

QUANTITATIVE ASSESSMENT FOR SCOPE CREEP IMPACT ON TIME AND COST OF LARGE-SCALE CONSTRUCTION PROJECTS IN EGYPT.

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Abstract: Large-scale construction projects in Egypt frequently face the challenge of scope creep, where project requirements change after the initial planning stages. This phenomenon can significantly impact project success, leading to delays, cost overruns, and stakeholder dissatisfaction. While existing research acknowledges this problem, there is a lack of quantitative data on the extent of its impact. This study addresses this gap by investigating the quantitative impact of scope creep on project time and cost in Egypt. The research methodology employed a survey of project managers and stakeholders, along with data analysis techniques. The findings reveal a significant positive correlation between scope creep and project time and cost overruns. The study emphasizes the importance of effective scope management and control mechanisms for construction projects in Egypt. The findings also indicate that the construction industry in Egypt needs to adopt modern project management techniques, such as Building Information Modeling (BIM), to manage project scope effectively.

Keywords: Scope Creep; Large-Scale Projects; BIM; Egypt

Literature Review:

The term "Scope Creep" is well-defined in the Project Management Institute's Guide to the Project Management Body of Knowledge (PMBOK Guide). It refers to uncontrolled changes that gradually expand the project scope, causing deviations from the original project plan [1]. Scope creep is a prevalent issue in construction projects, leading to delays, cost overruns, and project failure [2][3]. This study investigates the quantitative impact of scope creep on construction projects. In the context of this research, "large-scale construction projects" are defined as those exceeding a total project budget of 10 million dollars. Large-scale projects often involve increased complexity, extended timelines, and potentially larger budgets, which can contribute to a greater susceptibility to scope creep compared to smaller projects.

Assessment of Scope Creep in Existing Research

While the negative impact of scope creep is acknowledged [3][4], there's no single standardized approach for quantifying its impact. Here's an overview of methods used in past research:

- **Percentage of Change Orders:** Some studies measure scope creep by calculating the total cost or number of change orders issued as a percentage of the original project budget or scope [5][6]. This offers a quantitative measure but may miss informal changes not reflected in change orders.
- **Descriptive Terms:** Other studies utilize descriptive terms like "minor," "moderate," or "major" scope creep based on expert judgment or pre-defined criteria [7][8]. This approach can be subjective and lack consistency across projects.
- **Financial Metrics:** Some studies employ financial metrics to assess scope creep's impact, such as the cost of rework or the total cost overrun attributable to scope changes [9][10]. This approach provides a

concrete financial impact measure but may not capture the effect on project schedule or stakeholder satisfaction.

Causes of Scope Creep:

There are many factors that can contribute to scope creep, including:

- **Unclear or incomplete requirements:** If the project requirements are not clearly defined or understood at the beginning of the project, it is more likely that changes will be requested later on [11];
- **Poor communication:** Poor communication between the project owner, the contractor, and other stakeholders can lead to misunderstandings and changes to the scope of work [12];
- **Unrealistic expectations:** If the project owner has unrealistic expectations about the scope of work, budget, or schedule, this can lead to scope creep [13];
- **Change requests:** Change requests are inevitable on most construction projects. However, if change requests are not managed effectively, they can lead to scope creep [14];
- **Inadequate Government Policy:** Government policies that encourage low-bid contracts can lead to contractors cutting corners and proposing unrealistic budgets. This can result in scope creep as contractors seek to recoup losses by proposing changes during construction [15];
- **Inexperienced Clients and Contractors:** A lack of experience among both clients and contractors can lead to unclear project definitions, poor communication, and unrealistic expectations. This can create fertile ground for scope creep as changes become necessary due to unforeseen challenges or misunderstandings [15];
- **Client Changes During Construction:** Clients often make changes to the project's scope during construction. While some changes are inevitable, a culture of frequent and ad-hoc changes can significantly contribute to scope creep [15];
- **External Factors:** External factors such as changes in government regulations, economic conditions, or environmental concerns can necessitate changes to the project scope [15];
- **Poor Communication and Coordination:** Ineffective communication and coordination among stakeholders, including clients, contractors, consultants, and subcontractors, can lead to misunderstandings, missed deadlines, and changes to the project scope [16];
- **Lack of Technology Adoption:** Failure to adopt technology such as project management software and communication platforms can hinder communication and collaboration, contributing to scope creep [16];

