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NETWORK ORGANIZATION RISK MANAGEMENT BASED ON SUSTAINABILITY INDICATORS[1]

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Importance: nowadays its becomes more important to pay attention to risk management in organizations, especially network ones. This importance is caused also by global processes. Thus, choice the most effective risk management method in certain context of organization can be the key. *Purpose*: the main purpose of this paper is the development of risk management method based on organization risk tolerance indicator which depends on sustainability. *Research design*: this research is based on the sustainability of network organization. Network organization sustainability depends on elements' sustainability including central. In its turn, element sustainability is based on sustainability of its departments and their activities. The main idea of research is using risk tolerance indicator based on potential sustainability of organization in case of risks occurrence. *Result*: a method for risk tolerance determining has been developed. To get potential sustainability loss, potential, criticality and impact on activity are determining for each risk. Potential sustainability can be represented as range or single value based on chosen method of calculation. This method can be used in risk management and organization structure assessment but requires some improvements like using time parameter as variable and risk interaction loops resolve.

Keywords: network organization, organization sustainability, risk tolerance, risk criticality, risk potential, potential sustainability, sustainability loss.

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Introduction

Explained in simple terms risk is the possibility of something bad happening. In the context of an organization, risk is defined as any event or circumstance that can negatively affect that organization [11].

Nowadays due to some global accidents like COVID-19 pandemic,

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unstable politic environments, energy crisis, etc., it's important to research risk management in the context of actual problems. For example, pandemic becomes the additional factor for risks in personnel management [7]. Also the increase of the relevance of financial statements, which can be linked to financial crisis, leads to the necessity of accounting risks research [10].

On other hand, the progress force us to get some new focuses in risk research. Digitalization leads to the growth of importance of cyber risks and organizations need to handle those risks [12].

According to researches, there're some ways of risk management. It can be knowledge management which has positive impact on the operational risk [6]. Another way is combing data analysis and enterprise modeling [1]. As Shi Qiao proposed, network organization can be used to solve consumer credit risk [8].

Thus, organizations can handle their risks in multiple ways based on which approach they choose. And sometimes it can be useful to do revision of risk management to understand how effective is current approach.

Speaking about network organizations, it is necessary to note that these systems can get additional points in risks management. For example, it can be more important to manage risks linked to cooperation with partners [2]. Also the dynamic nature of network organizations has to be taken into account while modeling human and organizational risks [9].

Thus, nowadays in the context of network organization research, specifically risk management research, it is important to take into account global processes, manifold of risk management approaches and network organizations' specialties.

This paper is focused on the risk management in the context of network organization sustainability. During previous stages of research sustainability indicator and methods of its calculation were developed. The main goal of current research is the development of method which will link sustainability and risk management.

Methods and results

Network organization sustainability

Previously, the integral indicator S_i was developed for assessing the integration sustainability of a networked economic system [3]:

$$S_{int} = f(S_{el}, S_c), \quad (1)$$

where S_{el} – indicator of «basic sustainability» of single network's element; S_c – aggregate indicator of central element's sustainability; f – function which determines additive value for separate sustainability indicators S_{el} and S_c.

Central element's sustainability is based on departments' and activities' sustainability:

$$S_c = f_c(\{f_{cd}\{d_{ci}, w_{ci}\}, f_{ca}\{a_{ij}, w_{cij}\}\}), \quad (2)$$

where d_i – sustainability of central element's i-th department; w_i – r_{ci} edge's

weight; a_{ij} – sustainability of j-th activity that refers to i-th department; w_{ij} – r_{ij} edge's weight; f_{cd} – function that determines central element's sustainability dependency from department; f_{ca} – function that determines central element's sustainability dependency from activity.

Activities sustainability on its hand depends on its efficiency level (e_{lij}), stability level (e_{sij}) and sustainability of linked activities:

$$a_{ij} = f_a\left(f_{ae}(e_{li}, e_{si}), \left\{f_{aa}\left(a_{\bar{ij}}, w_{(\bar{ij},ij)}\right)\right\}\right), \quad (3)$$

where f_{ae} – function of relation between activity's efficiency and stability and their impact on sustainability; $a_{\bar{ij}}$ – sustainability of linked activity which impacts on sustainability; $w_{(\bar{ij},ij)}$ – weight of $\bar{r}_{(\bar{ij},ij)}$ edge which describes link between activities; f_{aa} – function of activity's sustainability dependence on sustainability of another activity; f_a – function of activity sustainability a_{ij}.

