METHEDOLOGY OF THE STUDY OF FOOD SUPPLY FOR THE POPULATION OF THE REGION

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Abstract: *Reliable provision of the country and its regions with food is of great strategic importance, since both food and national security depend on it. An important condition for the country's food security is its self-sufficiency, which means meeting the needs for food products through domestic production. To characterize the potential opportunities at the macro level of agro-industrial complex management to meet their own needs in food, indices of production and consumption per capita, the degree of self-sufficiency of the country in their main types are important. Indicators of food consumption are among the most important characteristics of the level and quality of life of the population, are included in the system of generalizing indicators of socio-economic development of any country and are an integral basis of human life. The quality and structure of consumed food products affect the health of the country's population, determining its economic and food security. The article is devoted to the methodology of food supply monitoring for monitoring the country's food security in the context of global trends.*

Key words: *food, econometric models, consumption forecast, food costs, food demand, food commodities*
JEL codes: *C53, O13, B23*

1. Introduction

Food differs from other goods and services as the growth of population's need for them has certain physiological limits. Therefore, according to Engel's law, an increase in per capita income within a population group leads to proportionally lower growth of income spent on food. Supplying of a country on the basis of the territorial-sectoral labor' division in the agro-industrial complex: methodology and forecasting methods. (Altukhov, 2019) In addition, basic food needs of population in a particular region or country can be defined using demand econometric models with data obtained from household expenditure surveys across different income groups. As the COVID-19 pandemic of 2020 unfolds, considerable attention has focused on the resiliency of food supply chains in a time of crisis. Food supply chains have needed to adjust rapidly to demand-side shocks. (Hobbs, 2020)

2. Methodology and Data

Food industry plays an important role in providing basics and necessities for supporting various human activities and behaviors. (Abdul, 2020) The literature review showed that no common understanding of the definitions and principles of traceability exists, nor is there a sound common theoretical framework with respect to implementation of food traceability. (Karlsen et el 2013) The paper includes the theoretical considerations related to methodology of food supply monitoring. When no common theoretical framework exists, this affects the implementation process of traceability in the food industry. (Postacchini, 2019). Research methods used in the article: statistical, logical, empirical, econometric.

3. Results and Discussion

The level of effective market demand for a food product is determined by many factors. In particular, economic factors include supply of a specific product P, income levels of different population groups D, real and relative prices of selected products, C. Non-economic factors include demographic structure of population, size and composition of a household S, national and regional traditions, cultural context, etc. Economic factors are relatively mobile, especially the level of income and its differences within population groups. The other determinants' values change relatively slowly and thus have little effect on consumer demand in the short term (up to 3-5 years). Therefore, to represent their cumulative effect a time factor (t) is commonly included in current and future demand projections. In general terms, demand is a function of the factors above:

$$Y = f(P, D, C, S, t) \tag{1}$$

A system of econometric models should be specified in order to perform the calculation for certain groups and categories of foodstuffs. The historical values of output indicators and time series of statistically significant factors influencing food demand which are obtained from sample budget surveys covering different income groups are used as initial data set. In this case, the relationship between Y and (k-1) factors X2, X3, ...Xk is established. For each of these variables n observations are recorded as follows:

$$\begin{matrix} Y & X_2 & X_3 & \ldots\ldots\ldots\ldots & X_k \\ Y_1 & X_{21} & X_{31} & \ldots\ldots\ldots\ldots & X_{k1} \\ Y_2 & X_{22} & X_{32} & \ldots\ldots\ldots\ldots & X_{k2} \\ . & . & . & \ldots\ldots\ldots\ldots & . \\ Y_n & X_{2n} & X_{3n} & \ldots\ldots\ldots\ldots & X_{kn} . \end{matrix}$$

The problem is to estimate the parameters $b_1, b_2, b_3, \ldots, b_k$ using a least-squares procedure so that the expressions:

$$\overline{\mathbf{Y}}_i = b_1 + b_2X_{2i} + b_3X_{3i} + +\ldots. + b_kX_{ki}$$

approximate actual values Y_1, Y_2 ..... Y_n in the most appropriate way.

