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MATHEMATICAL-ECONOMIC METHODS FOR STUDYING DATA ON HOUSEHOLD CONSUMPTION OF FOUR BASIC FOOD PRODUCTS

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Abstract

The article presents mathematical-economic methods for studying data on household consumption of four basic food products in Bulgaria for the period 2004-2020. The mentioned information concerning meat, yoghurt, potatoes and dry beans has been structured and saved in a built relational database. Certain sets of criteria are used to form queries from the database. Subsequently, the obtained information from the queries has been processed. The pace of growth, respectively decrease of the considered indicator for the listed products has been analyzed. Hierarchical cluster analysis has been applied to these data on household consumption, average per person. The results showed a relative increase of the indicator for two foods (meat and yoghurt) during the last five years of the period. The indicator values for potatoes declined significantly for 2012-2017. The same dependence has been established for dry beans from 2011 to 2015. Grouping the indicated foods according to the values of the household consumption shows two clusters. Three clusters are obtained by grouping the relevant years according to the values of this studied indicator.

Key words**:** *analysis, data processing, relational database, basic food products, household consumption*

INTRODUCTION

Different organizations use significant amounts of data in their daily practice. The provided information should be complete, accurate and comprehensive (Kostagiolas, P., 2006 [8]). The mentioned requirement is not met in certain cases. The main reason is that the data are located in different sources and file formats. The data can be structured into relational databases. The study of Jatana N., et al., 2012 [6] notes that "A relational database is a collection of data items organized in formally-described tables from which data can be accessed or reassembled in many different ways" [6]. Relational databases often are used for storing different economic and financial data. According to Dongare Y. V., et al., (2011) [4] "success of relational database modeled for a given enterprise is depending on the design of relational schema" [4]. In addition, modern information technology offers powerful tools and approaches for data processing in each area [3].

National Statistical Institute of Bulgaria provides information concerning household consumption of certain foods [11], [12], [13] on its website [10]. The indicated data are extracted and entered into a built relational database [1], [2]. In this regard, a new relational scheme (Household consumption) has been created. As can be seen from figure 1, it contains eight attributes. Seven of them are strictly informational. The relational scheme Type of foods [1], [2] has been related to the mentioned above scheme. New information concerning consumption of the indicated products for the first, second, third and fourth quarters of each of the considered years, as well as the total quantities has been entered in chosen database tables.

One of the advantages of the database is the opportunity to expand it. Specially for the users, this process is quite important, as it allows the necessary additions and changes to be made. New records can be entered in selected tables, as well as new relational structures can be designed. The database provides relatively faster access to the listed objects, which are saved in certain tables. As a whole, it contains 9 relational schemes (Fig. 1). Different sets of criteria are used to form queries from the database. The obtained information from the queries can be analysed.

