Study of structural shifts in food consumption in the Russian Federation for the period 2013-2017

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Abstract. The paper presents the results of the study of the structural dynamics of food consumption by the population of Russia for the period from 2013 to 2017 per capita. The study is important to identify current trends in consumer behaviour in the context of food embargo and economic recession. The research methodology is presented by statistical analysis of coefficients and indexes of structural changes with a constant and variable base of comparison. The authors determined that starting in 2014, there are significant changes in the structure of consumed food products, which affect the structure of the retail turnover of food products with a time lag of two years. It has also been established that a 20% difference in the level of real disposable income creates a structural shift in the consumption of basic foodstuffs by the population in the range of 3-5%.

1. Introduction
Since 2014, the Russian food market has been operating under conditions of artificially restricting competition through the mechanism of the food embargo. At the same time, there is an increase in budgetary expenditures in the agricultural and food processing industries [1]. These factors contributed to an increase in agricultural production in the country and self-sufficiency indicators for the main types of products [2]. At the same time, experts do not estimate the current distribution of gains between the subjects of the food market from the existing restrictions in favour of the final consumers [3-5]. First, the prices of food products of both domestic and imported production have significantly increased. At the same time, during the entire study period, real incomes of the population decreased (figure 1). These trends are sustainable; they lead to a decrease in the economic affordability of food.

The consumer responds by redistributing expenditures within the food budget in favour of less useful, but cheaper types of products (replacement of vegetables for potatoes, beef for poultry, etc.) [4]. Second, the quality of food products has noticeably decreased, and there is an increase in counterfeits on food shelves. This is indicated by the individual results of inspections of the Russian Institute of Consumer Testing. In regional food markets, the expansion of such trade as food discounters is recorded. These facts indicate that the population actively saves on product quality [6]. One of the main criteria for choosing food becomes the "price/calorie" ratio. These negative trends affect the diet and its balance.
As a result, one can observe a decrease in the capacity of markets for individual foods, a decrease in the economic affordability of food, deterioration in product quality, and increased barriers to entry for small producers of natural farm products. These trends are especially vividly manifested in peripheral and local food markets: in rural areas, in remote areas (the Far North, regions of the Far East), as well as in small cities [7]. In this regard, the authors see the need for a deeper analysis of the structural dynamics of food consumption by the population, which predetermined the purpose of this study.

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2. Research methods and methodology
The methodological basis of the study is founded on the statistical analysis of structural changes based on coefficients and indices with a constant and variable base of comparison. The study period is selected from 2013 to 2017. The authors used official statistics of the Federal State Statistics Service of the Russian Federation. The main stages and directions of research are presented below.

Step 1. Calculation of statistical coefficients of structural changes was carried out in the following areas:

- the volume of food consumption in the Russian Federation per capita;
- structure of household expenditures on food products in the Russian Federation;
- food cost structure by main product groups;
- structure of retail trade turnover per capita in comparable prices by main product groups.

The statistical characteristics of the initial data set are given in table 1.
Table 1. Descriptive statistics of the initial data set for the period 2013-2017.

|                      | Consumption per capita, kg / pc | Retail turnover structure, % | Nutrition cost structure, % | Household expenditure structure, % |
|----------------------|---------------------------------|-----------------------------|-----------------------------|-----------------------------------|
|                      | min | max | medium | min | max | medium | min | max | medium | min | max | medium |
| G1 - Bread and bread products | 91.6 | 97.2 | 95.0 | 0.8 | 1.0 | 0.8 | 14.3 | 14.7 | 14.5 | 13.7 | 14.9 | 14.2 |
| G2 – Potatoes         | 55.9 | 61.4 | 59.5 | 2.5 | 3.1 | 2.7 | 1.9 | 2.6 | 2.3 | 2.5 | 2.9 | 2.7 |
| G3 – Vegetable and gourds | 91.7 | 99.7 | 96.8 | 8.6 | 11.3 | 10.0 | 10.3 | 10.6 | 10.5 | 11.2 | 12.4 | 11.9 |
| G4 – Fruit and berries | 78.6 | 81.4 | 79.9 | 7.3 | 9.3 | 8.2 | 9.3 | 9.9 | 9.6 | 9.6 | 11.1 | 10.5 |
| G5 – Meat and meat products | 83.9 | 89.1 | 86.0 | 22.5 | 30.3 | 26.5 | 29.9 | 31.4 | 30.8 | 27.0 | 29.5 | 28.2 |
| G6 – Milk and milk products | 254 | 270 | 265.3 | 28.0 | 30.8 | 29.6 | 15.3 | 15.7 | 15.5 | 15.1 | 15.8 | 15.4 |
| G7 – Eggs             | 213 | 232 | 223.3 | 3.6 | 4.4 | 4.0 | 1.8 | 1.9 | 1.9 | 1.7 | 1.8 | 1.7 |
| G8 – Fish and fish products | 20.9 | 22.7 | 22.1 | no statistics | 6.8 | 7.1 | 7.0 | 6.5 | 7.1 | 6.7 |
| G9 - Sugar and pastry | 30.9 | 32.2 | 31.6 | 15.4 | 19.7 | 17.4 | 6.3 | 6.7 | 6.5 | 7.2 | 7.3 | 7.3 |
| G10 – Vegetable oil and other fats | 11.0 | 11.5 | 11.3 | 0.8 | 1.0 | 0.8 | 1.4 | 1.6 | 1.5 | 1.3 | 1.6 | 1.5 |

