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Effect of Sub-Contractor Selection on Construction Project Success in Turkey

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ABSTRACT

The construction industry leads the national economy in developing countries. It involves industrial requirements, such as developing technologies, related expertise, demand variability, high production speed and progress. Firms in the industry use subcontractors to produce fast, effective solutions. Therefore, projects' success varies depending on subcontractors' rather than general contractors' performance. This study aimed to develop a model of selection criteria for subcontractors and measure their impact on project success. Construction firms using subcontractors were chosen as the target group. Data on the selection of subcontractors from 93 construction firms that employ subcontractors in their projects were collected through a survey. The impact of the subcontracting selection factor on projects' overall performance was presented with five hypotheses and modeled using a structural equation model. The weight of each selection factor in the subcontracting selection and the impact on the overall project were designated in the model by determining the standardized regression weights (β). Four hypotheses were accepted and one rejected. This study may contribute to the prequalification conditions in the process of selecting subcontractors in the future.

Keywords: Subcontracting, subcontractor selection factors, subcontractor project performance.

1. INTRODUCTION

Subcontracting is a popular term within the construction industry and Doloi et al.'s [1] model, which measures the impact of contractor selection on project success, was developed (by adding safety performance) and used to measure subcontractors' impact on project success[2]. General contractors tend to work with subcontractors for reasons such as cost, better management of time and quality and an opportunity to work with experts [3].

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Subcontractors can generally be defined as parties that co-operate with general contractors based on their skills and competencies in the execution of construction projects. The construction industry has a hierarchical structure consisting of the general contractor contracting with the customer, subcontractors working with the general contractor and numerous members of staff working in both.

A construction project is awarded to a general contractor, who is an expert in its field and has completed prior projects, to conduct a specific project. The general contractor is responsible for the management process, such as executing agreements with the clients, project finance, supplying material and equipment and reviewing the progress of the project [4]. The main purpose of contractor selection is to reduce the project risk, maximize the quality and maintain a strong relationship between the project parties. The same concept is applied to the subcontractor selection process. According to Albino and Garavelli [5], the success of subcontractors is the key element of the performance of the general contractor. This is asserted by the study conducted by Mbachu [6] as well. According to some proprietors, the cost is the most fundamental criterion in the contractor selection process. However, following the research conducted, more consideration should be given to a selection process with multiple factors in contractor selection. Many general contractors and owners only deal with the lowest bidder and ignore other criteria in their consideration. A similar situation applies to the subcontractor selection process [7].

Subcontractors have a vital role in the construction industry and are specialized contractors hired to conduct specific tasks in a project. In many projects, especially building projects, the work carried out by subcontractors can amount to 80–90% of the total work. Hinze and Tracey [8] and Dainty et al. [9] stated that 57% of the gross amount of construction work (including small-scale maintenance repairs) consists of consumables and subcontracting services. The larger and the more complex a project becomes, the more subcontractors are needed [10]. Therefore, whenever a large construction project takes place, the number of subcontracts increases. Miller et al. [11] pointed out that material and service purchases from suppliers and subcontractors make up approximately 75–80% of the total cost. Kumaraswamy and Matthews [12] asserted that subcontractors can contribute up to 90% of the total construction project value. Subcontracting is a solution to uncertainty and complexity whereby trust, technical and financial risks are shared between the parties [13]. The subcontractor selection procedure varies according to conditions related to the necessities, environment and agreement. The more important the agreement is, the more attention should be paid to the selection and purchase processes [14].

The Turkish construction industry is one of the industrial sectors that uses subcontracting most comprehensively. Subcontracting services are considered as a fundamental and unchanging feature of construction-based organizations [15]. Subcontracting enables employment at the minimum and encourages expertise in construction projects [16]. Topcu [17], Ulubeyli et al. [18] and Polat et al. [19] conducted research related to the selection of subcontractors in Turkey. This study offers a different performance measurement model from others. The research objective is to measure the impact of subcontractor selection criteria on project success. In the literature section of this study, national and international studies related to subcontracting selection are examined. Hypotheses regarding this research are put forward. Finally, the findings and conclusions are presented.