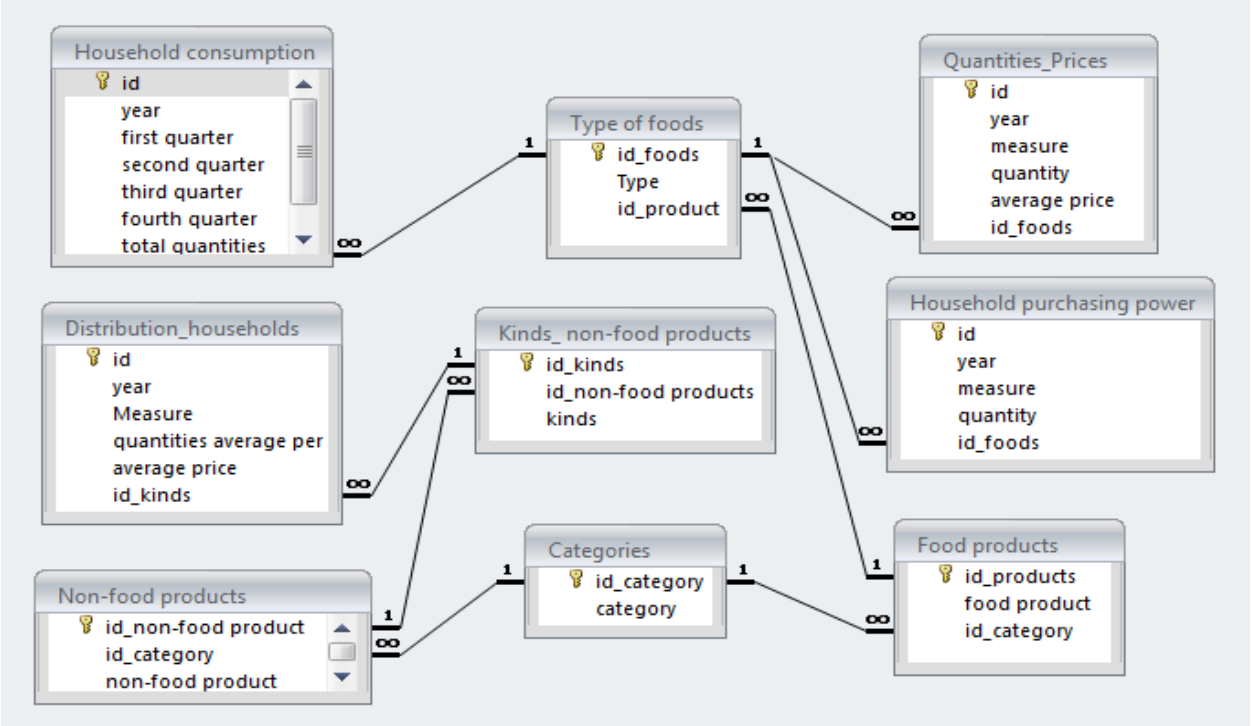

Fig. 1. General scheme
Source: Own conception.

The aim of this article is to present the application of mathematical-economic methods for studying data on household consumption of four basic food products in Bulgaria for the period 2004-2020.

MATERIALS AND METHODS

The designed database contains information related to various foods for twenty years interval. A part of them are considered in the current paper. The household consumption, average per person is investigated for the following basic foods:
- Meat;
- Yoghurt;
- Potatoes;
- Dry beans.

The characteristics of the listed objects have been entered into several fields located in different database tables. Certain subsets of data can be searched and found [14] through using different queries. Practically, they include the following components:
- Household consumption of the four foods, average per person during selected years;
- Chosen values of the attribute (household consumption) for the examined time interval;
- Household consumption of the given element (foods) for each quarter of the indicated year from the period.

The obtained data from the queries should be processed and summarized. In this regard, it is necessary to find:
- The sum (T_i) of the consumption of each product for the seventeen years time interval

$$T_i = \sum_{j=1}^{17} h_{ij}$$

where: h_{ij} - household consumption of i^{-th} food product during j^{-th} year, $1<=i<=4$, $1<=j<=17$;
- The sum (A_j) of the consumption of the four foods in a given year from the mentioned period

$$A_j = \sum_{i=1}^{4} h_{ij}$$

- The variable (W_{ij})

$$W_{ij} = \frac{h_{ij}}{h_{ij-1}}$$

where: h_{ij} and h_{ij-1} household consumption of i^{-th} product during $(j-1)^{st}$ and j^{-th} year, $2<=j<=17$;

- The variable (V_i)

$$V_i = \frac{T_i}{j}$$

where: j=17, 1<=i<=4;

- The relative share (N_{ij}) of household consumption of the considered product for one year to the total household consumption of this product for the indicated period:

$$N_{ij} = \frac{h_{ij}.100}{\sum_{j=1}^{17} h_{ij}}$$

- The relative share (B_i) of household consumption of the indicated food type to the total household consumption of the studied foods for the seventeen years interval:

$$B_i = \frac{\sum_{j=1}^{17} h_{ij}.100}{\sum_{w=1}^{4} T_w}$$

The dynamics of change of the mentioned indicator for the listed four products (meat, yoghurt, potatoes and dry beans) was investigated. The listed foods were grouped according to the values of the indicator (household consumption, average per person) through using the hierarchical cluster analysis [16], [7].

The MS Excel program [9] and software R Commander [5], [15] were applied for data processing. The obtained results were discussed and the relevant conclusions were presented for the seventeen years time interval.

