Comparative Analysis of The Caloric Performance of Products for People with Cardiovascular Disease

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Abstract

The comparative analysis of indicators of the caloric content of foodstuff using various methods of the analysis of data is carried out. The methods of moving average, weighted moving average, linear smoothing, repeated linear smoothing, and exponential smoothing of data on the nutritional value of products consumed by people with cardiovascular disease are used. As a result of research, patients with cardiovascular disease can adequately assess their diet and choose the proper diet, characterized by the coordination of data on the caloric content of various foods with the body's need to consume these products.

Keywords

Statistical Analysis, Information Technology, Comparative Analysis, Caloric Performance of products, Cardiovascular Disease, Business Analysis, Data Processing

1. Introduction

The rapid spread of cardiovascular disease among the world's population is often associated with high-calorie diets, which humans prefer. Such a systemic overload of the human body with high-calorie foods leads to problems with excess weight [1-4]. In the face of rapid globalization challenges related to climate change, the sustainable development of human capital, according to well-known scientists [5-9], has encountered significant obstacles to the growth of cardiovascular disease [10-13]. Each person needs a special diet that would consider the body's needs for a certain amount of calories [14-19]. The urgency of this problem is growing every year, as evidenced by data from the World Health Organization, both on the growing number of overweight people and the highest mortality worldwide due to cardiovascular disease [3, 4]. An unresolved problem in choosing the proper diet to improve the health of any person is establishing data on the caloric content of various foods. Comparative analysis of the caloric content of food will allow patients with cardiovascular disease to properly assess their diet and choose a diet that meets the characteristics of the disease, body condition, and doctors' recommendations.

Objective. To conduct a comparative analysis of the caloric content of food, which will allow people who suffer from cardiovascular disease or are overweight to evaluate their diet and choose the proper diet to improve their health, especially with cardiovascular diseases; promote greater availability of data on the caloric content of foods; to improve the effectiveness of their perception by stakeholders; to establish the relationship between the category of the product and its caloric content; propose an approach to the formation of a diet based on the caloric content of food for people with cardiovascular disease.

Problem proper food selection exists for many other diseases, such as congenital or acquired allergies, cancer, diabetes, etc. [11, 14, 15, 20-28]. With the help of the data obtained from our research, people will choose the foods and calories that will promote a healthy diet. Comparative analysis of the

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caloric content of food will allow people to find an alternative to those products that cause them an allergic reaction, disrupt the proper functioning of the gastrointestinal tract, and more. The problem of proper nutrition is directly related to the quality of food and its caloric content.

2. Literature review

To properly organize diets, you need to understand the essence of caloric foods and their role in human life. Caloric content, as indicated in [29], is an essential indicator of the nutritional value of foods. It is measured in kilocalories (kcal) or kilojoules (kJ). Often, the cause of overweight problems is that people do not understand the caloric content of their foods. The amount of food needed cannot be determined by weight, volume, or appetite because they do not characterize its nutritional value. The only correct criterion for the quantitative side of nutrition is its energy value. It is measured, like energy expenditure, in kilocalories (kcal).

The dataset choice [30-35] was due to data on the number of calories per 100 grams of a particular food product. A comparative analysis of the caloric food content is conducted based on a dataset on the caloric content of the products themselves and the quality requirements of conventional products. This study will help deepen people's understanding of the processes through which their body receives energy from the consumption of daily meals and a variety of snacks. Paying particular attention to the number of calories in the food they ate. Readers will have the opportunity to choose a diet that can improve their health.

Consider the attributes of this dataset [30]:

- FoodCategory - this contains data on the category of the food product;
- FoodItem - food product;
- per100grams - the amount of food;
- Cals_per100grams - the number of calories per 100 grams of food;
- KJ_per100grams - the number of kilojoules per 100 grams of food.

As noted by P. Menzel and F. D'Aluisio in [14], people's diets are shaped by their mentality, traditions, and wealth. To confirm their hypothesis, the researchers [14] travelled to about 80 countries to study the national characteristics of each country's diet and identify factors that affect people's diet. After surveying a significant number of respondents, researchers [14] calculated calories per day for the inhabitants of each country and assessed the nutritional value of the food they eat. The scale of the study is impressive not only in the number of people interviewed but also in the duration of it - about three years.

As an example, we can cite several results [14]. A seamstress from Bangladesh has a relatively modest daily diet with a caloric content of 1800 kcal, slightly lower than a woman's norm [14]. Marble Moahi, 32, from poor Botswana, eats very poorly. Her calorie intake per day is only 900, almost three times less than the norm for a woman her age. One look at these questionable foods that she eats during the day is enough to understand that a woman lacks vitamins and nutrients essential for the body's normal functioning. Such limited nutrition is a global problem for third-world countries, affecting their life level and duration [14]. But 54-year-old American Conrad Tolba is moving. The energy value of his diet, which consists mainly of unhealthy fast food, is 5400 kcal! Given that Mr Tolba works as a truck driver and does not lead a very active lifestyle, it is possible to suspect the presence of obesity and problems with the endocrine, cardiovascular and digestive systems [14].

Canadian Eskimo Willy Ishulutak, a 29-year-old professional stone carver [14], is also high in calories. His daily menu with 4,700 calories includes porridge, protein-rich meat, fish, dairy products, and simple carbohydrates in the form of cookies. Given that the weight of a Canadian is average, 64 kg at the height of 1 m 75 cm, this need for extra calories can be explained by a demanding profession [14]. Saleh Abdul is a 32-year-old camel seller from Egypt [14]. He eats a reasonably balanced diet. His menu is not a day, the energy value of which is 3,200 kcal, includes cereals and cereals, flour cakes, vegetables, meat dishes, and chicken eggs. Saleh's life takes place outdoors, so he is allowed to consume energy a little over the norm for a man his age [14]. Leland Melvin is an astronaut [14]. In his diet - not what he wants and loves. Leland's daily menu is carefully designed to fully meet the energy, nutrient, and nutrient needs of a 45-year-old man. The energy value of "space" food is 2700 kcal [14].

3. Methods

To solve the problems in this work, we use standard methods, including the following [36-43].

1. The correlation field is a graphical representation of statistical indicators, which gives an idea of the relationship between the studied features. We construct a correlation field, where the values of the factor characteristic (x) are plotted on the horizontal axis, and the resultant characteristic (y) is plotted on the vertical axis. They were postponing the correlation field at the intersection of the corresponding values of x and y. The nature of the location of points on the correlation field concludes the direction and form of communication [44-49]. If the points are randomly placed throughout the field, there is no relationship between the studied features. The nature of the distribution of points on the correlation field indicates the presence, shape, and direction of the relationship between factor and result characteristics. With the help of the graph, a conclusion is made about the choice of the type of mathematical equation for quantitative estimation of the connection (construction of a regression model by function (regression equation)) [44-49].

2. Correlation coefficient - used to estimate the degree of linear dependence between two variables x and y. We can take values from -1 to +1. With positive values of the correlation coefficient with increasing factor variable x increases the resulting variable y; with negative - with increasing factor variable x, the average value of the resulting variable decreases y [43-49].

3. The correlation ratio reflects the relative degree of variation (variance) of group means (y). The correlation ratio always has a positive value and ranges from 0 to + 1. It takes zero value when the relationship between the studied features is absent [42-43, 50-54].

4. Autocorrelation is the correlation of a function with itself shifted by a certain amount of independent variable. Autocorrelation is used to find patterns in several data, such as periodicity [42-43, 50-58]. It is often used in statistics and signal processing to analyze functions or data series. We could obtain the autocorrelation function graph by plotting the correlation coefficient of two functions (functions shifted by the value and basic one) on the ordinate axis y [55]. If the original function is strictly periodic, then the graph of the autocorrelation function will also be strictly periodic. Thus, from this graph, we can judge the periodicity of the essential function and hence its frequency characteristics [40-43, 56-58].

5. A correlation matrix is a matrix of correlation coefficients of several random variables [41, 47, 53].

6. The multiple correlation coefficient (R) characterizes the closeness of the relationship between the performance indicator and the set of factor indicators [53-58].

4. Experiments and Results

4.1. Data

Data generation was in the form of Excel. Dataset [30] consists of data on the caloric content of food. The following five attributes of the calories in the food items (per 100 grams) data set [30] are presented in Fig. 1. The Calories in Food Items (per 100 grams) [30] consist of the Calories/KJ for 2225 food items per 100 grams across 44 food categories.

FoodCategory	FoodItem	per100grams	Cals_per100grams	KJ_per100grams
BakingIngredients 4% Cakes&Pies 4% Other (2039) 92%	1993 unique values	100g 81% 100ml 19%	100 cal 1% 250 cal 1% Other (2173) 98%	420 kJ 1% 1050 kJ 1% Other (2173) 98%
Yogurt	Activia	100g	74 cal	311 kJ
Yogurt	Activia Lemon	100g	100 cal	420 kJ
Yogurt	Activia Strawberry	100g	97 cal	407 kJ
Yogurt	Aloe Vera Yogurt	100g	85 cal	357 kJ
Yogurt	Ayran	100ml	42 cal	176 kJ

Figure 1: The part of the data set [30]

4.2. Descriptive statistics

The average (arithmetic mean) is one of the main characteristics of the sample, which is the value of the characteristic, the sum of deviations from which all sample values are zero (including deviations). In other words, this is some average level of all measurements for a given group of numbers. It is determined by the formula [41, 59].

$$\tilde{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \,, \tag{1}$$

where n is the sample size.

We calculated the average values for each of the 44 product categories and presented them in the Cartesian coordinate system (Fig.2) and the polar coordinate system (Fig.3).

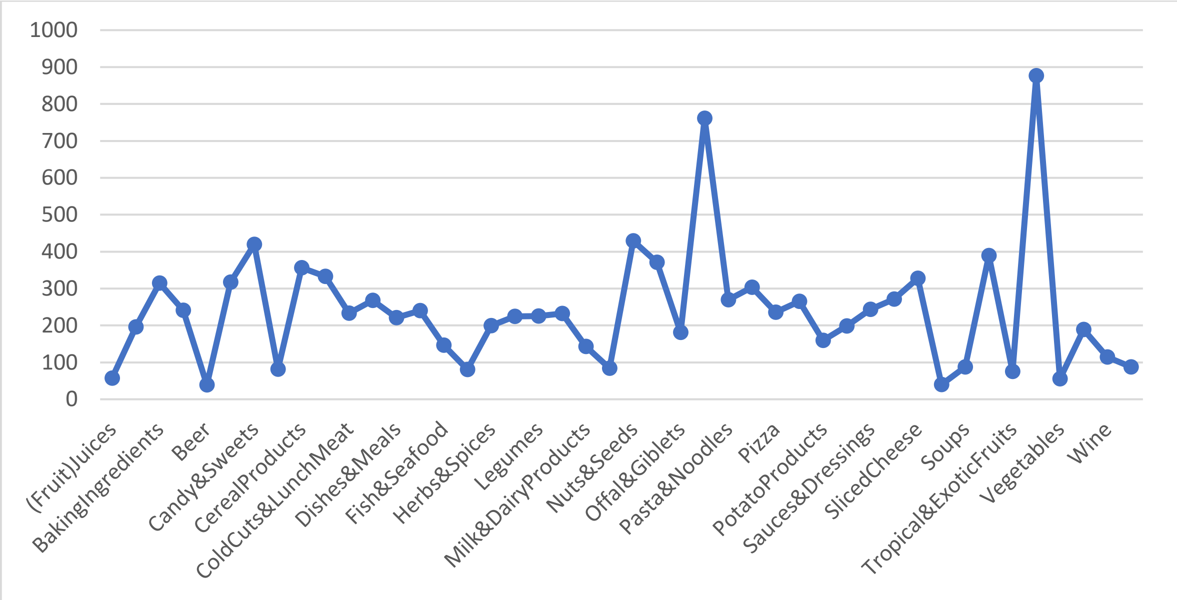

Figure 2: The Graph of average calories across 44 food categories in the Cartesian coordinate system

