THE EFFECTS OF UNCERTAINTY LEVEL ON SCHEDULE DELAYS IN CONSTRUCTION PROJECTS

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Abstract. *A changing reality has become an everyday reality we must adjust to.*
Construction projects constitute an economic growth engine worldwide. There are many conditions affecting their success. The project manager must synchronize several work factors; the project's workforce, necessary materials and timely delivery of work demand and availability, and site conditions. Project managers fulfill a significant role in driving the success of industry-oriented projects, such as construction. The project's ability to follow schedules, adhere to budget limits, and ensure project quality are all project success indicators.
In an ever-changing reality, traditional construction projects are challenging to manage while implementing methodologies that are neither change-sensitive nor flexible as they progress.
This study will focus on construction project management with frequent changes. The paper presents the findings of a study that examined the effects of various factors on project uncertainty and delays in project schedules. A few variables examined were the project manager's seniority, the assimilation of new systems, and changes that occurred while the project was running. Though construction projects are run worldwide daily, each project is unique due to specific aspects of the construction site and the circumstances of construction activity.
The above is supported by the notion that construction requires coordination of the involved parties and the necessary materials. Other unexpected factors, such as last-minute changes or unreliable vendors, may also lead to difficulties in ensuring that construction projects are completed on schedule.
The construction industry is expected to adapt to global changes and challenges and render construction projects swifter, more efficient, and flexible to change operations while learning about the generation of project managers growing in the industry.
This article addresses the effects of the changing reality on construction and delays in construction projects, emphasizing project management methodologies.

Keywords*: business management; project management; construction industry; changing reality; organizations change.*

Introduction

Across the globe, trillions of dollars are invested in public and private construction projects. The volume of construction activities is often directly related to a given

country's development. A construction project is a combination of activities carried out during a project's life cycle. One of the main objectives of the project is to ensure its success. The project's success factors are affected by the changing construction environment as the project is in the process (Naderpour, Asgari, & Kheyroddin, 2018). Quantitative results from this study may interest public construction clients, developers, project managers, planners, and contractors, as they shed light on the factors that significantly affect the project's success. The causes of schedule deviations are the focus of the research, aiming at expanding the knowledge relating to reducing variations. Understanding the root causes of the deviation may promote narrowing the extent of schedule deviations in construction projects.

The World Economic Forum figures published indicate that the world's population in urban areas has grown by two hundred thousand (200,000) per day. The construction industry is the number one supplier of raw materials and air pollution. However, the future design of construction has attained a breakthrough in thinking and technology (The Boston Consulting Group, 2016).

Given the small number of publications relating to schedule deviations, delays and the integration of more flexible project management techniques in the management of construction projects, the publication of the findings may enhance the understanding of the construction project delays phenomenon toward the reduction thereof. Also, this study's findings may affect the international setting, where similar issues to those experienced in the Israeli construction setting are observed in the local projects.

Due to frequent changes, significant decision-making dynamics have formed, resulting in rapidly changing global transformations. With the Covid-19 pandemic, problems arose in the worldwide supply chain that led to a rise in prices and delays in the delivery of raw materials. All those, affected project management processes and caused scheduling delays.

Consequently, all parties involved in the project encounter unnecessary conflicts, inconsistent work methods and norms, and inefficient use of valuable time and resources. The literature review characterized construction projects by several significant milestones: characterizing needs, initial planning, detailed planning, tender writing, contractor selection, agreement preparation, initial construction, and delivery (Ahmed et al., 2003)

In April 2022, the World Bank publication indicated that the Ukraine conflict had triggered the biggest commodities price shock in nearly 50 years, and the impact on food and energy is going to last until 2024 The World Bank, 2022)

In addition, raw material delivery times are still affected by COVID-19.
Furthermore, with the developments occurring globally, the sizes of construction projects have grown in scale, often with more complex interfaces, longer life cycles, and the involvement of more construction practitioners. Thus, traditional project management methods may no longer be suitable for managing these more complicated construction projects. The challenges stemming from global developments have rendered the implementation of construction projects even more complex; thus, successful management of construction projects is more difficult to attain (Chou & Yang, 2012).

Literature review

Many studies have been conducted about the factors that cause delays in construction projects in schedules and budgets worldwide.

This review summarizes the main causes of deviations in construction projects schedules and budgets in some articles and research.

In their paper, Sadi A. Assaf & Sadiq Al-Hejji (2006) identified 73 causes of delay through a field survey. Three parties participated in it. The common causes of delay arose from all parties were [1] change order by the owners during construction to avoid delay, [2] delay in progress payment, [3] ineffective planning and scheduling, [4] shortage of labor, [5] difficulties in financing on the part of the contractor.

