Modeling of object competitiveness based on hybrid method assessment

T L Bezrukova¹, G P Fomin², S S Kirillova¹, B A Bezrukov¹

¹ The Voronezh State University of Forestry and Engineering named after G.F. Morozov, 394087, Russia, Voronezh, Timiriazeva st., 8
² Russian University of Economics named after G.V. Plekhanov, 117997, Russia, Moscow, Ctremiannyj pereulok, 36

E-mail: bezrukova_t_l@mail.ru

Abstract. The article covers the aggregation informal and mathematical methods in competitiveness of objects of different origin basing on hybrid assessment method. The given method includes principles of systemic analysis of structurization and quantification that leads to the analysis of the competitiveness problem and complex implementation of multicriteria method of optimization, and also methods of ranging of characteristics of the object to be assessed, methods of dual comparisons, methods of integral programming, Hungarian method, reduction, method of tests and errors. The feature of the method is the advantages integration of different quality methods of analysis with formal methods to obtain the quantitative characteristics of results of competitiveness for different consumer levels. The certain extracts of the big solved task are given together with a lot of single and integrated assessments. The certain parts of a huge task solved are also presented in the article. The result tables with conclusions are also presented here. The results change primary view of consumer, make mental outlook wider and change the attitude of consumer towards the competitiveness in particular. The description of transition from methods and models use to the assessment of object competitiveness is given. That shows the possibility of hybrid method application according to the object competitiveness of different origin.

1. Introduction
At present some organizations are more successful than the others. Some are in deep crises. That is the natural economical process. To provide the competitiveness of the enterprise it is needed to reach a certain level of profit that will help it to survive in future. It is evident, that the mechanism of enterprise adaptation to the changeable market conditions should be created. The mechanism of competitiveness management should be worked out to aggregate measures for systematic development of constituent parts of the object. Methodology of competitiveness assessment for practical use has not been worked out by the present time.

The basis of the competitiveness of the enterprise is the competitiveness of its product, that is its system generated component. All parts of the chain are concentrated on it. That is the basis of the entrepreneurial activity. [1] Goods are the basis of entrepreneurial activity. Business and market policy are defined by product, goods and services. It is evident that competitiveness assessment is advisable to do in complex according to the more accessible indexes and direction of activity. Competitiveness deflection means risks, and deflection value defines the program, content and necessary investment to provide the object competitiveness.

2. Theoretical, Informational, Empirical, and Methodological Grounds of the Research
Target assessment of competitiveness is to reveal the readiness of staff and individual worker to fulfill the particular kind of activity and also to reveal the level of potential ability for professional and occupational development of individual worker [2].
Competitiveness of enterprise means: sales volume cost and quantity, profit, share of cost of unsold products in store, competitiveness index, profitability, costs. Assessment of competitiveness of object is a multi complex task that defines a good deal of factors of different origin. However, we need to carry out the given task for fulfillment of a number of activities such as finding of the main strategic ways for goods production, working out the firm staff training program to provide the competitiveness of the staff and the whole organization itself. The methodology of competitiveness has not been worked out properly for practical use by the present time. The complexity of origin of competitiveness specifies a number of methods of its assessment. [3]

Methods of competitiveness assessment are multifarious and are limited in usage. Competitiveness is preferable to assess in complex way according to the most accessible indexes and ways of activity. Deviation of competitiveness defines risk, but the value of deviation defines the program, content and investments needed to provide the competitiveness of the organization. Competitiveness of organization is defined by the following: sales volume cost and quantity, profit, share of cost of unsold products in store, competitiveness index, profitability, costs.

Assessment methods can be divided into three categories, they are: qualitative, quantitative and combined. [4] The most objective methods are quantitative because all the results are obtained in digits with the help of which it’s easier to compare them. To get more objective result the combination of qualitative and quantitative methods is used. It’s called combined method. [5]