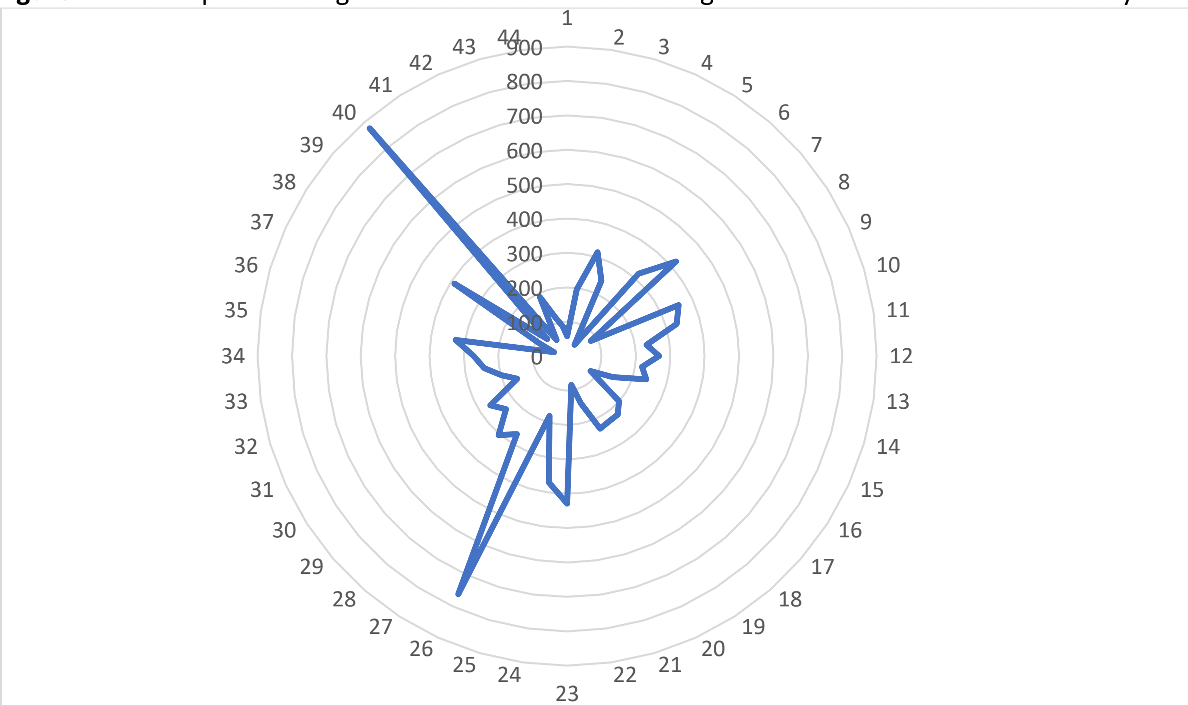

Figure 3: The Graph of average calories across 44 food categories in the Polar coordinate system

Mode, denoted by Mo, is one of the numerical characteristics of the probability distribution of a random variable. This value occurs in this series more often than in others [41, 59].

Median, denoted by Me, is in the mean of the mean when a series of numbers, ordered in ascending or descending order, take the average number (if the series consists of an odd number of numbers) or the arithmetic means of two averages (if the series consists from an even number of numbers) [41, 59].

Interval is an indicator that indicates the width of the range of values. It is the difference between the largest and smallest of these numbers.

The sampling variance is used to vary the indicator values relative to the average [41, 59].

$$v = \frac{\sigma}{x} \times 100\% \quad (2)$$

The coefficient of variation [59-61] is a relative value that characterizes the scattering (variability) of the trait. Represents the ratio of the standard deviation of σ to the arithmetic mean, expressed as a percentage.

Skewness [59-61] is an indicator that reflects the skew of the distribution relative to the fashion to the left or right. It is the case when some of the reasons contribute to the more frequent occurrence of values that are greater or, conversely, less than the arithmetic mean. Lower values are more common for left-handed or positive asymmetry in the distribution than right-handed or negative.

Kurtosis [59-61] is an indicator that reflects the height of the distribution. When any reasons promote the emergence of close to average values, the distribution with positive excess is formed. Suppose extreme values dominate the distribution and, at the same time, lower and higher. In that case, such a distribution is characterized by harmful excess, and in the center of the distribution may form a depression, which turns it into two vertices.

The descriptive statistics analysis tool creates a one-dimensional statistical report containing information about the initial range data's central trend and variability (Table 1).

Table 1
Descriptive Statistics

Attributes	Values
Average	240,58
Standard error	24,98
Median	228,62
Mode	342,00
Standard deviation	165,71
Sampling variance	27461,58
Kurtosis	5,64
Skewness	1,94
Range	837,30
Minimum	39,19
Maximum	876,50
Summands (addend)	10585,69
Count	44

4.3. Construction of the histogram

A histogram [59-61] is a diagram consisting of rectangles without gaps between them. Quantitative ratios of some indicators are presented in the form of rectangles, the areas of which are proportional. Most often, for ease of perception, the width of the rectangles is the same, and their height determines the ratio of the displayed parameter. Fig.4 shows the histogram of the distribution of average calories.

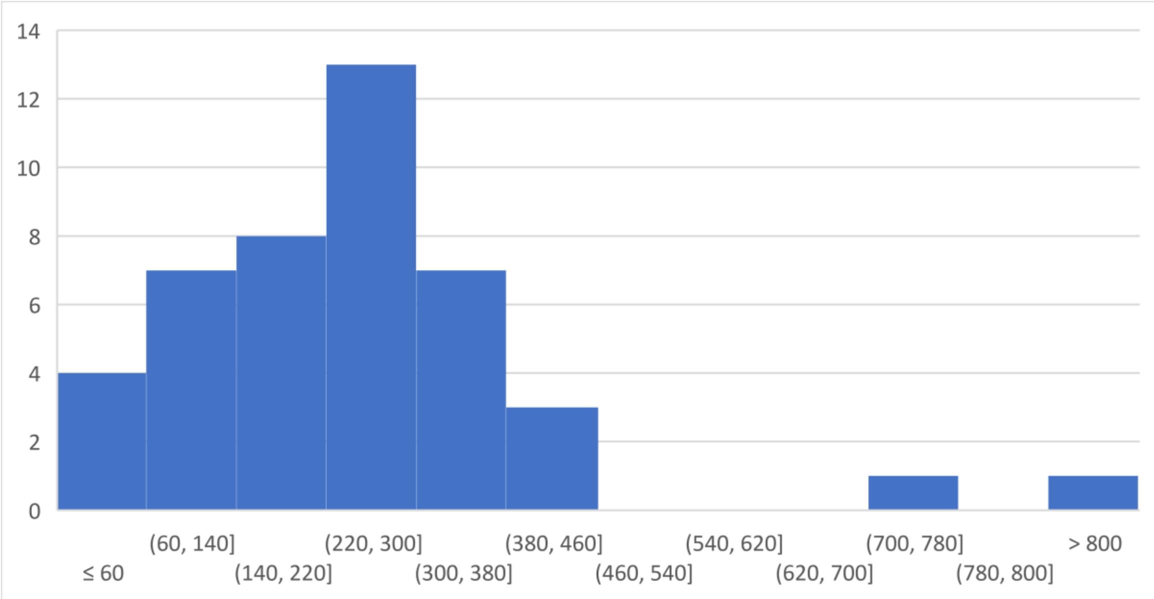

Figure 4: The histogram of the distribution of average calories

4.4. Building the cumulative frequency

One way to study the distribution series is to construct a cumulative. It allows you to graph the dependence of the value of the feature on the accumulated frequency. The cumulative, or polygon of accumulated frequencies, is often used to represent discrete data. To build a cumulative in Excel, enter data in rows or columns, click "insert" - "chart." Select one of the appropriate scatter charts, indicates the required data for construction (only two lines - the value of the sign and the accumulated frequency), and click "done" [59-61]. Fig.5 shows cumulative frequency of average calories.

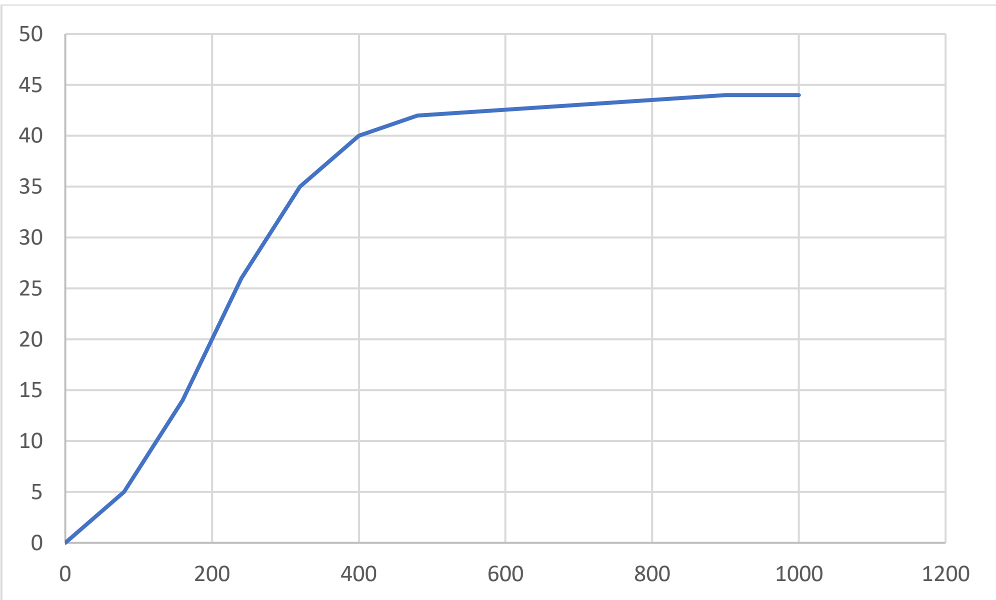

Figure 5: The cumulative frequency of average calories

4.5. A moving average method

The moving average method is the simplest way to smooth empirical curves [59-61]. The essence of this method is to replace the actual values of the indicator with their average values, which have much less variation than the initial levels of the series [59-61].

Simple moving averages are calculated for odd and even numbers of time intervals depending on the averaging period. Consider the procedure for constructing a moving average with an odd number of members.

A time series consists of levels $y_1, y_2, y_3, \dots, y_n$.

To determine the moving average, calculate the sum of *m* elements of the series (where *m* is an odd number), gradually moving from the first terms $y_1, y_2, y_3, \dots, y_n$ to the following groups of levels: $y_2, y_3, \dots y_{m+1}$; $y_3, y_4, \dots y_{m+2}$; $y_4, y_5, \dots y_{m+3}$; etc.