The Project Management Body of Knowledge (PMBOK) was established to provide project management guidelines and set standard terminology for project management. The most current PMBOK® Guide outlines ten Project Management Knowledge Areas. Studies in China have indicated that adherence to the PMBOK® Guide may significantly affect the overall performance of international construction projects (Ling, Low, Wang, & Egbelakin, 2008; Chou & Yang, 2012). As one of the ten Project Management Knowledge Areas, Project Schedule Management affects performance, which is also the key to a project's successful and timely completion, largely dependent on effective schedule management.

Towhid Pourrostam and Amiruddin Ismail (2012) surveyed to identify the causes of delays in construction projects. A questionnaire with 28 causes and six effects for delays is investigated. It highlighted the ten major factors that reduce client, consultant, and contractor delays. In the published paper of Narayanan, Chidambaram Ramanathan & Idrus (2012), the authors conducted a worldwide survey addressing delay factors and classified. The survey identified 113 causes of delay, and they are grouped into 18 different categories. The causes are analyzed and investigated through Importance Weight, Weighted average, Mean Standard Deviation, and Variance. The first five ranks in different studies are concluded from this paper.

Owolabi, Olusanya et al. (2014) indicated that in the project they surveyed, the causes and effects of delay on delivery time were investigated. A random sampling method was used in this study. The sample taken for this project is a population sample of 150, and a total sample of 93 was deployed. A questionnaire structured in the Linkert scale was used in the data analysis. From this investigation, the client has the highest value, 51.1%, with contractors having 35.5%, and the consultants having 13.3% of causes of delay in construction projects The 15 factors are identified and ranked according to the mean index score. A factor includes lack of funds, adequate information from consultants, slow decision-making, and insolvency of contractors.

Most construction industry organizations cannot conduct the project in each period. It represents the factors that affect the project in both civil engineering and construction project. It has also been seen that the construction industry's management staff takes more time than the state before starting the project. It is one of the big issues in the corporate sector. Harris, McCaffer, and Edum-Fotwe (2013) stated that completing the project within time is an efficient project in the construction industry.

Methodology

A quantitative research approach is implemented in this study to examine the compliance of projects to the schedule set for the project and the effect of incorporating changes during the planning and execution of the construction project to the project schedule.

This study aims to identify changes that have taken place throughout the management of construction projects and their influence on the project's success in meeting the schedule.

The research objectives are to discover the effect of uncertainty during the project on the number of changes and delays in the schedule set at the beginning and to identify the effect of uncertainty during the project when new systems, materials, or teams are involved.

Considering the above, this study's hypothesis is as follows:

1. Identify if the worker's seniority is strongly related to the project characteristics and schedule.
2. To understand the differences in the assessment project, uncertainty degrees will be identified between males and females.
3. To identify the differences between the various positions and roles in assessing the level of uncertainty degree.

The target population was given questionnaire surveys comprising several sets of well-recognized delay causes in order to gather primary data for the research. The questionnaires evaluated the relative importance of the various factors causing delays. In the field survey, the respondents were asked to indicate each cause's degree of contribution to the delay using the Likert five-point scale ranging from 1 (Very Low) to 5 (Very High).

The project's uncertainty degree will be examined using a translated questionnaire from research by Lederer & Prasad (1998). This questionnaire consists of 17 items and addresses the following two variables:

1. System characteristics (questions 1-10).
2. Project staff characteristics (questions 11-17).

The above variable consists of a five-point ordinal scale, with 1 indicating 'not true and 5 points indicating 'very true, addressing the project's uncertainty degree based upon the degree of truth. The variable's research-related reliability is 0.79.

The questionnaires were distributed to 45 experts in the construction industry and were answered by 41 participants, 91%.
51% of the participants were men, and the rest (49%) were women.
Participants in the survey are architects, contractors, and consultants with significant experience in Israel's public, commercial, industrial, and private construction.
Of eighteen participants, 43.9% were architects, 15 participants, 36.5% were contractors, and 8, 19.6% were project managers.

The age range for the participants is 24 to 65, where age 65 is the most frequent (mode of distribution).

The average age of the sampled population is 44.6 years. The seniority is between 1 and 24 years. The average seniority is 11.3 years.

The study assumes that integrating new materials or teams into the project causes intensified uncertainty in the project.

The significant uncertainty affects the schedule delays. The data collected were analyzed using graphs, charts, and tables.

The dependent variable is the uncertainty degree in the project and is composed of system and project team characteristics.

The independent variables are gender, job title, and work seniority.

