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Identifying Manageable Scope Creep Indicators and Selecting Best Practice Strategies for Construction Projects

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Abstract: Many construction projects suffer from changes to the scope of the project during the construction phase. Because the changes ultimately lead to substantial cost overruns and major scheduling delays, scholars and practitioners worldwide are assessing their impact and the critical causes behind them, but are finding it challenging to ameliorate or eliminate them with appropriate strategies. To mitigate the consequences of scope creep, it is beneficial to first identify the critical root causes so that appropriate strategies can later be implemented. The aim of this study is to identify the scope creep indicators (SCIs), then analyze and quantify the impacts of implementing best practices. For this purpose, a structured survey was developed and distributed to qualified professionals involved in construction projects. The research team collected 37 completed surveys, and used appropriate statistical data analysis to obtain the results. The results revealed that communication within owners, the number of oversight entities, and the project's location are three important factors that lead to scope creep, and that alignment, partnering, front-end planning, material management, and dispute prevention are important to mitigating its cost. The outcomes of this study will assist project managers in identifying potential sources of scope creep early in their projects, and in applying appropriate BPs to minimize their impact throughout the execution of construction projects.

1 INTRODUCTION

The construction industry suffers from cost escalation and schedule delays, especially in large-scale projects, where hundreds of individuals are involved in the planning phase, over multiple years (Hussain 2012; Sfapour et al. 2018). Consequently, completing construction projects on time and on budget is challenging (Ciccarelli 2012; Safapour et al. 2019). Many studies have been conducted to investigate the critical root causes of poor project performance (Shrestha and Maharjan 2018; Khanzadi et al. 2018; Xue et al. 2018; Habibi and Kermanshachi, 2019; Safapour and Kermanshachi 2019; Kermanshachi and Rouhanizadeh 2019), and researchers have found that scope creep/change is one of the critical root causes of cost overruns and schedule delays in large-scale construction projects (Hussain 2012; Amoatey and Anson 2017; Habibi et al. 2018a and 2018b; Safapour et al. 2018). Scope changes can seriously affect labor productivity (Hanna and Gunduz 2004; Kermanshachi et al. 2017) and project cost and schedule performance (Dixon 2006; Thakore 2010; Turk 2010; Du et al. 2016; Kermanshachi and Safapour 2019).

Neimat (2005) defined scope changes as uncontrolled and unexpected changes that are opposed to user expectations and requirements throughout the execution of a project. Similarly, Bronstein (2010) explained it as a stepwise and/or sudden change of scope that is usually implemented to keep the project sponsor satisfied. In 2014, Freshman-Caffrey stated that scope changes refer to the tasks required for a project that extend beyond the initial expectations. Likewise, Sindi (2018) described scope changes as the "sum total of all the activities that need to be performed in order to achieve the pre-determined goals of the project."

Gurlen (2003) believed that when a project scope is not clearly and accurately defined, unclear and vague information on what is to be achieved and/or how the project will be accomplished can lead to unfavorable consequences and eventually result in scope creep. Similarly, Amoatey and Anson (2017) and Turk (2010) explained that the main root causes of scope creep are a lack of clarity in the scope definition, and lack of formal review and approval procedures.

Best practices (BPs) are construction strategies that can improve the performance of construction projects and assist in managing them effectively (Safapour et al., 2017; Safapour and Kermanshachi 2019). The Construction Industry Institute (CII) introduced 15 BPs for managing construction project performance; ten of them could be most practicable for mitigating the cost of scope creep. The ten selected BPs are constructability, team building, alignment, partnering, front-end planning, risk assessment, material management, dispute prevention, quality management, and lessons learned, and their application can lead to a considerable reduction in the number of change orders issued. For instance, applying the partnering strategy helps the number of scope creep, as well as the cost of the change orders throughout the execution of a project (Abudayyeh, 1994). The definitions of the selected BPs are listed in Table 1. The challenge is in knowing how to select the appropriate strategy to mitigate the cost.

