [2].

Therefore, it is high time for us to take *Sustainability* and *Equity* into account and change the current food system which accounts for a massive environment footprint like biodiversity loss, deforestation and freshwater scarcity [3].

1.2 Our Work

In order to find out the benefits and costs of prioritizing *Sustainability* and *Equity* for our food system, we are required to establish an evaluation index model which determines the stability of a country's food system and make 'benefit & cost' analyses of the optimized system. By selecting essential aspects which contains respective indicators, we combine those low indicators to realize the four comprehensive indexes, which is efficiency, proficiency, sustainability and equity. Subsequently, the established model will be applied to different areas to test its scalability and adaptability, modifications will also be proposed simultaneously.

We will proceed as follows for the sake of tackling these problems:

State assumptions and make notations. Ignoring some insignificant impacts, we will focus our approaches on stability of regional food system. Then we will list some notations which are important for us to clarify our model and determine their definitions.

Establish an evaluation index model which represents the stability of a country's food system and measures the impacts of agricultural policy on certain indicators simultaneously. We will apply the entropy weight method to help calculate the comprehensive 'stability score' and support vector machine to predict various scores.

Make benefit & cost analyses by introducing the dynamic input-output analysis in a food system and compare the added value of food systems in both developed and developing countries.

The whole modeling process can be shown as follows:

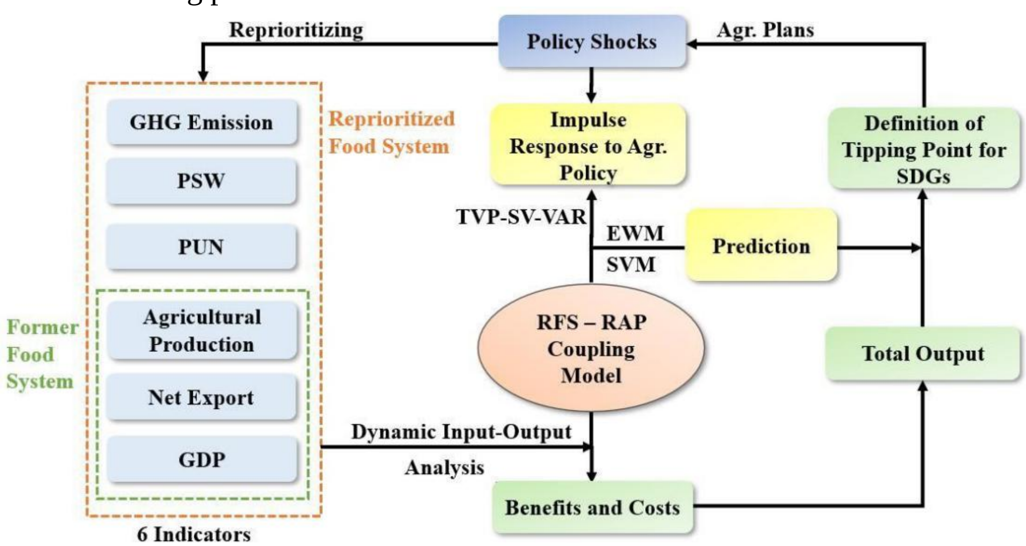

Fig.1 Technology Route for the Creation of Our Paper

2. Assumptions and Justification

To simplify the given problems and modify it more appropriate for simulating real-life conditions, we make the following basic hypotheses, each of which is properly justified.

We assume the country involved as a homogeneous unit in geographical and dietary manners. This is a prerequisite for us to do intensive study. As different people have diverse eating habits and the different locations own various agricultural systems.

3. The Rap-Rfs Coupling Model

The coupling model contains two parts, one is the RAP model which can illustrate the agricultural policy shocks on the food system, while another is the RFS evaluation model for the definition of the stability of a food system.