Table 1 Outlines the variables (Author's Own Source):

Variable type	Variable name	average	Standard deviation	range	reliability
Dependent	System characteristics	3.35	0.56	2.5-4.25	0.69
Dependent	Project team characteristics	3.2	1.06	1.83-4.83	0.72
Dependent	Uncertainty level	3.25	0.59	2.14-4.14	0.7
Independent	Seniority	11.3	3.6	1-24	
Independent	Job title	Categorical variables			
independent	gender				

The average uncertainty degree within the project, which consists of staff and system characteristics, is 3.25 points on a five-point scale. This value implies a relatively high uncertainty degree and a greater, more significant impact of changes on the project. System characteristics are more uncertain than staff characteristics (a 3.35-point average, compared to 3.2 points). Table 2 indicates a high reliability of parameters (0.69-0.72 based upon Cronbach alpha). Hence, this data item indicates that the questions comprising the parameter were derived from the same content area, thus providing a reliable and sufficient indication of the tested parameter. There are positively correlated variables.

Seniority is positively correlated with project uncertainty/the different characteristics have a medium to strong significant correlation with project uncertainty.

The strength of the effect (characteristics on uncertainty) grows with the participant's belief regarding the characteristic's importance.

To test hypothesis number 1, that there is a significant relationship between seniority and project characteristics, we performed Pearson's correlation analysis. We found a positive strong correlation ($p=0.00$, $r=0.3$), a positive significant correlation between

seniority and project team characteristics (p-0.01, r=0.29), and the general level of project uncertainty (p=0.01, r=0.3).

To test hypothesis 2, that there will be a significant difference between the number of males and females regarding the evaluation of project uncertainty, we performed a t-test for the independent samples.

To test hypothesis number 3, that there will be found significant differences in the valuation of different variables on project uncertainty based on job title, we performed one-way ANOVA statistical tests.

To test the predictive capacity of variables regarding the uncertainty level of the project, we performed multiple regression analysis and present the results in table 2:

Table 2 Regression analysis (Author's Own Source)

Variable	B	β	t
Cons.	0.40		4.72
System characteristics	0.23-	0.20	3.30
Human resource characteristics	0.35-	0.36	3.39
seniority	0.51	0.17	3.15
Gender (male=1)	0.02	0.01	0.34
Architect (Dummy variable)	0.66	0.46	3.22
Project manager (Dummy variable)	0.09	0.20	3.08
	0.12	0.31	3.08

In table 2, the results of multiple regression are displayed. As a part of the analysis, socio-demographic and professional variables known to affect uncertainty levels were controlled (job title, system characteristics, seniority, and gender). The model was statistically significant (p=0.04) and explains a large fraction of the data variability (R2=0.428).

Results and Discussion

In the construction industry, delayed performance means exceeding the performance time fixed by the contract or the project delivery date. Delay results in fiscal implications (Lo et al., 2006). Prominent arguments concerning time are, in fact, the contractor's demand to extend the course of the project or a specific activity relating thereof exceeding the agreed time, defining the deviation during the project and its costs. Project schedule delays directly affect the project's budget. If a public project is concerned, the issue may become political.

This study is part of doctoral research exploring the key factors affecting schedule delays in construction projects within an ever-changing reality.

This part of the research shall notify entrepreneurs and project managers of factors bearing the most significant effects on schedule deviations in construction projects.

Considering the few publications addressing his subject matter, this research will also bear implications on the construction set by the international arena. The publication of results may enhance the understanding of the schedule delay phenomenon and enlighten the public construction customers, entrepreneurs, project managers, planners, and contractors as to the delays' source, thereby reducing the construction schedule deviation scope.

This article presents the results of the quantitative research, which was conducted by means of a questionnaire that was filled out by 41 professionals in the construction area, architects, project managers, contractors, and entrepreneurs, who were asked about the factors contributing to uncertainty in construction projects.

Some of the questions addressed the influence of new, inexperienced project managers on the uncertainty of the project and its success, assimilation of new electro-mechanical systems or changes throughout the course of the project, etc.

There is great importance to the availability of raw materials, as 70% of the respondents indicated that factor as having a high effect on the project's uncertainty degree. These days, with the war in Ukraine and COVID-19 waves from Asia, we witness major delays of raw materials to the delivery construction branch worldwide, which greatly delays project completion. Additionally, those delays cause higher costs in the construction branch and the world economy in general.

63% mentioned that when a project is based on an electromechanical system, the workers don't have enough experience, which is a significant factor affecting project uncertainty. In cases where the project relies upon an electro-mechanic system or other systems with which the workers have no experience, the project's uncertainty and schedule delays are greatly affected.

