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## Examining the Performance and Responsibility of Consulting Engineers in Advancing Construction Projects in Terms of Costs and Time Management (Intra-Urban Bridges in Mazandaran Province)

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### Abstract

This research evaluated the performance and accountability of consulting engineers in optimizing cost and time management in intra-urban bridge construction projects in Mazandaran province. Classified as applied research with a descriptive survey methodology, the study focused on experts in construction projects due to their specialized knowledge. Key factors influencing project performance included material and labor procurement, on-site resource availability, workforce skill and productivity, stakeholder financial status, consultant and subcontractor expertise, economic and environmental conditions, contractor technology, site and design quality, management practices, and decision-making efficiency. The analysis revealed that factors such as resource availability, workforce productivity, subcontractor expertise, site conditions, and contractor management positively impacted cost and time efficiency. In contrast, delays in decision-making, rework, poor coordination, and environmental challenges were identified as constraints. The findings highlight the importance of addressing these factors to improve project outcomes.

**Keywords:** Cost, Time, Project management, Consulting engineers, Bridge construction.

## 1 | Introduction

In project management with limited resources, the ability to minimize the time and cost of implementation and maximize the quality of the project can play a significant role in profitability [1]. Project planning during the execution of several projects at the same time seeks to determine the appropriate combination and sequence for carrying out the project activities in such a way that the constraints of the priority and delay of the project network are simultaneously satisfied and certain measurement criteria such as the project implementation time, the total cost and the quality of the projects are optimized [2]. In general, the

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management and planning of the implementation of activities and the use of the required resources in a project require various analyses, one of which can be mentioned is modeling for the correct selection of the cost and time of the project implementation; this issue is related to the optimal management of the project and decision making in the conditions a crisis in a significant way [3].

Time, cost, and quality are among the main criteria for the success of a project, and all project managers and planners always seek to complete projects in the shortest time with the lowest cost and at the highest level of quality in order to achieve success in project implementation [4]. Choosing a suitable model to obtain the optimal combination of time, cost, and quality of the project is one of the main challenges facing project managers; how to optimize the three goals of time, cost, and quality in projects and to what extent spending more money on projects reduces the duration of projects. Also, their quality level will increase. The main topic of this study is that due to changes in the external environment, such as weather, lack of space, natural disasters, etc., the time and cost of project implementation are always associated with uncertainty, which causes the implementation to deviate from the schedule, that the critical chain approach is a preventive approach in facing this It is uncertainty [5].

## 2 | The Importance of Cost Management in His Project

Due to the unique characteristics of the construction industry, such as the dynamic organizational structure, long periods of complex processes, unsuitable environmental conditions, the strong dependence of work progress on financial issues and the sensitivity of completing projects on the due date, etc., this industry is a high-risk activity. Previous research has mainly focused on the time aspects of safety and cost studies. Some researchers have examined the risk management of construction projects in the conceptual/feasibility phase and construction design, but they have not examined it in a project life cycle.

It is impossible to eliminate all the risks of construction projects, and it requires a formal assessment and a process for risk management. The slow delay and lack of progress in urban construction projects, which causes the lack of sustainable urban management, indicates the existence of obstacles and root problems in the implementation of valuable urban projects, which seriously threaten the reconstruction and development of the urban space. For this purpose, the development of the road network in urban construction projects such as roads, bridges, and tunnels is very important due to its specific characteristics and limitations. However the biggest concern of financial managers of companies is how to manage the risk of project financing to prevent project failure. Managers are always faced with this question: what are the risks in financing projects that can cause projects to fail?

Today, the success of any project requires proper management of financing methods, but due to the rapid change in the dynamic economic environment today and the unfavorable economic situation of the country due to the existence of foreign sanctions and weakness in the country's financial management, financing methods are facing risks that if it is not managed, it will lead to the failure of projects and irreparable economic consequences for the country and organizations; therefore, identifying the types of financing risks and their management can be very important for organizations and cause success in financing methods. This is necessary for the current research to identify the factors affecting the financing risk of the project. The ever-increasing expansion of financing tools and methods has challenged financial managers with the decision to evaluate the risks of project financing; considering the uncertain nature of projects and the need to spend resources optimally, projects may fail in their financing due to lack of financial obligations. To face; therefore, risk management is well evident and can improve the performance of projects [6].

