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A MEASURE OF INTERNAL SYNERGY OF THE COLLECTIVE SYSTEM

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ABSTRACT. Background: The authors examine the methodology of HRM personnel management based on ratings. Proposed to represent a collective system that uses a matrix of pair relations as a system of linear differential equations. The condition of auto generation of an autonomous system can be determined by the application of the Laplace transformation to the system. This condition mainly depends on the main eigenvalue of dating relationships matrix. Assuming the oscillation frequency is straightly proportional to the system's synergy rating, a special algorithm of comparative evaluation of several collective systems was suggested.

Methods: The calculation of the rating of internal synergies is based on the representation of the collective system as a system of linear differential equations, the coefficients of which are obtained by questionnaire survey of all members of the team. Internal representation of the system's synergism as a stimulation of an autonomous system allows using the eigenvector of the system as a measure of internal synergies.

Results: The result of this method is the rating of members of interacting collective systems in terms of their contribution to the self-organization sharing behavior.

Conclusions: Using a matrix of pair relations allows without direct programming and only using MathCad determines the measure of internal synergy of a collective system.

Key words: synergy, rating, matrix of pair relations, autonomous system, differential equation, Laplace transform, frequency of auto generation, eigenvalue, eigenvector.

INTRODUCTION

According the concept of HRM, the most important task of any collective system is to establish the collective ratings of system activities. Nowadays the concept of ratings adopted as the basis of incentives for a team activities. Obviously, the mechanisms of ratings should be based on tangible results of each team's member. The purpose of the ratings is to provide greatest synergy [Lodon 2005] of the team as a collective system. In this regard, the rating of the members defined not by the system of an administrative control, but by the team itself is really important. Obviously such a rating takes into account the underlying mechanisms of synergy and can be used by the administration to identify the reserves for increasing the effectiveness of the system, not only from the point of view of the actual results, but also in terms of ensuring a favorable atmosphere inside the team. Moreover a mission of any organization is impossible without a clear, structured approach for its activities [Fedotova, Semenov, Siskin 2003], with identification of the active mediums of the mission [Shpak 2002].

The matrix criteria-oriented testing based on the game theory matrix of the states can play a special role in detection of the ratings.

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RESULTS AND DISCUSSION

Let us suppose a collective system as the dynamic system with absence of any non-linear mechanisms of interaction between the elements of the system. In this case, for a system of N elements, dynamic behavior of the system in time is described by a system of differential equations

$$\frac{dX}{dt}=AX+B,$$

where:

$X\equiv X(t)$, $X=(x_1,\ldots,x_N)^T$, $x_i(t)$ - dynamic behavior in time of i-element of the system,
B - administrative and other external influence on the system,
A - matrix of pairwise interactions of system's elements.

In our case the stationary behavior of the system is under interest, B = const and A = const. Our task is finding out the ratings of a collective system from the point of view of its internal synergy thus B=0 because we should consider the autonomous system.

The meaning of the matrix of pairwise interactions a_{ij} is to evaluate the usefulness for j-th member of business communication to i-th member of the team, for example in terms of scores from 0 to 10. The value $a_{12}=6$ means that second member evaluates the usefulness of a business communication with first member as 6 points. Thus, the matrix a_{ij} is asymmetric. From the standpoint of internal synergies $a_{ii}=0$, because this is not pair interaction.

So the task is to evaluate the dynamic behavior of an autonomous system of differential equations

$$\frac{dX}{dt}=AX(t)$$

with constant coefficient matrix a_{ij}. To solve the problem we pass from the time domain to the frequency domain by Laplace transform [5]:

$$X(p)=\int_0^\infty x(t)e^{-pt}dt=L(x(t))$$

In accordance with the property of the Laplace transform

$$L\left(\frac{dX}{dt}\right)=pX(p)$$

and the original autonomous system of partial differential equations comes to a system of linear algebraic equations:

$$pX=AX$$

Obviously, there will be a non-trivial solution X if the determinant

$$|A-p|=0$$

i.e.

$$\begin{vmatrix} a_{11}-p & a_{12} & \Lambda & a_{1N} \\ a_{21} & a_{22}-p & \Lambda & a_{2N} \\ \Lambda & \Lambda & \Lambda & \Lambda \\ a_{N1} & a_{N2} & \Lambda & a_{NN}-p \end{vmatrix}=0$$