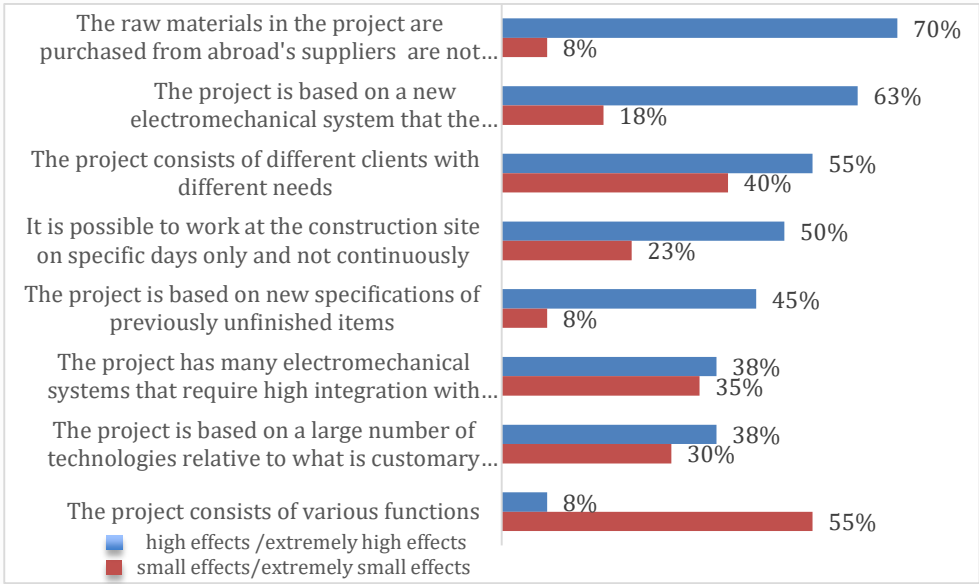

Figure 1 The distribution of extreme answers to the effects of the electro-mechanical system (Author's Own Source)

There is currently a lack of around 33 thousand foreign and Palestinian workers, and there is a significant saving in Israeli labor in the "wet" professions - out of 206 Israelis, only about 18 Israelis work in these professions. Israelis are reluctant to work in the field mainly because of the low image that has been "infected," lack of clarity about the work horizon, erosion, and awareness of reward and promotion options. According to the ISRAEL BUILDERS' ASSOCIATION and based on the International Economy and Business findings, we are witnessing a scarcity of employees in the construction field (https://en.acb.org.il).

In this study, 75% of the respondents indicated that the availability of manpower is of a great effect on a project's uncertainty, while 80% indicated the staff's lack of experience as a key resource affects the project's uncertainty degree.

The greater the employee's seniority, apparently the various characteristics are of greater affect the project's uncertainty degree. The various characteristics have a significant, medium, to strong positive effect on the project's general uncertainty degree. The greater the value attributed by the respondent to those characteristics, the greater their effect on the project's uncertainty degree.

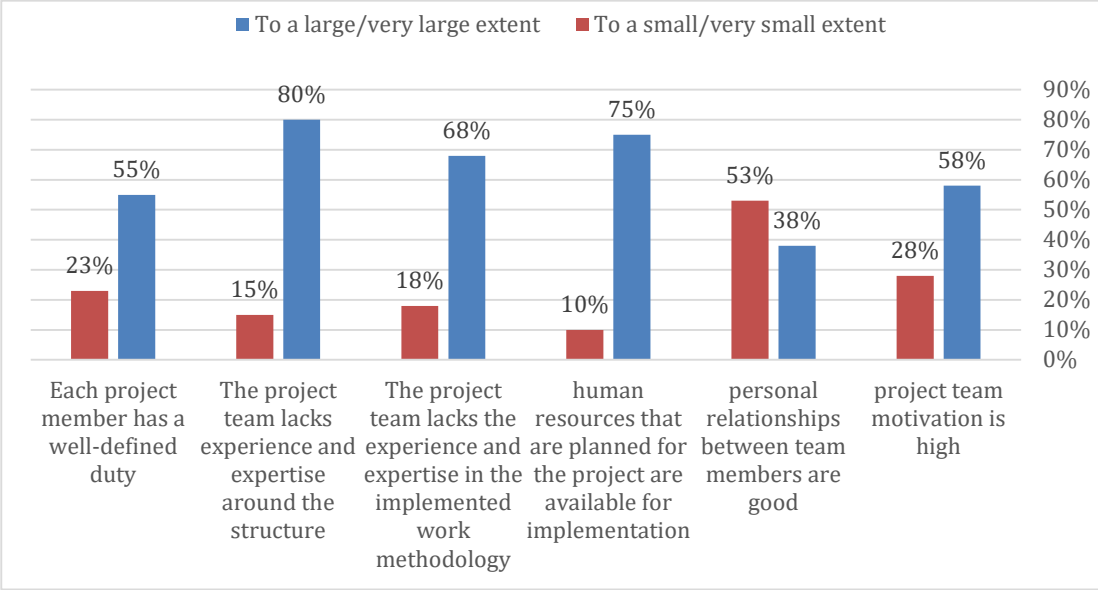

Figure 2 The distribution of extreme answers effects of human resources (Author's Own Source)