The authors used the following statistics:

a) Basic linear coefficient of absolute structural shifts:

$$L_{\text{basic}} = \frac{\sum_{i=1}^{10} |d_{ij} - d_{i2013}|}{k}$$  \hspace{1cm} (1)

where $L_{\text{basic}}$ – basic linear coefficient of absolute structural shifts of the coefficient; $d_{ij}$ – the value of the product of $i$ group in the considered structure/population of the corresponding $j$ year; $d_{i2013}$ – value of the product type in the considered structure/aggregate of the base year 2013; $k$ – the number of product groups.

b) Chain linear coefficient of absolute structural changes:

$$L_{\text{chain}} = \frac{\sum_{i=1}^{10} |d_{ij} - d_{i(j-1)}|}{k}$$  \hspace{1cm} (2)

where $L_{\text{chain}}$ – chain linear coefficient of absolute structural shifts of the coefficient; $d_{i(j-1)}$ – the value of the product type in the structure/population of the previous $(j-1)$-th year under consideration;

c) Baseline RMS absolute structural shift factor:

$$\sigma_{\text{basic}} = \frac{\sum_{i=1}^{10} (d_{ij} - d_{i2013})^2}{k}$$  \hspace{1cm} (3)

where $\sigma_{\text{basic}}$ - base RMS absolute structural shift factor;

d) Chain RMS absolute structural shift factor:
\[
\sigma_{\text{chain}} = \sum_{i=1}^{10} \frac{(d_{ij} - d_{(i-1)j})^2}{k},
\]

where \(\sigma_{\text{chain}}\) - chain RMS coefficient of absolute structural shifts.

Coefficients of less than 2% indicate the presence of small structural changes. Considered significant shifts for values of the coefficient from 2 to 10%, more than 10% are considered a major structural shift.

Stage 2. Analysis of structural changes in food consumption by decile population groups, differentiated depending on the level of real disposable income based on the Ryabtsev index:

\[
K_R = \sqrt{\frac{\sum_{i=1}^{k} (q_i^1 - q_i^0)^2}{\sum_{i=1}^{k} (q_i^1 + q_i^0)^2}},
\]

where \(K_R\) – Ryabtsev index, values are measured from 0 to 1; \(q\) - values of the product consumption in the compared aggregate.

The comparison was carried out between the values of 2013 and 2017. The initial data set is given in table 2.

**Table 2.** Baseline data on food consumption by decile population groups, differentiated depending on the level of real disposable income.