2. LITERATURE RESEARCH

Albino and Garavelli [5] explained the complexity of subcontractor selection among companies operating in the construction industry. According to Albino and Garavelli, this process is conducted following the intuition and experiences of the firm managers rather than depending on the data. Five measurement factors were defined, and each was measured with a single question and evaluated statistically. Hatush and Skitmore [20] identified a systematic multi-criteria decision analysis technique based on utility theory and evaluation according to the capacities of different subcontractors for proposal and selection in a construction project. Data on 24 measurement factors obtained from 5 contractors were evaluated. Okoroh and Torrance [21] and Abbasianjahromi et al. [22] used the fuzzy logic theory for subcontractor selection in repair projects. Dloi et al. [1] measured project success with (1) soundness of the business and workforce, (2) planning and control, (3) quality performance and (4) past performance. For this measurement, the effects of these factors on each other are included in the model. Piasny and Paslawski [23] researched the progress of quality by selecting the most appropriate subcontractor using survey data obtained from 8 construction projects. Bingöl and Polat [24] stated that general contractors' selection of subcontractors according to the lowest price results in them working with poor-quality subcontractors. They introduced a performance measurement system taking key performance indicators (KPI) as a model while mentioning the importance of performance assessment in the subcontractor selection process. Lew et al. [25] developed a structural equation model that evaluates the data obtained from 162 general contractor companies. Yu et al. [26] developed a model called PreCSAM for contractor selection. This model offers a three-stage evaluation with criteria such as the lowest offer and the best value.

In the doctoral study by Ulubeyli [15] on subcontractor selection in the Turkish construction industry, a fuzzy decision-making base model was developed and tested in a construction project. Graduate studies on the subcontractor selection process were carried out with the analytic hierarchy process (AHP) method [27] and the analytic network process (ANP) method [28]. Polat and Damci [29] determined the importance levels of the criteria used in the subcontractor selection of Turkish companies in international construction projects. Aydın et al. [30] solved the subcontractor selection problem through the TOPSIS and VIKOR methods. Ulubeyli et al. [18,31] examined the subcontractor selection of Turkish companies in international construction projects based on fuzzy importance weights. Erdoğan [32] used the TOPSIS methodology for risk-based subcontractor selection. The studies conducted mostly aimed to determine the importance level of subcontractor selection criteria, and no research has been conducted on the impact of these selection criteria on project success.

The analysis methods used in the literature research on subcontractor selection are generally based on AHP or first-generation statistical methods (such as regression analysis). Structural equation modeling, referred to as a second-generation data analysis technique [33], has been used in several studies (e.g. [1,25]). The structural equation model provides a systematic and comprehensive approach to a complex research problem in a single process by modeling the relationships between many dependent and independent variables [34]. In this study, a model was developed to measure the direct effects of expressions of subcontractor selection criteria on project success. The developed model is based on the model previously used by Dloi et al. [1]. In this model, the safety performance factor was included in addition to Dloi et al.'s measurement factors.

3. SUB-CONTRACTOR SELECTION IN CONSTRUCTION PROJECTS

Many general contractors work in the construction area and hire subcontractors. A general contractor can deal with some parts of the work itself; however, it should work with expert subcontractors to complete most of the project successfully. While a good subcontractor contributes to the success of a project, a bad subcontractor can lead a project into trouble.

The selection of the right subcontractor increases the general contractor's success in construction projects [35]. Different models have been presented in the literature regarding the importance of subcontractor selection. Mbachu [6], in his study, examined the effective criteria to evaluate the ability of subcontractors to be invited to participate in the tender process. Subcontractors are listed according to the decision makers' opinions in line with the determined criteria. In the selection of the best candidate, their parameters are considered, including the weight of each decision maker, the weight of each criterion and the subcontractor scores. Wang et al. [36] applied fuzzy logic and genetic algorithms together to develop a fuzzy hybrid model in subcontractor selection. In their work, they divided projects into sub-projects via fuzzy logic and assigned the best subcontractor to each sub-project. Ng and Luu [3] collected the prior records of successful and unsuccessful subcontractors and submitted a model that they built on case-based reasoning. Hartmann and Carteling [37] searched for the criteria that general contractors give more importance. The results obtained showed that the price is the most important criterion for general contractors. Kozlovska and Strukova [38] stated that reliability performance should be added to the determining key factors for the selection of a contractor or subcontractor.

