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**THE IMPACT OF INFORMAL INTERACTIONS ON ORGANIZATIONAL EFFECTIVENESS
IN THE MULTI-AGENT MODEL**

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Abstract

The purpose of this study is to analyze the impact of informal interactions in an organization on its effectiveness. The authors consider the organization model that combines a hierarchical management structure and project teams. Informal interactions in the model under consideration represent an inverse relationship between the performance level and higher levels of the management line. The paper presents an analysis of the organization's behavior using a multi-agent model with various adaptation abilities of individual agents. The stationary value for the proportion of agents adapted to changing external conditions was used as a characteristic of organizational effectiveness. The analysis showed the inverse relationship of informal interactions to the organizational effectiveness as a whole and found that the impact of informal interactions became significant at low and medium values of the adaptation abilities of individual agents. Following the analysis results, the authors suggested strategies for improving organizational effectiveness without changing the organization structure, in particular, through the development of informal interactions.

Keywords

Organizational effectiveness – Informal interactions – Structure – Organization development

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Introduction

The concept of organizational effectiveness is essential in the theory of organization, management theory, and corporate management¹. Increasing organizational effectiveness is one of the key objectives of the management process. Consequently, in modern highly competitive conditions, theoretical analysis is becoming increasingly important. The relationship between the organization structure and organizational effectiveness is one of the most interesting, but, due to its complexity, still insufficiently studied issues.

This question has drawn the attention of researchers for a long time². However, quantitative analysis of reserves for increasing efficiency by changing the organizational structure remains a complicated issue. At the same time, it is worth noticing the importance of the reserves for increasing efficiency associated with organizational changes³. As a rule, they do not require significant capital investments for their use, which gives this issue additional significance.

This paper considers an organization as a combination of two components – static, which determines the organization's structure, and dynamic, associated with decisions made by individual employees within the existing structure. Moreover, an organization is considered as a mechanism for processing information from the external environment. Changing the external environment can be the simplest model impact on the organization. This change will continue spreading throughout the organization, changing its state. In this case, the transition to a new state corresponding to the new state of the external environment is an informative characteristic of organizational effectiveness.

This characteristic allows for the efficient comparison of organizations with different structures⁴. Under variable external conditions, this characteristic can be evaluated as the percentage of the organization units that managed to adapt to the changed external conditions. Another approximation of the model to real-life organizations involves

¹ F. P. Adler, "Relationships Between Organization Size and Efficiency", *Management Science* Vol: 7 num 1 (1960): 80-84; M. P. Pokharel y S. O. Choi, "Exploring the Relationships between the Learning Organization and Organizational Performance", *Management Research Review*, Vol: 38 num 2 (2015): 126-148; F. Luban, "Measuring the Efficiency of a Hierarchical Organization with Fuzzy DEA Method", *Economia. Seria Management* Vol: 12 num 1 (2009): 87-97; M. Alvesson, "Concepts of Organizational Culture and Presumed Links to Efficiency", *Omega*, Vol: 17 num 4 (1989): 323-333 y D. Holthausen y T. Tsoulouhas, "The Good, the Bad and The Ugly: Agent Behavior and Efficiency in Open and Closed Organizations", *Economic Theory* Vol: 35 num 1 (2008): 73-97.

² R. Quinn y J. Rohrbaugh, "A Competing Values Approach to Organizational Effectiveness", *Public Productivity Review* Vol: 5 num 2 (1981): 122-140.

³ A. B. Pismennaya, "Analiz adaptatsionnykh vozmozhnostei organizatsii v izmenyayushcheisya vneshnei srede". *Regionalnye agrosistemy: ekonomika i sotsiologiya* num 1 (2018); A. B. Pismennaya, "Vliyanie neformalizovannykh vnutriorganizatsionnykh vzaimodeistvii na effektivnost raboty razlichnykh kompanii", *Agrarnyi nauchnyi zhurnal* num 8 (2015): 87-90 y A. B. Pismennaya y E. V. Novoseltseva, "Vliyanie neformalizovannykh vnutriorganizatsionnykh vzaimodeistvii na organizatsionnyu effektivnost", *Sovremennaya nauka: aktualnye problemy teorii i praktiki. Seriya "Ekonomika i pravo"* num 9-10 (2015): 24-27.