## 3 | Project Management

Project management has emerged to plan, control, and coordinate complex and diverse industrial, commercial, management, and information technology projects. All projects have one common feature: the design of ideas and activities in the form of new endeavors. There are always elements of risk and uncertainty in the project, meaning that the events and tasks that lead to the complete completion of the project can never

be fully predicted. Many examples of projects have been completed at a cost exceeding the estimated cost or later than the estimated time or have remained unfinished. Such failures are common and are observed in all types of projects in the business industry, especially in the public sector.

The purpose of project management is to anticipate risks and problems as much as possible in advance and to plan, organize, and control project activities to successfully complete the project despite all risks [7]. This process should begin before resources are committed and continue until the activities are completed. Project planning is an essential issue in project management. The existence of scarce resources and the precedence relationships between activities make project planning problematic.

Project planning problems are divided into two groups, resource-constrained project planning problems, and time-constrained project planning problems, according to the duration of the project completion and the level of availability of resources [8]. In resource-constrained project planning problems, various resources are limited, and the goal is to achieve the shortest project completion time [9].

In time-constrained project planning problems, the time for project completion is limited, and the goal is to determine the optimal level of resources and minimize the cost of resource use [10].

In project management, there are three distinct categories of resources:

- I. Renewable resources that are periodically limited, such as human resources and machinery.
- II. Non-renewable resources that are limited throughout the project duration, such as budget.
- III. Resources with double limitations, such as cash flow per unit of time.

## 4 | Factors Affecting Direct Cost

According to the definition of direct cost, the source factor is the most dominant factor affecting direct cost. Because contracting projects, with their complexity and dynamic nature, require a lot of time to complete, they are economically risky and have a long history of cost overruns. Total costs can be classified into direct costs related to doing the work and indirect costs. Direct costs include materials, labor, equipment, and subcontractor costs. They can cover direct costs affected by resources, including the unavailability of materials. The device and professional workforce create many obstacles to achieving better success [11]. Material-related factors affecting project performance can be related to material shortages, transportation, material manufacturing, shortages and changes in materials, and delivery. In some developing countries, such as Indonesia, the increase in the price of materials can affect the project schedule because the contractor has to wait until the price. In environmental factors, environmental clusters, economic, financial, and unexpected price increases of materials had a major impact on the cost performance of the building project. Equipment, especially capital equipment, has different characteristics and requirements for bulk material procurement.

## 5 | Factors Affecting Indirect Cost

Indirect cost, its two main elements that are determined in detail, are construction overhead costs and management costs. Construction overhead can be defined as the total costs incurred by the contractor at the construction site in relation to the delivered labor but are not included in the standard costs of labor, materials, and construction equipment. Management costs for maintaining functional units and personnel that perform general administrative activities, perform supervisory tasks, as well as control, record, and report are related to instructions and other tasks related to the organization, management and administration of construction companies [12].

Similar to physical development, indirect cost is more influenced by management, resource, and environmental factors. Various factors affect overhead and management costs. One of the most common factors that cause the final cost of the project to exceed the initial estimate (overhead) is force majeure. Even though the contractor is usually required to obtain insurance against this, if such an event occurs without this provision it may cause delays and further impact on costs. Legal compliance and environmental issues are

also considered important in influencing project cost performance. Project managers, in addition to their traditional duties, must set up processes to scan the environment, identify potential problems, and attempt to establish power relationships that can help manage the factors underlying successful implementation [13].

Construction managers and supervisors must use an appropriate leadership style in project management to minimize unnecessary costs. Inexperienced beneficiaries or new people can cause delays and increase costs. Factors related to contractor site management, factors related to design and documentation, and factors related to financial management can affect the increase in costs. The distribution of the relationship between the influencing factors with time and the cost performance index is shown in *Fig. 1*.

Most of the factors are distributed in the resource group, which indicates the importance of this group, especially in the provision and availability of materials, labor, and equipment. Labor productivity and the economic status of the contractor are also of great importance. The resource factor also has a great impact on time and cost performance, which is characterized by its effect on execution volume, direct cost, and indirect cost. The second rank was the management group with five factors, and the third rank was the environmental group with three factors [14].

## 6 | Main Components of Project Finance

Project Finance (PF) refers to the arrangement of financial support for a specific project to achieve future cash flows. Large and complex operations such as oil and gas exploration, dams, power plants, and roads mainly use PF. The types of projects considered for financing are:

- I. Long-term infrastructure.
- II. Industrial projects.
- III. Public utilities with a financial structure with limited access to resources.
- IV. Loan structure PF consists of three elements: Build Operate Transfer (BOT).