RESULTS AND DISCUSSIONS

Data related to the household consumption in Bulgaria for the considered four food products were studied in the period from 2004 to 2020. Certain queries were defined in order to find and extract chosen set of objects from the built database. These elements were searched from ten fields located in four related tables. The found information about each of these four foods were evaluated and compared in the relevant time intervals. The dynamics of change of the indicators were also tracked and analyzed for the given period.

The calculations show that the pace of growth of the variable A_j is more intensive for the first seven years. Practically, the total household consumption of the listed foods increased by 13.7 kg. The sum A_j over the next five years is relatively smaller. The levels of the examined indicator from 2010 were reached only in 2018-2020.

In the first half of the period the values of the second variable W_{ij} (i=1, 2<=j<=8) belong to the interval (1; 1.09). This means that the household consumption of meat average per person grow (Fig. 2). This process continues during 2013-2015 and 2017-2020, where the growth pace is slower.

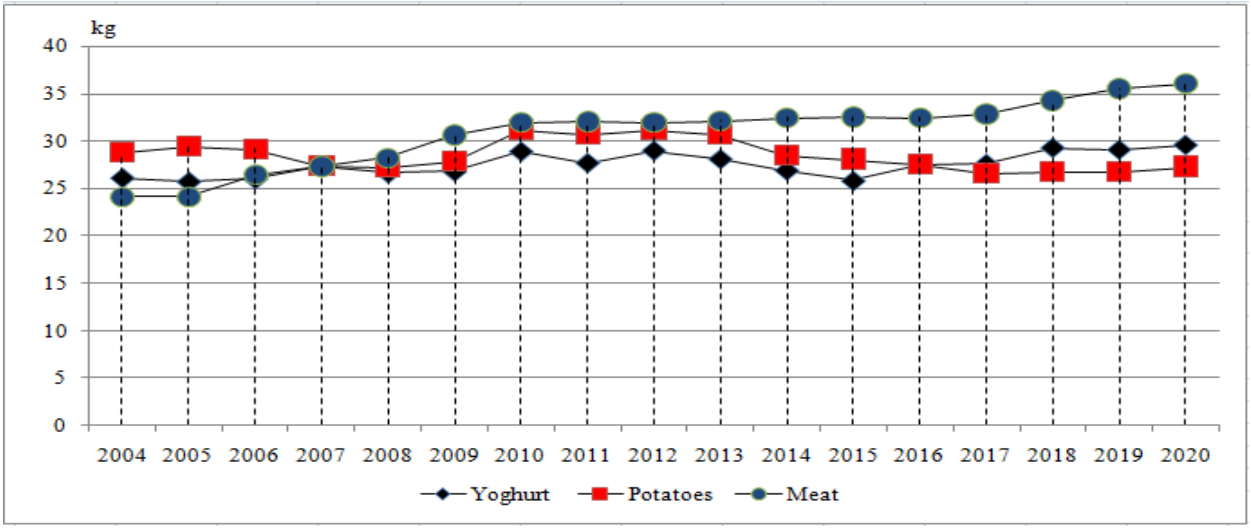

Fig. 2. Dynamics of household consumption for the examined three foods
Source: Data from [10, 11, 12, 13].

The situation for the studied data about the household consumption of yoghurt average per person was different. The indicator changes quite dynamically from 2004 to 2014. It grows or decreases in very small periods, which include one or two years. Over the next three years, the values of W_{ij} (i=2, 10<=j<=12) vary in range from 0 to 1. The obtained decline here is approximately 8%. This means that household consumption of yoghurt is reduced by 2.3 kg. The indicator for 2020 reached higher levels by about 7%.

The evaluation for the third considered element showed one decrease of 14% for the five years period (2013-2017). Therefore, the household consumption of potatoes average per person reduced by about 4.6 kg. Similar results were obtained for 2006-2008, where the variable W_{ij} (i=3, 3<=j<=5) is less than one. It should be noted that the decline here is only 2.3 kg. The growth pace of the indicator for the potatoes is much faster in the years 2009-2010 in comparison with the years 2018-2020, as can be seen from Fig. 2.

