UDC 005.346:339.144

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# MECHANISMS FOR DETERMINING OF THE STATISTICAL AGGREGATE SPLIT POINTS INTO CLUSTERS IN ABC ANALYSIS

# МЕХАНІЗМИ ВИЗНАЧЕННЯ ТОЧОК РОЗПОДІЛУ СТАТИСТИЧНОЇ СУКУПНОСТІ НА КЛАСТЕРИ В ABC-АНАЛІЗІ

**ANNOTATION**

The article provides the definition of MdSPSA-mechanisms for determining of the split points of a statistical aggregate. The main mechanisms of the statistical aggregate split points (MdSPSA) into clusters were revealed and were also defined specific features of each of those mechanisms; and the contrastive analysis concerning the labour intensity and procedure validity was made. The brief review of the basic methods for determining of the statistical aggregate split points is given in the range of the commodity stocks, such as the empiric method ("Pareto rule" or "80:20 rule"); the sum method; the differential method; the method of the polygon; the loop method (according to A. M. Gadzynskyi); the triangle method (according to S. V. Afanasiev); the analytic method (or the tangent method) (according to V. S. Lukinskyi); the method of average without a cumulative curve (author's method).

**Keywords:** commodity stocks, retail, ABC approach, clusters, mechanisms of the statistical aggregate split points (MdSPSA) into clusters.

**АНОТАЦІЯ**

У статті подано поняття МвТРСС-механізм визначення точок розподілу статистичної сукупності. Зібрано (виявлено) основні механізми визначення точок розподілу статистичної сукупності (МвТРСС) на кластери та визначено специфічні особливості кожного з механізмів, а також проведено їх порівняльний аналіз щодо трудомісткості й коректності процедур. Подано короткий огляд основних методів визначення точки розподілу статистичної сукупності в асортименті товарних запасів, таких як емпіричний метод («правило Парето» або «правило «80:20»); метод суми; диференціальний метод; метод багатокутника; метод петлі (за А.М. Гаджинським); метод трикутника (за С.В. Афанасьєвим); аналітичний метод (або метод дотичних, за В.С. Лукинським); метод середніх без кумуляти (авторський метод).

**Ключові слова:** товарні запаси, ритейл, ABC-підхід, кластери, механізм визначення точки розподілу статистичної сукупності (МвТРСС) на кластери.

**АННОТАЦИЯ**

В статье дано понятие МоТРСС-механизм определения точек разделения статистической совокупности. Собраны (выявлены) основные механизм определения точек разделения статистической совокупности (МоТРСС) на кластеры и определены специфические особенности каждого из механизмов, а также проведен их сравнительный анализ касательно трудоемкости и корректности процедур. Представлен краткий обзор основных методов определения точки разделения статистической совокупности в ассортименте товарных запасов, таких как эмпирический метод («правило Парето» или «правило 80:20»); метод суммы; дифференциальный метод; метод многоугольника; метод петли (по А.М. Гаджинскому); метод треугольника (по С.В. Афанасьеву); аналитический метод (или метод касательных, по В.С. Лукинскому); метод средних без кумуляты (авторский метод).

**Ключевые слова:** товарные запасы, ритейл, ABC-подход, кластеры, механизм определения точки разделения статистической совокупности (МоТРСС) на кластеры.

**Problem statement.** Retailer, to maximize meeting of customer demand, needs a focused attention and clear, correct management of commodity flow, which provides a faultless sale process and represents a practical proposition.

Volume and quantity of merchandise line group (supply) of a retail depends directly on its format and sales area rate. It is considered that, on average, retail can include up to 50–100 thousands of stock keeping units (SKU) or, items of one merchandise line, trade mark, commodity grade in one packing type of one intensity and stock numbers, of commodity stocks.

It is necessary to manage each of SKU stocks that is to set clear targets, form strategies and tactics, choose definite methods and ways of control.

Nowadays large arrays of information in network business and retails of different formats demand obligatory implementation of special modern methods and mechanisms of commodity stocks management.

ABC method, according to many scientists, theorists and specialists – practitioners, refers to such modern mechanisms of commodity stocks management.

Analysts mention that ABC method is a simple and powerful analysis tool, which allows to reveal objects that need paramount attention and this is really relevant in the deficit of managerial resources. However it is important to point out that there are some problems in using of this analytical approach and that they relate to the practice of clustering stocks into classes. The main problem is in the scientific sphere: today there is no common mechanism of dividing assortment of goods into relevant classes for the further relevant management of them. The economical literature does not give due consideration to the basis of correct using of specific mechanisms of dividing the whole into clusters in ABC analysis. In connection with this it is necessary to find the ways of this problem solution.