The arithmetic means are determined for individual sums, changing their value ("slides") as the parameter t increases. A new time series is formed from arithmetic averages, the elements of which are primarily free from random external influences on the forecast indicator. It is believed that moving averages more accurately characterize the tendency to change the feature than the levels of the original time series. Three- and five-membered averages are most often used in practice [59-61].

Table 2

Simple smoothing average calories at different w

W=0	W=3	W=5	W=7	W=9	W=11	W=13	W=15
57,63							
195,82							
315,09	189,51						
240,97	250,63						
39,19	198,42	169,74					
317,59	199,25	221,73					
419,48	258,76	266,47	226,54				
81,68	272,92	219,78	229,98				
356,56	285,91	242,90	252,94	224,89			
332,50	256,91	301,56	255,43	255,43			
233,10	307,39	284,66	254,30	259,57	235,42		
267,50	277,70	254,27	286,92	254,29	254,50		
220,64	240,41	282,06	273,07	252,03	256,76	236,75	
239,86	242,67	258,72	247,41	274,32	249,92	250,77	
146,39	202,30	221,50	256,65	255,30	241,32	246,97	230,93
80,59	155,61	191,00	217,23	217,65	245,08	228,93	232,46
199,24	142,07	177,34	198,19	230,71	234,32	225,72	232,69
224,41	168,08	178,10	196,95	216,03	216,59	239,96	226,65
225,30	216,31	175,18	190,92	204,11	229,64	232,86	225,60
231,95	227,22	192,30	192,53	203,99	218,32	218,44	238,45
142,89	200,05	204,76	178,68	190,14	201,08	223,15	226,81
84,51	153,12	181,81	169,84	175,02	187,57	202,22	204,47
429,35	218,92	222,80	219,66	196,07	202,28	209,67	227,65
371,02	294,96	251,95	244,20	221,03	215,96	220,28	228,62

4.6. Weighted moving average method

When constructing a weighted moving average on each active section, the value of the main level is replaced by the calculated one, determined by the formula of the weighted arithmetic mean [59-61]. In other words, the weighted variable average differs from the simple moving average in that the levels included in the averaging interval are summed with different weights.

A simple moving average considers all levels of the series included in the smoothing interval with equal weights. The weighted average assigns to each level a weight that depends on the distance of this level to the level in the middle of the interval. For a simple moving average in the smoothing interval, the calculation is performed based on a straight line - a first-order polynomial- and smoothing a weighted moving average using polynomials of higher orders, preferably second or second third. Therefore, the simple moving average method can be considered a particular case of the weighted moving average [59-61]. Fig. 6 – Fig. 12 show the linear smoothing at w = 3, 5, 7, 9, 11, 13, 15 according.