Main components of PF:

Financing long-term infrastructure projects: these projects not only have lower technological risk but also have a predictable market. They are the most suitable sector for the development of innovative financing techniques.

Without resources and limited financial structure: the Special Purpose Vehicle (SPV) is the only economic entity in which the project financing is carried out, and the source of the loan is the repayment in the event that the borrower is in debt, in case of structured financing it gives the lender the right to take possession of the SPV assets.

Payment from generated cash flow: to pay off the loan amount received, the cash flow generated from the implementation of the project is used. This cash flow is used to cover operating expenses and repay the debt. Any remaining funds can be used to pay dividends to the project management financiers [15].

Since no project is implemented without financing, financial planning begins at the time of feasibility study of the project implementation. It affects the project's implementation plans. Successful projects can consider proper financial planning in the project implementation strategies. All projects aim to reduce the costs associated with the project life cycle. Project financing requires accurate financial engineering to be able to identify the risks and opportunities of stakeholders in the project [16].

According to existing studies in the field of project financing methods, it is one of the risk factors during the project implementation process which, because its nature is related to the future, cannot be determined accurately based on past information financial evaluation in projects under conditions of risk and uncertainty is critical [16]. Observations have shown that companies' incorrect assessment of their investment projects leads to the destruction of value for shareholders. According to the existing literature, the value of a project depends on the amount of expected cash flow and its discount rate. In practice, there is evidence that

companies use only one discount rate to evaluate investment projects. PF is used to finance public and private facilities. PF is a growing sector of the economy, but it has not yet received much attention. However, the PF amount was higher than those raised through primary securities or investment funds, indicating that the financial crisis has impacted significant infrastructure financing and reflects global lending activity [17].

## 7 | Construction Projects and Financial Risks

Construction projects are dynamic and consist of limited resources. A complex project can cause risky and uncertain events that can cause delays and increase project costs, thus allowing uncertainty in the implementation process, which leads to various risks that ultimately cause losses to the parties involved in the construction project and affect the achievement of the intended goal. Risk is a situation in which there is a possibility of profit loss accompanied by losses such as cost loss, damage, and delay due to uncertainty in the implementation of the project [18]. One of the most influential risk factors is rescheduling. Delays in the implementation of projects are among the risks that often occur in the implementation of construction projects, especially in developing countries [19]. Project delays and cost overruns can harm projects [20].

Involving public and private actors in starting a local project and organizing the first two meetings is inexpensive, but it requires a lot of time, energy, and commitment from the changemakers and the inviting organizations that launch the project. Some market their projects and quickly attract a large number of resourceful participants, while others struggle to commit hard-to-get actors to participate in solving problems and sharing their knowledge and resources with other actors. Building a coalition of willing and capable actors takes time and requires patience, communication skills, and charisma. Indeed, more and improved financing is key to achieving global sustainability goals [21].

The occurrence of project risk can have positive or negative effects on one of the project objectives, such as time, cost, safety, quality, and sustainability. On the other hand, it can threaten the success of the project. Dealing with high costs and time overruns in project implementation has been a way to prevent failure. Eliminating all project risks is impossible and requires a formal assessment and process for managing the risk of all types of project risks. Risk management is a formal and systematic process for classifying, identifying, evaluating, and responding to risks throughout the life cycle of a project to achieve the optimal level of risk elimination or risk control.

Many methods have been proposed in the research literature for effective risk classification and management. Chapman [22] has grouped risk into different sectors, industries, customers, and project environments. Chen et al. have divided the project risk classification into six groups according to environmental risks: financial, legal, management, market, policy, and political and technical risks. They identified eight significant risks in project delay and ranked them based on a questionnaire survey with experts' opinions. They also provided necessary risk management and impact assessment suggestions through surveys and individual interviews. Risk assessment has several methods. Chen et al. [3] identified fifteen risk factors regarding project cost and divided them into resource, management, and parent factors. Various studies on construction risk have been conducted in several countries, including the United States of America [23].

