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A Fuzzy Model for Personnel Risk Analysis: Case of Russian-Finnish Export-Import Operations of Small and Medium Enterprises

Tatiana Yu. Kudryavtseva , *Angi E. Skhvediani* ✉, *Maiia S. Leukhina* , *Alexandra O. Schneider*

Peter the Great St. Petersburg Polytechnic University, Saint-Petersburg, Russia

✉ shvediani_ae@spbstu.ru

Abstract. Small and medium enterprises (SMEs) have limited resources for balancing risks which occur during international activities. The main hypothesis tested in this research is that the qualification of employees is the main area of personnel risks in cross–border cooperation. The fuzzy-logic model for personnel risks analysis was developed for quantification of the risks related to international activities. First, different risk factors and their elements were identified and formulated as linguistic variables. Second, with the use of experts' judgments, a fuzzy logic-based system was constructed and evaluated. Risk level was calculated using MATLAB fuzzy logic toolbox and its factors were ranked accordingly. This model was applied to survey data from SMEs on Russia-Finland import-export operations during the 2020–2021 period. The personnel risk related to export-import Russia – Finland operations belonged to the above-average risk levels. Based on a more detailed analysis of risk elements, such elements as personnel development and training had the greatest coefficient and is an obvious high-risk area. The second highest value of the risk coefficient belonged to the element associated with personnel management. The lowest value belonged to elements related to motivation and recruitment processes. Therefore, theoretical contribution of the article is a model which allows us to quantify and identify micro-level personnel related risks in cross-border cooperation and present linguistic interpretation of these risks. This model can be use in practice by managers of specific SMEs or policy makers for obtaining broader and more representative results on risks related to international activities.

Key words: personnel risk; risk analysis; risk evaluation; fuzzy logic; small and medium sized enterprises.

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1. Introduction

Internationalization processes were studied mainly for multinational companies, but less so for small and medium-sized enterprises (SMEs). SMEs are more affected by different types of risks when they enter markets of foreign countries. SMEs are vulnerable to threats because of their limited ability to neutralize them [1]. Some risks remain constant while others arise and diminish as the process progress. For example, the degree of uncertainty increased during the 2020–2021 period due to the spread of COVID-19 [2] and during 2022–2023, when the Russia-Ukraine conflict was started [3]. Therefore, improvements in the performance of SMEs in the international area can be achieved by identifying risks, which occur across export and import processes, and providing management implications [4].

Risk analysis became an important tool to identify major risk factors and devise effective strategies to maintain a level of

risk below the acceptable level [5,6]. The primary objective of a risk analysis is to identify and assess potential risks that may arise in the context of a project and are potentially dangerous for the trading activity, companies and those involved in the project [7].

One of the effective tools for analyzing and evaluating risks in the absence of quantitative probability models is fuzzy logic [8]. Fuzzy logic can consistently classify the underlying risks using both the available data and the expert opinions. In addition, it which can create a system using vague language terms such as low, medium, high, etc. Risks are quantified using fuzzy logic, which increases the accuracy of risk assessment and strictly prioritizes risk control measures [9].

One of the risks faced by exporting/importing companies is the risk connected to human resources and their management – the so-called personnel risk – which poses one of the most serious threats to SMEs [10], due to its size and limited resources [11, 12]. Lack of qualified personnel is significant barrier to the SMEs growth [13] and productivity [14]. The importance of human resources was also highlighted during the Covid-19 pandemic [15] and the Russia-Ukraine conflict [3], which led to greater frailty and instability of SMEs activities. Therefore, proper risk management in the field of human resource management must be ensured [16].

Personnel-related risk analysis and management research is mainly limited to several main fields.

The first field is identification of general areas, where risks may arise. For example, Hudakova & Masar [13] used questionnaire to identify relative importance of market, financial, personnel, economic, safety, legal, and operational SMEs risks in Czech Republic, Poland, Hungary, and Slovakia.

The second field is discussion of precise risks within some area. Tselyutina et al. [17] designed a two-stage method for estimating the probability of occurrence of 30 personnel risks in the management system of personnel flows of the studied organizations.

However, the main drawback of these research is limited attention to development of personnel-related risk identification techniques, discussion, and assessment of these risks in the context of import-export activities of SMEs.

Research, related to Russia-Finland cross border cooperation is mainly limited to country-level analysis in different areas. For example, Lundén [18] discussed cross-border cooperation in Europe from theoretical and historical point of view, Makarychev & Romashko [19] paid attention to security cooperation, while Gumenyuk et al. [20] justified that border traffic is an efficient tool for developing cross-border cooperation. However, to the best of our knowledge the topic related to identification and assessment of personnel risks related to cross-border Russia-Finland cooperation of SMEs during 2019–2021 was not discussed properly in scientific literature.

The research aim of this paper is to suggest a fuzzy model for personnel risk analysis and test it on sample data of SMEs performing export-import operations. This data was obtained from the surveys, which were performed as part of the project «Inclusive cross-border business networking of tomorrow» (INCROBB) within Program of cross-border cooperation «Russia-Southeastern Finland» in 2020–2021.

The main hypothesis tested in this research is that qualification of the employees is the main area of personnel risks in cross – border cooperation.

The paper is organized as follows. Section 2 reviews literature on personnel risk and methods of its assessment. Section 3 provides a framework for expert evaluation of risk factors using a questionnaire, as well as gives the details of chosen variables for a fuzzy logic-based algorithm for the evaluation of the personnel risk and its

elements. The construct of a logic-based system is also described in this section. Section 4 de-scribes the results of risk evaluation. Section 5 contains a discussion of the results. Finally, conclusions are given in Section 6.

2. Literature Review

There are various approaches for defining and calculating risks. Risk can be understood as mathematical expectation of losses multiplied probability of their occurrence. These losses may occur because of the implementation of a planned action. In other words, it is nothing more than the harm caused by performing a particular operation [21].

Operations in foreign markets are followed by higher uncertainty due to their complexity, differences, and unexpected changes in legal, policy and socio-cultural spheres.

Zang et al. [22] have explored cultural distance and cross-border diffusion of innovations. Using literature review, they have assessed 35 articles and found out that in general adoption and diffusion of innovation and new products are bound to be deeply influenced by cultural distance on country-level. However, they admit that at organizational and individual levels impact of national cultural dimensions on cross-border adoption and diffusion of innovation and new products may vary and requires deeper analysis.

