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RISK-MANAGEMENT OF PUBLIC-PRIVATE PARTNERSHIP INNOVATION PROJECTS

Abstract. *This paper recapitulates the argumentations from various scientific discussion concerning the issue of projects` risk management. The article mainly is aimed to analyze the process of risk-management of the innovation projects in the form of public-private partnership, to describe a methodologies of Failure mode, effects and criticality analysis and Fuzzy comprehensive evaluation model, to use above mentioned models in the evaluation of the stability risk of public-private partnership innovation projects. Previous research studies on the topic of public-private partnership defined the efficiency of state sector and business cooperation in a form of public-private partnership, demonstrated that it will allow making investments in the production capacity development, broaden the scope of domestic and foreign markets, accelerate industrial growth, refine the quality of goods, services and works, business activity and investment attractiveness. Especially it can be achieved through innovation project implementation. Moreover, systematization the results in the overview process of literary sources and approaches in the issue of innovation public-private projects` risk-management problem-solving specifies that a huge number of theoretical and practical problems, especially of risk evaluation is urgent, remain unsolved and still studied not enough nowadays. An underdevelopment of innovation projects' risk-management system, especially in our country, is conditioned the relevance of that scientific problem additionally existing in the circumstances of complex public-private partnership innovation projects` risks evaluation. Investigation of the topic «Risk management of public-private partnership innovation projects» in the article is fulfilled in the following logical sequence: defining the problems while literature review, focusing on project risk-management issue, describing the methodology of the research, demonstrating the results, and making conclusions. The object of research is the chosen by creating a prototype of innovation project in the infrastructure field, suggested that it will be implemented in the form of public-private partnership.*

Keywords: innovation projects, public-private partnership, PMBOK, risk-management, FCEM, FMECA.

Introduction. The importance of innovation for economic development is difficult to overestimate. In today`s world, indicators of innovation are increasingly becoming key in determining the state's economic

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level. Increasingly, attention to innovation is increasing significantly, as its results allow meet the growing and changing demands of the market. The efficiency of investing in innovative projects, in terms of their limitations and variability of the market environment, determines the significant relevance of the analysis of the investment process, improving its organizational and methodological framework. Currently, the investments from the public and private sectors are increased, seeing the deepening situation of instability worldwide. Simultaneously, infrastructure development stays one of the substantial elements on the process of creating a conducive climate for economic growth. The choice of public-private partnership (hereinafter – PPP) projects as a subject of the risk control system, to improve the management of such projects is caused by the fact that at the present stage of economy's development, one of the effective models of investment projects in priority areas of socio-economic development and private businesses in partnership. After all, the implementation of large-scope modernization projects in varied sectors of the economy demands significant investment resources, while as business may be proposed as a powerful source of it. Moreover, there is obligatoriness to define qualitatively innovative mechanisms and tools, which can be a key factor in the process of economy's investment development, especially in Ukraine, to find new forms and methods in the issue of public and private sector collaboration in the investment sphere, as well as to refine the innovative projects` risk-management system in a form of PPP.

Literature Review. The issues of our research are reflected in the scientific papers of many domestic and foreign authors. Particularly attention is focused on scientific and methodical approach to formation of system of controlling of risks of projects of PPP as information and analytical base of acceptance of administrative decisions in the work of Babiak (2014). Poliakova (2009) paid attention at her research to the specific and the problems of PPP formation in Ukraine. Shemaieva (2018) described at her work PPP as a tool for the development of the national economy. Varnavskyi et al. (2010) very deeply studied a phenomenon of the PPP. Wang et al. (2021) paid attention to the one of the probably predictable situations as a failure of the PPP contracts. Dehtiar and Narozhnyi (2013) and, also Brailovsky (2013) emphasized various availability of different forms and models of PPP innovation projects and define ways and classification of models and forms of PPP projects, which can be an influential factor in the analyzing risk-management system of such types of innovation projects. The risk management process is also fully described within the framework «A Guide to the Project Management Body of Knowledge» (PMBOK) developed by American Project Management Institute (PMI, 2017). Problems of forecasting and risk management of innovative projects are analyzed by Tkachova (2013). In its turn, Lipol and Haq (2011), also Bai et al. (2017) and Dukes et al. (2017) studied and analyzed the project risks describing the Model of Fuzzy Comprehensive Evaluation (FCEM) and using the Failure mode, effects, and criticality analysis (FMECA). Simultaneously, in the process of literature overview it was identified that a great variety of methodological and theoretical issues concerning the main trends of projects` risk-management allocation and mechanisms of its realization remain unsolved. Moreover, an overall theory of PPP is now enough imperfect, as well as all processes in business and state cooperation are characterized by the great ambiguity. Projects in the form of PPP have sensibility to an influence of various uncertain destructive factors. Albeit the problem of risks in partnership between state and business involved in PPP projects is deeply studied by scientists, the problem of innovation PPP projects` risk-management system and risk evaluation are still urgent and unsettled issue.