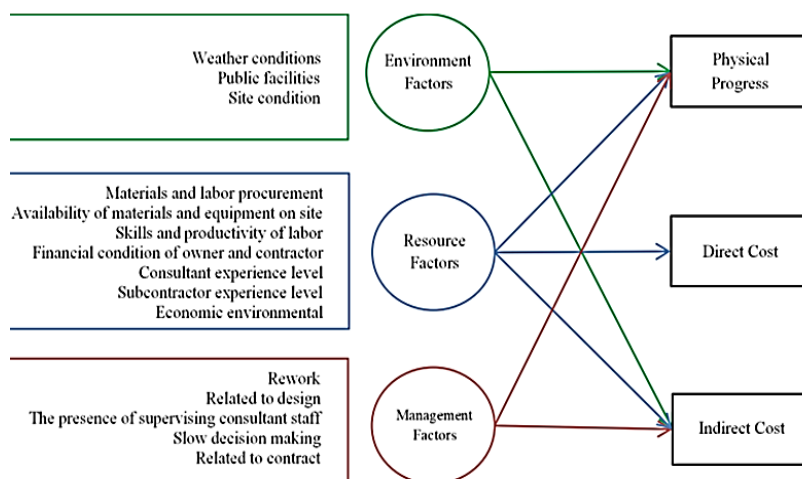


Fig. 1. The identified relationship between schedule and cost performance.

## 8 | Data Analysis Method

Data analysis in this study was carried out using the fuzzy DEMATEL approach, and its steps are as follows:

Fuzzy set theory is a theory for action in conditions of uncertainty. This theory can mathematically formulate many concepts, variables, and systems that are imprecise and ambiguous, as is often the case in reality, and provides the basis for reasoning, inference, control, and decision-making in conditions of uncertainty. This theory is a new mathematical framework for formulating and analyzing concepts and linguistic features not included in classical set theory. In other words, fuzzy sets are a natural generalization and extension of classical set theory consistent with human language and natural understanding. This theory was presented in 1995 by Professor Lotfi Askarzadeh, an Iranian-born scientist and professor at the University of Berkeley in the United States. Since its introduction, it has expanded, significantly deepened and found diverse applications in various fields.

## 9 | The Main Components of Financing the Project

- I. long-term infrastructure.
- II. Industrial projects.
- III. Public services with a financial structure with limited access to resources.
- IV. The project financing loan structure consists of three elements: BOT.

## 10 | Conclusion

According to the research findings, the safety of the project site was introduced as the most crucial factor in increasing the time and cost of the project. In many bridge construction projects in Mazandaran Province, since there are very large and high-flowing rivers, this causes the project site to be located in a high-risk environment, which causes problems such as difficulty in transportation, the risk of flooding, and loss of materials, which significantly affects the increase in project time and cost. On the other hand, other findings obtained from this research showed that the issue of project safety can have a significant impact on cost and time. In bridge construction projects, the safety issue must be taken very seriously because working in a high-risk environment and the slightest negligence may cause high costs for the project. Another factor in this research, which was one of the crucial factors in increasing the project's cost and time, was the rework issue. Rework is often due to a lack of coordination between the contractor and the employer and the contractor's lack of sufficient expertise, which causes the project to go back and requires a series of re-measures, which increases time and cost. Weather conditions and the contractor's experience level were identified as the fifth



factor affecting the time and cost of the project. Since the weather conditions in Mazandaran province are such that we see rainfall most days of the year, this causes lengthy interruptions in the project time and consequently increases costs. On the other hand, contractors selected for this purpose must have experience working in the bridge construction sector, because choosing a less experienced contractor may not be able to act correctly in the face of challenges and make the best decision, which increases the project's costs. Environmental issues were identified as the sixth factor in increasing the time and costs of bridge construction projects in Mazandaran Province.

- I. Considering that the condition of the site is the most important factor in increasing the cost and time of the project, it is suggested to secure the project site fully.
- II. Considering that coordination was mentioned as one of the factors affecting the cost and time in bridge construction projects, it is suggested to establish proper coordination between the employer and the contractors.
- III. Considering that the knowledge and expertise of the contractor was mentioned as one of the influencing factors on time and cost, therefore it is suggested to select contractors who have the necessary expertise.

## Author Contributions

Amir Hossein Goleij was solely responsible for the conceptualization, methodology, data collection, analysis, and interpretation of the research findings. The author designed the study framework, identified the critical factors influencing the cost and time of intra-urban bridge construction projects, and conducted the descriptive survey. Furthermore, Amir Hossein Goleij prepared and reviewed the manuscript for publication.

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## Data Availability

The data used and analyzed during this study are available from the author upon reasonable request.

## Conflicts of Interest

The author declares no conflicts of interest related to this study.

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