ANALYSIS OF MEAT CONSUMPTION BASED ON THE MATRIX OF GROWTH

Nada Lakić¹ and Mirjana Krivokapić¹

Abstract: Using the matrix of growth it is possible to examine, in a specific way, structural relations of growth in order to discover the mutual influences of activities and their linking into systems.

Considering that different sorts of meat can substitute one another in nutrition, during the observation of the dynamics of the consumption of a certain sort of meat, its change should be observed as a function of a scope of the consumption of other sorts of meat in the analyzed time period.

This work’s subject is an analysis of trends of the consumption of different sorts of meat in Central Serbia, in the period from 1994 to 2007, via the matrix of the consumption growth.

Key words: the matrix of growth, the meat consumption, substitutes.

Introduction

Among the possible aspects of examining agricultural activities the statistical-methodological takes the significant place. Depending on the purpose of the research, a great number of statistical methods are used in agriculture. The examination of the dynamics of agricultural activities is most commonly performed on the base of an index or a statistical model of trend. In the case of the analysis of time series of mutually connected agricultural activities is also possible to use a matrix of growth.

A model based on a matrix of growth is used for following the structural changes in ex post conditions, for making a projection of future structural relationships, for connecting the states of activities at the beginning and at the end of observed period, or for evaluating the interval for the projection of future development.

The application of the matrix of growth is especially suitable for an analysis of the consumption of products which can be mutually substituted. Considering this, the analysis of the consumption of different kinds of meat in nutrition of the

¹ Nada Lakić, PhD, professor, Mirjana Krivokapić, assistant, Faculty of Agriculture, Nemanjina 6, 11081 Beograd-Zemun, Serbia
population of Central Serbia, in period from 1994 to 2007 was performed in this work.

**The Matrix of Growth**

If the scope of the consumption of i-th kind of meat is marked with $Y_{it}$ and $Y_{i,t-1}$ ($i = 1,2,3...n$) in the period of time $t$ and $t-1$, respectively, then the absolute change consumption of i-th kind of meat in the period $(t-1,t)$ is:

$$
\Delta Y_{it} = Y_{it} - Y_{i,t-1}
$$

(1)

When put this change into dividing with the scope of the consumption of i-th kind of meat in period $t$ or $t-1$, as a result we get a direct rates of growth of the consumption of i-th kind of meat:

$$
r_{iit} = \frac{\Delta Y_{it}}{Y_{it}} \quad \text{and} \quad r^{'}_{iit} = \frac{\Delta Y_{i,t}}{Y_{i,t-1}} \quad i = 1,2,3...n \quad ; \quad t = 1,2,3,...T
$$

(2)

An indirect rate of growth of the consumption (between i-th and j-th kind of meat) is defined as the quotient between the change of consumption of i-th kind of meat, $\Delta Y_{it}$ and the total amount of consumption of j-th sort, $Y_{jt}$, during the period $t$ or $t-1$:

$$
r_{ijt} = \frac{\Delta Y_{it}}{Y_{jt}} \quad \text{and} \quad r^{'}_{ijt} = \frac{\Delta Y_{i,t}}{Y_{j,t-1}} \quad i,j = 1,2,3...n \quad ; \quad t = 1,2,3,...T
$$

(3)

Direct and indirect rates of growth of the consumption can be represented as matrixes of the consumption growth:

$$
R_t = \left[ \begin{array}{cccc}
        r_{i1t} & \ldots & r_{int} \\
        \vdots & \ddots & \vdots \\
        r_{n1t} & \ldots & r_{nt} \\
\end{array} \right] \quad \text{or} \quad R^{'}_t = \left[ \begin{array}{cccc}
        r^{'}_{i1t} & \ldots & r^{'}_{int} \\
        \vdots & \ddots & \vdots \\
        r^{'}_{n1t} & \ldots & r^{'}_{nt} \\
\end{array} \right] \quad t = 1,2,3,...,n
$$

where elements on the main diagonal denote the correlations between consumptions of observed sorts of meat in direct shape, and others denote these correlations in indirect shape.

