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Emergency risk assessment and management

Evaluación y gestión de riesgos de emergencia

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ABSTRACT

This article attempts to study the role of ***emergency risk management in the era of the digital economy***. ***The main purpose*** of the article is to identify the major patterns that determine the features of risk assessment in business as the main element contributing to the achievement of economic security of the organization, as well as to carry out a comparative analysis of risk assessment and management methods in emergencies. The modern economic analysis employs various risk management methods. The most effective ways to reduce risk in conditions of the economic and political instability in Russia are the method of scenarios and the method of hierarchy analysis, as well as diversification, i.e. the distribution of risks between several business participants. Emergencies may have a different character depending on the nature of the adverse event. This article deals with natural and man-made emergency dangers.

Keywords: Model; Threat; Risk; Risk management; Emergencies; Security.

RESUMEN

Este artículo trata de estudiar el papel de la gestión de riesgos de emergencia en la era de la economía digital. El objetivo principal del artículo es identificar los principales patrones que determinan las características de la evaluación de riesgos en las empresas como principal elemento que contribuye a la consecución de la seguridad económica de la organización, así como realizar un análisis comparativo de los métodos de evaluación y gestión de riesgos en emergencias. El análisis económico moderno emplea diversos métodos de gestión de riesgos. Las formas más eficaces de reducir el riesgo en condiciones de inestabilidad económica y política en Rusia son el método de escenarios y el método de análisis jerárquico, así como la diversificación, es decir, la distribución de los riesgos entre varios participantes en el negocio. Las emergencias pueden tener un carácter diferente según la naturaleza del evento adverso. Este artículo trata de los peligros de emergencia naturales y los provocados por el hombre.

Palabras claves: Modelo; Amenaza; Riesgo; Gestión de riesgos; Emergencias; Seguridad.

1. INTRODUCTION

Human life and the existence of people communities are associated with many different factors. Certainly, one of the goals of human life is, above all, a safe and carefree life. It is obvious that each human, no matter what social stratum of the population is, strives for a high standard of living, and tries to ensure a healthy and comfortable life with good living conditions, including protecting himself against any danger and aggression.

Safety is a condition in which there is no danger. Perhaps this definition of security is quite simple, but in our opinion, it is the most accurate and, reflects the essence of this phenomenon.

Nature is beautiful, however, not all of its manifestations can please us. Some natural manifestations can be so dangerous that they can destroy entire villages, towns, cities, even countries. This explains such a high role of security. Many natural disasters are inactive today but can awake from a state of hibernation and become a threat to humanity.

Therefore, states around the world are making efforts to combat the terrible natural phenomena, and not only with natural phenomena. Interpol and the UN are among the few examples of international organizations that have united to ensure security on our planet. To ensure security, in different countries there are specialized state bodies. For example, in Russia, this is the Federal Rescue Service (EMERCOM) and the Russian State System for Emergencies (RUERS) – a single national system for preventing and liquidating emergencies.

How do emergencies occur? Who becomes their catalyst? According to the official approach, the cause of an emergency is called the **source**. There is a more complete definition –the source is a natural cataclysm or a man-made catastrophe that resulted from emergencies (Akimov *et al.*, 2001; The Civil Code of the Russian Federation, 2003; Government of the Russian Federation, 1996; Ministry of the Russian Federation for Civil Defense, 1995; Shoigu *et al*., 1997; State Committee of the Russian Federation for Standardization and Metrology, 1995a, 1995b, 1995c). For example, the explosion of the Chernobyl nuclear power plant in 1986, or the outbreak of COVID-2019 in China, which caused today's pandemic.

There are a large number of definitions of the concept of **Risk**. In this work, the **risk** is understood as the possibility of incurring adverse actions. Risk is a quantitative assessment of a "bad scenario", which will result in losses (Chereshkin, 2014; Gubanov, 2014; Kiseleva and Simonovich, 2014; Kleiner, 2014; Shapkin and Shapkin, 2013).