Tian & Deng [23] have also used literature review and assessed 100 articles to synthesis empirical studies dedicated to the impact of culture on international business. They have proposed organizational framework, which can be used for achieving sustainable innovation. This framework includes relationships between different cultural dimensions, introduced by Hofstede, antecedents, output, and commercialization of innovations.

Calcada et. al. [24] explored economic effects of trade policy uncertainty and revealed that uncertainty about trade policy in 2018 may have lowered aggregate U.S. investment by 1 % at firm-level. In addition, they have expanded empirical results by modelling trade policy uncertainty transmission in a two-country general equilibrium model with heterogeneous firms and endogenous export decision. They found out that both higher expected tariffs and increased uncertainty about future tariffs deter investment, with exporters accumulating less capital than nonexporters.

Crowley et. al. [25] in the same manner have explored trade policy uncertainty and foreign market entry by Chinese firms. They have found that due to the use of contingent tariffs during 2000–2009 Chinese entry into foreign markets have been roughly 2% lower per year.

Gebre Borojo et al. [26] have investigated effect of trade policy uncertainty on trade flow of emerging economies and low-income developing countries. They have found out that the higher level of trade policy uncertainty in a destination country, the higher business exposure to risks and, consequently, the lower trade performance of its trade partner countries.

Considering such complexity and limited resources of SMEs, which can be used for coping with uncertainty and mitigating risks, it is essential to discuss role of human resources in it.

Becker & Smidt [27] stated that there is lack of research in the intersecting fields of risk management and human resource management. They highlighted eight main areas of risks, related to the human resource management, including: health and well-being, productivity, financial, labor turnover, attendance rates/patterns, reputation, legal, innovation.

Personnel related risks discussed partly, for example, by Cooke & Lin [28] during analysis of challenges of entering Vietnamese market by Chinese firms. They reasoned organizational resource deficit, expressed in lack of managerial capabilities of young Chinese firms. These firms did

not have enough expertise for running up overseas operations and, consequently, underestimated total operation costs.

For risk analysis are used the following methods: sensitivity analysis, fault tree analysis, Monte Carlo analysis, event tree analysis, and scenario planning [29]. However, for the effective application of these complex quantitative methods, high-quality statistical data is required. Personnel related risks, which may occur during export – import operations, are not always obvious and not always can be linked to the concrete financial losses. Therefore, it is important to implement risk assessment methods, which take in account imprecise and non-numerical information.

Tselyutina et al. [17] proposed two-stage method for estimating the probability of occurrence of 30 personnel risks characteristic of different types of personnel flows. The evaluation of the probability of personnel risks was done by expert assessments. The experts were the chief executive officers or chief human resource officers of the studied organizations. Then possible scenarios were simulated using the Scenario Manager method.

Tikhonov [30] also proposed a methodology, which is based on the expert assessment method. He proposed to use two criteria to assess personnel risks: result (magnitude of consequences) from the manifestation of risk and the likelihood of risk manifestation. As the result, the "Probability – damage" matrix was built.

As we can see, only a few studies are using mathematical models and quantitative methods of personnel risk assessment. One of the perspective methods in this field is fuzzy-logic approach. It was frequently used to solve problems of uncertain nature, since it allows estimating the relationships between risk sources and the consequences [31]. For example, Uzhga-Rebrov & Grabusts [32] proposed fuzzy version of the prospect theory, Santana et al. [33] proposed credit classification fuzzy rules system, Sardasht & Rashedi [34] proposed audit detection method based on fuzzy logic etc.

Organizational and personnel related issues were also discussed in the context of fuzzy modelling.

Luo [35] proposed conceptual model for risk assessment of import and export enterprises based on fuzzy logic and neural networks.

Wulan & Petrovic [36] used fuzzy logic for risk analysis and evaluation within enterprise collaborations.

Afzal et al. [37] proposed a risk assessment procedure by developing a fuzzy logic model to estimate the cost overrun risk in international projects.

Hugo et al. [38] did quantitative risk analysis in project management using fuzzy logic as well.

One of the motivations of the work, performed by Albadan et al. [39] was to analyze the personnel selection processes.

Izquierdo et al. [40] applied fuzzy logic to the personnel performance evaluation process. Therefore, fuzzy logic can be used for analysis of personnel related risks, which may face SMEs in high uncertainty spheres.

Therefore, our research fills in research gap related both to the methodological issues of personnel risk assessment using fuzzy-logic and identification of personnel related risks in cross border cooperation.

3. Materials and Methods

3.1. Research algorithm

Research included several stages, which were performed to develop fuzzy logic-based model for personnel risk analysis of exporting/importing SMEs (Figure 1).

First, survey was conducted to identify opportunities, risks, and barriers for cross – border cooperation between Russia and Finland. Next, comparative analysis of survey results was conducted, and most important factors of cross border cooperation were identified the. Next, experts with relevant expertise to assess personnel risks of cross-border cooperation were selected. At final stage obtained results