3.1 Measurement of Food System Optimization Based on Rap Model

As the current food system is to be reprioritized for sustainability and equity, we combine our goals to the SDGs (Sustainability Development Goals) proposed by the United Nations. Agricultural policy has its uncertainty when it comes to food system improvement goals. How the food system elements response to the agricultural policy really counts as it measures the degree to which the food system is optimized.

Based on the traditional structural vector autoregressive model (SVAR), the TVP-SV-VAR model not only considers the nonlinear effect of the mutation system on the variables, but also estimates the correlation between the variables through the time-varying coefficient, and can solve the model heteroscedasticity through the time-varying volatility, so that the accuracy of model estimation can be improved.

We select 1,2 and 3 period ahead of the responses to respectively describe the impact of shortterm, medium-term and long-term agricultural policy shocks on carbon emissions. As there are many sovereign countries throughout the world, we choose the developed country Canada as an example to analyze the impacts of reprioritizing the food system for sustainability and equity. Subsequently, the indicator GHG (mostly CO_2 eq) emissions is selected for impulse response analysis under the agricultural shocks because of the severity of the global warming the high percentage of food system brings GHG emissions to the atmosphere. The result of equal-interval impulse responses is shown in Fig.2. The frequency in sampling used in MCMC simulation is 10000, and the Geweke values of the results were all lower than 1.96 under the significance level of 5%, the inefficiency values all conform to the reasonable value. Therefore, the result below is valid.

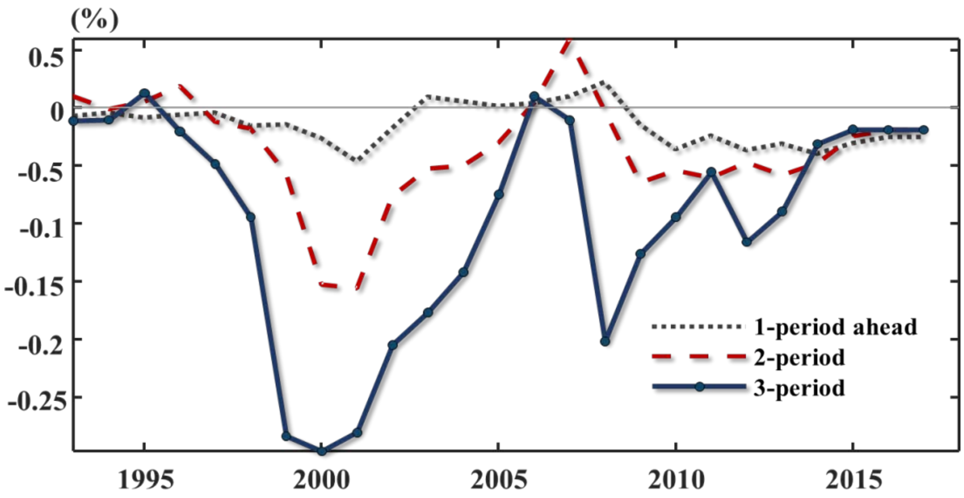

Fig.2 Time-varying impulse response to the agricultural policy shocks ($\varepsilon_t \uparrow \rightarrow GHG$) in Canada from1991 to 2017.

As is illustrated above, the time-varying impulse response of the CO_2 eq /kg product (kg) under one-standard-deviation shock goes under different levels. Since 2000, the Canadian government has been concentrating on building a multi-target-oriented agricultural support policy framework system [5]. The CO_2 emissions had deceased sharply by about 0.29% under the shock of the longterm (the blue line) agricultural plans in 2000. As time goes by, agricultural goals progressed smoothly, the CO_2 emission deceased at a lower rate till 2006. It is obvious that the decreasing rate of the GHG had another quick fall in 2008. Because, at that time, the first Growing Forward (20082013, GF) agricultural policy framework system was formulated, with the policy goal of enhancing the competitiveness and sustainable development of agriculture [5]. Therefore, the food system obtains an efficient response to the agricultural policy. However, the mid-term impulse response show results inferior to the long-term response, and the longer the policy period lasts, the more negative impulse response to the agricultural policy, that is, the optimized food system works under the influence of agricultural policy.