2. RESEARCH METHODS

Methods of cognition, retrospective and documentary analysis, as well as synthesis, generalization, and systematization were used in the performance of the work.

The risk can be assessed using certain quantitative indicators. They should clearly show which source is more dangerous, which is more destructive, etc. Certainly, these indicators should be primarily objective and should not lead to false judgments.

According to the official methodology, the risk is the probability Q depending on time t, where t is the period in which events may happen. As a rule, t corresponds to a period of one year. Thus, one resulting indicator is $Q(t)$.

The next variable is damage. In this work, the damage is associated with an occurred emergency. In quantitative terms, damage w is expressed as the cost of the damage suffered.

Finally, the risk indicator is the calculated mathematical expectation of damage from an emergency for a period t:

$$\overline{W} = \sum_{i=0}^{1} P(H_i) w_i = Q(\Delta t)\, w, \quad (1)$$

$$\text{where } P(H_0) = Q(\Delta t)_, P(H_1) = 1 - Q(\Delta t)_, w_0 = w, w_1 = 0. \quad (2)$$

If the number of events is greater than one (N > 1), then the amount of damages incurred is taken as:

$$\overline{W} = \sum_{i=0}^{N} w_i = a(\Delta t)\, \overline{w}, \quad (3)$$

The risk indicator is calculated by the formula:

$$Risk\ indicator\ [\frac{damage}{time}] = frequency\ [\frac{events}{time}] \times average\ damage\ [\frac{damage}{events}] \quad (4)$$

3. RESULTS

As a result of the present research, it is necessary to provide descriptions of various types of risk, the frequency of their occurrence, and the damage/losses incurred as a result of an emergency, expressed in quantitative terms. The results of the study are given in Tables 1-5.

Table 1. Quantitative estimates of the natural disaster and calamity frequency in the territory of Russia.

Dangerous event	Frequency, $year^{-1}$
Natural emergencies, including those resulting from:	200…500
Forest fires (an area of more than 100 hectares)	50…200
Storms, hurricanes, tornadoes, and squalls	60…100
Man-made emergencies , including those resulted from:	$(0,5…1,5)*10^3$
Fires and explosions;	200…300
Accidents on pipelines;	30…80
Aviation disasters;	10…40
Major car accidents;	80…150
Major rail crashes;	5…10
Hydrodynamic accidents	2…5
Biological and social emergencies	50…150
Lightning strike into an unprotected self-propelled rocket launcher	$(2…4)*10^{-4}$
The severe nuclear reactor accident	$10^{-5}…10^{-6}$
Radiation accident with nuclear ammunition	$10^{-6}…10^{-7}$
Aircraft impact to a nuclear reactor	$10^{-10}…10^{-11}$

Table 2. The damage in absolute quantitative terms in the form of the number of fatalities, the number of injured persons, material damage, and the area of action of dangerous factors.

Parameter	Value
Number of injured and fatalities	
From emergencies in 2003:	15,624
Including the fatalities	909
From the Chernobyl disaster:	600 thousand
Including the fatalities (as of 1986)	31
Prognosis of the number of deaths from radiation-induced cancer among liquidators during later life	700
Number of persons with disturbed living conditions (resettled)	
From the Chernobyl disaster;	350 thousand

From the Kyshtym radiation accident	10.2 thousand
Declared material damage, bln rubles.	
From emergencies in 2000:	
Technogenic;	1.4
Natural;	23.3
Biological and social.	0.1
From the Chernobyl disaster (in 1987 prices)	
Straight	10
Indirect	250
Area in sq. km of the zones of hazardous factors (radioactive contamination at the level of 1 Ki/sq. km)	
Chernobyl radioactive trace;	130 thousand
The East Ural radioactive trace (1957)	1.4 thousand

Let consider other types of risk.

Depending on who has suffered from the risk, it can be individual or group. In the first case, the damage is borne by one person, in the second - by a group of people. For example, if a human was born with a genetic disease, then this is a purely individual risk because it affects only this person. If one is in distress, there is a risk of bankruptcy.