It is possible to analyse and forecast the consumption of basic foodstuffs using econometric models framework which assume that there is an exact relationship between aggregate expenditure on food, price level and aggregate income. Based on official statistics, different approaches are possible. In particular, the first approach is based on sample budget surveys covering population groups with different levels of food expenditure. On this basis, taking into account the representativeness of the sample, a system of models is being constructed which allows one to estimate the expected demand for basic foodstuffs as well as evaluate the effect which food expenditures and constant prices have on it: Y = f (P, S). In this case, the population's demand for food is determined by the formula:

$$Q_i^D = S_i \times N \tag{2}$$

$$S_i = \frac{(a_iR + b_ic_i + \sum_{j=1}^{n} d_{ij}c_j)}{c_i} \tag{3}$$

Where:

i, j - are the indices of primary food categories;

Q_i^d - demand (need) of the product i;

S_i - is per capita consumption of the product i in kind;

N - is projected population;

$a_i b_i d_i$ - are the coefficients of the regression equations corresponding to the product i;

R - is household expenditure on food;

c_i - is the price of the product i;

I - is a set whose elements are the indices of primary food products.

According to the second approach, econometric models of demand are based on budget statistics for each population group and thus enable estimating a particular group's food expenditure pattern. Since income is the most important factor influencing demand, the evaluation of demand and consumption is defined by a function of per capita monetary income and the price of the product: y = f (D, P). In this case, the following model is used to calculate the level of food demand:

$$Q_i^D = a_i + b_i P_i + c_i D \tag{4}$$

Where:

D_i^d - is the aggregate consumption of the product i;

P_I - is the average retail price of the product i;

D - is the aggregate consumer income.

The initial dataset includes time series of price, income and consumption of food products. All price and income values should be normalized to the same level by means of appropriate annual inflation rates. While conducting analysis of purchasing demand, it is worth applying single-factor demand functions of income – Engel curves, as well as the Törnqvist function. (Törnqvist 1981)

The third approach to evaluating demand implies average food consumption growth (decline) rates, assuming that indicators represent a geometric progression over time. The calculation is being performed on the basis of time series of explanatory and explained variables representing excess demand over past years taken as the average value of food consumption according to the following formulas:

$$Q_i^D = \left(\overline{K}_p\right)^n \times Q_i^b, \qquad \overline{K}_p = \sqrt{Y_j Y_i} \tag{5}$$

where

Q_i^D - is a fitted value of the demand for the food product i;

$\overline{K}_p$ - is the average growth rate;

n - is the number of intervals of the predictive dynamic series;

Q_i^b - is the value of the benchmark (the last one in the series);

$Y_j Y_i$ - are the initial and final indicators of the series.

According to the fourth approach, demand for particular food can also be calculated as a function of time and projected by the following equations:

$$Y = a + bt; Y = a^t; Y = \frac{l}{(a = bt)}; Y = a + bt + ct^2, \quad (6)$$

Where:

Y - is the level of specific foods consumption;

T - is an index number of observation in a series.

The parameters of the given economic and statistical models, as well as the related indicators of their adequacy and accuracy, can be calculated using various software tools: spreadsheets or spreadsheet processors, general-purpose software packages, specialized statistical packages.

If it is necessary to detail the structure of basic foodstuffs consumption, the linear programming (the fifth approach) is used to create a selection set (i.e. food basket). The set composed is intended to meet the medical requirements and standards, to be aligned with prospective nutritional pattern and to fit the level of consumption projected for various population groups. Special attention should be paid to the socially vulnerable categories of people, those with the lowest per capita income, who account for a relatively high share of total population.

The model shall be written as follows:

$$Z = \sum_{j=1}^{n} C_j X_j \to min, \quad (7)$$

$$R_s - \sum_{j=1}^{n} C_j X_j \to max, \quad (8)$$

The limitations:

$$\sum_{j=1}^{n} A_{ij} X_j \geq B_i, \quad i = 1,2, \dots . m; \quad (9)$$

$$d_j \leq X_j \leq D_j, \qquad j = 1,2, \dots . n; \quad (10)$$

Where:

i - are nutrients, i = 1, 2…….m;

j - are foodstuffs; j = l, 2. ...n;

X_j - is the quantity of food of j-kind included in the food ration;

B_i - is a minimum percentage of the i- type nutrient in the food ration;

d_j, D_j - are the lower and upper boundaries of the j-type food consumption included into the food ration;

A_{ij} - is the quantity of the i- type nutrient contained in the mass unit of the j-type food;

C_i - is the sale price of the mass unit of the j-type food;

R_s - is the income of the socio-economic group with index s.

In addition to the above factors, consumer preferences, the number of children in the family, other demographic and social factors can also have a significant impact on demand for food.