The processed data for the dry beans are quite more different. The values of the variable W_{ij} (i=4, 5<=j<=6, j=8 and j=17) are equal to 1 in some years of the studied period. Then, the household consumption of dry beans average per person remained unchanged in 2007-2009, 2010-2011 and 2019-2020. The levels of the studied indicator marked a huge increase of about 25% for 2010. As is shown in Fig. 3, the decrease pace is slower for 2012-2015.

The present work calculates the total sum of the consumption of each one product (T_i) for the seventeen years period. Invariably, the highest value of T_i (i=1) is obtained for the meat (526.1 kg). The found values for the next two foods (yoghurt and potatoes) are 468 kg and 485.4 kg, respectively. Quite naturally, the value of T_i (i=4) is the lowest for the dry beans (71.700 kg).

The presented results for the variable B_i (1<=i<=3) showed close percentages for three of the considered elements (meat, yoghurt and potatoes) (Fig. 4). The share of dry beans is about 6 times smaller than the share of listed foods.

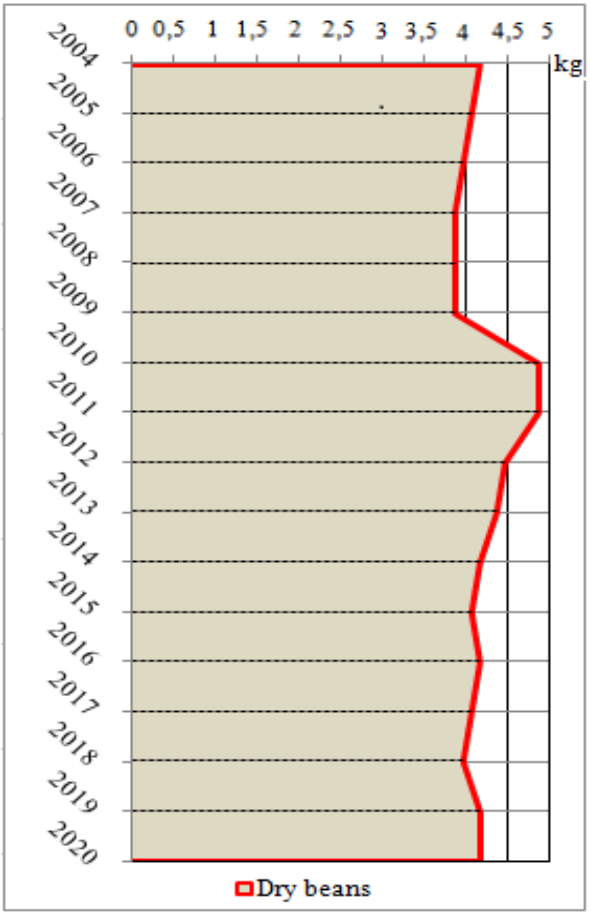

Fig. 3. Dynamics of the indicator for dry beans
Source: Data from [10, 11, 12, 13].

In addition, the average consumption of each product V_i for the investigated period was found. The value of the indicator for the meat is 30.947 kg, while for the other three foods (yoghurt, potatoes and dry beans) - 27.529 kg, 28.553 kg and 4.218 kg respectively.

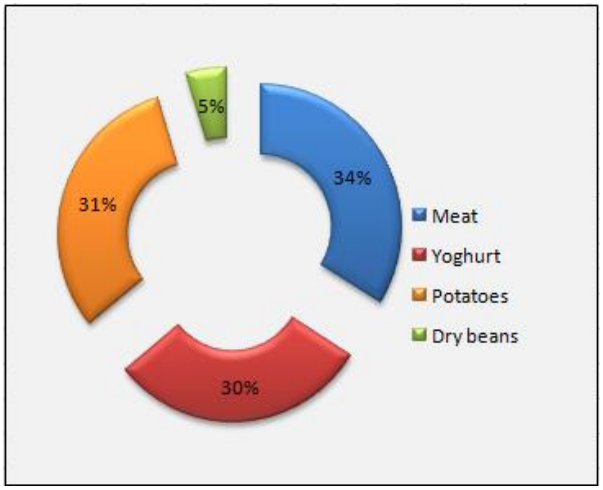

Fig. 4. The shares of the household consumption of considered four foods
Source: Own calculations on the basis of data from [10, 11, 12, 13].