However, the methods mentioned in the article do not allow of getting the objective results for competitiveness assessment of the organization, personnel, group of workers, staff of the division and department. Moreover, the methods are labor intensive at initial data collection. [6] That gave cause for usage of advantages of the existing qualitative and quantitative methods in combining them with the other methods. To eliminate the given faults in the existing models of competitiveness assessment the hybrid method of competitiveness assessment of object, organization, staff or product is proposed to apply. Multitude of qualitative and quantitative indexes of any object is suggested to use as a background. In general we shall work with indexes that define its ability to dominate in the specific sphere of activity, then we shall work with ranging with the calculation of weight next following and estimation of integral characteristics along the all levels of hierarchical indexes tree, that makes the competitiveness of object. All mentioned above made us formulate the hybrid method of competitiveness assessment from the point of systems analysis which is suitable for the objects of different origin. Nowadays problems of competitiveness assessment and conducting the optimization of investments are the most popular discussed among the bosses within international forums. The purpose of competitiveness assessment is to reveal the readiness of the staff and individuals the ability to fulfill exactly that kind of activity which they should do. And also the task is to reveal the potential of the workers for defining the professional and official growth.

3. Results
The following methods are worked out basing on contraction of criteria, indexes or characteristics where one scalar criterion instead of multitude of different origin partial criterion is considered. It is acquired by combination of partial criterion. There are multiplicative and additive methods of criteria contraction. The criteria must be commensurate, for example, standardized and weight criteria defined, that characterizes the importance of every criterion. Then we build a new efficiency function and the task of scalar criterion optimization is fulfilled [7].

In this case, the method of transition from several i.e. multitude indexes P_1, P_2, ..., P_m to one specified by a new function \( Q = \sum (V_j P_j) \) is called compression or the method of generalized criterion, where \( V_j \) are weight coefficient criteria, provided weight sum \( \sum V_j = 1.0 \). It’s fairly evident that the more is \( V_j \) the more contribution j index is being contributed to the integrated criterion Q.
In this case, for each quality index \( p_j(a_i) \) of the object \( a_i \in A \) its weight \( V_j \) is calculated defining its meaning, after that the weighed sum of these indexes can be considered as a summarized assessment of the competitiveness of the object \( a_i \):

\[
K(a_i) = \sum_{j=1}^{n} V_j p_j(a_i)
\]  

(1)

The suggested type of competitiveness assessment can be formulated as a three-level structure and modify the existing methods for competitiveness assessment of product, organization or personnel [8]. As a framework it’s necessary to use individual, single, group and integral aggregation indices (table 1). In this case at the beginning a hierarchical, usually a three-level structure of indices of the object being under consideration is been graphed.

### Table 1. Analyses of the object characteristics.

| \( X_1 \) | \( X_2 \) | \( X_3 \) | \( X_4 \) | \( X_5 \) | \( X_6 \) | \( X_{7,1} \) | \( X_{7,2} \) | \( X_{7,3} \) | \( X_8 \) | \( X_9 \) |
|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| \( A_1 \) | 150 | 1998 | 589 | 1580 | 170 | 12.8 | 10.2 | 6.3 | 7.7 | 182 | 124 |
| \( A_2 \) | 150 | 1998 | 591 | 1601 | 170 | 11.2 | 10.6 | 6.8 | 8.2 | 180 | 18 |
| \( A_3 \) | 150 | 1998 | 564 | 1469 | 172 | 11.2 | 10.6 | 6.8 | 8.2 | 180 | 31 |
| \( A_4 \) | 150 | 1998 | 463 | 1455 | 210 | 9.8 | 8.20 | 5.9 | 6.7 | 187 | 0 |
| \( A_5 \) | 150 | 1998 | 415 | 1455 | 195 | 11.9 | 10.5 | 6.8 | 8.1 | 188 | 7 |
| \( A_6 \) | 141 | 1997 | 410 | 1454 | 200 | 11.3 | 10.8 | 6.8 | 8.2 | 178 | 62 |
| \( A_7 \) | 167 | 2384 | 420 | 1750 | 200 | 11.0 | 12.8 | 7.3 | 9.3 | 175 | 2 |
| \( A_8 \) | 148 | 1998 | 410 | 1580 | 180 | 11.5 | 9.60 | 6.5 | 7.6 | 180 | 85 |
| \( A_9 \) | 152 | 1798 | 405 | 1505 | 180 | 9.0 | 10.6 | 6.8 | 8.0 | 192 | 6 |
| \( A_{10} \) | 150 | 1390 | 470 | 1621 | 200 | 9.6 | 10.1 | 6.7 | 8.0 | 192 | 3 |