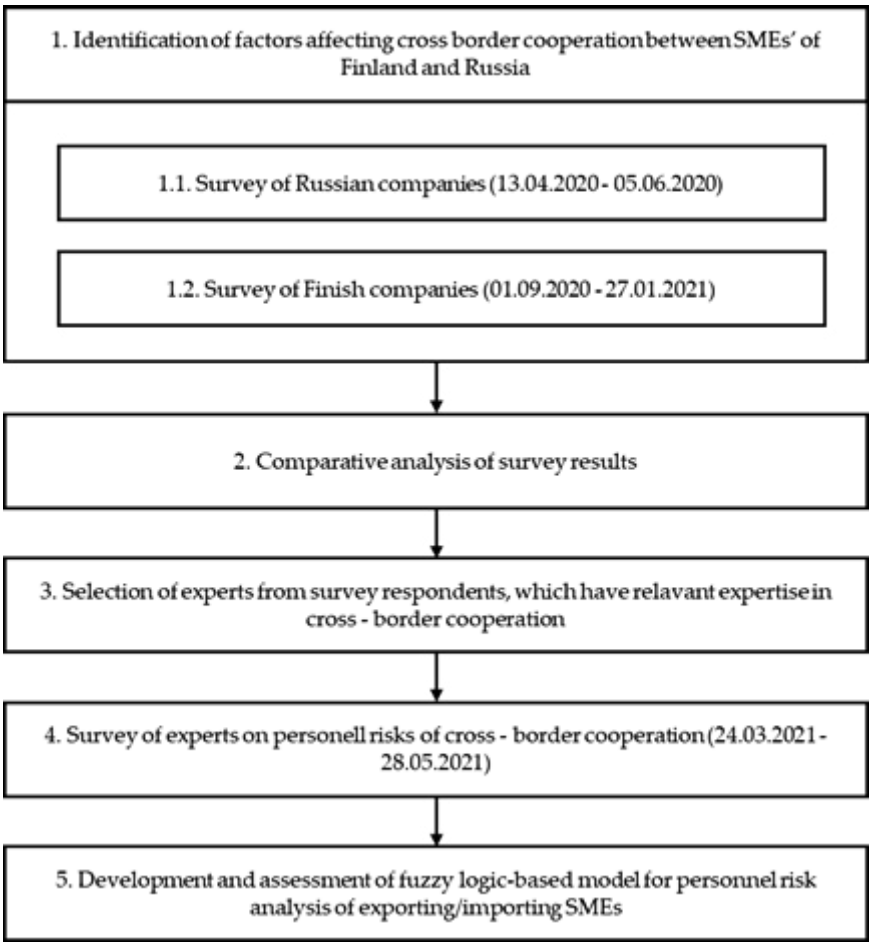

Figure 1. Research algorithm (the authors)

were used for development of fuzzy logic-based model.

3.2. Surveys for identification of factors affecting cross border cooperation and personnel risks of cross-border cooperation

At the first stage of the study, survey was developed and conducted using the Google Forms online service. The survey was aimed at identifying opportunities and barriers for sustainable cross-border cooperation between small and medium-sized enterprises of the Russian and Finnish companies, as well as their expectations from such cooperation.

The survey was conducted among Russian companies from 04/13/2020 to 06/05/2020 and among Finnish companies – from 09/01/2020 to 01/27/2021. The questionnaire was published on the official websites and pages of social networks of the Chamber of Commerce and Industry of St. Petersburg, Peter the Great St. Petersburg Polytechnic University (SPbPU), the INCROBB project, Lappeenranta University of Technology (LUT), South Karelia Entrepreneurs Association, South-East Finland-Russia CBC 2014-2020 program.

In addition, these organizations have distributed the survey between their partners using email. A total of 168 Russian and 76 Finnish companies took part in the survey. We invited to fill in this survey SMEs from St. Petersburg, the Leningrad Region, the Republic of Karelia, and regions

of South-Eastern Finland, because these companies could have relevant experience in cross-border cooperation. Respondent was classified as representative of SME if average number of employes was lower than 250 and if annual turnover was lower than 2000 mil. Rub for Russian enterprises or 50 mil. Euro for Finish enterprises.

Next, we selected experts from respondents, who have filled in the survey. We defined whether respondent can be called an expert based on his experience in cross – border cooperation and their position in the company. We classified top-managers or owners at SMEs operating in Russian Federation and Finland, that regularly export and/or import and have experience in Russia-Finland cross-border cooperation, as experts. These people have relevant expertise in the field and can assess relevance of risks connected to personnel. We focused on personnel risks since personnel qualification was named as one of the most crucial factors in successful cross-border cooperation during first survey.

Results from second questionnaire, which was distributed among selected experts, were used as sample data for testing fuzzy model for personnel risk analysis. We received 16 replies from the experts. All replies were received from experts from Russian enterprises. For fuzzy logic method application such number of experts is acceptable.

For example, Osei-Kyei et al. [41] provide example of using small samples (from 12 to 46) in an international e-mail/ web-survey based research in public private partnerships, Hsieh et al. [42] used survey of 6 experts in order to evaluate risks in new software development projects, Mastrocinque et al. [43] used replies from 19 experts to test model, which assesses the open innovation level of the company, while Rajak & Vinodh [44] used opinions of 10 experts in order to evaluate social sustainability performance of an Indian automotive component manufacturing organization.

3.3. A fuzzy-logic-based approach for risk analysis

We have identified the elements of risks that afflict the human resources in small and medium-sized enterprises. Most existing risk analysis models as we saw in literature review are based on quantitative techniques such as Monte Carlo Simulation and Annual Loss Expectancy. However, the information that is related to most uncertainty factors is not numerical. Fuzzy logic provides an approximate model for the evaluation of the risk faced by SMEs through a linguistic approach.

Since Zadeh [45] introduced fuzzy set theory, it has been frequently used to solve problems of uncertain nature. Fuzzy logic is a popular risk analysis tool that has proven to be easy to understand and apply under many criteria and many attributes [46].

A fuzzy system is composed of three primary elements, namely fuzzy sets, membership functions, and fuzzy production rules.

Membership functions of various forms (e.g. linear, sigmoidal, triangular, etc.) can be defined to obtain the degree of belonging to a particular group, as discussed in [47, 48]. For this analysis, we will use triangular membership functions. Triangular membership functions are chosen because they are simple, and the assessment results obtained with the model are consistent with widely held opinions. Most importantly, triangular membership functions can approximate most non-triangular ones [49].

Thus, we can form four elements of risk and final personnel risk functions of the factors to interpret fuzzy linguistic variables in specific mathematical expressions:

$$PR = fPR(W, Y, Z), \quad (1)$$

$$W = fW(w_1, w_2, w_3), \quad (2)$$

$$X = fX(x_1, x_2), \quad (3)$$

$$Y = fY(y_1, y_2), \quad (4)$$

$$Z = fZ(z_1, z_2), \quad (5)$$

where the resulting estimate for the personnel risk (PR) forms the following indicators and their aspects: W – Motivation; w_1 – motivation system; w_2 – initiative and commitment to the company; w_3 – staff turnover rate; X – Development and training of employees; x_1 – the amount of money spent on training; x_2 – the number of people that took a traineeship; Y – Recruitment process; y_1 – qualification of employees; y_2 – compliance with employees' qualifications with the requirements; Z – Management of employees; z_1 – the level of education and professional training of the manager; z_2 – work experience in the field of the manager.

The presented elements were sent to experts, who were asked to provide their range of values for each variable. Linguistic variables, that are presented in Table 1 and Table 2, will be assessed qualitatively.

Each row displays a conditional statement that binds the fuzzy values of input and output variables. Assume that the linguistic variables w_1, w_2, y_1, y_2 and z_1 are evaluated on the following scale:

– L – low;
– bA – below average;
– A – average;
– aA – above average;
– H – high.