This equation determines the condition of finding the eigenvalues p of A. For matrix A of size N the number of eigenvalues is equal to N, since this problem is equivalent to the calculation of roots of N-degree polynomial. Indeed, if we expand the determinant of A by the rules of its calculation, we obtain a polynomial equation of N-degree relatively to *p*. Among the eigenvalues may be real and complex roots. Complex roots do not have any meaningful interpretation. The real roots within the meaning of the variable *p* in Laplace transform represent the frequencies of the excitation of the system. If we identify a collective system with the cybernetic system, the system will always be excited at the largest positive frequency. From the point of view of the collective system, this means that the system tends to its most dynamic state in order to ensure the greatest internal synergies. The largest positive value of eigenvalue is known as the principal eigenvalue. If we compare some collective systems by the principal eigenvalue then the rating of internal synergies will match the ranking of principal eigenvalues in descending order. If we know the principal eigenvalue λ of the matrix A then we can determine the contribution of each x_i element of the system in formation of the excited state of the system at a frequency of λ:

$$A\overset{\circ}{X}=\lambda\overset{\circ}{X}$$

The solution of this system of equations for A is called an eigenvector of the system, which obviously will not be zero, as | A-λ | = 0. The resulting eigenvector can have positive or negative values, which in terms of their contribution to the internal synergies does no matter. That is why it is necessary to recalculate

$$\overset{o}{X} = \left|\overrightarrow{\overset{o}{X}}\right|$$

in accordance with the rules of vectorization in Mathcad. The measure of internal synergies in the form of λ and $\overset{o}{X}$`completely characterizes the system as a dynamic linear system. The contribution of each element of the system $x_i$ to the internal synergy is defined by ranking of the vector $\overset{o}{X}$` in descending order. The largest contribution to the internal synergies provides the resulting $\overset{o}{X}_1$.

The problem above is solved in full volume using Mathcad only. Suppose that we have a matrix A:

$$A = \begin{bmatrix} 0 & 1 & 5 & 8 \\ 3 & 0 & 9 & 4 \\ 9 & 1 & 0 & 7 \\ 2 & 6 & 3 & 0 \end{bmatrix}$$

in which each column *j* determines a value of the business relationship a_{ij} with i-th member of the team. Calculate with Mathcad the eigenvalues of A

$$p := \text{eigenvals}(A)$$

$$p = \begin{pmatrix} 14.177 \\ -7.638 \\ -3.269 + 4.727i \\ -3.269 - 4.727i \end{pmatrix}$$

among which we choose the principal eigenvalue λ = 14.177. For this eigenvalue compute eigenvector X1:

$$\lambda := p_1$$

$$X1 := \text{eigenvec}(A, \lambda)$$

$$X1 := \left|\overrightarrow{X1}\right|$$

$$X1 = \begin{pmatrix} 0.466 \\ 0.561 \\ 0.542 \\ 0.418 \end{pmatrix}$$

As follows from X1 greatest contribution to the internal synergy makes the 2nd team member, and the smallest - the 4th member.

Consider the second collective system with the matrix A:

$$A := \begin{bmatrix} 0 & 1 & 2 & 5 & 6 \\ 5 & 0 & 7 & 4 & 8 \\ 6 & 8 & 0 & 3 & 9 \\ 7 & 10 & 1 & 0 & 1 \\ 3 & 4 & 5 & 6 & 0 \end{bmatrix}$$

Similarly to the first system we calculate the principal eigenvalue λ2 = 19.972, which implies that the internal synergy of the second system is higher than of first system. Calculate the eigenvector of the system

$$X1 = \begin{pmatrix} 0.308 \\ 0.516 \\ 0.547 \\ 0.414 \\ 0.411 \end{pmatrix}$$

Comparative analysis of the rating systems must consider their principal eigenvalue as a measure of self-organizing systems. One can assume that the measure of self-organization of a system is proportional to the principal eigenvalue, i.e. oscillation frequency of the system. For a comparative analysis of rating indicators of the two systems together let us recount rating $X1_2$ as follows:

$$X1_2 = X1_2 \frac{\lambda_2}{\lambda_1},$$

$$X1 = \begin{pmatrix} 0.433 \\ 0.727 \\ 0.77 \\ 0.583 \\ 0.579 \end{pmatrix}$$

where λ_1 - the principal eigenvalue of the first system.