**Analysis of recent research and publications.** Nowadays the question of ABC-analysis is widely covered in thematic literature by both national and foreign scholars. Despite considerable interest of national and foreign scholars and practi-

tioners to ABC-analysis it should be pointed out that the existing development is mainly devoted to its relevance, general description, questions of possibility of using in the enterprises of different fields, and much lesser – to algorithm analysis, namely to distributing methods of statistical aggregate into three unequal parts A, B and C. The rationale for choosing distributing method of line of goods into groups A, B and C is absent at all in many works.

An exception is the research of the following authors: S.V. Gryshko and Ye.V. Peresada [1] – they suggest variants of economic mathematical models for stocks classification according to the criteria of ABC-analysis; S.V. Afanasiev [2] – presents an author's method of clustering – "triangle method", A.O. Fisher [3], T.Ya. Lagotskyi [4], V.S. Lukinskyi [5] and A.M. Gadzynskyi [6] – in their works they fully reveal essence and mechanism of the method, describe algorithms of different ways of ABC-analysis (for instance, empirical, graphical, and various types of analytical).

Therefore the question of choosing the effective distributing method of line of goods into clusters within ABC-analysis, taking into account the specific character of retail, needs more details and refinement.

**Statement of a problem.** The aim of the article is to find out the main mechanisms for determining of the statistical aggregate split points (MdSPSA) into clusters and identify the specific features of separate mechanisms, as well as a comparative analysis of their complexity and correctness of procedures.

The study used methods of theoretical generalization and comparison, analysis and synthesis, as well as systematization.

**Results.** In the last decade of XX century method of ABC-analysis has been widely used in practice due to the sharp increase of logistic systems development and due to the start of implementation of category management: there is a need solving complex management problems involving a large number of parameters for the effective management of commodity stocks throughout the whole supply chain.

The end of the last century became a new stage in the development of the ABC-analysis method. If earlier the empirical abstract principle was mainly used – the proportion of the aggregate distribution of 20: 80, in the 90th of the twentieth century the foundations of scientifically based formalized mechanism of differentiation of statistical sampling to separate clusters began to be laid. The main element of this mechanism is the method of determining the position measurement or value of the cluster boundaries. Further propose to call it the "split point of a statistical aggregate (SPSA)".

At the beginning of the XXI century plenty of different modifications and variations of the ABC-analysis method and its mechanisms has appeared.

However, so far as in scientific, educational and so in the business literature you can see a material, which refers to the "Pareto law or rule with a proportion of aggregate distribution of 20:80". And there is practically no evidence of the mechanism(s) of the SPSA (MdSPSA) definition.

Therefore it is necessary to prove the incomplete correctness of a statement about the existence of "law 20:80, and provide an overview of MdSPSA methods.

ABC-analysis, as already was mentioned, is widespread. However, even today many of the analysts – practitioners perceive, and some of the authors – theorists describe ABC-analysis as a fairly simple (if not primitive) method of research, abstract theorems of which are simple and obvious: "take an aggregate of objects and simply divide them in the propotion of 20:80 according to Pareto law".

But it should be noted that the generally known proportion of 20:80 has never been proven by anybody and does not belong to the scientific form of the established law. Actually, none of the authors of this approach has never claimed to do it. Therefore, consideration of this particular proportion distribution as a set digital pair and recommended as "empirical variant" (proposed by many authors with lack of options, almost as a proven pattern) – is insufficiently correct in fact . Authors of many scientific and educational works interpret the proportion as the "Pareto law" only because of not clear understanding of the essence of this proportion (as a result of ignorance of the history of its origin). The range of variation of parameters value of so-called "law" is quite considerable: for the point A – 50% and 15%, for B – 30% and 40%, for C – respectively 15% and 50%.

Offered in a variety of sources variants of SPSA borders of empirical values are the result of specific studies, by authors, of non-representative local aggregate which do not have and can not have a theoretical justification for the correctness of disseminating values for all other aggregates. Therefore the values of parameters can be applied (used) in practice only as local recommendations for those enterprises on the information base of which these authors conducted the study.

Of course, depending on the urgency of the task, and the degree of understanding of the research object DMP can a priori (analog method, intuition), use one of the following proportions (ie SPSA) referred to in the literature for rapid distribution of the aggregate of its object of study into clusters.

It should be noted that in the theoretical arsenal of the ABC analysis method, there are not only a priori intuitive and empirical, but also special scientifically based mechanisms for determining the split points of statistical aggregates (MdSPSA) into clusters.

