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ANALYSIS OF THE SAFETY CLIMATE AS AN IMPORTANT SEGMENT OF PROJECT EFFICIENCY: THE CASE OF INFRASTRUCTURE PROJECTS IN SERBIA

Nenad Milijić, Ivan Mihajlović, Ivan Jovanović, Dejan Bogdanović, Anđelka Stojanović

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Abstract: This paper presents the results of the analysis of the safety climate as an important segment in the efficient achievement of project goals. The paper aims to validate and test the proposed conceptual model of safety climate. Hence the SEM (Structural Equation Modeling) methodology was applied. Statistical analysis was performed using the software package SPSS 18.0 and Smart PLS 3. The five-hypothesis model was developed and tested on a sample of 96 participants employed in 6 project-based companies, whose main activity was the realization of infrastructure projects. Results of empirical research confirm the formulated hypotheses, but show significant differences in the strength of the observed impacts. Within research conclusions the special emphasis is placed on those safety climate factors whose improvement would increase the efficiency of project tasks realization. Finally, the results indicate the fact that development of an adequate safety climate positively influences the efficient achievement of project results.

Keywords: Safety climate, infrastructure projects, employees, project efficiency

1. INTRODUCTION

Infrastructure projects, such as the construction of roads, railways, airports and power plants, have a very important position in economic and social development, especially in developing countries [1,2], among which there is Serbia, as well. However, such projects face increasingly complex both technical and technological, as well as socio-economic challenges. The reason is the rapid changes occurring in the environment on the one hand, and on the other hand, the long time of realisation and complexity of infrastructure projects, difficulties in their realization, as well as high levels of uncertainty [3]. In such conditions, from the point of view of the contractor, it is necessary to achieve goals such as time, costs, quality, performance and occupational safety [4]. In practice, occupational safety often remains a marginalized area. Additionally, the participation of numerous stakeholders in infrastructure projects realization, using complex technology, contributes to a high level of occupational safety risks, as well as frequent work-related injuries [1]. The need for better occupational safety performances is obvious. Numerous research papers suggest that a more efficient occupational safety managemet system is needed through improving safety risks management, communication, occupational safety monitoring, as well as safety training [5,6,7,8]. A more efficient occupational safety managemet system would improve establishing a positive safety climate that would have a long-term impact on reducing work-related injuries and ultimately more efficient project realization. Therefore, there is a need for research aimed at discovering organizational factors which can influence the improvement of the safety climate on infrastructure projects, i.e. finding solutions applicable in practice [9].

The safety climate can be defined as the perception of employees in terms of values, attitudes, policies and procedures related to occupational safety in an organization [10]. Since the safety climate positively influences occupational safety and work-related injury prevention [11], this concept has been in the focus of research by numerous authors. Their goal was to determine influential factors, both demographic and organizational. It is necessary to emphasize that these factors do not have to be uniform in different economies (due to the impact of cultural differences), and the focus is on unifying the perception of employees [12,13]. Therefore, in order to create a positive safety climate, it is necessary to achieve a consensus on the opinions, attitudes, perceptions and ultimate perceptions of safety among the members of various expert groups on the project [14]. In this way, the basis for a satisfactory occupational safety is formed. Finally, under such conditions, the project goals achievement is facilitated [13].

This paper presents the results of the analysis of the safety climate as a significant factor in the efficient achievement of project goals in the case of infrastructure projects in Serbia.

