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MULTI-CRITERA SELECTION OF A CORPORATE SYSTEM BY USING PAIRED COMPARISON ANALYSIS

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ABSTRACT

The paper presents the results of comparing foreign corporate information systems (CISs) obtained by using the classical analytic hierarchy process (AHP). The eight most common corporate information systems of international standards were analyzed by 43 criteria, grouped into 7 classes of characteristics. Besides identifying the corporate systems which are the most preferable for implementation, there were determined some classes of criteria which are vital when selecting a system, and for each criterion 3-4 most suitable systems were identified.

Keywords: corporative information systems, multi-criteria assessment and selection, paired comparison analysis, analytic hierarchical procedure, classes of criteria.

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INTRODUCTION

At present, corporate information systems (CISs) are the only possible option for large enterprises and corporations to automate all aspects of their activities and to take managerial decisions [1-5].

The main task of the CIS is the effective management of the material, technical, financial, technological and intellectual resources of an enterprise to maximize the profit and to meet material and professional needs of all the employees of the enterprise.

Managing a company by means of CIS should be based not only on an in-depth data analysis, but also on the extensive use of information support systems for decision-making within a business management strategy.

Modern CISs make up a single information system, coordinate the activities of employees and business units on the basis of providing access to the necessary information at the appropriate level of detail, and supply the management with reliable data on implementing the production process, assisting strategic and operational decision-making. The most sophisticated CISs are designed to automate all the functions of corporate management.

There have been various CISs in the world, both international and Russian [6, 7]. In the Russian market of ERP-systems there are a number of suppliers: both foreign and Russian ones. According to some experts, the main market share (over 48%) is held by the German vendor SAP AG, followed by Microsoft Business Solution products enjoying a share of about 13%, with Oracle coming third controlling over 11% of the Russian market of ERP-systems. Such a considerable breakaway by SAP can be partly explained by the German concern being the first to enter the Russian market. As for the world market, the situation is a bit different, with the main competitors being SAP and Oracle.

Currently, there are about a dozen Western and three to four Russian information systems present in the Commonwealth of Independent States which can be considered as corporate ones [7].

In this paper, we will confine ourselves to studying the best world practices in the sphere of designing and implementing CISs, from which we chose eight most widely used ones.

METHODS

In order to determine which characteristics of CISs are the most important when selecting the best product and which of the foreign CISs are the most preferable from the point of view of implementing their characteristics which are considered essential, it is advisable to use a multi-criteria assessment apparatus which allows comparing characteristics with one another and objects by the degree of intensity of the compared characteristics. The most popular method for multi-criteria assessment is the hierarchy analysis method [8].

In this paper, the problem of selecting the best CIS will be solved using the classical Saati hierarchy analysis method, which means taking the following steps [8, 9]:

1. Top-down hierarchical decomposition of the problem.

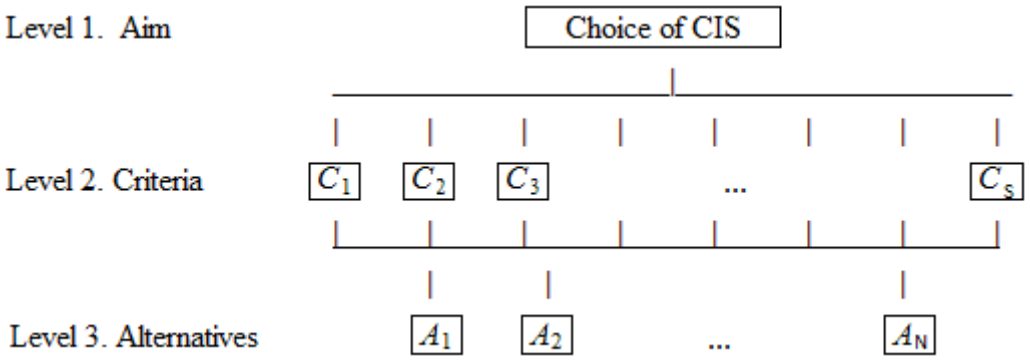

Fig.1. General form of the hierarchy

The criteria for evaluating a CIS

K_1. Compliance with business processes

K_2. Scalability

K_3. Compliance with organizational strategy

...

K_{43}. Qualification level of specialists.

The description of the alternatives

To conduct a comparative analysis of foreign CISs, the following products were selected: SAP R/3, Oracle Applications, Oracle Business Suite, IFS Applications, Baan ERP, iRenaissance, MS Dynamics AX, and MS Dynamics NAV.