3.2 The Rfs Evaluation Model for Sdgs

As the reprioritized model is optimized for goal of sustainability and equity, therefore, we should take specific indicators into account, such as nutrition, safely drinking water and so on.

3.2.1 Primary Indicator System

Since the United Nations have set 17 goals of sustainability development for the food system. Therefore, we select 6 indicators concerning these goals to help define the stability of a food system. If the indicators were to meet the goals, the food system would be more stable. For reprioritization, we define the stability of a food system from the four levels.

Fig.3 Process flow for the establishment of the stability evaluation criteria. From the perspective of 4 target goals--sustainability, equity, efficiency, and proficiency, the model defines 6 indicators and incorporate them into stability index based on the impulse response to agricultural policy shocks.

(1)Efficiency

For the efficiency, or effectiveness, of a national food system, we choose the ratio of agricultural output to actual cultivated land,

(2)Proficiency

For the profitability of a country, we choose different first-level indicators for quantitative judgment, including net exports, gross national product, etc. .

(3)Sustainability

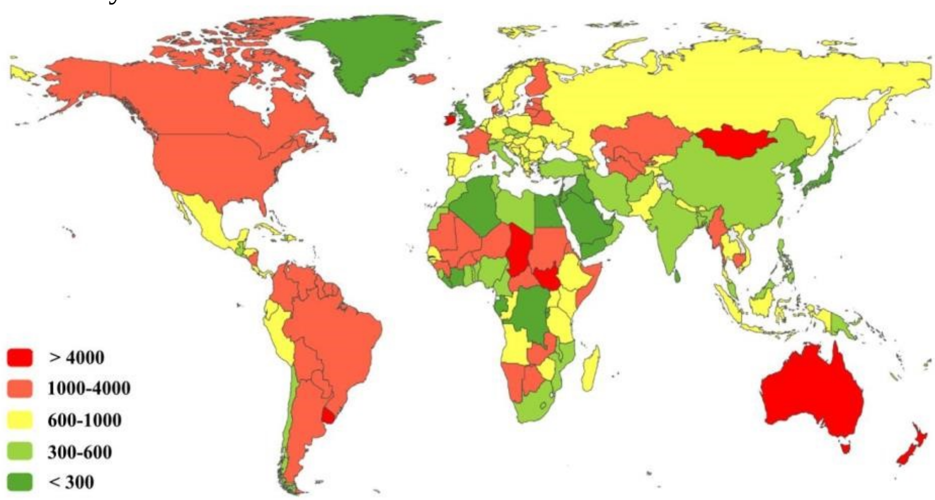

Fig.4 Co$_2$ Eq Kg/Per Capita of Each Country in 2018

As is shown in the figure above, five different colors represent the average CO_2 eq emissions of different levels in countries according to the formula we've calculated above. Simultaneously, the higher the level of sustainability, the darker of the 'green area', and similarly, the higher level of unsustainability, the darker of the 'red area'.

(4) Equity

In terms of equity, we take into account the shortage of food supply and the waste of food, and therefore consider attributing the equity of the national food system to the problem of food supply and food waste, so these two measures were chosen to show fairness.

3.2.2 Calculation of Score Based on Evm

With the evaluation indicators defined above, we further determine the weights of these indicators, resulting in the combination of primary indicators. Recalling on the Entropy Weight Method (EWM), we would carry out the standardized treatment, making the optimal and worst value of each variables after alternation be 100 and 0, respectively. The evaluation indexes are $X_1, X_2, \cdots, X_m$, where $X_i = \{x_{i1}, x_{i2}, \cdots, x_{in}\}$. Among there, *m* and *n* are the number of defined evaluation indicators and first-level indicators under each evaluation indicator, where *m*=4.