Variables w_3, x_1, x_2, and z_2 will be assessed quantitatively. Afterwards, the data gathered from the experts were used to design the membership functions that reflected these fuzzy terms. Fuzzy logical equations, put in accordance with the knowledge matrices, allow us to evaluate the integral assessment of personnel risk from the values of partial indicators.

Fuzzy logic-based systems use rules to represent the relationship between observations and actions. These rules consist of a precondition (IF-part) and a consequence (THEN-part). The precondition can consist of multiple conditions linked together with AND or OR conjunctions. Conditions may be negated with a NOT. The computation of fuzzy rules is called Fuzzy Inference. Knowledge acquisition methodologies, such as interviews or questionnaires, can also be used to build the rules [50].

One of many types of rule representation is a logical matrix (Table 2). For this we apply a simple procedure for filling in logical matrices of N-dimensions, which includes the following steps:

1. The qualitative and quantitative levels are matched:

$$H = 1,\ aA = 2,\ A = 3,\ bA = 4,\ L = 5. \quad (6)$$

2. The output is calculated like an integer, closest to:

$$(Input_1 + Input_2 + \ldots + Input_N)/N. \quad (7)$$

3. The qualitative value of an output variable is identified opposite to step 1.

What these rules are saying can be shown with a couple of examples from the rules:

IF the qualification of employees is average and compliance of employees' qualifications with the requirements is high THEN the risk from the recruitment process is below average.

IF the qualification of employees is high and compliance of employees' qualifications with the requirements is low THEN the risk from the recruitment process is average.

3.4. Construction of a fuzzy inference system

Based on the average values for the risk indicators collected from the experts, and by using MATLAB fuzzy logic toolbox, the triangular membership functions for the input variables (i.e., risk elements) and the output variable (risk factors) were defined to give numerical meaning to each label.

The set of membership functions is five-level. Each membership function identifies the range of inputs and outputs values that corresponds to a label as shown in Figure 2, where the x-axis represents the input values provided by the experts

Table 1. **Scale for evaluating partial quality indicators (the authors)**

Partial indicator	Low	Below average	Average	Above average	High
w_1 – motivation system	Lack of a staff motivation program. Payment of labor consists only of salary.	An underdeveloped system of motivation. – salary; – bonus.	Medium-developed motivation system. – salary; – social package; – bonus.	Developed motivation system. – salary; – social package; – bonus based on the results of the work.	Highly developed motivation system. – salary; – social package; – bonus based on the results of the work; – additional perks.
w_2 – initiative and commitment to the company	Lack of interest in the operation and development of the organization. Lack of proposals and initiatives.	Low interest in the operation and development of the organization. Only a small part of the staff is proactive.	Average interest in the operation and development of the organization. About half of the staff is proactive.	High interest in the operation and development of the organization. More than half of the staff is very proactive and of the organization.	Very high interest in the operation and development All employees regularly make suggestions and initiatives.
y_1 – qualification of employees	Low	Below average	Average	Above average	High
y_2 – compliance of employees' qualifications with the requirements	Complete inadequacy of employees' qualifications with the requirements imposed on them.	The qualifications of the employees do not sufficiently meet the requirements imposed on them.	The qualifications of the employees meet the requirements imposed on them only partially.	The qualifications of employees are mostly meeting the requirements imposed on them.	Full compliance of employees ' qualifications with the requirements imposed on them.
z_1 – the level of education and professional training of the manager	The manager does not have higher education.	The manager's education does not correspond to the position or industry.	The manager's education does not correspond to the position or industry, but the manager has special skills and abilities.	The education of the head corresponds to the position or industry.	The manager has higher education that corresponds to the position or industry. Additionally, the manager has special skills and abilities.

Table 2. **Logical matrix for two input variables (the authors)**

Input variable y_1 (employees' qualification)	Output variable Y, where y_2 (compliance with the requirements) =				
	L	bA	A	aA	H
L	H	H	aA	aA	A
bA	H	aA	aA	A	A
A	aA	aA	A	A	bA
aA	aA	A	A	bA	bA
H	A	A	bA	bA	L

(from 1 to 5 representing the scale from Low to High) and the y-axis represents the degree of membership (from 0 to 1) for each membership function. The same procedure has been completed for the second level of our system, where we estimate the elements of risk.

The type of fuzzy inference system we will be using is called the Mamdani system, since it has more intuitive and easier to understand rule bases, they are well-suited to expert system applications where the rules are created from human expert knowledge. Figure 3 displays a diagram of the fuzzy inference system with the names of each input variable on the left, and those of each output variable on the right, as shown in the next figure. The sample membership functions shown in the boxes are just icons and do not depict the actual shapes of the membership functions.

Here, we can see the example of how the system of Y variable looks. The fuzzy inference systems for X and Z have the same features: 2 inputs, 25 rules and 1 output. The fuzzy inference system for W is a little more complicated and has 3 inputs, 125 rules and 1 output.

The next step is to build a three-dimensional curve that represents the mapping from the qualification of employees and compliance of employees'

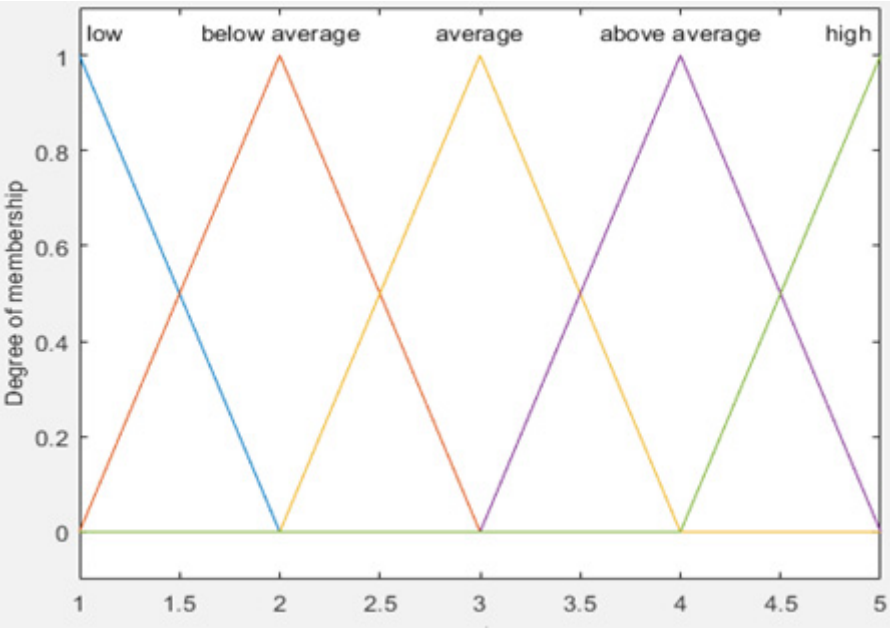

Figure 2. The system of triangular membership functions for the factors of risks (the authors)

