Methods of marketing assessment of enterprise market position based on the analysis of indicators in assortment space

A M Pishchukhin

Orenburg State University, 13, Victory Avenue, Orenburg, 460018, Russia

E-mail: Pishchukhin55@mail.ru

Abstract. Multidimensional space is a convenient means of presenting large amounts of information. This fully applies to the assortment space of a particular enterprise. The novelty of the approach of this study is based on the fact that a large amount of information on the sales of products of each type from the range is reduced to three integral indicators: the total sales, remoteness from the beam of norms in the plane of equal contributions and the angle of rotation of beam on image point relative to main view products. In this case, the norm beam is constructed as a locus of points with the same ratio between coordinates based on regional statistics on the types of studied products. Remoteness and rotation angle are determined in the plane of equal contributions, that is, where enterprises are located, with the same total sales. The paper shows that such a presentation allows simplifying and cheapening the marketing algorithm, increasing the management system speed of an enterprise.

1. Introduction

The use of multidimensional space, as a way of presenting a large amount of information used to formulate and solve complex control problems, provides many advantages. Such methods are intensively developed in line with the processing of big data using OLAP technologies. In multidimensional space, it is possible to determine the target area of normal state of control object and its current state to be evaluated in relation to this area. At the same time, it is also convenient to form a strategy of returning to this area in case of emergency situations [1-4].

2. Theory

The ideas of multidimensional space were expressed in the 18th century by I Kant and J D’Alamber, and multidimensional geometry was constructed by A Cayley, G Grassmann and L. Schleffi in the past century [5]. The advantage of the method with a small dimension is visibility. Tasks with a dimension of up to three coordinates can be illustrated on two-dimensional paintings, drawings and drawings, which greatly helps the study. However, with more measurements, the visibility of this method is lost. Nevertheless, a multidimensional representation of the state of an enterprise in the assortment space allows building an enterprise management strategy even if there are competitors [6].

Consider this method of presenting and analyzing data in more detail. To do this, in a multidimensional space, coordinates are plotted along the coordinate axes, estimating the sales values in the corresponding units of measure for each of the products of enterprise range. Obviously, in stable market conditions, there are norms for the consumption of all products, and even if total sales volumes...
change when going from one regional market to another, the ratio between sales volumes for each type of product approximately remains.

The locus of the points having the same ratio between the coordinates will be the ray emanating from the origin described by the equation

\[ x_i = tx_{Ai} \]  \hspace{1cm} (1)

where \(x_{Ai}\) are the components of the radius of the vector defining the beam, \(t\) is an arbitrary parameter that allows you to run along this beam. It can be called the ray of norms.

Exploring this formulation of the problem, the authors note that the points are important and the scale of the enterprise, that is, the total volume of sales and the state of an enterprise must be compared with its equal in scale. The locus of points with the same sum of coordinates is the hyperplane, described by the equation

\[ \sum_{i=1}^{n} x_i + D = 0 \]  \hspace{1cm} (2)

A distinctive feature of this formula are the unit coefficients at all coordinates. For two coordinates, this property has a straight line running at an angle of 45 degrees to the axes of coordinates. On such a line for each point, increasing one coordinate results in equal decreasing the other, so the amount will be saved.

Similar reasoning in three-dimensional space leads to a plane inclined at equal angles to all coordinate planes.

However to maintain the properties of equal scale in the formula (2) and the coordinates must be equal. However, the actual sales for each type of product are obviously different. To overcome this problem, the authors use scaling factors. In Figure 1, the products are arranged in ascending order of sales for 10 types of products marked along the horizontal axis, indicated by the corresponding histograms in arbitrary units.

![Figure 1. Determination of scaling factors.](image)

The authors take the center line of these histograms as the reference level. As it follows from the figure, product types 1 to 5 have scale factors greater than one, and from 7 to 10 less than one.

Turning to the new coordinates, the authors keep the proportions of sales when the scale of the enterprise changes, which increases as they move along the beam as they move away from the origin. The hyperplane described by equation (2) in these coordinates is called the plane of equal contributions.

3. Model

The beam of norms can be constructed using the statistics of this region. To determine the position of the vector defining the beam by the formula (1), the authors use the method described in [7]

\[ \sum_{j=1}^{m} x_{ij} (\sum_{k\neq i}^{n} x_{Ak})^2 + x_{Ai} \sum_{k\neq i, k=1}^{n} x_{Ak} (\sum_{j=1}^{m} x_{ij} - \sum_{j=1}^{m} \sum_{i=1}^{n} x_{ij}) = 0, i = 1, ... n \]  \hspace{1cm} (3)

Here \(x_{ij}\) is the \(i\)-th coordinate of the \(j\)-th enterprise, of all enterprises \(m\).

However, in practice, the depicting point describing this enterprise will deviate in the plane of equal contributions from the point of intersection of this plane with the beam of norms. This is due to local
circumstances - for example, features of retail outlets.

The difference between a niche of a particular enterprise can be assessed by two parameters determined in the plane of equal contributions: the distance of the imaging point from the point of intersection of the norm beam and the plane of equal contributions and the angle of rotation of the beam to the imaging point.

To determine the distance of the imaging point $B$, one must first build a plane with the same sum of coordinates. To do this, the authors substitute its coordinates into equation (2) and find the parameter $D$.