2. RESEARCH HYPOTHESES AND THE CONCEPTUAL MODEL

2.1. SAFETY AWARENESS AND COMPETENCE AND PROJECT GOALS

Safety awareness and competence of employees represents a result of an adequate implementation of an occupational safety management system [15]. Employees who are dedicated to occupational safety, with adequate safety perceptions at their workplace experience significantly less work-related injuries than employees who are not adequately dedicated to this problem [15,16]. Naturally, in order for employees to behave safely at their workplace, it is necessary to have certain knowledge related both to work activities and to the field of occupational safety in general [17,18,19]. In fact, these skills and knowledge enable adequate information reception, problem solving, critical thinking, interpersonal relationships management, communication and other factors that increase dedication in implementing occupational safety procedures [17]. However, in a project environment, companies with limited resources focus on the progress of project activities and the quality of work. Then, the members of a project team give lower priority to occupational safety. Under such conditions, the role of top management is crucial in promoting safety culture and developing safety awareness of employees. Indirectly, improving project performance is more effective in this way [15]. Thus we suggest:

Hypothesis H1: *Safety awareness and competence positively affects project goals achievement.*

2.2. MANAGEMENT SUPPORT AND AND PROJECT GOALS

According to numerous authors, management support and commitment to occupational safety belongs to a group of key safety factors [20,21,22,23]. Therefore, occupational safety management should be one of the main tasks of management [24]. Occupational safety management is an adequate indicator of the positive and supportive attitude of the management towards the integrity and safety of employees [25] and is reflected through various actions such as increased financial investments in safety, regular training and safety education, introduction of new safety programs, etc. [23]. Supporting these actions and perceiving positive attitudes and management actions by employees leads to the reduction of work-related injuries and the improvement of occupational safety [26,27]. Finally, maintaining a balance between occupational safety and work pressure should be one of the management's priorities [23]. Hence, we suggest:

Hypothesis H2: *Management support to safety positively affects project goals achievement.*

2.3. SAFETY TRAINING AND PROTECTIVE EQUIPMENT AND PROJECT GOALS

In 1931, Heinrich, one of the pioneers in the study of occupational safety, stated that among the most important factors that cause work-related injuries are physical and psychological incompetence of employees, negligence, lack of supervision and control, and finally, lack or inadequate safety training [28]. However, in preventing work-related injuries, the greatest responsibility is on the management of the organization [29]. In order to improve the safety of employees at workplaces, work organization should be improved. In addition to other elements in the field of work organization that have been discussed previously, the safety training and the adequate use of protective equipment should be emphasized here [30]. Besides introducing employees in the technical aspect of performing work tasks in a correct and safe way, safety training also has a psychological dimension in terms of raising awareness [17,31]. Hence, we suggest:

Hypothesis H3: *Safety training and protective equipment positively affects project goals achievement.*

2.4. SAFETY PRACTICE AND PROCEDURES AND PROJECT GOALS

The working conditions, i.e., safety of employees at workplaces are improved by an efficient implementation of an occupational safety management system. The occupational safety management system is implemented through the application of safety practices and procedures adopted by the top management of the organization [32]. Management and safety supervisors are responsible for enforcing all safety practices and procedures [30]. The consistent operation of the authorities in this area reduces the number of work-related injuries, while the performance of the entire organization and project improves concurrently [33,34]. Thus we suggest:

Hypothesis H4: *Safety practice and procedures positively affects project goals achievement.*

2.5. ORGANIZATIONAL ENVIRONMENT AND PROJECT GOALS

Kwon and Kim conducted a study of a work environment with the aim of identifying elements that affect occupational safety. According to them, the competencies and motivation of employees do not have such a significant impact on occupational safety compared with the safety features of the work environment and the compliance of safety procedures with real requirements [35]. On the other hand, certain authors emphasize that individual perceptions of safety perceptions and subjective evaluation of the organizational environment have the same importance for occupational safety and behavior in accordance with safety rules as well as objective safety measures of the organizational environment [36].

Some research studies are based on the fact that there are organizational differences in the large and small companies, i.e., public and private companies, causing a different attitude towards occupational safety. These conclusions refer to the ergonomic, physical and chemical factors of the work environment related to occupational safety [37].

Organizational environment is also determined by working conditions, i.e., project activities dynamics and work pressure, which has a direct impact on the safety climate. Therefore, there is the obvious interdependence of the organizational environment and the efficiency of the project goals achievement [34,38]. Hence, we suggest:

Hypothesis H5: *Organizational environment positively affects project goals achievement.*

Based on the 5 proposed research hypotheses, a conceptual model of positive effects was formed, which is shown in Figure 1.