The purpose of this article is to analyze the process of risk-management of the innovation projects in the form of PPP, paying attention to the sustainability risk's assessment.

Methodology and research methods. At the current stage of economic development, the market environment is characterized by the presence of different risks and high level of uncertainty. The main problem in innovation PPP projects planning system is to understand the risks' origin. One more important peculiarity is that conventional innovation projects are less complex than the same projects in the form of PPP. Mainly the reasons for above-mentioned issue may be lay in the difficulties that appears in the process of agreeing on the goals of the state and the private partner, in liability and risks allocation between PPP partners. The system of risks' controlling of innovation projects in a form of PPP promotes to avoid the situation of ambiguity. The following stages in the system's framework can be distinguished: risk's identification, evaluation and accounting of PPP projects risks, risks' control and audit, the final formation of information and analytical database for the successful management decisions which is aimed to minimize the PPP projects' risks. Risk controlling becomes a detached management tool, which has its own purposes, objects, methods, functions. Identifying the maximum quantity of possible risks and their successive quantitative analysis with a help of using statistical methods promotes to identify the most substantial risks, that is defined as an object of risk control. Based on the analyzed material, the concept «system of risk controlling of innovative projects» can be defined as a holistic system of management decisions in methodological, analytical, and informational aspects in the process of implementation of partnership agreements in the possible situations of economic instability and with a high probability of risks, that is aimed at identifying and further timely neutralization of external and internal destructive factors. Characterized by dynamism, the effectiveness of the risk management system and its further strategies depend on a rapid response to external and internal factors. Accordingly, the successful risk management should focus on understanding the guiding methods of risk management, on the ability to promptly find a reasonable solution, on the aptitude to assess the specific economic situation quickly and accurately. In the framework of our research topic, the risk management process is studied within the Project Management Body of Knowledge (PMBOK) (PMI, 2017). It is a universal guide where formation approaches and common view of project management are defined, project activities are identified and structured, concepts and terminology are fixed, recommendation to the methods application at the various phases are defined. PMBOK can be implemented as a framework for the innovation PPP projects.

As a standard management system, the project risk management system consists of processes that directly represent the stages. According to the PMBOK, there are seven stages, which can be identified, and which is closely related with each other (Figure 1).

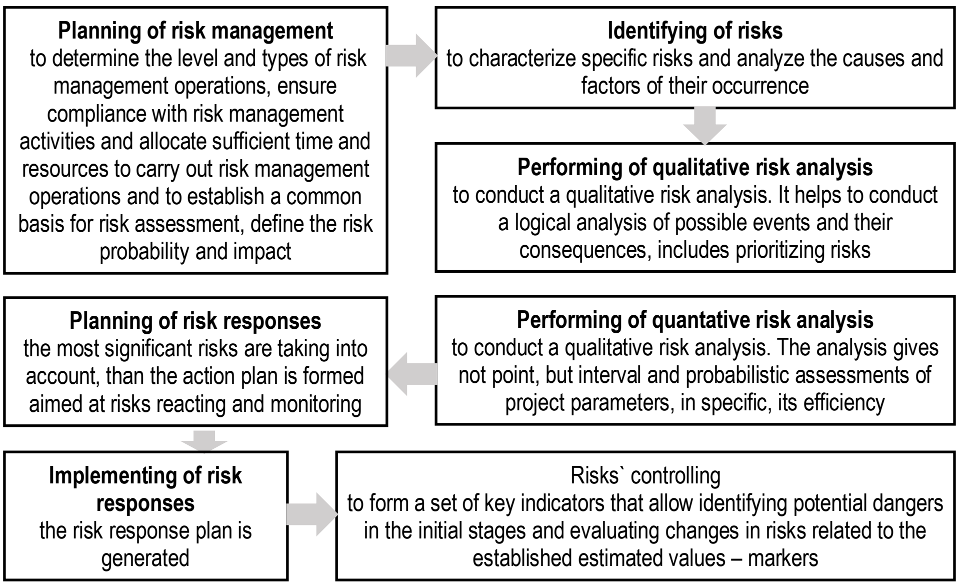

Figure 1. Stages of project risk management process

Sources: developed by the authors based on (PMI, 2017).