Thus, individual risk is the probability of negative consequences for the health of one person. This may happen due to his stay in the territory of a dangerous zone, in which there are many sources of danger.

Table 3. The individual risks of human death.

Risk source			Causes of death	Individual risk of death, $year^{-1}$
Area	Environment	Natural	Accidents during earthquakes, hurricanes, floods, etc.	$10^{-8}…10^{-5}$ ($1,0*10^{-5}$)[1]
		Man-made	Accidents at home, in transport, morbidity from environmental pollution, etc.	$10^{-6}…10^{-3}$ ($0,9*10^{-5}$)[6]
	Human habitat	Social	Suicides and self-harm, murders and injuries with criminal purposes, murders and injuries related to military operations, etc.	$10^{-4}…10^{-2}$ ($3,8*10^{-4}$)[4] ($3,1*10^{-4}$)[5]
		Internal (body)	Genetic and somatic diseases	$10^{-4}…10^{-2}$ ($1,6*10^{-2}$)[1]
Activity	Professional		Occupational diseases, accidents	$10^{-6}…10^{-2}$ ($1,4*10^{-4}$)[2]
	Unprofessional		Morbidity and accidents in amateur sports and all types of non-professional activities	$10^{-4}…10^{-2}$ (10^{-2})[3]

In contrast to individual risk, there is a group risk. According to the official methodology, it is called a collective (social) risk. This type of risk is associated with a group of people, caused by the fact that this group stays near sources of danger. For example, the research group, which carried out works near the Chernobyl nuclear power plant, where an accident occurred in 1986. And although the tragedy happened a very long time ago, in some places near the sarcophagus, high levels of radiation can persist to this day. Collective risk differs from individual risk in that it refers to a group, which means it has an integral characteristic.

The damage from collective risk is measured by the number of deaths *n* caused by emergencies.

According to the classification, risks can be divided into those that are committed voluntarily and involuntarily. For example, if one is going to jump with a parachute, then he consciously assumes the possible risk of dying by jumping from an airplane. If an employee works near the Chernobyl nuclear power plant and this work is his responsibility, then the risk will be forced. Thus, risks can also be divided into voluntary and involuntary.

The latter is often associated with work and professional activity. Certainly, one chooses a job voluntarily, but the purpose of the profession is primarily to earn a living. If a nuclear physicist who has worked at a nuclear power plant for 20 years is deprived of his job, then in fact he is deprived of a part of his life. The profession is vital for every member of society, and it is because of this that the risks associated with the professional activity are attributed to involuntary risks.

The society in which we live covers involuntary, professional risks, because such activities are vital.

Table 4. Operating conditions and the quantitative risk assessments associated with them, as well as assessment of risk acceptability.

Operational conditions	Risk level per year	Risk acceptability assessment
Safe	$\leq 10^{-4}$	Negligible level of risk
Relatively safe	$10^{-4}\ldots10^{-3}$	Relatively low level of risk
Dangerous	$10^{-3}\ldots10^{-2}$	High level of risk; security measures must be taken
Extremely dangerous	$\geq 10^{-2}$	Extremely high level of risk; protective measures must be applied

Among the situations that can be arranged by the level of danger close to emergencies, we can also note certain events, such as major international financial crises, but they are not emergencies. Economic crises do not lead to drastic consequences in the life of the population; they lead to deaths and losses very rarely. Here, an analogy can be drawn with chronic and non-chronic diseases. Chronic diseases develop gradually and are rarely fatal, while non-chronic, acute diseases develop rapidly.

The factors affecting a person can be very different. They can be divided into several types.

1) Radiation. For example, the explosion at the nuclear power plant in Japan in 2009.

2) Mechanical. In its pure form, the mechanical damaging factor is quite rare, it is often combined with other factors.

3) Biological. For example, the COVID-2019 pandemic, as a result of which, today, more than 500 thousand infected are registered in Russia.