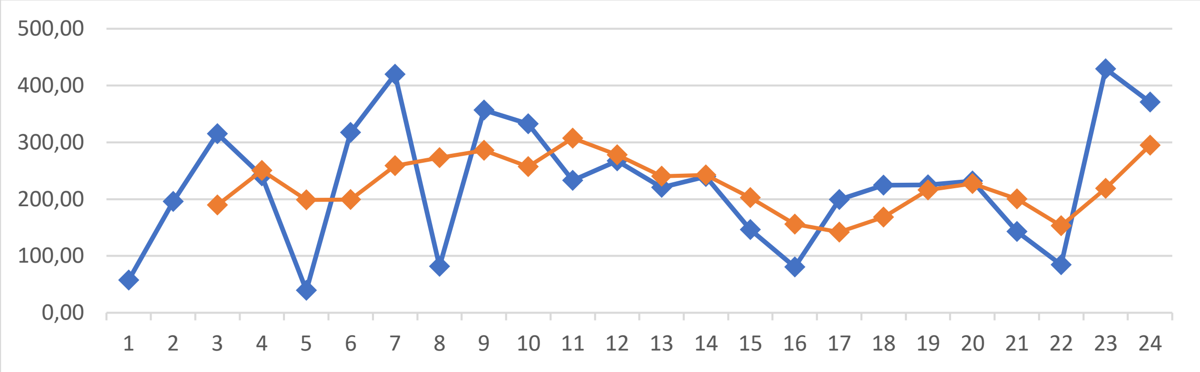

Figure 6: The result of linear smoothing at w = 3

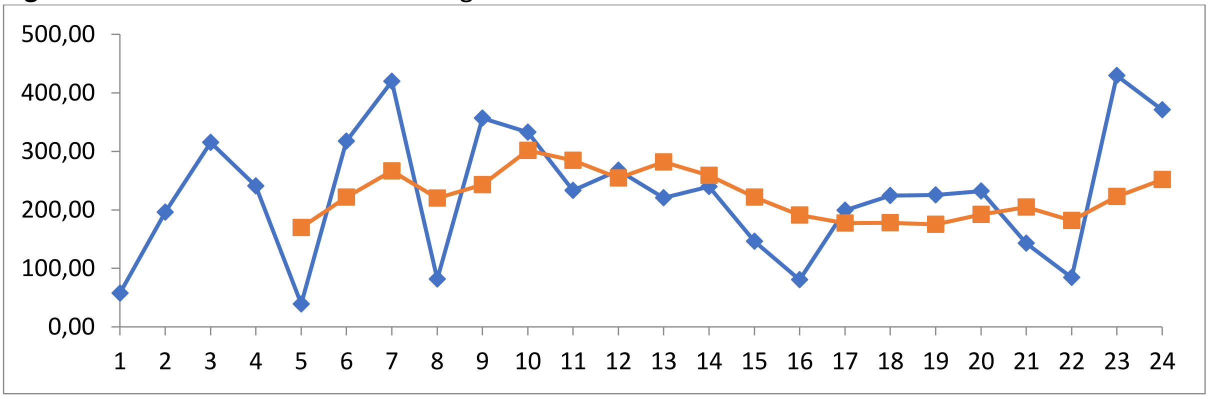

Figure 7: The result of linear smoothing at w = 5

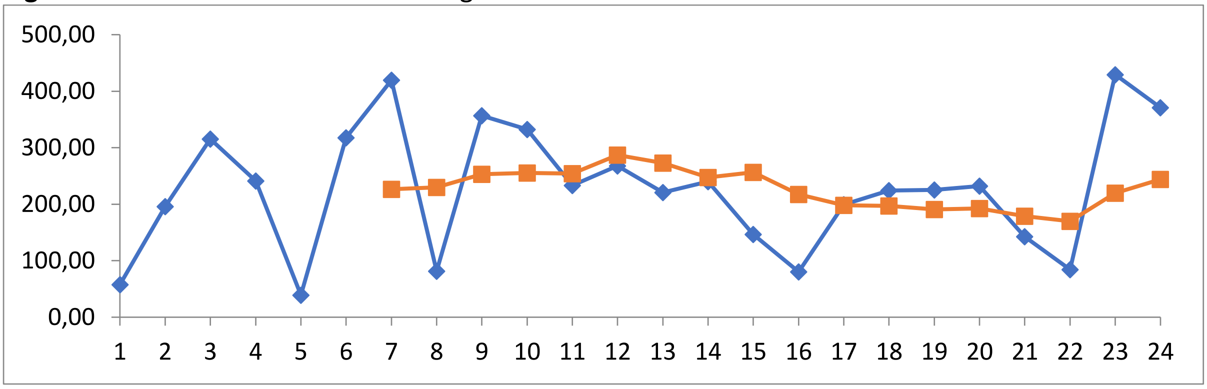

Figure 8: The result of linear smoothing at w = 7

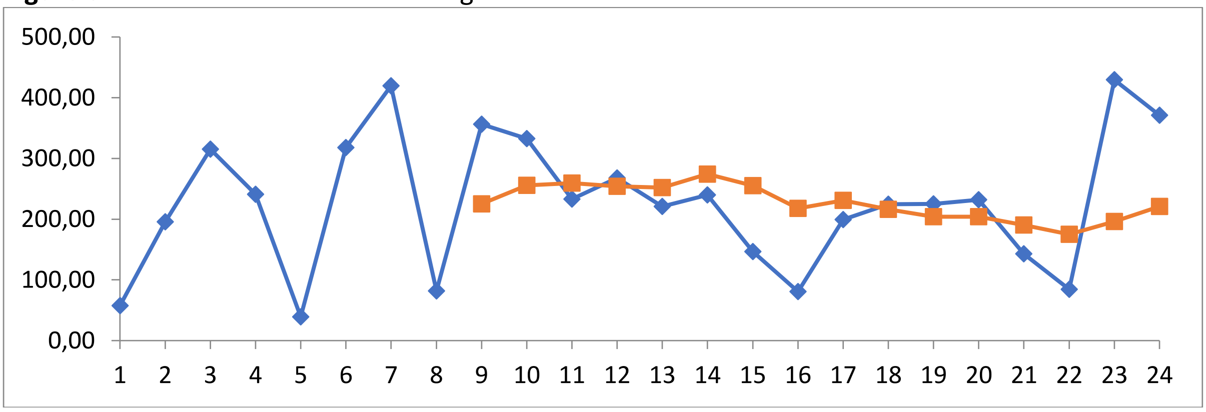

Figure 9: The result of linear smoothing at w = 9

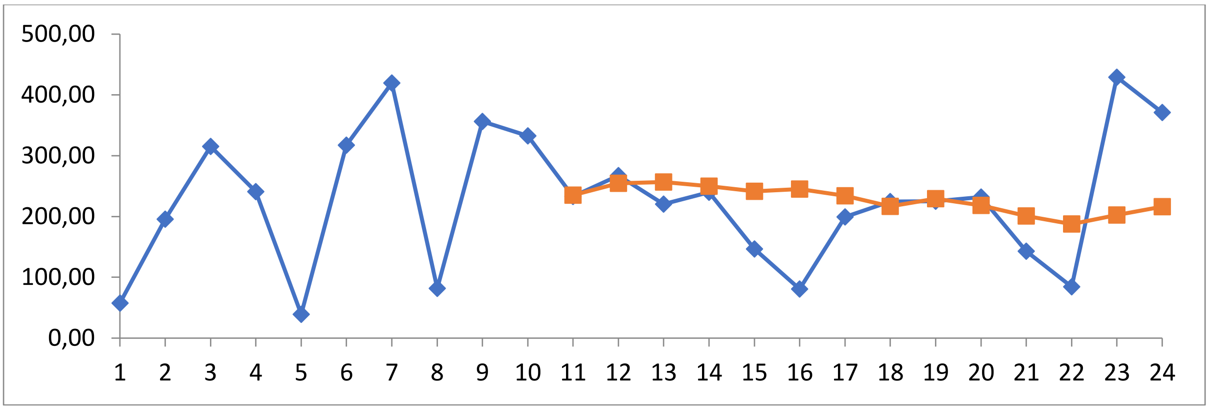

Figure 10: The result of linear smoothing at w = 11

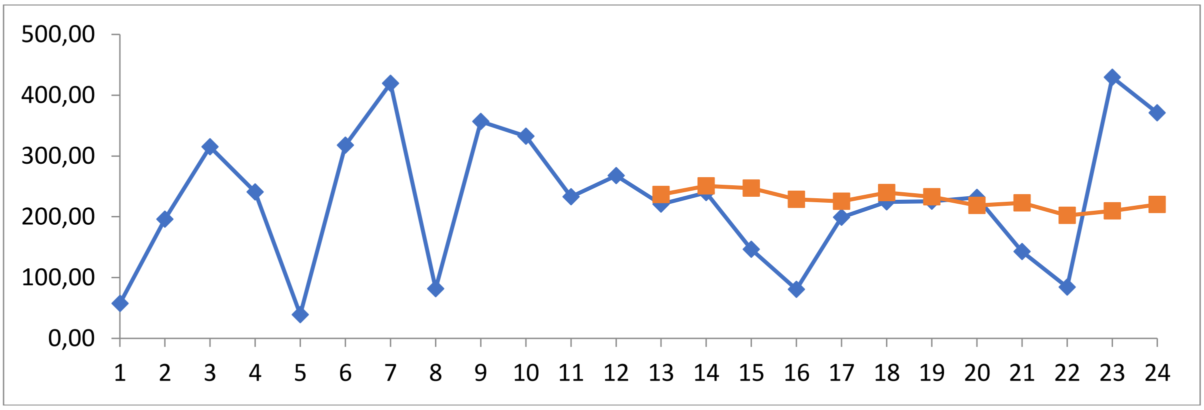

Figure 12: The result of linear smoothing at w = 13

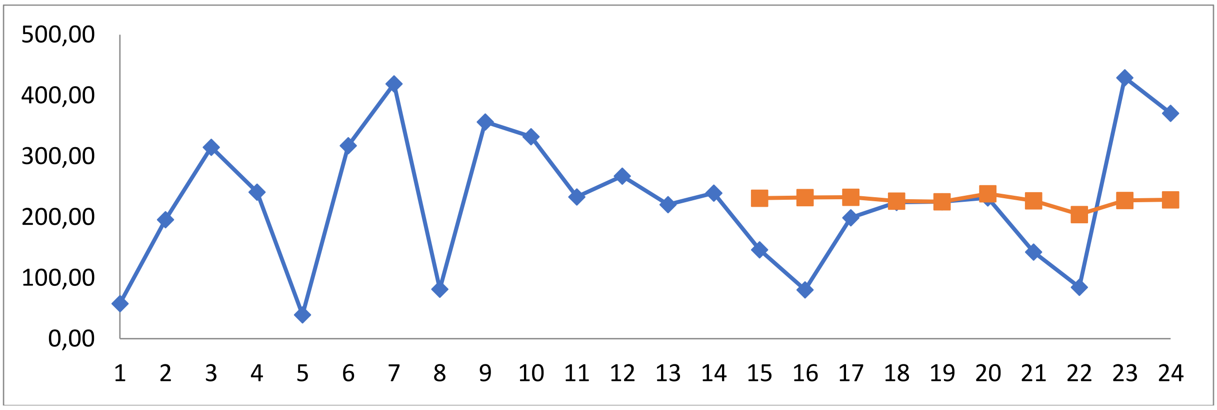

Figure 12: The result of linear smoothing at w = 15

Properties of moving average

1. When using the method of moving averages, choosing the value of the smoothing interval should be made based on substantive considerations and tied to the period of possibly existing oscillatory processes. If the average moving procedure is used to smooth the time series in the absence of any fluctuations, the value of the smoothing interval is often chosen equal to three, five, or seven. The larger the averaging interval (smoothing), the smoother the trend chart looks [59-61].

2. Neighboring members of a series of moving averages are strongly correlated, as their formation involved the same members of the original series. It may lead to many moving averages containing cyclic components missing in the original series. This phenomenon is called the Slutsky-Yul effect [59-61].

3. As a method of averaging, in addition to the above-mentioned conventional arithmetic mean can be considered as weighted moving averages, i.e., when the value of the original series in the smoothing interval is summed with specific weights. Such procedures are appropriate if the change in time series over time is nonlinear [59-61].

4.7. Rationing of time sequences

The rationing of time sequences makes it possible to compare the indicators obtained for different objects. In such rationing, the structure of the series (proportionality between levels in the series) remains unchanged. It is possible to compare the calculated indicators and models based on such data [59-61].

The criterion of efficiency of smoothing of time series

The use of one or another smoothing method depends on meeting the requirements of the problem itself and the series structure. Therefore, it is essential to determine the effectiveness of existing methods. Various criteria are used, among which the most adequate for this problem are: the criterion of turning points and the correlation coefficient between the original and smoothed series [59-61].

4.8. Criteria for turning points.

To assess the smoothing effect, it is proposed to use the criterion of turning points, the content of which is the standard calculation of levels whose values are greater or less than two neighboring [59-61]. This criterion is easily implemented in Excel [53].

Correlation coefficient. To estimate the closeness of the relationship between the original - the original series and the smoothed correlation coefficient is used. There is a special option in the add-on "Data Analysis" [53] to find it in Excel.

The formula for calculating turning points

$$IF\ ((I3 > I2); (I3 > I4); OR\ (IF\ (I3 < I2); (I3 < I4)))$$

Weighted moving average formula

The formula determines the weighted moving average [59-61].

$$WMA = \frac{\sum_{i=1}^{n} P_i * W_i}{\sum_{i=1}^{n} W_i} \quad (3)$$

where p_i - the value of the price of i -periods; w_i - the value of the scales for the price of i -periods ago.

The weighted moving average is the arithmetic weighted fluctuations of prices over time [43]. As an analytical tool, it removes some of the shortcomings of conventional sliding but does not eliminate them.

4.9. Re-smoothing

Fig.13 – Fig. 19 show re-smoothing with Kendall formulas for w = 3, 5, 7, 9, 11, 13, 15 according.