In [3-6] the authors, practitioners and scholars, research and discuss methodological features of ABC-analysis, considering the important and

unresolved in its final form such a problem as the search for mechanisms of correct and easy-to-use method to detect edges (split dots) clusters or, as stated earlier, the mechanisms for determining the split points of statistical aggregates (MdSP-SA) to the corresponding clusters.

The study showed that the main methods of determining the SPSA and clustering in large statistical aggregates, for example in the range of commodity stocks are: the empiric method, the sum method; the differential method; the method of the polygon; the loop method ( according to A.M. Gadzhinskyi); the triangle method (by S.V. Afanasiev); the analytic method (or the tangent method) (by V.S. Lukinskyi); the method of average without a cumulative curve.

The first method – empiric (often is called "Pareto rule" or "80:20 rule") is seen almost in all of the investigated sources, including [1–10, etc.].

When applying the empiric method of Pareto (or the law 20:80) determination of the limit point of serial number iA (to determine the boundaries of the group A) involves finding in the sequence of ranked values such a cumulative value, which corresponds to 80% (or close to it value). All commodity groups located in a row above the number of the found product group (ie, the value of which 0.01 to 79%), shall be referred to group A.

Further, in the remaining 20% of the cumulative characteristics values, it is necessary to determine the limit point of the serial number of SPSA iB of the group B. Remaining after splitting of the cluster A series of cumulative values, in turn, divide into two groups in a ratio of 80% to 20%. Considering that 80% of 20 is 16%, we obtain the corresponding number SPSA iB with a value of 96% (at the same time is often referred to in the literature value of 95% [11, p. 196; 12, p. 195–196]. Thus, the commodity groups, with numbers located between SPSA iA (80%) and SPSA iB (96%) make up group B. The value of the commodity group of numbers, which exceeds the SPSA iB 96%, indicates that it belongs to the group C.

Except of purely experimental results, exist the theoretical ones justifying the principle of empirical method of ABC-analysis. One of them is presented in a paper by Razgulyaev [13]: it is necessary to obtain such a grouping, when the sum of the contribution of the objects in the grand total (cumulative, cumulative total), and the proportion of the number of these objects from the total number of objects will be equal to 100%.

The second – the sum method is recognized in [3] as a modification of the classical empiric method. It allows the selection of groups on the amount of the contribution of these objects share the common result: the boundary of A and B will be in the SPSA, the sum of the shares which will be equal to 100%, and SPSA groups B and C – where the sum of the corresponding indexes will be equal to 145%.

In the literature there are also other values of SPSA, for example, in [10], write that method SPSA amounts of A and B passes through the point of the diagram, the sum of coordinates of which is equal to the 80% ($\approx$ 10% +70%), while in the SPSA groups B and C – the point with the amount of coordinates 120% ($\approx$ 30% +90%).

The third method – differential. The basis of the differential method, according to [3], is the average (for all objects), the value factor. Objects whose value factor of six or more times greater than the average value for all objects belong to the group A. Group C includes those objects whose value factor of two or more times less than the average factor of the whole aggregate. The remaining objects belong to the group B.

These are the most common limiting factors. Nevertheless, there are other variants thereof. Should be noted that, in practice, the differential method gives too small group A (B – between 40–50% A – less than 5%) and a large group C.

Fourth – the polygon method or the method of double tangent. Its essence, according to [3; 10] is as follows: in the curve ABC-analysis of the polygon must be entered so that the area between the curve and polygon was minimal. Results for the application of this method are similar to the results of differential method: A group is too small and very large group C.

The fifth – loop method is suggested by A.M. Gadzhinskyi [6, p. 120–125]. It is designed to solve the problem of optimal allocation of two groups – high and low values – based on the notion of curvature of the curve, which is defined by its radius. For this it is necessary to select a part on the Pareto chart that has the greatest curvature (smallest radius of curvature), i. e. the transition between the more vertical (steep) part of the diagram to a horizontal (sloping). Algorithm of the method is to construct the trajectory of the end of the segment perpendicular to the tangent in the Pareto chart. The advantage of this method, according to many experts, there is a more precise definition of boundaries of the group, as well as the ability to automate the process.

The sixth method of the triangle is mentioned in the S.V. Afanasiev's article [2] and [3; 10]. This method, just like the loop method also solves the problem of optimal allocation of two clusters in the diagram Pareto: groups of high and low values are distinguished. The method is based on a mathematical feature by which the set of all Pareto charts that pass through one of the Pareto points, lies in an area that is bounded by two limiting Pareto charts, which have a shape of two-linked polygonal curves. The main advantage of the triangle is its flexibility – the method shows a high accuracy in both the average values of the Pareto point, and in the region of the boundary values. It is noted that in the mean values this method loses in precision to the polygon method.