Project management requires a guideline that is relevant to any project scope, various industries, and cultures. PMBOK is a splendid concept, which is oriented on process. It defines the knowledge, which is necessary to operate the life cycle of any program, project, and portfolio through processes. It recognizes outputs and inputs tools, techniques required for each step of the process. In practice, a great verity of techniques and methods are used to evaluate and in a case of risks of projects in a form of PPP in the process of validation and implementation of investment decisions that influence the efficiency of public investment policy. In epy practice, during the process of evaluation of risks and situations of ambiguity, methods of expert assessment and probability theory are used. It is quite thoroughly described in modern scientific works. In a process of risks' identifying, all risks concerning the PPP project are identified. There are great variety of approaches which is used in the classification and systematization of the PPP projects' risks. Risks can be classified in the following way: the risks associated with work of state authorities; business risks; risks related with the involvement of the public sector as a partner; risks correlated with incompliance of the population, international organizations, and public. There are a great variety of risk's classifications. We've recommended to study kinds of risks in the Table 1.

Table 1. PPP project's risks

Classification	Types of risks
According to its origin	social, external, organizational; political and economic, natural, managerial, technical, financial, resource
According to the likelihood of emergence	risks with a low likelihood of emergence; risks with an average likelihood of emergence; risks with a significant likelihood of emergence; risks with a high likelihood of emergence
According to the level of possible damage	tragic risk, crucial risk, considerable risk, permissible risk, slight risk
According to the consequences	project implementation costs; risks of shortfall due to the unexpected economic situation; risks of negatory impact on the environment in a process of project implementation; risks with other consequences

Sources: developed by the authors based on (Babiak, 2014).

In this research we`ve tried to concentrate a huge attention to such an urgent and relatively new type of risk – sustainability risk, in the framework of innovation PPP projects. Risk of sustainability can be identified as a kind of risk that gathers probabilities and effects of events that involve company's sustainable growth. Risks of such type can be also associated with the hypothesis of stable development. Moreover, it is studied in the definition of a triple approach which is aimed at measurement of social, financial, and environmental company`s performance over a period.

Sustainability risk can occur in various industries and areas. Speaking about the sphere of innovation PPP project management, the risk evaluation relates to 4 key main characteristics: society, environment, resources, and economy. It was developed to monitor trends in innovation PPP projects, correct strategies according to the future prospective and find a balance between above mentioned four aspects.

Simultaneously, the accuracy of sustainability risk evaluation, it is important to assume, that it is clearly different from usual project types, performs a considerable role for innovation PPP project. In innovation projects in a form of PPP despite other project categories, investors have a great interest in the project's sustainability, as the overall fact that in such situation the amount of investment may be increased if PPP projects don't meet this issue of sustainable standards. The fact of sustainability risk means that this type of PPP project's risk can be assessed, controlled, and precluded during the application process.

The analysis of the key influence of this type of risk was done using the Failure mode, effects, and criticality analysis (FMECA) and Fuzzy comprehensive evaluation model (FCEM). The above-mentioned models are aimed to analyze and assess the influence of the sustainability risks' factors in various categories on the total innovation PPP project. In that process we`ve dived these risks into 5 groups of 1st degree risks according to the FMECA framework: economical risks, cultural and social risks, project and organizational risks, environmental risks, political risks Additionally, all 1st degree risks are divided into more comprehensive categories of 2nd degree risks. A great verity of factors that a thoroughly connected with the degree of sustainability risk in the process of risk evaluation can be with a strong fuzzy ambiguity and it's hard to assess risks of this type, using overall methods, furthermore it is troublesome to consider a result of evaluate only one key criterion. We recommend considering the solution of this issue using FCEM. FCEM is mainly based on the process of qualitative transformation to the quantitative one with the helps of fuzzy mathematics. Currently it can be proposed as an effective multifactorial method for all-round evaluation. In common collaboration with the methods of expert evaluation, demonstrated model may be totally represent on the estimation criteria and the indicators influencing the ambiguity and then guarantee the assessment results closer to the existing situation. FCEM has been used since 1990s to decide widespread practical issues and research on the implementation of that model has been rapidly expanding to various spheres. According to this research, the reason of recommendation for such models as tools for sustainability risk evaluation is that its sustainability is higher than in the other approaches. Assessment process is demonstrated in the Table 2, 3.