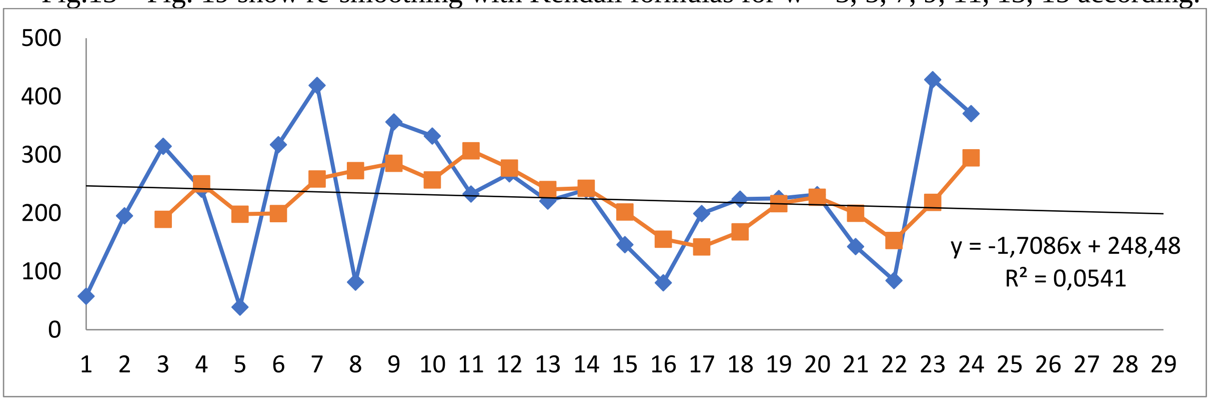

Figure 13: Re-smoothing at w = 3

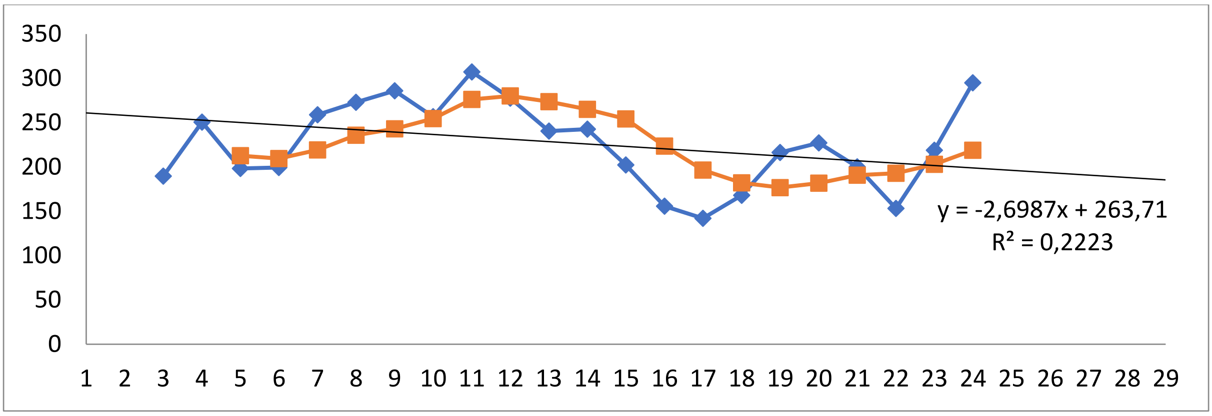

Figure 14: Re-smoothing at w = 5

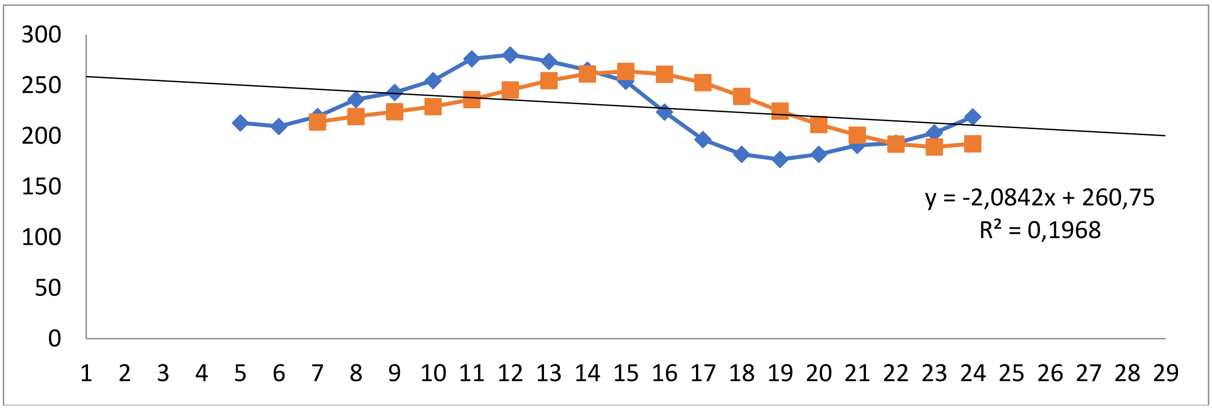

Figure 15: Re-smoothing at w = 7

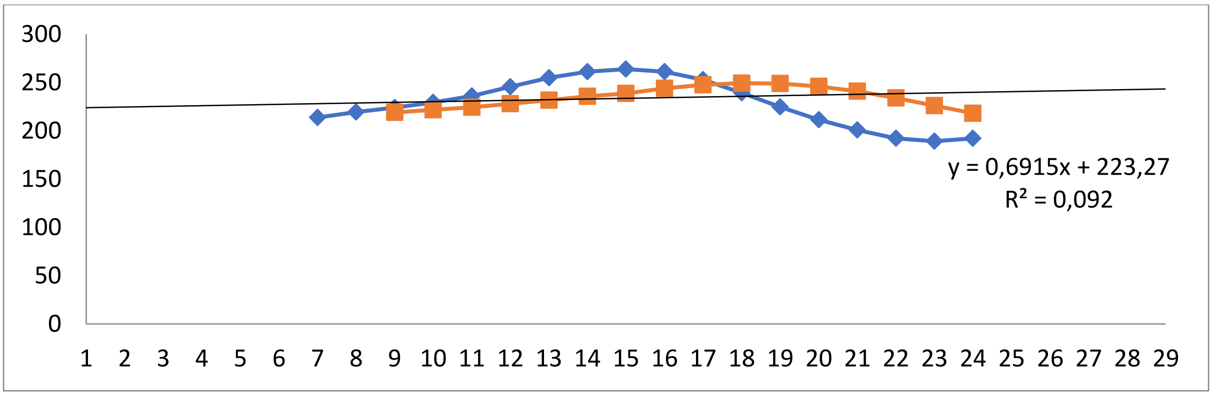

Figure 16: Re-smoothing at w = 9

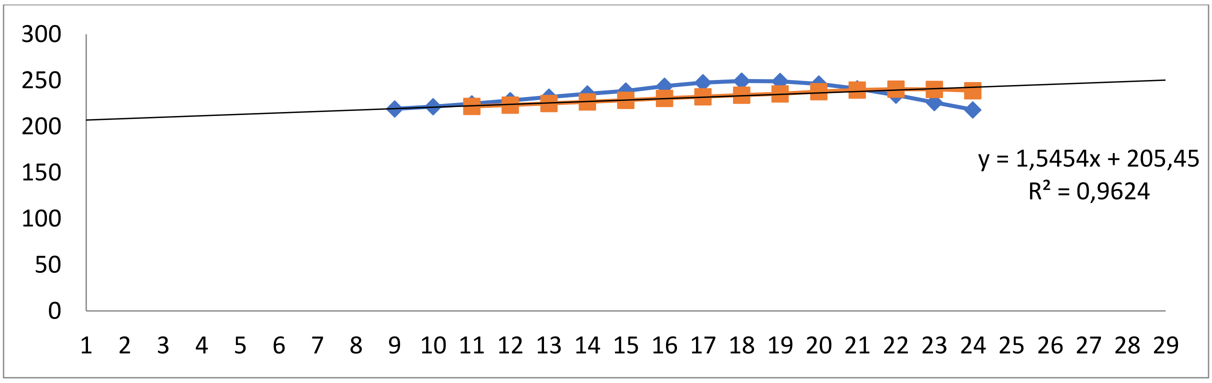

Figure 17: Re-smoothing at w = 11

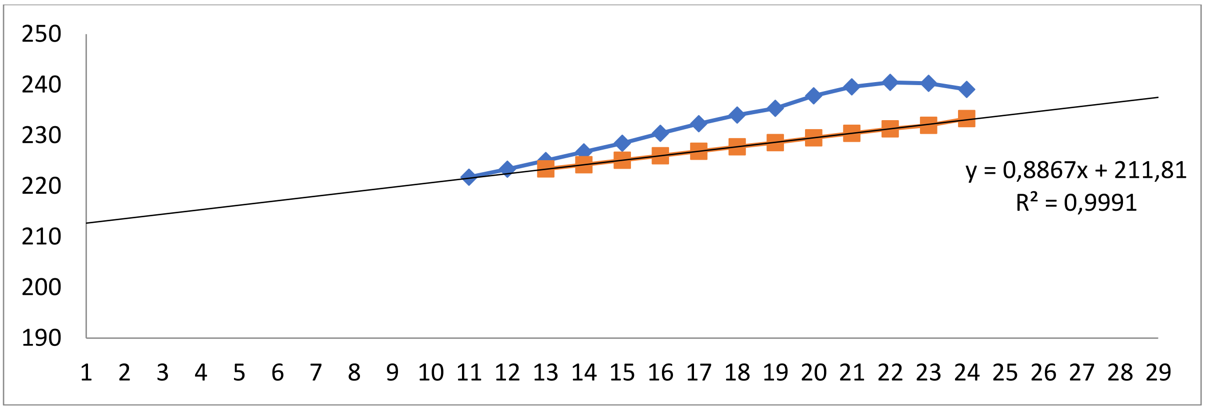

Figure 18: Re-smoothing at w = 13

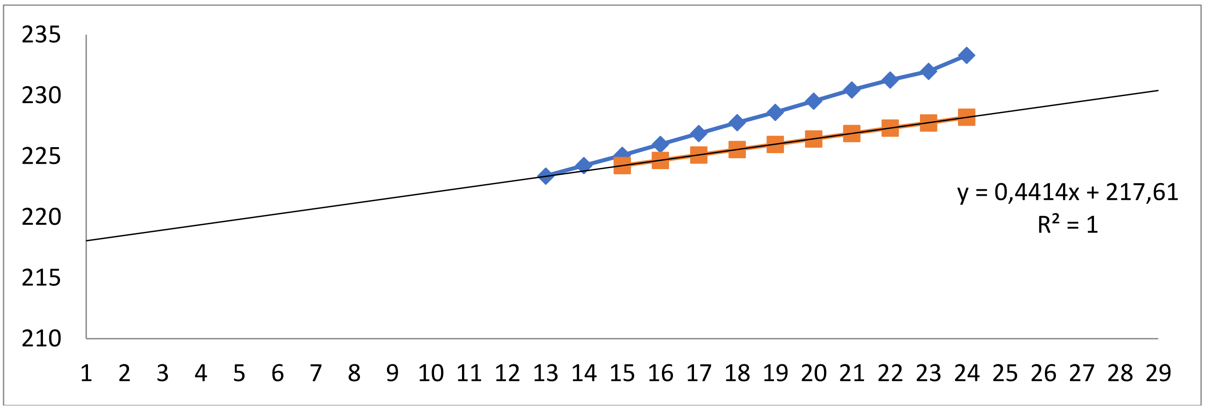

Figure 19: Re-smoothing at w = 15

4.10. Exponential smoothing

The main parameter of exponential smoothing is the parameter α, which takes values in the range $0.1 \leq \alpha \leq 0.3$. It is necessary to perform smoothing of the same series with the parameter α = 0.1, 0.15, 0.2, 0.25, 0.3. Fig.20 – Fig. 24 show exponential smoothing for α = 0.1, 0.15, 0.2, 0.25, 0.3 according.

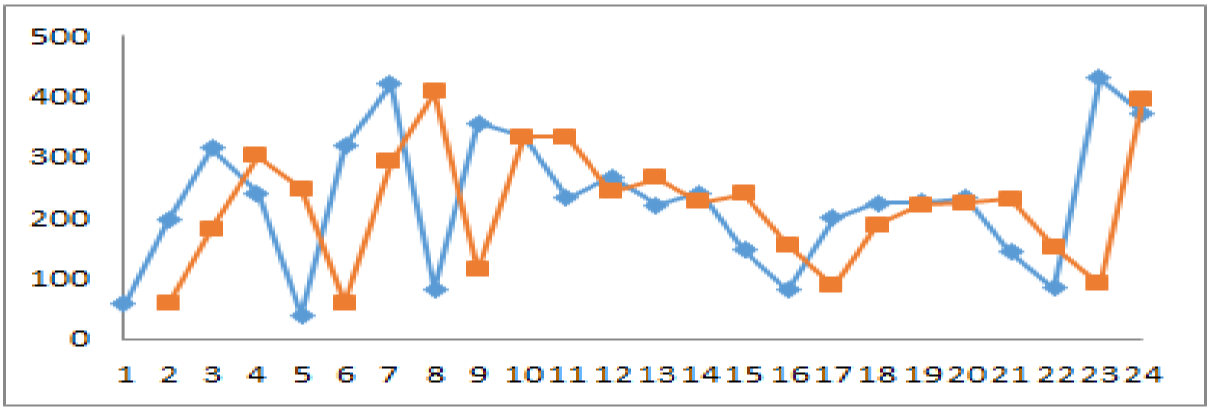

Figure 20: The result of exponential smoothing at = 0.1

In all these cases [59-61], finding the number of turning points and correlation coefficients between the original values and smoothed.