2. Comparative importance assessment of the hierarchical structure elements in reference to a higher level on the basis of a unified scale.

Table 1. Unified preference scale

Assessment s_i	Importance scale	Interpretation
1	Equal	Equal contribution of the elements to a higher level
3	Moderate	Slight contribution preponderance of one of the elements
5	Considerable	Considerable contribution preponderance of one of the elements
7	Predominant	Very large contribution preponderance of one of the elements
9	Uppermost	Overwhelming preponderance of one of the elements

A set of matrices of paired comparisons of elements H_i and H_j of any hierarchical level $A^k=\|a_{ij}^k\|_{h\times h}$, $a_{ij}^k=s_i/s_j$, where h is the number of base elements to be compared is *a subjective model of rational choice*, where the preference of elements for a decision maker is calculated as $H_i \succ H_j$, if $a_{ij}^k>1$; $H_i \approx H_j$, if $a_{ij}^k=1$; $H_i \prec H_j$, if $a_{ij}^k<1$.

3. Calculation of the priority of options by aggregating the partial estimates of the elements of the top-down hierarchical structure, starting from the lowest level and going up to the highest level.

partial estimate of variant A_i with respect to q^{th} criterion K_q

$v_i^q = v^q(A_i) = c_i^q / \sum_{j=1}^m c_j^q$, $c_i^q = (\prod_{j=1}^m a_{ij}^q)^{1/m}$, $a_{ij}^q = s_i^q / s_j^q$,

relative importance (weight) of criterion Kq

$w_q = w(K_q) = c_q^0 / \sum_{l=1}^n c_l^0$, $c_q^0 = (\prod_{l=1}^n a_{ql}^0)^{1/n}$, $a_{ij}^0 = s_i^0 / s_j^0$,

total importance (priority) of variant A_i in the form of additive convolution

$v(A_i) = \sum_{q=1}^n w_q v^q(A_i) = w_1 v^1(A_i) + w_2 v^2(A_i) + \ldots + w_8 v^8(A_i)$,

w_q – *vector of local priorities of criteria.*

4. Assessment of the consistency of decision-makers' preferences.

Monitoring the meeting of the conditions of inverse symmetry $a_{ij} \cdot a_{ji} = 1$ and compatibility $a_{ij} \cdot a_{jk} = a_{ik}$ for elements of all the matrices of paired comparisons $A = \|a_{ij}\|_{h \times h}$.

Consistency index $I_h = (\lambda_h^{max} - h)/(h - 1)$,

Consistency ratio $R_h = I_h / I_h^{cp}$.

$\lambda_q^{max} = \sum_{i=1}^m a_i^q v_i^q$, $a_i^q = \sum_{j=1}^m a_{ij}^m$, $\lambda_0^{max} = \sum_{q=1}^n a_q^0 w_q$, $a_q^0 = \sum_{l=1}^n a_{ql}^0$.

Empirical indices of average consistency for inversely symmetric matrices of rank *h*.

Table 2. Empirical indices of average consistency

h	2	3	4	5	6	7	8	9	10	11
I_h^{cp}	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51

Subjective preferences of the decision maker when comparing the elements of the hierarchy are considered to be consistent if the consistency ratio R_h is within empirically established limits of 0.1- 0.15. The closer is the value of λ_h^{max} to the eigenvalue h of the ideal matrix A, the more consistent are the elements a_{ij}^k of the real matrix A^k, and the matrix A^k itself will be closer to the matrix A.

Main part

Basing on the literature review [1-4, 6-7], about 70 criteria were systematized, of which 43 were selected by comparison and aggregation to form 7 classes:

Class 1 – Needs of the organization (NoO1 - Compliance with business processes, NoO2 - Scalability, NoO3 - Compliance with organizational strategy, NoO4 - Availability of industrial solutions, NoO5 - Ease of use by support staff, NoO6 – Advanced means of customizing business processes);

Class 2 - Applied technologies (AT1 - Software architecture, AT2 - Technical architecture, AT3 - Implementation technology of ERP system, AT4 - Use of standard widely used IT-technologies);

Class 3 - Functionality (F1 - Integration, F2 – Good layout, F3 - Compliance with the regulatory framework, F4 - Use of the most effective methods of work organization, proven by the world best practices, F5 - Functional reserve, F6 – Ease of upgrading and improving system functionality, F7 - Controllability and reliability of the system, F8 - Terms of implementation, F9 - Composition of modules);

Class 4 - Support (S1 - Support cycle, S2 – Availability of a training technology and materials to work with the system, S3 - Implementation experience, S4 - Availability of tools facilitating the implementation process, S5 – Availability of a standard implementation technology for all partners, S6 - Qualitative documentation and contextual help, S7 - Availability of service desk);