Table 1- List of Construction Best Practices

Best Practice	BPs Explanation	Previous Studies
Partnering	Companies may partner in order to achieve specific business objectives by maximizing the effectiveness of each participant's resources.	Wang (2016)
Alignment	The condition where appropriate project participants are working within acceptable tolerances to develop and meet a uniformly defined and understood set of project priorities.	Griffith (2001)
Front end planning	The process through which owners develop sufficient strategic information to address risk and commit resources in order to maximize project success.	Hwang (2012)
Constructability	The optimal use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives.	Kifokeris (2017)
Team building	A project-focused process that builds and develops shared goals, interdependence, trust and commitment, and accountability among team members.	Spatz (2000)
Risk assessment	The process used to identify, assess, and manage risk. The project team evaluates risk exposure for potential project impact to provide focus for mitigation strategies.	Jannadi (2003)
Material management	An integrated process for planning and controlling all necessary efforts to make certain that the quality and quantity of materials and equipment are appropriately specified in a timely manner, are obtained at a reasonable cost, and are available when needed.	Akintoye (1995)
Dispute prevention	Use of a dispute review board as an alternative to litigation. The Dispute Review Board technique provides a process for addressing disputes in their early stages, before the dispute affects the progress of the work, creates adversarial positions, and leads to litigation.	Gebken (2006)
Quality management	This strategy incorporates all activities conducted to improve the efficiency, contract compliance, and cost effectiveness of design, engineering, procurement, QA/QC, construction, and start-up elements of construction projects.	Chandra (1993)
Lesson learned	Knowledge gained from experience, successful or otherwise, for improving future performance.	Costa (2006)

Although a few studies have attempted to determine how utilizing best practices reduces the number of scope changes, no study has been conducted to assess and prioritize their impact. Therefore, the overall goal of this study is to identify and prioritize a list of causes of weighted scope creep to analyze how their impact can be minimized by implementing appropriate best practices.

As stated earlier, issuing scope creep in a construction project is one of the major causes of poor project performance. The best strategy for mitigating the scope creep is to identify the causes of rework at the right time. Thus, the aim of this study is to determine the significant scope creep indicators for a construction project, and to learn how to select the appropriate best practice strategies to mitigate the cost of scope creep. For this purpose, the following objectives were formulated: (1) identify the potential scope creep variables, (2) determine the significant scope creep indicators, (3) weight and rank the scope creep indicators, (4) assess the impact of implementing each construction best practice on managing the unfavorable consequences of scope creep, and (5) weight the identified best practices for mitigating the impact of scope creep. This study will assist researchers and professionals in accurately assessing the construction scope changes at the right time to prevent substantial cost overruns.

2 RESEARCH METHODOLOGY

A six-step research methodology was developed and implemented, as shown in Figure 1. The details of each step are explained below.

Step 1. A comprehensive literature review was conducted to define the focus of the present study, and the potential variables of scope creep were identified.
Step 2. A structured survey was developed according to the potential variables of scope creep, and was distributed to experienced practitioners. Thirty-seven (37) surveys were completed and returned.
Step 3. A preliminary data analysis was conducted after the data was collected.
Step 4. According to the type of collected data (continuous and seven-point Likert scale), appropriate statistical tests, including the two-sample *t*-test and Kruskal-Wallis test, were performed to determine the significant scope creep indicators. Then, the significant scope creep indicators were statistically weighted and ranked.
Step 5. As the collected data related to the level of implementing BPs was the seven-point Likert scale, the Kruskal-Wallis statistical test was used to determine the impact of each BP on the challenges associated with the causes of scope creep. Then, the impact of each significant BP was measured and assessed.
Step 6. Finally, the results were analyzed and discussed.

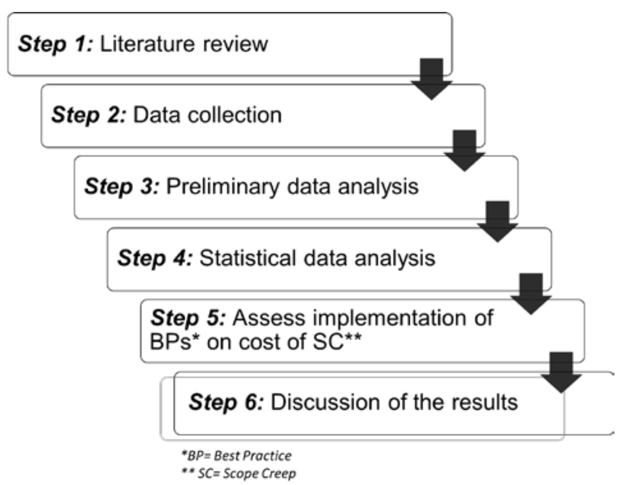

Figure 1. Research Approach.