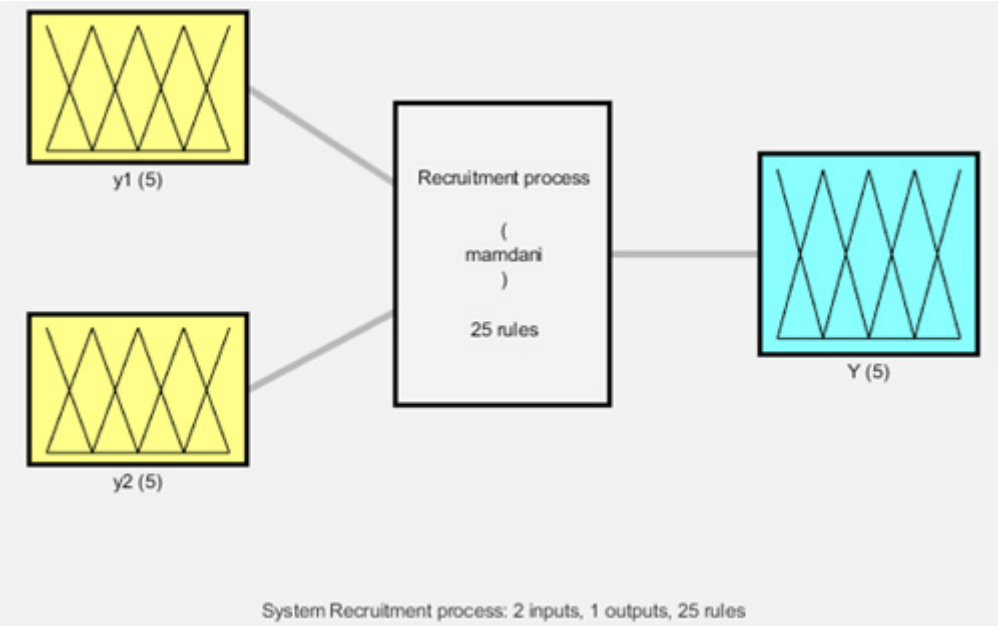

Figure 3. Fuzzy inference system for the Recruitment process (the authors)

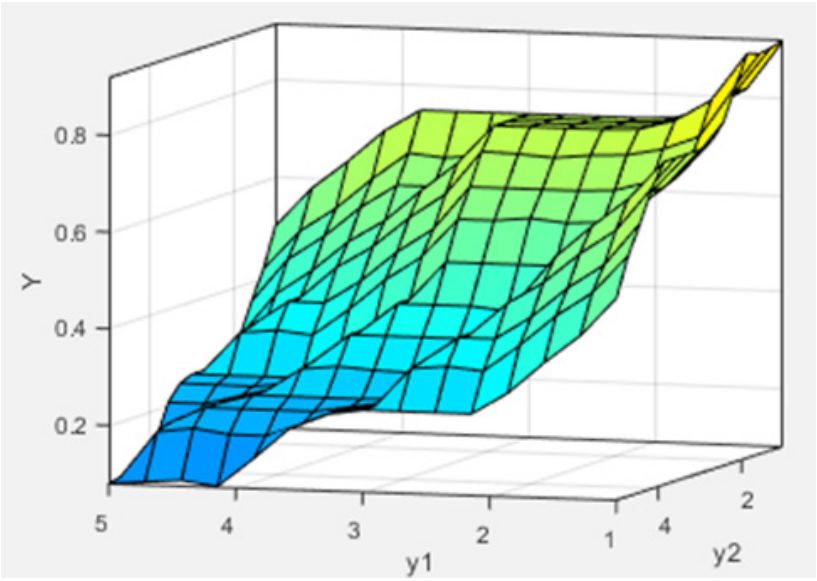

Figure 4. Fuzzy inference system in surface view (the authors)

qualifications with the requirements to risk from recruitment process amount. Because this curve represents a two-input one-output case, we can see the entire mapping in one plot. The graph is shown in Figure 4.

The output of each rule is a fuzzy set derived from the output membership function and the implication method of the fuzzy inference system.

The final system for measuring personnel risk connects calculated *W*, *X*, *Y*, and *Z* inputs together. The fuzzy inference system for PR (personnel risk) has the following features: 4 inputs, 625 rules and 1 output.

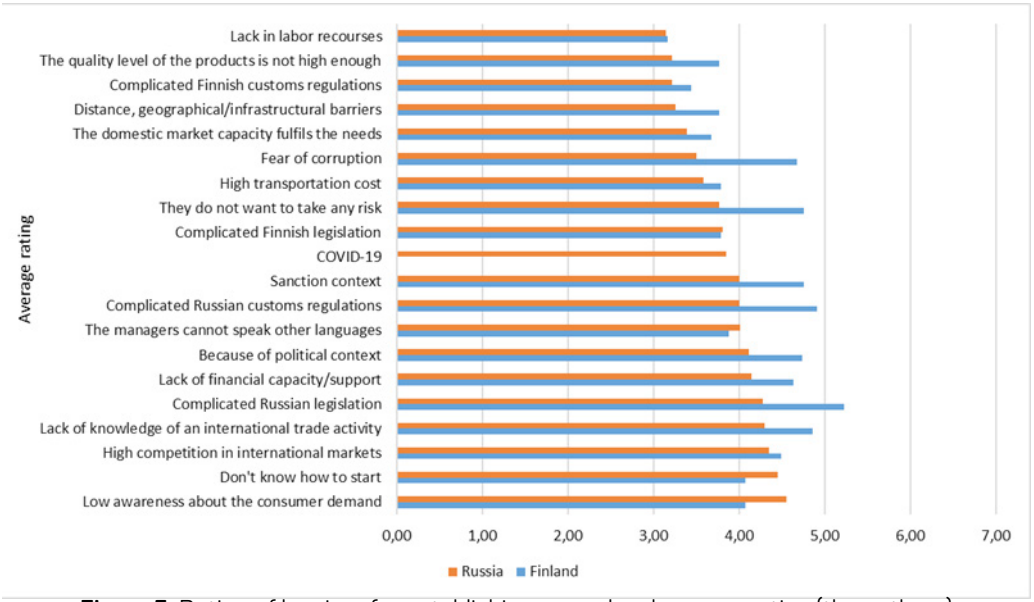

Figure 5. Rating of barriers for establishing cross-border cooperation (the authors)