In this study, the fundamental factors that can be used for subcontractor selection by general contractor companies in construction projects were identified using an evaluation undertaken through literature research on similar studies (e.g. [1, 25, 29, 39, 40]) in the construction industry or in different organizations. On the other hand, as subcontractors are a kind of contractor, they make use of the factors formed for the selection of the general contractor. In this context, five selection factors that play a role in subcontractor performance were investigated in this study: (1) soundness of the business and workforce (SBW), (2) planning and control (PC), (3) quality performance (QP), (4) past performance (PP) and (5) safety performance (SP). The overall project success (OPS) was determined through the variables of duration, budget, quality and cost. Please find the measurement factors used in the study in Table 1.

Table 1 - Measurement factors used in the research.

Factors and indicators	**Source reference**
Soundness of business and workforce (SBW)	
• Technical expertise (SBW1)	
• Defects liability attitude (SBW2)	
• Site safety records (SBW3)	Doloi et al. [1]
• Successful past projects (SBW4)	Lew et al. [25]
• Yearly turnover (SBW5)	
• Relevant work experience (SBW6)	
• Working capital (SBW7)	

Table 1 - Measurement factors used in the research. (Continue)

Factors and indicators	Source reference
Planning and control (PC)	
• Plant maintenance programs (PC1)	
• Work method statement (PC2)	Doloi et al. [1]
• Work's quality record (PC3)	Lew et al. [25]
• Flexibility in the critical paths (PC4)	
• Failure to comply with quality specifications (PC5)	
• Failure in on-time delivery (PC6)	
Quality performance (QP)	
• Tender quality (QP1)	Doloi et al. [1]
• Tender timeliness (QP2)	Lew et al. [25]
• Safety initiatives record (QP3)	Polat and Damci [29]
• Quality control and quality assurance programs (QP4)	
• Query response timeliness (QP5)	
• Failure to perform safety requirements (QP6)	
Past performance (PP)	
• Length of relationships (PP1)	Doloi et al. [1]
• Regulation knowledge (PP2)	Lew et al. [25]
• Turnover fluctuations (PP3)	Polat and Damci [29]
• Time in business (PP4)	
• Overall trade experience (PP5)	
• Past record of conflicts and disputes (PP6)	
Safety performance (SP)	Subramaniam et al. [39]
• Safety control (SP1)	Lew et al. [25]
• Investigation of causes of accidents (SP2)	Polat and Damci [29]
• Safety trainings (SP3)	
• High safety motivation (SP4)	
Overall project success (OPS)	
• On-time project delivery (OPS1)	Doloi et al. [1]
• On-budget project delivery (OPS2)	Tam et al. [40]
• Desired quality outcomes (OPS3)	
• Cost savings (OPS4)	

4. RESEARCH METHODOLOGY

A survey was conducted to determine the effect of subcontractors on the success of construction projects. The survey form used in this study was prepared following principles determined using scientific research methods [41]. The survey questions were evaluated on a five-unit Likert scale from “totally agree to totally disagree.”

The sample of this study, which examined the impact of subcontractors on project success, was determined as construction projects hiring subcontractors. The judgment sampling method was used to identify the research sample due to the lack of a database showing

projects in which subcontractors were hired. The subcontractors that participated in the research consisted of technical staff and firm managers. For this reason, project managers, project supervisors, technical office managers, chefs and engineers in the construction area were determined as the target respondents of the research. Following the determination of the sample and target respondents, 150 construction companies, in conformity with the determined factor, were contacted in person, by telephone or by e-mail; 98 participants formed the scope of the study, and 5 survey forms were omitted from the assessment due to insufficient information. Therefore, the information obtained from 93 participants in the survey, which aimed to measure the impact of subcontractors on project success, was assessed following the guidance.