Rates of growth are relative indexes, which quantify how many units of the consumption growth of i-th kind of meat come to a spent unit of i-th or j-th kind of meat in t-th period or (t-1)-th.
The matrix of the consumption growth, \( R_t \), can also be defined as the outer product of the vector of the consumption increment \( \Delta Y_t = (\Delta Y_{1t}, \ldots, \Delta Y_{nt}) \) and the vector of reciprocal values of the consumption \( \left( \frac{1}{Y_t} \right) = \left( \frac{1}{Y_{1t}}, \ldots, \frac{1}{Y_{nt}} \right) \):

\[
R_t = \Delta Y_t \left( \frac{1}{Y_t} \right) = \begin{bmatrix} \Delta Y_{1t} \\ \vdots \\ \Delta Y_{nt} \end{bmatrix} \cdot \begin{bmatrix} \frac{1}{Y_{1t}} \\ \vdots \\ \frac{1}{Y_{nt}} \end{bmatrix}
\]

(4)

where \( \Delta Y_t \) is a column vector, of the order nx1, and \( \left( \frac{1}{Y_t} \right) \) is a row vector, of the order 1xn.

Besides annual changes, it is often necessary to analyze changes in longer period of time. For this purpose, an average matrix of consumption is used.

Elements of the average matrix of consumption, \( \bar{R} \), can be defined as:

1) deliberate arithmetical mean of corresponding elements of the matrix of growth for successive periods, for \( t = 1,2,3,\ldots,T \):

\[
\bar{r}_{ij} = \frac{\sum_{t=1}^{T} r_{ijt} Y_{jt}}{\sum_{t=1}^{T} Y_{jt}} \quad i,j = 1,2,3,\ldots,n
\]

(5)

2) geometrical mean of corresponding elements of the matrix of growth for successive periods, for \( t = 1,2,3,\ldots,T \):

\[
\bar{r}_{ij} = \sqrt[\sum_{t=1}^{T} r_{ijt} ]{ r_{ijt} }
\]

(6)

3) outer product of a vector of consumption increment in observed period (0,t), \( \Delta Y_{0/T} = (\Delta Y_{1,0/T}, \ldots, \Delta Y_{n,0/T}) \) and a vector of reciprocal values of the total consumption in the period (0,t) for \( t = 1,2,3,\ldots,n \):

\[
\begin{bmatrix} \frac{1}{\sum_{t=1}^{T} Y_t} \\ \sum_{t=1}^{T} Y_{1t} \\ \vdots \\ \sum_{t=1}^{T} Y_{nt} \end{bmatrix} = \begin{bmatrix} \frac{1}{\sum_{t=1}^{T} Y_{1t}} \\ \sum_{t=1}^{T} Y_{1t} \\ \vdots \\ \sum_{t=1}^{T} Y_{nt} \end{bmatrix}
\]

that is
Results and Discussion

The consumption of fresh and frozen meat in households in Central Serbia in period from 1994 to 2007 year is shown in table 1.

**Tab. 1. – The consumption of meat, fish and prepared fish in Serbia**

- Per household, in kg, $Y_{it}$ -

| Year | Beef and baby beef | Veal | Pork | Pork (of suckling pig) | Mutton and goat's meat | Poultry meat | Offal | Fish and prepared fish |
|------|-------------------|------|------|------------------------|------------------------|--------------|-------|------------------------|
| 1994 | 16.5              | 2.5  | 37.4 | 12.2                   | 5.1                    | 24.6         | 1.1   | 9.1                    |
| 1995 | 21.4              | 3.5  | 40.0 | 14.6                   | 6.5                    | 32.3         | 2.4   | 10.8                   |
| 1996 | 17.9              | 2.9  | 34.6 | 13.7                   | 5.5                    | 30.9         | 2.6   | 10.4                   |
| 1997 | 18.2              | 3.0  | 35.3 | 15.1                   | 4.2                    | 33.9         | 2.6   | 13.3                   |
| 1998 | 15.8              | 1.9  | 24.6 | 11.8                   | 2.8                    | 31.5         | 2.2   | 11.9                   |
| 1999 | 14.6              | 2.1  | 22.8 | 10.1                   | 2.1                    | 28.8         | 2.1   | 8.6                    |
| 2000 | 12.0              | 2.5  | 26.3 | 11.8                   | 2.7                    | 29.2         | 1.9   | 7.6                    |
| 2001 | 15.1              | 2.2  | 32.6 | 10.3                   | 3.1                    | 20.6         | 1.9   | 11.2                   |
| 2002 | 15.0              | 2.3  | 32.5 | 10.6                   | 3.0                    | 39.5         | 2.0   | 10.4                   |
| 2003 | 15.5              | 2.6  | 33.8 | 10.7                   | 2.3                    | 39.2         | 2.5   | 14.5                   |
| 2004 | 15.5              | 2.6  | 36.9 | 10.7                   | 2.1                    | 41.7         | 2.4   | 12.0                   |
| 2005 | 14.5              | 2.5  | 35.0 | 10.2                   | 2.0                    | 44.3         | 2.4   | 11.3                   |
| 2006 | 15.1              | 2.0  | 40.3 | 7.7                    | 3.6                    | 40.4         | 2.8   | 19.0                   |
| 2007 | 13.9              | 1.1  | 47.3 | 7.0                    | 3.9                    | 43.2         | 1.6   | 18.5                   |

The source: Bulletin poll about the consumption in households; materials RZSS, Belgrade.