To assess competitiveness of the object and to choose the preferable one we distinguished some models of vehicles: \( A_1 \) – Honda CR-V, \( A_2 \) – Hyundai ix 35, \( A_3 \) – KIA Sportage, \( A_4 \) – Mazda CX-5, \( A_5 \) – Mitsubishi ASX; \( A_6 \) – Nissan Qashqai; \( A_7 \) – Opel Antara; \( A_8 \) – Toyota RAV 4; \( A_9 \) – Skoda Yeti; \( A_{10} \) – Volkswagen Tiguan, their characteristics are given in Table 1 according to the indices: \( X_1 \) – engine capacity (h.p.), \( X_2 \) – volume of engine (\( \text{cm}^3 \)), \( X_3 \) – boot volume (l), \( X_4 \) – laden mass (kg), \( X_5 \) – clearance (mm), \( X_6 \) – acceleration up to 100 km/h, \( X_7 \) – petrol consumption (l/100 km): \( X_{7,1} \) – town, \( X_{7,2} \) – motorway, \( X_{7,3} \) – mixed; \( X_8 \) – max speed (km/h), \( X_9 \) – hijacking (item).

To estimate the weight of each index we use the following formula

\[
V_i = \frac{S_i}{n^2}
\]  

(2)

Ranging of the indices to define their meaningfulness we follow the rule due to which the domination of matrix elements is defined

\[
b_{ij} = \begin{cases} 
1, & \text{if } P_i \text{ equivalent } P_j, \\
0, & \text{if } P_i \text{ less important than } P_j, \\
2, & \text{if } P_i \text{ dominates over } P_j
\end{cases}
\]  

(3)

Ranging operations and defining the weight of indices we conduct foe each group of indices and we put the down into the table 2, for example, economic, technical, comfort ability, esthetics, safety. [9]

By-turn, each group contains the characteristics. We conduct the ranging and also define the weight – meaningfulness of each index.
The above-mentioned method allows us to conduct an activity of indices convolution converting into a single integral one considering the weight of each and their absolute meanings. It’s important to mention that the high index value is not always good, sometimes it’s vice versa. For example, fuel consumption of the vehicle, it’s necessary to introduce 5 or 10 grade assessment of indices $B_i(p_i)$ due to the scale “worse-better”, where the worst index gets low grade. For instance, vehicle operation costs to be compared with sale proceeds. Indeed, the higher the content of grade the $B_i(p_i)$ the better index [10]. Table 2 shows interval indices values in grades. So, we transform the model of competitiveness of the object to the following

$$K(a_i) = \sum_{i=1}^{n} V_j B_j(p_j(a_i))$$

(4)

| $B_i(p_i)$ | 1 | 2 | 3 | 4 | 5 |
|-----------|---|---|---|---|---|
| X1        | 140.0 – 145.0 | 146.0 – 151.0 | 152.0 – 157.0 | 158.0 – 163.0 | 164.0 – 170.0 |
| X2        | 1390.0 – 1589.0 | 1590.0 – 1789.0 | 1790.0 - 1989.0 | 1990.0 – 2189.0 | 2190.0 – 2390.0 |
| X3        | 400.0 – 439.0 | 440.0 – 479.0 | 480.0 – 519.0 | 520.0 – 559.0 | 560.0 – 600.0 |
| X4        | 170.0 – 177.0 | 178.0 – 185.0 | 186.0 – 193.0 | 194.0 – 201.0 | 202.0 – 210.0 |
| X5        | 13.00 – 12.2 | 12.10 – 11.40 | 11.30 – 10.6 | 10.50 – 9.80 | 9.70 – 9.00 |
| X6        | 13.00 – 12.0 | 11.90 – 11.00 | 10.90 – 10.0 | 9.90 – 9.00 | 8.90 – 8.00 |
| X7        | 175.0 – 179.0 | 180.0 – 183.0 | 184.0 – 187.0 | 188.0 - 191.0 | 192.0 – 195.0 |
| X8        | 124.0 – 100.0 | 99.00 – 75.00 | 74.00 – 50.00 | 49.00 – 25.00 | 24.00 – 0.00 |
| X9        | 140.0 – 145.0 | 146.0 – 151.0 | 152.0 – 157.0 | 158.0 – 163.0 | 164.0 – 170.0 |

Thus, the method was created on the basis of qualitative and quantitative indexes of object application basing on requirement usage. The hybrid methods comprises aggregation of a few methods of research: interview method, expert judgment, method of paired comparison, rank method, method of grade assessment, method of integer programming, Hungarian method, reduction method, trial and error method.