In this study, the structural equation model was used to analyze the data. Since the structural equation model involves adding the effect of each measurement indicator to the model, it has frequently been used in recent years [42,43,44]. The structural equation model was used to examine the hypotheses proposed above and presented in Figure 1. To increase the strength of the structural equation model [45,46,47], the width of the sample was upgraded with the bootstrap algorithm, and the value of the bootstrap was set as 500.

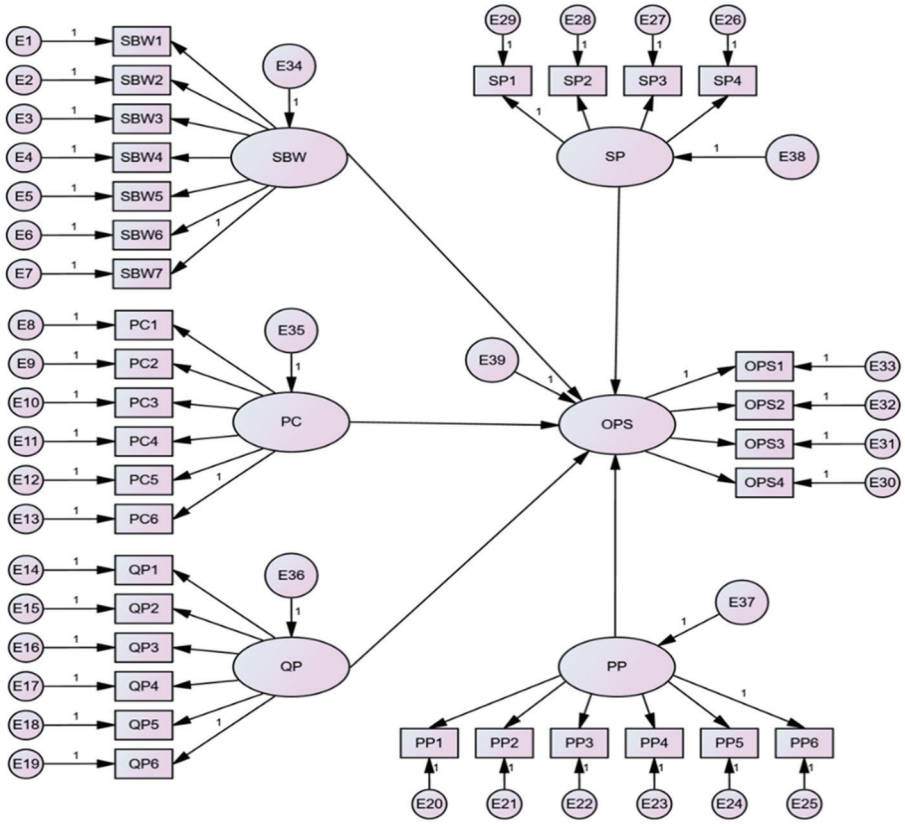

Figure 1 - Hypothetical model of the relationship between subcontractor performance and overall project success.

The studies mentioned above provided a theoretical base for the model created in this study and presented in Figure 1. Five research hypothesis were presented in this study to investigate the impact of five fundamental factors used in subcontractor selection (SBW, PC, QP, PP and SP) on the overall project success (OPS).

H1: The soundness of the business and workforce (SBW) has a positive and significant effect on the overall project success (OPS).

H2: Planning and control (PC) have a positive and significant effect on the overall project success (OPS).

H3: Quality performance (QP) has a positive and significant effect on the overall project success (OPS).

H4: Past performance (PP) has a positive and significant effect on the overall project success (OPS).

H5: Safety performance (SP) has a positive and significant effect on the overall project success (OPS).

5. RESEARCH FINDINGS

Information on the participants in the research is presented in Table 2. The table shows that 42% of the participants are in the age range of "30–40," 29% are 30 years old or younger, 23% are in the age range of "40–50," 5% are in the age range of "50–60" and 1% are aged 60 years or more. The distribution of project types found in the survey is 54% "general projects," 27% "public projects," 15% "road projects" and 4% "infrastructure projects." Information regarding the subcontracting companies that had their contracts terminated during the project are also presented in Table 2: 70% of the participants responded "no," 29% responded "yes" and the response of 1% was "unspecified".

Table 2 - Information about the participants.