On the basis of data given in the table, the matrix of growth of meat consumption, for period 1994/95, defined as the outer product of the vector of the consumption increment $\Delta Y_t$ and the vector of reciprocal values, $\left( \frac{1}{Y_{it}} \right)$ is:

$$\mathbf{R} = \Delta Y_{0/T} = \begin{bmatrix} Y_{1,0/t} & \cdots & Y_{n,0/t} \end{bmatrix} \begin{bmatrix} 1 \\ \frac{1}{\sum_{t=1}^{T} Y_{it}} \\ \cdots \\ \frac{1}{\sum_{t=1}^{T} Y_{nt}} \end{bmatrix}$$

(7)
Elements of the matrix of the consumption growth have the following meaning: elements in i-th raw denote the growth of consumption of i-th kind of meat in relation to the consumption of other kinds of meat, and elements in j-th column denote the growth of consumption of observed categories in relation to the consumption of i-th kind of meat.

Therefore, elements in the first raw of matrix \( R_{94/95} \) denote relative increment of consumption of beef and baby beef meat in relation to the scope of consumption of other kinds of meat. Direct rate of growth, i.e. element \( r_{11} = 22.99 \), denote that the consumption of beef and baby beef meat in observed period is increased for 22.99%; \( r_{13} = 12.25 \) denotes the rate of growth of consumption of beef and baby beef meat in relation to the consumption of pork in 1995 year, etc.

Elements in the second raw denote relative increment of consumption of veal in relation to the scope of consumption of all observed kinds of meat, etc. Elements in the first column denote the rate of growth of consumption of all kinds of meat in relation to the scope of consumption of beef and baby beef meat, for example, \( r_{31} = 12.15 \) represents the relative increment of consumption of pork in relation to the scope of consumption of beef and baby beef meat, etc.

The matrix of the consumption growth for period 1995/96 year is:

\[
R_{95/96} = \begin{bmatrix}
-0.1379 & 0.223 & -0.0782 & 0.0112 & -0.1379 \\
-0.0335 & -0.0782 & 0.0112 & 0.0112 & -0.0335 \\
-0.3017 & -0.0503 & 0.0559 & -0.0112 & -0.3017 \\
0.0112 & 0.0782 & 0.0112 & -0.0112 & 0.0112 \\
-0.0223 & -0.1379 & 0.0112 & -0.0112 & -0.0223 \\
\end{bmatrix}
\]

where direct and indirect rates have negative sign which appears because in period from 1995 to 1996 the consumption of all kinds of meat except offal decreased, as is seen in the eight raw in the matrix.

There are similar tendencies in period 2005/06

\[
R_{05/06} = \begin{bmatrix}
-0.0916 & -0.0382 & 0.3588 & -0.1145 & 0.1221 \\
-0.6000 & -0.2500 & 2.3500 & -0.7500 & 0.8000 \\
-0.0298 & -0.0124 & 0.1166 & -0.0372 & 0.0397 \\
-0.1558 & -0.0649 & 0.6104 & -0.1948 & 0.2078 \\
-0.3333 & -0.1389 & 1.3056 & -0.4167 & 0.4444 \\
-0.0297 & -0.0124 & 0.1163 & -0.0371 & 0.0396 \\
-0.4286 & -0.1786 & 1.6786 & -0.5357 & 0.5714 \\
-0.0632 & -0.0263 & 0.2474 & -0.0789 & 0.0842 \\
\end{bmatrix}
\]

In the next period there is an increase of the consumption of beef and baby beef meat, as well as poultry meat (matrix \( R_{06/07} \)).
The average (constant) matrix of the growth of consumption of meat for period from 1994 to 2001 year, calculated as a product of the vector of the increment of consumption and the vector of reciprocal values of total consumption in the observed period is:

