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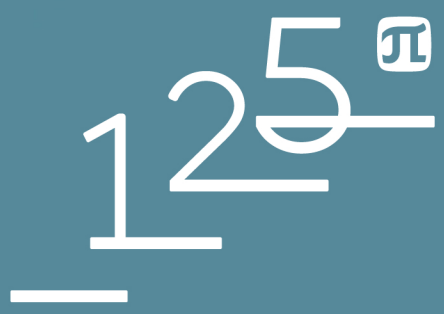

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RPA TECHNOLOGY AS A TOOL FOR BOOSTING THE EFFICIENCY OF AN INDUSTRIAL ENTERPRISE UNDER DIGITAL TRANSFORMATION

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Abstract. In the conditions of modern economy enterprises need to respond to internal and external changes in time to ensure the required level of quality. The main condition for ensuring competitiveness of any enterprise is the quality of its products. Analysis and monitoring of effectiveness and efficiency of quality management system processes is necessary to assess the level of development of the system and its impact on improving the efficiency of the enterprise. In order to analyze performance of an enterprise, it is necessary to evaluate each process in terms of effectiveness and efficiency, to find critical points as a result of these processes, and to develop corrective measures for each sub-process of the company. One of the vectors of business process improvement is the use of information environment. Modern industrial enterprises on the way of continuous improvement of their business processes use different approaches and methods of management, most of which are associated with informatization, which includes the need to collect, accumulate, store and process large amounts of data to improve business processes. This study considers a number of basic, supplementary and managerial processes and standards that regulate them, and shapes a set of criteria for the transfer of processes into automated mode and simulation of processes in the functional models "AS IS", and "TO BE".

Keywords: sustainable development, innovative development, enterprise innovation potential, digitalization, automation, efficiency improvement, industrial enterprise, business processes, RPA

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ТЕХНОЛОГИЯ RPA КАК ИНСТРУМЕНТ ПОВЫШЕНИЯ ЭФФЕКТИВНОСТИ ДЕЯТЕЛЬНОСТИ ПРОМЫШЛЕННОГО ПРЕДПРИЯТИЯ В УСЛОВИЯХ ЦИФРОВОЙ ТРАНСФОРМАЦИИ

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Аннотация. В условия современной экономики предприятиям необходимо своевременно реагировать на внутренние и внешние изменения, чтобы обеспечивать требуемый уровень качества. Основным условием обеспечения конкурентоспособности любого предприятия является качество выпускаемой продукции. Анализ и мониторинг результативности и эффективности процессов системы менеджмента качества необходим для оценки уровня развития системы и её влияния на повышение эффективности деятельности предприятия. Для того чтобы проанализировать деятельность предприятия, необходимо оценить с точки зрения результативности и эффективности каждый процесс, выявить критические точки в результате функционирования этих процессов, и разработать корректирующие мероприятия по каждому из подпроцессов компании. Одним из векторов совершенствования бизнес-процессов является использование компонентов информационной среды. Современные промышленные предприятия на пути постоянного совершенствования своих бизнес-процессов используют различные подходы и методы к управлению, большинство из которых связанны с информатизацией, включающей необходимость сбора, накопления, хранения и обработки больших объемов данных. для совершенствования бизнес-процессов. В работе рассмотрен ряд основных, вспомогательных и управленческих процессов и стандарты, которые регламентируют деятельность этих процессов, сформирован комплекс критериев для перевода процессов в автоматизированный режим и произведено моделирование процессов в функциональных моделях «AS IS», «TO BE».

Ключевые слова: устойчивое развитие, инновационное развитие, инновационный потенциал предприятия, цифровизация, автоматизация, повышение эффективности, промышленное предприятие, бизнес-процессы, RPA

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Introduction

At present, in the context of macroeconomic instability, domestic industrial enterprises are facing new challenges caused by disruptions in the logistics supply chains, a sharp increase in purchases from the defense-industrial complex with strict monitoring of the volume and timing of shipments of finished products and the need to design their own developments in unrelated niches and market segments. The current situation allows domestic enterprises to develop actively, but requires a significant amount of resources, which companies often simply do not have. Under such conditions, increase of labor productivity and reduction of production time can be achieved through the use of RPA system. Technology of robotic process automation (RPA - Robotic Process Automation) is to perform operations, according to a pre-set sce-

nario - the robot. The robot can use elements of the user interface (GUI), and connects to information systems and other programs using a software interface (API). RPA can be used to automate the management of actions such as extracting information from scanned documents using optical character recognition (OCR) to create metadata and convert content into a format suitable for big data or machine learning (ML) processes (Disterer, 2013). The following prerequisites, shown in Figure 1, have contributed to the development and active adoption of RPA in enterprises.

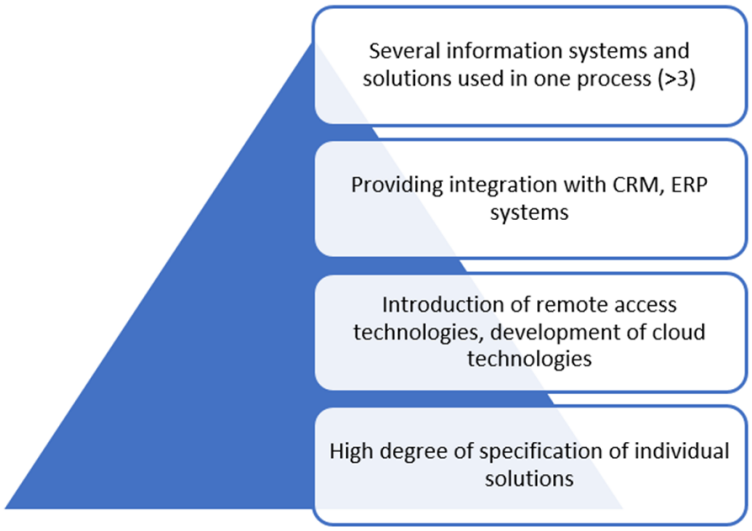


Fig. 1. Prerequisites for the development and implementation of enterprise-based RPA technology

Not only RPA technology can be used as automation tools for web applications, but also APIs. An API is a software interface through which programs can interact at the code level. The speed of interaction at the API level is faster than with RPA. However, RPA technology can communicate with both web applications and software products deployed in the company, which is an advantage when comparing with API (Glazkova, 2020). The use of RPA in data management processes greatly improves the efficiency of tasks such as data entry, collection, creation, and updating. All of these tasks are cyclical and tend to lead to errors, which reduces the quality of the incoming data. Data quality (QD) is the degree to which certain characteristics of data satisfy the stated and intended needs when used under specified conditions. Let's address the basic documents regulating quality of the data presented in the table 1.

Table 1. Data quality management standards

List of standards	Contents
1. ISO/TS 8000 "Data quality" (GOST R 56214-2014/ISO/TS 8000-1:2011	The ISO 8000 standards ensure the improvement of the quality of information used both independently, and as part of quality management systems (Glukhova, 2017).
2. ISO 9000 group, ISO 9001 "Quality management systems" (GOST R ISO 9000-2015, GOST R ISO 9001-2015)	SMK. Basic Provisions and terms; SMK. Requirements
3. ISO/IEC 25010:2011 "Systems and software engineering - Systems and software Quality Requirements and Evaluation (SQuaRE) - System and software quality models"; (GOST R ISO/IEC 25010-2015)	Systems and software quality requirements and evaluation (SQuaRE). Quality models for systems and software products (Perez-Castillo, 2018).

List of standards	Contents
4. Group ISO/IEC 25012-2008 Software engineering - Software product Quality Requirements and Evaluation (SQuaRE) - Data quality model	Software Engineering. Software product quality requirements and evaluation (SQuaRE). Data quality model (Timerbaev, 2019).
5. ISO/IEC 27000 Group "Information technology - Security techniques" (GOST R ISO/IEC 27000-2012)	Information security management system. Overview and terminology.

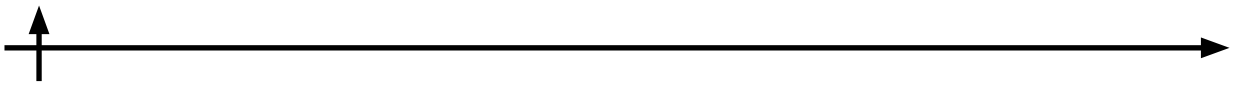
Turning to these standards, let's define the characteristics of software and data used in business processes. Product Quality - the extent to which the software satisfies the stated and implied needs when used under specified conditions. The characteristics of the software are shown in Table 2.

Table 2. Software characteristics that affect quality

Group	Features
Functional suitability	– functional completeness; – functional accuracy; – functional correctness.
Performance	– temporal efficiency; – resource utilization; – power.
Compatibility	– integration with other IS; – maintaining versioning.
Practicality	– accessibility; – protection against user errors.
Reliability	– stability; – recoverability; – fault tolerance; – availability.
Security	– confidentiality; – integrity; – accountability; – authenticity.
Repairability	– modularity; – reusability; – analyzability; – modifiability; – testability.
Tolerability	– adaptability; – installability; – replaceability.

In order to identify a data management problem, it is necessary to determine the indicators that define data quality:

1. Completeness - information about components and attributes for a particular process;
2. Actuality - the consistency of the data provided at the current time;
3. Accuracy - full compliance with the set requirements for the values and filling;
4. Validity - data conformity to the established template, i.e. whether the data is correctly entered by object;
5. Consistency - the degree of logical relationship, considers the internal and external degree of data consistency;
6. Data availability and accessibility - accessibility refers to the time and effort it takes to obtain data in the required format.



Data quality management must begin with the development of methods and procedures to ensure data quality. The implementation of methodologies is necessary to ensure a uniform QD assessment process. What is more, to ensure the required level of quality, it is necessary to implement software solutions that meet certain quality metrics. Thus, when highlighting the main advantages of using RPA technology in industrial enterprises, attention should be paid to:

– Increasing the speed of routine operations by transferring to robotic mode (on average, the robot performs 3-4 times faster);

– No need to make critical changes to the current process;

– Reducing the probability of error in data entry into information systems and further processing (only errors related to the performance of information systems can arise, the influence of human factor is absent);

– No need to perform long and expensive integration of information systems, because robots can work with almost all software that has a user interface.

Materials and Methods

The study involved an in-depth analysis of international and interstate standards, in particular ISO/TS 8000 "Data quality", ISO 9000, ISO 9001 "Quality management systems", ISO/IEC 25010:2011 "Systems and software engineering - Systems and software Quality Requirements and Evaluation (SQuaRE) - System and software quality models", ISO/IEC 25012-2008 Software engineering - Software product Quality Requirements and Evaluation (SQuaRE) - Data quality model, ISO/IEC 27000 "Information technology - Security techniques", the works of leading researchers on innovative technologies to improve the efficiency of industrial enterprises (Chapman, 1997). The information obtained was processed taking into account current trends in the management of industrial enterprises, on the basis of tools in the field of quality management, such as PDCA and PDPC diagrams, as well as by general scientific methods:

– Analysis and synthesis.

– Comparison.

– Classification.

Results

The use of breakthrough technologies, particularly RPA, is becoming a requirement for competitiveness. The enterprise needs to flexibly reconfigure internal processes in order to respond quickly to changing external conditions under the influence of the digital economy through the adoption of high-quality and justified data. Introducing RPA technology into an enterprise for subsequent automation is quite a complex task (Rafique, 2012; Mashtakov et al., 2023).

According to the level of automation, software robots are classified into:

– Attended Robots (serviced, or requiring human attention and participation). Users who need to automate their processes run these bots from their computers;

– Unattended Robots (fully automatic). These bots do not require human involvement - they run autonomously on the servers on a particular schedule;

– Hybrid. These bots are of the mixed type.

The major features that can be optimize with the help of RPA include:

1. Read the information from the screens;
2. Perform data entry via peripheral devices;
3. Manage the operation of applications;
4. Perform individual transactions using enterprise applications;
5. Automate query processing;
6. Search and collect data;

7. Send responses and confirmations;
8. Interact with external systems;
9. Initiate inquiries to counterparties;
10. Interact with workflow management systems (Workflow), business process management (BPM), business content management (ECM, EIM).

Processes that software robots can perform: the use of structured input data, the presence of formal rules and a strict sequence of operations, repeatability and high frequency, no need for human decision-making based on information that lies outside the context of the process being performed, high quality requirements for the result (Strubalin, et.al., 2019). Implementation of RPA should be considered as a project implemented on the basis of the enterprise. Like any other project, the project under consideration has deadlines, resources (Nixon, 1990). Let's consider the main stages of RPA implementation at the enterprise, starting from the initiation of the potential project to its implementation in the stage of execution (by developers/analysts) (fig. 2).

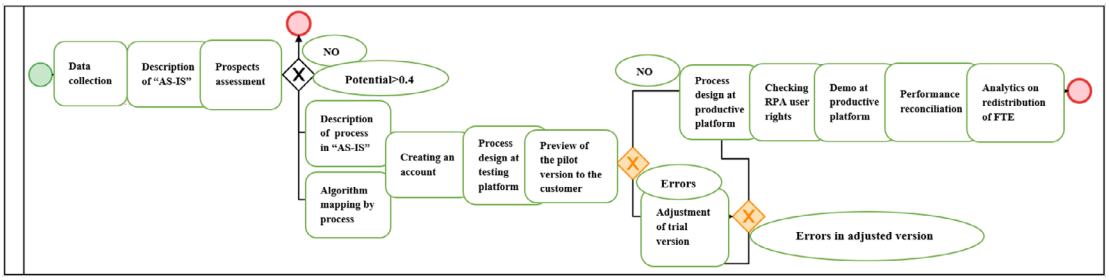


Fig. 2. Stages of RPA technology implementation at an industrial enterprise

The first block includes the stages (the collection of initial data, and the description of the business process in the AS-IS model). At these stages, the need to convert the process in question to robotic mode is determined. It is based on evaluation of the process according to the following parameters presented in Table 3.

Table 3. Process evaluation parameters for robotization

№	Parameter Name	Data type	Weight (j)
1	Number of repetitive actions during the process	Numerical value	0.125
2	Number of launches in the period under review	Numerical value	0.175
3	Number of IPs used in the process	Numerical value	0.2
4	Time required to perform 1 process	Numerical value	0.25
5	Complexity of automation	Selection from a list (directory)	0.15
6	Number of users waiting for the process to complete	Selection from a list (directory)	0.1
Total			1

Based on the results of the initial evaluation, which is performed by an analyst, the following indicator "Robotics Potential" (Ri) is calculated, which determines the need to transfer the process in question to the robotic mode. The distribution of the indicator "Robotics potential" is presented in Table 4.

Table 4. Distribution of robotization potential indicator

№	Indicator range	Description
1	0.1 < Ri < 0.4	Low potential for robotization - the process in question should not be moved to robotic mode, and other automation tools should be considered to optimize it and ensure the necessary quality of data used at the input and output of the process.
2	0.4 < Ri < 0.6	Average potential for robotization - the investigated process can be selected to be transferred to robotized mode completely or partially (with the allocation of the stages that are sources of time losses).
3	0.6 < Ri = < 1	High potential for robotization - the process in question requires conversion to robotic mode, since several information systems and process participants are involved in the execution of the process.

The reasons for the low value of robotization potential may include:

1. Additional mandatory confirmation of authorization in information systems, for example, by entering a code from an SMS message.

2. Unstable web applications, which will cause the robot to restart, and exceed the execution time.

3. Business processes that require a manual pre-check from the employee to run the next part of the process. With such limitations, the process cannot be converted to a fully robotic mode.

The next block includes compilation of the process algorithm in the TO-BE model, and creation of accounts for the IPs used. When a high level of robotization potential is established, the process is describes in a "As it should be" model and create accounts for the robot user in a productive and test environment (Geyer-Klingeberg, 2018). Creation of accounts for the robot is a prerequisite, as all actions implemented during the run must be performed under the name of the robot, so that in case of failure it is possible to revert to the previous version and undo the actions, otherwise a failure can lead to a violation of the data structure and quality (Zhigalov, et.al., 2020).

The development block includes the stages of development in a testing, demonstration of the test version to the customer, making adjustments if necessary, and then transferring to a productive environment and acceptance of the process (Belykh, 2020). Depending on the information systems used in the process, the development stages in the test and production environments can be performed in parallel. After that analytics is made based on the results of the process. Timekeeping at each stage is also performed, which helps free up some of the employee's time and redirect it to the tasks requiring more attention (Frantsuzov, 2020).

Maintaining the necessary level of completeness, reliability and consistency of data for making quality management decisions is the main task of data quality management. The reasons for poor data quality can include:

1. Incorrect input data (input data is in the wrong format, for example, instead of date format comes the same value, but in a text format, respectively. Because of the incorrect type of data further steps in the process will not be performed.

2. Data distortion over time (when performing integration between two information systems, the data were recoded, and in the output we get the wrong format).

The development of data quality management systems and their integration with existing information systems will help to bring the information support of the enterprise to a new level:

– informed management decisions and risk management in the decision-making process;

– reducing the costs of (re)checking and processing data;

– consolidation of disparate business systems by normalizing data and unambiguous definitions;

– unification of business processes related to data delivery to information systems and automation of their routine operations.

Consider the application of RPA system at an industrial enterprise in order to improve the efficiency of business processes, and, as a consequence, to increase labor productivity and operational efficiency. The enterprise has implemented and operates a quality management system, which applies to all stages of the product life cycle and processes. The processes of quality management system are defined and functioning at the enterprise.

Processes are identified, people responsible for the process are determined, the sequence of process performance and resources (process documentation) are defined. All processes are documented. Input, output and criteria for definition of the process effectiveness are specified in the process documentation, process owners and resources are defined as well. All processes running in the company are divided into three groups: management processes, product lifecycle processes and supporting processes (Estdale, et.al., 2018).

Let's consider the automation process for the main QMS processes (the list of which includes the processes of execution, contracting and warranty maintenance of sales contracts) (Chernikova, 2020). When choosing the optimal solution for the automation of QMS processes, different factors were taken into account, and it was decided to deploy the RPA system on the basis of its own team, with the possibility of additional training from the platform owner. The advantages of this option are implementation and deployment of RPA system on the basis of own company and team, from the company's employees, with the possibility of further transfer of knowledge in case of departure of one of the key employees of the company. Subsequently, the release of time resource, will not only reorient the work of sales support group, but also improve the quality of data and processes in the enterprise (Belomyttsev, 2019).

The process was further assessed by the primary evaluation: description in the functional model "AS-IS" (fig. 4), calculation of the complex evaluation of the process in accordance with the defined criteria of robotization described above. The process under consideration consists of 9 stages (signing of specification, authorization in ERP system, transition to the required transaction, transition to the delivery item on the basis of which similar items should be made, performing a cycle of actions to form the delivery item in the project structure, sending the changes made for saving) (Viktorova, 2023). The overall process score was 0.6, which, according to table 3, is an average level of robotization potential, meaning the process can be selected for transfer to robotized mode completely or partly. Fig. 3 shows the sequence of steps "Forming specification file" (step 1) and "Entering data into ERP system" (steps 2-8). If the process is converted to robotic mode, the actions that do not require manual confirmation to move to the next step will be performed by the robot, while the remaining actions will be under control of the employee in charge.

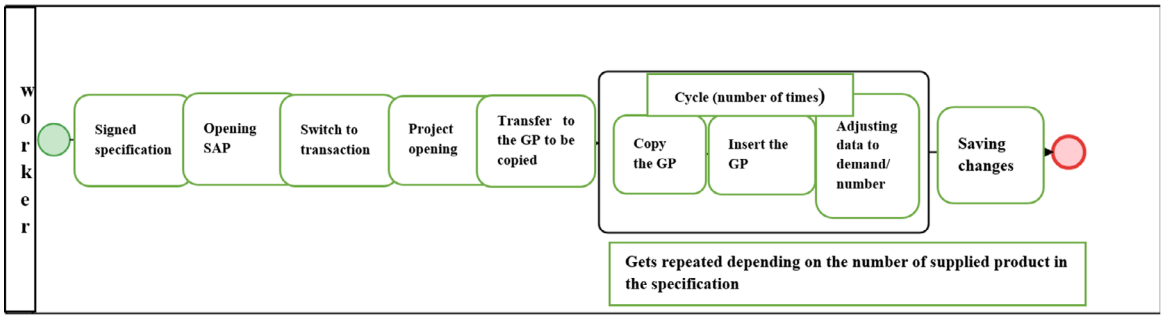


Fig. 3. Process description in the "AS-IS" model (Process #1)

Let's describe the process in the "TO-BE" functional model and consider what it will look like after being converted to robotic mode. According to fig. 4. We can observe the conversion of up to 90% of the functions into robotic mode (8 out of 9 steps), the employee is left with the

activity of signing specification and creating a notification for the robot user to start the process, thereby freeing up the employee's time for the remaining tasks. Once the robot finishes the task, the user receives a notification and checks the data.