So we have a decisive rule: object $a_i$ is more preferable than object $a_j$, if $K(a_i)>K(a_j)$. Then we find integral indices $K_1, K_2, K_3, K_4, K_5, K_6$ all through the groups, after that – weight – meaningfulness $V_s, V_r, V_a, V_{sc}, V_0$ of group indices, and at last, we find the integral index of competitiveness according to the formula:

$$K(a) = \sum V_i K_i$$

(5)

Thus, we define competitiveness of the object in the large:

$$K(a) = V_s K_s + V_r K_r + V_a K_a + V_{sc} K_{sc} + V_0 K_0$$

(6)

In the large the structure of object indices consists of several groups: technical, aesthetic, mechanical, safety, economical. Due to this we define the indices weight of group of characters by the method of paired comparison:

$$V_s = 0.36V_s + 0.28V_k = 0.04V_{sc} = 0.12V_e = 0.2K_6$$

(7)

Thereupon we write the following target function:

$$K(a) = V_s K_s + V_r K_r + V_a K_a + V_{sc} K_{sc} + V_0 K_0 = 0.36V_s + 0.28V_k = 0.04V_{sc} = 0.12V_e = 0.2K_6$$

(8)
After that we conduct the ranging of each group of characteristics by the method of paired comparison, involving experts - specialists. We define their weights, grades of characteristics and integral grades due to their aggregates (table 3). It allows us to calculate the following:

\[ K_s = 3.82K_r = 2.8K_r = 1.6K_{sc} = 3.2K_{sc} = 1.1. \]  

(9)

Basing on the mentioned above we define general competitiveness:

\[ K(a) = V_1K_s + V_2K_r + V_3K_r + V_4K_{sc} + V_5K_{sc} + V_6K_{sc} = 0.36 \times 3.82 + 0.28 \times 2 + 0.04 \times 2.6 + 0.12 \times 3.2 + 0.2 \times 2.2 = 2.822, \]  

(10)

| A_1   | X_1 | X_2 | X_3 | X_4 | X_5 | X_6 | X_7 | X_8 | X_9 |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 0.188 | 0.64 | 0.78 | 0.156 | 0.10 | 0.609 | 0.094 | 0.23 | 2.22 |
| 0.188 | 0.64 | 0.78 | 0.156 | 0.28 | 0.609 | 0.047 | 1.17 | 3.30 |
| 0.188 | 0.64 | 0.78 | 0.156 | 0.28 | 0.609 | 0.094 | 0.94 | 3.11 |
| 0.188 | 0.64 | 0.312 | 0.78 | 0.38 | 1.015 | 0.188 | 1.17 | 4.10 |
| 0.188 | 0.64 | 0.156 | 0.624 | 0.19 | 0.609 | 0.188 | 1.17 | 3.19 |
| 0.094 | 0.64 | 0.156 | 0.624 | 0.28 | 0.609 | 0.047 | 0.70 | 2.58 |
| 0.470 | 0.080 | 0.156 | 0.624 | 0.28 | 0.203 | 0.047 | 1.17 | 3.03 |
| 0.188 | 0.064 | 0.156 | 0.312 | 0.19 | 0.812 | 0.141 | 0.47 | 2.33 |
| 0.282 | 0.048 | 0.156 | 0.312 | 0.47 | 0.609 | 0.235 | 1.17 | 3.28 |
| 0.188 | 0.016 | 0.312 | 0.624 | 0.47 | 0.609 | 0.235 | 1.17 | 3.11 |

Table 3. Integral grades of indices.