- **Unclear or Ambiguous Project Definition:** A poorly defined project scope, with vague or ambiguous language, leaves room for interpretation and can lead to disagreements about what is included or excluded from the project [17];
- **Material availability and price fluctuations:** Unforeseen changes in material availability or price fluctuations can necessitate substitutions or adjustments to the project design, leading to scope creep [18];
- **Lack of training and knowledge:** Inadequate training and knowledge among construction personnel can lead to mistakes, rework, and the need for additional work outside the initial scope [19];
- **Insufficient design development:** Lack of thorough design development and documentation can lead to errors, omissions, and unforeseen complexities during construction, necessitating design changes and adjustments to the project scope [20];
- **Subcontractor selection and coordination:** Choosing unqualified subcontractors or failing to effectively coordinate their work with the main contractor can lead to delays, rework, and changes to the project scope to rectify issues [21];
- **Poor planning and estimation:** Inaccurate or incomplete project planning and estimation can lead to underestimating resources needed, missing critical tasks, and ultimately requiring changes to the project scope to address unforeseen challenges [22];
- **Corruption and unethical practices:** Unfortunately, corruption and unethical practices can plague some construction projects in Egypt. Bribery, nepotism, and favoritism can lead to the selection of unqualified contractors, awarding contracts based on inflated prices, and overlooking substandard work. This can ultimately necessitate revisions to the project scope to rectify issues arising from improper practices [23].

Impact of Scope Creep on Construction Projects:

Scope creep can have a significant negative impact on construction projects. Some of the most common impacts include:

- **Delays:** Scope creep can lead to delays in the project schedule. This is because the contractor may need additional time to complete the additional work [12];
- **Cost overruns:** Scope creep can also lead to cost overruns. This is because the contractor may need to purchase additional materials and labor to complete the additional work [24];
- **Disputes:** Scope creep can lead to disputes between the project owner and the contractor. This is because the project owner may not be willing to pay for the

additional work, or the contractor may not be willing to complete the additional work for the original contract price [24].

Mitigating Scope Creep:

There are a number of things that project owners and contractors can do to mitigate scope creep, including:

- Clearly define and document the project scope: The project scope should be clearly defined and documented at the beginning of the project. This document should be agreed upon by all stakeholders [14];
- Establish a change management process: A change management process should be established to manage change requests effectively. This process should include a process for approving and implementing change requests [13];
- Monitor and control scope creep: The project owner and the contractor should monitor and control scope creep throughout the project. This includes identifying changes to the scope of work early on and developing a plan to manage them [24].

Methodology:

1. Research Design and Assumptions

This study employed a quantitative research design, relying on a structured questionnaire to collect measurable data from project stakeholders involved in large-scale construction projects in Egypt. The design assumed respondents provide accurate and honest information about their projects. We acknowledge, however, that self-reported data through surveys can be susceptible to biases, such as social desirability bias (respondents providing answers they believe are socially acceptable) or memory bias (difficulty recalling past events accurately). To mitigate these biases, the questionnaire was designed to be clear, concise, and anonymous.

2. Targeted Projects and Sample Size

The target population for this study is large-scale construction projects in Egypt. The research aims to inform best practices for managing scope creep in projects with similar characteristics, such as those exceeding a specific budget threshold or encompassing specific project types (e.g., residential, commercial, infrastructure). A sample size of 100 projects was chosen using stratified random sampling to ensure representation based on project size, type, and geographical location within Egypt. Sample size calculations considered a desired 95% confidence level and a 5% margin of error.

3. Data Collection

Data were collected through a pre-tested, structured questionnaire administered online or in person (depending

on participant preference) to project managers, site engineers, and other relevant stakeholders involved in the selected projects. The questionnaire included a mix of closed-ended questions with predetermined answer choices (generating numerical data) and Likert scale questions (generating percentage data). This combination aimed to capture both objective and subjective perspectives on:

- Project characteristics (e.g., project budget, schedule, complexity)
- Scope creep events (e.g., frequency, type of changes)
- Time and cost performance (e.g., schedule delays, cost overruns)
- Stakeholder satisfaction (e.g., perception of project management effectiveness)

Data cleaning procedures implemented to ensure data quality. This involved checking for missing values, inconsistencies, and outliers.