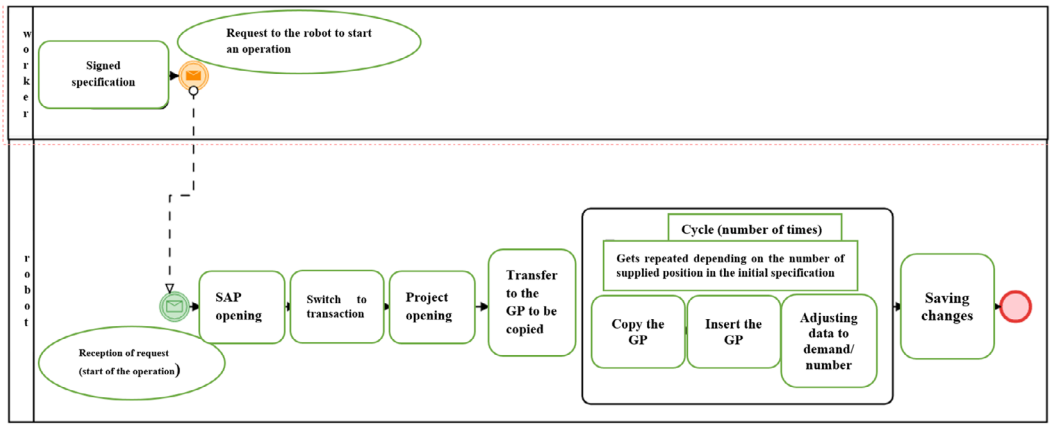


Fig. 4. Process description in the "TO-BE" model

Comparison of these models allows noticing that the transfer of functions to robotic mode has freed up staff time and reoriented them to other functions that require additional work. Freeing up time resources will allow reallocating to such important tasks as:

1. Increase in project contracting;
2. Increasing the level of control over the execution of projects (prevention of fines);
3. Releasing FTE to work with customer stations;
4. Reducing errors in project structure in the ERP-system, there by ensuring consistency and adequacy of data quality;
5. Increased data processing speed;
6. Creation of a single account to make changes to the process.

The presented process is a component of more enlarged processes of the sales block. Accordingly, the already implemented algorithm can also be adapted to other processes within the framework of the QMS project automation.

Conclusion

Process automation now takes place at almost every stage of the life cycle, and is an integral part in the process of continuous improvement of business processes. The company has also developed a standard for information technology support, which approves the procedure for licensing, installation, purchase of software, integration capabilities with other information systems of the enterprise. The standard also establishes requirements for the use of hardware and communication complex, networking, telephone and communications. To assess the effectiveness of this criterion it is proposed to consider the following performance indicator: the degree of coverage of the business processes of the company by the information technology for process automation (the ratio of the automated business processes of the company to all processes of the company).

Transfer of a part of processes into the robotized mode allows increasing the quality of data, which are the main source of information on the project and further processing. Together with the improvement of data quality, this technology will ensure the accuracy and transparency of processes, creating a single vision of the process, which in turn leads to improved quality of staff management. Thus, a mechanism was proposed to automate the business processes of an industrial enterprise in order to improve the efficiency of its activities in the conditions of digi-

tal transformation through the implementation of RPA technology. This technology allows not only to optimize the process, but also to improve the quality of data as an input resource for multiple processes, as it minimizes the level of human errors during data entry/transformation. The processes under consideration are presented in "AS-IS" and "TO-BE" descriptions.

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ON THE PROBLEM OF NOMINAL DATA CORRELATION

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Abstract. This article suggests a new methodological approach to calculating the correlation coefficient between nominal data. In the course of the study, it was revealed that most of the work with nominal data uses two Yule coefficients and Pearson coefficient. Moreover, these coefficients are proposed based on the same assumption that there is no correlation between the variables. As a result of the study, this assumption is questioned by the authors, and a new coefficient of correlation between nominal data is proposed. A comparative analysis of the application of the three classical coefficients with the new coefficient is conducted. The advantages of the new coefficient are shown.

Keywords: correlation coefficient, nominal data, Yule coefficient, Pearson coefficient, correlations

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К ВОПРОСУ О КОРРЕЛЯЦИИ НОМИНАЛЬНЫХ ДАННЫХ

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Аннотация. В данной статье представлен новый методический подход к расчету коэффициента корреляции между номинальными данными. В процессе исследования выявлено, что в большинстве случаев работы с номинальными данными используют два коэффициента Юла и один коэффициент Пирсона. Причем эти коэффициенты предлагаются исходя из одного и того же предположения об отсутствии корреляционных связей между переменными. В результате исследования данное предположение ставится авторами под сомнение и предлагается новый коэффициент корреляции между номинальными данными. Проводится сравнительный анализ применения трёх классических коэффициентов с новым коэффициентом и показываются преимущества нового коэффициента.

Ключевые слова: коэффициент корреляции, номинальные данные, коэффициент Юла, коэффициент Пирсона, корреляционные связи

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Introduction

In this scientific research, correlation analysis tools are used to confirm the presence of the cause-and-effect relationships. Due to the originality of the nominal data, the study of their correlation differs significantly from the studies in other sections of the correlation analysis. At the same time, despite the numerous efforts of scientists to develop and improve this section of correlation analysis, it still does not provide a satisfactory solution to the problem of identifying and evaluating correlation. The difficulty in determining the correlation between data measured in nominal data is explained by the fact that no mathematical operations can be performed on these data. Occurrences of some numbers are already the data of the metric scale, and these data can be processed statistically. The number of occurrences of nominal numbers is used to judge whether or not there is a relationship between the nominal numbers.

Materials and Methods

The most convenient way to work with the data on the number of occurrences of nominal numbers is to put them into a table, which is commonly called a "conjugacy table" (Table 1).

Table 1. General vision of the conjugacy table

	The first characteristic of attribute A, x_1	The second characteristic of attribute A, x_2	Total
The first characteristic of attribute B, y_1	a	b	a+b
The second characteristic of attribute B, y_2	c	d	c+d
Total	a+c	b+d	N=a+b+c+d

Attribute A in the conjugacy table is, for example, the sex of a person. And attribute B in the same table is a preference between lipstick (the first characteristic) and strong alcohol (the second characteristic) a, b, c, d are the numbers of observations on the conjugate features, e.g. a is the number of women who stop to look at the lipstick counter with interest and b is the number of men who do the same. The researcher's task is to infer from the observations of the numbers a, b, c, d whether or not there is a correlation between the attributes A and B. This is not an easy task (Cramer, 1946).

If there is some correlation between the attributes A and B, it manifests itself in certain proportions between the numbers a, b, c and d. But no one knows this proportion a priori. Furthermore, these proportions are different for different properties. Therefore, the task is to try to describe this proportion with the help of some tool and to evaluate the strength of its manifestation, or in other words, to measure the strength of the correlation between the attributes. How can one generally determine the presence or absence of a correlation between the nominal data? Let us give some description of such situations, using the most general idea of the presence or absence of a correlation (Yates, 1934).

There is no correlation if a change in one attribute no effect has whatsoever on another attribute - it remains unchanged. For example, attribute A is the sex of the TV viewer interviewed in Russia, and attribute B is his attitude towards the two parties in Honduras: y1 is the Liberal Party of Honduras and y2 is the National Party of Honduras. Since ordinary Russian viewers have no idea about the political system of Honduras and will express their attitude towards them not by their characteristics but by their names, there is no correlation between the attributes in this case (Reagle, Vinod). Some of the respondents will like the word "Liberal", others – "National" (Boon, 2020). Therefore, this is the type of data most likely to be obtained in this case.

Table 2. An example of a situation where there is no relationship in the conjugacy table

	Male TV viewers, x_1	Female TV viewers, x_2	Total
Preference for the Liberal Party, y_1	149	101	250
Preference for the National Party, y_2	151	99	250
Total	300	200	500

Here, there is no correlation, as a relationship between two random factors, and the coefficient reflecting this situation should be equal to zero. The lack of correlation in the nominal data manifests itself in the fact that when the characteristics of one attribute A change, the characteristics of another attribute B do not change.

The most common coefficient in practice today, with the help of which a researcher tries to assess the strength of the correlation between two groups of nominal data, is Yule's association coefficient:

$$Q = \frac{ad - bc}{ad + bc} \quad (1)$$

The main idea for substantiating the form of this coefficient, which Yul outlined in an article in 1912, is as follows: "If the two attributes are combined entirely independently, the proportion that possesses, say, the first character will be the same, or more or less approximately the same, amongst those which possess and those which do not possess the second. If these two proportions differ, the two attributes are not independent but associated: positively associated if the proportion possessing the first character is greater amongst the objects or individuals possessing the second character than amongst those not possessing it, negative in the contrary case". Mathematically, this idea, taking into account the notation of Table 1, will be written as follows:

$$\frac{a}{a+c} = \frac{b}{b+d} \quad (2)$$

Whence:

$$ab + ad = ab + cb \rightarrow ad - cb = 0 \quad (3)$$

That is, if there is no relationship between the attributes, as Yule understood it, then the right-hand side of (3) will be equal to zero. And if the relationship ("association" - according to Yule) exists, then the equality to zero is violated. In this case, the difference (ad-cb) will be greater or less than one (Thompson, 2019).

In order to transform this condition into a computationally friendly coefficient that varies modulo from zero to one, Yule divided the right-hand side of (3) by its conjugate value and obtained formula (1).

Exactly the same result can be obtained if the proportions are calculated not by columns, but by rows, because:

$$\frac{a}{a+b} = \frac{c}{c+d} \rightarrow ac + ad = ac + cb \rightarrow ad - cb = 0 \quad (4)$$

One can make sure that the right part (3) is the numerator (1).

While explaining the reason for the fact that he designated the new coefficient with the letter Q, Yule wrote that: "I took the symbol from the first letter of Quetelet". At the time of Yule, the name Lambert-Adolph-Jacques Quetelet, as one of the founders of statistics, was widely known all over the world.

For the convenience of studying the properties of the association coefficient (1), Yul transformed it into this form:

$$Q = \frac{ad - bc}{ad + bc} = \frac{1 - \frac{bc}{ad}}{1 + \frac{bc}{ad}} = \frac{1-k}{1+k} \quad (5)$$

He went on to introduce such designations:

$$p_0 = \frac{a}{a+c}; \; p_1 = \frac{b}{b+d} \quad (6)$$

Taking into account the coefficient k, these two components can be written as:

$$p_0 = \frac{1}{1+\sqrt{k}}; \; p_1 = \frac{\sqrt{k}}{1+\sqrt{k}} \quad (7)$$

Their difference:

$$\omega = p_0 - p_1 \tag{8}$$

is also some measure of the relationship: "...why not use ω itself as the coefficient of association instead of the function Q?".

He called this coefficient ω the coefficient of colligation. It is more convenient to use this coefficient in a form approximating the form of the association coefficient (1) with those variables used in the coefficient of association. This can be easily done by substituting for k its values taken from (6):

$$\omega = \frac{1-\sqrt{k}}{1+\sqrt{k}} = \frac{\sqrt{ad}-\sqrt{bc}}{\sqrt{ad}+\sqrt{bc}} \tag{9}$$

Obviously, the condition $|\omega| \le 1$ is met for this coefficient as well.

As can be seen, both Yule`s coefficients are based on the assumption that there is no relationship between the two attributes X and Y only if there is a condition of proportion (2) or (3) between them. In all other cases, these coefficients will be modulo greater than zero (Deisenroth, Ong, Faisal).

In the previous paragraph, we determined that the lack of correlation between the attributes means the absence of any influence at all from X on Y and vice versa.

This means that either X or Y must be evenly distributed in the conjugacy table, as shown in Table 2. If there is a proportional distribution, then this indicates that there is some established relationship between the attributes. Another thing is that this relationship does not change with the change of the attributes, but it is there (Zudin, 2023).

Consequently, there is still a relationship between the two attributes X and Y, although not significant.

Using the example of Table 2 in the previous paragraph, we have examined the case where there is no correlation between the factors. Let us now apply both of Yule's coefficients to this table, knowing that it simulates a non-correlation situation. We obtain:

$$Q = \frac{70\cdot 100 - 100\cdot 230}{70\cdot 100 + 100\cdot 230} = -0,53; \quad \omega = \frac{\sqrt{70\cdot 100}-\sqrt{100\cdot 230}}{\sqrt{70\cdot 100}+\sqrt{100\cdot 230}} = -0,29$$

The association coefficient shows the presence of a relationship, and the coefficient of colligation indicates that there is a relationship, but rather a weak one. The discrepancy in the readings of these two coefficients should not be surprising. It is a well-known fact that Yule`s coefficient of association modulo is always greater than the coefficient of colligation of Yule.

And the fact that these two coefficients reveal a correlation where, in our opinion, it cannot be, is also not surprising, because both coefficients proceed from the fact that there is no relationship if and only if there is some invariable proportion between the numbers of columns (and rows).

In practice Pearson's mutual conjugacy coefficient is less often used. However, it has found the most widespread use in the scientific environment since, unlike Yule's coefficients, it is obtained by using a statistical distribution. Taking into account the designations we use; Pearson's conjugacy coefficient will take this form:

$$\phi = \frac{ad-bc}{\sqrt{(a+c)(b+d)(a+b)(c+d)}} \tag{10}$$

K. Pearson is one of the founders of mathematical statistics and his contribution to this science is enormous. In particular, he proposed and carefully studied the x^2 distribution which is known today in mathematical statistics:

$$\chi^2 = \sum_i \frac{(y_i - y_i^{\wedge})^2}{y_i^{\wedge}} \quad (11)$$

Pearson suggested using the x^2 distribution to identify the correlation between the nominal data. The essence of his proposal is as follows. In the conjugacy table there are some real data. They need to be compared with such calculated values where there is no relationship between the attributes (Edwards, David).

These calculated values are most often called "theoretical". Having these two groups of data, it is possible to calculate (11).If the real values coincide with the "theoretical" ones or are close to them, then x^2 will be equal to or close to zero.

The obtained value of x_2 can be compared with the critical value (from the table, which is available in all textbooks on mathematical statistics) and if the calculated value of x_2 exceeds the critical value, it indicates that the assumption of no association is not true.

The real values of the numbers are available in the original conjugacy table. These are values a, b, c, and d. But how can we find unknown "theoretical values" at which there is no any relationship?

To do this, one can use Yule's suggestion (2).

Let b/a = k (k>0). Since there is no relationship according to Yule when (2) is met, then by substituting b = ak into it, we obtain that the following equality should be met: d = ck. Or: b/a = d/c = k. Let us substitute these values in the conjugacy table.

Table 3. General view of the conjugacy table

	x_1	x_2	Total
y_1	a	ak	a(1+k)
y_2	c	ck	c(1+k)
Total	a+c	(a+c)k	N=(a+c)(1+k)

Suppose now we know only the final rows and columns of the conjugacy table 5, and the values inside it are not known to us.

Table 4. Conjugacy table 5 in the absence of internal numbers

	x_1	x_2	Total
y_1			a(1+k)
y_2			c(1+k)
Total	a+c	(a+c)k	N=(a+c)(1+k)

Under these conditions, how can one calculate "theoretical values" when there is no relationship? To do this, the simple proportion shown in Table 5 should be used.

Table 5. Simple proportion in the conjugacy

	x_1	x_2	Total
y_1	?		a+b
y_2			c+d
Total	a+c	b+d	N

Unknown or "theoretical" elements of the table, with the help of this simple proportion, will be found as follows:

$$a' = \frac{(a+b)(a+c)}{N}, \quad b' = \frac{(a+b)(b+d)}{N}, \quad c' = \frac{(c+d)(a+c)}{N}, \quad d' = \frac{(c+d)(b+d)}{N} \tag{12}$$

Substituting the total columns and rows of Table 6 into (12), we obtain that in the absence of a relationship, as Yule understood it, we obtain that a'=a, b'=b, c'=c, d'=d. That is, now for any values of the numbers in the conjugacy table, those very "theoretical" values for which Yule`s coefficients will be zero, can always be calculated using the total values of rows and columns, which, according to Yule, indicates a lack of correlation.

The distribution of x_2 in relation to the case under consideration will be written as follows:

$$\chi^2 = \frac{(a-a')^2}{a'} + \frac{(b-b')^2}{b'} + \frac{(c-c')^2}{c'} + \frac{(d-d')^2}{d'} \tag{13}$$

Let us show how this method works.

Table 6. Conditional example

	x_1	x_2	Total
y_1	34	66	100
y_2	88	62	150
Total	122	128	250

According to the total values of this table, "theoretical" values can be calculated.

Table 7. Calculation of "theoretical" values according to Table 6

	x_1	x_2	Total
y_1	48,8	51,2	100
y_2	73,2	76,8	150
Total	122	128	250

The value of the criterion x^2 (13) in this case is calculated by the formula:

$$\chi^2 = \sum_{i=1}^{2}\sum_{j=1}^{2} \frac{(y_{ij} - y\!\!\!E_{ij})^2}{y\!\!\!E_{ij}} \tag{14}$$

where y_{ij}- is the real value of the indicator, located in the i row and in the j column, $y\!\!\!E_{ij}$ is its "theoretical" value.

Substitute in formula (14) the real values from Table 8 and the "theoretical" values from Table. 9. We obtain:

$$\chi^2 = \frac{(34-48,8)^2}{48,8} + \frac{(66-51,2)^2}{51,2} + \frac{(88-73,2)^2}{73,2} + \frac{(62-76,8)^2}{76,8} = 14,649 \tag{15}$$

Let us compare the value of the criterion x^2 with the critical values. It is equal to 3.841 with a significance level of 0.05. Our value (15) exceeds significantly the critical value, so it can be argued that there is correlation between the nominal numbers Table. 7. But how close is this correlation? The answer to this question cannot be derived from (15), but the researcher is interested not only in the fact that there is a relationship between the attributes, but also in the degree of this relationship. And it is impossible to determine it by analyzing the data obtained.

Therefore, based on (13), Pearson proposed a coefficient that modulo will vary from minus one to plus one:

$$\phi = \sqrt{\frac{\chi^2}{N}} \tag{16}$$

Substituting in (17) the values of x^2 and the number of observations N, we obtain:

$$\phi = \sqrt{\frac{14,649}{250}} = 0,242 \quad (17)$$

It follows from (16) that in the case where the real values coincide with the "theoretical" ones and x^2 is equal to zero, Pearson's conjugacy coefficient will be also equal to zero. And for $x^2 \rightarrow \infty$ it tends modulo to one. That is, the requirements for the limits of the correlation coefficient change are satisfied here: in the absence of correlation, the coefficient is equal to zero, and in the presence of strong correlation, it tends to one.

Since the Pearson correlation coefficient for the case in question turned out to be insignificant φ =0,242, it should be stated that this coefficient diagnoses a weak relationship between the two attributes. But this multi-iterative approach is not very convenient for practical application. To calculate Yule's coefficient, simply substitute the values from the conjugacy table into his formula and the result is immediately available. It is necessary to simplify the calculation of Pearson's conjugacy coefficient. And this can be done.

If we now replace x^2 in (16) with its value from (13) and, in its turn, replace (13) with the "theoretical" values as determined from (12), we obtain a formula suitable for calculations. Once this has been done, by reducing and grouping, it is possible to obtain a formula suitable for calculating Pearson's conjugacy coefficient (10). Without claiming that his coefficient is better than Yule's one, Pearson gives an example of an evaluation of vaccination effectiveness, the one Yule had previously used. "Taking the small-pox returns for the epidemic of 1890, we have".

Table 8. Example of K. Pearson

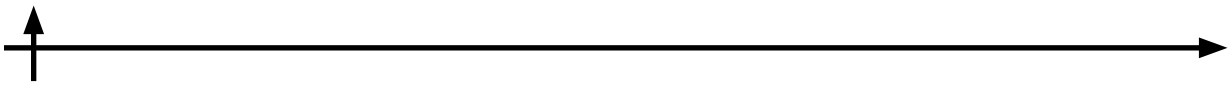
	Recoveries	Deaths	Total
Present	1562	42	1604
Absent	383	94	477
Total	1945	136	2081

For the data in this table, Yule's association coefficient will be 0.803, and Pearson's conjugacy coefficient will be 0.29. The first coefficient indicates that there is a strong correlation between the attributes, and the second coefficient indicates that if there is a correlation, it is very weak (Wu, Gan, Ma, 2007).

Having received this conclusion, Pearson pointed out that the comparison of these two coefficients should be carried out on a large number of examples, and only then would it be possible to conclude which of the two coefficients should be preferred. In cases where the numbers in the conjugacy tables are added so that the proportions (2) or (12) are satisfied, then both coefficients will be equal to zero (Agarwal, 2006). But, as follows from (2), if at least one of the numbers in the conjugacy table is zero, then both Yule`s coefficients (1) and (9) will be equal to one, regardless of whether there is a relationship between the attributes or not. They will be close to one, even if one of the numbers in the conjugacy table is extremely small, compared to the rest of the numbers. The example in Table 11 illustrates this peculiarity.

Table 9. Conditional example

	x_1	x_2	Total
y_1	1	5000	20
y_2	200	100000	5001
Total	201	105000	100200



For this table we have: Q = -0.8182, ω = -0.5195 and φ = -0.0088. This means that the Yule`s coefficients indicate a strong relationship between the factors, and the Pearson's conjugacy coefficient indicates its absence (Pearson, 1904).

The sensitivity of Yule`s coefficients to the presence of small numbers in the conjugacy table has led to a theoretical preference for Pearson's conjugacy coefficient over Yule`s coefficients (Rauber, Nesbitt).