Table 4 shows the following criteria of choice: Y_1 – correlation of price and quality (min), Y_2 – horse power cost (rub.), Y_3 – petrol consumption for 60000 km (rub.), Y_4 – cost of three Technical Checkup (rub.), Y_5 – Insurance (Compulsory Automobile Insurance) within 3 years (rub.), Y_6,7 – cost reduction within 3 years in% (thousand rub.), Y_8 – quality integral grades (max), Y_9 – total cost of possession.

| X | Y_1 | Y_2 | Y_3 | Y_4 | Y_5 | Y_6 | Y_7 | Y_8 | Y_9 |
|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| A_1 | 549346 | 8127 | 192780 | 30973 | 16632 | 31 | 841 | 2.219 | 618275 |
| A_2 | 324332 | 7127 | 200340 | 18870 | 16632 | 42 | 620 | 3.296 | 684822 |
| A_3 | 356995 | 7399 | 200340 | 26442 | 16632 | 43 | 632 | 3.109 | 720671 |
| A_4 | 304177 | 8300 | 154908 | 26850 | 16632 | 30 | 871 | 4.093 | 571590 |
| A_5 | 332287 | 7060 | 198450 | 23348 | 16632 | 25 | 794 | 3.187 | 503108 |
| A_6 | 399534 | 7305 | 204120 | 29692 | 14256 | 38 | 638 | 2.578 | 639468 |
| A_7 | 374340 | 6796 | 241920 | 27565 | 19008 | 31 | 783 | 3.032 | 640043 |
| A_8 | 474023 | 7459 | 181440 | 26500 | 16632 | 31 | 762 | 2.329 | 566812 |
| A_9 | 313528 | 6770 | 200340 | 18347 | 19008 | 40 | 618 | 3.282 | 649295 |
| A_10 | 337837 | 7000 | 190890 | 25867 | 16632 | 41 | 602 | 3.108 | 681559 |

Table 4. Calculations of choice criteria.

Various criteria given in the table 4 denote the choice A_5 – Mitsubishi ASX.
4. Conclusions and recommendations

The obtained results let us evaluate competitiveness of other objects to be compared. Thus we can choose one object out of multitude or formulate a set of choices in the long run. We can also conduct a comparison evaluation of competitiveness of organizations, enterprises, personnel. We can work out some management measures for various spheres of activity.

It’s necessary to point out that the attention must be given to the analysis of risks in the system of organizations for it’s a factor of competitiveness raise. Risk analysis is on of the widely spread in spheres of production and trading.

The given hybrid method can be used for competitiveness assessment of personnel where the etalon-indicators are the initial data. They are the requirements for every occupation (competence). Then the comparison of individual person of the staff is made both positive features (communicative skills, professional experience) and negative (aggressiveness, contentiouseness, irritability). After that the comparison of the list of characteristics, ranging, weight defining is made. After that we proceed to the formulation of the integer-valued programming task which can be solved with the help of Hungarian method available for users in the internet. Consequently, the most complicated, force consuming and important is the collection of the initial data and the task formulation.

To be concluded, the hybrid method of competitiveness has bee made basing on the implementation of quantitative and qualitative indices of object of different origin. The hybrid methodology includes a number of research methods and techniques: method of interview, method of expert assessment, method of paired comparisons, ranging method, grading evaluation, method of integer-valued programming, Hungarian method, method of reduction, method of trial and error. The hybrid method of competitiveness assessment has lots of advantages those are the various quality methods of analysis that means result comparison convenience all through the customers levels.

References

[1] Bezrukova T L, Stepanova Yu N, Shanin I I, Busarina Yu V and Nesterov S Yu 2017 European Research Studies Journal 20 №3 183-92
[2] Gashenko I V, Romanov D G, Vokina S G, Bezrukova T L and Kozenko Y A 2016 Contemporary Economics 10 №4 363-72
[3] Han Y, Jeong J, Ko M H, Lee S and Kim J 2018 ICIC Express Letters, Part B: Applications 9(4) 339-46
[4] Lau H C, Ip A, Lee C K M and Ho G T S 2018 Benchmarking 25(7) 2216-29
[5] Zakeri A, Saberi M, Hussain O K and Chang E 2018 International Journal of Fuzzy Systems 20(4) 1224-39
[6] Bobel I 2017 Competitiveness Review 27(4) 433-435
[7] Kuhlman C, Ramamurthy K N, Sattigeri P, Lozano F C, Mojsilovic A and Varshney K R 2017 IBM Journal of Research and Development 61(6) 81673366
[8] Caseiro N and Coelho A 2018 Competitiveness Review 28(2) 213-26