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Development of Model of Integration Potential of Participants of Project

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***Abstract*—Projects of complex multifunctional objects, which are characterized by a large number of participants, are prone to integration risks. An important reason for reducing the success of such projects may be the risks of disruption of integration ties between participants. Breaking the integration link and leaving a project participant can have extremely negative consequences, almost stopping the project. A new approach to qualitative risk analysis is proposed to prevent integration risks. In the course of the research, a model of project participants' integration potential was developed based on the use of quality management methods such as Pareto analysis, ABC analysis to identify the participants with the highest number of integration links and project management tools, namely cash flow calculation, for determining the capacity of integration links between participants. The combination of the results obtained is the basis for creating a matrix of integration potential of project participants. The use of the proposed approach to qualitative risk analysis of the integration gap between project participants at the beginning of the project will allow identifying participants with high integration potential. The integration links of these participants must be further analyzed, as leaving such a participant in the project can significantly affect the success of the project.**

Keywords— integration risks, qualitative risk analysis, matrix of integration potential of participants.

I. Introduction

Integration risks fall into the category of risks the consequences of which can be catastrophic for the project - a break in the integration links can lead to the destruction of the entire system. Therefore, integration risks in projects constitute one of the most important risk groups, and their allocation to a particular category is justified because they affect the viability of the project [1].

This type of risk is inherent in all project participants, but its implications for the project depend on which group the participants belong to - major or minor. Catastrophic consequences can occur if the integration links between the main participant (investor, customer, general contractor, etc.) and other project participants are discontinued. When it comes to minor participants, the consequences of integration risks may not be as significant for the project. In this case, a preliminary risk analysis helps to influence the situation and preserve the integrity of the project as a system.

Integration risk management includes such processes as: risk management planning, risk identification, qualitative risk analysis, quantitative risk analysis, risk response planning, risk response implementation, risk monitoring [2].

Particular attention should be paid to risk analysis. At the stage of qualitative analysis, it is necessary to identify the sources of possible integration risks of the project, ie to identify those project participants, whose actions may lead to disruption of integration ties in the project. For this purpose it is proposed to use quality management methods, namely: Pareto analysis, ABC analysis, as well as the matrix of integration potential. The qualitative analysis of integration risks, which is to determine the integration potential of project participants, is proposed to be carried out in stages:

I. Generation of input data to create an integration potential matrix.

II. Creation of model of matrix of integration potential.

III. Determining the integration potential of project participants [3].

The proposed sequence of analysis of project integration risks allows in the absence of reliable information about the project implementation conditions:

- identify the elements of the project participants most prone to integration risks;
- determine the integration potential of project participants - the degree of impact on the sustainability of the project system.

II. Generation of input data to create an integration potential matrix.

A. Separation of project participants into groups according to the number of their integration ties with other partners.

The Pareto analysis is proposed to identify participants' propensity to integrate risks. The input to the analysis is the set of integration links between project participants, and the output is a Pareto diagram.

A qualitative analysis of project integration risks using a Pareto diagram consists of the following steps:

- Creating a contiguity matrix that reflects the presence (1) or the absence (0) of integration relations between the elements (Table 1);
- analysis of the significance of the obtained results, which is reflected in the table of aggregated data (Table 2);
- construction of the Pareto diagram (Fig. 1);
- carrying out the ABC analysis of project participants (Fig. 2).

For the sake of clarity, we will conduct a case study of 12

equal participants.
Participants have integration links that can be described using a contiguity matrix (Table 1).

Table 1. Matrix of contiguity of elements (partners, project participants)

Element (partner, project participant)	1	2	3	4	5	6	7	8	9	10	11	12
1	0	1	1	1	1	1	1	0	0	1	0	0
2	1	0	1	1	1	1	1	1	1	0	1	0
3	1	1	0	0	1	0	0	0	1	0	0	0
4	1	1	0	0	1	1	1	1	0	0	0	0
5	1	1	1	1	0	1	0	0	1	0	1	0
6	1	1	0	1	1	0	0	0	1	0	0	1
7	1	1	0	1	0	0	0	0	0	0	0	0
8	0	1	0	1	0	0	0	0	0	0	0	0
9	0	1	1	0	1	1	0	0	0	1	0	0
10	1	0	0	0	0	0	0	0	1	0	0	0
11	0	1	0	0	1	0	0	0	0	0	0	0
12	0	0	0	0	0	1	0	0	0	0	0	0

Analysis of integration links between project participants based on the results presented in Table. 1, it is possible to carry out the following indicators:
- the number of connections of this element with other elements of the system;
-% of the connections of this element with other elements in the total number of integration links between system elements, which is presented in Table. 2.