In the case of efficiency, profitability and equity indicators, a country's food system is in direct proportion to those indicators; in the case of similar sustainability indicators, based on limited data, first-level indicators, including carbon emissions, are inversely proportional to food systems, resulting in sustainability indicators being inversely proportional to national food systems, the less sustainable the food system is, the less robust it is. Thus, we have

$$\begin{cases} y_{ij} = \dfrac{x_{ij} - min(x_i)}{max(x_{ij}) - min(x_i)} \\ y_{ij} = \dfrac{max(x_i) - x_{ij}}{max(x_{ij}) - min(x_i)} \end{cases}, j = 1, 2, ..., n \quad (1)$$

After standardization, we succeeded in transforming to implicate the national food system. Then we introduce

$$p_{ij} = y_{ij} \Big/ \sum_{j=1}^{n} y_{ij} \quad (2)$$

Then, we can derive four comprehensive evaluation indicators: Efficiency Indicators, profitability, sustainability and fairness indicators, based on these calculated weights. On the basis of those calculated weights, we have

$$\begin{cases} Efficiency_j = w_1 y_{1j} \\ Proficiency_j = w_2 y_{2j} \\ Sustainability_j = w_3 y_{3j} + w_4 y_{4j} + w_5 y_{5j} \\ Equity_j = w_6 y_{6j} \end{cases} \quad (3)$$

3.3 Score Prediction

As the kernel function of SVM, the parameters to be determined in the model include penalty factor C, the width coefficient of the kernel σ and insensitive parameters. Finally, the parameter value is determined by the parameter tuning.

The parameters calculated by the two SVM methods are C=1, =1, =0.1, accuracy rate=46%;

Non-stationary time series, after eliminating their local level or trend, show a certain degree of homogeneity. In other words, some parts of the sequence are very similar to other parts at this time. This non-stationary time series can be converted into a stationary time series after difference processing. We call such a time series a homogeneous non-stationary time series. The degree of difference is the homogeneous order.

The entropy weight method is used to transform the comprehensive evaluation index into the evaluation Score. Considering some characteristics of the score itself based on the time series, the Arima model is used to solve the problem. Finally, ARIMA (0, 2, 2) model was chosen to forecast the comprehensive food System score of Canada, and the result was reasonable, AIC = 128.02. Use the model to make predictions and get results, among them.

$$\varepsilon_t \sim N(0,1)$$

$$\nabla^2 x_t = \varepsilon_t - 1.29\varepsilon_{t-1} + 0.48\varepsilon_{t-2} \quad (4)$$

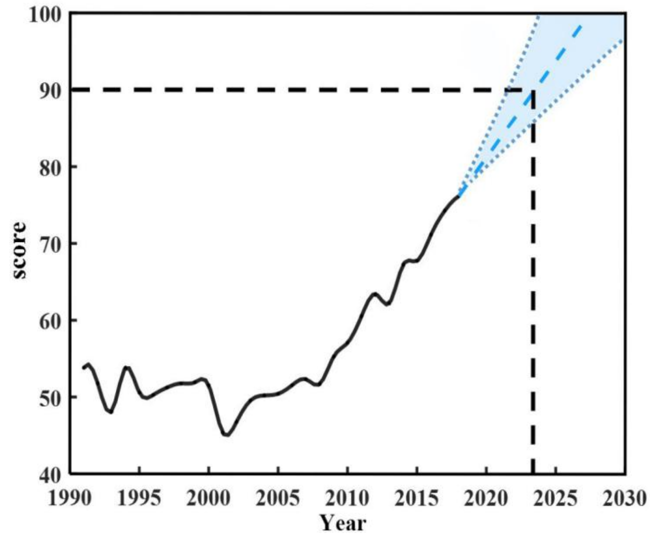

Fig.5 The Prediction of Comprehensive Score under Agricultural Policy Shocks. The Black Line is made by the Method of Cubic Spline; the Blue Lines and the Filled Areas Are the Prediction Results.

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