4. Results

168 Russian and 76 Finnish companies took part in survey for identification of factors affecting cross border cooperation between Russia and Finland in 2020-2021. As part of this survey were studied barriers that companies face when establishing cross-border cooperation. Russian enterprises highlighted that main obstacles to cross-border cooperation are lack of awareness of consumer demand, lack of knowledge on how to start this collaboration, as well as high competition in international markets. On the other hand, for Finnish enterprises the most significant barriers were complexity of Russian legislation, followed by the difficulties in the Russian customs regulation and lack of knowledge about the peculiarities of international trade (Figure 5).

Results of the rating reveal that lack in labor resources has the lowest average score among all barriers. This means, that on average enterprises does not feel lack of labor resources. On the other hand, most of other micro-level barriers, which have higher scores, are related to qualification and knowledge of the employees. Among these barriers are low awareness about consumer demand on target market, poor knowledge of language, legislation of target country and international trade activity state, lack of knowledge on procedures and possible steps of entering foreign markets.

In addition, most of these macro-level barriers are factors, which increase uncertainty. Higher uncertainty requires higher qualification of the employees, since they must be able to cope with it using limited resources of SMEs. Taking it into account, we proceed to the second stage of the research, where we assessed personnel risk related to export-import operations in context of Russia-Finland cross-border cooperation.

At second stage we have selected respondents, who can be called experts, since they have had experience in Russia-Finland cross-border cooperation and hold top management positions. We focused on top management positions since they oversee the whole enterprise and can assess personnel related risks in cross border cooperation. We have distributed second survey among them and received 16 replies from Russian respondents. Table 3 presented characteristics of experts.

Table 3. **Experts profile (the authors)**

Characteristics	№ of experts	% of experts
1. Current position in the company		
Top manager and owner	14	88%
Top manager	2	13%
2. Experience of the expert in cross border cooperation		
1–3 years	2	13%
3–5 years	3	19%
5–10 years	4	25%
10 years and more	7	44%
3. Intensity of communication with foreign partners		
Daily	8	50%
Weekly	4	25%
On request	4	25%
4. Type of enterprise activities		
Engineering	4	25%
Sale of industrial equipment	4	25%
Production of equipment and components for industry	2	13%
Production of LED equipment	1	6%
Production of construction materials	1	6%
Production of smart and green technologies	1	6%
Production of telecommunication components	1	6%
Production of measurement equipment	1	6%
Production of decorative plastic	1	6%
5. Type of cross border cooperation		
Import	12	75%
Export	12	75%
Personnel training	5	31%
Joint provision of services	4	25%
Joint production and research	3	19%
6. Number of employees		
0–49	5	31%
50–99	3	19%
100–149	2	13%
150–199	3	19%
200–250	3	19%

Most experts were both owners and top managers of their companies. Eleven experts out of sixteen have had eleven years of experience in cross-border co-operation. Twelve experts indicated that they communicated with their foreign partners on daily or weekly basis. Four experts were managing companies, which provided consulting services in engineering, four experts were managers of trade companies, which have solely imported goods to Russia and six experts were managing production enterprises in various spheres. Mostly companies were performing import and export operations of final goods, components, and materials.

However, some of them additionally were organizing joint training sessions with their partners and conducted joint business activities in production and consulting spheres. 50% of the experts were managers at companies with number of employees less than 100, while 31% of experts were managing companies with staff size between 100-199 person employed and 19% of experts were man-aging companies with staff size between 200-250 person employed.

Taking it into account, we have built final model for measuring personnel risk. We have focused in this survey on personnel risk, since it was one of the most important barriers, highlighted in the first survey. In accordance to the methodology described above, we have calculated the output. These output fuzzy sets are combined into a single fuzzy set using the aggregation method of the fuzzy inference system.

Then, to compute a final crisp output value, the combined output fuzzy set is defuzzified. For this study, we used the centroid method to defuzzify. The result is shown also in Figure 6 with the output membership.

The crisp output for the personnel risk during import-export operations is 0.5245. This allows us to determine the degree to which the indicator of personnel risk belongs to a particular group. Classifying it according to the proposed scale by membership functions, we can see that it is 43% in the zone of average level, and 57% in the zone «above average». The next part of this algorithm was to match the result with the definition of values of output variable – personnel risk. These values are shown in Table 4.

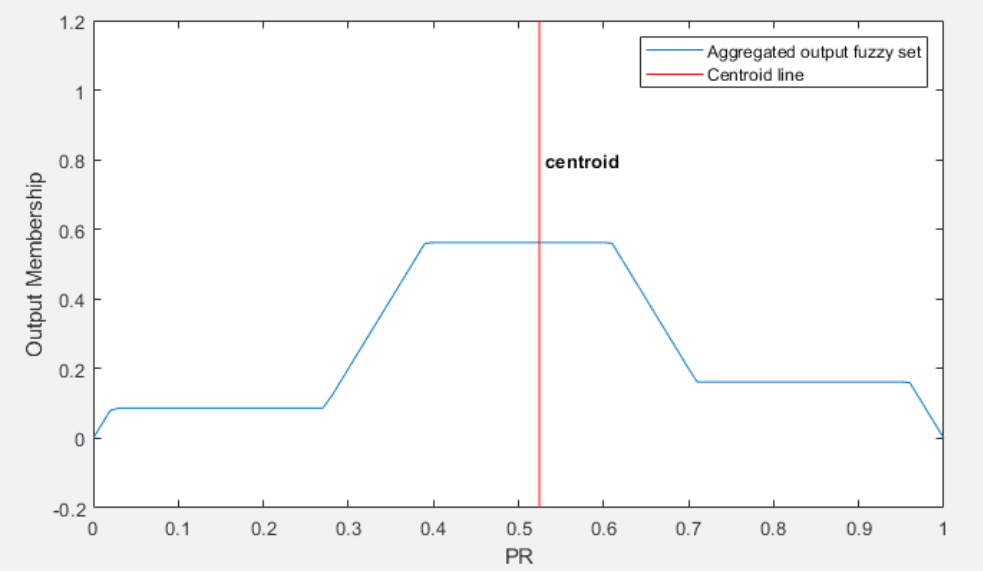

Figure 6. Aggregated fuzzy output (the authors)