The income-to-expenditure ratio is used to determine the income elasticity of demand. According to Engel's Law, the lower the household's income, the greater share of its total expenditures is spent on food. It is known that increase in income makes demand for selected high-quality and expensive foods rise, and, conversely, makes demand for cheaper foods such as bread and potatoes decline.

When identified the demand for food commodities within social and demographic groups of the population, the quantities of agricultural raw materials can be calculated by means of factors attributable to food conversion into raw materials using the formula:

$$B_i^s = \sum_{j=1}^{ni} k_{ij}^s X_j, \quad i = 1,2, \dots m, \ \ s \in R \tag{11}$$

Where:

m - is the number of groups of homogeneous food items;

i - is the index of the homogeneous group of food items;

ni - is the quantity of food items in the i group; \

j - is the index of the product;

R - types of agricultural raw commodities;

B_i^s- -agricultural raw materials of type s required for food items group i;

k_{ij}^{s}I - s the conversion rate attributable to the j food item of the i group being converted into agricultural raw materials s;

X_j - is the consumption value of the food item j.

In order to ensure the stability of the population's economic access to food and guarantee its distribution primarily among agricultural producers, it is necessary to regulate the balance of demand and supply in the domestic food and agriculture market, so they should be estimated in advance. Thus, in order to assess the potential of the food and agriculture market saturation as a result of domestic food sources and imports, it is necessary to identify possible food production and to compare it with demand values using balance sheet models.

In order to determine the most likely level of production with resources given, it is worth using the input-output production function, which is regarded as a function of fundamental production factors: labour, capital and land. The model is represented by the Cobb-Douglas function as follows:

$$Q_i^s = a_o \Pi R_{if} \alpha_{if} \quad (12)$$

Where:

Q_i^s - is gross output of the 1st type of product(i=1, 2, ...n);

a_o - is a scale factor;

P - is a multiplication sign;

R_{if} - is demand for the f production factor in the i sector of the economy;

α_{if} - is the elasticity of the output of the i product in relation to the input of the f production factor;

F - is a set whose elements are indices of the main production factors.

The output should be evaluated by assessing the impact of resources on output.

When performing the predictions of the short- and medium-term average per capita production and consumption of individual foodstuffs, it is worth using a set of trend models that provide a reasonably accurate description of the indicators' dynamics. Many years of experience in applying approximation functions for forecasting purposes have shown that the following mathematical models are the simplest and most commonly used in scientific research:

linear model

$$\mathrm{y(t)} = a_o + a_1 \mathrm{t} \quad (13)$$

logarithmic model

$$y(t) = a_o + a_1 \ln(t) \tag{14}$$

square parabola model

$$y(t) = a_o + a_1 t + a_2 t^2 \tag{15}$$

power model

$$y(t) = a_o t^{a_1} \tag{16}$$

exponential model

$$y(t) = a_o e^{t a_1} \tag{17}$$

the Fourier series equation

$$y(t) = a_o + \sum_{k=1}^{m} (a_k \cos kt + b_k \sin kt) \tag{18}$$

Where:

$y(t)$ - is the theoretical value of average per capita production and consumption of selected types of food;

a, b - are the coefficients of regression equations; t is the time;

k - is a harmonic of series;

m - is the number of harmonics in a series.

A methodological approach to forecasting effective demand which appears to be the most preferred according to domestic economic literature, is the use of a normative method based on extrapolation of an indicator which describes the degree to which the need for particular food is satisfied, the formula is as follows (Alktukhov, 2019):

$$K = \frac{Y}{\overline{Y}} \tag{19}$$

Where:

Y - is the actual level of this particular food item consumption;

$\overline{Y}$ - is the rational norm of food consumption.

The food needs satisfaction indicator is determined by projected period, the relation is denoted by a linear regression equation:

$$K = \overline{K} + b(t_i + \bar{t}) \tag{20}$$

Where:

$\overline{K} = \frac{K_i}{n}$ - is the average degree of satisfaction; n is the number of observations included in the sample;

$\bar{t} = \frac{t_i}{n}$ - is the average mean of the period investigated;

$t_i = t_1 + t_2 + \cdots + t_m$ - is the total sum of period studied;

$b = \frac{nt_i \times K_i - t_i \times K_i}{nt_i^2 - (t_i)^2}$ - is the estimate of the angle tangent.