Table 2. Methodology of FCEM (Phase 1–3)

Phase	Essence	Formulas
1	Establish a risk evaluation factor set	$= \{F_1, F \dots, F_i, F \dots, F_n\}$ (1) $F_i = \{F_{i1}, \dots, F_{ij}, \dots, F_{im}\}$ $(i = 1,2, \dots, n; j = 1,2, \dots, m)$ (2) where n - the amount of 1st-degree factors in F; F - the risk evaluation factor set; F_i $(i = 1,2, \dots, n)$ - the i the 1st-degree factors; F_{ij} - the jth 2nd-degree factor of F_i; m - the amount of 2nd-degree factor.
	Establish a risk evaluation	$\mathrm{D} = \{d_1, d_2, d_3, d_4, d_5\}$ (3) *where* d_1, d_2, d_3, d_4, d_5- are the comments demonstrating the sustainability risk degree are scored from 1 to 5, from destructive to the desirable one; D - the risk evaluation comment set;
2	Determine the fuzzy comprehensive assessment matrix Q and $Q_i (i = 1,2, \dots, n)$	$Q_i = \begin{Bmatrix} q_{i11} q_{i12} q_{i13} q_{i14}\ q_{i15} \\ q_{i21} q_{i22} q_{i23} q_{i24}\ q_{i25} \\ q_{i31} q_{i32} q_{i33} q_{i34}\ q_{i35} \\ \dots \dots \dots \dots \dots \dots \\ q_{im1} q_{im2} q_{im3} q_{im4}\ q_{im5} \end{Bmatrix}$ (4) where $Q = \{Q_1, Q \dots, Q_i, Q \dots, Q_n\}$ and $Q_i (i = 1,2, \dots, n)$ - the evaluation matrix of F and F_i; $q_{imk} (k = 1,2,3,4,5)$ is the comment of 2nd-degree factor F_{im}.
3	Build a worth of vector V; and $V_i^`$.	$\mathrm{V} = \{V_1, V_2, \dots, V_i, \dots, V_n\}$ (5) $V_i^` = \{V_{i1}^`, V_{i2}^`, \dots, V_{ij}^`, \dots, V_{im}^`\}$ $(i = 1,2 \dots, n; 1 \leq j \leq m)$ (6) $\sum_{i=1}^{n} V_n = 1$ (7) $\sum_{j=1}^{m} V_{im}^` = 1$ (8) *where* V and $V_i^`$ - the worth of vector of 1st-degree and the 2nd-degree factors, $V_i$ and $V_{im}^`$ - the worth of F_i and F_{im}.

Sources: developed by the authors based on (Dukes et al., 2017).

The following step is that the evaluation of V_i and $V_{im}^`$ can be presents in accordance with the method of FMECA. Scientists Lipol and Haq (2011) demonstrated FMECA as an excellent analytical tool for the risks` assessment and that helped them to analyze the potential failures in the project due these risks.

During the analysis overlook and assessment failure are made, the impact of these faults on the project is studied, and future implications for safeness is defined. In accordance with analysis, the value of factors can be assessed by Formula 9 and Formula 10:

$$W_i = \frac{H_i \times S_i \times D_i}{C_i} \quad (9)$$

$$W_{im} = \frac{H_{im} \times S_{im} \times D_{im}}{C_i m} \quad (9)$$

where W_i – the cross-sectional sphere of 1st-degree sustainability risk factor F_i; W_{im} – the cross-sectional sphere of the 2nd – degree sustainability risk factor F_{im}; H_i – the occurrence likelihood of F_i; S_i – the loss and effect after F_i occurs; D_i – the perceived level of F_i; C_i – the ability to operate and indemnify the loss after F_i, occurs.