Table 4. **Values of personnel risk (the authors)**

Set of values	Title	Description
0-0.333	Low	Great and thought though motivation program for the employees, therefore employees are proactive and rarely leave the company. A lot of expenses go to development and training programs for the employees. The recruitment process is aimed at finding personnel with high qualifications according to the requirements. The manager has great experience in managing people and qualification and certain skills to it.
0.167-0.50	Below average	Thought through motivation program for the employees, therefore employees are proactive and rarely leave the company. Some expenses go to development and training programs for the employees. The recruitment process is aimed at finding personnel with above-average qualification according to the requirements. The manager has experience in managing people or at least qualification and certain skills to it.
0.333-0.667	Average	Ordinary motivation program for the employees, that does not include additional perks, therefore employees are not very proactive and sometimes leave the company. Only a few employees attend development and training programs. The recruitment process is aimed at finding personnel with basic qualification according to the requirements. The manager has little experience in managing people and poor qualification.
0.50-0.833	Above average	Ordinary motivation program for the employees, that does not include additional perks, therefore employees are not proactive and leave the company often. Only a few employees or none attend the development and training program. The recruitment process is random and sometimes the hired personnel does not accord to the requirements. The manager has little experience in managing people and no qualification or skills.
0.667-1	High	No or low-quality motivation program for the employees, therefore employees are not proactive and/or leave the company. No or low-quality development and training possibility of employees. Inadequate or failed recruitment process. The manager has neither experience in managing people, nor certain qualities and skills to it.

For a more detailed analysis, we need to look at the values of the risk elements (Table 5). As we can see, such element as personnel development and training has the greatest coefficient and is the obvious high-risk area. The reason for such a high value of the coefficient is an insufficient financial investment in training and retraining of employees or a small number of employees undergoing this training.

This risk related to the ability of the enterprise to adjust quickly to sudden changes in external environment and to cope with uncertainty in more effective and efficient ways. For example, Oh & Han [51], Rudolph et. al. [52] stated that investments in personnel training may lead to quick recovery and higher performance of the company after the crisis. The same can be applied for risks, which occur during import-export operations and cross-border activities, since global complexity and uncertainty is much higher than local or national [53, 54]. This result supports conclusion from the first stage of the research, where we highlighted that one of the most important barriers are lack of knowledge or competencies of the

employees and provide proof for hypothesis stated in this research.

Table 5. **Ranking of risks elements (the authors)**

Risk element	Value
Development and training of employees	0.80345
Management of employees	0.47836
Motivation	0.39063
Recruitment process	0.29048

The second highest value of the risk coefficient belongs to the element associated with personnel management. In addition, lowest value belongs to the element Recruitment process. This may mean that, in general, this process is functioning well in companies, in fact, qualified workers are being hired for positions with appropriate requirements.

One of the possible explanations on low values of risk coefficient for recruitment process is that companies does not support unfavorable recruitment processes and aim to reduce risks related to employing inadequate workers [55]. On the other hand, selection bias an also be presented here. HRs usually search for positions, which are related to international activities, applicants with higher educational and professional background [56, 57]. These conclusions are also supported by results from the first stage of the research since lack of the personnel was scored on average level.

The motivation element did not get the highest coefficient value as well. Accordingly, the companies participating in the survey have set up an adequate system of motivation and encouragement for employees. Employees of these companies are moderately interested in the development and the success of the company and the turnover of personnel at the enterprises is not high.

5. Discussion

Fuzzy-logic allowed us to quantify these risks and range them precisely for the case of import-export Russia-Finland operations in 2020–2021. To the best of our knowledge, research in this field was limited to identification and analysis of macrolevel threats and risks on conceptual level [18, 19].

Afzal et al. [37] proposed a risk assessment procedure by developing a fuzzy logic model to estimate the cost over-run risk in international projects. However, this procedure deals mostly with quantitative data on costs rather than qualitative data. Therefore, knowledge on risks in cross-border cooperation and results of its evaluation are quite limited.

Based on the results of our analysis, it can be concluded that personnel-related risks during import-export Russia-Finland operations in 2020–2021 from the experts' evaluation generally belonged to the average and above-average risk levels. Special attention should have been paid to the development and training of employees since its risk indicator was the highest of the considered elements. Training is even more important in small companies because the effect of it is many times higher than in large ones.

This conclusion corresponds with results of Cooke & Lin [28], who stated that low qualification of Chinese managers in SMEs led to underestimating of operational costs in Vietnamese market. Therefore, employee training can help to save on external contractors, optimize internal costs for standard operations, reach a new level of quality and increase quality of management.

Limitation of this contribution related to the low number of experts, who took part in evaluation. In addition, developed model focused on internal sources of risks, assuming, that organization should be capable to adapt to any changes in external environment.

Another contribution of the paper is fuzzy model to analysis and systemization of

personnel-related risks. Previous research in the field of fuzzy logic application to human resource management were focused on such topics as: human resource management practices for promoting product innovation in formal and non-formal R&D firms [58], collective competence assessment, based on performance indicators [59], talent management [60], competency-based selection and assignment to various positions and types of works [61, 62] etc.

However, to the best of our knowledge, they did not discuss risks, related to the human resources. Fuzzy logic model allows to estimate personnel related risks for companies operating in complex and unstable international environment using imprecise and non-numerical information.

Main limitation of developed model is that it does not provide detailed information on precise risks related to different areas of personnel risks. To identify precise risks detailed analysis should be performed.

6. Conclusions

The paper presents a fuzzy model for personnel risk assessment. This model was applied to the data of exporting/importing SMEs. Experts' judgments and MATLAB fuzzy logic toolbox were used to graph the membership functions of each risk element (the inputs), to risk factor (the output), in the second stage of each risk factor (the in-puts), to personnel risk level (the output). The risk levels were calculated based on a set of rules generated using the experts' data.