⁴ A. B. Pismennaya y E. V. Novoseltseva. "Vliyanie neformalizovannykh vnutriorganizatsionnykh vzaimodeistvii na organizatsionnyu effektivnost", *Sovremennaya nauka: aktualnye problemy teorii i praktiki. Seriya "Ekonomika i pravo"* num 9-10 (2015): 24-27.

considering informal interactions among individual employees⁵. Informal interactions can have significant impact on organizational dynamics, which was confirmed by the analysis of several real organization structures⁶.

Model and methods

In this paper, the authors analyze the impact of a specific type of informal interactions (in which information is transferred from the lower to the higher levels of the organizational hierarchy) on organizational effectiveness.

This paper considers an organization as a set of identical interacting agents. This approach allows omitting the influence of individuals on the organization's performance, focusing on the influence of the organization's structure and the characteristics of interaction between individual agents. Each agent can be in two states – initial, corresponding to the initial state of the organization, and target, corresponding to the new state of the environment. The transition from one state to another happens with a certain probability, which depends on the adaptation abilities of an individual agent and on the number of his or her connections with other agents. Two characteristics are crucial for the system behavior – the organization's structure as a whole, i.e. how the individual agents are interconnected, and the individual effectiveness of each agent, determining the dependence of his or her adaptation abilities on the amount of information received about agents that have already transited to a new state. This model allows simulating the dynamics of various organizational structures. Simulation of the organization's behavior is implemented by sending a signal to one of the agents and analyzing its distribution throughout the entire organization.

This study has modeled the behavior of a hybrid organization structure, which is a combination of hierarchy and design structure in Kuhn's terms [6] in a rapidly changing environment and various internal interactions that provide feedback from lower management levels to the higher management levels. The structure under consideration consisted of several organizational units (each of which had from 3 to 5 agents), with an organized communication structure among all agents. The model had a hierarchical management system, which was typical for infrastructure organizations, including transport organizations. The external influence was modeled as changes happening at each modeling step observed by the agent heading the management hierarchy. Those changes were subsequently transmitted throughout the organizational structure. The number of agents in the target state compared to the total number of agents at the end of a fixed period, averaged over numerous experiments, was used as a characteristic of the organization's adaptation abilities. This characteristic correlates with the organizational effectiveness parameter suggested earlier⁷ – the time of the organization's adjustment to the changing external conditions – and is its development in the case of variable external conditions with a period shorter than the organization's adjustment time.

⁵ A. B. Pismennaya, "Vliyanie kharakteristik neodnorodnosti vnutriorganizatsionnykh vzaimodeistvii na effektivnost razlichnykh vidov kompanii", Innovatsii i investitsii num 6 (2014): 22-25.

⁶ A. B. Pismennaya y G. V. Vlasyuk, "Vzaimosvyaz konkurentosposobnosti, organizatsionnoi struktury i chelovecheskikh resursov", Mir transporta num 5 (2016): 238-248.

⁷ A. B. Pismennaya, "Vliyanie kharakteristik neodnorodnosti vnutriorganizatsionnykh vzaimodeistvii na effektivnost razlichnykh vidov kompanii", Innovatsii i investitsii num 6 (2014): 22-25.

The authors experimented with several feedback options: direct communication of different numbers of agents of the lower hierarchical levels with agents located at the highest levels, varying in the impact of communication considering the past values of the connected agents – communication with delay.