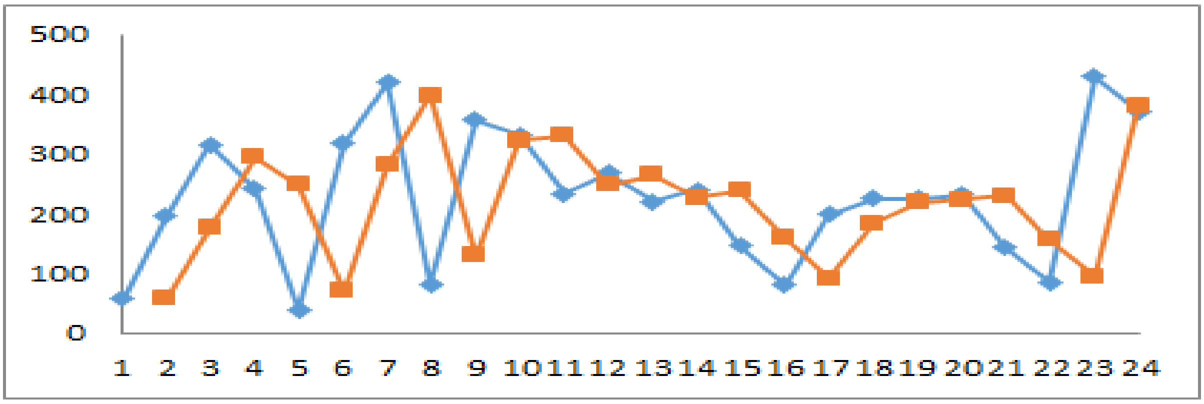

Figure 21: The result of exponential smoothing at = 0.15

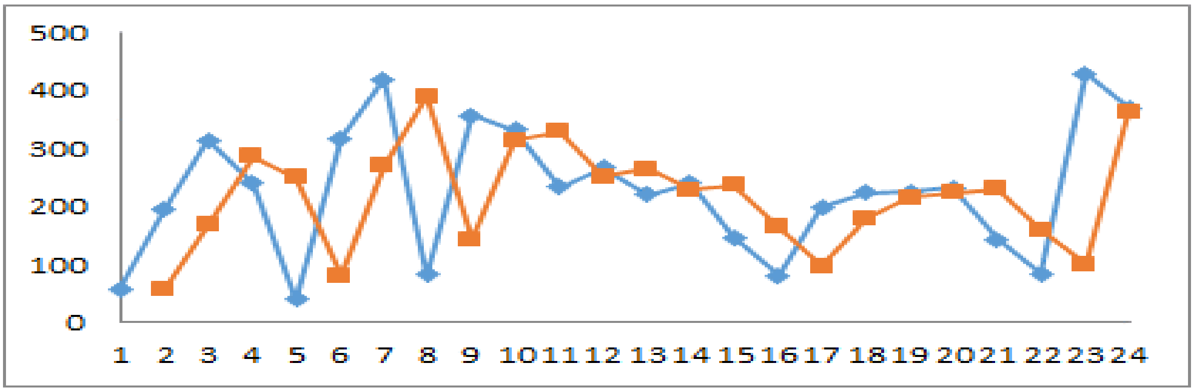

Figure 22: The result of exponential smoothing at = 0.2

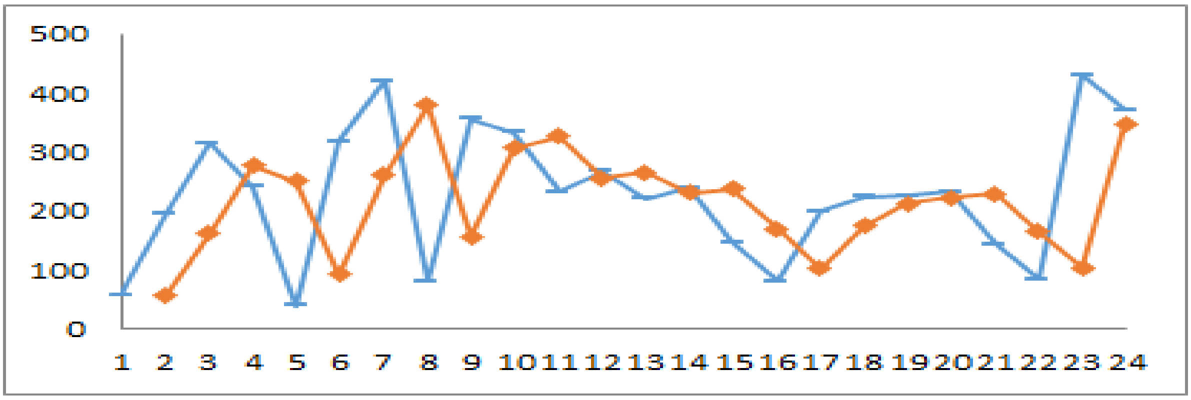

Figure 23: The result of exponential smoothing at = 0.25

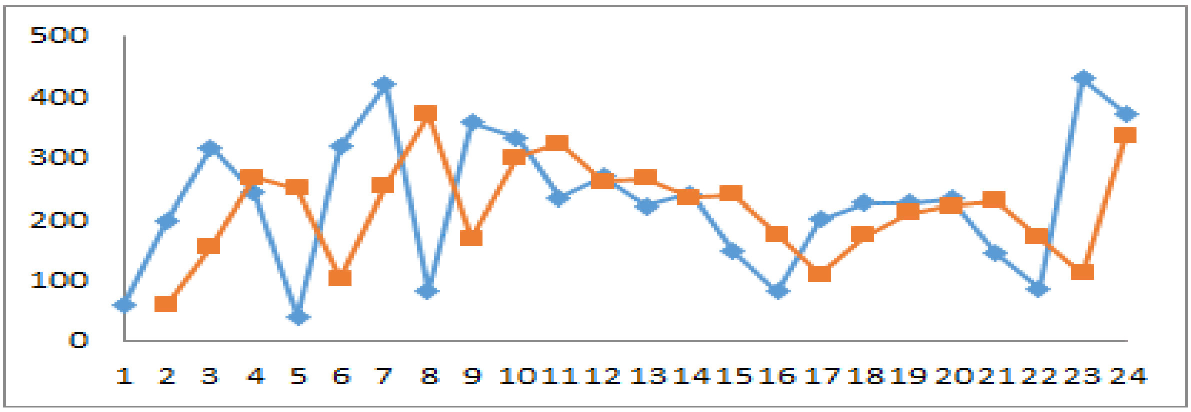

Figure 24: The result of exponential smoothing at = 0.3

5. Discussing

We conducted a comparative analysis of the caloric content of food using various data analysis methods. We used moving average, weighted moving average, linear smoothing, repeated linear smoothing, and exponential smoothing methods to smooth the nutritional value of foods consumed by people with cardiovascular disease [59-61]. The relationship between the category of food and its caloric content has been established. Data on the nutritional value of foods consumed by people with cardiovascular disease, collected in the study data [30], allowed to establish the relationship between the category of the product and its caloric content [62-65]. Studies of the caloric content of food are helpful for patients who suffer from cardiovascular disease or are overweight and want to assess the caloric component of the diet [66-70]. As a result of the comparative analysis, patients and doctors can choose the proper diet to improve patients' health [71-78]. We propose using the approach outlined in [11] to form a diet based on the caloric of food for people with cardiovascular disease. A greater information field creates a stable information field that improves the efficiency of selecting relevant foods and their quantity in the diets of various segments of the population.

To implement recommendations [79] on a healthy living and eating diet, you should choose a diet as soon as possible where you can agree on calorie levels and body weight levels. This recommendation is important when cardiovascular disease occurs or becomes chronic [80-91]. We recommend choosing from such groups of products with low (140-220 kJ), low-medium-calorie (220-300 kJ) inform therapeutic nutrition for cardiovascular disease be due to the exclusion of fats and carbohydrates. In addition, it is important to limit the amount of salt and substances that excite the cardiovascular and nervous systems. As can be seen from the results obtained above, the group of products must have medium and low-calorie levels. It includes yesterday's bread; uncomfortable cookies and biscuits; vegetarian soups; lean meats, fish, poultry; milk, sour milk drinks and cheese; dishes from different cereals; boiled pasta; boiled and baked vegetables; soft ripe fruits and berries, honey, jam. It is also important to control the number of micronutrients needed for the heart: potassium and magnesium. Potassium is found in bananas, cabbage, and dried apricots. Magnesium is found in walnuts, carrots, beets and cereals.

With the help of a comparative analysis of the caloric content of food, patients with cardiovascular disease have the opportunity to assess their diet and choose the proper diet correctly. A feature of the proposed approach is harmonizing data on the caloric content of various foods with the body's need to consume these foods.

Problem proper food selection exists for many other diseases, such as congenital or acquired allergies. With the help of the data obtained as a result of our research, people will be able to choose the foods and calories that will promote a healthy diet. Comparative analysis of the caloric content of food will allow people to find an alternative to those products that cause them an allergic reaction, disrupt the proper functioning of the gastrointestinal tract, and more. Comparative analysis of the caloric content of food in the diet is designed to help both doctors and patients with various diseases properly assess their diet and choose a diet that meets the characteristics of the disease, a particular state of the body, and relevant recommendations of doctors on nutrition. Recommended systems [92-114] based on comparative analysis, cluster analysis and machine learning methods will help to optimize the work of doctors with patients on diet selection.

6. Conclusions

The problem of proper nutrition is directly related to the quality of food and its caloric content. Many people worldwide suffer from cardiovascular diseases, often caused by being overweight. The paper found that the root cause of the studied problem is the inability of people to properly assess their diet in terms of its caloric content and adequately choose the proper diet.

The comparative analysis of indicators of the caloric content of foodstuff using various methods of the analysis of data is carried out. The methods of moving average, weighted moving average, linear smoothing, repeated linear smoothing, and exponential smoothing of data on the nutritional value of products consumed by people with cardiovascular disease are used. The relationship between the product category and its caloric content has been established.

As a result of research on the caloric content of food, the relationship between the category of product and its caloric content will allow patients suffering from cardiovascular disease or overweight to assess their diet and choose the proper diet to improve their health. An approach to the formation of a diet based on the caloric content of food for people with cardiovascular disease has been proposed, which, with greater availability of data on the caloric content of foods, improves the efficiency of selection of appropriate foods and their number in the diets of different populations. Patients with cardiovascular disease have the opportunity to properly assess their diet and choose the proper diet, the feature of which is to reconcile the data on the caloric content of various foods with the body's need to consume these foods.

Comparative analysis of the caloric content of food in the diet of patients with cardiovascular disease is designed to help both physicians and patients properly assess their diet and choose a diet that meets the characteristics of the disease, body condition, and doctors' recommendations. Problem Proper food selection exists for many other diseases, such as congenital or acquired allergies. With the help of the data obtained as a result of our research, people will be able to choose the foods and calories that will promote a healthy diet. Comparative analysis of the caloric content of food will allow people to find an alternative to those products that cause them an allergic reaction, disrupt the proper functioning of the gastrointestinal tract, and more. We used moving average, weighted moving average, linear smoothing, repeated linear smoothing, and exponential smoothing methods to smooth the nutritional value of foods consumed by people with cardiovascular disease. The relationship between the category of food and its caloric content has been established.

7. References

[1] NCD-RisC. Rising rural body-mass index is the main driver of the global obesity epidemic in adults. Nature 569, 260–264 (2019).

[2] Sustainable Development Goals: 17 Goals to Transform our World (UN, 2015).

[3] Astrup, A. et al. WHO draft guidelines on dietary saturated and trans fatty acids: time for a new approach? BMJ 366, l4137 (2019).

[4] WHO Framework Convention on Tobacco Control (WHO, 2019).

[5] O. Kuzmin, M. Bublyk, A. Shakhno, O. Korolenko, H. Lashkun, Innovative development of human capital in the conditions of globalization, in: E3S Web of Conferences, volume 166, 2020, 13011.

[6] R. Lupak, B. Mizyuk, V. Zaychenko, M. Kunytska-Iliash, T. Vasyltsiv, Migration processes and socio-economic development: interactions and regulatory policy, Agricultural and Resource Economics, 2022, № 8(1), pp. 70-88. https://doi.org/10.51599/are.2022.08.01.04.

[7] I. Jonek-Kowalska, Towards the Reduction of CO2 Emissions. Paths of Pro-Ecological Transformation of Energy Mixes in European Countries with an Above-Average Share of Coal in Energy Consumption. Resources Policy, vol. 77, 2022. doi:10.1016/j.resourpol.2022.102701.

[8] M. Bublyk, V. Vysotska, Y. Matseliukh, V. Mayik, M. Nashkerska, Assessing losses of human capital due to man-made pollution caused by emergencies, volume Vol-2805 of CEUR Workshop Proceedings, 2020, pp. 74-86.

[9] O. Maslak, N. Grishko, O. Bezruchko, Undeveloped competitive opportunities of enterprises using in cyclical development conditions. Economic Annals-XXI, 2015, volume 1-2(2), pp. 43–46.

[10] GBD 2017 Risk Factor Collaborators. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet 392, 1923–1994 (2018).

[11] D. Mozaffarian, Dietary and Policy Priorities for Cardiovascular Disease, Diabetes, and Obesity: A Comprehensive Review, Circulation, 2016, 133 (2), pp. 187–225. Doi: 10.1161/CIRCULATIONAHA.115.018585

[12] O. Voloshynskyi, V. Vysotska, M. Bublyk, Cardiovascular Disease Prediction Based on Machine Learning Technology, in: Proceedings of 16th International Scientific and Technical Conference on Computer Sciences and Information Technologies, CSIT, 2021, 1, pp. 69–75. DOI: 10.1109/CSIT52700.2021.9648587.