Table 2. Aggregate data for integration links of elements (partners, project participants)

Element (partner, project participant)	Number of integration links	The cumulative sum of the number of integration links	% of integration links in total	Cumulative%
2	9	9	16,67	16,67
5	7	16	12,96	29,63
1	7	23	12,96	42,59
4	6	29	11,11	53,70
6	6	35	11,11	64,81
9	5	40	9,26	74,07
3	4	44	7,41	81,48
7	3	47	5,56	87,04
10	2	49	3,70	90,74
11	2	51	3,70	94,44
8	2	53	3,70	98,15
12	1	54	1,85	100,00

We build a Pareto diagram of partners' integration relationships using the data of the analysis. On the abscissa axis, we arrange the elements according to the degree of integration integration, and along the ordinate axis, the percentage of integration relations of the elements in the total and the cumulative percentage of integration relations (Fig. 1).

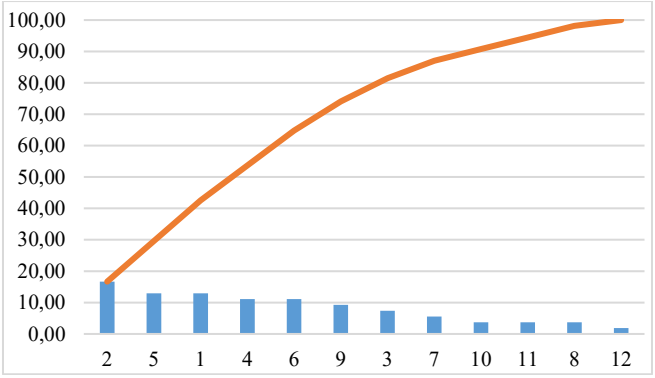

Fig. 1. Pareto diagram of the integration links of project participants

The input data for the ABC analysis is the Pareto analysis data and the output is the ABC analysis chart. Using the ABC analysis toolkit, we identify the groups of importance for managing integration risks:
- group A - the most important elements of the system that have the most integration with other elements. The relative percentage of group A in the total number of elements is usually from 60 to 80%. Elements of Group A include participants 2; 5; 1; 4; 6; 9, with an aggregate percentage of integration links of 74.07%.
- group B - elements with a total of no more than 20%. These include Elements 3; 7, whose aggregate share is 12.97%.
- group C is the least significant element to which participants have no more than two integration links, namely: 10; 11; 8; 12. They account for 12.96% of the project links (Fig. 2).

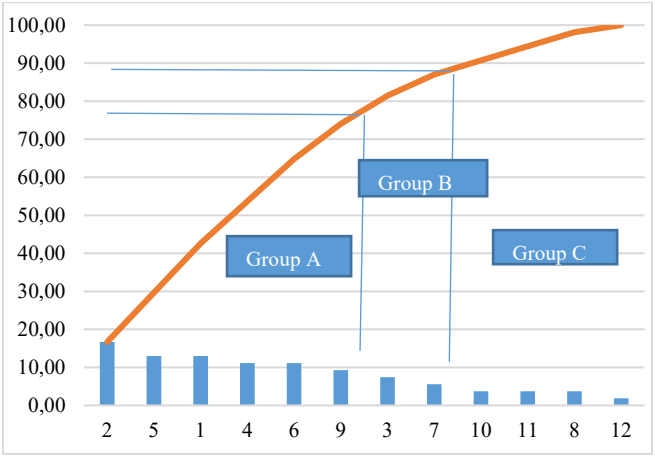

Fig. 2. ABC-analysis of project participants

The above methods allow to make a qualitative assessment of the integration risks of each project participant according to its relationship with other elements. However, quality assessment alone is not sufficient as the system element may have a large number of integration links and the power of these connections may be negligible.

B. Determination of integration capacities of project participants.

We propose to determine the power of the integration link taking into account the number of realized relations

(transactions) using this connection and the cash flow (cost) of the respective operations.

An example of how to calculate the value of the number of transactions over a given time period (hour, day, week ...) that corresponds to the integration links of the project element is presented in Table 3.