Cohen's d method (Cohen, 1988) was used and applied to quantify the weight of each scope creep indicator. The value of Cohen's d was obtained by the difference in means of two sample groups, divided by standard deviations. Equation (1) was applied for the two-sample *t*-test:

$$Cohen's\ d = \frac{Mean_2 - Mean_1}{SD_{pooled}} \qquad (1)$$

where $Mean_1$ and $Mean_2$ are the means of two sample groups (cost of scope creep associated with two sample groups), and the denominator is pooled standard deviation.

$$SD_{pooled} = \sqrt{\frac{(n_1-1)SD_1^2+(n_2-1)SD_2^2}{n_1+n_2-2}} \quad (2)$$

According to equation (2), SD_1 and SD_2 are associated with the standard deviation of the two sample groups, respectively. Additionally, n_1 and n_2 are components that correspond to the first and second sample sizes, respectively. The significant SCIs were then ranked, based on the calculated values of their impact, and the weighted rank sum method was used to calculate the normalized weight of each significant scope creep indicator and facilitate their ranking.

$$w_i = \frac{T-r_i+1}{\sum_{j=1}^{T} T-r_j+1} \quad (3)$$

where w_i , r_i and, T represent "weight of the *i*th scope creep indicator, rank of the *i*th scope creep indicator, and total number of scope creep indicators, respectively.

3 DATA COLLECTION

The authors developed a set of potential scope creep indicators, based on the existing literature, and a survey was developed to collect essential data, with each potential SCI becoming one question of the survey. The questions were divided into two main sections: (1) general project description, and (2) potential scope creep indicators. Figure 2 shows two samples of the questions. As presented in this figure, the questions were designed in two forms: continuous number and seven-point Likert scale. The first part of the questionnaire consisted of 18 questions that pertained to general information and project characteristics; the second part consisted of 27 questions that were associated with the potential SCIs.

Question 29. How many financial approval authority thresholds existed on your project?

Question 45. How effective was the communication within owner stakeholders?

Extremely Effective			Moderate			Not at all
1	2	3	4	5	6	7
☐	☐	☐	☐	☐	☐	☐

Figure 2. Two Example Questions of the Survey.

The survey was distributed to qualified professionals who had worked in the construction industry for at least ten years. After two follow-up emails, 37 completed surveys were collected.

4 PRELIMINARY DATA ANALYSIS

Based upon 37 construction projects, Table 2 presents the breakdown of information pertaining to the baseline, actual budgets, and schedules for the construction phase, as well as the cost of scope creep. This table indicates that the medians of the baseline and actual budget were roughly $25 million and $30 million, respectively. The maximum actual cost was approximately $2.5 billion, and the maximum baseline budget was approximately $0.7 billion. Additionally, the medians of the baseline and actual schedules were 12 months and 15 months, respectively.

Table 2 indicates that the maximum cost of the scope creep was roughly $9.5 million; the median cost was approximately $725 thousand. To avoid any bias created by larger projects, the cost of the scope creep was normalized, based on the size of the projects, and was used for the rest of the analyses conducted. The normalized cost of scope creep was computed according to the cost of scope creep, divided by the baseline budget of the construction phase.

Table 2- Preliminary Data Analysis for Collected Data

Category	Construction Phase	Minimum	Median	Maximum
Cost	Baseline Budget	$337,721	$26,600,000	$740,100,000
	Actual Cost	$327,000	$29,349,500	$2,500,000,000
Schedule	Baseline Schedule	4 Months	12 Months	40 Months
	Actual Schedule	3 Months	15 Months	46 Months
Scope creep	Owner-Derived	$5,970	$725,127	$9,600,000

5 STATISTICAL DATA ANALYSIS

The next step of this study was to determine the significant SCIs by applying appropriate statistical analysis. As illustrated in Figure 3, each potential SCI indicator leads to a cause of change order (scope creep). Next, each of the cause of scope creep derives scope creep in construction projects.