H_i , S_i , $D_i$and C_i are evaluated by experts grading method (EGM) in score from 1 to 5 (11, 12, 13, 14).

$$H_i = \begin{matrix} 1\text{–}Lowest\ probability\ of\ risk \\ 5 – Higest\ probability\ of\ risk \\ h_i – Otherwise \end{matrix} \quad (11)$$

$$S_i = \begin{matrix} 1\text{–}Slightest \\ 5 – Worst\ of\ faced \\ s_i – Otherwise \end{matrix} \quad (12)$$

$$D_i = \begin{matrix} 1\text{–}Most\ easily\ to\ be\ perceived \\ 5 – Most\ difficult\ to\ be\ perceived \\ h_i – Otherwise \end{matrix} \quad (13)$$

$$C_i = \begin{matrix} 1\text{–}Most\ difficult\ to\ control \\ 5 – Most\ easily\ to\ control \\ h_i – Otherwise \end{matrix} \quad (14)$$

Then, the worth of different degrees of sustainability risk factors V_i and V_{im} would be accomplished after stabilized the worth of $V_i^{``}$i and $V_{im}^{`}$.

Table 3. Methodology of FCEM (Phase 4–5)

Phase	Essence	Formulas
4	Establish a FCEM *R* to reflect the sustainability risk degree of the innovation project in a form of PPP	$R = V \times L^T$ (15) $L = (L_1, \dots, L_i, \dots, L_n)$ (16) $L_1 = V_i^{`} \times Q_i$ (17) where R - the FCEM which could indicate the sustainability risk degree of innovation PPP project, L_i - the FCEM of the 1st-degree sustainability risk factor $F_i(i = 1,2, \dots, n)$, L - the FCEM set.
5	Calculate the value of sustainability risk degree of innovation PPP project	$= D \times R$ (18) $Z^{`} = (Z_1, \dots, Z_i, \dots, Z_n)$ (19) $Z_i = D \times L_i$ (20) *where* $Z$ – the sustainability risk degree of the project, $Z_i$ - the sustainability risk degree of the 1st-degree risk factor $F$; $Z^{`}$- the set of the 1st-degree risk factors` sustainability risk degree.

Sources: developed by the authors based on (Dukes et al., 2017).

Results. The represented types of factors of sustainability risk of innovation PPP project is generally used while risk assessment in projects of infrastructure field. It is important to mention, that it is crucial to represent the enhancement and effectiveness of the sustainability risk evaluation model, how that model of assessment can be applied to the project (we've implied that X Project is an example of project in future).

It was assessed sustainability risk using the models, which were demonstrated above. F, which was defined as a factor set for upcoming assessment. As all risks were classified into two degrees: the amount of 1st degree sustainability risk factor is five (n = 5), the set of 1st degree factor -F; the 2nd degree of factors, its quantity is various, simultaneously the set of 2nd degree factors is characterized as F_{ij}. In our case for X Project, it was in the following way: for first factor m = 24; for second – m = 10; for third – m = 16; for fourth – m = 12; for fifth – m = 10.

Consequently, the risk evaluation of X Project, D, can be recognized, where $D = \{d_1, d_2, d_3, d_4, d_5\}$ = $\{1,2,3,4,5\}$. We defined the D and $Q_i(i = 1,2, \ldots, n)$ applying the experts` results in the form of simple survey. With the aim to gather the results, we designed a Google Form for experts, which were selected from the database SumDU Stakeholders. The purposes of this survey were experts of various structural levels: technical staff, project managers, as well as staff in banking and finance. The overall number of forms was 100. In the next phase we gathered the answers to the questions recommended for participates and we determined their comments of sustainability risks. The level of 2nd-degree risk factor F_{im}:

$$q_{imk} = \frac{Frequency\ (F_{imda})}{\sum_a^5 1Frequency\ (F_{imda})} \tag{21}$$

where (F_{imda}) - the period that the survey object assessed the risk degree of F_{im} is d_a (d = 1, 2, 3, 4 or 5). Then, the matrix of factors is created (it is represented only for Q_1):