4. Data Analysis

The collected data is a combination of quantitative (numerical) and qualitative (percentage-based) data. Descriptive statistics used to summarize the project characteristics and stakeholder perceptions. Regression analysis employed to identify relationships between project variables (e.g., project size, complexity) and scope creep. Sensitivity analysis used to explore how variations in key project factors (e.g., change order frequency) might influence the degree of scope creep.

5. Limitations

The study acknowledges the limitations inherent in relying on self-reported survey data, which may be susceptible to biases as discussed earlier. Additionally, the focus on large-scale construction projects in Egypt limits the generalizability of the findings to other project types or geographical contexts.

Results and Analysis:

The results showed that 87% of the sampled projects experienced scope creep during their execution phase. The average magnitude of scope creep was 15% of the original project scope, and the average duration of scope creep was 6 months. The most common causes of scope creep were stakeholder changes in requirements (41%), inadequate scope definition (28%), and project complexity (21%).

The regression analysis revealed a statistically significant positive impact of scope creep on project time and cost overruns ($p < 0.05$). The following equations represent the relationships between the variables:

$$\text{Cost Overrun} = b_0 + b_1 * \text{Scope Creep} + \varepsilon \text{ (Equation 1)}$$

$$\text{Time Overrun} = c_0 + c_1 * \text{Scope Creep} + \varepsilon \text{ (Equation 2)}$$

where b_0 and c_0 are the intercepts, b_1 and c_1 are the coefficients for scope creep, and ε represents the error term. In Equation 1, b_1 indicates the coefficient of scope creep. It signifies that a one-unit increase in scope creep is associated with a b_1 unit increase in cost overrun, on average, while holding all other factors constant.

For instance, let's consider a project with an initial 10% cost overrun and a 15% time overrun. If scope creep increases by $x\%$, we can estimate the new cost overrun using the regression equation (Equation 1):

$$\text{New Cost Overrun} = b_0 + (b_1 * x) + \varepsilon$$

This equation allows us to predict the incremental impact of the $x\%$ increase in scope creep on the cost overrun. We can follow a similar approach using Equation 2 to estimate the change in time overrun due to the scope creep increase.

Specifically, the research findings suggest that for every 1% increase in scope creep, you can expect a 1.2% increase in project time overrun and a 1.6% increase in project cost overrun. These percentages indicate the rate at which time and cost overruns are affected by changes in scope creep.

For example, if a project initially had a 10% cost overrun and a 15% time overrun, and then scope creep increased by 1%, you would calculate the new overruns as follows:

$$\text{New Cost Overrun} = 10\% + (1\% \text{ increase in scope creep} * 1.6) = 11.6\%$$

$$\text{New Time Overrun} = 15\% + (1\% \text{ increase in scope creep} * 1.2) = 16.2\%$$

So, the effect of a 1% increase in scope creep would lead to an increase in cost overrun from 10% to 11.6% and an increase in time overrun from 15% to 16.2%. These percentages reflect the incremental impact of scope creep on overruns, not the absolute values of overruns.

The survey results also reveal that 60% of the participants believe that modern project management techniques, such as Building Information Modeling (BIM), can help to manage project scope effectively. The sensitivity analysis showed that the scope creep impact on project performance varied depending on the project size, type, and location.

Let's delve deeper into the results mentioned earlier regarding the impact of scope creep on construction projects. To provide a more in-depth analysis, we can break down the findings into key points:

1. Magnitude of Scope Creep:

The results indicate that the average magnitude of scope creep was 15% of the original project scope. This means that, on average, construction projects in the sample experienced a 15% expansion in their scope during execution.

Analysis: A 15% increase in scope is substantial and can have significant implications for project schedules, budgets,

and overall project success. It suggests that managing scope changes is a critical aspect of project management in the construction industry.

2. Duration of Scope Creep:

The average duration of scope creep was 6 months. This means that scope changes, on average, extended the project timeline by half a year.