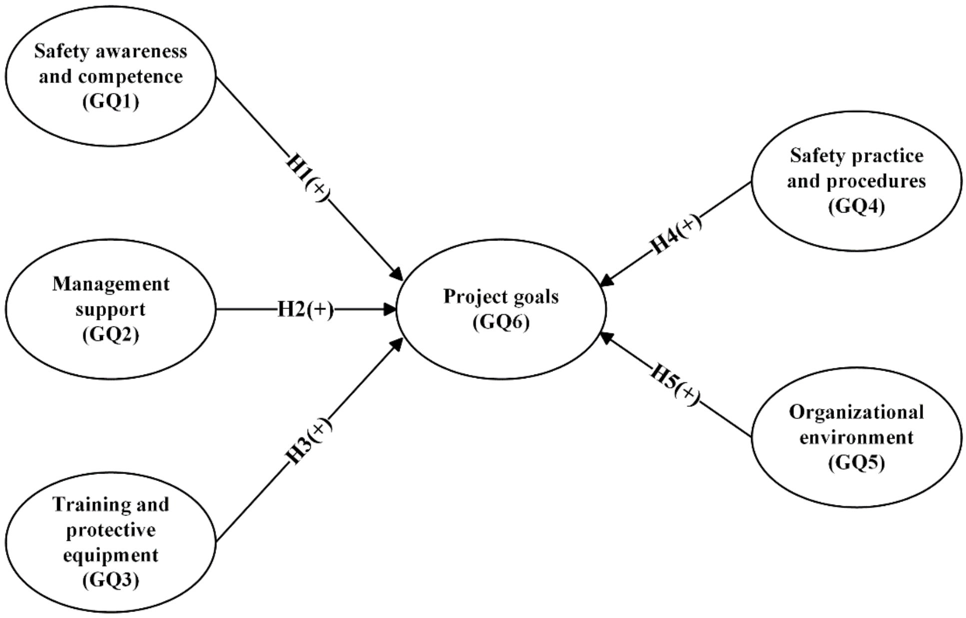


Figure 1. Conceptual model

3. RESEARCH METHODOLOGY

Within the conducted research, the methodology of the questionnaire was used to collect data. The questionnaire was developed by the authors of this paper, based on previous research of occupational safety issues in production companies, as well as available relevant literature [10,23,34,38,39,40,41]. The questionnaire paper consists of two parts. The first part contains 8 questions demographic in character, while the second part consists of 36 questions divided into 6 groups related to the field of safety climate on the projects.

3.1. SAMPLING AND DATA COLLECTION

Anonymous survey was conducted among employees within the 6 project-based companies at the territory of Serbia. The business scope of these companies is the realization of infrastructure projects. The survey was conducted on a sample of 96 employees A five-point Likert scale with values from 1 to 5 was used for grading the responses, where 1 meant the lowest importance (I strongly disagree with the given statement), and 5 meant the highest importance (I strongly agree with the given statement).

Demographic characteristics of the participants of the survey are presented in Table 1.

Table 1. Demographic characteristics of the sample

Variables	Category	N	Percentage %
Gender	Male	82	85.4
	Female	14	14.6
Age	Less than 25 years	0	0
	26 – 35 years	11	11.5
	36 – 45 years	41	42.7
	46 – 55 years	33	34.4
	Above 56 years	11	11.5
Years of work experience	Less than 5 years	12	12.5
	6 – 10 years	13	13.5
	11 – 20 years	23	24.0
	21 – 30 years	31	32.3
	Above 31 years	17	17.7
Educational level	Elementary school	6	6.3
	High school	57	59.4
	Higher education	11	11.5
	University	22	22.9
	Doctoral degree	0	0
Project position	Manager	20	20.8
	Production workers	67	69.8
	Workers indirectly related to production	9	9.4
Size of company	Less than 10 employees	0	0
	11 – 50 employees	44	45.8
	51 – 250 employees	52	54.2
	Above 251 employees	0	0
Company's existence (years)	Less than 6 years	0	0
	6 – 10 years	0	0
	11 – 20 years	59	61.5
	21 – 30 years	37	38.5
	Above 31 years	0	0
Ownership structure of the company	Domestic ownership	59	61.5
	Foreign ownership	37	38.5
	Mixed ownership	0	0