Results

For direct communication of agents of the highest hierarchical level (this study considered agents of the second hierarchical level) with agents of the lower hierarchical level, there are two areas of different influence of such communication on the adaptation abilities of the organization: the areas of low and high values of individual adaptation abilities of agents included in the organization. In the case of high values of individual adaptation abilities, inner-organization interaction between the lower and upper hierarchical levels contributes to the higher organizational effectiveness. The case of rapid changes in external conditions with a short transition period is the most difficult for the organization's adaptation, as was confirmed previously⁸. In this case, the organization does not have time to adjust to changing external conditions. With a clear hierarchy and a relatively large size of the organization, some agents remain unadjusted. In the case of low individual effectiveness of agents, the influence of communication between the lower and the higher hierarchical is the opposite – worsening the organizational effectiveness.

Intermediate values of individual effectiveness can have two effects: the transmission of "correct" signals from already adapted agents from the lower hierarchical levels and the expansion of the information background at certain values of the external exposure period, which can compensate each other. This leads to an increased efficiency compared to the situation where there is no communication between the lower and higher hierarchical levels. However, the range of these optimal values is rather limited.

With increased individual effectiveness in the values of the organizational effectiveness, one can observe a pronounced threshold effect. An increase in individual effectiveness above certain values leads to a sharp change in the organization's performance (in this study, a 20% change in individual efficiency near the threshold resulted in an increase in organizational effectiveness by up to 6 times). At the same time, high levels of individual organizational effectiveness supplemented with communication between the higher and the lower hierarchical levels provide an increase in the organization's adaptation abilities even when the ordinary hierarchy turns ineffective.

In view of this somewhat negative impact of communications between the higher and the lower hierarchical levels, the authors considered the possibility of reducing the negative impact through weakening this interaction by giving it less weight compared with communications within the formal structure. The researchers examined the impact of a weakened connection on the system's behavior if (for simplicity) there was only one connection between the lowest and highest hierarchical levels.

As expected, the effect of a weakened connection between the lower and the higher hierarchical levels is different for high and low individual effectiveness. In the case of high individual effectiveness, this impact is generally negative, and the weakened connection leads to a significant decrease in corporate efficiency, especially where stable

⁸ A. B. Pismennaya, "Analiz adaptatsionnykh vozmozhnostei organizatsii v izmenyayushcheisya vneshnei srede", Regionalnye agrosistemy: ekonomika i sotsiologiya num 1 (2018).

connection leads to an increase in corporate efficiency compared to the case of clear hierarchy. In the case of low individual effectiveness, the impact of weakened interaction is positive, leading to an increase in corporate efficiency for all values of the period of external exposure. At the same time, the weakened interaction between the lower and higher hierarchical levels has significant impact on the organization's behavior at intermediate values of individual efficiency – the area of relatively high values of corporate effectiveness increases, which allows for managing corporate effectiveness solely through organizational changes.

The delayed transition of information from one hierarchical level to another is an additional parameter that must be considered when analyzing inner-organization interactions. This effect is particularly pronounced in the indirect exchange of information among agents. In the simplest case, this effect is similar to lengthening the chain of information exchange among the agents. The authors examined its impact on organizational effectiveness through the interaction of higher and lower hierarchical levels.

With high levels of individual effectiveness, the delayed transition does not have a fundamental effect on the organization's behavior. The general values of the organization's adaptation abilities remain high for any delay values. In the case of frequent external changes, the overall organizational effectiveness slightly increases at certain delayed values, which is apparently explained by the adaptation wave spreading throughout the organization (part of which arrives at the highest hierarchical level) synchronized with the new adaptation signal coming from higher hierarchical levels.

In the case of low levels of individual effectiveness, the delayed transition of information from lower to higher levels leads to a more pronounced maximum of organizational efficiency with average values of the external impact period. At the same time, the dynamics of organizational effectiveness for large and smaller periods (compared to the optimal one) are multidirectional. With more frequent external impact, the organizational effectiveness decreases with increasing delays – signals that do not correspond to the state of the external environment reach the highest hierarchical levels. If the period of external influence corresponds to the time of delay, organizational effectiveness increases, while signals from the lower hierarchical levels arrive in time to the external signals. A further increase in the period of external impact results in a more pronounced degradation of organizational effectiveness with an increased delay in signal transmissions.