Efficiency level can be measured by different methods of assessment. For example, it can be KPI method, 360-degree method, employee's knowledge testing, etc. It depends on structure of activity.

Considering HR sustainability usage of competency model combined with stability index has been proposed as tool for sustainability assessment [4, 5]. In this context the most valuable part of this tool can be stability index:

$$e_s = 1 - \frac{k * \sum_{i=1}^{n}(\Delta L_i * c_i)}{n}, \quad (4)$$

where k – parameter of total dynamics pattern (depends on similarity of level's change: stable that is only growth, fall, still, or unstable that is combination of growth and fall); ΔL_i – difference between levels during determined (i) period; c_i – parameter of certain dynamic pattern during i-th level change that depends on if level growths or falls; n – periods count.

Depend on activity structure its sustainability can be heavily or slightly relied on stability index. Talking about risks situation can be the same. That's why it is important to take into account both stability index and efficiency level.

Activities impact on sustainability of department where they are produced. That means department's sustainability can be calculated based on its activities' sustainability values:

$$d_i = f(\{a_{ij}, w_{ij}\}), \quad (5)$$

where d_i – sustainability i department; a_{ij} – sustainability of j-th activity produced in i-th department; w_{ij} – r_{ij} edge weight.

Structure of risk

In this context of network organization sustainability, we need to determine some types of risks. Low sustainability may lead to some risk occurrence. On other hand some risk occurrence may lead to fall of sustainability. Thus, we can determine two types of risk by its connection with sustainability:

– dependent risk that is occurs due to sustainability loss;

– influential risk that is leading to sustainability loss.

Since many activities and departments can be interconnected some risks can be both dependent and influential. We should consider their types taking activity into account they linked with.

Occurred risk leads to need of recovery. Depending on recovery cost it can lead to department or activity shutdown: partial or total. Taking this into account we can determine types of risk criticality by its recovery cost:

– low-cost risk which recovery doesn't require any activity shutdown;

– medium-cost risk which recovery requires shutdown of activities without impact on other activities or departments;

– high-cost risk which recovery requires shutdown of activities and leads to other activities and departments sustainability loss

– critical risk which recovery will lead to shutdown of all department's activities.

Speaking about source of risk, we can determine internal and external risks. Internal risk occurs due to reasons linked to internal organization events. External risk occurs due to outer reasons (e.g. political, environmental, economical, etc) and usually cannot be managed by organization resources: organization can only manage risk consequences, but not its occurrence.

On other hand, network organization is an object of study. In context of central element, risk which produced by non-central element can be considered as internal for non-central and external for central and vice versa. In the context of this paper we will use simplified version of classification considering all internal risks as internal for every element of network.

Thus, source of internal risk can be determined as state of activity or department. Since activities and departments parameters are involved in sustainability parameters, we can use sustainability parameters for risk calculation.

Since risk is only the possibility of something bad happening, to calculate risk tolerance we need the last parameter of risk: potential of occurrence. In context of research we distinguish next types of potential:

– zero potential: risk will not occur;

– low potential: risk will occur with low possibility;

– medium potential: risk will occur with medium possibility;

– high potential: risk will occur with high possibility;

– guaranteed potential: risk will occur.

If risk can occur in different ways so it can have different cost of recovery we should understand that there can be such event like risk escalation which means, for example, guaranteed potential for low-cost risk and medium potential for medium-cost one.

Based on this structure terms of risk integral the model of risk tolerance has been developed.

Potential risk consequences

In current context time parameter is taken as constant. It has to be understood that risk occurrence result may be different depending on period length and presented models can become more complicated by adding time variable as parameter to each formula.

To get risk tolerance we need to have information about potential organization sustainability in determined context. Thus, we need to produce chain calculation: get dependent risks potentials based on determined sustainability values, then get potential influential risks results. By this way external risks considered as only influential due to their lack of internal source.