The current paper also studies the share of household consumption of a given food product for each year to the total household consumption of that product for the considered time period. Table 1 visualizes the results from the respective calculations. Generally, the surveyed variable N_{ij} for two of the foods (yoghurt and potatoes) varies in range from 5.48% to 6.43%. For the other two foods - meat and dry beans the mentioned variable is changed between 5.44%-6.83% and 4.60%-6.86%, respectively.

Table 1. Calculated values of relative shares N_{ij} (%)

Year	Meat	Yoghurt	Potatoes	Dry beans
2004	4.60	5.58	5.93	5.86
2005	4.60	5.49	6.08	5.72
2006	5.04	5.56	6.02	5.58
2007	5.21	5.83	5.64	5.44
2008	5.38	5.68	5.60	5.44
2009	5.84	5.73	5.75	5.44
2010	6.08	6.18	6.43	6.83
2011	6.10	5.92	6.35	6.83
2012	6.08	6.20	6.43	6.28
2013	6.12	6.00	6.35	6.14
2014	6.18	5.75	5.87	5.86
2015	6.20	5.51	5.79	5.72
2016	6.18	5.88	5.67	5.86
2017	6.25	5.90	5.48	5.72
2018	6.52	6.26	5.50	5.58
2019	6.77	6.22	5.50	5.86
2020	6.86	6.32	5.62	5.86

Source: Own calculations on the basis of data from [10, 11, 12, 13]

The examined data related to the household consumption of the listed four foods average per person are grouped according to their values. For this purpose, hierarchical cluster analysis is used. The results from the processed information are presented in Table 2. Three of the considered foods (meat, yoghurt and potatoes) are included in one cluster. The next cluster contains only one product - dry beans.

Grouping the relevant years according to the household consumption of the considered foods is visualized in Table 3:

- Five of the surveyed years (from 2004 to 2008) form a cluster;
- The time interval 2014-2017 as well as 2009 are included in the next cluster;
- The third cluster contains the following years: 2010-2013 and 2018-2020. The indicator values here are the highest.

Table 2. The results from the processed data on household consumption, average per person

Cluster	**Studied foods**	**Household consumption (kg), average per person in 2004-2020**
1	Meat	526.000
	Potatoes	485.400
	Yoghurt	468.000
2	Dry beans	71.700

Source: Own calculations on the basis of data from [10, 11, 12, 13].

Table 3. Formed groups as a result from the performed analysis

Considered product types		
Cluster	Year	Total quantities (kg)
1	2004	83.300
	2005	83.500
	2006	85.700
	2007	86.000
	2008	86.00
2	2009	89.300
	2014	92.100
	2016	91.700
	2015	90.600
	2017	91.200
3	2012	96.700
	2010	97.000
	2020	97.200
	2018	94.300
	2019	95.600
	2011	95.500
	2013	95.500

Source: Own calculations on the basis of data from [10, 11, 12, 13].

CONCLUSIONS

The designed database contains information concerning basic foods in Bulgaria. They are organized in several fields located in the relevant database tables. Different queries have been used to extract and visualize the necessary information from the indicated database. Subsequently, the obtained subsets of data are processed and summarized.

The article presents application of mathematical-economic methods for studying data on household consumption of four basic

foods (meat, yoghurt, potatoes and dry beans) in Bulgaria. The investigated period includes the years from 2004 to 2020. The presented results from the performed analyses showed the following:

- The pace of growth of this surveyed indicator for meat was faster during the first eight years from the period;
- A relative increase of the indicator for two of the considered foods (yoghurt and meat) was calculated for the last five years;
- The indicator values for potatoes declined significantly from 2012 to 2017, while for the dry beans in the period 2011-2015;
- Grouping the mentioned foods according to the household consumption presented two clusters;
-Three clusters were obtained by grouping the indicated years according to the values of this examined indicator (household consumption).

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