Seventh is the analytical method or the method of tangents is considered in [3; 5; 10]. This method can be implemented in two ways: analytical and geometric (graphical) and analytical – calculating.

Analytical method (graphical method). In its application the graphical construction is performed according to the progressive total of the serial number of commodity groups in the ordered sequence of descending values of the analyzed parameters – volume of commodity stocks.

The average value of the analyzed aggregate parameter of commodity groups in % can be calculated as

$$\mathrm{T}^{\%} = \frac{100\%}{N}, \qquad (1)$$

where $N$ is the total number of commodity groups in the given set.

Group B includes commodity groups, the value of which exceeds the average value for a truncated set of product groups, of which the group A is excluded.

In [5, p. 32–34] V.S. Lukinskiy gives an implementation algorithm of the graphical method. The algorithm consists of six steps, using the method of ordinary least squares (OLS) to obtain a system of normal equations, and Lagrange's method to calculate the abscissa of the point of tangency.

It should be noted that this method of implementation of the ABC method does not depend on empirical relationships, such as "80%:20%" more objectively and consider the nature of growth of the total parameter $\sum^{\%}$ depending on the index $i$. However, this approach does not allow to identify any groups in the case where the curve is not convex.

Analytical method (calculating way). In this case, the numerical values of the indexes $i_A$ and $i_B$, defining partition of the aggregate of commodity groups, are determined by calculations. To use this method, first the normalization of raw data is carried out, leading them to the interval $0 - 1$. To do this, use the value as an argument

$$x_i = \frac{i}{N}. \qquad (2)$$

where $N$ – total number of commodity groups in the given set.

And as a analyzed function share inventory (turnover) commodity groups are used cumulatively.

Further, based on the type of functional dependence approximation of a type is carried out

$$y = f(x, a_p). \qquad (3)$$

where $a_p$ – some constant coefficients.

Values of these coefficients are selected from the best approximation by using OLS.

This method is a formalization of the graphical method. And so, apparently, will retain its shortcomings.

Eighth – graphical analytical method of average without a cumulative curve is elaborated by authors of this paper and will be explained and described more fully.

This graphical analytical method is offered as an alternative scientifically based and simpler (without using the Lagrangian, OLS, etc.) to use a method for identifying SPSA ABC-analysis.

Analytical study correctness of the suggested method is given in [14]. Method is proposed as an alternative and more simple methodological tool to determine the SPSA. The offered method provides the following algorithm for the formation of groups A, B and C:

1) ranking of values of the main factors/ indicators in descending order (but, unlike other methods, without calculating of the cumulate) is carried out;

2) the arithmetic mean of the proportion of all product groups in the final index (in%) is calculated. Group A includes all commodity group, the unit weight of which exceeds the average value;

3) the second average unit weight for a new set of product groups ( those that are not included in the group A) is defined in the same way. Group B includes those commodity groups that will be between the bottom of Group A and above second average unit weight for a new set of product groups;

4) commodity groups that remained after the separation of the groups A and B (ie, below the second average unit weight for a new set of product groups) are included into group C.

Thus, the method of average without a cumulate (descending) allows the formation of groups A, B and C without formation depending funded share turnover for various commodity groups as a percentage of the commodity group numbers after sorting descending own share. This method allows to be limited by sorting commodity groups in descending order of their proportion in the total.

**Conclusions.** The main element of science – based formalized mechanism of differentiation of statistical sampling to separate clusters mechanism is correct and easy to use method to detect edges (split points) clusters.

In the theoretical arsenal of the ABC analysis method, there are not only a priori intuitive and empirical, but also special scientifically based mechanisms for determining the split points of statistical aggregates (MdSPSA) into clusters.

The main methods of determining the SPSA and clustering in large statistical aggregates, for example in the range of commodity stocks are: the empiric method, the sum method, the differential method, the method of the polygon, the loop method (according to A.M. Gadzhinskyi), the triangle method (according to S.V. Afanasiev), the analytical method (or the method of tangents) (according to V.S. Lulinskyi), the method of average without a cumulate.

The results of this study may be defined not only of theoretical interest, but also in practice to promote the correct division of the aggregate of commodity stocks of retail into clusters for the further appropriate management.

Prospects for further research in this direction is to develop recommendations for strategic and tactical management of clusters identified with the help of MdSPSA using ABC analysis.

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