The personnel risk related to export-import Russia-Finland operations in 2020–2021 from the experts' evaluation belongs to the average and above-average risk levels. Personnel development and training had the greatest coefficient and is the obvious high-risk area.

The reason for high value of the coefficient is an insufficient financial investment in training and retraining of employees or a small number of employees undergoing this training. The lowest value belongs to the element Recruitment process. This may mean that, in general, this process is functioning well in companies, in fact, qualified workers are being hired for positions with appropriate requirements. Therefore, special attention should be paid to the development and training of employees since its risk indicator is the highest of the considered elements.

Theoretical contribution of the paper is model, which allows to quantify and identify micro-level personnel related risks in cross border cooperation and present linguistic interpretation of these risks. Presented approach using fuzzy logic, allows to quantify and identify micro-level risks and present linguistic interpretation of these risks.

From practical point of view developed model could be adapted by a user for a specific small and medium-sized enterprise or by policy makers for obtaining broader and more representative results on risks related to international activities of the enterprises. In addition, this model can be used for personnel related risk assessment in other spheres of SME's activities.

Future areas of research include development of more complex fuzzy logic model for personnel risk analysis and inclusion to it specific aspects, related exclusively to the international activities of the companies.

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INFORMATION ABOUT AUTHORS

Tatiana Yurievna Kudryavtseva
Doctor of Economics, Professor, Graduate School of Industrial Economics, Peter the Great St. Petersburg Polytechnic University, Saint-Petersburg, Russia (194064, Saint-Petersburg, Polytechnic street, 29); ORCID https://orcid.org/0000-0003-1403-3447 e-mail: kudryavtseva_tyu@spbstu.ru

Angi Erastievich Skhvediani
Candidate of Economic Sciences, Associate Professor, Graduate School of Industrial Economics, Peter the Great St. Petersburg Polytechnic University, Saint-Petersburg, Russia (194064, Saint-Petersburg, Polytechnic street, 29); ORCID https://orcid.org/0000-0001-7171-7357 e-mail: shvediani_ae@spbstu.ru

Maiia Sergeevna Leukhina
Master Student, Graduate School of Industrial Economics, Peter the Great St. Petersburg Polytechnic University, Saint-Petersburg, Russia (194064, Saint-Petersburg, Polytechnic street, 29); ORCID https://orcid.org/0009-0003-1303-8235 e-mail: maya.leuhina@mail.ru

Alexandra Olegovna Schneider
Master Student, Graduate School of Industrial Economics, Peter the Great St. Petersburg Polytechnic University, Saint-Petersburg, Russia (194064, Saint-Petersburg, Polytechnic street, 29); ORCID https://orcid.org/0009-0007-6039-5672 e-mail: shnejder.ao@edu.spbstu.ru

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Т. Ю. Кудрявцева , ***А. Е. Схведиани*** ✉, ***М. С. Леухина*** , ***А. О. Шнейдер***

Санкт-Петербургский политехнический университет Петра Великого, г. Санкт-Петербург, Россия

shvediani_ae@spbstu.ru

Аннотация. Малые и средние предприятия (МСП) имеют ограниченные ресурсы для противодействия рискам, возникающим в ходе осуществления международной деятельности. В рамках данного исследования тестируется гипотеза о том, что квалификация сотрудников является основной сферой рисков в ходе осуществления приграничного сотрудничества. Для анализа кадровых рисков, возникающих в ходе осуществления приграничного сотрудничества, была разработана модель нечеткой логики. Для проведения оценки различные факторы риска и их элементы были идентифицированы и сформулированы как лингвистические переменные. Далее с использованием экспертных оценок была построена и оценена система на основе нечеткой логики. Уровень риска рассчитывался с помощью инструментария MATLAB fuzzy logic. Методика была апробирована на данных МСП, занимающихся импортно-экспортным операциям между Финляндией и Россией в период 2020–2021 гг. Кадровый риск, связанный с экспортно-импортными операциями между Россией и Финляндией, согласно экспертной оценке, был оценен как выше среднего. Такой элемент, как развитие и обучение персонала, имеет наибольший коэффициент и является областью повышенного риска. Второе по величине значение коэффициента риска принадлежит элементу, связанному с управлением персоналом. Наименьшее значение имеют элементы, связанные с процессами мотивации и найма. Вклад исследования в теорию состоит в разработке модели, которая позволяет анализировать и идентифицировать кадровые риски приграничного сотрудничества на микроуровне и предоставляет лингвистическую интерпретацию этих рисков. Данная модель может быть использована менеджерами МСП или региональными руководителями для получения более детальных результатов анализа о рисках, связанных с международной деятельностью.

Ключевые слова: кадровый риск; анализ рисков; оценка рисков; нечеткая логика; малые и средние предприятия.

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ИНФОРМАЦИЯ ОБ АВТОРАХ

Кудрявцева Татьяна Юрьевна
Доктор экономичнских наук, доцент, профессор Высшей инженерно-экономической школы Санкт-Петербургского политехнического унивеститета Петра Великого, г. Санкт-Петербург, Россия (194064, г. Санкт-Петербург, ул. Политехническая, 29); ORCID https://orcid.org/0000-0003-1403-3447 e-mail: kudryavtseva_tyu@spbstu.ru

Схведиани Анги Ерастиевич
Кандидат экономических наук, доцент Высшей инженерно-экономической школы Санкт-Петербургского политехнического унивеститета Петра Великого, г. Санкт-Петербург, Россия (194064, г. Санкт-Петербург, ул. Политехническая, 29); ORCID https://orcid.org/0000-0001-7171-7357 e-mail: shvediani_ae@spbstu.ru

Леухина Майя Сергеевна
Магистрант Высшей инженерно-экономической школы Санкт-Петербургского политехнического унивеститета Петра Великого, г. Санкт-Петербург, Россия (194064, г. Санкт-Петербург, ул. Политехническая, 29); ORCID https://orcid.org/0009-0003-1303-8235 e-mail: maya.leuhina@mail.ru

Шнейдер Александра Олеговна
Магистрант Высшей инженерно-экономической школы Санкт-Петербургского политехнического унивеститета Петра Великого, г. Санкт-Петербург, Россия (194064, г. Санкт-Петербург, ул. Политехническая, 29); ORCID https://orcid.org/0009-0007-6039-5672 e-mail: shnejder.ao@edu.spbstu.ru

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