Class 5 - Cost of ownership (CoO1 - Cost of software, CoO2 - Cost of hardware, CoO3 - Cost of maintenance, CoO4 - Cost of modernization and upgrading, annual investment in system development);

Class 6 - Principles of developing a CIS (PoCIS1 - System operational environment, PoCIS2 - Open platform and open system interfaces, PoCIS3 - Open system structure and open source code of all applications, PoCIS4 – Decision-making support technology, PoCIS5 – CASE-technology support);

Class 7 - Image characteristics (ICh1 - System manufacturer consistency, ICh2 – Presence of the system in the market, in the industry, in the region, and users' reviews, ICh3 - Presence of the supplier and system in the local market, ICh4 - Strategy for system development and modernization, ICh5 - Structure and capability of a partner network to implement the system, ICh6 – Presence of specialists in the market, ICh7 - Evaluations of successful and unsuccessful projects, ICh8 - Qualification level of specialists).

The hierarchy of selecting a CIS can be seen in Figure 2.

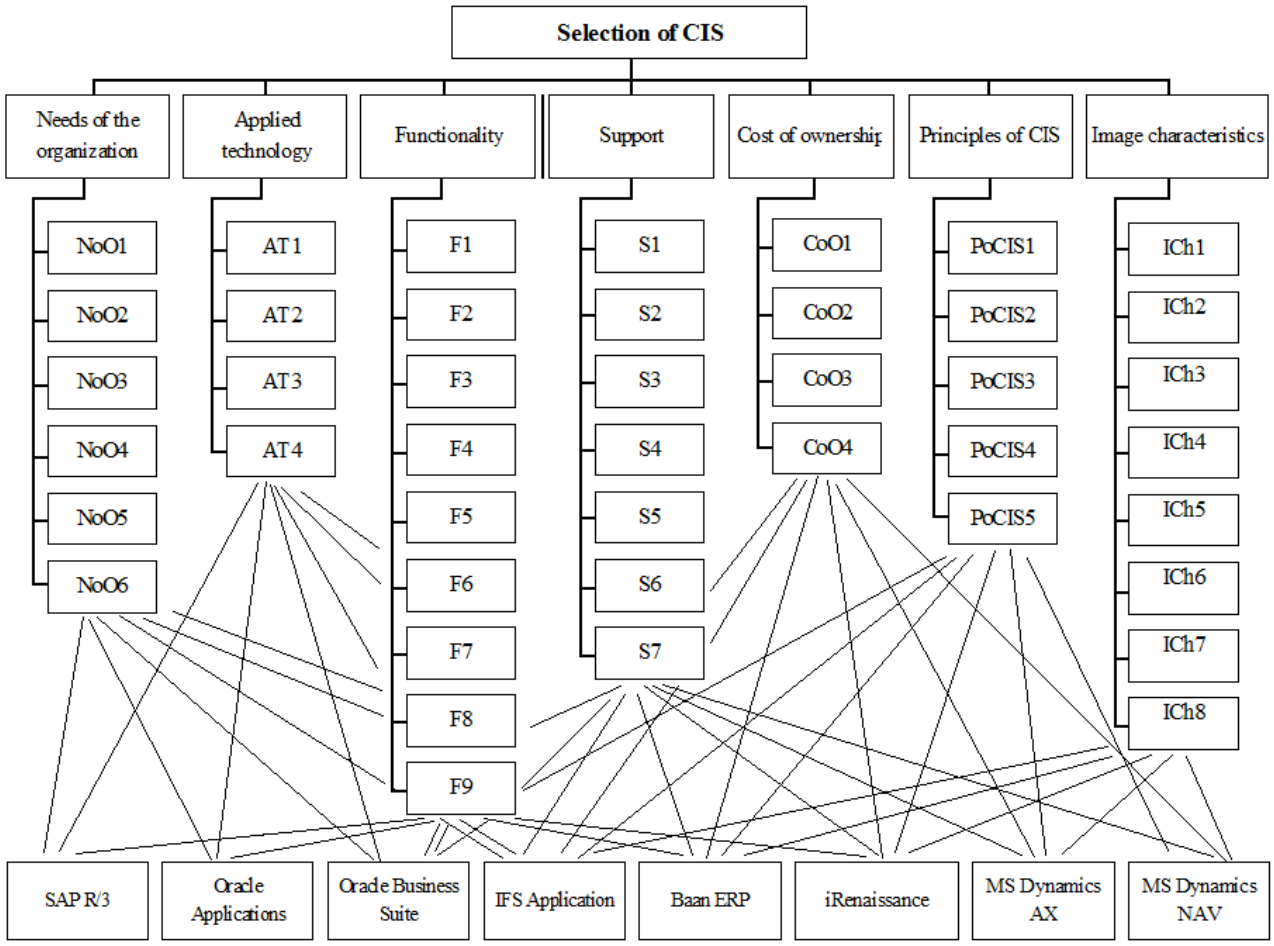

Fig.2. Hierarchy of selecting a CIS

Since 43 criteria are used to compare CISs, these criteria are grouped into classes with no more than 7-9 objects in each according to AHP, after which the priorities of each class when choosing a CIS are calculated, and the criteria are compared pairwise in each class, determining their importance for the class. Local priorities of the criteria are finally weighed by the weight of the corresponding class, resulting in obtaining the priority of each criterion in relation to the goal.

Table 3. Matrix of paired comparisons (MPC) of groups of criteria

Selection of CIS	Needs of organization	Applied technologies	Functionality	Support	Cost of ownership	Principles of developing a CIS	Image characteristics	Vector of local preferences
Needs of organization	1	4	2	3	3	6	5	0.339614986
Applied technologies	1/4	1	1/3	2	1/2	3	1/2	0.084260388
Functionality	1/2	3	1	4	2	5	2	0.224730595
Support	1/3	1/2	1/4	1	1/3	2	3	0.079518387
Cost of ownership	1/3	2	1/2	3	1	4	3	0.16173539
Principles of developing a CIS	1/6	1/3	1/5	1/2	1/4	1	1	0.044304308
Image characteristics	1/5	2	1/2	1/3	1/3	1	1	0.065835948

Thus, the most important groups when selecting a CIS are: the needs of the organization, functionality, technology, and cost of ownership.