4. RESULTS

The set of collected data was analyzed using statistical tool software packages SPSS 18.0 and Smart PLS 3.

4.1. DESCRIPTIVE STATISTICS

Table 2 shows the descriptive statistics of the studied sample. Standard statistical parameters are shown: sample size, range, mean, standard deviation and variance.

Table 2. Descriptive statistics

Variable	N	Range	Mean		Std. Deviation	Variance
			Statistic	Std. Error		
Q 1_1	96	4	4.47	.082	.807	.652
Q 1_2	96	3	4.57	.072	.707	.500
Q 1_3	96	3	4.19	.085	.837	.701
Q 1_4	96	4	4.10	.106	1.041	1.084
Q 2_1	96	4	3.55	.115	1.123	1.260
Q 2_2	96	4	3.16	.134	1.317	1.733
Q 2_3	96	4	3.00	.126	1.231	1.516
Q 2_4	96	4	3.12	.131	1.283	1.647
Q 2_5	96	4	3.44	.111	1.084	1.175
Q 2_6	96	4	3.35	.130	1.273	1.621
Q 3_1	96	4	2.93	.129	1.267	1.605
Q 3_2	96	4	3.83	.103	1.012	1.025
Q 3_3	96	4	3.56	.117	1.150	1.322
Q 3_4	96	4	3.56	.107	1.044	1.091
Q 3_5	96	4	3.66	.110	1.074	1.154
Q 3_6	96	4	3.56	.113	1.103	1.217
Q 4_1	96	4	3.46	.111	1.085	1.177
Q 4_2	96	4	3.64	.111	1.087	1.181
Q 4_3	96	4	3.35	.118	1.161	1.347
Q 4_4	96	4	3.25	.127	1.248	1.558
Q 4_5	96	4	3.44	.103	1.014	1.028
Q 4_6	96	4	3.33	.116	1.139	1.298
Q 4_7	96	4	3.25	.121	1.188	1.411
Q 5_1	96	4	3.01	.123	1.210	1.463
Q 5_2	96	4	2.97	.116	1.137	1.294
Q 5_3	96	4	2.96	.122	1.196	1.430
Q 5_4	96	4	3.16	.122	1.191	1.417
Q 5_5	96	4	2.95	.123	1.208	1.460
Q 5_6	96	4	3.14	.120	1.175	1.381
Q 6_1	96	4	3.29	.103	1.004	1.009
Q 6_2	96	4	3.48	.096	.940	.884
Q 6_3	96	4	3.48	.090	.882	.779
Q 6_4	96	4	3.45	.105	1.025	1.050
Q 6_5	96	4	3.43	.113	1.103	1.216
Q 6_6	96	4	3.06	.087	.856	.733
Q 6_7	96	4	3.27	.094	.923	.852

4.2. THE RELIABILITY ANALYSIS OF THE SAFETY CLIMATE INDICATORS ON THE PROJECTS

High quality statistical data processing requires the determination of the validity and reliability of the measuring scale as a starting point, i.e. of the results obtained on the basis of the collected and processed data [42]. For this purpose, the assessment of internal consistency of the instrument for data collection was carried out using Cronbach alpha test [43,44]. Cronbach's formula is used to calculate the average values of the correlation between items of the measuring instrument (alpha coefficient) when the answers to questions are rated on the basis of the degree of the given threshold (e.g. The Likert five-point scale).