	Distribution	**Rate**
Age range of the participants	30 and under	29%
	From 30 to 40	42%
	From 40 to 50	23%
	From 50 to 60	5%
	60 and above	1%
Project type	Public project	27%
	Road project	15%
	Infrastructure project	4%
	General project	54%
Did you terminate the contract of any subcontractors?	Yes	29%
	No	70%
	Unspecified	1%

In the scope of the research, reliability analysis of the data to be used in the evaluation of the five subcontractor selection factors that have an impact on project success was performed by means of the SPSS program. Reliability analysis aims to determine the consistency of the questions among the measurement subjects. The Cronbach's alpha (α) values obtained as a result of the reliability analysis and the average and standard deviation values regarding the variables are presented in Table 3.

Table 3 - Mean (μ), standard deviation (σ), Cronbach's alpha (α) and average variance extracted (AVE) values of the variables used in the study.

Factor	Item number	Mean (μ)	Standard deviation (σ)	Cronbach's alpha (α)	AVE
Soundness of the business and workforce	7	3.800	0.73945	0.880	0.497
Planning and control	6	3.916	0.70167	0.825	0.414
Quality performance	6	3.932	0.72844	0.826	0.691
Past performance	6	3.950	0.64024	0.769	0.412
Safety performance	4	4.151	0.82305	0.858	0.749
Overall project success	4	4.048	0.73593	0.796	0.412

The Cronbach's alpha (α) value is an average of the standard change in weight that is found by the ratio of the sum of the variances stated in the questions in the sample to the overall variance. Whenever the Cronbach's alpha (α) value is 0.70 and above, the questions stated in that group are considered as reliable [48]. The Cronbach's alpha value of all the variables provided in Table 3 is above 0.70 and therefore the measurement is statistically reliable. As presented in Table 3, all the obtained average variance extracted (AVE) values exceed the recommended value of 0.50 [49]. Eliminated measurement items (SBW2, SBW5, SBW7, PC3, PC6, QP1, QP2, QP5, PP3, PP4, SP4) were not taken into consideration in the evaluation as they weaken the strength of the model when calculating the AVE value.

The structural model recommended for the research method was analyzed using Amos 23.0. The recommended goodness-of-fit (GOF) values obtained from the solution of structural models are stated in Table 3. The recommended level of GOF values was obtained from the studies by Tawalare et al. [50], Durdyev and Ihtiyar [51], Zhao et al. [52] and Civici [53].

The reliability of the results obtained from the model was interpreted using the GOF results given in Table 4. As a result of the analysis of the model, it can be seen that the GOF values are above the recommended threshold values, and this indicates that the B values obtained as a result of the analysis are significant and reliable. In Figure 2, the standardized regression weight values are presented regarding the measurement items related to the variables used in the model.

Table 4 - Results of GOF and the recommended level of GOF measures.

Goodness-of-fit (GOF) measure	Results of GOF	Recommended level of GOF
X^2/degree of freedom	1.137	≤3.0
GFI (goodness-of-fit index)	0.863	≥0.90
AGFI (adjusted goodness-of-fit index)	0.765	≥0.80
NFI (normal fit index)	0.897	≥0.90
CFI (comparative fit index)	0.986	≥0.90
TLI (Tucker–Lewis index)	0.977	≥0.95
IFI (incremental fit index)	0.986	≥0.95
RFI (relative fit index)	0.839	≥0.90
RMSEA (root mean square error of approximation)	0.039	≤0.05