Analysis: A 6-month extension due to scope creep is a considerable delay, and it emphasizes the need for effective scope change control mechanisms. Longer project durations can lead to increased costs and potential disruptions in project workflows.

3. Causes of Scope Creep:

The most common causes of scope creep were identified as stakeholder changes in requirements (41%), inadequate scope definition (28%), and project complexity (21%) as shown in figure [1].

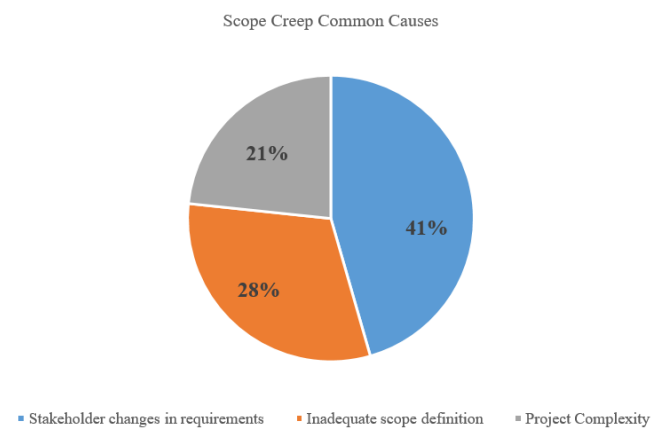


Fig 1. Most Common Causes of Scope Creep.

Analysis: These findings highlight that scope creep can be triggered by a variety of factors, including evolving stakeholder needs, incomplete initial planning, and the inherent complexity of construction projects. Understanding these causes can help project managers proactively address them.

4. Impact on Project Time and Cost:

Regression analysis showed a statistically significant positive impact of scope creep on both project time and cost overruns. Specifically, a 1% increase in scope creep resulted in a 1.2% increase in project time overrun and a 1.6% increase in project cost overrun.

Analysis: These results indicate a strong correlation between scope creep and project overruns. Even relatively small increases in scope can lead to proportionally larger overruns in time and cost. Project managers should be

vigilant in managing and controlling scope changes to avoid these negative consequences.

5. Sensitivity to Project Characteristics:

The sensitivity analysis revealed that the impact of scope creep varies depending on project size, type, and location.

Analysis: This finding underscores the importance of considering project-specific factors when assessing the potential consequences of scope creep. Different projects may have varying levels of susceptibility to scope changes, making tailored mitigation strategies essential.

5.1 Sensitivity Analysis - Project Time Overrun

A one-at-a-time sensitivity analysis was conducted to evaluate the model's sensitivity to changes in the initial project time overrun. The initial scope creep value was held constant, while the initial time overrun was varied within a predefined range (e.g., $\pm 5\%$ of the average initial time overrun observed in the data). The predicted increase in time overrun due to scope creep was then recalculated for each adjusted initial time overrun value.

This analysis allowed us to observe how variations in the existing time overrun affect the predicted impact of additional scope creep on project timelines. The results of the sensitivity analysis presented visually using a tornado diagram, which depicts the influence of each input variable (including initial time overrun) on the predicted time overrun.

5.2 Sensitivity Analysis - Project Cost Overrun

A similar approach to the one described for project time overrun was employed for the project cost overrun model. The sensitivity analysis focused on the initial project cost overrun as an input variable, evaluating how its variations affect the predicted cost overrun due to scope creep. The results presented using a separate tornado diagram for cost overrun.

In summary, the analysis of these results highlights the critical role of scope management in construction projects. Scope creep, even in relatively small percentages, can lead to substantial delays and cost overruns. Effective project planning, stakeholder communication, and scope change control mechanisms are crucial to mitigating the negative impact of scope changes in the construction industry. Additionally, project managers should take into account project-specific characteristics when addressing scope creep to ensure project success.