[13] Vors, C. et al. Milk polar lipids reduce lipid cardiovascular risk factors in overweight postmenopausal women: towards a gut sphingomyelin-cholesterol interplay. Gut https://doi.org/10.1136/gutjnl-2018-318155 (2019).
[14] P. Menzel, F. D'Aluisio, What I Eat: Around the World in 80 Diets, 2010.
[15] D. Mozaffarian, Dietary and policy priorities to reduce the global crises of obesity and diabetes, Nature Food (IF), 1, 2020, pp. 38–50. DOI: 10.1038/s43016-019-0013-1.
[16] USFDA. Trans Fat https://www.fda.gov/food/food-additives-petitions/trans-fat (2018).
[17] Flor, R. Focusing on “Protective Foods” to Reduce the Global Burden of Disease. Rockefeller Foundation (April 2019).
[18] Pomeranz, J., Mozaffarian, D. & Micha, R. Mandating front-of-package food labels in the U. S. – What are the First Amendment obstacles? Food Policy 86, https://doi.org/10.1016/j.foodpol.2019.05.005 (2019).
[19] Association of National Advertisers. Three New International Food Advertising Restrictions https://www.ana.net/content/show/id/42549 (2019).
[20] Wang, D. D. et al. Global improvement in dietary quality could lead to substantial reduction in premature death. J. Nutrit. 149, 1065–1074 (2019).
[21] I. Bodnar, M. Bublyk, O. Veres, O. Lozynska, I. Karpov, Y. Burov, P. Kravets, I. Peleshchak, O. Vovk, O. Maslak, Forecasting the risk of cervical cancer in women in the human capital development context using machine learning, volume Vol-2631 of CEUR workshop proceedings, 2020, pp. 491-501.
[22] Ye, J. et al. Dietary protein intake and subsequent risk of type 2 diabetes: a dose-response meta-analysis of prospective cohort studies. Acta Diabetol. 56, 851–870 (2019).
[23] I. Rishnyak, O. Veres, V. Lytvyn, M. Bublyk, I. Karpov, V. Vysotska, V. Panasyuk, Implementation models application for IT project risk management, volume Vol-2805 of CEUR Workshop Proceedings, 2020, pp. 102-117.
[24] Zhao, J. V. & Schooling, C. M. Effect of linoleic acid on ischemic heart disease and its risk factors: a Mendelian randomization study. BMC Med. 17, 61 (2019).
[25] Livesey, G. et al. Dietary glycemic index and load and the risk of type 2 diabetes: a systematic review and updated meta-analyses of prospective cohort studies. Nutrients 11, 1280 (2019).
[26] Fretts, A. M. et al. Associations of circulating very-long-chain saturated fatty acids and incident type 2 diabetes: a pooled analysis of prospective cohort studies. Am. J. Clin. Nutr. 109, 1216–1223 (2019).
[27] Zong, G. et al. Associations between linoleic acid intake and incident type 2 diabetes among U.S. men and women. Diabetes Care 42, 1406–1413 (2019).
[28] Wang, Y. et al. Effects of the resistant starch on glucose, insulin, insulin resistance, and lipid parameters in overweight or obese adults: a systematic review and meta-analysis. Nutr. Diabetes 9, 19 (2019).
[29] A. Marsh, How Counting Calories Became a Science: Calorimeters defined the nutritional value of food and the output of steam generators, 2020. URL: https://spectrum.ieee.org/how-counting-calories-became-a-science.
[30] Koustubhk, Calories in Food Items (per 100 grams) 2225 food items across 44 food categories, 2022. URL: https://www.kaggle.com/kkhandekar/calories-in-food-items-per-100-grams
[31] Caloric table, 2022. URL: https://www.tablycjakalorijnosti.com.ua/tablytsya-yizhyi
[32] Calories - what is it? Calculation of caloric content of food - formulas and recommendations, 2022. URL: https://fitness.org.ua/kalorii-sho-ce-rozrahynok-kaloriinosti-iji-formyli-ta-r/
[33] Average number of calories available per person per day (kcal)https://gateway.euro.who.int/ru/indicators/hfa_440-3200-average-number-of-calories-available-per-person-per-day-kcal/
[34] Total amount of food available for consumption when converted into kilocalories. Source FAO Statistics Division, Food Balance Sheets http://faostat3.fao.org/home/index.html
[35] Food balance sheets – a handbook, 2022. URL: available from http://www.fao.org/docrep/003/X9892E/X9892E00.HTM.
[36] M. Bublyk, A. Kowalska-Styczen, V. Lytvyn, V. Vysotska, The Ukrainian Economy Transformation into the Circular Based on Fuzzy-Logic Cluster Analysis. Energies 2021, 14, 5951. https://doi.org/10.3390/en14185951

[37] O. Maslak, M. Maslak, N. Grishko, O. Hlazunova, D. Pirogov, Innovative Safety of the Ukrainian Electrical Industry: Benchmarking Indicators for Provision, 2021 IEEE International Conference on Modern Electrical and Energy Systems (MEES), 2021, https://doi.org/10.1109/MEES52427.2021.9598492.
[38] O. Ilyash, R. Lupak, M. Kravchenk, O. Trofymenko, N. Duliaba, I. Dzhadan, A forecasting model for assessing the influence of the components of technological growth on economic security, Business: Theory and Practice, 2022, volume 23, issue 1, pp. 175-186. https://doi.org/10.3846/btp.2022.15298.
[39] V. Yakimtsov. Analytic overlook of the methodology of synergetics in postnonclassical science. Baltic Journal of Economic Studies, 2018, 4 (2), p. 254-260. DOI: https://doi.org/10.30525/2256-0742/2018-4-2-254-260.
[40] M. Bublyk, Y. Matseliukh, Small-batteries utilization analysis based on mathematical statistics methods in challenges of circular economy, CEUR workshop proceedings Vol-2870 (2021) 1594-1603.
[41] A. Agresti, Analysis of Ordinal Categorical Data, John Wiley & Sons, 1984.
[42] R. Yurynets, Z. Yurynets, M. Kokhan, Econometric analysis of the impact of expert assessments on the business activity in the context of investment and innovation development, volume Vol-2604 of CEUR Workshop Proceedings, 2020, pp. 680-694.
[43] S. Glen, Kendall's Tau (Kendall Rank Correlation Coefficient), Elementary Statistics for the rest of us, 2022. URL: https://www.statisticshowto.com/kendalls-tau/
[44] V. Vysotska, A. Berko, M. Bublyk, L. Chyrun, A. Vysotsky, K. Doroshkevych, Methods and tools for web resources processing in e-commercial content systems, in: Proceedings of 15th International Scientific and Technical Conference on Computer Sciences and Information Technologies, CSIT, 1, 2020, pp. 114-118.
[45] Standard error, 2022. URL: https://ua.nesrakonk.ru/standard-error/.
[46] Standard deviation, 2022. URL: https://studopedia.su/10_11382_standartne-vidhilennya.html.
[47] K.O. Soroka, Fundamentals of Systems Theory and Systems Analysis, Kharkiv, 2004.
[48] Yu.P. Surmin, Systems theory and system analysis, Kyiv, 2003.
[49] A. Berko, I. Pelekh, L. Chyrun, M. Bublyk, I. Bobyk, Y. Matseliukh, L. Chyrun, Application of ontologies and meta-models for dynamic integration of weakly structured data, in: Proceedings of the 2020 IEEE 3rd International Conference on Data Stream Mining and Processing, DSMP, 2020, pp. 432-437.
[50] Construction of an interval variable sequence of continuous quantitative data, 2022. URL: https://stud.com.ua/93314/statistika/pobudova_intervalnogo_variatsiynogo_ryadu_bezperernih_kilkisnih_danih.
[51] I.V. Stetsenko, Systems modeling, Cherkasy, 2010.
[52] S.S. Velykodnyi, Modeling of systems, Odessa, 2018.
[53] Statistical models of marketing decisions taking into account the uncertainty factor, 2022. URL: https://excel2.ru/articles/uroven-znachimosti-i-uroven-nadezhnosti-v-ms-excel.
[54] Grouping of statistical data - BukLib.net Library, 2022. URL: https://buklib.net/books/35946/
[55] Graphic presentation of information, 2022. URL: https://studopedia.com.ua/1_132145_grafichne-podannya-informatsii.html.
[56] D. Koshtura, M. Bublyk, Y. Matseliukh, D. Dosyn, L. Chyrun, O. Lozynska, I. Karpov, I. Peleshchak, M. Maslak, O. Sachenko, Analysis of the demand for bicycle use in a smart city based on machine learning, volume Vol-2631 of CEUR workshop proceedings, 2020, pp. 172-183.
[57] V. Husak, L. Chyrun, Y. Matseliukh, A. Gozhyj, R. Nanivskyi, M. Luchko, Intelligent Real-Time Vehicle Tracking Information System, CEUR Workshop Proceedings Vol-2917 (2021) 666-698.
[58] Forecasting the trend of the time series by algorithmic methods, 2022. URL: http://ubooks.com.ua/books/000269/inx42.php.
[59] M. J. Schervish, Theory of Statistics, Springer Science & Business Media, New York, 2012.
[60] F. X. Diebold, Econometrics. Streamlined, Applied and e-Aware, Mc Graw Hill, Boston, 2013.
[61] C. F. Baum, An Introduction to Modern Econometrics Using Stata, Mc Graw Hill, Boston, 2020
[62] Swinburn, B. A. et al. The global syndemic of obesity, undernutrition, and climate change: the Lancet commission report. Lancet 393, 791–846 (2019).

[63] Hjorth, M. F. et al. Prevotella-to-Bacteroides ratio predicts body weight and fat loss success on 24-week diets varying in macronutrient composition and dietary fiber: results from a post-hoc analysis. Int. J. Obes. 43, 149–157 (2019).
[64] Berko, Y. Matseliukh, Y. Ivaniv, L. Chyrun, V. Schuchmann, The text classification based on Big Data analysis for keyword definition using stemming, in: proceedings of IEEE 16th International conference on computer science and information technologies, Lviv, Ukraine, 22–25 September, 2021, pp. 184–188.
[65] Kabisch, S. et al. Fasting glucose state determines metabolic response to supplementation with insoluble cereal fibre: a secondary analysis of the optimal fibre trial (OptiFiT). Nutrients 11, 2385 (2019).
[66] General information on the ESS alcohol measure, 2022. URL https://www.europeansocialsurvey.org/docs/round7/survey/ESS7_appendix_a9_e03_0.pdf
[67] U.S. Department of Health and Human Services. 2008 Physical Activity Guidelines for Americans. Washington (DC): U.S. Department of Health and Human Services; 2008. ODPHP Publication No. U0036, 2015. URL: http://www.health.gov/paguidelines.
[68] Beals, E. et al. Addition of milk fat globule membrane-enriched supplement to a high-fat meal attenuates insulin secretion and induction of soluble epoxide hydrolase gene expression in the postprandial state in overweight and obese subjects. J. Nutr. Sci. 8, e16 (2019).
[69] Zeng, L. et al. Trends in processed meat, unprocessed red meat, poultry, and fish consumption in the United States, 1999–2016. J. Acad. Nutr. Diet. 119, 1085–1098 (2019).
[70] Blachier, F. et al. High-protein diets for weight management: interactions with the intestinal microbiota and consequences for gut health. a position paper by the new gut study group. Clin. Nutr. 38, 1012–1022 (2019).
[71] The 2015-2020 Dietary Guidelines for Americans Executive Summary, 2020. URL: https://health.gov/sites/default/files/2019-10/DGA_Executive-Summary.pdf
[72] Hjorth, M. F. et al. Pretreatment fasting glucose and insulin as determinants of weight loss on diets varying in macronutrients and dietary fibers-the POUNDS LOST study. Nutrients 11, 586 (2019).
[73] Halmos, E. P., Mack, A. & Gibson, P. R. Review article: emulsifiers in the food supply and implications for gastrointestinal disease. Aliment Pharmacol. Ther. 49, 41–50 (2019)
[74] The Scientific Report of the 2015 Dietary Guidelines Advisory Committee and consideration of Federal agency and public comments, 2015. URL: https://health.gov/sites/default/files/2019-09/Scientific-Report-of-the-2015-Dietary-Guidelines-Advisory-Committee.pdf
[75] Tindall, A. M., Johnston, E. A., Kris-Etherton, P. M. & Petersen, K. S. The effect of nuts on markers of glycemic control: a systematic review and meta-analysis of randomized controlled trials. Am. J. Clin. Nutr. 109, 297–314 (2019).
[76] Estruch, R. et al. Effect of a high-fat Mediterranean diet on bodyweight and waist circumference: a prespecified secondary outcomes analysis of the PREDIMED randomised controlled trial. Lancet Diabet. Endocrinol. 7, 6–17 (2019).
[77] Public Comments on the Scientific Report of the 2015 Dietary Guidelines Advisory Committee, 2015. URL: https://health.gov/our-work/nutrition-physical-activity/dietary-guidelines/previous-dietary-guidelines/2015/advisory-report/public-comments/public-comments-scientific-report-2015-dietary-guidelines-advisory-committee
[78] Snelson, M. et al. Metabolic effects of resistant starch type 2: a systematic literature review and meta-analysis of randomized controlled trials. Nutrients 11, 1833 (2019).
[79] U.S. Department of Health and Human Services and U.S. Department of Agriculture. 2015 – 2020 Dietary Guidelines for Americans. 8th Edition, 2015. URL: https://health.gov/our-work/food-nutrition/previous-dietary-guidelines/2015.
[80] Key Elements of Healthy Eating Patterns, USDA Food Patterns: Healthy U.S. Style Eating Pattern, 2022. URL: https://fns-prod.azureedge.us/sites/default/files/usda_food_patterns/USDAFoodPatterns SummaryTable.pdf
[81] Nutritional Goals for Age-Sex Groups Based on Dietary Reference Intakes and Dietary Guidelines Recommendations, 2018. URL: https://www.apa.org/obesity-guideline/nutritional-goals-age-sex.pdf.