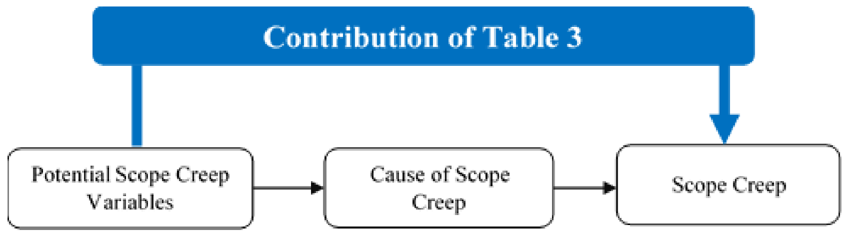

Figure 3. Formation Structure of Scope Creep Indicators.

The significant SCIs were statistically determined and are presented in Table 3. The first column shows a list of potential SCIs; the second column depicts the causes of scope creep, which were identified from the literature review; and the third column illustrates the results of the statistical tests (i.e., *P*-Values). As mentioned earlier, the questionnaire consisted of numerous and seven-point Likert scale questions. Therefore, two-sample *t*-tests and Kruskal-Wallis tests were conducted for numerous and Likert scale questions, respectively. As can be seen in Table 3, the statistical analysis was first conducted at the 0.05 significance level, then it was raised it to 0.1 to include more potential SCIs.

Table 3. Significant Scope Creep Indicators and Corresponding *P*-Values

Scope Creep Indicators	Cause of Scope Creep	*P*-Value
SCI-1. Number of active internal stakeholders in decision making process	Impediment of prompt decision-making process (Sanvido, 1998)	0.049**
SCI-2. Alignment quality of internal stakeholders	Poor coordination (Arain, 2005)	0.043**
SCI-3. Number of owner organizations	Impediment of prompt decision-making (Sanvido, 1998)	0.066*
SCI-4. Communication effectiveness within owners	Owner fail to make decision right time (Jadhav, 2015)	0.001**
SCI-5. Number of executive oversight entities above the project management	Low speed of decision making (Chan, 1997)	0.045**
SCI-6. Total number of joint-venture partners in a project	Low speed of decision making (Chan, 1997)	0.079**
SCI-7. Number of funding phases from concept to project completion	Delay in payment (Karthick, 2015)	0.090*
SCI-8. Compare target project schedule against industry/internal benchmarks	Poor scheduling (Wu, 2005)	0.066*
SCI-9. Impact of project location on the project execution plan	Site safety consideration (Hsieh, 2004)	0.081*
SCI-10. Clarity of owner's project goals and objectives	The owner may make changes to achieve certain milestones within a given time frame (Wu, 2005)	0.091*
SCI-11. Project population density	Local residents (Sunday, 2010)	0.090*

** denotes significant differences with 95% confidence; * denotes significant differences with 90% confidence

The results revealed that 11 identified variables have significant impacts on causing scope creep in construction projects. Table 3 indicates that without strong and effective communication among the owners (SCI-4. communication effectiveness within owners), conflicts may occur, making reaching an agreement very time consuming (Kamalirad et al. 2017; Kamalirad and Kermanshachi, 2018).

SCI-6 increases the number of joint venture partners in a project, which means that more stakeholders have authority in the decision-making and approval processes (Kermanshachi et al. 2019; Safapour et al. 2019). In addition, joint venture partnerships lead to shared ownership, which increases the possibility of conflict. Generally, the more people that are involved, the more problems pertaining to decision-making and consensus are likely to occur due to miscommunication (Safapour et al. 2019), increasing the possibility of a greater number of scope changes that lead to major change orders in the construction phase.

Reaching an agreement considering SCI-3, which belongs to the organization category, can be very time consuming due to project probable conflicts between owners. Consequently, the process of decision making by owner entities takes a lot of time and increases the possibility of scope changes and/or modifications. Generally, the more parties that are involved in concerns pertaining to decision making, the more likely are disagreements, which increase the possibility of major scope changes in the construction phase. In the case of SCI-10 (clarity of project scope and goal), if the scope and goal of a project is clarified late in the project, the owners' expectations, as well as the project's limitations, could also be clarified late. If the project scope is not well defined and organized, the requirements for selecting skilled and qualified designers and contractors could also be poorly defined and affect the quality of collaboration and communication between and within stakeholder parties (Nipa et al. 2019). Thus, the probability of scope changes and/or modifications could increase.