Another significant advantage of Pearson's conjugacy coefficient over Yule`s coefficients is that it can be used for conjugacy tables of dimension greater than 2x2 - with any number of columns l and rows m. None of Yule's coefficients is suitable for this.

As studies have shown, the x^2 changes in leaps and bounds in conjugacy tables as new data arrive, because it is based on calculating integers that change in leaps and bounds. And x^2 statistics were originally proposed for continuous distributions. In some cases, the analysis of conjugacy tables leads to misunderstandings in the interpretation of the values obtained. Therefore, in 1934, Yates's correction was proposed, which attenuates these jumps. To do this, when calculating x^2, the following correction is introduced into the numerator when calculating x^2.

$$\chi^2 = \sum_i \frac{(|y_i - y_i| - 0,5)^2}{y_i} \tag{18}$$

Different studies have also been carried out on Pearson's conjugacy coefficient itself. The famous Russian statistician Alexander Tschuprow proposed a correction to this coefficient for the case of a conjugacy table with more than four elements:

$$C = \sqrt{\frac{\chi^2}{N\sqrt{(l-1)(m-1)}}} \tag{19}$$

where l and m are the number of rows and columns in the conjugacy table.

Another popular coefficient that develops Pearson's idea and is based on x^2 is Cramer's V coefficient.

$$V = \sqrt{\frac{\chi^2}{N \min(l-1)(m-1)}} \tag{20}$$

There are several other auxiliary coefficients, but they have no independent meaning, so we will not consider them here.

Let us look at a number of other examples to see if the claims of practitioners about the accuracy of diagnosing the correlation between the nominal data of Yule`s and Pearson`s coefficients are justified. Using the rule in Table 5, we will generate a situation in where there is no correlation according to Yule (and Pearson), and where their coefficients are equal to zero. Let a = 10, c = 120, k = 2. Then:

Table 10. Lack of relationship according to Yule and Pearson

	x_1	x_2	Total
y_1	3	9	12
y_2	10	30	40
Total	13	39	

As expected, all three coefficients considered earlier are equal to zero for the data in Table 12. Now let us do this. Reduce the number d in the conjugacy table from 30 to 11.

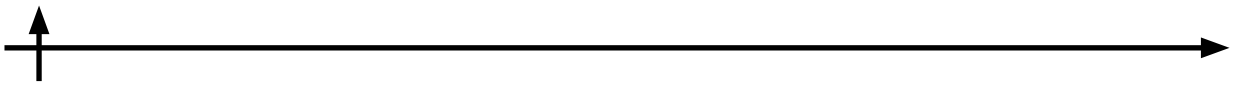


Table 11. Lack of relationship according to Yule and Pearson

	x_1	x_2	Total
y_1	3	9	12
y_2	10	11	21
Total	13	20	

As can be seen from this table, as the number of observations for one attribute increases, so does the number of observations for another attribute: in the totals column - from 12 to 21, in the totals row - from 13 to 20. That is, we see that there is a positive correlation - an increase in one corresponds to an increase in the other. And what do the coefficients discussed above diagnose us according to the data in this table?

Here are their values: Q = -0,463, ω = 0,246 and φ = -0,223. That is, they diagnose a negative relationship between the factors - the opposite of what actually exists.

And this is understandable because the coefficients are equal to zero under the conditions of Table 12, and reducing the value of d in this table by at least one (Table 14) causes all the coefficients to become negative (Q = -0,017, ω = -0,008 and φ = -0,006).

Table 12. Inverse relationship according to Yule and Pearson (negative coefficients)

	x_1	x_2	Total
y_1	3	9	12
y_2	10	29	39
Total	13	38	

And increasing the value of d by the same unit (Table 15) results in all three coefficients becoming positive (Q = 0,016, ω = 0,008 and φ = 0,006).

Table 13. Direct relationship according to Yule and Pearson (positive coefficients)

	x_1	x_2	Total
y_1	3	9	12
y_2	10	31	41
Total	13	40	

In both the first and the second cases, an increase in the values of the quantities of one attribute is accompanied by an increase in the quantities of the values of the other attribute. This means a positive relationship. Here is an example that confirms this paradox even more vividly.

Table 14. Conditional example

	x_1	x_2	Total
y_1	10	200	210
y_2	120	250	370
Total	30	50	580

An analysis of the numbers in Table 16 shows that when moving from x1 to x2, the numbers in each row increase: from 10 to 200, from 120 to 250. And as you move from y1 to y2, the numbers in the columns increase: from 10 to 120, from 200 to 250. If the growth in the

indicators of one attribute is accompanied by the growth in the indicators of another attribute, then we have an obvious positive relationship. What do the coefficients Q, ω and φ give us for this case?

And here's what we get: Q = - 0,811, ω = - 0,512, φ = -0,319.

That is, they unanimously signal the presence of a negative relationship between the factors. But the increase in the value of one indicator is accompanied by a similar increase in the value of another indicator, not by its decrease!

Results and Discussion

The assumption of Yule and Pearson that a zero correlation is diagnosed when the proportions between the values of the numbers in the conjugacy table b/a = d/c = k are kept, is not true. The coefficients they propose will therefore give a distorted picture of the situation. An alternative coefficient, based on different assumptions about the presence or absence of a relationship, is required (Pearson, 1900).

The lack of correlation between the attributes means that if one of the attributes changes, the characteristics of the other attribute will not react in any way. This gives reason to propose an appropriate correlation coefficient for its use according to the data of the conjugacy tables.

First of all, let us note that the conjugacy tables under consideration between two attributes can be represented graphically in a three-dimensional space. The axes of this space are the attributes x and y, and the number of observed occurrences of each of these attributes n (Fig. 1).

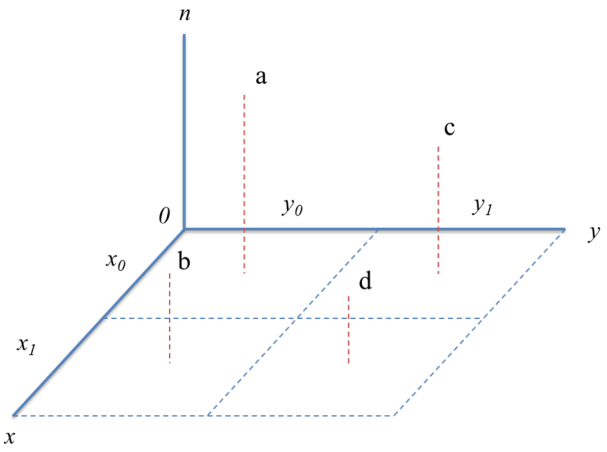


Fig. 1. A Table of feature conjugacy in graphical interpretation

Four points in three-dimensional space are projected onto each of the planes that make up the space. The n0y and n0x planes are of interest since the quantities n are not projected onto the x0y plane, and for any distribution of numbers of any nominal scale, the same points will be depicted on this plane.

The first of the considered planes n0y looks like this.

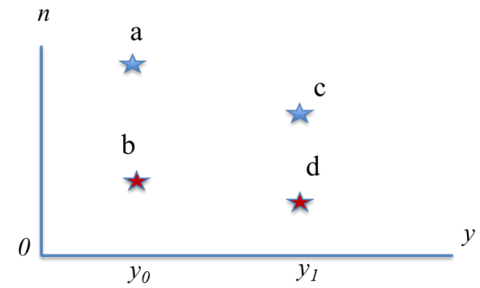


Fig. 2. Projections of the conjugacy table points on the plane n0y

It is well known that one and only one straight line can be drawn through two points. Let us do this by drawing a straight line on the plane in question through points a and c, since these two points reflect a change in one attribute, and through points b and d - another one, since they reflect a change in the number of observations of another attribute. We obtain:

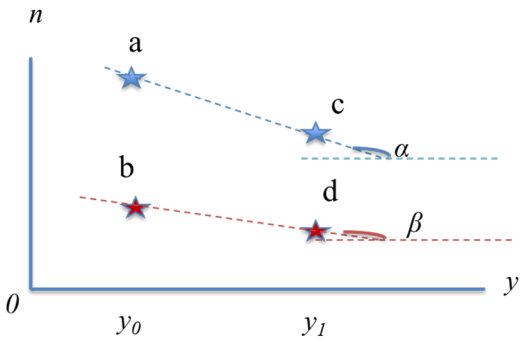


Fig. 3. Straight lines on the plane n0y

Therefore, in the calculated coefficient, we should calculate the arithmetic mean of the moduli of the tangents on each plane. It will characterize how far the points in the conjugacy table are from equal values. For the plane n0y we have:

$$\frac{|a-c|+|b-d|}{2} \tag{21}$$

And for another plane n0x:

$$\frac{|a-b|+|c-d|}{2} \tag{22}$$

If we multiply these two arithmetic means of the tangent moduli and extract the square root of their product, then the geometric mean of these means modulo tangents will be obtained:

$$\frac{1}{2}\sqrt{(|a-c|+|b-d|)(|a-b|+|c-d|)} \tag{23}$$

The geometric mean (23) can be as large as you like - this is the tangent. To bring the desired coefficient within the required limits of minus one to plus one, the value (23) must be scaled so that it does not exceed modulo one. How to do this?

To do this, the numbers in the conjugacy table a, b, c, d should be divided by the maximum value of these numbers. In this case, none of the tangents of the angles will exceed one, and

their geometric mean (23), scaled in this way will be between zero and one. Then we get:

$$\frac{1}{2}\frac{\sqrt{(|a-c|+|b-d|)(|a-b|+|c-d|)}}{\max(a,b,c,d)} \tag{24}$$

At the same time (24) will be always positive, regardless of whether there is a negative or positive correlation between the attributes. When calculating the required coefficient, it is necessary to ensure that it has a "+" sign for a positive connection and a sign "-" for a negative connection (Mills, 2017).

If one plane shows a generally upward tendency and the same tendency is generally reflected on the second plane, this indicates that the relationship has a positive sign. But if these two tendencies, both on the first and on the second plane, are of a downward nature and their tangents are negative, then this is also a direct dependence, since a decrease in the values of one attribute results in a decrease in the values of another attribute, i.e. they change in one direction (Janning).

But if multidirectional trends are observed on the planes, that is, an increase in one attribute is accompanied by a decrease in the other one, and then this means feedback between the attributes.

Consequently, the sign of the direction of the relationship between the nominal data can be determined by multiplying each other the sums of the tangents on each of the planes, i.e.

$$(ac+bd-(bc+ad))\cdot(ab+cd-(cb+ad)) \tag{25}$$

The sign of this product should be applied to the required coefficient.

MS Excel has such a built-in function that determines the sign of any mathematical operations. If the researcher is using another software product that does not have this function, the sign to be put before the calculated coefficient, can be found as follows:

$$\xi = \frac{(ac+bd-(bc+ad))\cdot(ab+cd-(cb+ad))}{|(ac+bd-(bc+ad))\cdot(ab+cd-(cb+ad))|} \tag{26}$$

The coefficient ξ, as one can see, takes only two values - plus one or minus one.

Taking into account this sign, which determines the direction of the correlation, the required coefficient will have the following form:

$$S = \xi\frac{1}{2}\frac{\sqrt{(|a-c|+|b-d|)(|a-b|+|c-d|)}}{\max(a,b,c,d)} \tag{27}$$

It will be equal to zero if the tangent of both lines is zero on at least one of the planes considered, and in all cases, it will be modulo greater than zero but less than one.

Now it is necessary to understand how to interpret the values of the coefficient (27), modulo in the range from zero to one.

For example, what does S=0.5 show? Is the correlation between the attributes strong or weak? The fact that it is straight is indicated by the "+" sign, and what is the strength of the relationship?

At first glance, it seems that a linear scale for interpreting correlation coefficients values could be used to diagnose the strength of the relationship, the one which the researchers usually use when calculating Yule`s and Pearson`s coefficients. Normally they are given this interpretation.

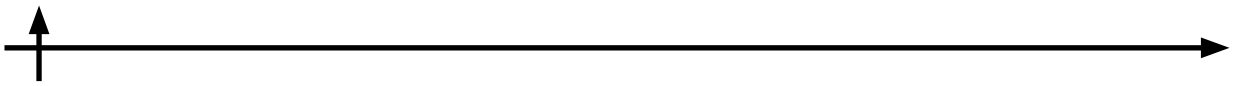


Table 15. Standard interpretation of correlation coefficients values

The value of the coefficient module, k (Q ∨ ω ∨ φ)	Strength of relationship
0 <k <0,1	Absence of relationship
0,1 ≤ k <0,2	Weak
0,2 ≤ k <0,4	Average
0,4 ≤ k <0,6	Relatively strong
0,6 ≤ k <0,8	Strong
k ≥ 0,8	Very strong

But in fact, this table cannot be applied directly to the interpretation of the values of the coefficient (27). The fact is that the coefficient S is a tangent, which has been formed in a complicated way by averaging and calculating the geometric mean. And the tangent is a non-linear function, and the linear interpretation presented in Table 17 cannot be applied to it.

For the calculated coefficient (27), the angles of inclination act as an argument, which, depending on the degree of connection of attributes, vary linearly from zero to the maximum angle whose tangent modulus is equal to one. This linear change is transformed by (27) into a non-linear change of the new correlation coefficient (Yule, 1912). Therefore, it is necessary to "tie" the change in the angle of inclination to the linear scale of Table 17, and then to find the correspondence of the coefficient (27) to one or another degree of the relationship between the nominal data. Let us do this.

Our starting point is that the maximum value of (27) is modulo one. The tangent is equal to one if the argument (the angle of inclination φ) is π/4. The minimum modulo value of the coefficient (27) is zero and it corresponds to the zero angle of inclination. Consequently, a change in the argument from 0 to π/4 corresponds to a change in the strength of the correlation tie from its absence (at zero angle of inclination) to the highest degree (when the angle of inclination is equal to π/4).

Then we can propose the following interpretation of the values of the coefficient modulus S (with rounding off to convenient numbers).

Table 16. Interpretation of coefficient values (27)

The value of the coefficient module, k (Q ∨ ω ∨ φ)	The value of the argument (angle φ) corresponding to the segment of the relationship degree scale	The modulus of the coefficient S as the tangent of the argument	Strength of relationship
0<k <0,1	0< φ < π/40	0 ≤ S_{gs} <0,08	Absence of relationship
0,1 ≤ k <0,2	π/40 ≤ φ < π/20	0,08 ≤ S_{gs} <0,16	Weak
0,2 ≤ k <0,4	π/20 ≤ φ < π/10	0,16 ≤ S_{gs} <0,33	Average
0,4 ≤ k <0,6	π/10 ≤ φ < 3π/20	0,33 ≤ S_{gs} <0,5	Relatively strong
0,6 ≤ k <0,8	3π/20 ≤ φ < π/5	0,5 ≤ S_{gs} <0,73	Strong
k ≥ 0,8	φ ≥ π/5	S_{gs} ≥ 0,73	Very strong

Now it is possible to get an answer to the question of what the value of the coefficient S=0.5 indicates. If it were Yule`s association coefficient, it would diagnose a relatively strong degree of association (Table 17). And such a value of the new coefficient diagnoses a strong relationship between the attributes (Leibniz, Clarke, 2000).

Let us test how the new coefficient works on those examples that questioned the acceptability of existing coefficients for diagnosing the degree of connection between the attributes. Thus, in

tables 14 and 15 the conditional values of the numbers were given at which these coefficients had negative (Table 14) and positive (Table 15) values, although the essence of the relationship did not change much - it was direct and positive. This is easily verified by both the numbers in these tables and their graphical representation, which is shown in Fig. 4.

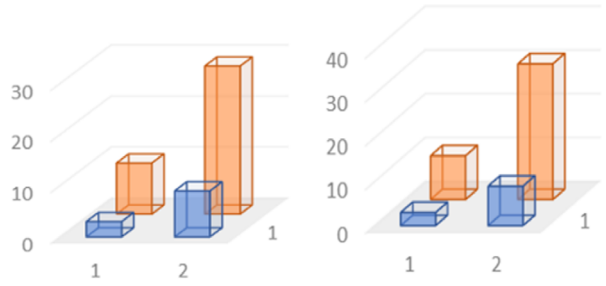


Fig. 4. Graphical representation of the data in Table 14 (left) and Table 15 (right)

It can be seen from the figure that in both one case and another, the growth of one attribute is accompanied by the growth of another attribute, i.e. the condition of a positive relationship between them is fulfilled. They differ from each other in that the last number in the tables, which corresponds to the upper right column in the figures, changes its values from d=29 (Table 14) up to 31 (Table 15), while the other numbers remain unchanged.

On the graph, this change by two units is not even noticeable. However, for the graph of the values presented on the left side of the figure, the following coefficients are calculated: Q = -0,017, ω = -0,008 and φ = - 0.006, and for the values presented on the right side of the figure, they become positive: Q = 0,016, ω = 0,008 and φ = 0,006.

The proposed coefficient (27) for the first case of Table 14 is equal to S = 0.448, and for the case of Table. 15, it is equal to S = 0.448. Both in one case and the other, a positive relationship between the attributes is diagnosed, which, in accordance with the recommendations of the Table can be interpreted as relatively strong.

Let us check how the proposed coefficient (27) works on other conditional examples that were given in the tables of the previous paragraphs, except for the examples just discussed in Tables 14 and 15, and compare it with what the coefficients Q, ω, φ show.

For the convenience of subsequent interpretation of the values of all four coefficients, let us summarize in a single table of the correspondence between the values of these correlation coefficients to the strength of the relationship from Tables 17 and 18.

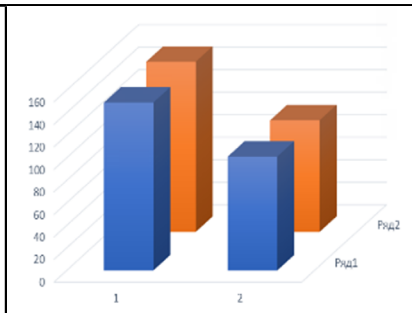
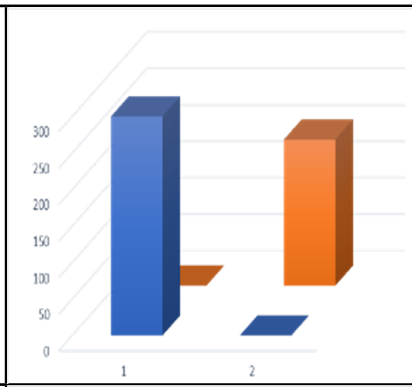
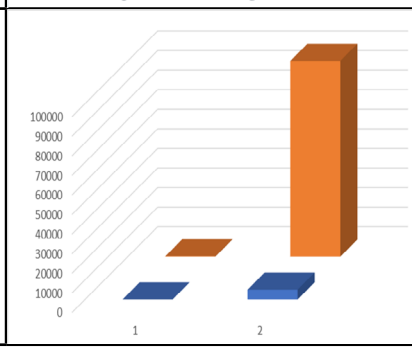
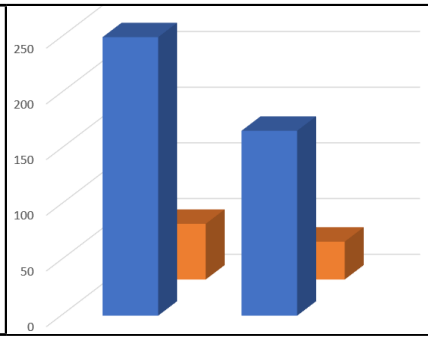
Table 17. Standard interpretation of correlation coefficients values

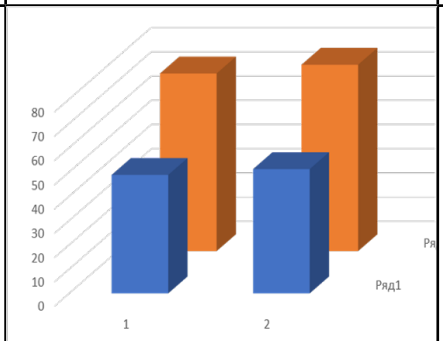
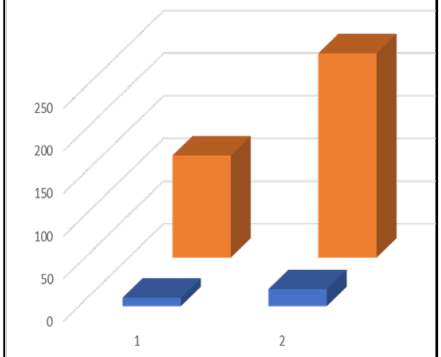
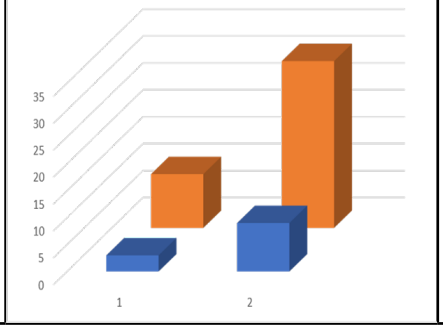
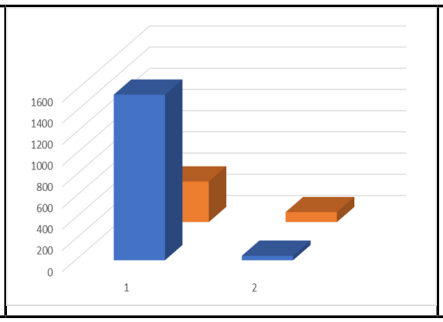
k (Q ∨ ω ∨ φ)	Strength of relationship	S
0<k <0,1	Absence of relationship	0 ≤ S <0,08
0,1 ≤ k <0,2	Weak	0,08 ≤ S <0,16
0,2 ≤ k <0,4	Average	0,16 ≤ S <0,33
0,4 ≤ k <0,6	Relatively strong	0,33 ≤ S <0,5
0,6 ≤ k <0,8	Strong	0,5 ≤ S <0,73
k ≥ 0,8	Very strong	S ≥ 0,73

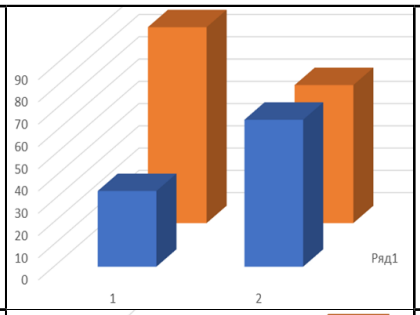
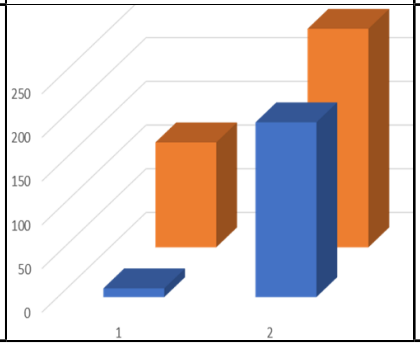
But before interpreting certain values of the calculated coefficients, it should be noted that in correlation practice it has long been believed that Yule`s coefficient slightly overstates its values with respect to the true value of the strength of the relationship, and that his colligation coefficient and Pearson's conjugacy coefficient slightly understate their values with respect to

the real degree of correlation. But since we are offering an alternative to these coefficients, we will not go into these details any further. Let us divide all these tables into groups with a typical situation and summarize the results of the calculation of all the coefficients.