Finally, the equation of the plane

$$\sum_{i=1}^{n} x_i - \sum_{i=1}^{n} x_{Bi} = 0$$

Now it is necessary to find the point $C$ of the intersection of the norm ray with the plane thus defined, for which the authors substitute the coordinates (1) into equation (4) and determine the desired point $C$ through the parameter

$$t_C = \frac{\sum_{i=1}^{n} x_{Bi}}{\sum_{i=1}^{n} x_{Ai}}$$

As a result, remoteness is estimated by the following formula

$$\rho = \sqrt{\sum_{i=1}^{n} (x_{Bi} - \frac{\sum_{k=1}^{n} x_{Bk}}{n} x_{Bi})^2}$$

The angle of rotation of the beam on the imaging point in the plane of equal contributions must be counted from some line. The authors take in this quality the line of intersection of the constant plane on the reference product (considered basic at the enterprise) with the plane of equal contributions. The equation of this line is as follows.

$$\sum_{i=1}^{n} x_i - \sum_{i=1}^{n} x_{Bi} = 0$$

where $x_1 = \text{const} = x_{C1}$

It is accepted that the direction vector $\vec{d}$ of this line has unit coordinates and obeys the system of equations (7) from which one can find its second coordinate

$$a_2 = \sum_{i=1}^{n} x_{Bi} - x_{C1} - n - 2$$

The ray on the image point has a vector representation.

$$\vec{x}_{BC} = \vec{x}_{C} + t(\vec{x}_{B} - \vec{x}_{C})$$

The angle between the straight lines is determined by the scalar product

$$\cos \varphi = \frac{\vec{a} \cdot \vec{x}_{BC}}{||\vec{a}|| ||\vec{x}_{BC}||}$$

From here

$$\varphi = \arccos \left[ \frac{\sum_{i=1}^{n} x_{Bi} - x_{C1} - n - 2 + \sum_{i=1}^{n} (x_{Bi} - x_{C1}) \sqrt{\sum_{i=1}^{n} x_{Bi} - x_{C1} - n - 2 + \sum_{i=1}^{n} (x_{Bi} - x_{C1})}}{x_{C1}^2 + \sum_{i=1}^{n} (x_{Bi} - x_{C1})^2 + n - 2 + \sum_{i=1}^{n} (x_{Bi} - x_{C1})} \right]$$

Using this technique, information of multidimensional space is integrated in only three indicators: the total volume, the distance of the imaging point and the angle of rotation of the beam.

4. Data and modeling results

To test the effectiveness of the proposed methodology, a beam of norms was constructed on the basis of the assortment presented on the histogram of Figure 1. For this, the histograms were blurred with variance 2 and shifted by two units as well. Sales volumes are reduced to conventional units and are presented in the table.

| Sales by product | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|------------------|---|---|---|---|---|---|---|---|---|---|
| Sales,           | 1 | 3 | 4 | 5 | 8 | 10| 11| 15| 17| 21 |
| conventional units | | | | | | | | | | |

The results of the calculations are presented in Figure 2.
5. Discussion
The results are presented in a cylindrical coordinate system; on a horizontal plane, the distance \( \rho \) and the angle of rotation \( \phi \) are deposited. The vertical axis shows the total sales. The niche occupied by an enterprise is highlighted by a cylinder, therefore approaching the borders of this cylinder and, even more so, going beyond them should be perceived by the marketing service as a guide to action. Going beyond the boundaries of the cylinder vertically means overproduction or underproduction of products; going beyond the side formers means distortions in production in one direction or another.

The results obtained quite clearly show the effectiveness of the developed methodology, which increases with increasing assortment diversity.

6. Conclusion
Thus, the method of marketing assessment of the market position of a company allows quickly integrally assessing the situation based on the analysis of all three indicators in the assortment space. It has the following advantages:
- increases the speed of the management system and, accordingly, accelerates the company's response to market changes;
- transfers control to the deviation mode, which greatly simplifies the corresponding control algorithms;
- saves management resources

Appropriate algorithms and their software implementation will allow minimizing the influence of the personal factor on the accuracy of market diagnostics and the formation of the most effective strategy of enterprise behavior. Thus, the work of the marketer is transferred to another level with a quick orientation in a large amount of information.

References
[1] Constantiou I D, Kallinikos J 2015 New games, new rules: Big data and changing context of strategy. *J. of Information Technology* **30** 44–57
[2] Daniel N 2016 The Declining use of the Term Market Research: An empirical analysis *Int. J. of Market Res.* https://doi.org/10.2501/IJMR-2016-031
[3] Maheswari S N 2014 Elements of Financial Management. *Sultan Chand & Sons*, (Educational Publishers, New Delhi)
[4] Woerner S, Wixom B 2015 Big data: Extending the business strategy toolbox. *J. of Information Technology* **30** 60–62
[5] Yushkevich A P 1972 *The history of mathematics (volume 3). Mathematics of the XVIII century* (Moscow: Nauka) 496 p.
[6] Pishchuhin A M 2017 Enterprise management based on the forecast in the assortment space
Economy of the region. \textbf{13(1)} 216–225

[7] Akimov S, Vedeneev P, Kiyaeva E, Laryushina I, Notova S, Pishchukhin A A 2017 multidimensional approach to assessing the elemental status of the organism \textit{J. of Physics: Conf. Ser.} \textbf{913(1)} 012002

[8] Akimov S, Vedeneev P, Pishchukhin A M 2018 Multidimensional model for estimating the error in the diagnosis of the organism elemental status \textit{Int. Rev. of Automatic Control}. \textbf{11(4)} 198–202