| Decile group | Year | G1 | G2 | G3 | G4 | G5 | G6 | G7 | G8 | G9 | G10 |
|--------------|------|----|----|----|----|----|----|----|----|----|-----|
| First        | 2013 | 81 | 49.6 | 60.4 | 39.8 | 53.1 | 174 | 160 | 14.2 | 22.9 | 8.4 |
|             | 2017 | 91.8 | 54.1 | 67.3 | 38.8 | 56.1 | 174 | 171 | 13.6 | 25.1 | 9.1 |
| Second       | 2013 | 88.6 | 56.3 | 74.4 | 52.4 | 66.9 | 216 | 183 | 17.3 | 26.6 | 9.4 |
|             | 2017 | 93.7 | 56.6 | 81.3 | 38.8 | 56.1 | 174 | 171 | 13.6 | 25.1 | 10.1 |
| Third        | 2013 | 91.7 | 57.6 | 82.4 | 60 | 73.4 | 238 | 196 | 19.1 | 28.5 | 10.1 |
|             | 2017 | 96.7 | 59.3 | 92.1 | 59.1 | 74.6 | 209 | 195 | 16.6 | 28.4 | 10.1 |
| Fourth       | 2013 | 95.2 | 60.2 | 89.7 | 66.9 | 80.1 | 256 | 203 | 21.1 | 30.5 | 10.3 |
|             | 2017 | 98.5 | 60.2 | 97.6 | 82.4 | 74.4 | 237 | 211 | 18.5 | 30.2 | 10.6 |
| Fifth        | 2013 | 98.3 | 62 | 95.5 | 74.1 | 84.7 | 234 | 214 | 19.1 | 28.5 | 10.1 |
|             | 2017 | 98 | 59.4 | 99.4 | 68.3 | 85.4 | 264 | 227 | 20.8 | 30.8 | 10.8 |
| Sixth        | 2013 | 97.9 | 61.9 | 99.5 | 78.9 | 87.5 | 286 | 220 | 23.8 | 32.5 | 10.9 |
|             | 2017 | 97.3 | 60.6 | 104 | 74.2 | 90.1 | 272 | 233 | 22.1 | 32 | 10.7 |
| Seventh      | 2013 | 97.7 | 62.4 | 102 | 86.5 | 89.5 | 297 | 232 | 23.1 | 33.6 | 11 |
|             | 2017 | 99.4 | 61 | 109 | 80.2 | 96.1 | 293 | 240 | 23.6 | 33.3 | 11.1 |
| Eighth       | 2013 | 98.3 | 62.1 | 108 | 92.2 | 96.2 | 302 | 304 | 26.3 | 34.2 | 11.4 |
|             | 2017 | 101 | 63 | 118 | 89.6 | 104 | 304 | 305 | 26.3 | 34.2 | 11.4 |
| Ninth        | 2013 | 103 | 65.1 | 120 | 104 | 103 | 322 | 356 | 27.6 | 36.2 | 11.7 |
|             | 2017 | 98.9 | 60.8 | 123 | 97 | 108 | 321 | 269 | 26.4 | 35.1 | 11.6 |
| Tenth        | 2013 | 106 | 67.2 | 126 | 105 | 106 | 326 | 268 | 28.5 | 38 | 12.7 |
|             | 2017 | 97.1 | 59.7 | 129 | 102 | 111 | 323 | 277 | 26.8 | 34.2 | 11.7 |

3. Results and discussion

3.1. The results of the analysis of statistical coefficients of structural changes

Calculations of linear and root-mean-square coefficients of structural shifts carried out in accordance with the presented methodology are given in tables 3-4.
Table 3. Structural changes in average consumption and retail trade turnover per capita.

| Year | Consumption per capita, kg/pc | Retail turnover, % |
|------|--------------------------------|-------------------|
|      | L<sub>basis</sub> | L<sub>chain</sub> | σ<sub>basis</sub> | σ<sub>chain</sub> | L<sub>basis</sub> | L<sub>chain</sub> | σ<sub>basis</sub> | σ<sub>chain</sub> |
| 2014 | 7.26 | 7.26 | 73.388 | 73.388 | 1.9 | 1.9 | 0.069 | 0.69 |
| 2015 | 6.12 | 2.8 | 15.754 | 12.938 | 1.5 | 0.4 | 0.0423 | 0.038 |
| 2016 | 8.98 | 3.1 | 135.456 | 38.586 | 0.8 | 1.7 | 0.09 | 0.675 |
| 2017 | 5.87 | 3.45 | 74.519 | 30.403 | 2.3 | 2.6 | 0.13 | 0.173 |

Basing on the analysis of the presented values, the authors draw the following conclusions. During the period from 2013 to 2017, there was a significant change in the average food consumption per capita. Moreover, a change is noted both in terms of the base coefficient and the chain coefficient. The consumption structure relative to the base year 2013 deviated most significantly in 2016. The factor that influenced was the strongest fall in the real incomes of the population in 2016 (by 5.8% from figure 1). At the same time, a low food inflation rate was recorded in 2017, which allowed reducing the basic structural deviation in 2017 partially.

The retail market reacted to the food consumption change of the population more restrained, which is explained by rising prices for final products, as well as an increase in government subsidies in agriculture. But in the period of 2016-2017, there was a significant change (more than 2% in linear interpretation and by 17.03% in rms) of the turnover structure, which determined a significant structural shift relative to the base year 2013. The general conclusion of the table is the following: for the considered period there were significant changes in the consumption of food products, which affected the retail turnover of food products with a time lag of 2 years.

The shifts in the cost of food for households and the structure of their expenditures are shown in Table 4.