Table 18. Comparative analysis of correlation coefficient calculations from previous tables

Number of the table	Representation of data in three-dimensional form	Q	ω	φ	S
Lack of correlation					
2		-0,017 No correlation	-0,008 No correlation	-0,008 No correlation	-0,066 No correlation
Strong correlation					
3		0,999 Very strong correlation	0,984 Very strong correlation	0,983 Functional correlation	0,826 Very strong correlation
11		-0,818 Very strong negative	-0,519 Relatively strong negative	-0,009 no correlation	0,499 strong
There is a correlation, but Yule`s and Pearson`s coefficients show that there is none					
4		0 Lack of correlation	0 Lack of correlation	0 Lack of correlation	0,364 Relatively strong

Number of the table	Representation of data in three-dimensional form	Q	ω	φ	S
9		0 Lack of correlation	0 Lack of correlation	0 Lack of correlation	0,112 Weak positive
12		0 Lack of correlation	0 Lack of correlation	0 Lack of correlation	0,449 Relatively strong
15		0,016 Lack of correlation	0,008 Lack of correlation	0,005 Lack of correlation	0,451 Relatively strong positive
An example of Yule and Pearson					
10		0,803 Very strong positive	0,503 Relatively strong positive	0,291 Average positive	-0,477 Relatively strong negative

Number of the table	Representation of data in three-dimensional form	Q	ω	φ	S
The correlationis positive, and the Yule`s and Pearson`s coefficients show a negative correlation					
8		-0,467 Relatively strong negative	-0,248 Average negative	-0,242 Average negative	0,329 Average positive
16		-0,811 Very strong negative	-0,512 Relatively strong negative	-0,319 Average negative	0,452 Relatively strong positive

These are very interesting results. It is an undeniable fact that as a person ages, he is more careful about his health, at least due to the fact that he gets sick more often and chronic diseases appear. From this unconditional fact, it is logical to conclude that, among the various aspects of increased attention to their health by the elderly, there should also be a growing interest in healthy lifestyles as one of the ways of independent health care for the residents of the region (Geddes, 2022).

However, the coefficients have shown a negative direction of the correlation. However, of the three classical coefficients, only one indicates a weak negative correlation - this is Yule`s association coefficient and the S coefficient shows the presence of an average negative relationship. The other two show that, in fact, there is essentially no correlation here.

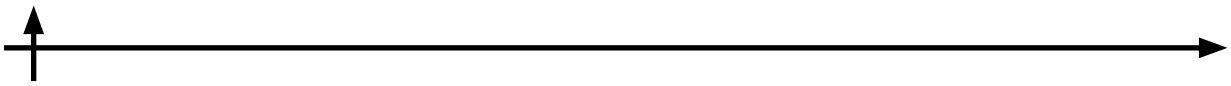
2. Young people from another region of Russia were asked, among other things, on the problem whether they trusted political parties or youth associations more?

The results of this survey are presented below.

Table 19. Conjugacy Table of Healthy Lifestyle

The meaning of the signs	x_1 - from 18 to 45 years	x_2 - from 45 years and older	Total
y_1 - interested	215	234	449
y_2 - not interested	175	136	311
Total	390	370	760

Q	ω	φ	S
-0,167 (Weak)	-0,084 (Lack of correlation)	-0,082 (Lack of correlation)	-0,191 (Average)



These are very interesting results. It is an undeniable fact that as a person ages, he is more careful about his health, at least due to the fact that he gets sick more often and chronic diseases appear. From this unconditional fact, it is logical to conclude that, among the various aspects of increased attention to their health by the elderly, there should also be a growing interest in healthy lifestyles as one of the ways of independent health care for the residents of the region (Geddes, 2022).

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2. Young people from another region of Russia were asked, among other things, on the problem whether they trusted political parties or youth associations more?

The results of this survey are presented below.

Table 19. Conjugacy Table of Healthy Lifestyle

The meaning of the signs	x_1 - political parties	x_2 - youth associations	Total
y_1 - trust	14	35	49
y_2 - do not trust	28	6	34
Total	42	41	83

Q	ω	φ	S
-0,842 very strong inverse	-0,547 relatively strong inverse	-0,529 relatively strong inverse	0,614 strong direct

Yule`s association coefficient shows that young people trust youth associations more than political parties. Two other classical coefficients also confirm the direction of this dependence but note that this dependence is relatively strong. But the new coefficient S diagnoses the opposite situation. It points out that young people show a direct dependence between the attributes, i.e. they trust parties but not youth organizations (Tschuprow). Since all youth organizations registered in Russia are pro-government and work in line with the policies of the main pro-government parties, and since there is at least some disagreement with the authorities and pro-government parties among the registered parties, the conclusion given by the coefficient S should be preferred - among the youth there is a large percentage of nihilists or rebels who do not agree with any government (represented by adults), so they will trust heterogeneous parties more than homogeneous youth organizations.

Conclusions

Yule`s and Pearson`s classical coefficients are based on such assumption about the situation of the absence of correlation between data, which introduces inaccuracy into the procedure for estimating the degree and direction of correlation between the data. The new coefficient was proved based on other prerequisites and the situation of lack of relationship between attributes, where a change in one attribute does not affect in any way a change in another attribute.

A comparative analysis of all coefficients - both old and new – has shown that the coefficient S successfully copes with its task assigned to it. It both assesses the degree of correlation and identifies its direction. It both assesses the extent of the relationship and identifies its direction. This coefficient is slightly more difficult to calculate than Yule`s and Pearson`s coefficients. But who calculates such coefficients by hand nowadays? And for computer calculations, the new coefficient presents no difficulties. This new coefficient has one significant drawback

compared to Pearson's conjugacy coefficient - it can only work with two-dimensional conjugacy tables. And Pearson's conjugacy coefficient, which is calculated using the x^2 distribution, can be applied to conjugacy tables of any dimension.

Therefore, the coefficient S for multidimensional cases and conjugacy tables can only be used by reducing them to a two-dimensional case by a method well known to practitioners - property A, and all other properties are not A. The solution to the problem in this way becomes quite labor-intensive, but today, with the digitalization of the scientific process, it should not embarrass anyone.

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SMART UNIVERSITY: GLOBAL CHALLENGES OR LOCAL TASKS?

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Abstract. The article discusses the concept of "Smart Universities": prerequisites for development, innovative breakthroughs and subsequent results, the change of educational paradigms in society and the impact on industrial and post-industrial societies. The main smart processes taking place at a Smart university are also considered, and the main smart infrastructure for providing activities is described. As a result, e-information and educational environments are considered in the example of Peter the Great St. Petersburg Polytechnic University and MIT OpenCourseWare and edX.

Keywords: smart university, digital education, industry 4.0, digital economy, educational technologies

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УМНЫЙ УНИВЕРСИТЕТ: ГЛОБАЛЬНЫЕ ВЫЗОВЫ ИЛИ ЛОКАЛЬНЫЕ ЗАДАЧИ?

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Аннотация. В статье рассматривается концепция "Умных университетов": понятие, предпосылки создания, инновационные прорывы и последующие результаты, изменение образовательных парадигм общества и влияние на индустриальное и постиндустриальное общества. Также, рассмотрены основные смарт-процессы, происходящие в умном университете, и описана основная смарт-инфраструктура для обеспечения деятельности. В итоге, электронные информационно-образовательные среды рассматриваются на примере Санкт-Петербургского политехнического университета Петра Великого и MIT OpenCourseWare и edX.

Ключевые слова: умный университет, цифровое образование, индустрия 4.0, цифровая экономика, образовательные технологии

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Introduction

The object of this research is a concept of Smart universities in the education system. It implies a change in the approach in the learning process: education should become multi-format and personalized. It is possible to implement this by introducing new information systems into the management structure of universities. Such changes concern not only the educational process, but also the organizational structure of universities as a whole.

The subject of this research is scientific articles by Russian and foreign authors on the topic of the introduction of digitalization (Industry 4.0) in the education system. In the course of research, theoretical and practical methods were applied, including: analysis, generalization, comparison.

The purpose of writing this paper is to examine the current set of concepts that should build up the basis for a Smart University to function properly. This research aims to analyze the current state of digitalization implementation in the process of Smart Education, identify the basic concepts and show the relationship between them by analyzing existing practices.

The research is aimed at:

1. analysis of “Smart University” as an education-related concept;
2. identification of prerequisites for the emergence of the “Smart University” concept;
3. assessment of necessary elements for launching the “Smart University” concept;
4. examination of changes that take place in the educational paradigms during the society’s transfer from industrial to post-industrial mode.

In the recent years, the issue of digitalization of the economy has been discussed vastly. In

particular, a lot is said about the concepts with the prefix "Smart", and "Digital". Under these concepts, a lot of funding is being allocated on a competitive basis, even ministries of digitalization have appeared at all levels. Accordingly, concepts such as Smart university have appeared, alongside the concepts of Smart City, Smart Home, Smart Transport, and much more “smart” or “digital” entities. “Smart” is a property of an object that characterizes the integration of two or more elements that were not previously connected. This sort of connection is established thanks to the Internet. "Smart" technologies contribute to the expansion of mobility in various fields: education, public service, production, etc. Vast coverage of this trend determines the relevance of this research (Wiesmeth, 2016).

Materials and Methods

Smart technologies are changing the education system, which is manifested by:

1) introduction of the “life-long learning” principles;
2) application of the latest distance and e-learning technologies;
3) facilitated licensing and accreditation procedures.

Smart universities, acting as centers of scientific and innovative development of each region and stimulating interest in the intensive development of all sectors of the Russian economy, shape the basis of Smart cities. A smart university is a model for creating a unified environment of digital services that are adaptive to the processes and goals of the university and suitable for replication (Borisenko, 2015). The main goal of creating a Smart University is to transform the basic and management processes at the university with the help of digital technologies. The "Smart University" model involves the introduction of the most modern technologies in the educational process, widespread use of online platforms, personalized educational trajectories and courses, new space opportunities and modes.

A smart university is not just about online courses. Neither the e-timetable, nor the elements of online education by themselves, make universities digital. The transformation should affect the essence of the educational process, improve the quality of the final educational result and the motivation of students and faculty (Bochkareva, Danilova, 2021).

In the scientific work “Organization of management in a smart university”, Grishin V.I., Kalinina I.A., Karasev P.A., Kulapov M.N. and Shklyaev A.E. consider a Smart University as an information space with intellectual products of a special kind (Grishin, Kalinina ,et. al., 2018). In the concept, the authors propose to integrate digitized processes in the educational, scientific and financial activities. In this case, the university’s structure consists of seven main components: leadership, personnel, resource infrastructure, educational products and scientific products, education and scientific activity, strategy – making the vision of the future (Grishin, Shevchenko, 2022).

New opportunities for “University 2.1” are not only an increase in the number of students, but also their quality. In recent years, this has been typical for universities and faculty, but first of all, achieving strategic development goals with minimal resources. For now it is possible to say that we have almost reached the limits of the size of university education in the traditional format, in terms of the number of students and the volume of academic hours. This led to a decrease in the reputation and image component of university education, and a growing share of the "entertainment" part of education (Glukhov, 2017).

In order to make a "smart" university, it is necessary to look for and implement mechanisms for concentrating resources on breakthrough areas, as well as to abandon inefficient activities. Therefore, it is very important to change the structure of the university, which ceases to dominate in the process of creating educational products. Projects aimed at creating new scientific and educational products at a smart university are changing the organization of university activ-

ities. They require a transition to network or cluster types of interaction with partners to create an out-of-system education. And in the education system, which is based on the principles of "lego" - assemble your education yourself. This also leads to an increase in the market of educational services for "competent customers" - parents, employers and students. These organizations activate the formation of the student's environment in order to influence the change in the development of competence under control of an interested party (Walter, 2014).

It is impossible to dispute against the facts put forward by N.V. Dneprovskaya, E.A. Yankovskaya, I.V. Shevtsova in their article "Conceptual foundations of the concept of smart education". According to this paper, modern smart universities are very different from average students in terms of development. Firstly, the faculty for a Smart University should be comprehensively trained and able to quickly navigate in modern life. These changes set new vectors of the educational process, and contribute to realizing the potential of teaching staff and students in creating new technologies (Dneprovskaya, Yankovskaya, 2015).

A virtual campus is advisable to be created in a smart universities, so that all students and faculty could freely use resources in accordance with their role in education. This requires the availability of technical infrastructure (computer network, computers, telecommunication and communication devices, presentation equipment, access control systems for educational content, information security system) (Stepanova, 2019). Another important component is information infrastructure, that includes a set of digital resources, applications and services of the intra-university information environment, personal IDs for access to Smart campus resources.

In the article "Smart University", V.V. Meshkov and I.A. Suslova argue that for successful a integration of the system, it is necessary for the university to meet the following requirements: to use the best practices in creating smart infrastructure; to ensure communication between students, teachers and staff through information technology; to invite innovative technologies that improve the quality of information services, while saving money. The authors also note that the intellectual infrastructure of the university has multiple facets: management of the material and technical complex, management of educational activities, and supporting processes (Meshkov, Suslova, 2019).

The article by G. Sidorov "Digital University: Application of digital technologies in modern educational institutions" examines five levels of the conceptual model of a digital university, formed for successful collaboration between Russian and foreign universities. The first level is represented by researchers (NPR), students, industry and university partners of the university, graduates of the university. The external and internal stakeholders of the university are also based here. At the second level, there are basic information services that determine the information support for digital communication within the university. Examples include services, such as: video screens for lectures and seminars, wireless communication throughout the university (including dormitories), and cloud data storage (Glukhova, Kaziev, et.al., 2021).

The third level implies a number of services that significantly facilitate the work of students and faculty of a modern university. The fourth level is the most resource-intensive in terms of implementation, but at the same time, allows the university to get the greatest added value. It consists of services, such as digital marketing, research project management, procurement management, interaction with applicants and students (Nesterov, 2015). The fifth level consists of digital technologies, which are highly likely to be widely used in the university environment from 2018-2019. Such technologies, for example, include drones (unmanned aerial vehicles).

There is no universal solution that ensures the achievement of concrete results through the use of digital technologies. But by listening to the opinion of end users, it is possible to acquire the most valuable information and use it as a basis for further actions (Rabenatulutra, 2022).

The prerequisite for the emergence of the concept of Smart universities was Industry 4.0.

Tarasov I.V., in his article "Industry 4.0: Concept and Development Trends", builds his research around the concept of "Industry 4.0", which was first introduced by the German Federal government as a strategic plan for the development of German industry, based on the unification of industrial equipment and information systems in a single information space, allowing them to interact on their own, without human involvement (Tarasov, 2017).

Another work “The concept of a “Smart University”, published in the journal “Automation and Software Engineering”, V.A. Zhmud describes the development of a model of a "Digital University" and its replication to the higher education system. According to the author, based on the data of the Ministry of Education, a conditional framework has already been defined for the model of a "Digital University" to be built. The framework will consist of four blocks - university management information systems and online support of the educational process.

V.A. Zhmud claims that the "Digital Transformation Center" is needed in order to transform the formation and content of education. The author uses this example to show that the form can be changed using digital services and technologies (Zhmud, 2019). The Ministry of Communications will create highly-effective platforms that are necessary for obtaining public services online. The student will be able to receive certificates and register at the military enlistment office online. Changes in the content of education are also planned, and along with the already developing segment of online courses, courses using AR and VR will be introduced. Today, thanks to modern technologies, it will be easier for students to study their profession hands-on (Sidorov, 2017).

A. Schwindt, in his turn, mentions that in addition to the "Digital University", emphasis will be placed on the individual trajectory of education, that is, collecting information not only according to the teacher's assessments, but also according to the results of online courses. Such information will be collected, processed and personalized based with the help of AI, which would be time-saving for both, students and faculty.

Results and Discussion

All of the above mentioned works also provide arguments that relate to the specifics of the transition from an industrial to a post-industrial society in education. Not all participants of the educational process are ready to change educational paradigms. Without this change in education, it is impossible to achieve the concept of Smart Universities, but society and the state are doing everything possible to implement this concept into education.

Table 1 describes the components of paradigms that change, as does the way of our society and the economy: from industrial to post-industrial society.

Table 1. Changing educational paradigms

Components of paradigms	Industrial Society	Post-industrial society
Values	1. public education is realized in special educational institutions; 2. education for industries – professional training.	1. personal career and fulfillment are prioritized before public interests; 2. personalized approach to teaching; 3. creative education, life-long learning.
Motives	1. training = duty; 2. activity of a teacher is observed as fulfillment of one’s professional duty; 3. the optimal educational unit is a group.	1. students' interest in education; 2. joy of achieving results; 3. teachers are interested in the development of students, find reward communicating with them; 4. the optimal educational unit is an online network team.
Norms	1. the teacher is responsible for the training; 2. the authority of the teacher is maintained by keeping distance, and requiring discipline from students.	1. students take responsibility for their learning; 2. the authority of the teacher is created by his personal qualities and professional merits.

Components of paradigms	Industrial Society	Post-industrial society
Goals	1. training is focused on the acquisition of scientific knowledge; 2. learning while young makes a "life's main asset".	1. training is focused on mastering the basics of human culture and competencies; 2. life-long learning.
Roles of participants in the educational process	1. teacher = knowledge transmitter; 2. teacher's position is higher.	1. the teacher creates space for developing personal educational environment, and encourages independent learning; 2. efficient learning rests on cooperation and co-authorship between teachers, students, practitioners and international PPP communities.
Forms and methods	1. hierarchical and authoritarian methods, stable structure of academic subjects; 2. stable forms of organization of the educational process; 3. emphasis on classroom work under the guidance of a teacher.	1. individual educational trajectory; 2. modular open world intellectual resources; 3. emphasis on planned education itself.
Tools	1. textbook makes the main means of teaching; training stands and laboratory work.	1. the textbook is complemented by the world's open educational resources, potential of online expert communities, and the opportunities provided by social networks and the media.
Control and quality of education	1. monitoring and evaluation are carried out mainly by the teacher.	1. shifting the emphasis on self-control and self-management in students; 2. participation in the assessment of the quality of education of professional communities; 3. education becomes open to criticism.

A smart university cannot exist without a well-functioning smart infrastructure and smart processes. Smart processes are based on trained people, digital literacy, innovative approaches, continuous updating, active use of Information and Communication Technologies, dynamic interaction and a high level of motivation (Tuluzakova, 2022). They should occur and be supported in all areas of the educational process and the organization as a whole: in smart education, science, and management (Kaptur, 2019; Bolchek, 2023).

In smart education, these are: innovative teaching materials, a dynamic interaction between teachers, technical support and students, updating information about the educational process: schedules, personal accounts of students, resources for teachers and etc. (Krishtal, 2019)

In the management system, these are: the educational process, scientific work and management and finance. Scientific work is intertwined with the educational process and the management system. The smart infrastructure includes a well-established corporate network, IoT, smart-learning, and a management system (Sarsembayeva, 2017).

A detailed diagram describing the processes at a smart university is presented in Figures 1-3.

