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SUSTAINABLE DEVELOPMENT OF TECHNOLOGICAL INTEGRATION: RISK SITUATIONS AND ASSESSMENT OF OPPORTUNITIES

The article focuses on the results of the development of the scientific concept of sustainable development of technological integration in crises. The proposed methodology of sustainable development in risk situations reveals goals and objectives of technological integration, the organizational and managerial procedure for identifying risk situations, and methodological foundations for the formation of risk areas in a dynamic external environment. The distinctive feature of the proposed methodology is the systematization of the classification factors of risk situations, ensuring the possibility of attributing risk events to factors that violate sustainable development. The proposed concept develops basic elements of the neoclassical theory of sustainable development, which allows considering risk events both as threats and as conditions for sustainable development. Within the framework of the practical implementation of the methodology for the sustainable development of technological integration, there is justified transformation of risk areas, which allows minimizing possible losses as much as possible. This makes it necessary to develop a methodological approach, based on quantitative methods for identifying risk situations. The advantage of the quantitative method is the ability to formalize the results of risk situations and assess their impact on the sustainable development of technological integration. The advantages of quantifying a risk situation are: 1) the possibility of quantifying the amount of loss or profit from the action of a risk situation, which may become the object of developing a procedure for managing the sustainable development of technological integration; 2) a high probability of identifying risk factors that require a rapid response; 3) a high degree of influence of various risk factors on the sustainable development of technological integration; 4) the

possibility of preparing the basis for the development of rational options for sustainable behavior of participants in technological integration in a risk situation.

Keywords: technological integration; risk situations; method of a quantitative assessment; production; industrial enterprises

Introduction

The sustainability management system concerning the participants of technological integration can be considered as an independent project due to the multidimensional nature of its purpose. The objectives of ensuring sustainable development are often included as a measure of ensuring economic security in the strategic direction of technological development of industrial enterprises. In periods when certain trends of progressive development are replaced by a downturn in the economy, the tools for the formation of sustainable development of technological integration and leveling the consequences of crises come to the fore. At present, risk situations that accompany the stability of business entities at all stages of technological integration, when technological processes are being deepened, new technologies are being introduced and existing technologies are being improved, have become of particular importance for industrial enterprises. A distinctive feature of technological integration is the compression of the innovation cycle of creating new products and services. It became possible due to the digitalization of the research process and the development of communication methods between industrial enterprises and parties interested in the effectiveness of their work. At the same time, as practice shows, the wider the opportunities and prospects of the integration process, the greater the probability of the occurrence of adverse events caused by gaps in the organization of production, research and development activities, difficult financial and economic situation. This serves as the basis for finding ways to minimize the risk situations of technological integration of industrial enterprises, which, as a rule, have connections with other economic entities and organizations. Therefore, the risk situations of the technological integration participants have a common nature of occurrence but differ in the specifics of the methods of their identification. The difficulties of the sustainable development of technological integration consist in the fact that there is no single methodological tool for leveling risk situations, since both economic theory and business practice associate the ongoing organizational and structural changes only with the management process, but do not include an assessment of the sustainable development of technological integration in these changes [1, 2].

Scientists and specialists from the position of developing unified rules for organizing production, marketing products and providing services, and activating research activities consider the problem areas of technology integration at the level

of its subjects. General and specific risks are present in each of these areas, while constantly emerging risk situations are of primary importance for the sustainable development of technological integration [1–12]. Evaluating the theoretical approaches to the study of risk situations, it can be concluded that when creating or organizing innovations, the subjects of technological integration face uncertainty: there is no unambiguous option for what its implementation may turn out to be and how it will affect the preservation of sustainable development. The ideas of the subjects of technological integration about the positive outcome of the development of events assume specifics in setting a certain goal: making a profit or having another positive effect. At the same time, the existence of uncertainty suggests that the development of further events may develop unfavorably, and, consequently, the set goal of making a profit will not be achieved [3, 4].

Materials and methods

The authors selected key provisions of the management theory, neoclassical risk theory, and modern theories of sustainable development as the fundamental research methods. There was used a wide range of scientific research methods in the research process. Methods of description, generalization, and abstraction are necessary to identify the current technical and technological trends in the sustainable development of the subjects of technological integration that have been formed to date. The classification method will allow us to justify the typologization of risk situations that limit the sustainable development of technological integration subjects. The method of argumentation aims at substantiating an instrumental approach that allows us to obtain fundamentally new results in the study of the processes of sustainable development of technological integration. The method of a quantitative assessment of risk situations will ensure the achievement of the task and will allow identifying their impact on the sustainable development of technological integration of industrial enterprises. The computational and analytical method will allow applying operational monitoring, thanks to the vector orientation of which it becomes possible to carry out regular adjustments to the key parameters of the impact of sustainable development of technological integration on the results of industrial enterprises' production activities, taking into account emerging risk situations.