Discussion

The impact of formal and informal signals, creating a single information background, is the main mechanism affecting the behavior of an individual agent. The information background observed by an individual agent combined with his or her individual adaptation abilities determines the dynamics of his or her behavior. The mechanism of feedback impact with the low adaptation abilities of individual agents is as follows: additional signals from the lower hierarchical levels, which are generally not yet adapted to the new environment, create an additional unfavorable information background for decision-making at the highest hierarchical level. It is noteworthy that with an increase in the number of interactions between the lowest and highest hierarchical levels, the intensity of this background increases, which results in a significant decrease in organizational effectiveness (by more than 3 times when adding one additional link, according to experiments). In the case of increasing adaptation abilities of individual

agents, the impact of the unfavorable information background decreases and the organizational effectiveness increases; however, this growth has a natural limit: if an individual agent requires a single signal for adaptation, the continued increase in his or her adaptation abilities will no longer lead to an increase in the organizational effectiveness. However, under these conditions, the efficiency can increase due to a greater number of signals for adaptation per unit time, which will result in a growing potential of individual agents for switching to an adapted state. In the proposed model, this mechanism is implemented through informal interactions between the lower and higher hierarchical levels.

In the case of weakening informal interactions, there is a similar mechanism for additionally influencing the system's behavior by the information background: higher adaptation abilities of an individual agent reduce the impact of information on environmental changes through informal channels.

This results in decreased organizational effectiveness. In the case of low adaptation abilities, the weakened informal interactions allow filtering the information background observed by an individual agent and provide a slightly increased effectiveness.

The availability of such a mechanism, which has significant positive and significant negative impact with a monotonic change in the parameter of the adaptation abilities of an individual agent, suggests its significant effect on the system dynamics at intermediate values of the adaptation abilities of an individual agent, which was discovered in modeling the organization's behavior. In this mode, it is possible to significantly affect the organizational effectiveness solely through changing the characteristics of informal interactions, without adjusting its structure.

The delay effect in the feedback loop has significant effect on the organization's behavior. This effect is especially pronounced in the indirect exchange of information among agents. In the simplest case, this effect is similar to lengthening the chain of information exchange among agents. In the presence of delay, the information background observed by an individual agent consists of timely and delayed parts.

The effect of the delayed part becomes significant when the external environment changes somewhat periodically. In this case, the researchers observed two waves of adaptation – going through formal and informal channels of interaction. The presence of these two waves indicates the possibility of synchronization effects. In the presence of delays in the feedback loop, the highest hierarchical level is influenced by two signal sources – the environmental signal through a higher hierarchical level and the signal of the inner-organization state at the lower levels.

These two signals determine the agents' behavior at a high hierarchical level and can both help and hinder their adaptation. In this case, it is possible to increase the effectiveness by changing such a parameter as the delay time in the chain of information communication between the lowest and highest hierarchical levels.

Conclusion

Improving the individual effectiveness of agents in the organization is the most effective way to increase organizational effectiveness. Moreover, the impact of this

increase has a pronounced threshold character. However, after reaching a certain level of individual effectiveness, the creation of links between the lower and higher organization levels becomes an essential reserve for increasing effectiveness.

At the same time, establishing such links can result in increased efficiency in certain external conditions, in which a clear organizational hierarchy is ineffective. Managing the strength of information communication from the lowest levels of hierarchy to the highest levels is another means of increasing organizational effectiveness. Delays in this information communication can make intra-organizational dynamics at the lower hierarchy levels an independent information source, which can have both positive and negative effects on corporate adaptation abilities.

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