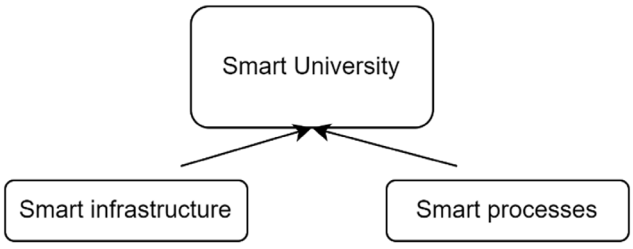

Fig. 1. Processes in a Smart University

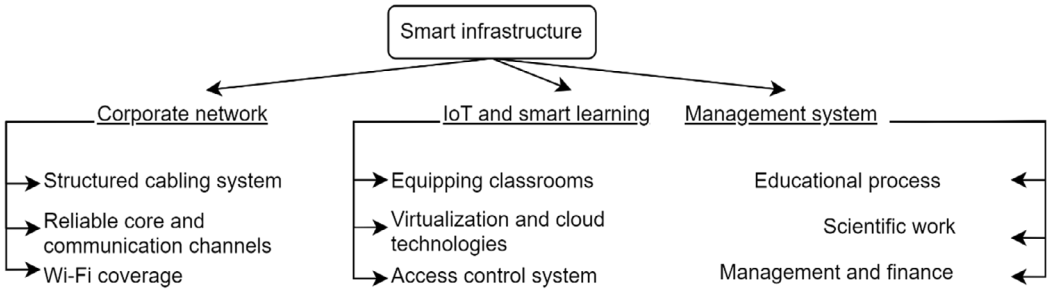

Fig. 2. Processes in a Smart University

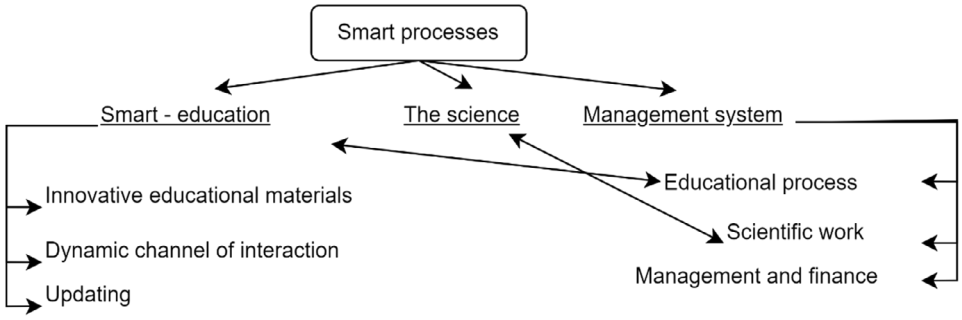

Fig. 3. Processes in a Smart University

Conclusions

Overall, the major reasons why it is difficult to digitalize universities include the following:

– The second most conservative social institution is a university;

– The professor always knows how and what to teach;

– It is possible to fulfill all formal indicators requested by the system without changing anything in real activity;

– The professor does not want to be evaluated by the students, importance of student feedback is neglected;

– Employers do not know who they will hire in 4-6 years, clarity in this regard is absent.

– Students and graduates are not ready to take responsibility for their career choice and education;

– It is necessary to significantly change the space and infrastructure of the campus;

– For now, there is no model of effective higher education;

– The concept of “average” university in the country is a myth.

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AFFILIATE MARKETING AS A PART OF THE DIGITAL MARKETING STRATEGY OF BANKS AND FINTECH COMPANIES

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Abstract. This article explores the use of affiliate marketing in the banking and fintech industries, specifically in the Russian region. The paper begins with an overview of affiliate marketing, its popularity globally, and the payment models commonly used. The article then delves into case studies of how affiliate marketing has been used in the banking and fintech industries, including American Express and Robinhood. The research also includes an analysis of the affiliate programs of leading banks in Russia. The paper concludes that affiliate marketing is a viable digital marketing tool for financial institutions, citing successful case studies and industry statistics. The conclusion emphasizes that affiliate marketing is a cost-effective and efficient way to acquire new customers and generate revenue for banks and fintech companies in Russia.

Keywords: affiliate marketing, digital marketing, banking industry, fintech industry, payment models, customer acquisition

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ПАРТНЕРСКИЙ МАРКЕТИНГ КАК ЧАСТЬ ЦИФРОВОЙ МАРКЕТИНГОВОЙ СТРАТЕГИИ БАНКОВ И ФИНТЕХ-КОМПАНИЙ

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Аннотация. В данной статье рассматривается использование партнерского маркетинга в банковской и финтех-индустрии, в частности в российском регионе. Статья посвящена обзору партнерского маркетинга, его популярности во всем мире и используемых моделей оплаты. В статье приводятся конкретные примеры использования партнерского маркетинга в банковской и финтех-индустрии, включая American Express и Robinhood. Исследование включает в себя анализ партнерских программ ведущих банков России. Партнерский маркетинг является экономически эффективным и действенным способом приобретения новых клиентов и получения дохода для банков и финтех-компаний в России. В результате исследования, делается вывод о том, что партнерский маркетинг является жизнеспособным инструментом цифрового маркетинга для финансовых учреждений, что подтверждается наличием успешных примеров и статистических данных по отрасли. Партнерский маркетинг является экономически эффективным и действенным способом приобретения новых клиентов и получения дохода для банков и финтех-компаний в России.

Ключевые слова: партнерский маркетинг, цифровой маркетинг, банковская отрасль, финтех-индустрия, модели оплаты, привлечение клиентов

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Introduction

In recent years, digital marketing has become an increasingly important aspect of the banking and financial technology (fintech) industry worldwide. According to a report by McKinsey, digital channels are expected to account for up to 90% of all customer interactions in the banking industry by 2024. This trend is particularly relevant in Russia, where the fintech industry has been rapidly growing, driven by increased adoption of digital technologies and growing demand for online financial services. As of 2022, the fintech market in Russia was valued at $1 billion, growing up from $0.5 billion in 2017.

One digital marketing strategy that has gained significant traction in various industries, including e-commerce, travel, and entertainment, is affiliate marketing. However, its use in the banking and fintech industry has been relatively limited, despite its potential benefits. By leveraging the reach and influence of affiliate partners, banks and fintech companies can increase brand awareness, attract new customers, and drive revenue growth.

In Russia, the use of affiliate marketing in the banking and fintech industry has not been extensively studied. This article aims to fill this gap by analyzing the role of affiliate marketing in the digital marketing strategies of banks and fintech companies in the Russian region. Specifically, it will review existing literature on affiliate marketing and digital marketing in the Russian banking and fintech industry, and analyze the trends, challenges, and opportunities related to affiliate marketing in this context (Beranek,

2018).

The article also presentы findings on the spreading of affiliate marketing in the digital marketing strategies of banks and fintech companies in Russia, based on research of leading companies' data and market analytics. Overall, this article seeks to contribute to the growing body of research on digital marketing strategies in the Russian banking and fintech industry and highlight the potential of affiliate marketing as a powerful tool for driving customer acquisition and revenue growth in the Russian market (Khyzhnyak, 2017).

Affiliate marketing is a marketing strategy that involves partnering with third-party affiliates to promote a company's products or services (offers). It works by rewarding affiliates for each customer they refer to the company who then makes a purchase. This type of marketing is typically performance-based, meaning that affiliates are only paid when they generate a sale or lead for the company. In role of "affiliate" could be any person or entity that has ability to bring value to businesses: website publisher, social media influencer, advertising agency or even average individual (Korzhova, Sokolinskaya, 2018).

According to a report by Influencer Marketing Hub, the affiliate marketing industry is expected to grow to $14.3 billion by the end of 2023 globally and it is expected to reach $15.7 billion by 2024. As for the Russian market share, unfortunately, there is not enough data in public sources to specify it but, based on AdIndex Survey of 253 top executives from the Russian marketing industry in 2021, spendings on affiliates are 15,7% of the total marketing budget on average.

There are several common payment models used in affiliate marketing, including:

– Cost per Acquisition (CPA): This is the most popular payment model in affiliate marketing, where the affiliate is paid a commission for each sale that they generate. The commission is typically a percentage of the sale amount and can range from a few percent to as high as 50% or more.

– Cost per Lead (CPL): In this payment model, the affiliate is paid a commission for each lead they generate for the company. A lead refers to a potential customer who has provided their contact information and expressed interest in the company's products or services. The commission is typically a fixed amount per lead and can vary depending on the industry and the value of the lead.

– Cost per Install (CPI): This payment model is commonly used in mobile app affiliate marketing, where the affiliate is paid a commission for each app install they generate. The commission is typically a fixed amount per install and can vary depending on the app and the targeted audience.

– Revenue Share: This payment model involves the affiliate receiving a percentage of the revenue generated by the customer they referred over a specific period of time. This could be a percentage of the customer's lifetime value or a percentage of the revenue generated during the first few months of the customer's subscription.

– Pay per Click (PPC): In this payment model, the affiliate is paid a commission for each click they generate on the company's ad or link. The commission is typically a fixed amount per click and can vary depending on the industry and the targeted audience.

Respectively, it is possible to match payment models with the most popular digital business directions:

– e-commerce: The most common payment model in e-commerce is Cost per Acquisition (CPA). This is because e-commerce companies typically have a clear conversion funnel, with the goal of driving sales and revenue. CPA incentivizes affiliates to drive high-quality traffic and conversions and allows companies to measure the ROI of their affiliate marketing campaigns.

– B2B products and lead generation: In industries that rely heavily on lead generation, such as finances and education, Cost per Lead (CPL) is a common payment model. CPL incentivizes affiliates to generate high-quality leads that are more likely to convert into paying customers and allows companies to measure the cost of acquiring a lead.

– Mobile applications and games: In mobile app affiliate marketing, Cost per Install (CPI) is the most common payment model. This is because the goal of mobile app marketing is typically to drive app

installs, and CPI incentivizes affiliates to drive high-quality app install`ls.

– Subscription services (including SaaS and B2C products): For subscription-based services, Revenue Share is a common payment model. This is because the lifetime value of a customer is more important than a one-time sale, and Revenue Share incentivizes affiliates to drive high-value customers who are more likely to stay subscribed for a longer period of time.

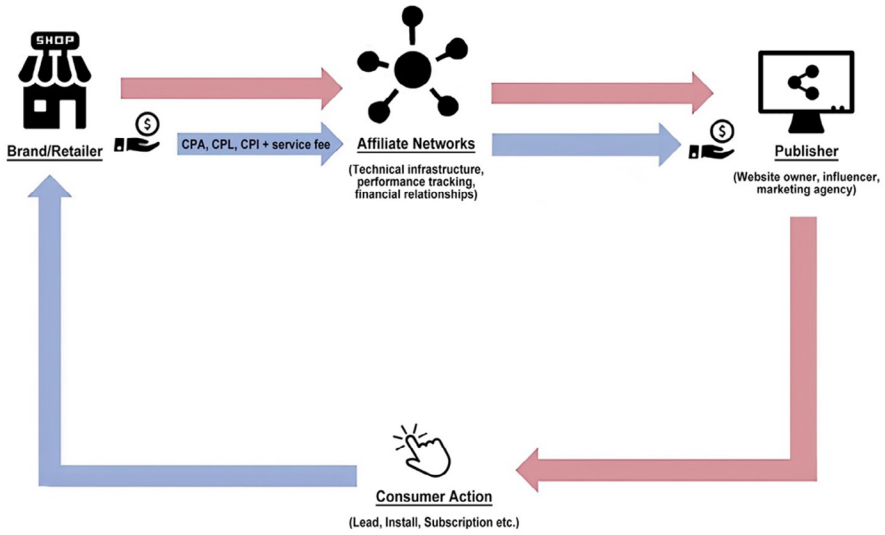

Fig. 1. General overview of affiliate marketing flows

In creating an affiliate marketing strategy for business it's important to note that different payment models may work better for different industries and types of products or services. It's also important to set clear expectations and goals with affiliates upfront, to ensure that the payment model is mutually beneficial and leads to a successful partnership.

To technically implement affiliate marketing, companies typically use affiliate networks or platforms to manage their affiliate partnerships. These networks act as intermediaries between the company and its affiliates, providing tracking, reporting, and payment processing services. Examples of popular affiliate networks include CJ Affiliate, ShareASale, and Rakuten Marketing (Morris, 2009). In addition to affiliate networks, companies can also use in-house affiliate programs, where they manage their own affiliate partnerships and tracking systems. This approach provides greater control and flexibility but requires more resources and expertise to set up and manage. Therefore, affiliate marketing is a powerful tool for driving customer acquisition and revenue growth, and its popularity is expected to continue to grow in the coming years. Companies looking to implement affiliate marketing can leverage existing affiliate networks or platforms, or create their in-house affiliate program to manage their affiliate partnerships (Influencer Marketing Hub, 2023).

Materials and Methods

The study involved a comprehensive analysis and assessment of international and domestic vision of affiliate marketing standards. The major data for analysis was acquired from such reliable sources as: IA Banki.ru, Admitad report-2020, Yahoo Finance: Trending Tickers, Capital one shopping affiliate and influencer program, Annual report of the Bank of Russia-2022, etc. The information obtained was processed taking into account current trends in marketing strategies. The research also invites general

scientific methods, including analysis and synthesis, comparison, and classification.

Results and Discussion

The use of breakthrough technologies, particularly RPA, is becoming a requirement for competitiveness. The enterprise needs to flexibly reconfigure internal processes in order to respond quickly to changing external conditions under the influence of the digital economy through the adoption of high-quality and justified data. Introducing RPA technology into an enterprise for subsequent automation is quite a complex task (Rafique, 2012).

Affiliate marketing has become a vital tool of digital marketing for financial institutions bringing a significant share of clients. Demonstrative case studies of multi-billion fintech and banking organizations could help us to understand the mechanics, models of payments and approach to apply on local markets and new ventures:

– American Express - multinational financial services corporation specializing in payment cards. As of March 2023 American Express has a market cap of $122.73 billion. This makes American Express the world's 104th most valuable company by market cap according to Yahoo Financa data (Yahoo Finance), 2023. The American Express affiliate program offers a variety of credit cards and financial products for affiliates to promote. Affiliates are given access to a range of promotional materials including text links, banner ads, and social media posts. The program uses a Cost Per Acquisition (CPA) payment model, where affiliates are paid a commission for every new customer who signs up for an American Express product through their referral link. The commission rates vary depending on the product being promoted but can range from $50 to $200 per acquisition. From the technical perspective, American Express program operates through Daisycon affiliates platform (American Express Finance, 2023).

– Robinhood - American financial services company that facilitates commission-free trades of stocks, exchange-traded funds, and cryptocurrencies as well as individual retirement accounts via a mobile application. As of March 2023 Robinhood has a market cap of $8.4 billion and 16.3 million active users which makes it the most popular trading platform in the world for retail investors (average individuals).. The Robinhood affiliate program offers a commission for every new user who signs up and makes a deposit on the commission-free trading app (FinTech finance forecast, 2023). Affiliates are provided with access to a variety of marketing materials including banner ads, text links, and email templates. The program uses a CPA payment model. The commission rate is $10 for every new user who makes a deposit of at least $100. As a technical solution, Robinhood uses Impact Radius for onboarding, tracking, and accounting affiliate program (Affiliate Program of Robinhood, 2023).

– Capital One - is an American bank holding company specializing in credit cards, auto loans, banking, and savings accounts. As of December 2022, it keeps $453,3 billion in assets under management which makes it the 9th biggest bank in US market, according to federal reserve data. The Capital One affiliate program offers a variety of credit cards and financial products for affiliates to promote. Affiliates are given access to a range of promotional materials including text links, banner ads, and social media posts. The program uses a hybrid payment model, which includes both a base commission and performance-based incentives (Deryabina, 2021). Affiliates earn a base commission of $25 for each new customer who signs up through their referral link and funds an account. They can also earn additional performance-based incentives depending on the amount of spending activity generated by their referrals (Capital one shopping affiliate and influencer program, 2023).

According to a report by Admitad, a leading affiliate network in Russia, affiliate marketing has become an increasingly popular channel for customer acquisition in the financial industry in Russia (Admitad report, 2020). In 2020, the financial services sector was the second largest advertiser in the Admitad network, accounting for 17.2% of total advertiser spend. The report also found that the most popular payment model used in the financial sector in Russia was CPA, with over 80% of advertisers using this model (Suryanarayana, 2021). Unfortunately, Russian affiliate market players, especially in financial

industry, do not regurarly disclose information about transactions volume, market shares and trending directions due to sensivity of this data and lack of transparency culture. To assess the current condition of affiliate programs in Russia, we analyzed 10 biggest Russian banks by assets under management based on information from research portal Banki (Annual Report of the Bank of Russia, 2022; Banks rating, 2022) (Table 1).

Table 1. Current condition of affiliate programs in Russia

№	Company	Managed assets (th.rub.)	Affiliate program	Affiliate offers	Models of payment	Own platform or affiliate networks?
1	Sberbank	39 109 367 769	Yes	Debit bank cards	CPA	Both
2	VTB	19 825 106 187	Yes	Debit bank cards Credit bank cards Cash loans Bank accounts for business	CPA	Both
3	Gazprombank	8 934 718 940	Yes	Debit bank cards Premium debit bank cards Credit bank cards Cash loans Bank accounts for business	CPA	Both
4	Alfa-Bank	6 141 402 076	Yes	Debit bank cards Premium debit bank cards Credit bank cards Cash loans Bank accounts for business Mortgage Car loan	CPA	Both
5	Russian Agricultural Bank	4 219 609 693	Yes	Bank accounts for business	CPA	Affiliate networks
6	Moscow Credit Bank	3 670 971 328	Yes	Bank accounts for business	CPA	Own platform
7	Otkritie	3 414 829 360	Yes	Debit bank cards Credit bank cards Cash loans Bank accounts for business Mortgage	CPA	Both
8	Sovcombank	1 988 001 169	Yes	Credit bank cards Cash loans Bank accounts for business Mortgage	CPA	Both
9	Raiffeisen Bank Russia	1 625 463 058	Yes	Bank accounts for business	CPA	Both
10	Rosbank	1 572 439 546	Yes	Debit bank cards Credit bank cards Bank accounts for business	CPA	Both

Based on the data we can conclude that all leading russian banks use affiliate marketing as a part of their customer acquisition strategy (CPA market in Russia, 2023). Note that companies integrate it both for marketing in B2C and B2B directions. Other than that, 60% banks have more than 2 product offers for their partners what signs that affiliate marketing as a advertisement channel can be used for wide range of audiences with different needs (Kurasova, Rinchinova, 2020). All companies pay partners on CPA model so there is a room for improvement for testing of CPL or revenue share models in the future

if business model of the bank can afford it. 80% companies activate both own platforms and external affiliate networks what shows advanced level of technical infrastructure because tracking, analyzing and gathering marketing data from different sources are challenging tasks as well as integrations of existing tools to new platforms (Zudin, 2018).

Conclusion

The prospects for affiliate marketing in the financial sector are promising for several reasons. The industry is expected to expand significantly due to the increasing adoption of digital channels and the trend towards online shopping and banking. Moreover, financial companies need to stay ahead of the competition, and affiliate marketing can provide a cost-effective customer acquisition channel with clear tracking and reporting mechanisms, as well as flexible payment models. Finally, technological advancements, such as artificial intelligence and machine learning, can enhance the targeting and optimization of affiliate marketing campaigns, making them more precise and effective (Morozkin, 2019). As a result, affiliate marketing is set to continue to play a vital role in the digital marketing strategies of financial companies, both traditional and fintech, in the years ahead. In addition, affiliate marketing holds great potential for the fintech and banking industries in Russia. Firstly, due to the limited access of Russian businesses to global advertising platforms, affiliate marketing can provide a cost-effective alternative for customer acquisition. Secondly, the fintech market in Russia is growing rapidly, creating a need for effective and efficient marketing strategies to attract and retain customers. Finally, affiliate marketing allows for a more targeted approach to customer acquisition, which is especially important in a competitive and growing market. As such, affiliate marketing has the potential to play a significant role in the digital marketing strategies of Russian fintech and banking companies (McKinsey & Company, 2022).

In conclusion, affiliate marketing has become an increasingly popular channel for customer acquisition and sales in the financial industry. With the rise of fintech and digital banking, affiliate marketing has provided banks and financial institutions with an effective way to drive new customer acquisition and increase sales. As we've seen, affiliate marketing allows banks and fintech companies to work with a network of affiliates to promote their products and services to a wider audience. This can result in increased visibility, higher customer acquisition rates, and improved ROI. Moreover, the different payment models available in affiliate marketing, such as CPA, CPL, and CPI, provide flexibility to advertisers to choose the most suitable payment structure for their business. Additionally, affiliate marketing is a cost-effective way for companies in the financial industry to acquire new customers, as they only pay commissions when a new customer is acquired. While there are challenges in the implementation of an affiliate marketing program, such as finding the right affiliates and managing relationships with them, the potential benefits of affiliate marketing outweigh the risks.In summary, affiliate marketing is an essential component of digital marketing for banks and fintech companies. With the right strategy and execution, affiliate marketing can help banks and fintech companies to grow their business and gain a competitive edge in the marketplace.