The level of food consumption for the projected period is then determined by the formula:

$$Y = K\overline{Y} \qquad (21)$$

Different methods can be used for each variable to be determined over the years of the projection period, but the most straightforward one assumes the growth rate, which remains unchangeable and allows that at the end of the projection period, a rational norm of food consumption is achieved:

$$C_{\text{ф}} = \text{C}_t \times \text{t} \qquad (22)$$

where

t - is the time of the projection period;

$C_{\text{ф}}$ - is the actual demand in the last year of the base period;

C_t - expected demand in the latest year of projection period;

C - is the annual absolute increment evaluated as follows:

$$C = \frac{C_{\text{пр}} + \text{C}_{\text{ф}}}{t} \qquad (23)$$

Where:

$C_{\text{пр}}$ - is demand in the last year of the projection period (Yashina, 2012) .

The assessment of the prospective demand for food in the region is underpinned by analyses of the real demographic structure of the region’s population alongside with evidence-based recommendations for various age groups regarding the daily demand for nutrition’s and microelements that match physiological needs and sound metabolism. The future needs of each type of food can then be estimated using the formula (Belozerova et el, 2011):

$$\Pi_i = P_{ij} \times Л_{ij} \qquad (24)$$

Where:

Π_i - is the entire region’s annual demand for the i-type of food according to scientifically proved dietary standards, tons of;

P_{ij} - is annual need of food of type i within the population category j (taken according to regional norms or as an average for the country), kg per capita, annually;

$Л_{ij}$ - is the number of people in category j living in the region who consume the i product, per capita; i is the type of food produced (i = 1...п); j is the age group (category) of the population (j = 1...m).

To perform evaluation aggregated values may be used:

$$\Pi_i = P_i \times Л \qquad (25)$$

Where:

P_i - is the average annual human need for the 1st type of food, kg per capita; Л is the population of the region.

The real annual need of the entire population of the region for some food category is determined by the formula that may be written:

$$\Pi_i = P_{bi} \times R_{oi} \times \frac{1+f}{1+y} \times R_{poi} \times R_{noi} \qquad (26)$$

Where:

P_{bi} - is the annual consumption of the food of type i achieved by the population in the region in the base year per inhabitant, tons per capita;

R_{oi} - is a coefficient that takes into account the expected change in the population's consumption of the food of type i in the estimated year compared to the base year;

Л is the projected size of population of the region in the estimated year, calculated by the formula:

$$Л = Л_б \times R_o + Л_м \qquad (27)$$

Where:

$Л_б$ - is the population of the region in the base year, person;

R_o - is the rate of natural population change in the estimated year, which is determined by the formula:

$$R_o = 1 + \frac{Л_р - Л_у}{Л_б} \qquad (28)$$

Where:

$Л_р$, $Л_у$ - are respectively the estimated number of births and deaths in the estimated year;

$Л_м$ - is expected number of migrants in the region in the estimated year;

F - is a coefficient that takes into account the growth of income of the population in the estimated year;

Y - is the rate of expected inflation in the estimated year;

R_{poi} and R_{noi} - are the expected coefficients taking into account the level of reserves and funds allocated to provide the food of i type support to the population ($R_{poi} > 1$, $R_{noi} > 1$).

The year preceding the year assessed is the most convenient to adopt as a base one. As for the y, it is projected in the federal budget. Food reserves for basic foodstuffs are usually set at 10 % level of the need (R_{poi}= 1,1) and population support funds (for the poor) are formed at the discretion of the regional executive or legislative authorities.

Since the deepening of the sectoral division of labour in the country's agricultural and industrial production implies the development of interregional exchanges aiming to reduce the differentiation in the level of food consumption among the population, thus the feasibility and effectiveness of existing interregional food linkages should be assessed and relative measures should be outlined to improve them. Therefore, it is important to identify the agricultural production potential in terms of products, raw materials and food in the region, the effective demand of the population and the distribution of food and agricultural commodity flows.

4. Conclusions

For an objective assessment of the state and the need to maintain food security at an optimal level, a system of special indicators should be used, allowing it to be simultaneously and comprehensively considered in dynamics and in comparison. For this, an economic-mathematical, statistical, econometric apparatus is used, which helps to quantitatively and qualitatively determine the parameters of indicators at the level of individual territories. In modern conditions, food security as a dynamic socio-economic phenomenon has a complex hierarchical system that includes many elements and subsystems. On the one hand, it is increasingly becoming global, since to one degree or another practically affects all countries, and its provision depends on numerous factors of an internal and external nature that go beyond not only agriculture and the agricultural sector, but also the entire economy, but on the other hand, it is inextricably linked, first of all, with national and economic security, the influence of the international situation. This makes food security one of the most important and acute global problems of our time, requiring analysis and study.

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