According to this test, the values of the coefficient α greater than 0.70 represent a good possibility of modeling results of the questionnaire based on the considered population [45,46]. Judging by the obtained Cronbach alpha coefficients of internal consistency of the sets of questions in the questionnaire (GQ1 – GQ6), the validity and reliability of the questionnaire on safety climate on the projects was proved (Table 3). In this way, one can expect reliable results of the conducted research.

Table 3. Interconsistency coefficients of the questionnaire

Groups of questions	Number of Items	Cronbach alpha coefficient
GQ1 (Safety awareness and competence)	4	0.731
GQ2 (Management support)	6	0.926
GQ3 (Training and protective equipment)	6	0.874
GQ4 (Safety practice and procedures)	7	0.896
GQ5 (Organizational environment)	6	0.788
GQ6 (Project goals)	7	0.863

4.3. FACTOR ANALYSIS

4.3.1. Kaiser–Meyer–Olkin (KMO) and Bartlett test

In order to apply factor analysis, testing the adequacy of the sampling was performed (MSAs - Measures of adequacy sampling) using a Kaiser-Meyer-Olkin (KMO) test and Bartlett test of sphericity. On the basis of the literature recommendations, the minimum acceptable value for KMO indicator is 0.6, while the level of significance of the Bartlett's test is $p \leq 0.05$ [47].

The obtained result of the KMO coefficient of the studied sample is 0.842, which indicates that the collected data are suitable for the application of the factor analysis. Furthermore, the Bartlett test of sphericity indicates significance ($\chi^2 = 3331.223$, $p < 0.000$), indicating that there are correlations among the items within the measurement instrument [48].

4.3.2. Correlation matrix of the safety climate factors

Next sections of the study examine the correlation between the 36 items of the questionnaire on the safety climate on the projects. For large samples the correlation coefficients at the 0.01 level are considered acceptable, while with the smaller ones the level of acceptability of correlation coefficients is 0.05 [49]. In the studied sample most of correlation coefficients in the matrix fulfill the eligibility level of 0.05. This indicates a significant correlation between the 36 items of the questionnaire, and therefore the application of factorial analysis is justified. Correlation matrix of six factors of safety climate on the infrastructure projects is shown in Table 4.

Table 4. Inter-correlations among six safety climate factors within proposed model

Coefficient	GQ1	GQ2	GQ3	GQ4	GQ5	GQ6
GQ1	1.00					
GQ2	0.31	1.00				
GQ3	0.43	0.77	1.00			
GQ4	0.33	0.65	0.67	1.00		
GQ5	0.57	0.53	0.32	0.42	1.00	
GQ6	0.23	0.57	0.58	0.43	0.42	1.00

4.3.3. Exploratory Factor Analysis

Exploratory factor analysis (EFA) was carried out with the aim of extracting the main factors of safety climate on the infrastructure projects. The relations between the measured variables are such that on the basis of the recorded correlations the regrouping into a smaller set of variables can be performed, which represents a concise and understandable structure of the studied field [50].

By EFA analysis conducted over the set of 36 variables connections and relationships among the proposed groupings were established, and the obtained results (factor loadings and communalities) are shown in Table 5. Factor loading represents the correlation coefficient between the original variable and the extracted factor. Communality variable (h^2) is defined as a proportion of its total variance calculated on the basis of common factors [51].