[82] Redesigning the Process for Establishing the Dietary Guidelines for Americans, 2017. URL: https://nap.nationalacademies.org/catalog/24883/redesigning-the-process-for-establishing-the-dietary-guidelines-for-americans
[83] V. Lytvyn, A. Hryhorovych, V. Hryhorovych, L. Chyrun, V. Vysotska, M. Bublyk, Medical Content Processing in Intelligent System of District Therapist, CEUR Workshop Proceedings Vol-2753 (2020) 415-429.
[84] M. Fedorov, A. Berko, Y. Matseliukh, V. Schuchmann, I. Budz, O. Garbich-Moshora, M. Mamchyn, Decision support system for formation and implementing orders based on cross programming and cloud computing, volume Vol-2917 of CEUR workshop proceedings, 2021, pp. 714–748.
[85] V. Lytvyn, Y. Burov, P. Kravets, V. Vysotska, A. Demchuk, A. Berko, Y. Ryshkovets, S. Shcherbak, O. Naum, Methods and Models of Intellectual Processing of Texts for Building Ontologies of Software for Medical Terms Identification in Content Classification, CEUR Workshop Proceedings Vol-2362 (2019) 354-368.
[86] S. Makara, L. Chyrun, Y. Burov, Z. Rybchak, I. Peleshchak, R. Peleshchak, R. Holoshchuk, S. Kubinska, A. Dmytriv, An Intelligent System for Generating End-User Symptom Recommendations Based on Machine Learning Technology, CEUR workshop proceedings Vol-2604 (2020) 844-883.
[87] V. Vysotska, V. Lytvyn, Y. Burov, A. Gozhyj, S. Makara, The consolidated information web-resource about pharmacy networks in city, CEUR Workshop Proceedings Vol-2255 (2018) 239-255.
[88] N. Oleksiv, O. Oborska, K. Mykich, S. Mushasta, Y. Pukach, O. Tereshchuk, Information System of Dynamic and Adaptive Control of Human Diet Based on Machine Learning Technology, CEUR Workshop Proceedings Vol-2917 (2021) 373-406.
[89] M. Odrekhivskyy, V. Pasichnyk, N. Kunanets, A. Rzheuskyi, G. Korz, D. Tabachyshyn, The Use of Modern Information Technology in Medical and Health Institutions of Truskavets Resort, CEUR Workshop Proceedings Vol-2631 (2020) 184-197.
[90] V. Lytvynenko, M. Voronenko, S. Sitalo, O. Boskin, I. Lurie, N. Savina, Y. Tanasiichuk , N. Krugla, Using a Bayesian Network to Assess the Atmospheric Pollution Influence on Immunological Parameters, 2nd International Workshop on Informatics & Data-Driven Medicine, Lviv, Ukraine, November 11 - 13, 2019 (IDDM'2019), pp.222-233, urn:nbn:de:0074-2488-2, http://ceur-ws.org/Vol-2488/
[91] N. Antonyuk, L. Chyrun, V. Andrunyk, A. Vasevych, S. Chyrun, A. Gozhyj, I. Kalinina, Y. Borzov, Medical news aggregation and ranking of taking into account the user needs, CEUR Workshop Proceedings 2488 (2019) 369–382.
[92] V. Husak, O. Lozynska, I. Karpov, I. Peleshchak, S. Chyrun, A. Vysotskyi, Information System for Recommendation List Formation of Clothes Style Image Selection According to User's Needs Based on NLP and Chatbots, CEUR workshop proceedings Vol-2604 (2020 788-818.
[93] V. Lytvyn, V. Vysotska, V. Shatskykh, I. Kohut, O. Petruchenko, L. Dzyubyk, V. Bobrivetc, V. Panasyuk, S. Sachenko, M. Komar, Design of a recommendation system based on Collaborative Filtering and machine learning considering personal needs of the user, Eastern-European Journal of Enterprise Technologies 4(2-100) (2019) 6-28. DOI: 10.15587/1729-4061.2019.175507
[94] I. Balush, V. Vysotska, S. Albota, Recommendation System Development Based on Intelligent Search, NLP and Machine Learning Methods, CEUR Workshop Proceedings Vol-2917 (2021) 584-617.
[95] O. Artemenko, V. Pasichnyk, N. Kunanets, K. Shunevych, Using sentiment text analysis of user reviews in social media for e-tourism mobile recommender systems, CEUR workshop proceedings Vol-2604 (2020) 259-271.
[96] D. Aksonov, A. Gozhyj, I. Kalinina, V. Vysotska, Question-Answering Systems Development Based on Big Data Analysis, in: Proceedings of the IEEE 16th International Conference on Computer Sciences and Information Technologies (CSIT), 2021, 1. pp. 113–118.
[97] N. Shakhovska, S. Fedushko, M. ml. Greguš, I. Shvorob, Y. Syerova, Development of Mobile System for Medical Recommendations, in: The 15th International Conference on Mobile Systems and Pervasive Computing (MobiSPC), 155 (2019) 43-50.

[98] V. Yakovyna, N. Shakhovska, Modelling and predicting the spread of COVID-19 cases depending on restriction policy based on mined recommendation rules, Mathematical Biosciences and Engineering 18(3) (2021) 2789–2812.
[99] P. Kravets, Y. Burov, V. Lytvyn, V. Vysotska, Gaming method of ontology clusterization, Webology 16(1) (2019) 55-76.
[100] P. Kravets, Y. Burov, V. Lytvyn, V. Vysotska, Y. Ryshkovets, O. Brodyak, S. Vyshemyrska, Markovian Learning Methods in Decision-Making Systems, Lecture Notes on Data Engineering and Communications Technologies 77 (2022) 423-437.
[101] P. Kravets, V. Lytvyn, V. Vysotska, Y. Burov, I. Andrusyak, Game Task of Ontological Project Coverage, CEUR Workshop Proceedings Vol-2851 (2021) 344-355.
[102] M. Bublyk, V. Lytvyn, V. Vysotska, L. Chyrun, Y. Matseliukh, N. Sokulska, The Decision Tree Usage for the Results Analysis of the Psychophysiological Testing, CEUR workshop proceedings Vol-2753 (2020) 458-472.
[103] P. Kravets, V. Lytvyn, I. Dobrotvor, O. Sachenko, V. Vysotska, A. Sachenko, Matrix Stochastic Game with Q-learning for Multi-agent Systems, Lecture Notes on Data Engineering and Communications Technologies 83 (2021) 304-314.
[104] P. Kravets, Y. Burov, O. Oborska, V. Vysotska, L. Dzyubyk, V. Lytvyn, Stochastic Game Model of Data Clustering, CEUR Workshop Proceedings Vol-2853 (2021) 214-227.
[105] I. Lurie, V. Lytvynenko, S. Olszewski, M. Voronenko, A. Kornelyuk, U. Zhunissova, O. Boskin, The Use of Inductive Methods to Identify Subtypes of Glioblastomas in Gene Clustering, CEUR Workshop Proceedings Vol-2631 (2020) 406-418.
[106] Y. Meleshko, M. Yakymenko, S. Semenov, A Method of Detecting Bot Networks Based on Graph Clustering in the Recommendation System of Social Network, CEUR Workshop Proceedings Vol-2870 (2021) 1249-1261.
[107] S. Babichev, B. Durnyak, I. Pikh, V. Senkivskyy, An Evaluation of the Objective Clustering Inductive Technology Effectiveness Implemented Using Density-Based and Agglomerative Hierarchical Clustering Algorithms, Advances in Intelligent Systems and Computing 1020 (2020). Springer, Cham. https://doi.org/10.1007/978-3-030-26474-1_37.
[108] V. Bakhrushin, A. Bakurova, M. Pasichnyk, E. Tereschenko, Risks of data inconsistency in information systems used for predicting the pandemics development, volume Vol-2805 of CEUR Workshop Proceedings, 2020, pp. 1–15. http://ceur-ws.org/Vol-2805/invited1.pdf
[109] S. Babichev, M. A. Taif, V. Lytvynenko, V. Osypenko, Criterial analysis of gene expression sequences to create the objective clustering inductive technology, in: Proceedings of the International Conference on Electronics and Nanotechnology, ELNANO, 2017, pp. 244–248. doi: 10.1109/ELNANO.2017.7939756.
[110] S. Babichev, V. Lytvynenko, V. Osypenko, Implementation of the objective clustering inductive technology based on DBSCAN clustering algorithm, in: Proceedings of the 12th International Scientific and Technical Conference on Computer Sciences and Information Technologies, CSIT, 2017, 1, 479-484.
[111] S. A. Babichev, A. Gozhyj, A. I. Kornelyuk, V. I. Lytvynenko, Objective clustering inductive technology of gene expression profiles based on SOTA clustering algorithm, Biopolymers and Cell 33(5) (2017) 379–392. doi: 10.7124/bc.000961.
[112] S. Babichev, B. Durnyak, I. Pikh, V. Senkivskyy, An Evaluation of the Objective Clustering Inductive Technology Effectiveness Implemented Using Density-Based and Agglomerative Hierarchical Clustering Algorithms, Lecture Notes in Computational Intelligence and Decision Making 1020 (2020) 532-553.
[113] V. Lytvynenko, W. Wojcik, A. Fefelov, I. Lurie, N. Savina, M. Voronenko, et al.: Hybrid Methods of GMDH-Neural Networks Synthesis and Training for Solving Problems of Time Series Forecasting, Lecture Notes in Computational Intelligence and Decis Making 1020 (2020) 513-531.
[114] V. Lytvynenko, I. Lurie, J. Krejci, M. Voronenko, N. Savina, M. A. Taif., Two Step Density-Based Object-Inductive Clustering Algorithm, CEUR Workshop Proceedings Vol-2386 (2019) 117-135.
[115] N. Shakhovska, V. Yakovyna, N. Kryvinska, An improved software defect prediction algorithm using self-organizing maps combined with hierarchical clustering and data preprocessing, Lecture Notes in Computer Science 12391 (2020) 414–424.