Table 4. Structural changes in the cost of food and household expenditures.

| Year | Стоимость питания | Расходы домохозяйств |
|------|------------------|---------------------|
|      | L<sub>basis</sub> | L<sub>chain</sub> | σ<sub>basis</sub> | σ<sub>chain</sub> | L<sub>basis</sub> | L<sub>chain</sub> | σ<sub>basis</sub> | σ<sub>chain</sub> |
| 2014 | 0.16 | 0.16 | 0.036 | 0.036 | 0.56 | 0.56 | 0.6 | 0.604 |
| 2015 | 0.21 | 0.25 | 0.079 | 0.085 | 0.4 | 0.38 | 0.29 | 0.288 |
| 2016 | 0.42 | 0.23 | 0.33 | 0.105 | 0.54 | 0.3 | 0.42 | 0.282 |
| 2017 | 0.38 | 0.22 | 0.326 | 0.084 | 0.5 | 0.1 | 0.38 | 0.018 |

The calculated values of the coefficients presented in table 4 confirm the trends identified from the analysis of the previous table. The values of the basic and chain coefficients in the structure of the food cost indicate significant changes that affect the redistribution of household expenditures within the food budget. The most significant deviation from the structure of the food cost for the base year 2013 was also recorded in 2016. The same dynamics can be traced for the structure of household food expenditures.

Summarizing this part of the study, the authors conclude that the food market is undergoing a noticeable negative change in the structure of consumer needs, costs and consumption, which in turn changes the supply structure and also stimulates manufacturers to reduce the quality of the final product.

3.2. Analysis of changes in food consumption by decile groups of the population, differentiated depending on the level of real disposable income

The decline in real incomes and the rise in prices primarily affect the low-income strata of the population, exacerbating social inequality. The data of table 5 demonstrate how it affected the comparative consumption of food.

Table 5. Ryabtsev indices for estimating changes in food consumption by decile groups of the population, differentiated depending on the level of real disposable income.

| Groups compared | Ryabtsev basic index | Groups compared | Ryabtsev chain index |
|-----------------|---------------------|-----------------|---------------------|
|                 |                     |                 |                     |

5
Comparing the Ryabtsev basic indices for 2013 and 2017, the authors come to the conclusion that the differences in consumption somewhat decreased, primarily due to alignment of the structural dynamics towards the first group (with the lowest incomes). If in 2013 the structures of the tenth and first groups differed by 28.8%, in 2017 the difference was 27.6%. In general, only the second and third groups of the population have an insignificant difference in consumption patterns, and starting from the fourth group, the structures on the Ryabtsev scale already have significant differences. Ryabtsev chain index suggests that the adjacent groups do not have significant differences in consumption, and the accumulation of structural shift goes through one group. That is, a 20% difference in income level creates a significant structural shift in the consumption of basic foodstuffs by the population.

Figure 2 shows the calculations of the Ryabtsev index for consumption patterns of the same groups by disposable income in 2013 and 2017.

| Group          | 2013 | 2017 | Group          | 2013 | 2017 |
|----------------|------|------|----------------|------|------|
| Second and first | 0.091 | 0.08 | Second and first | 0.091 | 0.08 |
| Third and first  | 0.133 | 0.132| Third/second    | 0.043 | 0.052|
| Fourth and first | 0.164 | 0.161| Fourth/third    | 0.031 | 0.03 |
| Fifth and first  | 0.194 | 0.175| Fifth/fourth    | 0.031 | 0.015|
| Sixth and first  | 0.212 | 0.191| Sixth/fifth     | 0.019 | 0.017|
| Seventh and first| 0.231 | 0.218| Seventh/sixth  | 0.022 | 0.029|
| Eighth and first | 0.24  | 0.243| Eighth/seventh | 0.013 | 0.028|
| Ninth and first  | 0.277 | 0.267| Ninth/eighth   | 0.041 | 0.026|
| Tenth and first  | 0.288 | 0.276| Tenth/ninth    | 0.015 | 0.013|

Figure 2. Ryabtsev indices when comparing food consumption patterns by respective groups in 2013 and in 2017.

The values of the indices obtained indicate that the consumption patterns of groups in 2013 and 2017 are practically identical. Only for the first group (with the lowest incomes), the fourth group and the eighth group, slight structural changes occurred. The results indicate a gradual and noticeable deterioration of the situation with both the volume of food consumption and the structure of the diet for the population of the Russian Federation.

4. Conclusion
Summing up, the authors state that the overall structural dynamics has substantial negative trends. The situation can be changed under the condition of reducing production costs in agriculture (for example,
by increasing subsidies, investing in resource saving), reducing the length of food supply chains to the retail market (for example, through the systems of territorial logistic food centres), ensuring income growth through reductions in military spending of the federal budget and redistribution in favor of social items). Further direction of the authors’ research within the framework of a given topic will include the study of changes in the energy structure of the diet, as well as the study of structural dynamics at the level of the subjects of the Russian Federation.

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