Results and discussion

Assessment of the stability of technological integration participants to emerging risk situations is a complex process, and its main stages are presented in Table 1. These stages of assessing the stability of technological integration participants to emerging risk situations are not directive. Depending on the method of assessing the stability of participants in technological integration applicable in a particular situation, these stages may be supplemented if necessary. For a clear structuring of problems, as well as an analysis of their impact on the situation, it

is necessary to classify risk situations in order to choose effective management of the stability of participants in technological integration [5, 6, 7,].

Table 1 – Stages of risk assessment focused on ensuring the sustainability of technological integration

№	Stages of risk situation assessment	Content of a risk situation	Target orientation (ensuring the sustainability of technological integration)
1.	Identification of risk situations	Formation of a complete list of risk situations that can lead to both positive and negative changes in the stability of technological integration	Possibility of using both objective and subjective data in order to ensure the sustainability of technological integration
2.	Identification and grouping of possible risk situations	Identification of risk situations similar in the direction of impact	Identification of the relationship of risk situations with the stability of technological integration
3.	Identification of the probability of occurrence of a risk situation	Risk situations are assessed based on a certain period	Determination of the number of methods used, the possibility of comparing the obtained results with different methods of ensuring the stability of technological integration
4.	Quantitative assessment of the scale of risk situations	Determination of the scale of risk situations by quantitative methods based on the obtained probability of occurrence of the event	Determination of the number of methods used to ensure the sustainability of technological integration
5.	Making a management decision	The choice of further actions based on the received assessments of risk situations	Determining the degree of responsibility for ensuring the sustainability of technological integration
6.	Monitoring of risk situations	Operational monitoring of risk situations indicators	Each risk situation will receive its own algorithm for monitoring the stability of technological integration

Source: author’s development

Currently, there are different opinions and approaches to the classification of risk situations in the economy. So far, the authors who have studied this issue have not developed a generally accepted approach. Therefore, there is a practice when all existing risk situations are associated with various methods of ensuring the stability of participants in technological integration. To analyze the financial and economic activities of participants in technological integration and evaluate these risk situations, it is necessary to identify and formulate the goals and objectives of the classification.

When carrying out activities, participants in technological integration need to have tools for measuring and calculating possible losses because of the manifestation of any risk situations. To do this, the participants of technological integration need the availability of appropriate data for the application of a particular method, as well as the availability of tools to determine the degree of compliance of the selected assessment method with the type of risk situation. These aspects complicate the process of assessing risk situations among participants of technological integration. Thus, all methods of assessing a particular risk situation have a scope of application, and the choice of this method should depend on the accuracy of the information received about the production activities of participants in technological integration.

Methods of assessing risk situations are divided into qualitative and quantitative. Qualitative methods are based on the opinions of individual groups of people (experts) about a risky event that is likely to occur in the activities of technological integration participants. The opinion of experts, in this case, is based on their work experience, as well as on comparing the situation of participants in technological integration with a similar one. Qualitative methods include methods of rating assessments, expert methods, as well as methods using analogs. Quantitative methods are based on the use of mathematical techniques and are divided into statistical and analytical, and their application depends on the amount of data obtained [8].

Among the quantitative methods, it is necessary to distinguish the statistical one. Statistical methods based on the number of estimated values include single-factor and multi-factor methods. When determining the stability of technological integration, this method allows determining the change of difficult-to-predict factors that affect the stability of participants in technological integration. To ensure the sustainability of technological integration, the assessment of risk situations is based on quantifiable indicators that have different scales for measuring risk situations. At the moment, there is no scientifically justified possible magnitude of various types of risk situations, which in turn is an independent task of the stability of participants in technological integration, and depends on the industry in which these participants operate. There is also no consensus on the nature of risk situations, which manifest themselves not only as a possibility of loss but also as the probability of making a profit. There is no single approach to drawing up scales of risk situations and their impact on the stability of technological integration. In this regard, it is proposed to consider the level of the risk situation to ensure the stability of technological integration, depending on the probability of a risk situation (risk event).

It is necessary to note that there might be scales of risk situations, the use of which is based on such criteria as the average expected value and the standard deviation to determine the characteristics of the level of risk situations. The probability of occurrence of a risk event, in this case, can be defined as the coefficient of variation.