Now the matrix of paired comparisons of the criteria will be filled inside each class. Table 4 shows the matrix of paired comparisons of the criteria within Class 1.

The most important criteria for this group are: Compliance with business processes, Compliance with the organizational strategy, and advanced means of customizing business processes.

Table 4. MPC of the criteria within Class 1

Needs of organization	NoO1	NoO2	NoO3	NoO4	NoO5	NoO6	Vector of local preferences
NoO1	1	5	3	6	6	4	0.452038347
NoO2	1/5	1	1/3	1/2	1/2	2	0.071325711
NoO3	1/3	3	1	4	4	2	0.224022333
NoO4	1/6	2	1/4	1	1	1/3	0.069190941
NoO5	1/6	2	1/4	1	1	1/3	0.069190941
NoO6	1/4	1/2	1/2	3	3	1	0.114231727

After completing and processing the MPCs for the remaining 6 classes in the same way, the priority criteria for each class are summarized in the table (Table 5). The table includes three

priority criteria from each class, except for the classes Applied Technologies and Cost of Ownership, for which the local priorities of Level 3 are incomparable with the former two. Having weighed the obtained vectors of the local priorities of the criteria by the classes with the priority values of the corresponding classes, the values of the components of the local priority vectors of 43 criteria (the sum of the components equals 1) were calculated. Afterwards, the priorities of each CIS for each of the comparison criteria were calculated (Table 6).

Table 5. Summary table of priority criteria for each class

Class	Priority 1	Priority 2	Priority 3
Needs of organization	Compliance with business processes	Compliance with organizational strategy	Advanced means of customizing business processes
Applied technologies	Software architecture	Technical architecture	
Functionality	Functional reserve	Integration	Compliance with the regulatory framework
Support	Support cycle	Availability of service desk	Availability of tools facilitating the implementation process
Cost of ownership	Cost of software	Cost of hardware	
Principles of developing a CIS	System operational environment	Open platform and open system interfaces	Open system structure and open source code of all applications
Image characteristics	Presence of the system in the market, in the industry, in the region, and users' reviews	Presence of the supplier and system in the local market	Qualification level of specialists