$$Q_1 = \begin{bmatrix} 0{,}660 & 0{,}160 & 0{,}080 & 0{,}050 & 0{,}050 \\ 0{,}800 & 0{,}100 & 0{,}070 & 0{,}010 & 0{,}020 \\ 0{,}500 & 0{,}250 & 0{,}100 & 0{,}100 & 0{,}050 \\ 0{,}600 & 0{,}150 & 0{,}100 & 0{,}050 & 0{,}100 \\ 0{,}700 & 0{,}150 & 0{,}100 & 0{,}020 & 0{,}030 \\ 0{,}360 & 0{,}190 & 0{,}080 & 0{,}100 & 0{,}270 \\ 0{,}470 & 0{,}340 & 0{,}090 & 0{,}070 & 0{,}030 \\ 0{,}360 & 0{,}450 & 0{,}120 & 0{,}060 & 0{,}010 \\ 0{,}080 & 0{,}240 & 0{,}120 & 0{,}200 & 0{,}360 \\ 0{,}120 & 0{,}340 & 0{,}150 & 0{,}140 & 0{,}250 \\ 0{,}020 & 0{,}080 & 0{,}140 & 0{,}300 & 0{,}460 \\ 0{,}060 & 0{,}130 & 0{,}450 & 0{,}340 & 0{,}020 \\ 0{,}230 & 0{,}140 & 0{,}280 & 0{,}300 & 0{,}050 \\ 0{,}460 & 0{,}350 & 0{,}080 & 0{,}060 & 0{,}050 \\ 0{,}450 & 0{,}320 & 0{,}030 & 0{,}100 & 0{,}100 \\ 0{,}010 & 0{,}190 & 0{,}020 & 0{,}320 & 0{,}460 \\ 0{,}370 & 0{,}240 & 0{,}080 & 0{,}170 & 0{,}140 \\ 0{,}040 & 0{,}060 & 0{,}280 & 0{,}140 & 0{,}480 \\ 0{,}020 & 0{,}020 & 0{,}080 & 0{,}350 & 0{,}530 \\ 0{,}030 & 0{,}050 & 0{,}150 & 0{,}470 & 0{,}300 \\ 0{,}030 & 0{,}070 & 0{,}310 & 0{,}460 & 0{,}130 \\ 0{,}050 & 0{,}040 & 0{,}080 & 0{,}200 & 0{,}630 \\ 0{,}070 & 0{,}040 & 0{,}080 & 0{,}360 & 0{,}450 \\ 0{,}020 & 0{,}080 & 0{,}050 & 0{,}150 & 0{,}700 \end{bmatrix}$$

In the next phase we applied FMECA to assess vectors V and $V_i^{`}$, output of which perform a substantial role in determining the degree of sustainability risk. So that we`ve involved 5 experts in PPP risk management to participate in research and grade the values of H_i, S_i , $D_i$and C_i and the assessing results of the 1st-degree factors are represented in Figure 2.

F		1st estimation					2nd estimation					3rd estimation					4th estimation					5th estimation					Avg
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
F1	H			x						x					x				x					x			8,16
	S				x						x		x						x				x				
	D	x						x								x		x							x		
	C				x				x						x					x				x			
	W1			3					13,3					10					4,5					10			
F2	H				x						x			x						x					x		15,9
	S				x				x						x						x					x	
	D		x							x				x						x				x			
	C			x							x			x					x					x			
	W2			16					12					5					26,7					20			
F3	H					x					x				x			x								x	15,2
	S				x					x				x					x					x			
	D			x				x						x						x			x				
	C		x						x				x							x			x				
	W3			24					13,3					18					6					15			
F4	H					x			x						x				x						x		22
	S				x					x				x						x					x		
	D				x					x					x						x					x	
	C		x				x								x				x						x		
	W4			10					48					12					20					20			
F5	H				x					x					x				x							x	12
	S			x					x						x					x					x		
	D	x						x						x					x					x			
	C			x				x							x				x					x			
	W5			4					12					12					12					20			

Figure 2. H_i , S_i , $D_i$and C_i scored by experts

Sources: developed by the authors.

$$V = \{V_1, V_2, V_3, V_4, V_5\} = \{0{,}111; 0{,}217; 0{,}208; 0{,}300; 0{,}164\}$$

Similarly, we evaluate the worth of 2nd degree sustainability risk factors $V_i^`$:

$$V_1^` = \begin{Bmatrix} 0{,}027; 0{,}031; 0{,}059; 0{,}025; 0{,}026; 0{,}013; 0{,}063; 0{,}053; 0; 041; 0{,}043; 0{,}032; 0{,}043; \\ 0{,}043; 0{,}015; 0{,}042; 0{,}017; 0{,}043; 0{,}039; 0{,}034; 0{,}053; 0{,}103; 0{,}024; 0{,}078; 0{,}053 \end{Bmatrix}$$

$$V_2^` = \{0{,}095; 0{,}150; 0{,}098; 0{,}096; 0{,}066; \ 0{,}140; \ 0{,}047; \ 0{,}103; 0{,}084; 0{,}121\}$$

$$V_3^` = \begin{Bmatrix} 0{,}023; 0{,}035; 0{,}036; 0{,}060; 0{,}110; 0{,}086; 0{,}042; 0{,}042; 0{,}049; 0{,}100; \\ 0{,}046; 0{,}064; 0{,}038; 0{,}086; 0{,}096; 0{,}049 \end{Bmatrix}$$