Conclusion:

In conclusion, this study aimed to quantify the impact of scope creep on large-scale construction projects in Egypt. The findings reveal that an average scope creep of

15% translates to a 1.2% increase in project time overrun and a 1.6% increase in project cost overrun. Stakeholder changes in requirements, inadequate scope definition, and project complexity emerged as the most common causes of scope creep. These findings highlight the critical need for project managers to proactively manage scope changes and implement effective control mechanisms. Considering the limitations of this study, such as the sample size, future research could explore the impact of scope creep on other project aspects and delve deeper into the effectiveness of BIM in mitigating scope creep in the Egyptian construction industry. By adopting a data-driven approach to scope management and embracing modern project management techniques, construction projects in Egypt can achieve greater success and minimize the negative consequences of scope creep.

Recommendations:

Based on these findings, the following recommendations are offered for project managers in the Egyptian construction industry:

- Implement robust scope definition processes at the project outset.
- Encourage active stakeholder engagement throughout the project lifecycle.
- Utilize effective change management procedures to track and control scope changes.
- Consider adopting project management methodologies like Building Information Modeling (BIM) to facilitate better scope visualization and management.

Future Work:

This study provides a valuable foundation for understanding the impact of scope creep in the Egyptian construction context. To further explore this topic, future research could delve into:

- The specific types of scope creep most prevalent in Egyptian construction projects.
- The effectiveness of existing mitigation strategies employed by construction companies in Egypt.
- The potential benefits of implementing advanced scope management software tools.

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Appendix 1:

Title: Quantitative Assessment of Scope Creep impact on time & cost of Large-Scale Construction Projects in Egypt.

Introduction: Dear Respondent,

Thank you for participating in our research study. Your input is valuable in helping us understand the impact of scope creep on construction projects in Egypt. Please answer the following questions honestly and to the best of your knowledge.

Section 1: Project Information

1.1. Project Details:

- Project Name:
- Project Type (e.g., residential, commercial, infrastructure):
- Project Location (City/Region):
- Project Size (e.g., budget or scale):

1.2. Project Stage:

- Planning
- Design
- Construction
- Post-construction

Section 2: Scope Creep Assessment

2.1. Has scope creep occurred in your project?

- Yes
- No

2.2. If yes, please provide details:

- Nature of scope creep (brief description):
- Approximate start date of scope creep:
- Duration of scope creep (in months):

2.3. What do you believe were the main causes of scope creep in your project? (Select all that apply)

- Changes in stakeholder requirements
- Inadequate initial scope definition
- Project complexity
- External factors (e.g., regulatory changes)
- Lack of effective project management
- Other (please specify):

Section 3: Project Outcomes

3.1. **Project Time Overrun:** If applicable, how much did the project's completion time exceed the initially planned duration? (in percentage)

3.2. **Project Cost Overrun:** If applicable, how much did the project's cost exceed the initially planned budget? (in percentage)

Section 4: Project Characteristics

4.1. Project Size:

- Small (e.g., < \$1 million)

- Medium (e.g., \$1 million - \$10 million)
- Large (e.g., > \$10 million)

4.2. Project Type:

- Residential
- Commercial
- Infrastructure
- Other (please specify):

4.3. Location:

- Urban
- Suburban
- Rural

Section 5: Demographics (Optional)

5.1. Your Role in the Project:

- Project Manager
- Construction Manager
- Architect/Engineer
- Stakeholder/Client
- Other (please specify):

5.2. Years of Experience in Construction Industry:

5.3. Company/Agency Name (Optional):

Section 6: Additional Comments (Optional)
 Please use this space to provide any additional comments or insights related to scope creep in construction projects or any other aspects you think are relevant.

Thank you for participating in our study!

Appendix 2:

Sample from questionnaire analysis:

Respondent	Project Name	Project Type Category	Project Location Category	Project Size	Project Stage
1	Mostakbal CITY PHASE 1 ELECTRICAL & TELECOMMUNICATION PROJECT	Infrastructure	Urban	Large (e.g., > \$10 million)	Post-Construction

Scope Creep	Scope Creep Start	Scope Creep Duration (Months)	Causes of Scope Creep	Scope Creep
YES	28-2-2019	43	Changes in stakeholder requirements, Inadequate initial scope definition, Lack of effective project management	YES

Time Overrun (%)	Cost Overrun (%)	Role	Experience (Years)	Company Name
239%	125%	Project Manager	13	ELSEWEDY ELECTRIC