Table 3. Number of integration operations of element "1"

Connection	Time period						Total
	1	2	3	4	5	6	
1–2	3	4	5	6	4	3	25
1–3	2	6	4	3	1	5	21
1–4	4	3	2	5	6	4	24
1–5	7	8	6	9	11	7	48
1–6	5	6	8	7	4	3	33
1–7	6	9	10	8	8	7	48
1–10	8	4	6	9	3	5	35

By the number of transactions, the most popular is the connection 1-5 and 1-7. But for the sake of completeness of the importance of this or that integration connection we suggest to consider not only the number but also the cost of the performed operations. Their output will determine the cash flows between the elements of the system that create the integration link. This will allow you to determine the amount of work done on a system that is relevant to a particular integration link:

$$CF_{ij} = q_{ij} \cdot c_{ij}, \quad (1)$$

where CF_{ij} is the cash flows moving from the i-th to the j-th element between which the integration link is established;
q_{ij} - number of operations between i-th and j-th elements;
c_{ij}- the average cost of one operation between i-th and j-th elements.

To determine the power of the integration link between system elements - project participants - we apply the formula:

$$N_{ij} = \frac{CF_{ij}}{t_{ij}}, \quad (2)$$

where t_{ij}- the time spent performing operations between the i-th and j-th elements.

Based on the obtained values of the capacities of the integration links, it is possible to determine their rating (Table 4).

Table 4. Rating of integration links of element "1"

Connection	Number of operations	The average cost of one operation	Cash flow	Connection power	Connection power rating
1–2	25	120	3000	500	3
1–3	21	50	1050	175	6
1–4	24	42	1008	168	7
1–5	48	77	3696	616	2
1–6	33	210	6930	1155	1
1–7	48	60	2880	480	4
1–10	35	35	1225	204	5

The most powerful is the link between the "1" and "6" elements (meaning direct link between the elements, no feedback is involved).

It is possible to determine the total power of all element integration links by the formula:

$$N_i = \sum_{j=1}^{m} N_{ij} \left(i = \overline{1,n} \right). \quad (3)$$

Thus, the total integration power of element "1" is 3298 (monetary units / time unit). If you make a similar assessment for other elements of the system, you can determine the rating and overall power of the integration links for each project participant. Based on the results obtained, a management decision should be made to manage the integration risks in the project.

II. Creation of model of matrix of integration potential.

To determine the integration potential of project participants, it is proposed to use the model of the integration potential matrix. The ordinate axis determines the power rating of the element integration links (1–4 - significant power, 5–8 - average power, 9–12 - insignificant power). The ordinate axis defines the areas of ABC analysis that reflect the number of integration links of participants (group A is large, group B is medium, group C is insignificant) (Table 5).

Table 5. Matrix of integration potential

Connection power	The importance of project participants (by number of integration links)		
	Group A	Group B	Group C
significant	high	high	high
average	high	average	low
insignificant	average	low	low

For the example of the project, the matrix of integration potential is presented in Fig. 3.

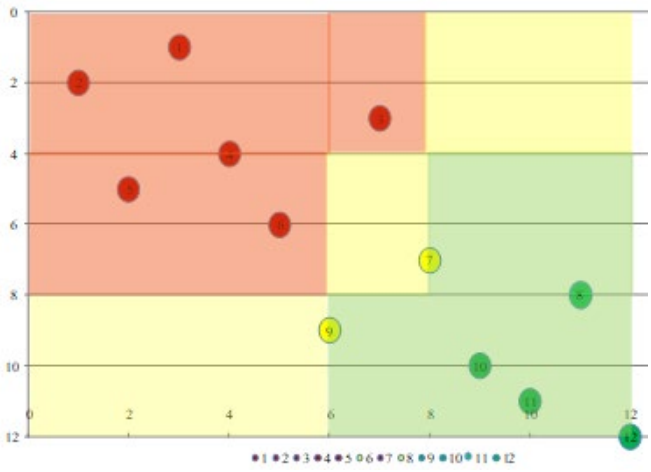

Fig. 3. Matrix of integration potential of project participants

The integration capacity matrix allows the project participants to be divided into areas of high, medium and low integration potential of the participant. Depending on which area of the matrix a particular project participant falls in, it is possible to determine its integration potential, that is, the degree of influence on the stability of integration ties between project participants.

III. Conclusions

The approach proposed in the paper allows for an analysis of integration risks and to prevent the integration gap between project participants, which, in turn, should have a significant impact on project performance. Positive results can be obtained by applying the tools of modern management concepts. A model of integration potential of project participants is presented, which makes it possible to identify the participants most vulnerable to the impact of the risk of rupture of integration ties. The creation of the matrix is based on the information obtained in the previous stages of qualitative risk analysis: determining the amount and power of integration links. The application of the model allows to divide participants into zones of high, medium and low integration potential. Depending on the degree of depth of analysis, a number of participants are identified for which further analysis of the individual integration links should be conducted and the causes of the risks of rupture should be identified.

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