Table 6. Summary table of priorities considered by CIS

Criteria	Priority 1	Priority 2	Priority 3
NoO1	SAP R/3	Oracle EBusiness Suite	Microsoft Dynamics NAV
NoO2	BAAN	iRenaissance	SAP R/3
NoO3	SAP R/3	BAAN	Oracle EBusiness Suite
NoO4	SAP R/3	IFS Applications	Oracle EBusiness Suite
NoO5	IFS Applications	Oracle EBusiness Suite	Microsoft Dynamics AX
NoO6	Oracle EBusiness Suite	SAP R/3	Oracle Applications
AT1	Oracle EBusiness Suite	BAAN	IFS Applications
AT2	Microsoft Dynamics AX	Microsoft Dynamics NAV	IFS Applications
AT3	SAP R/3	Oracle Applications	Microsoft Dynamics AX
AT4	Microsoft Dynamics AX	iRenaissance	Microsoft Dynamics NAV
F1	Oracle EBusiness Suite	Microsoft Dynamics AX	Microsoft Dynamics NAV
F2	Oracle EBusiness Suite	BAAN	iRenaissance
F3	BAAN	IFS Applications	Microsoft Dynamics NAV
F4	SAP R/3	Microsoft Dynamics AX	Microsoft Dynamics NAV
F5	SAP R/3	Oracle EBusiness Suite	Microsoft Dynamics NAV
F6	IFS Applications	Microsoft Dynamics AX	Microsoft Dynamics NAV
F7	SAP R/3	Oracle Applications	Oracle EBusiness Suite

F8	Microsoft Dynamics NAV	Microsoft Dynamics AX	iRenaissance
F9	Oracle Applications	SAP R/3	Oracle EBusiness Suite
S1	SAP R/3	IFS Applications	Oracle Applications
S2	SAP R/3	Microsoft Dynamics AX	Microsoft Dynamics NAV
S3	SAP R/3	Microsoft Dynamics NAV	Microsoft Dynamics AX
S4	SAP R/3	Microsoft Dynamics AX	Microsoft Dynamics NAV
S5	SAP R/3	Oracle Applications	Oracle EBusiness Suite
S6	Oracle EBusiness Suite	BAAN	Oracle Applications
S7	SAP R/3	Oracle Applications	Oracle EBusiness Suite
CoO1	BAAN	iRenaissance	Microsoft Dynamics AX
CoO2	Oracle EBusiness Suite	Microsoft Dynamics AX	Microsoft Dynamics NAV
CoO3	IFS Applications	Microsoft Dynamics AX	Microsoft Dynamics NAV
CoO4	SAP R/3	Oracle Applications	Microsoft Dynamics AX
PoCIS1	SAP R/3	Oracle Applications	IFS Applications
PoCIS2	Oracle Applications	Oracle EBusiness Suite	IFS Applications
PoCIS3	IFS Applications	Microsoft Dynamics NAV	Microsoft Dynamics AX
PoCIS4	BAAN	Microsoft Dynamics NAV	Microsoft Dynamics AX
PoCIS5	iRenaissance	Microsoft Dynamics NAV	Microsoft Dynamics AX
ICh1	SAP R/3	Oracle Applications	Oracle EBusiness Suite
ICh2	SAP R/3	Microsoft Dynamics AX	Microsoft Dynamics NAV
ICh3	SAP R/3	Oracle Applications	Oracle EBusiness Suite
ICh4	SAP R/3	Microsoft Dynamics AX	Microsoft Dynamics NAV
ICh5	Microsoft Dynamics NAV	SAP R/3	Oracle Applications
ICh6	SAP R/3	Microsoft Dynamics AX	Microsoft Dynamics NAV
ICh7	IFS Applications	iRenaissance	Microsoft Dynamics AX
ICh8	SAP R/3	Oracle Applications	Oracle EBusiness Suite

Based on the calculations, a vector of global priorities of alternatives - foreign CISs - was created, which is of the form shown in Table 7.

Table 7. Vector of CIS global priorities

SAP R/3	Oracle Applications	Oracle EBusiness Suite	IFS Applications	BAAN	iRenaissance	Microsoft Dynamics AX	Microsoft Dynamics NAV
0.15943	0.10729	0.14768	0.10587	0.1288	0.0832	0.1322	0.13554

Thus, the most preferred is SAP R / 3, followed by Oracle EBusiness Suite, with Microsoft Dynamics NAV running third.

CONCLUSION

Among seven classes of the criteria identified in the paper, there were determined the most important ones in terms of selecting the best corporate system, in particular: needs of organization, functionality, applied technologies, and cost of ownership.

The study of the systems present in the market showed that based on a multicriteria analysis, SAP R / 3 is the most preferred, followed by Oracle EBusiness Suite, and Microsoft

Dynamics NAV coming third. However, considering all the available criteria, none of the systems is a universally recognized leader. Choosing one of the above CISs, even the most preferable one, the company's management should be ready that the system they have purchased needs adapting and debugging to meet the specific requirements of the organization.

The systematized criteria can be used when evaluating and selecting different classes of software to solve a wide range of tasks.

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