Table 5. Results of Exploratory Factor Analysis

Variable	Factor loading						Communalities
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	
Q 1_1						.848	.747
Q 1_2						.862	.766
Q 1_3						.639	.637
Q 1_4						.867	.771
Q 2_1				.590			.720
Q 2_2				.597			.796
Q 2_3				.697			.793
Q 2_4				.601			.699
Q 2_5				.708			.763
Q 2_6				.624			.783
Q 3_1					.493		.540
Q 3_2					.802		.751
Q 3_3					.788		.811
Q 3_4					.634		.727
Q 3_5					.593		.715
Q 3_6					.737		.784
Q 4_1	.688						.688
Q 4_2	.678						.780
Q 4_3	.784						.772
Q 4_4	.780						.775
Q 4_5	.567						.641
Q 4_6	.793						.645
Q 4_7	.665						.592
Q 5_1			.758				.656
Q 5_2			.876				.815
Q 5_3			.813				.789
Q 5_4			.724				.769
Q 5_5			.722				.688
Q 5_6			.553				.589
Q 6_1		.644					.631
Q 6_2		.622					.571
Q 6_3		.591					.555
Q 6_4		.747					.617
Q 6_5		.730					.676
Q 6_6		.688					.569
Q 6_7		.771					.690

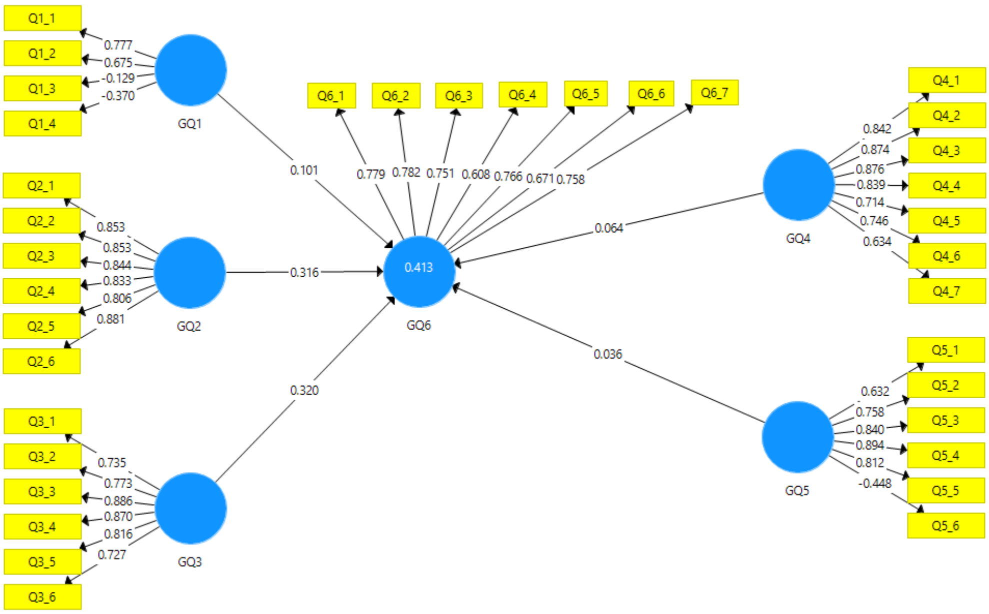
4.4. STRUCTURAL MODEL

Partial least squares structural equation modeling (PLS-SEM) was utilized to statistically validate the final model of safety climate on infrastructure projects. Using the Smart PLS 3 software package the links between the safety climate factors and project goals achievement were analyzed.