\[
\mathbf{R}_{06/07} = \begin{bmatrix}
0.0611 & 0.4000 & 0.0199 & 0.1039 & 0.2222 & 0.0198 & 0.2857 & 0.0421 \\
-0.0687 & -0.4500 & -0.0223 & -0.1169 & -0.2500 & -0.0223 & -0.3214 & -0.0474 \\
0.5344 & 3.5000 & 0.1737 & 0.9091 & 1.9444 & 0.1733 & 2.5000 & 0.3684 \\
-0.0534 & -0.3500 & -0.0174 & -0.0909 & -0.1944 & -0.0173 & -0.2500 & -0.0368 \\
0.0229 & 0.1500 & 0.0074 & 0.0390 & 0.0833 & 0.0074 & 0.1071 & 0.0158 \\
0.2137 & 1.4000 & 0.0695 & 0.3636 & 0.7778 & 0.0693 & 1.0000 & 0.1474 \\
0.0112 & 0.0690 & 0.0058 & 0.0146 & 0.0364 & 0.0065 & 0.0769 & 0.0192 \\
-0.0223 & -0.1379 & -0.0116 & -0.0292 & -0.0727 & -0.0129 & -0.1538 & -0.0385 
\end{bmatrix}
\]

The average (constant) matrix of the growth of consumption of meat for period from 1994 to 2001 year, calculated as a product of the vector of the increment of consumption and the vector of reciprocal values of total consumption in the observed period is:

\[
\mathbf{R} = \begin{bmatrix}
-0.0130 & -0.0839 & -0.0060 & -0.0181 & -0.0594 & -0.0056 & -0.0884 & -0.0159 \\
-0.0070 & -0.0452 & -0.0032 & -0.0098 & -0.0320 & -0.0030 & -0.0476 & -0.0085 \\
0.0494 & 0.3194 & 0.0227 & 0.0690 & 0.2260 & 0.0214 & 0.3367 & 0.0604 \\
-0.0260 & -0.1677 & -0.0119 & -0.0362 & -0.1187 & -0.0112 & -0.1769 & -0.0317 \\
-0.0060 & -0.0387 & -0.0028 & -0.0084 & -0.0274 & -0.0026 & -0.0408 & -0.0073 \\
0.0929 & 0.6000 & 0.0427 & 0.1296 & 0.4247 & 0.0401 & 0.6327 & 0.1135 \\
0.0025 & 0.0161 & 0.0011 & 0.0035 & 0.0114 & 0.0011 & 0.0170 & 0.0031 \\
0.0469 & 0.3032 & 0.0216 & 0.0655 & 0.2146 & 0.0203 & 0.3197 & 0.0574 
\end{bmatrix}
\]

On the basis of determined average matrix it is seen that the average consumption of beef and baby beef meat, veal, pork of suckling pig, mutton and goat’s meat decreased in the observed period in relation to the consumption of all observed kinds of meat, but average consumptions of pork, poultry meat, offal and fish increased in the observed period.

**Conclusion**

The applicability of the matrix of growth in economic research is great, because the growth is the characteristic of every economic process. This work is confirmation that the consumption can be successfully analyzed by using the model of matrix of growth.

From this work it is seen that using the matrix of growth, more precisely, some of its elements, direct rates of growth from successive periods, it is possible to recognize the dynamics of consumption of one kind of meat. Also, using indirect rates of growth it is possible to recognize the connection between consumptions of different kinds of meat as well as structural changes.

Elements of an average matrix of growth show that in period from 1994 to 2007 year, in Central Serbia, the consumption of pork, poultry meat, offal and
fish per citizen was increased, but the consumption of other kinds of meat was therefore decreased.

On the basis of direct and indirect rates of growth it is possible to make predictions for the consumption in future periods.

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ANALIZA UPOTREBE MESA BAZIRANA NA MATRICI RASTA

Nada Lakić¹ i Mirjana Krivokapić¹

Rezime

Cilj rada je bio da se izvrši analiza potrošnje različitih vrsta mesa novom metodologijom zasnovanom na matrici rasta. U tu svrhu korišćeni su podaci, za period od 1994. godine do 2007. godine, za potrošnju goveđeg i junećeg mesa, telećeg, svinjskog, prasećeg, ovčijeg i kozijeg, zatim živinskog mesa, iznutrica, ribe i preradevina od ribe po članu domaćinstva u Centralnoj Srbiji.

S obzirom da se različite vrste mesa mogu zamenjivati u ishrani između njihove potrošnje postoji povezanost. Stopama rasta, kao relativnim pokazateljima, kvantifikovano je koliko jedinica rasta potrošnje i-te vrste mesa dolazi na potrošenu jedinicu i-te ili j-te vrste mesa u t-tom periodu. Direktne i indirektne stope rasta utvrđene su za dve uzastopne godine i za ceo period od 1994. godine do 2007. godine.

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¹ Dr Nada Lakić, redovni profesor, Mirjana Krivokapić, asistent, Poljoprivredni fakultet, Nemanjina 6, 11081 Beograd-Zemun, Srbija