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CONVENTION AND EXHIBITION INDUSTRY IN THE CONTEXT OF DIGITALIZATION TRENDS AND DEVELOPMENT PROBLEMS

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Abstract. Currently, the convention and exhibition industry is at the stage of active development. Despite the events related to the impact of the pandemic on all fields of life and activity of society, new commercial and non-profit organizations continue to appear in the industry, whose activities are aimed at the development and implementation of projects of various formats, directions and levels. The purpose of the study is to identify trends and problems in the development of the congress and exhibition industry under the conditions of the digitalization of the economy. In the course of this research, a comparative characteristic and assessment of the state of the market of the congress and exhibition industry during the period of pre-covid restrictions was carried out, the dynamics of events in the market of congress and exhibition services is presented. As a result of the study, an analysis of the formats of project implementation and directions of activities for the period 2020-2021, a hierarchy of project implementation formats is presented. In addition, the study demonstrated the total number of events depending on the direction of their implementation as a percentage of all formats of implementation, the comparison by the average number of participants and the average cost of registration fees.

Keywords: digitalization, business model, congress and exhibition activity, exhibition activity, activity assessment, investment, investor, risk assessment

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ПРОБЛЕМЫ РАЗВИТИЯ КОНГРЕССНО-ВЫСТАВОЧНОЙ ИНДУСТРИИ В УСЛОВИЯХ ЦИФРОВИЗАЦИИ ЭКОНОМИКИ

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Аннотация. В настоящее время конгрессно-выставочная индустрия находится на этапе активного развития. Несмотря на события, связанные с влиянием пандемии на все сферы жизни и деятельности общества, в отрасли продолжают появляться новые коммерческие и некоммерческие организации, деятельность которых направлена на развитие и реализацию проектов различного формата, направления и уровня. Целью исследования является выявление тенденций и проблем развития конгрессно-выставочной индустрии в условиях цифровизации экономики. В процессе исследования проведена сравнительная характеристика и оценка состояния рынка конгрессно-выставочной индустрии в период доковидных ограничений, представлена динамика мероприятий на рынке конгрессно-выставочных услуг. В результате исследования представлен анализ форматов реализации проектов и направлений мероприятий за период 2020-2021 г.г., иерархия форматов реализации проектов. Помимо этого, в результате исследования продемонстрировано общее количество мероприятий в зависимости от направления их реализации в процентном соотношении ко всем форматам реализации, сравнение по среднему количеству участников и по средней стоимости регистрационных взносов.

Ключевые слова: цифровизация, бизнес-модель, конгрессно-выставочная деятельность, выставочная деятельность, оценка деятельности, инвестиции, инвестор, оценка риска

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Introduction

Currently, the convention and exhibition industry is at the stage of active development. Despite the events related to the impact of the pandemic on all fields of life and activity of society, new commercial and non-profit organizations continue to appear in the industry, whose activities are aimed at the development and implementation of projects of various formats, directions and levels (international, regional, etc.).

Since economic processes are in constant and dynamic motion, the demand for services in the service sector is growing, and the possibility of attracting and implementing large and large-scale projects on the territory of the Russian Federation is becoming increasingly relevant. In this regard, many companies are beginning to engage in active processes of improving functionality and their activities (Sul, 2020). Many of the processes that are currently taking place in the hospitality industry are due to the current state of the market. On the one hand, it is impossible not to note the negative impact of the epidemiological situation on the activities of organizations. Some establishments lose their competitive positions due to their inability to adapt to modern operating conditions, however, there are also such firms that, in a difficult period, found an opportunity to improve internal processes, business models and, as a result, the functioning of their activities. These events allowed the companies to maintain a competitive advantage in the market and made them one of the most progressive and stable ones at this

stage of the development of the hospitality industry.

Despite the epidemic that has affected all aspects of the activities of enterprises, recently there has been an increase in interest on the part of international organizations and associations to carry out major international projects on the territory of Russia or with the participation of domestic specialists. This trend can be traced because the country has a great resource potential, and in the context of globalization and cultural integration, the emergence of new areas of the hospitality industry and the development of innovative tourist products, it is necessary to provide and expand opportunities in relation with the digital transformation of the economy for new and existing organizations operating in the congress and exhibition industry.

Materials and Methods

In the course of this research, the material collected from several reports of the International Association of Congresses and Conferences compiled by specialists of the hospitality industry, scientific papers revealing and describing the methods and goals of building business processes in the congress and exhibition industry were analyzed.

Some of the works used in the study define the format of events as a way to restrict the freedom of project participants. The choice of the project format or process optimization measures depends on time, context and space (Bharadwaj, 2013). Other authors note that the formats of changes at the enterprise are directly related to the work of a large number of people who occupy various roles and positions at the enterprise (De Smet, 2018).

The work uses a large amount of information aimed at analyzing the topic. In addition, the work contains a set of methods that were used for the purpose of the most detailed study of all aspects of the subject matter. Among the methods, the following can be distinguished (Hankinson, 2005):

– Analysis and synthesis.
– Comparison.
– Classification.

Results and Discussion

Despite all the recent events, the convention and exhibition industry continues to struggle for its place in the market. In order to describe all the processes taking place in the industry in the most detail, it is necessary to understand what the congress and exhibition market itself is, to assess its current state as well as to determine the trends of further development (Wong, 2019).

Membership in the International Association of Congresses and Conferences (ICCA) is very prestigious among the largest hospitality organizations. The Association was created to optimize the interaction of all subjects involved in the field, as well as to create a large-scale information field that allows participating countries to freely compete with each other, exchange ideas, goals, experience in preparing and implementing various events (Smagina, 2017).

One of the most important documents in the congress and exhibition industry is the annual report of the International Association of Congresses and Conferences on events that are organized all over the world, including Russia (Voronova, Liashchuk, Smirnova, Belokurova, 2019). This report also presents a ranking by the number of events held in each country and the largest cities. This rating allows you to determine the place of a particular state in the world ranking of the hospitality industry and choose further ways of development, as well as to trace the dynamics of the development of the industry in the world and a specific destination. Table 1 presents a comparative description and assessment of the current state of the market of the convention and exhibition industry in Russia and St. Petersburg (Kahveci, 2022).

Table 1. Comparative characteristics and assessment of the state of the congress and exhibition industry market during the period of Pre-Covid restrictions

2017	2018	2019
The number of events held in Russia Total number of countries – 41		
87 events (21st place among European countries)	83 events (22nd place among European countries)	117 events (20th place among European countries)
Number of events held in St. Petersburg Total number of cities – 200		
31 events (49th place among European countries)	19 events (80th place among European countries)	36 events (42nd place among European countries)

In addition, Figure 1 shows the dynamics of events in the market of congress and exhibition services held in Russia and Saint Petersburg between 2017 and 2019

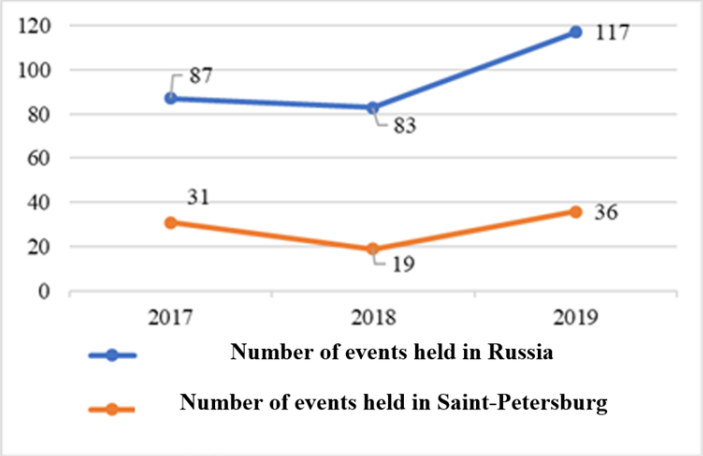

Fig. 1. Dynamics of events in the market of congress and exhibition services

Based on the graph, it can be seen that even despite the crises taking place in the world, the dynamics are generally positive. Of course, the chart cannot show constant growth or constant decline, since the market is very dynamic and depends on many factors. And such fluctuations just indicate its development and improvement. Russia's position in the ranking of countries is at an average level, but St. Petersburg is one of the most leading cities in Russia, along with Moscow, which allows us to judge the trend of increasing attractiveness of the market of congress and exhibition services in Russia (Serebryakova, Petrikov, 2018).

Exploring the market of congress and exhibition services in Russia and St. Petersburg by the number of events held, it is also necessary to trace the dynamics of participants attending congress and exhibition events. This factor is fundamental in the hospitality industry, since it is visitors and customers who form new market needs. A total of 64 countries were included and studied. Table 2 presents a comparative description of the state of the Russian congress and exhibition industry market by the number of event visitors between 2017 and 2019.

Table 2. Comparative characteristics of the number of visitors to events in Saint-Petersburg and Russia

2017	2018	2019
The number of visitors to events in Russia Total number of countries - 64		
Less than 20.000 participants (60th place)	22.947 participants of the event (43rd place)	28 152 participants (43rd place)
The number of visitors to events in St. Petersburg Total number of cities – 120		
Less than 10.000 (out of rating)	Less than 10.000 (out of rating)	10.249 participants (111 places)

Figure 2, on the other hand, visually presents this dynamic of visitors in the market of congress and exhibition services between 2017 and 2019 in Russia and Saint Petersburg.

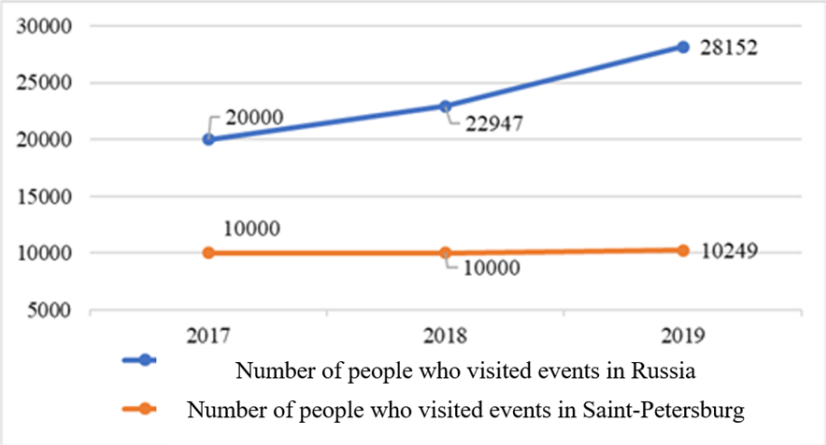

Fig. 2. Dynamics of visitors in the market of congress and exhibition services

The graph shows a positive trend in terms of growth in the number of visitors (both local and international). This is highly evident when comparing indicators for Russia (on average 2717 more people visited these events annually, meaning a 12.07% annual average increase). The trend is a positive factor that indicates an increase in public interest in events of various formats. However, conducting a more detailed study, it should be noted that in 2017 and 2018 St. Petersburg was out of the rating in terms of the number of visitors, this factor undoubtedly negatively affects the positioning of the city in the market of convention and exhibition services (Martin, 2003).

Comparing the indicators of 2017–2019, and also taking into account the fact that only 120 of the largest megacities in Europe participated in the rating, it can be noted that St. Petersburg accounts for a large share of participants in Russia (50.00%, 43.58% and 36.41% in 2017, 2018 and 2019, respectively) taking into account that in terms of the number of participants in 2019 it was even ahead of Moscow (Moscow took the 115th place in the ranking in 2019 lagging 4 places behind Saint Petersburg). The data coincide with the study given in Table 2 and reflect the growing attractiveness of the destination. Every year the indicators built up positive dynamics, allowing Saint-Petersburg to break out into the leaders of Russia in the market of congress and exhibition services (Expocenter, 2019).

For a more complete assessment of the market, it is necessary to consider the events that have taken place in Russia and all over the world in the last 2 years. Figure 3 shows data on 2020 events as a percentage (EXPOCLUB.ru, 2020). Speaking of 2020, it turned out to be one of the most difficult years for the congress and exhibition services market. According to the statistical data of the ICCA report, 8.5 thousand events were planned for 2020 around the world. More than 40% of all planned projects have

been cancelled. This was especially acute at the beginning of the year 2020.

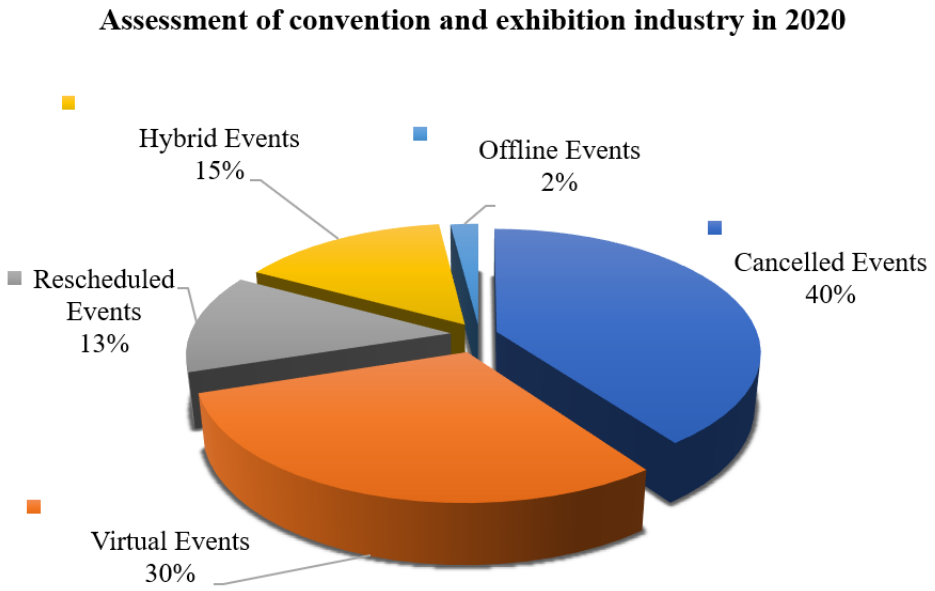

Fig. 3. Distribution of event forms based on 2020 events (Expocenter, 2020)

Over the past one and a half year, virtual events have gained popularity, their influence increased to 30% in 2020 (Expocenter, 2020). Previously, a small segment, which was used exclusively by large industry players, has now increased to a huge size. At present, it occupies the first place among all forms of events, and the trend of their development has shown an exceptionally positive dynamics, since this form of event organization is closely connected with the IT segment, which is now the most promising industry in all spheres of society. In other words, even negative external factors can serve as an incentive for the development and search for new ways of doing business (Levina, Ilyin et al., 2019).

The segment "Postponement of the event date" ran to about 13% of the total market. However, by the end of 2020, the share of postponed events decreased, which is undoubtedly a positive factor. This segment can also serve as a big problem for many players of the congress and exhibition market who carry out their activities in the segment of small and medium-sized businesses, since the vast majority of companies operate at the expense of borrowed funds. Each delay and rescheduling can trigger solvency problems of enterprises and hinders normal liquidity in the existing conditions.

Two percent of the total number of events were held in full-time format. The share of such projects is relatively smaller than the rest of the segments, which was a kind of "sore point" of the congress and exhibition industry throughout 2020. The drop in the number of face-to-face events is undoubtedly one of the main economic problems, which is expressed in the loss of all resources: financial, human, technical, etc. Many firms could not cope with these losses and left the market forever (e.g "MAKO" Congress Management).

By the end of 2021, the hybrid form of organizing and holding events was the most developed (there was an increase to 15%). Since due to restrictions it was impossible to organize a full-time presence of people, so the use of a joint format of online and offline participation was decided on.

Thus, it is possible to identify the market trend towards an increase in virtual and hybrid forms of participation, which, first of all, are implemented through the tools necessary to ensure offline participation. Such tools are online platforms, CRM systems, video installations (cameras, applications, etc.), virtual and augmented reality systems (Romanova, 2014).

Figure 4 shows the hierarchy of event implementation formats.

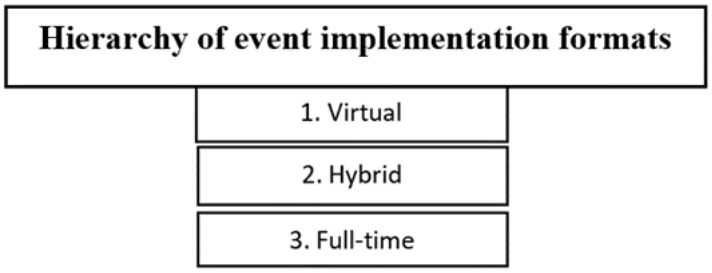

Fig. 4. Hierarchy of event implementation formats 2020-2021

Analyzing the market of congress and exhibition services, it is also necessary to identify the most popular destinations by the end of 2020 and the beginning of 2021. The analysis includes the study of all options for the organization of events as well as all identified areas.

At the end of 2020 and the beginning of 2021 around 50% of events on this topic were conducted in a virtual format (up by 20% points from 2020), 8% in a hybrid and only 3% in full-time format (Figure 5). These data clearly illustrate the trend of transition to the virtual space. Separately, it is necessary to highlight the fact that IT events are the format with the lowest share of postponement of the date (30%), as well as with the lowest cancellation rates (only 9%) (Official website of the Administration of St. Petersburg, 2021).

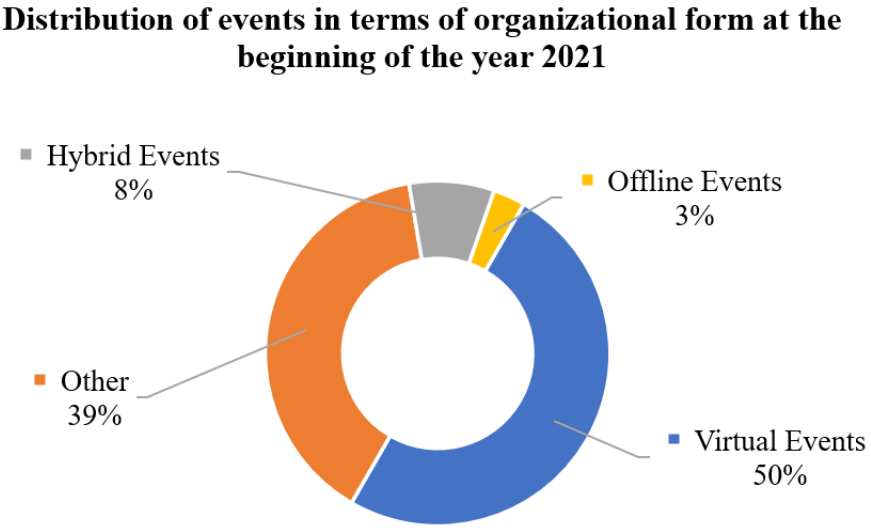

Fig. 5. Distribution of events by organizational form

The conducted research allows us to form the idea that the future of the congress and exhibition industry consists in the use of modern technical means, providing financial resources for all information components of the business and the availability of modern automated systems (including CRM systems). The emergence of these new formats for the implementation of events is undoubtedly a catalyst for the development of technologies for every company being present in the hospitality market. The economic effect of these events has also undergone some changes. The presence of virtual and hybrid meetings has a direct impact on the venue of events, the costs associated with transportation and living expenses. Prices for services and materials necessary for the normal operation of companies are also

changing (Perova, 2016).

With the help of virtual and hybrid formats, it is possible to increase the number of participants, organize as many international projects as possible without being tied to a specific place. At the same time, there are certain problems, such as the difference in time zones, poor communication on the global Internet, the lack of technical capabilities of the company as a whole.

In the 2020 statistical report from ICCA (2020), a study was conducted that combines all of the above observations. Based on the data and activity reports received from ICCA member countries and cities, it is possible to create schedules reflecting the real situation in the convention and exhibition industry.

The comparison reflects the difference between the face-to-face format and the virtual one, since the latter events occupy the first place in the hierarchy of formats for the implementation of events in 2020-2021. Figure 6 shows a comparison by the average number of participants. A 49.9% increase in the number of participants of virtual events could be traced by the beginning of 2021. The "number of participants" indicator is almost 2 times more than the data obtained for face-to-face formats of events, which is undoubtedly one of the criteria for the development of convention and exhibition industry as a whole.

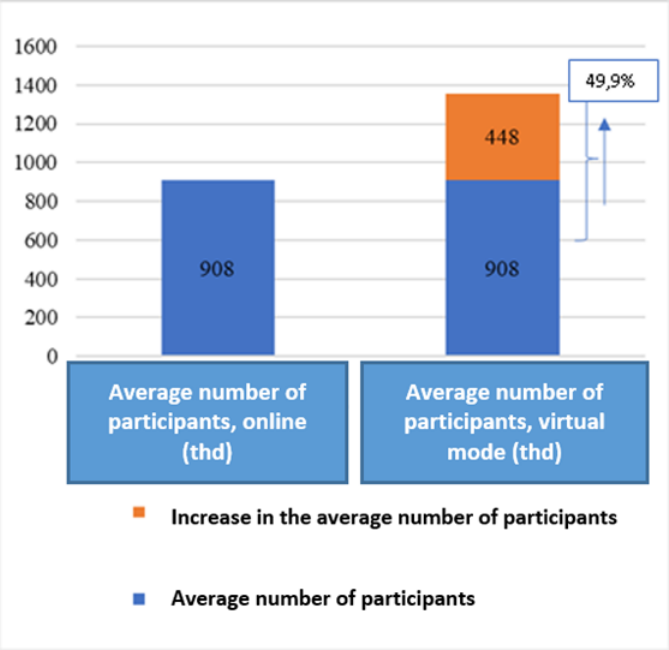

Fig. 6. Comparison by average number of participants

The epidemiological situation has largely affected all processes, on the one hand, negatively, but on the other hand, it has allowed to reveal new aspects and ways of development for the congress, exhibition, hotel and tourism segment.