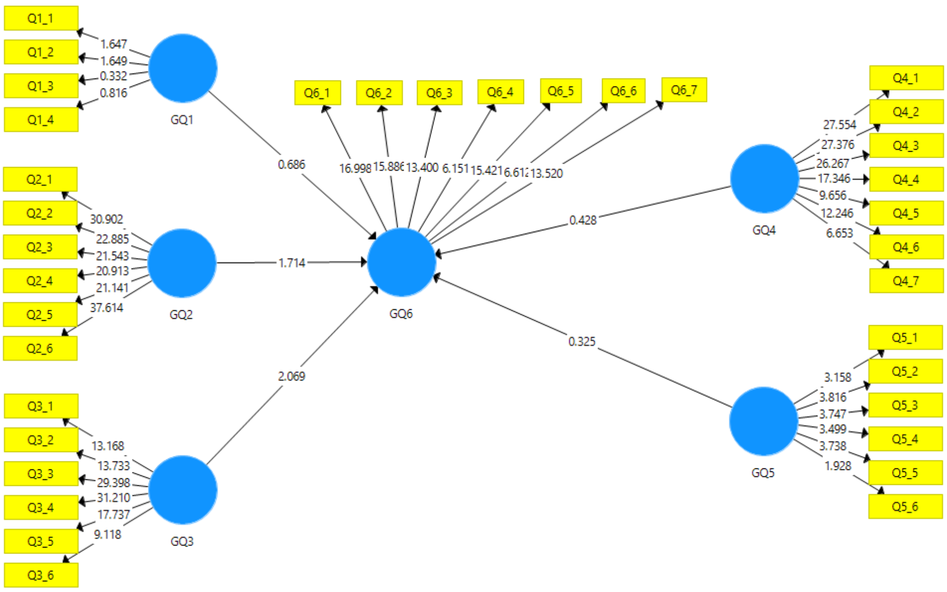
As with any other methodology in the development and in application of PLS-SEM methology, there are numerous supporters and critics [52,53], in particular with regard to its validity in relation to the standard SEM analysis [54]. However, PLS-SEM analysis is very suitable in situations where the sample is smaller than 100, which is the case in the conducted research [55,56]. In addition, this approach represents a good compromise between the theoretically oriented approaches based on the covariance and the predictive power of the Artificial Neural Networks, and provides excellent precision during the assessment of smaller samples [57]. For the above reasons, the number of studies in the field of management, economics and other disciplines witch using the PLS-SEM methodology is growing [54,56,58,59].

The PLS method focuses on maximizing the variance of the dependent variables explained by an independent variable instead of composing a covariance matrix as in the case of a standard SEM analysis [54].

Figure 2 shows the results of the structural model analysis. Figures 2a) shows the regression coefficients values. They explain the strength of the links between dependent and independent variables and relate to the impact of Safety awareness and competence (GQ1), Management support (GQ2), Training and protective equipment (GQ3), Safety practice and procedures (GQ4) and Organizational environment (GQ5) at the dependent variable Project goals (GQ6). The determination coefficient (R^2) is displayed on the graphical symbol of the dependent variable. It indicates the participation of the explained variability in the total, or how variations of the dependent variables are explained by the predictor variable. Figure 2b) shows the t-test values.



a)



b)

Figure 2. Structural model: a) Path coefficients, b) T statistics

Table 6 shows the results of the structural model.

Table 6. Results of structural model

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Safety awareness and competence -> Project goals	0.101	0.041	0.147	0.686	0.493
Management support -> Project goals	0.316	0.296	0.184	1.714	0.087
Training and protective equipment -> Project goals	0.320	0.326	0.155	2.069	0.039
Safety practice and procedures -> Project goals	0.064	0.071	0.149	0.428	0.669
Organizational environment -> Project goals	0.036	0.018	0.110	0.325	0.745

5. DISCUSSION

Based on the results shown in Table 1, it can be seen that from a total of 96 respondents, 14.6% were female and 85.4% were male. The highest number of respondents possessed a high school education diploma (59.4%), while 22.9% went through university education. This data is in accordance with the data that 69.8% of the people participating in the survey were production workers, and only 20.8% of them were managers. Less than a half of the respondents (42.7%) was in the most productive age, from 36 to 45 years of age, while only 11.1% of respondents belonged to the most experienced employees, older than 56 years. Of the total number of surveyed employees, 12.5% of them have been working less than 5 years in the company in which they are currently employed, while 32.3% of respondents has been engaged in the company for more than 21 years, which indicates a rather experienced workforce on infrastructure projects. All research participants are employed in small and medium-sized companies.

The results of descriptive statistics (Table 2) show that the mean of the worst-rated issue by respondents is 2.93, while the mean of the best-rated issue is 4.57. It is obvious that employees have a pronounced negative attitude towards a certain number of issues from some groups (Management support – GQ2 and Organizational environment – GQ5). On the other hand, respondents very positively assessed the questions from the group Safety awareness and competence – GQ1. The standard deviation in respondents' responses ranges from 0.707 to 1.317, and such a great range indicates a different perception of the safety climate on projects among production and non-production workers, or managers.