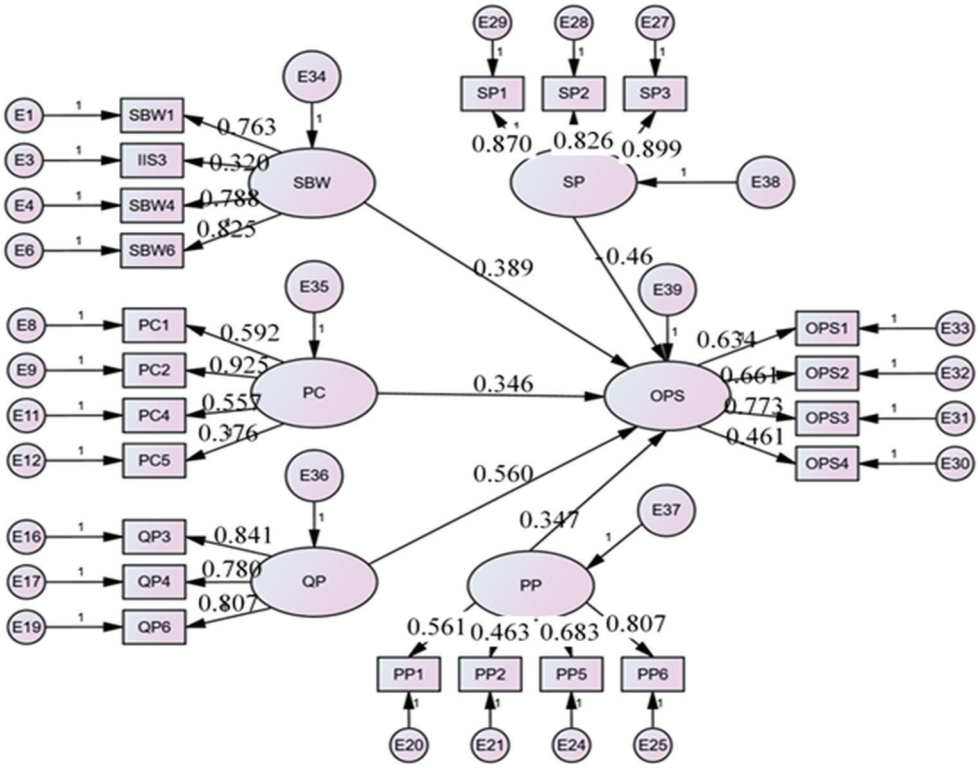

Figure 2 - Measurement model with standardized path coefficients.

The weights for all the measurement items were found to be statistically positive and significant ($p<0.05$) except for the impact of safety performance (SP) on the overall project success, which was found to be statistically negative and not significant ($p=0.617$, $p>0.05$).

6. CONCLUSIONS

The main purpose of the contractor selection process is to reduce the project risk, maximize the quality and ensure timely completion of the project by maintaining a strong relationship between the project parties. The same process applies to the subcontractor selection process. This process is quite important for companies that have a project commitment. In this study, the performance factors of subcontractors used in construction projects were assessed and the impact of the subcontractor performance on the overall project performance was measured. Construction firms that use subcontractors were selected as the target group, and data were collected through the survey method. A reliability analysis was conducted on the data obtained from 93 participants. As in every scientific study, this study was carried out within a certain scope due to resource limitations. These limitations were time, financial resources, human thinking and interpretation capacity.

Four of the five hypotheses proposed in this study were accepted, and only safety performance was rejected. An examination of Figure 2 shows that "quality performance" (QP) is the leading criterion among the subcontractor selection factors. These factors were observed as a situation that was overemphasized by the participants during the face-to-face data collection process. Numerous contractual sanctions and audit frequency regarding quality performance made these factors important for the general contractors' selections. The soundness of the business and workforce (SBW) was measured as a secondarily important factor. The underlying reason for the importance of the factor is that subcontractors represent general contractors in their work. They continue to work with the subcontractors with which they have previously worked and been satisfied in forthcoming projects. General contractors give importance to the past performance (PP) and the planning and control (PC) of subcontractors. While these two factors show the success of the completed work, they are also a reference for the projects that they will perform. Safety performance puts pressure on overall project success, both at the subcontractor level and at the general contractor level. Since it is the responsibility of the general contractor to ensure work safety in the project, subcontractor employees are often expected to follow only the safety instructions. Therefore, although it is an important factor for general contractors, there is no statistically significant relationship between the overall project success and this situation.

The most important contribution of this study is that four factors that have a direct positive effect on project success and the expressions used in their measurement can be used in the pre-evaluation process of subcontractor selection. Thus, general contractors will realize more successful projects with subcontractors that have a certain prequalification. The most important limitation of this study is the small number of participants. This situation affects the number of measurement factors. In the future, considering the subcontractors' fields of activity, more research with more measurement factors and more participants is recommended.

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