First step is risk occurrence:

$$R_k = (c_{kl}, p_{kh}) = f(\{A, D\}), \quad (6)$$

where R_k – k-th risk occurrence which is presented as combination of p_{kl} and c_{kl}; c_{kl} – l-th criticality of k-th risk occurrence; p_{kl} – h-th potential of k-th risk occurrence; A – set of activities sustainability a_{ij} related to risk occurrence reason; D – set of departments sustainability di related to risk occurrence reason.

Both sets can be empty. In this case risk is determined as external. For internal risks at least one set has to contain at least one element.

This formula can be represented as system of equations. For example:

$$R_2 = \begin{cases} c_{2.1}, p_{2.1}, 0 \le a_{1.1} \le 0.2 \\ c_{2.1}, p_{2.2}, 0.2 < a_{1.1} \le 0.5 \end{cases}, \quad (7)$$

In this case activity 1 of department 1 ($a_{1.1}$) can cause risk 2 (R_2) occurrence with 1st type of criticality ($c_{2.1}$, *low-cost risk*) with low or medium potential ($p_{2.1}$ *or* $p_{2.1}$) depending on sustainability level.

Risk occurrence may lead to sustainability loss of activities and departments. It can be based on risk parameters:

$$\Delta a_{ijk} = f(\{C_k, P_k\}), \quad (8)$$

where Δa_{ijk} – loss of activity a_{ij} sustainability in case of occurrence k risk with set of risk parameters; C_k – set of k-th risk criticalities; P_k – set of k-th risk potentials.

Based on sustainability loss potential and current level of sustainability potential range of sustainability can be calculated:

$$\begin{cases} a_{ijkmax} = a_{ij} - min(f(\{C_k, P_k\})) \\ a_{ijkmin} = a_{ij} - max(f(\{C_k, P_k\})) \end{cases}, \quad (9)$$

where a_{ij} – current level of *ij*-th activity sustainability; a_{ijkmin} and a_{ijkmax} – minimal and maximal levels of sustainability that are possible in case of k risk occurrence; $f(\{C_k, P_k\})$ – function of sustainability loss.

Minimal and maximal potential levels form potential sustainability range

$$ap_{ijk} = [a_{ijkmin}; a_{ijkmax}]. \quad (10)$$

By this range the worst and the best possible potential organization sustainability can be calculated.

Risk tolerance can be determined by acquiring potential sustainability. To get comprehensive potential sustainability all risks occurrence consequences must be taken into account.

Activity sustainability a_{ij} can be replaced with department sustainability d_i in these formulas.

Risk tolerance

Risks in simultaneous occurrence may impact on the same sustainability subject. In this case it is needed to acquire system of risks interaction. In context of research we propose two ways of interaction solutions.

First solution is loss diminishing function which will decrease each next loss to negate possibility of huge impact on sustainability of all risks occurring simultaneously. It can be logarithmic function.

Second solution is risk interaction matrix which determines function applied to pair of sustainability loss values caused be simultaneous risk occurrence. Function can be like sum, max, etc. For this solution priority of functions is required.

When risk interaction pattern is developed, matrix of risk tolerance needs to be constructed (table 1):

Table 1

Matrix of risk tolerance

Risk	Criticality	Potential	d_1	…	d_n	$a_{1.1}$	…	a_{nm}
R_1	…	…	$\Delta d_{1.1}$	…	$\Delta d_{n.1}$	$\Delta a_{1.1.1}$	…	$\Delta a_{n.m.1}$
…	…	…	…	…	…	…	…	…
Potential sustainability loss min			Δd_{1min}	…	Δd_{nmin}	$\Delta a_{1.1min}$	…	$\Delta a_{n.mmin}$
Potential sustainability loss max			Δd_{1max}	…	Δd_{nmax}	$\Delta a_{1.1max}$	…	$\Delta a_{n.mmax}$
Potential sustainability range			dp_1	…	dp_n	$ap_{1.1}$	…	$ap_{n.m}$

Each row in this matrix represents combination of risk and criticality. First 3 columns reserved for risk data: risk id, criticality of risk occurrence, potential of risk occurrence with certain criticality. Next columns represent departments and activities sustainability. Intersection of risk and sustainability contains sustainability loss that will be caused by risk occurrence with determined type of criticality.