Reliability and validity of the measurement scale was determined based on the estimates of the interconsistency of the instrument used to collect the data by means of the Cronbach alpha test. Based on the results shown in Table 3 (values of Cronbach alpha coefficients for all 6 groups of questions are higher than the recommended value of 0.7), it can be concluded that there is an internal consistency of all 6 groups of the control model.

In order to apply factor analysis, the testing of the adequacy of sampling was performed using KMO and Bartlett test of sphericity. The value of KMO indicator of the tested sample was 0.842. Bartlett test of sphericity indicates significance (χ^2 = 3331.223, $p < 0.000$), meaning that there are important correlations among the items within the measuring instrument (the majority of the correlation values is around, or above 0.50) (Table 4). Based on these indicators it is evident that the given data are suitable for the application of factor analysis.

By applying Exploratory Factor Analysis (Table 5) 6 factors were extracted (groups of questions). These results indicate the correctness of the formation of the conceptual model.

The structural model of the safety climate on infrastructure projects with the results of the hypothesis testing is shown in Figure 2. The obtained results show that all five hypotheses are confirmed. All the regression coefficients (path coefficients) have positive values, which means that all five independent variables have a positive effect on the dependent variable project goals. Observing the results of the t-test, it is noted that it is only hypothesis H3 (Safety training and protective equipment positively affects project goals achievement) that is confirmed and acceptable with statistical significance, since the t-test value is above the recommended value of 1.96 ($t=2.069$; $p<0.05$).

Such results point to the conclusion that Management support, as well as Training and protective equipment, have a rather strong impact on the project goals achievement (regression coefficients are 0.316; 0.320, respectively). This means that only well trained workers, with the use of adequate protective equipment, and with the absolute support of the management, can perform their work tasks without interruption. In such circumstances, project goals achievement is facilitated significantly. On the other hand, the remaining three elements of the safety climate (Safety awareness and competence, Safety practice and procedures and Organizational environment) perform a positive, but quite small impact on project goals achievement (the regression coefficients are 0.101; 0.064; 0.036 respectively). The possoble explanation, why, based on the opinion of the respondents, Organizational environment has the lowest impact on occupational safety, i.e. on project goals achievement, most likely lies in the high unemployment rate in Serbia. Therefore, workers are forced to perform their work activities in bad organizational conditions, all due to the fear of losing their jobs. Finally, the most likely reason why Safety awareness and competence and Safety practice and procedures have very low impact on project goals achievement is the following. Project goals are always a company's priority, so despite satisfactory safety awareness and competence, workers do not abide by a number of safety practices and procedures, in order to achieve company priorities (project goals).

6. CONCLUSION

The analysis of safety climate factor on infrastructure projects, as a significant segment of project efficiency, provides some important conclusions. Safety climate on infrastructure projects can be reliably described using 36 questions (variables), grouped into 6 groups (latent variables), representing a proposed conceptual model. The study found that all variables describe formed groups in a reliable and valid way. The final conclusion was done by analyzing the structural model, i.e. testing hypotheses, based on the conceptual model. Safety awareness and competence, Management support, Training and protective equipment, Safety practice and procedures and Organizational environment positively affect effective project goals achievement. However, Safety awareness and competence, Safety practice and procedures and Organizational environment have a positive, but quite small impact on project goals achievement. By strengthening the safety climate, a higher level of occupational safety on projects would be achieved, the number of work-related injuries would be reduced, and project efficiency would be further accelerated. In order to achieve this, it is necessary to improve Organizational environment along with providing adequate Management support, so that all safety competences of the workers will come to the fore. Such a level of development of safety climate on projects can be achieved only when occupational safety is of the same priority as project goals.

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