$$V_4^` = \begin{Bmatrix} 0{,}077; 0{,}056; 0{,}039; 0{,}139; 0{,}094; 0{,}102; 0{,}089; 0{,}068; 0{,}136; 0{,}044; \\ 0{,}100; 0{,}056 \end{Bmatrix}$$

$$V_5^` = \{0{,}083; 0{,}123; 0{,}097; 0{,}134; 0{,}068; 0{,}123; 0{,}054; 0{,}103; 0{,}094; 0{,}121\}$$

Then, the methodology matrix of 1st – degree risk factors can be assessed (using Formula 17):

$$\begin{aligned} L_1 &= |0{,}237; 0{,}170; 0{,}146; 0{,}218; 0{,}230| \\ L_2 &= |0{,}034; 0{,}072; 0{,}223; 0{,}422; 0{,}248| \\ L_3 &= |0{,}237; 0{,}394; 0{,}263; 0{,}073; 0{,}033| \\ L_4 &= |0{,}027; 0{,}074; 0{,}240; 0{,}364; 0{,}294| \\ L_5 &= |0{,}041; 0{,}094; 0{,}241; 0{,}456; 0{,}168| \end{aligned}$$

According to the Formulas 15 and 16, matrix R can be calculated:

$$R = V \times L^T = V \times \begin{vmatrix} L_1 \\ L_2 \\ L_3 \\ L_4 \\ L_5 \end{vmatrix} =$$

$$= |0{,}111; 0{,}217; 0{,}208; 0{,}300; 0{,}164| \times \begin{vmatrix} 0{,}237; & 0{,}170; & 0{,}146; & 0{,}218; & 0{,}230 \\ 0{,}034; & 0{,}072; & 0{,}223; & 0{,}422; & 0{,}248 \\ 0{,}237; & 0{,}394; & 0{,}263; & 0{,}073; & 0{,}033 \\ 0{,}027; & 0{,}074; & 0{,}240; & 0{,}364; & 0{,}294 \\ 0{,}041; & 0{,}094; & 0{,}241; & 0{,}456; & 0{,}168 \end{vmatrix} =$$

$$= |0{,}064;\ 0{,}174;\ 0{,}232;\ 0{,}460;\ 0{,}160|$$

Consequently, Formulas 18–20 assess the value of Project`s X sustainability risk estimation, Z, and the sustainability risk degree of 1st-degree risk factors, Z_i:

$$\mathrm{Z} = P \times G = |1\ 2\ 3\ 4\ 5| \times \begin{vmatrix} 0{,}064 \\ 0{,}174 \\ 0{,}232 \\ 0{,}460 \\ 0{,}160 \end{vmatrix} = 3{,}75 \qquad \mathrm{Z}_1 = |1\ 2\ 3\ 4\ 5| \times \begin{vmatrix} 0{,}237 \\ 0{,}170 \\ 0{,}146 \\ 0{,}218 \\ 0{,}230 \end{vmatrix} = 3{,}03$$

$$\mathrm{Z}_2 = |1\ 2\ 3\ 4\ 5| \times \begin{vmatrix} 0{,}034 \\ 0{,}072 \\ 0{,}223 \\ 0{,}422 \\ 0{,}240 \end{vmatrix} = 3{,}78 \qquad \mathrm{Z}_3 = |1\ 2\ 3\ 4\ 5| \times \begin{vmatrix} 0{,}237 \\ 0{,}394 \\ 0{,}263 \\ 0{,}073 \\ 0{,}033 \end{vmatrix} = 2{,}27$$

$$\mathrm{Z}_4 = |1\ 2\ 3\ 4\ 5| \times \begin{vmatrix} 0{,}027 \\ 0{,}074 \\ 0{,}240 \\ 0{,}364 \\ 0{,}294 \end{vmatrix} = 3{,}82 \qquad \mathrm{Z}_5 = |1\ 2\ 3\ 4\ 5| \times \begin{vmatrix} 0{,}041 \\ 0{,}094 \\ 0{,}241 \\ 0{,}456 \\ 0{,}168 \end{vmatrix} = 3{,}61$$

Figure 3 demonstrates the degree of risk of sustainability of 1st-degree risk factors.