Depend on risks structure last rows can represent potential sustainability range or singe potential sustainability level. It will be range if any risk has number of criticalities so every criticality must be taken into account. On other hand, in case of single-criticality risks in table or taking «the most possible» case into account, last row will contain single potential sustainability value:

$$Sp_c = f_c(\{f_{ca}\{dp_{ci}, w_{ci}\}, f_{ca}\{ap_{ij}, w_{cij}\}\}), \quad (11)$$

where S_{pc} – potential sustainability level of central element; d_{pci} – potential sustainability of *i*-th department; a_{pij} – potential sustainability of *ij*-th activity.

Central sustainability loss can be acquired by potential sustainability level:

$$\Delta Sp_c = S_c - Sp_c. \quad (12)$$

Risk tolerance can be determined by central sustainability loss:

$$RS_c = f(\Delta Sp_c). \quad (13)$$

It is necessary to distinguish external and internal risks calculations because external are not manageable for organization. Thus, risk tolerance formula should be corrected by this way:

$$RS_c = f(\Delta Spe_c, \Delta Spi_c), \quad (14)$$

where ΔSpe_c – potential sustainability loss due to external risks; ΔSpi_c – potential sustainability loss due to internal risks.

Also it is necessary to note that departments' sustainability has only informative function in risks rows. For potential sustainability loss it has to be calculated based on activities' potential sustainability values since department's sustainability is based on its activities' sustainability values.

Another notable property of table is activities' sustainability interaction representation necessity. If one activity can impact on sustainability of another one, then sustainability loss has to be placed for both activities. It will exclude necessity of post-calculations for total potential sustainability of activities.

Matrix usage example. Potentials priority

To make previously described matrix work, an expert has to choose the way of potential sustainability calculation. There can be three main potential risk types:

– potential sustainability in the worst case;

– potential sustainability in the best case;

– potential sustainability in the most possible way.

The worst and the best cases work in pair. The worst case sustainability is based on the highest critical risks way of occurrence (i.e. every risk occurs with the highest criticality). The best case sustainability can have the same value as actual sustainability if there're no «guaranteed» risks. In another way it will be based on the «guaranteed» risks occurrence only.

«The most possible way» means implementing of potential's filter with criticality priority. An expert has to determine risk potential's breakpoint for risks calculation. All risks with potential which is lower than breakpoint will not be included in calculation. For other risks there will be another set of rules:

– if two or more ways of risk occurrence have different potential only one with the highest potential stays;

– if two or more ways of risk occurrence have similar potential only one with the highest priority criticality stays;

Criticalities priority list has to be determined by an expert according to context.

For example, let's take matrix with four risks. Next parameters of matrix are used:

– potential sustainability type: single, the most potential;

– potential's breakpoint: «high»;

– criticality priority: critical > high > medium > low;

– risk interaction: sum of losses for every risk combination.

Objects' sustainability values presented in next table:

Table 2

Organization sustainability values

S_c	d_1	d_2	$a_{1.1}$	$a_{1.2}$	$a_{1.3}$	$a_{2.1}$	$a_{2.2}$
0.7	0.6	0.75	0.7	0.5	0.7	0.8	0.75

Matrix of risk tolerance is presented below:

Table 3

An example of risk tolerance matrix

Risk	Criticality	Potential	d_1	d_2	$a_{1.1}$	$a_{1.2}$	$a_{1.3}$	$a_{2.1}$	$a_{2.2}$
R_1	**low**	**guaranteed**	**0.05**	-	**0.10**	-	-	-	-
R_1	medium	medium	0.10	-	0.15	-	-	-	-
R_1	high	low	0.20	0.05	0.25	0.10	-	-	0.10
R_2	low	**high**	-	0.02	-	-	-	0.01	0.01
R_2	**medium**	**high**	-	**0.10**	-	-	-	**0.08**	**0.08**
R_3	**medium**	**high**	**0.08**	**0.07**	-	-	**0.12**	**0.10**	-
R_3	high	medium	0.15	0.10	0.05	0.05	0.12	0.10	0.08
R_3	critical	medium	0.25	0.20	0.10	0.10	0.12	0.100	0.15
R_4	critical	zero	0.40	0.15	0.20	0.20	0.20	0.15	0.15
The most potential sustainability loss			-	-	0.10	0.00	0.12	0.18	0.08
Potential sustainability			0.52	0.63	0.6	0.5	0.58	0.62	0.67

Sustainability level can have value between 0 and 1.