It is also necessary to compare the dynamics of the average cost of services for participation in congress and exhibition events in 2020-2021. Figure 7 shows a comparison of the average cost of registration fees. Since the report data contains information on financial indicators in foreign currency (US dollars), the figure shows the transfer of the amount to the Russian ruble as of the beginning of 2021 (ICCA Annual Report, 2020).

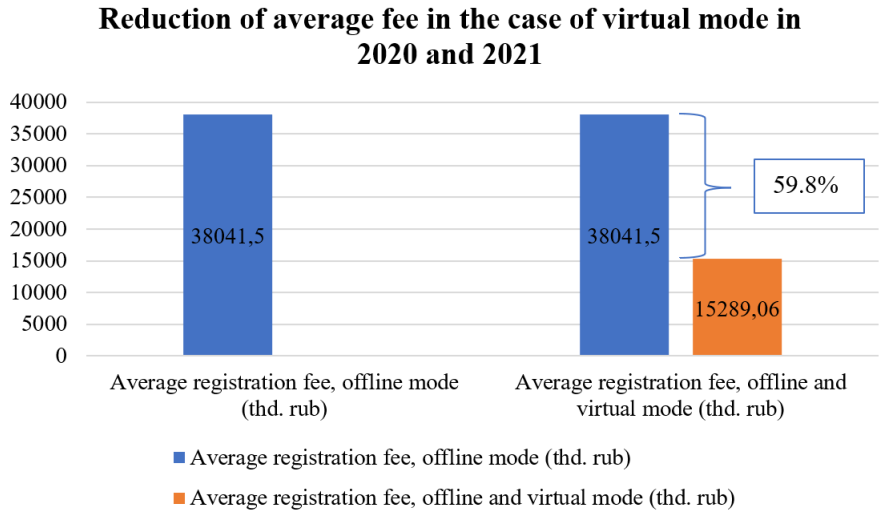

Fig. 7. Comparison by average cost of registration fees

The graph shows that the average cost of registration fees has decreased by almost 60%. This dynamic is due to the fact that virtual and hybrid formats are the most popular event formats nowadays. The cost of participation costs has decreased, since the so-called "hidden costs" are not included, such as the cost of booking, service fee for using the payment system not only on the Internet, but also at the venue of the event, living expenses, meals, human resources costs (costs of "manual" labor), etc.

These market fluctuations indicate its adaptation and adaptation to modern changing conditions and shows the capabilities and abilities of the congress and exhibition services market to withstand harsh conditions. The segment has completely changed, new opportunities and growth points have emerged for many companies, but there is one need that needs to be in the forefront – a person needs communication.

Realizing this, many players in the market have taken all possible ways to increase the time for the preparation and implementation of events, including through the introduction of subsidies to small and medium-sized businesses in order to retain players in the market. Right now, it is so important to have a reliable regulatory framework regulating business activities.

Unfortunately, Russia and St. Petersburg, in particular, do not have a sufficiently developed legislative framework in this area. The congress and exhibition services market has been working towards the development and implementation of a priority project for the development of the sector since January 31, 2018. The main goal is to increase tourist flows, especially business tourists who for the target group. This project is aimed at increasing the number of congress events held in St. Petersburg and accounted for by ICCA.

Conclusions

Thus, based on all the data, the following trends in the development of the industry can be identified:

– Changing the format of the events held to hybrid and virtual.

– The use of IT technologies in the activities of companies.

– The growth of public interest in events of various formats.

– Increasing the number of events and entering new markets.

– Development of areas of implementation of projects related to medicine, science, education and the IT segment.

– Providing financial resources for all modern automated systems (including CRM systems).

– An increase in the average number of participants in congress and exhibition events.

– Reduction of the average cost of registration fees.

– Development of the legislative framework in terms of preparation and implementation of measures.

– Development of the activities of congress and exhibition operators in order to increase their positions in the rating of the International Association ICCA.

The current market analysis, opportunities and threats, the emergence of new formats inevitably led to changes in interaction with customers, suppliers and competitors. Modern conditions dictate new rules of doing business, therefore, it is necessary to approach the study of the market and its assessment comprehensively, through the study of some economic and organizational characteristics of companies and enterprises.

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TECHNOLOGICAL INDEPENDENCE AND IMPORT SUBSTITUTION IN THE IMPLEMENTATION OF ENERGY PROJECTS IN THE ARCTIC

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Abstract. Existing macroeconomic challenges, existing sectoral restrictions, including a ban on working with Russian energy companies for most Western equipment manufacturers and suppliers, the proclaimed course for the full-scale development of the Arctic have led to the emergence of a number of industrial and technological challenges, the successful overcoming of which largely determines the possibility of independent implementation of ambitious projects . The efficient and safe implementation of projects in the Arctic requires science and industry to create fundamentally new technical and technological solutions, often comparable in complexity to technologies for the space industry or nanotechnologies. Currently, there are about 30 smart fields in Russia, which already provide almost a third of all hydrocarbon production. Maintaining leadership positions in the development of Arctic resources requires the state to pursue its own technological policy and develop a national standardization system, which will lead to a change in the engineering culture in the country. It is obvious that the implementation of programs aimed at avoiding import dependence as soon as possible and achieving technological sovereignty requires the consolidation of actions at all levels of government: from the executive and legislative authorities to energy companies, industry associations, unions and business communities.

Keywords: Arctic, import substitution, technological sovereignty, institute of oil and gas technological initiatives, shelf, hydrocarbon resources

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ТЕХНОЛОГИЧЕСКАЯ НЕЗАВИСИМОСТЬ И ИМПОРТОЗАМЕЩЕНИЕ ПРИ РЕАЛИЗАЦИИ ЭНЕРГЕТИЧЕСКИХ ПРОЕКТОВ В АРКТИКЕ

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Аннотация. Существующие макроэкономические вызовы, существующие отраслевые ограничения, включая запрет на работу с российскими энергетическими компаниями для большинства западных производителей и поставщиков оборудования, провозглашенный курс на полномасштабное освоение Арктики привели к возникновению ряда производственных и технологических вызовов, успешное преодоление которых во многом определяет возможность самостоятельной реализации амбициозных проектов. Эффективная и безопасная реализация проектов в Арктике требует от науки и промышленности создания принципиально новых технических и технологических решений, зачастую сравнимых по сложности с технологиями для космической отрасли или нанотехнологиями. В настоящее время в России насчитывается около 30 интеллектуальных месторождений, которые уже обеспечивают почти треть всей добычи углеводородов. Сохранение лидерских позиций в освоении арктических ресурсов требует от государства проведения собственной технологической политики и развития национальной системы стандартизации, что приведет к изменению инженерной культуры в стране. Очевидно, что реализация программ, направленных на скорейший уход от импортной зависимости и достижение технологического суверенитета, требует консолидации действий на всех уровнях власти: от исполнительной и законодательной власти до энергетических компаний, отраслевых ассоциаций, профсоюзов и бизнес-сообществ.

Ключевые слова: Арктика, импортозамещение, технологический суверенитет, институт нефтегазовых технологических инициатив, шельф, углеводородные ресурсы

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Introduction

The introduced sectoral restrictions and the current macroeconomic and foreign policy challenges led to the start of the implementation of alternative substitution programs by the Russian Federation, aimed at the speedy avoidance of import dependence and the achievement of technological sovereignty in the energy sector. Import substitution is understood as the creation of domestic goods, works and services produced (provided) with the help of Russian equipment and technical and technological solutions with the involvement of Russian personnel to perform the work. Special attention also deserves the possibility of localizing foreign production in Russia with the possibility of R&D (Saitova et al., 2022).

The goals of implementing import substitution programs are to ensure the technological independence of the energy industry, develop healthy competition between domestic equipment manufacturers, and reduce the capital intensity of ongoing projects (Bolsunovskaya and Sentsov, 2016).

Technological solutions in the oil and gas sector, especially those used in Arctic projects, almost always belong to the “high-tech” category, which, on the one hand, is most dependent on imported solutions, and on the other hand, has significant potential for the development of Russian industry (Diden-

ko and Cherenkov, 2018). Among the examples of high-tech solutions that currently have the potential for development at Russian facilities, the following can be distinguished: equipment and technologies for completing wells with multi-stage hydraulic fracturing and related software for modeling these processes, telemetry and logging instruments, rotary steerable systems, pumps high pressure (Brazovskaia et al., 2021; Larchenko et al., 2019; Volkov, 2020).

For work on the shelf, first of all, it is worth noting such areas and technologies as underwater production complexes and drilling equipment, ships and equipment for seismic exploration, as well as generating equipment (Carayannis et al., 2017; Sheveleva, 2022).

The domestic oil refining industry also needs today compressors for technological processes, pumps for technological processes of oil refineries, additives for oil refining and petrochemicals, as well as hydroprocessing catalysts (Chanysheva and Ilinova, 2021; Tsukerman et al., 2019; Veretennikov et al., 2018).

All this necessitates the consolidation of resources at all levels of management, active interaction between energy companies both among themselves as part of the consolidation of demand for high-tech products, and with Russian industrial enterprises. It is necessary to create "uniform rules of the game" in the field of standardization of equipment and technologies for the oil and gas complex.

Materials and Methods

Most modern energy companies have chosen the digitalization of their activities as an unconditional production priority (Pezzella and Pliushch, 2022). In addition to the presence of “smart fields” controlled on the basis of digital interpretation of a lot of received data, unmanned aerial vehicles, digital twins are becoming widespread, Russian fields are already using underwater production complexes and robotic drilling rigs that allow hydrocarbon production without the direct participation of the operator (Katysheva and Tsvetkova, 2019, 2017; Samylovskaya et al., 2022; Tsvetkova and Katysheva, 2017).

The growth of manufacturability of solutions in the oil and gas sector can be clearly seen, including in the context of the constant increase in sea depths, on which exploration and production wells are being built today for oil and gas production.

One of the technological solutions that allows increasing the oil recovery factor is the construction of wells with horizontal outlets. Currently, wells on the Arctic shelf are being built not only at impressive vertical sea depths, but also with horizontal diversions for kilometers (the world record is 15 km).

Energy project operators working in the Arctic face the following key challenges (Tsvetkova and Katysheva, 2017):

– Harsh climatic conditions and remoteness;
– Lack of developed service infrastructure;
– The need to promote legislative initiatives;
– Technological support of projects;
– The need to preserve the sensitive ecosystem of the Arctic zone.

At the same time, additional threats and risks should be taken into account: challenges associated with conflicts of national interests of circumpolar countries and regions; the geopolitics of the world powers and their integration and military-political alliances, the economic and military-political interests behind them; expanding the range of claims for participation in the "Arctic pie" of countries that do not have access to the Arctic territories and seas; expansion and intensification of the global competition of transnational capitals and corporations for the wealth of the Arctic shelves (Dmitrieva and Romasheva, 2020; Romasheva and Dmitrieva, 2021; Vasilev et al., 2020).

The issues of technological support for the implementation of projects in the Arctic are particularly acute (Romashkina et al., 2017). Along with this, it is important to take into account the high heterogeneity of water areas in the Arctic: if the Barents-Kara region is characterized by relatively favorable conditions for exploration and mining (due to the warm Gulf Stream), then the water areas of the east-

ern Arctic are characterized by extreme natural and climatic conditions. Accordingly, for the southern part of the Barents Sea, the Kara Sea, proven exploration and development technologies exist and are used (floating and jack-up drilling rigs, subsea facilities, fixed platforms, artificial ice and gravel islands, fixed ice-resistant platforms, extended reach drilling, ships using ice management systems) (Dudin et al., 2016; Fadeev et al., 2022). For the northern part of the Barents Sea, the central and northern parts of the Kara Sea, new technologies are being developed to enable operation in multi-year ice, including autonomous underwater drilling complexes (Abramov et al., 2021; Biev, 2019; Romashkina et al., 2017).

Thus, the main areas of import substitution in the implementation of offshore projects include:

– support vessels for offshore projects
– equipment for marine seismic surveys
– floating drilling rigs
– spare parts and components for offshore projects
– generating complexes for offshore projects
– drilling equipment for offshore projects
– equipment and technologies for oil spill response
– underwater production complexes.

Results

Obviously, the implementation of high-tech projects requires the creation of a number of solutions aimed at avoiding import dependence.

Speaking of sanctions, it is worth noting that they did not have the critical impact on the implementation of Russian projects in the Arctic that their creators were counting on. It is possible that the sanctions have made the implementation of projects a little less convenient for Russian energy companies, but thanks to the measures taken to reorient supplies from West to East, as well as the development of import substitution programs, companies are able to implement already launched projects in accordance with their plans.

But the main advantage of the current macroeconomic situation is that the sanctions have made it possible to intensify the development of the national service supplier market. The imposition of sanctions has hit, among other things, foreign manufacturers: many foreign companies are forced to limit their activities in Russia. In this regard, niches appear on the market, which are occupied by domestic suppliers.

For the Russian industry, sanctions have created technological challenges, often associated with the development and production of new unique products, which require serious scientific and industrial work, government incentives and coordination with customers. However, Russia already has quite tangible successes in this direction.

Since 2014, the Ministry of Energy of Russia, in cooperation with the Ministry of Industry and Trade of Russia, as well as with other interested federal executive authorities and companies in the fuel and energy complex, has been working to reduce dependence on imported equipment, technologies and materials. The total amount of state support for import substitution programs amounted to billions of rubles, which led to the creation in Russia of fundamentally new technical and technological solutions that made it possible to completely get away from import dependence in a number of segments.

As an example, it is worth noting the creation of domestic autonomous bottom stations "Crab". This is a joint project of Gazprom Neft, the Ministry of Industry and Trade of Russia, OJSC Marine Arctic Exploration Expedition and LLC Marine Technical Center. "Crab" is a mobile hardware and software complex for marine seismic exploration and monitoring in transit zones and on the shelf. It was built on the basis of four-component autonomous bottom stations, which are serviced in container-laboratories of the complex. "Crab" is intended for seismic regional studies and exploration of offshore hydrocarbon fields. LLC "Marine Technical Center" also sells mobile hardware and software systems for marine seis-

mic and monitoring in transit zones and on the shelf Flounder and Coral. The use of the aforementioned complexes has been implemented at the Yuzhno-Kirinskoye and Kirinskoye fields in the Sea of Okhotsk.

It is also important to note the creation of a Russian mobile complex for the extraction of hard-to-recover oil reserves (a fleet for hydraulic fracturing), which consists of 12 high-tech units. The unique Russian equipment was created by the Moscow Institute of Thermal Engineering Corporation with the participation of several dozen Russian enterprises in accordance with the decision of the President and the order of the Government of the Russian Federation as part of the import substitution program in the interests of the domestic oil and gas complex.

A very promising option is the creation of joint ventures and the localization of production capacities and R&D of leading foreign manufacturers in Russia. Among such strategic areas may be: equipment for offshore seismic surveys, support for directional and horizontal drilling, high-tech well completion; pumps and compressors for oil refining, catalysts for oil refining and petrochemicals, etc.

Obviously, the construction of all of the above must be provided by appropriate sites, shipyards and factories in the Russian Federation, created both by domestic contractors independently and in partnership with foreign high-tech partners.

Discussion

Since 2014 the majority of Russian energy companies have announced a course towards the implementation of their own corporate alternative substitution strategies aimed at creating new, previously import-dependent, nomenclature positions produced by Russian enterprises. Some companies created separate structural divisions, some simply appointed responsible persons, but often companies tried to work in the field of import substitution on their own.

Basically, such work began with a dialogue with Russian equipment manufacturers regarding the possibility of producing pilot batches of equipment. This was followed by pilot tests of the manufactured equipment and, in the event of a positive assessment of the results of such tests, new equipment manufactured in Russia could be purchased by an energy company.

As a rule, the time from the idea of implementing joint projects between industrial and energy companies to the possibility of organizing supplies within the framework of ongoing procurement procedures was at least a year (and sometimes several years). In addition, the system of attestation and accreditation of industrial enterprises by an oil and gas company also took a significant amount of time, often requiring considerable financial costs on the part of equipment manufacturers. At the same time, if a particular manufacturer had a desire to start work within the framework of the manufactured equipment with another energy company, then the entire process of confirming the released equipment to the stated requirements of the energy company had to be repeated. Taking into account the number of energy companies in Russia, the time required to pass compliance assessments, as well as the organizational and financial costs of organizing this process, this approach to ensuring process safety could hardly be called effective.

Recently, the American Petroleum Institute (API), which is a recognized world certification body, has stopped issuing its certificates to Russian producers (and in some cases there are revocations of previously issued documents). The need to consolidate efforts at the industry level has become obvious, including in the development of common standards for equipment and certification systems.

The Scientific and Technical Council for the Development of Oil and Gas Equipment under the Ministry of Industry and Trade of Russia became the main platform for joint discussion of issues and decision-making. Within the Council, more than 10 expert groups were created, whose activities covered almost all key target areas of import substitution for the oil and gas industry - from exploration and production to transportation and processing of hydrocarbons (Gruzinov et al., 2019).

The main difficulties faced by oil and gas companies engaged in import substitution were:

– unification of product requirements by all consumers;

– search for objects and conducting pilot tests;

– mutual recognition of the results of pilot tests for accelerated scaling of production and implementation of emerging solutions in the procurement system of oil and gas companies.

The main problem that underlies all the indicated difficulties is the massive use of normative documents of foreign standardization systems. Established in 2015 The heavy dependence of the oil and gas sector on technologies created in the US and the EU in the implementation of projects both in the production and processing of oil and gas has led to the dominance of references to foreign standardization systems in design decisions and procurement specifications. References to international standardization systems due to problems with confirmation of conformity often become artificial barriers to the use of domestic equipment in projects - in the presence of comparable imported or even superior Russian analogues in terms of characteristics.

Additional restrictions under the sanctions policy arise when the manufacturer supplies equipment and materials to companies and projects under sanctions. Standardization systems may impose a direct ban on such supplies, and a possible strengthening of the sanctions regime creates the risk of an "institutional void" in industry standardization, that is, the loss of a quality benchmark.

In 2019, it became obvious that these issues need to be addressed not at the tactical, but at the strategic level. This idea became the prototype of the idea of combining the efforts of energy companies to address issues of import substitution and promote innovation by creating an appropriate industry organization.

As a response to these challenges, in 2020 four Russian oil and gas companies - Gazprom, Gazprom Neft, Sibur and Tatneft - became the founders of the creation of an autonomous non-profit organization Institute of Oil and Gas Technology Initiatives (INTI), whose main task is to develop and approve Russian industry standards for oil and gas equipment and technology and assessing the compliance of Russian enterprises with the developed standards.

The initiative to create a single organization, which is designed to ensure the development of uniform industry standards, was twice presented to the President of the Russian Federation Vladimir Putin and, following relevant instructions, nine other Russian energy companies joined the INTI project as observers. Russian energy companies were instructed, together with INTI, to ensure the transition to a unified industry standardization and conformity assessment system, as well as to consolidate resources and efforts in the field of import substitution.

At the same time, the founders set very ambitious tasks for the Institute: up to 2025. development and approval of at least 500 industry standards is required. For these purposes, the Institute is expected to attract more than 5,000 experts from the industry and professional community, and the number of conformity assessments carried out should exceed 3,000.

In 2020, INTI was also introduced to Mohammed Barkindo, the then Secretary General of the Organization of the Petroleum Exporting Countries OPEC. Having received a high appraisal of its activities, INTI began its international expansion. Currently, there are seven energy companies in the Institute as foreign observers: three from the CIS countries - SOCAR (Azerbaijan), KazMunayGas (Kazakhstan), Uzbekneftegaz (Uzbekistan), as well as four from the countries of the Opec + agreement - ADNOC (UAE), Kuwait Petroleum Corporation (Kuwait), Sonatrach (Algeria), Sonangol (Angola).

For equipment manufacturers, the presence of foreign companies in the Institute means the following: having received a conformity assessment at INTI, they gain the opportunity not only to work unhindered in the Russian market without the need to confirm the results of pilot tests or pass a specialized certification system, but also a barrier-free access to high-tech oil and gas markets companies that have joined the INTI project.

Obviously, the activities of the Institute of Oil and Gas Technology Initiatives create mutual benefits

for both equipment manufacturers and energy companies. First of all, we are talking about technological development and independence through the consolidation of existing resources and competencies, as well as demand from oil and gas companies in order to develop innovative and import-substituting solutions for the needs of the oil and gas complex.

The creation of a unified Russian standardization system contributes to the accelerated introduction of products and technologies (including innovative and import-substituting ones) of domestic manufacturers of oil and gas equipment and developers, an increase in the share of purchased local equipment and technologies for their use in major investment projects and operating activities of oil and gas and energy companies, and an increase in the competitiveness of local manufacturers equipment and technologies.