Comparing vector $X1_1$ and $X1_2$ we can define a total contribution of each member of the collective on their own internal synergies. As we can see, the third element of the first system has the largest rating in this regard, and the lowest rating is in the fourth element of the first system.

CONCLUSION

The proposed method of calculating measures of internal synergies could be on a par with other rating indicators useful in identifying formal and informal leaders and outsiders in the collective system.

The method is attractive because the initial data is one unified question and its solution does not require direct programming, since the problem can be easily solved by means of Mathcad [Chernyak 2003].

HRM concept of openness of the collective system from the standpoint of human resource management is one of the most important conditions for the moral climate in the collective. The identification of the internal rating of synergy may be an additional motivation for the team's unity in the conditions of the transition to the business-process structuring. Obviously, during reengineering [Oyhman, Popov 1997] of this transition, taking into account internal synergy eliminates the negative aspects of the reorganization of the team from the point of synergy [Novikov, Kharitonov 2011].

The proposed method of application of the criteria evaluation matrix is of particular interest in the implementation of mechanisms for management decisions [Ulyashina 2007] at stages of training of government specialists.

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POMIAR SYNERGII WEWNĘTRZNEJ SYTEMU

STRESZCZENIE. **Wstęp:** Autorzy przeprowadzili badanie metodologii zarządzania pracownikami HR w oparciu o metodę rankingową. Omawiana metoda pozwala na zastosowanie matrycy zależności jako systemu równań liniowych.
Metody: Przygotowanie ranking wewnętrznych zależności zostało oparte na przedstawieniu badanego systemu jako systemu równań liniowych, których współczynniki zostały dobrane na podstawie przeprowadzonych ankiet. Wewnętrzne przedstawienie synergizmu systemu jako czynnika stymulującego autonomiczny system pozwala na zastosowanie wektorów własnych systemu jako mierników wewnętrznych synergii.
Wyniki: Zaprezentowano ranking członków złożonego systemu w odniesieniu do ich udziału w współtworzenie organizacyjne tego systemu.
Wnioski: Zastosowanie macierzy wzajemnych zależności pozwala bez konieczności bezpośredniego programowania, a tylko za pomocą MathCad, na wyznaczenie mierników synergii wewnętrznej system złożonego..

Słowa kluczowe: synergia, ranking, macierz wzajemnych zależności, system autonomiczny, równanie, transformacja Laplace'a, częstotliwość autogeneracji, wartość własna, wektor własny.

BEMESSUNG DER INNEREN SYNERGIE EINES SYSTEMS

ZUSAMMENFASSUNG. Einleitung: Die Autoren haben eine Untersuchung in Bezug auf die Methodologie des Managements von HR-Mitarbeitern in Anlehnung an die Ranking-Methode durchgeführt.
Methoden: Die Ermittlung des Rankings von inneren Abhängigkeiten wurde auf die Projizierung eines Systems als System von Linien-Gleichheiten, deren Koeffizienten auf Grund von gewonnenen Fragebögen erfasst wurden, gestützt. Die innere Projizierung des System-Synergiesmus als des das autonomische System stimulierenden Faktors erlaubt, die eigenen Vektoren des Systems als Messer der inneren Synergien anzuwenden.
Ergebnisse: Es wurde das Ranking der Mitglieder eines komplexen Systems in Bezug auf deren Beteiligung am organisatorischen Aufbau des betreffenden Systems präsentiert.
Fazit: Die Anwendung der Matrix für gegenseitige Abhängigkeiten erlaubt ohne die Notwendigkeit eines direkten Programmierens, sondern lediglich mithilfe von MathCad, die Messwerte der Synergie innerhalb eines komplexen Systems zu ermitteln.

Codewörter: Synergie, Ranking, Matrix für gegenseitige Abhängigkeiten, autonomisches System, Gleichung, Laplace-Transformation, Frequenz der Autogeneration, eigener Wert, eigener Vektor

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