At the same time, it is impossible not to mention the scales of risk situations in which the possible amount of damage should be compared with the size of the assets of participants in technological integration and correspond to the volume of production. These scales should be used to assess the acceptability of a management decision as an event that carries a risky situation. Then, the risk area will be a certain part of the economic activity, within the framework of which the possible amount of losses does not exceed the maximum value of the established level of the risk situation. According to this, it is advisable to identify four main areas of risk situations in the process of implementing the activities of participants in technological integration [9]:

1 The area of an acceptable risk situation, which is characterized by both a zero level of losses from the manifestation of a risk event, and a negative level of losses, which does not exceed the expected net profit of participants in technological integration.

2 The area of an acceptable risk situation, the level of losses from which exceeds the size of the estimated profit of the technological integration participants. This area is acceptable for determining the boundaries of risk situations.

3 The area of a critical risk situation, the level of losses from which exceeds the amount of the predicted profit and, under unfavorable circumstances, the amount of revenue. In other words, the participants of technological integration lose not only profit, but also all the costs that were invested in production.

4 The area of a catastrophic risk situation, the level of losses from which ranges from full revenue to the size of the equity capital of the participants of technological integration and their property. The consequences of a catastrophic risk situation can lead to the bankruptcy of participants in technological integration. The main reasons for such a risky situation are environmental disasters, as well as those risky situations that pose a danger to people's life and health.

Thus, based on different approaches to the perception of risk situations, it is possible to conclude that this phenomenon is ambiguous when ensuring the stability of technological integration. This is since the risk situation is a complex, structural concept that is in the process of constant changes, and has different, sometimes inconsistent, characteristics. This is because risk situations in the production activities of participants in technological integration contain conditions that manifest the factors of risk situations, and therefore their causes, at a certain point in time. Consequently, the risk situation determines the possibility of a loss of stability of technological integration, and its increase may negatively affect the results of the production activities of its participants [10].

The advantages of the proposed approach are the possibility of regulating the classification of risk situations by participants of technological integration;

quantitative assessment of risk situations. The identification of risk situations allows expanding the range of analyzed risks for the participants of technological integration. Moreover, it is possible to monitor the emergence of new risks that can slow down sustainable development.

The figure 1 shows differences in the identified risk situations:



Source: author's development

Figure 1 – Comparison of the applied and proposed approaches to identifying risk situations in order to achieve sustainable development of technological integration

This figure shows that the identification of risk situations with achieving sustainable development of technological integration in the proposed approach is wider than in the applied one. The number of risk situations in the proposed approach is also higher. It means that this approach allows taking into account all the conditions and reasons that hinder the sustainability of technological integration in more detail. Thus, the effectiveness of the proposed approach is justified by the fact that it allows anticipating a much larger number of risk situations, which helps to identify and level them at an early stage.

Conclusions

Thus, the applied quantitative method for the sustainable development of technological integration makes it possible to conduct operational monitoring of the factors causing risk situations, and to minimize the error in the final assessment of the possible amount of damage from the occurrence of risk events, as well as the probability of their occurrence.

Enterprises of any industry affiliation can become an area of using a methodological approach to the sustainable development of technological integration in conditions of risky situations. It allows assessing the vector orientation of the main technical and economic indicators, as well as assessing the dynamics of their changes, both in the short and long term. The indisputable advantage of developing methodological tools related to risk situations of sustainable development of technological integration allows changing approaches to forecasting and planning the production activities of participants in technological integration. The development of technological integration encourages the search for new complex forms of evaluating the effectiveness of production activities with timely consideration of possible risk factors.

The results correspond to the current trends in the development of the world economy. They are in line with the global priorities of the technical and technological transition in the production and economic activities of industrial entities and are expressed in the methodology of dynamic development of technological integration under risk situations developed within the framework of research. This complements the neoclassical theory of risk, thereby contributing to the substantiation of the modern scientific base of economic research at the global level, as well as the theoretical justification of the content and development of directions for the implementation of the organizational and economic model for the development of technological integration at industrial enterprises within the framework of sanctions restrictions. Moreover, it forms a list of fundamentally new directions for the study of the process of technological integration development.

It should be concluded that the development of a quantitative method for assessing the stability of technological integration would not be linear. The vector orientation of the quantitative method of sustainable development of technological integration can change under the influence of technical, technological, and organizational changes in production activities, the action of environmental factors, goal-oriented managerial influences. Operational monitoring of the vector orientation of the development of the quantitative method of sustainable development of technological integration in the conditions of risk situations allows for regular adjustments of key parameters of the production activity of industrial enterprises.