An effective dialogue between oil and gas companies, manufacturers and engineering companies takes place on the INTI digital platform. Joint work allows more efficient and faster development and promotion of technologies and equipment of domestic manufacturers and developers in domestic and foreign markets through the development of common INTI standards and conformity assessment on them.

The benefits for equipment manufacturers are obvious: unification of customer requirements, reduction in production costs, assistance with conformity assessment, recognition of test results by consumers, product promotion and, of course, the introduction of manufactured equipment into purchases. For energy companies, cooperation with INTI opens up opportunities for developing competencies and exchanging experience, joint technological development, expanding the pool of suppliers, reducing audit costs and, as a result, leveling sanctions risks. The Institute invites all interested equipment manufacturers to take part in the development of standards approval. If the standard for manufactured equipment already exists, then manufacturers have the opportunity to pass an assessment of compliance with this standard, which allows them to work seamlessly with all energy companies that have joined INTI at once.

Currently, there are three digital services on the site https://inti.expert/ that provide the above tasks:

– INTI Docs is a service for the development and approval of INTI standards, which includes functions for the development of standards and a catalog of accepted standards.

– INTI Quality is a service for conformity assessment and testing of equipment and materials. Designed for local providers. With the help of this service, suppliers can undergo a conformity assessment.

– INTI Insights is a database of local equipment that meets INTI standards. Designed for equipment customers (oil and gas companies, licensors, EPC contractors). With the help of this service, it is possible to find the necessary equipment according to the specified criteria, get access to reports on the results of conformity assessment, and get acquainted with the available references.

Conclusions

The development of offshore hydrocarbon fields in the Arctic is a strategic task for the Russian Federation, the solution of which requires the consolidation of efforts at all levels of government.

Arctic resources are not only building up the resource base of the state, which, without a doubt, is a competitive advantage of the country, but also loading the most important industries, creating a significant number of jobs, increasing the tax base, stimulating scientific developments, as well as improving the demographic situation by attracting highly qualified personnel for work in the Arctic regions.

The current foreign economic and political challenges have created the prerequisites for a speedy departure from import dependence and for the Russian Federation to pursue its own technology policy, which should be based on the joint work of the state, energy companies, science and industry.

The development of the Russian system of standardization in the energy sector is a direct and effective tool for import substitution, aimed at the speedy achievement of technological sovereignty by the Russian oil and gas complex.

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RISK-BASED APPROACH IN TESTING LABORATORIES ACCORDING TO THE REQUIREMENTS OF GOST ISO/IEC 17025-2019

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Abstract. At present, in the context of digital transformation, the issues of improving quality of management at enterprises on the basis of a risk-based approach are vastly considered. The enterprise is affected, on the one hand, by macroeconomic instability and consequent international resource constraints, and, on the other, by the growing need to adopt information technologies that enable sustainable development. In such an environment, a risk orientation ensures the sustainability of all operations. Sustainability in testing laboratories is essential, as it represents exactly what guarantees the validity and accuracy of the overall performance and output. The updated revision of GOST ISO/IEC 17025-2019 introduces requirements for a risk-based approach in testing labs. This study focuses on the changes in standards and innovations regarding risk management. As a result of this research, the authors come to the conclusion that it is a matter of fundamental importance to introduce risk-oriented thinking in the quality management system of the labs' testing.

Keywords: quality management system, laboratory, quality management, risk and opportunity assessment, risk-based approach

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РИСК-ОРИЕНТИРОВАННЫЙ ПОДХОД В ИСПЫТАТЕЛЬНЫХ ЛАБОРАТОРИЯХ СОГЛАСНО ТРЕБОВАНИЯМ ГОСТ ISO/IEC 17025–2019

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Аннотация. В настоящее время в условиях цифровой трансформации, вопросам совершенствования системы менеджмента качества предприятий на основе риск-ориентированного подхода уделяется большое внимание. На предприятие оказывают влияние, с одной стороны, макроэкономическая нестабильность и, как следствие, международные ресурсные ограничения, с другой, необходимость внедрения информационных технологий, позволяющих предприятию устойчиво развиваться. В таких условиях ориентация на риск обеспечивает устойчивость операционной деятельности. Устойчивость деятельности в испытательных лабораториях крайне необходима, так как именно это позволяет гарантировать достоверность и точность полученных результатов. В новой редакции стандарта ГОСТ ISO/IEC 17025-2019 впервые появляются требования к риск-ориентированному подходу для испытательных лабораторий. В работе проанализированы изменения в стандарте и нововведения относительно менеджмента риска. В результате проведенного анализа сделаны выводы о необходимости внедрения риск-ориентированного мышления в системе менеджмента качества испытательной лаборатории.

Ключевые слова: система менеджмента качества, лаборатория, управление качеством, оценка рисков и возможностей, риск-ориентированное мышление

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Introduction

One of the main tasks of testing laboratories today is to convince the customer in the reliability of test results and, consequently, promote and justify the competence of the lab itself. Accuracy and trustworthiness of laboratory tests play a key role in industry and trade decision-making.

The main problem, however, is that not all laboratory tests can produce reliable results due to errors occurring at different stages of testing, as each stage is inevitably exposed to risks. In order to obtain reliable test results, labs must establish an analytical system aimed at studying, preventing and managing risks. In this regard, risk management implies performing actions to identify risks, assess and differentiate them, and establish a risk register with a detailed plan to eliminate or minimize the impact, monitor changes and control the potential risk probability.

The risk management system functions and rests on documenting procedures aimed at eliminating emerging risks, and assessing the impact of existing and potential risks. Competent risk management staff of the laboratory is a prerequisite for a reliable and impeccable process of development and operation of the lab. Each laboratory must first assess the likelihood of risks and outline the actions required to detect and prevent them before they lead to any undesirable

outcome. Undoubtedly, this can be achieved via risk management, as required by ISO 17025.

Materials and Methods

Throughout the course of this research, an in-depth analysis of international and domestic standards, in particular GOST ISO/IEC 17025-2019 was carried out. What is more, the work of leading standardization researchers and the management risks were considered. The information obtained was processed with due consideration of modern trends in management of state institutions, in particular, labs based on quality management tools such as the PDCA and PDPC chart, and general scientific methods:

– analysis and synthesis;
– comparison;
– classification.

Results and Discussion

For several years now, ISO/IEC 17025 has been the basis for testing and calibration laboratories worldwide, and has allowed laboratories to guarantee their customers the ability to provide reliable results (Kalra, 2004).

By the rule of the International Board for Standardization, Metrology and Certification, in 2019, ISO/IEC 17025–2009 GOST was replaced by ISO/IEC 17025–2019 GOST. The updated version of this standard outlines significant innovations that improve e-document management, and introduces a risk-based approach to quality management. The introduction to the new standard clarifies that the changes will allow laboratories to achieve the desired quality standard via the implementation of control measures, prevention and minimization of negative consequences (Gusarova, et.al., 2020; Ilin, 2022).

Risk arises in any activity because no one can guarantee exactly what will happen and what implications might occur in the future. The ISO 31000–2019 GOST defines risk as the impact of uncertainty on the achievement of goals. Risk always brings specific results that can be negative, positive or negligible. Interest in exploring ways to manage uncertainty and its consequences has grown significantly over the past decade. This has led to the development and application of tools, methods, processes and methodologies, collectively known as risk management. Risk management is one of the most studied topics among researchers and managers. The purpose of risk management is to increase the probability and impact of positive outcomes and to reduce the likelihood and impact of adverse events on the project (Latfullina, 2019).

There are many approaches to structuring risk management. Behm proposed an option consisting of two main phases: the first phase, risk assessment, comprising identification, analysis, differentiation; and the second phase of control, comprising planning and monitoring of risk management. A broader approach consisting of nine phases of risk management is proposed by Chapman and Ward. The approach described by the Kremljak consists of four steps (fig. 1): planning, evaluation, processing and monitoring. This process coincides with Deming's cycle of consistent improvement in quality management (PDCA - Plan, Do, Check, Act). The author stresses that risk management is a continuous process, not a random sequence of events.

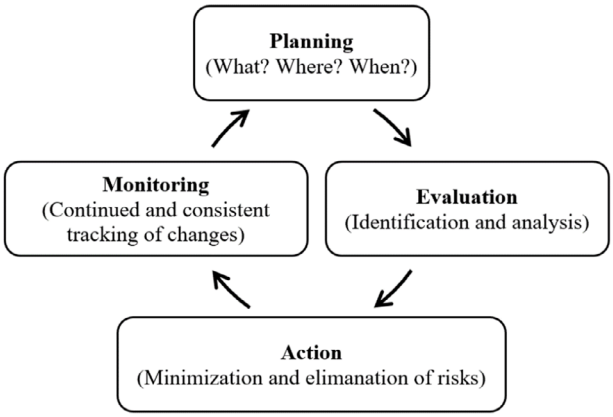


Fig. 1. Elements of Risk Management

It is important to consider separately the elements of risk management in the Kremljak's approach (Kremljak, 2016):

1) Planning. Risk planning is acontinuous process of developing an integrated approach to risk management in general. This phase begins with the development and documentation of a risk management strategy. It includes strategy design, outlining goals and objectives, and development of a risk and impact assessment methodology, together with the identification of resources, methods of documentation related activities, and staff training.

2) Evaluation. This stage entails, in addition to directly assessing the risk itself, an analysis of the effects and risk tolerance, as well as ways to suppress them or minimize their impact. Quantitative or qualitative methods, or a combination of these, are used for evaluation. The quantitative method determines the practical significance and cost of the consequences, their probability, and assigns the value of the risk level in the established units. Qualitative assessment establishes the relationship between impact, probability and risk level on a given scale.

A risk matrix is often used to assess risk, which allows prioritization and direction. Based on a risk and process efficiency matrix, a decision diagram (PDPC) can be constructed enabling each identified risk to develop a corrective action plan to avoid the risk.

3) Action. This stage is a so-called risk treatment, and includes methods of dealing with existing risks, their classification, performance of tasks to minimize the impact or eliminate the risk. This also includes scheduling, responsibility and cost estimation. The main objective of this phase is to reduce the impact of effects on the target. There are many methods for this, but they can be grouped into four main categories: risk prevention, risk control, risk acceptance and risk transfer.

4) Monitoring. Risk monitoring and control – a continuous process of tracking changes in both, already established risks, and identifying new ones, as market conditions and other circumstances affecting the target tend to be very fluid.

Many technologies exist to implement the second phase. Detailed description of risk assessment technologies includes GOST R 58771-2019. The choice of technology is determined by adaptability, scope of application, and the scale of the problem. It was also important to consider resource constraints, alternative solutions and the possibility of providing information to stakeholders (Boehm, 1991). The presented step-by-step risk assessment process allows the successful implementation of a risk-based approach. The main complexity of this process is the choice of risk assessment technology, as it will be individual for each specific lab and each specific risk register.

The 2019 version of the standard emphasizes the use of a risk-based approach that drives

QMS performance growth, leading to better results and minimizing negative impacts (Vikulov, 2020). It is important to note, that it is up to labs to decide whether they should develop a better and more sophisticated risk management methodology using a different standard, or not. Testing laboratories now need to carefully analyse the current situation and decide for themselves how to develop and implement a risk-based approach in specific settings that will ensure that the laboratory operates in accordance with the new criteria for accreditation. It is also essential to document the procedure developed before implementation (Viktorova, 2023).

Risk identification is a key step in risk management practice that is critical to an effective risk management process. Through the identification process, we record risks that directly affect the achievement of the goal. The results of the identification become later inputs to the risk and impact analysis process. At the same time, identification is a major step in risk management. It is also the most complex, as its goal is to create a comprehensive risk register, that would allow identifying as many uncertainties as possible that might affect the outcome (Fukayama, et.al., 2008).

The already mentioned GOST R 58771-2019 contains a set of tools for risk identification, including data collection methods and data analysis. The new version of the standard aims to minimize risks even before they occur. This is why a well-informed and thorough risk identification process is needed, as this is what minimizes risks before they even occur. In our opinion, the best method for identifying risks is the expert method, as experts with experience in the field are involved (Uglanova, 2019). Most importantly, they can take a broader look at the problem and assess even the smallest and most non-obvious risks by analyzing the big picture. The updated version of the standard defines supplier relations more strictly to minimize risk, assigns duties and responsibilities to staff, establishes the need for verification and validation, and so on.

The new version of the standard revised supplier relations and introduced new requirements, including the ones aimed at mitigating of external risks. It also clarified the need for a system and processes to evaluate external suppliers. The lab must identify and inform the supplier on the requirements it places on the products and services provided, acceptance criteria, and competence (Dmitrieva, Kopylova, 2020). The standard obliges the laboratory to have procedures and records in place, and ensure that products and services from external suppliers comply with those before they are used in the operation or handed over to the customer, allowing the laboratory to share the risk between itself and the external supplier. The reduction of the risk of non-performance of contractual obligations faced by any enterprise in the modern environment is reduced by the innovations in this section of the standard (Glukhova, 2017).

A more structured and concise staff-related section enshrines the responsibilities of all personnel in competence, impartiality and working in accordance with the management system. Whereas the previous version of the standard placed full responsibility on laboratory management. The new paragraphs and requirements of the standard oblige the laboratory to have procedures and records for defining competency requirements, selecting, training and supervising personnel, monitoring competencies, etc., which reduces internal laboratory risks. In order for laboratories to obtain reliable results and achieve customer satisfaction, errors must be minimized at all stages of the process. This requires all staff engaged in laboratory activities to understand the importance of considering the risks associated with their performance. In this way, each individual lab worker will be able to assess the possible risks associated with their actions and will be able to make uncertainty management decisions (Chapman, 1997).

Accreditation to the testing laboratory standard guarantees impartiality and confidentiality of activities and results. For its own impartiality on an ongoing basis, the laboratory must identify risks, including those arising from relationships that are based on ownership, management,

staff, resources, finances, and others. If the analysis reveals these risks, the laboratory must demonstrate how it eliminates or minimizes them (Raz, et.al., 2005).

The 2019 version of the standard introduces the terms "method verification" and "method validation" for the first time, making them mandatory. According to studies, 46% to 68% of laboratory errors occur during the preliminary phase, which is the sampling process. At this stage, most laboratory errors occur, including sample manipulation problems before samples reach the lab. Serious errors can be made in the transport, handling and identification of samples. The preliminary phase should therefore invite strict controls to avoid problems (Afanasyeva, Mokeeva, 2021).

One of the main differences between the old and the new version of the standard is the inclusion of the sampling in a laboratory process that is equivalent to testing and calibration, which means that it is subject to the requirements of the standard. The sampling procedure is becoming more controlled and accurate. Although the inclusion of sampling in the laboratory process increases the workload, it makes the test results more reliable. Recording documentation for sampling reduces the risk of claims from the customer (Lima-Oliveira, et.al., 2017). In the post-analysis phase, 18.5% to 47% of errors occur. Post-analysis activities within the laboratory include: checking the results, processing them in the information system and communicating with clients. Clear requirements for handling complaints and inappropriate work have therefore been included in the new standard.

The complaints section has been completely redesigned to include expanded requirements for the process of receiving, handling and resolving complaints. All interested parties should be familiar with the claims procedure. Upon receipt of the complaint, the laboratory must send the complainant the results of the investigation, which was prepared and approved by a person who did not participate in the activity complained of, in other words, the investigation into the causes must be independent (Fedchenko, et.al., 2019). Complaint assessment and documented consumer feedback is the evidence base for risk-based thinking.

It is important not to lose sight of the fact that since the date of introduction of the previous version of the standard, technology has come a long way. The standard now requires the information management system to be thoroughly tested before implementation. It is necessary to maintain a system that will guarantee data integrity and record system failures and corrective actions (Plebani, 2006). It is necessary to revisit the system and continuously improve it. The new version of the standard now divides the quality management system requirements into options (fig. 2).

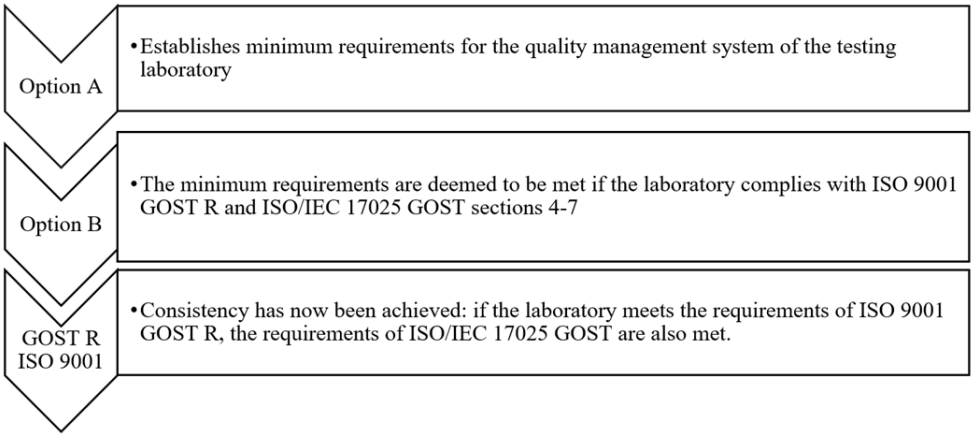
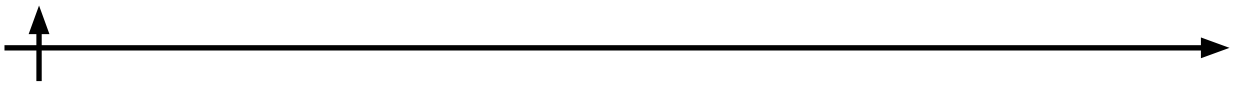


Fig. 2. Options for Quality Management System Requirements



The proposed options make it much easier for laboratories to develop a management system, since now they have the right to choose which path to follow. The updated version of the standard has achieved consistency that was not previously achieved: it can now be said that if the laboratory meets the requirements of ISO 9001 GOST R, it automatically meets the requirements of ISO/IEC 17025-2019 GOST.

Conclusions

Based on the comparative analysis, it can be concluded that the new version of GOST ISO/IEC 17025 is more concise, with clear and precise requirements. The updated version of the standard is more risk-based and less procedure-based.

The risk-based approach is not new, but it first appears applicable to testing and calibration laboratories in ISO/IEC 17025-2019 GOST, which sets out requirements for planning and assessing risks and opportunities, although it does not involve a full risk management system, as in ISO 31000 GOST R. The new version requires laboratories to implement a risk-based approach and demonstrate commitment to risk management in one form or another: definition of authority, mechanism for resolving conflict issues (complaints), improvements, etc.

The previous version of the standard refers only to the need to consider risks in decision-making. The standard now requires laboratories to include a documented risk and opportunity management procedure in the quality management system. Thus, there has been a shift from risk management to the creation of a fully fledged risk-centred procedure.

GOST ISO/IEC 17025-2019 does not contain specific and explicit requirements, thus providing the laboratory with an independent decision-making in terms of methodology. It is important to bear in mind that the laboratory makes the notion of "risk" more tangible, so that the staff involved in all laboratory activities understand what it means to analyse and consider risks in their activities, thus helping them to spread a culture of risk-based thinking not only within the laboratory, but throughout the field.

All the main processes of the lab must be described in the organization standards (STO), which regulates the requirements for the process in the form of a description of the sequence of operations, definition of areas of responsibility and methods of execution, as well as controlled indicators. At the same time, the requirements of GOST ISO/IEC 17025-2019 are aimed at describing the activities as they are.

The processes are developed in accordance with ISO/IEC 17025-2019 GOST 7 "Process Requirements", which defines the core processes of the laboratory, and ISO 9001-2015 GOST R 4.4.1, which states that the organization must define the processes, their application and interaction to maintain and continuously improve the QMS. The need for implementation in QMS laboratories arises from the necessity to obtain valid and reliable results through the creation of stable, reproducible test conditions.

ISO/IEC 17025-2019 GOST provides laboratories with the flexibility to develop a quality management system, provided they can provide proof of compliance and stability of application of the selected process. The current standard requires laboratories to consider, assess and act on both risks and opportunities associated with their operations. In addition, the laboratory needs to take into account the risks of impartiality.

In introducing a risk-based approach, the laboratory should consistently consider the following aspects:

– define the impediments to achieving the goal: establishment of a risk register;
– identify events that will enable the laboratory to achieve its goals faster or at lower cost;
– establish an inventory of ways to minimize the likelihood of undesirable consequences;
– create an action plan to reduce the impact of undesirable consequences on the achieve-

ment of goals;

– realize the opportunities for improvement that arise from the beneficial effects of risk.

Improving these areas altogether makes the risk assessment process more efficient, thereby, contributing to the development of a risk-based approach. When building a quality management system based on ISO/IEC 17025-2019 GOST, laboratories work on these areas, document the results and successfully implement risk management and an effective quality management system. As a result, it is possible to conclude that the accreditation to GOST ISO/IEC 17025-2019 demonstrates that the laboratory guarantees the validity of its results, besides making its activities more sustainable, as this is what the risk-based approach is aimed at. The use of ISO/IEC 17025-2019 by GOST laboratories makes research results not only valid worldwide, but also better and more reliable than similar laboratories that do not implement the standard.

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