Potential sustainability in this case will be equal to 0.6. Risk tolerance will be calculation by function using 0.1 as sustainability loss value.

How calculations were produced:

– all risks occurrence ways with potential lower than high were excluded;

– R_1 and R_3 had only one occurrence way;

– R_2 had two occurrence ways, the one with low criticality was excluded;

– losses for every activity were summed based on risks which left in table after filtration, they are bold in the table 3;

– based on losses activities' potential sustainability values were calculated. For example, $a_{2.1}$ current sustainability level is 0.8 and its potential loss is 0.18 due to R_2 and R_3 occurrence. That means potential sustainability of this activity is 0.62;

– departments' potential sustainability values were calculated based on activities' potential sustainability values;

– potential sustainability of central element and sustainability loss were calculated based on values mentioned above.

Conclusion

Network organization sustainability can be represented as current sustainability and potential sustainability. Potential sustainability is the way of how business can be going on if there will be no changes to current state. Understanding the priority of necessary changes can help to reduce critical losses in case of risks occurrence.

Developed risk tolerance and method of its calculation can be some of tools which can impact on process of decision making.

First benefit is understanding the priority of risks. If some risk doesn't have high impact on sustainability, then it can be ignored in case of presence of more critical ones.

Second benefit is understanding of dangerous activities links, especially interdepartmental. If risk occurrence in one department will lead to the shutdown in the another one due to link between their activities, it can be the signal to consider restructure of activities architecture. Thus, risk tolerance matrix can become also a tool of organization's structure analysis.

In combination if risk register which contains the set of actions required for risk resolve this tool can be used for resource planning. If some risk has high potential in some context and there is no way to lower its potential, resources for its resolve can be reserved in advance.

On other hand it has some flaws which require additional actions.

Firstly, the method described in this paper doesn't use time parameter as variable: it has to be constant. So if someone is using risk tolerance matrix, they need to create three versions of this: short-term, middle-term and long-term. Every of these three version of matrices has to be taken into account during the process of decision making to understand which risk is important now and which will be important soon.

Secondly, risk interaction can be looped. Activity A impacts on B while activity B impacts on C. If activity C impacts on A, then any risk which involve one of this activity will start the loop. The method of resolving loops like this has to be developed.

Thirdly, in reality the sum of losses will not probably work just as intended. Simultaneous risks occurrence can lead to different situations, so it is necessary to develop the method of risks interaction calculation that will be the most fitted for determined context.

According to advantages and flaws of developed method mentioned above we can say this method will require some human resources to be used in efficient way. To be automated it has to be improved.

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УПРАВЛЕНИЕ РИСКАМИ СЕТЕВОЙ ОРГАНИЗАЦИИ НА ОСНОВЕ ПОКАЗАТЕЛЕЙ УСТОЙЧИВОСТИ[1]

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Предмет: в настоящее время, в том числе из-за глобальных процессов, становится все более актуальным уделять внимание управлению рисками в организациях, особенно сетевых. При этом важным становится выбор того метода, который будет эффективен в конкретном контексте. *Цель*: основной целью данной статьи является разработка метода управления рисками на основе показателя устойчивости к риску, который зависит от устойчивости организации. *Дизайн исследования*: исследование основано на применении показателей устойчивости организации в контексте управления рисками. Устойчивость сетевой организации зависит от устойчивости элементов, в том числе центральных. В свою очередь, на устойчивость элемента влияет устойчивость как его отделов в целом, так и их деятельности в частности. Основная идея заключается в определении показателя рисковой устойчивости, который основан на потенциальной устойчивости организации в случае реализации рисков. *Результаты*: разработан метод определения рисковой устойчивости. Чтобы получить потенциальную потерю устойчивости, для каждого риска определяют потенциал, критичность и влияние на деятельности отделов. Потенциальная устойчивость может быть представлена в виде диапазона или единичного значения в зависимости от выбранного метода расчета. Разработанный метод может быть использован в управлении рисками и оценке организационной структуры, но требует некоторых улучшений, таких как использование временного параметра в качестве переменной и разрешение циклов взаимодействия рисков.

Ключевые слова: сетевая организация, устойчивость организации, устойчивость к риску, критичность риска, потенциал риска, потенциальная устойчивость, потеря устойчивости.

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