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ТЕХНОЛОГИЯЛЫҚ ИНТЕГРАЦИЯНЫҢ ТҰРАҚТЫ ДАМУЫ: ТӘУЕКЕЛ ЖАҒДАЙЛАРЫ ЖӘНЕ МҮМКІНДІКТЕРДІ БАҒАЛАУ

Мақалада дағдарыс жағдайында технологиялық интеграцияны тұрақты дамытудың ғылыми тұжырымдамасын әзірлеу нәтижелері қарастырылады. Тәуекел жағдайларында тұрақты дамыдың ұсынылып отырған әдіснамасы технологиялық интеграцияның мақсаттары мен міндеттерін, тәуекел жағдайларын анықтаудың ұйымдастырушылық-басқарушылық рәсімін және серпінді сыртқы ортада тәуекел аймақтарын қалыптастырудың әдіснамалық негіздерін ашады. Ұсынылған әдістеменің ерекшелігі тәуекел оқиғаларын тұрақты дамуды бұзатын факторларға жатқызу мүмкіндігін қамтамасыз ететін тәуекел жағдайларының жіктеу факторларын жүйелеу болып табылады. Ұсынылған тұжырымдама тұрақты дамыдың неоклассикалық теориясының негізгі элементтерін дамытады, бұл қауіп-қатер оқиғаларын да, тұрақты даму жағдайларын да қарастыруға мүмкіндік береді. Технологиялық интеграцияның тұрақты даму әдіснамасын практикалық іске асыру шеңберінде ықтимал шығындарды барынша азайтуға мүмкіндік беретін тәуекел аймақтарын трансформациялау негізделген. Бұл қауіпті жағдайларды анықтаудың сандық әдістеріне негізделген әдіснамалық тәсілді әзірлеуді қажет етеді. Сандық әдістің артықшылығы-қауіпті жағдайлардың нәтижелерін ресімдеу және олардың технологиялық интеграцияның тұрақты дамуына әсерін бағалау мүмкіндігі. Тәуекел жағдайын сандық бағалаудың артықшылықтары мыналар болып табылады: 1) Технологиялық интеграцияның орнықты дамуын басқару рәсімін әзірлеу объектісі болуы мүмкін тәуекел жағдайының іс-әрекетінен болған шығындар немесе пайда мөлшерін сандық бағалау мүмкіндігі; 2) тез ден қоюды талап ететін тәуекел факторларын анықтаудың жоғары ықтималдығы; 3) технологиялық интеграцияның тұрақты дамуына әртүрлі тәуекел факторларының әсер етуінің жоғары дәрежесі;

4) тәуекел жағдайында технологиялық интеграцияға қатысушылардың тұрақты мінез-құлқының ұтымды нұсқаларын әзірлеу үшін негіз дайындау мүмкіндігі.

Кілтті сөздер: технологиялық интеграция; тәуекелді жағдайлар; сандық бағалау әдісі; Өндіріс; өнеркәсіптік кәсіпорындар

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УСТОЙЧИВОЕ РАЗВИТИЕ ТЕХНОЛОГИЧЕСКОЙ ИНТЕГРАЦИИ: СИТУАЦИИ РИСКА И ОЦЕНКА ВОЗМОЖНОСТЕЙ

В статье рассматриваются результаты разработки научной концепции устойчивого развития технологической интеграции в условиях кризисов. Предлагаемая методология устойчивого развития в рискованных ситуациях раскрывает цели и задачи технологической интеграции, организационно-управленческую процедуру выявления рискованных ситуаций и методологические основы формирования зон риска в динамичной внешней среде. Отличительной особенностью предлагаемой методики является систематизация классификационных факторов рискованных ситуаций, обеспечивающая возможность отнесения рискованных событий к факторам, нарушающим устойчивое развитие. Предлагаемая концепция развивает основные элементы неоклассической теории устойчивого развития, которая позволяет рассматривать рискованные события как угрозы, так и условия устойчивого развития. В рамках практической реализации методологии устойчивого развития технологической интеграции обоснована трансформация зон риска, позволяющая максимально минимизировать возможные потери. Это делает необходимым разработку методологического подхода, основанного на количественных методах выявления рискованных ситуаций. Преимуществом количественного метода является возможность формализовать результаты рискованных ситуаций и оценить их влияние на устойчивое развитие технологической интеграции. Преимуществами количественной оценки рискованной ситуации являются: 1) возможность количественной оценки размера убытков или прибыли от действия рискованной ситуации,

которая может стать объектом разработки процедуры управления устойчивым развитием технологической интеграции; 2) высокая вероятность выявления факторов риска, требующих быстрого реагирования; 3) высокая степень влияния различных факторов риска на устойчивое развитие технологической интеграции; 4) возможность подготовки основы для разработки рациональных вариантов устойчивого поведения участников технологической интеграции в ситуации риска.

Ключевые слова: технологическая интеграция; рисковые ситуации; метод количественной оценки; производство; промышленные предприятия

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