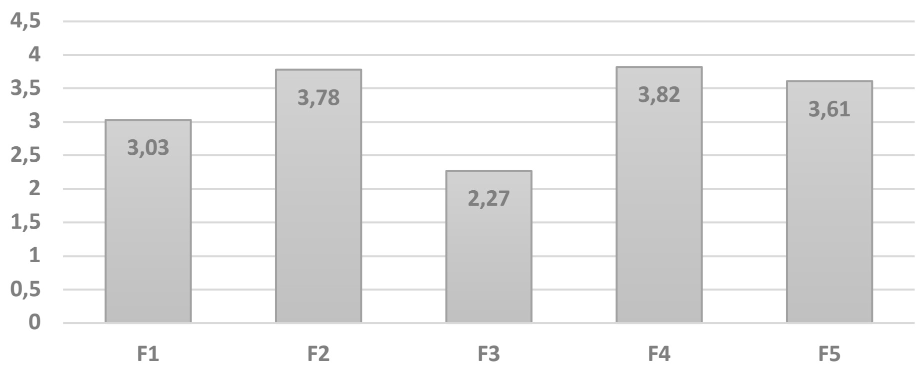

Figure 3. Sustainability risk degree of 1st-degree risk factors

Sources: developed by the authors.

In Figure 3 the value of Project`s X sustainability risk evaluation is according to the exponent, from lowest to highest: 1) F_3; 2) F_1; 3) F_5; 4) F_2; 5) F_4. Consequently, ecology/environmental and project/organization are the highest sustainability risk factors. These risks are the first that worth managing in a case of the X Project implementation. In the process of comparing different innovative PPP projects, it is easy to see that the level of sustainability risk of similar elements is different in different projects due to the specificities of different project; it demonstrates that the degree of sustainability risk of various factors is contrastive, which requires managers to take into account the practical situation in the decision-making process of managing sustainability risks for various innovative PPP projects.

Conclusions. In the process of this research the scientific task, which was aimed to study the process of risk-management of the PPP innovation projects, studied the evaluation process of the sustainability risk of innovation PPP projects was solved. Innovation and improving the risk-management system can be a crucial factor in the process of successful PPP projects realization. The collaboration between business and state in the form of PPP can have a variety of pros as well as cons for both partners. All difficulties that concern PPP projects` growth requires exigent decision. Innovation PPP projects can be influenced by various external and internal destructive factors. Consequently, it is crucial to organize a well-organized a risk-management system of innovation project. Through the variety of risks, the sustainability risk of innovation PPP project can be considered as a key factor in innovation project implementation.

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Ризик-менеджмент інноваційних проектів державно-приватного партнерства

У статті систематизовано аргументи та контраргументи в рамках наукової дискусії щодо питань управління ризиками проектів. Основною метою дослідження є аналіз процесу управління ризиками інноваційних проектів державно-приватного партнерства, опис методології комплексних моделей оцінки ризиків стабільності інноваційних проектів державно-приватного партнерства. Актуальність дослідження означеної проблематики полягає в тому, що оцінка ризиків інноваційних проектів державно-приватного партнерства є непростим завданням через недосконалу систему управління ризиками інноваційного проекту. Об'єктом дослідження є створений прототип інноваційного проекту, який буде реалізовано у формі державно-приватного партнерства. У ході дослідження «Управління ризиками інноваційних проектів державно-приватного партнерства» застосовано наступну логічну послідовність: 1) теоретичний аналіз проблеми управління ризиками проекту; 2) опис методології дослідження; 3) висвітлення результатів та формулювання відповідних висновків. Результати аналізу наукових напрацювань, присвячених питанням державно-приватного партнерства, свідчать про ефективну та односпрямовану взаємодію між державою та приватним сектором у проектах державно-приватного партнерства, що сприяє зростанню інвестицій в розвиток виробничої сфери, покращенню промисловості, розширенню внутрішнього та зовнішнього ринків, підвищенню інвестиційної привабливості та ділової активності. Водночас систематизація наукових джерел та підходів до розв'язання проблеми управління ризиками інноваційних проектів, які реалізуються у формі державно-приватного партнерства, дозволила виявити ряд теоретичних та прикладних проблем у визначенні основних напрямків управління ризиками, особливо оцінки ризику, які є недостатньо вивчені та потребують термінового вирішення.

Ключові слова: інноваційні проекти, державно-приватне партнерство, PMBOK, управління ризиками, FCEM, FMECA.