4) Thermal.

5) Informational.

Besides, risk factors can be electromagnetic, sound, thermal, acoustic, and other sources.
They can be divided into primary and secondary. Primary factors are related to the source, while secondary factors are not related to the source.

Table 5. The characteristics of destruction for different types of structures. The estimate is given for wind speed in meters per second.

Types of structures	Degree of destruction		
	Light	Medium	Strong
Industrial buildings	35-40	40-60	60-80
Brick low-rise buildings	30-35	35-50	50-70
Transformer substations of closed type	45-55	55-80	80-110
Ground metal tanks	40-50	50-65	65-80
Gas tanks	40-45	45-55	55-65
Rectification columns	35-40	40-50	50-65
Lifting and transport equipment	45-50	50-60	60-70
Ground pipelines	45-55	55-70	70-90
Low voltage overhead lines	35-40	40-55	55-70
Cable terrestrial communication lines	30-35	35-45	45-60

The values given in the Table were determined empirically. If a structure can withstand a powerful hurricane, then it is resistant.

Any risk is associated with losses. Losses mean that people are becoming inactive. For example, during the war, died are attributed to irretrievable losses. The wounded are also considered a loss, as they are unable to continue taking part in hostilities.

The loss shows the material damage caused during the emergency. Damage can be direct and indirect. The first is caused by damaging actions that lead to damage or destruction, failure of objects of economic, and social purpose, loss of property, and adverse impact on the environment. Indirect damage is associated with possible interruptions of economic activities, any lost profits, the costs incurred to eliminate an emergency, and its consequences.

4. DISCUSSION

Risk management is the activity focused on finding and adopting the best possible scenario that will minimize the accepted risk. This approach is actively used both in public institutions and private businesses. The purpose of risk management is to reduce the scale of risk and take protective measures (Domashchenko and Finogenova, 2010; Foss, 2007; Makarenko, 2020; Morrow *et al*., 2007; Tereshchenko, 2019; Vakhitov, 2018).

Risk management includes several components:

1) Risk analysis

2) Data collection

3) Risk identification

4) Risk assessment

5) Development of recommendations

The risk management process begins with risk analysis followed by data collection.

The next stage of risk management is risk identification. Here, the main tasks are to analyze the entire system for potential hazards and their documentation.

The next, most significant stage of risk analysis is the identification of hazards. Here, the main task is to track down all the inherent hazards of the system and their description.

The risk assessment stage is highly mathematized and uses well-established risk assessment methods, which are described in a variety of domestic and foreign sources (Artemov and Ketko, 2018; Bezuglaya, 2013; Gomola *et al*., 2019; Karmanov *et al*., 2021; Kiseleva *et al*., 2019a, 2019b; Nesterenko, 2018; PwC, n.d).

The development of recommendations is the final stage of risk management. At this stage, recommendations are being developed to reduce the level of risk. Any large company must have a risk management department, whose tasks include providing consulting services to management to reduce the risks assumed. In some cases, this function can be performed by third companies in the framework of outsourcing.

5. CONCLUSION

Risk management is the activity focused on finding and adopting the best possible scenario that will minimize the accepted risk. This approach is actively used both in public institutions and private businesses. The purpose of risk management is to reduce the scale of risk and take protective measures.

Digitalization of the economy from the perspective of financial risk management is an ambiguous phenomenon. On the one hand, it creates many advantages in terms of saving labor and time resources, simplifying data analysis systems, their storage and accumulation, as well as the quality and accuracy of economic calculations. On the other hand, digitalization also creates new risks, most of which are related to cybercrime and fraud on the Internet. To reduce the probability of these risks, companies need to modernize their security system promptly and comply with the requirements for providing data to government agencies that control the purity of financial transactions.

Economic crises do not lead to drastic consequences in the life of the population, very rarely do they lead to deaths and losses. The nature of risk is always associated with the existence of some degree of uncertainty.

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