The significant SCIs were weighted, using Cohen's d method, and then were normalized, as presented in Table 4. This table indicates that SCI-4 (communication within owners), with the normalized weight of 0.1666, was ranked first in issuing scope creep. This value illustrates that roughly 16.5% of the scope changes occur due to a lack of effective communication among owner entities. As owners need to address potential shared challenges of a construction project, effective communication is a very important factor in the prevention of scope creep. As can be seen in Table 4, the second SCI in the ranking was SCI-5, with a normalized weight of 0.1515. This value indicates that approximately 15% of the scope changes occur because several entities oversee the execution of the construction project.

Table 4. Relative Weighting and Ranking of Scope Creep Indicators

Scope Creep Indicators	Weight	Rank
SCI-4. Communication within owners	0.1666	1
SCI-5. No. of oversight entities	0.1515	2
SCI-9. Impact of project location	0.1363	3
SCI-2. Alignment internal entities	0.1212	4
SCI-3. No. of owner organizations	0.1060	5
SCI-7. No. of funding phases	0.0909	6
SCI-10. Clarity of project goals	0.0757	7
SCI-11. Project population density	0.0606	8
SCI-8. Target project schedule	0.0454	9
SCI-6. No. of joint-venture	0.0303	10
SCI-1. No. of active internal entities	0.0151	11

Selection of the appropriate strategy is based on its level of impact on the management of scope creep. Cohen's d method was used to measure the weight of each implemented BP in reducing the cost of scope creep, and the results are presented in Table 5. This table shows that adoption of alignment, partnering, front-end planning, material management, and dispute prevention strategies result in effective management of the cost of scope changes.

Table 5. Best Practices to Reduce Scope Creep and Corresponding *P*-Values

Best Practices	**Scope Creep**
Constructability	0.186
Team Building	0.346
Alignment	0.052*
Partnering	0.004**
Front End Planning	0.073*
Risk Assessment	0.311
Material Management	0.043**
Dispute Prevention	0.041**
Quality Management	0.475
Lesson Learned	0.243

** denotes significant differences with 95% confidence;
* denotes significant differences with 90% confidence

As depicted in Table 5, implementation of front-end planning and alignment strategies results in better management of scope creep early indicators corresponding to the project group, and enables the owner(s) to address project risks properly and provide the required resources to maximize project success. Implementation of these BPs leads to clarification of the owner's goals and aligns the attitudes of team members to achieve the targeted goals of construction projects. The table also illustrates that implementation of partnering and dispute prevention leads to effective management of late scope changes. Adoption of the mentioned strategies builds an organized framework within which businesslike communication can be established in an organization, reducing the cost of scope changes throughout the life of a construction project.

Table 6 depicts the validated results of ranking the impact of the implementation of each BP on the management of scope creep cost reduction. This table presents that partnering (0.6753) and dispute prevention (0.5152) most effectively manage indicators of change orders associated with scope creep.

Table 6. Weights Associated with Implementation of Best Practices to Mitigate Scope Creep

Best Practices	**Scope Creep**
Alignment	0.3825
Partnering	0.6753
Front End Planning	0.4523
Material Management	0.3277
Dispute Prevention	0.5152

6 CONCLUSION

The aim of the present study was to identify and prioritize the scope creep indicators. Additionally, the significant best practice strategies for mitigating the cost of scope creep were determined. The results demonstrated that communication among owners, the number of oversight entities, and impacts of the project location were the top three critical root causes of scope creep. The results also revealed that alignment, partnering, front-end planning, material management, and dispute prevention were significant in mitigating the cost of scope creep, and that implementing partnering and dispute prevention results in effective management of late scope changes. Adoption of the mentioned strategies builds an organized framework within which businesslike communication can be established, reducing the number and cost of scope changes throughout the life of a construction project. It is anticipated that the outcome of this study will assist project managers in timely recognition of scope creep indicators in order to mitigate scope modifications and/or changes throughout the execution of construction projects.

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