According to the study's hypotheses, this research, too, suggests issues relating to skills, professionalism, and availability of personnel in the branch, affecting the project's uncertainty, which, in turn, affects the meeting of the project's deadlines.

1. The worker's seniority is strongly related to the project characteristics.
2. Differences in the assessment project's uncertainty degree will be identified between males and females.
3. Differences between the various positions in project uncertainty degree will be identified.

Table 3 Pearson correlations between the study variables (Author's Own Source)

variable	1	2	3	4	M	SD	N
seniority		**0.3	**0.29	**0.3	11.3	3.6	41
System characteristics			*0.17	**0.34	3.35	0.56	41
Team characteristics				**0.29	3.2	1.06	41
Uncertainty level					3.25	0.59	41

*p<0.05 **p<0.01

Based on table 3, there are positively correlated variables.
Seniority is positively correlated with project uncertainty/the different characteristics have a medium to strong significant correlation with project uncertainty.
The strength of the effect (characteristics on uncertainty) grows with the participant's belief regarding the characteristic's importance.
Hypothesis 1 was reinforced, meaning that as the worker has more seniority, he will put more weight on system and project team characteristics having more influence on project uncertainty.

Table 4 shows the average effect of system characteristics as slightly higher for males (3.37 vs 3.34), but the difference is not significant (p=0.25). meaning males and females, on average, valued similarly the influence of system characteristics on project uncertainty.

Table 4 The average effect of system characteristics (Author's Own Source)

Table 4	The influence of system parameters among males N=21	The influence of system parameters among males N=20	t(39)=0.36, p=0.25
Average M	3.37	3.34	
Standard deviation SD	0.6	0.5	

In table 5, the average perceived influence of project team characteristics is slightly higher for males vs. females (3.25 vs. 3.16), but the difference is not statistically significant (p=0.38), meaning males and females on average values similarly the effect of project team characteristics on the uncertainty level in a project.

Table 5 The average perceived influence of project team characteristics (Author's Own Source)

Table 5	The influence of project team parameters among males N=21	The influence of project team parameters among males N=20	t(39)=0.17, p=0.38
Average M	3.25	3.16	
Standard deviation SD	1.07	1.02	

In table 6, the average perceived level of project uncertainty is slightly higher for males (3.3 vs. 3.2), but the difference is not statistically significant (p=0.15), meaning males and females, on average valued similarly the effects on project uncertainty.
Based on the displayed results, the hypothesis was rejected at the alpha=0.05 level regarding the effect of gender on the valuation of the effects of different variables on project uncertainty.

Table 6 The average perceived influence of project team characteristics (Author's Own Source)

Table 6	The influence of uncertainty among males N=21	The influence of uncertainty among males N=20	t(39)=0.44, p=0.15
Average M	3.3	3.2	
Standard deviation SD	0.57	0.6	

Based on table 7, the influence of system characteristics among architects is higher than the average of contractors and project managers (3.38 vs. 3.34/3.3), but the difference is not statistically significant (p=0.13), meaning on average, there is no influence of job title on the perceived effect of system characteristics on project uncertainty.

Table 7 The average perceived influence of project team characteristics (Author's Own Source)

Table 7	Sample size N	Average system characteristics M	Standard deviation SD
Project manager	8	3.30	0.60
architect	18	3.38	0.56
contractor	15	3.34	0.58

*p>0.05

Based on table 8, there is a slight difference for project managers regarding the effect of the perceived project team characteristics on project uncertainty (3.26 vs. 3.16/3.2 for contractors and architects), but the difference is not significant (p=0.17), meaning there is on average no effect of job title on the perceived influence of project team characteristics on project uncertainty level.

Table 8 The average perceived influence of project team characteristics (Author's Own Source)

Table 8	Sample size N	Average system characteristics M	Standard deviation SD
Project manager	8	3.26	0.90
architect	18	3.20	1.05
contractor	15	3.16	1.09

Based on table 9, the average perceived level of architects on the effect of overall variables on the uncertainty level in a project is higher than in other professions (3.3 vs. 3.2/3.28 for contractors and project managers) this effect is not statistically significant (p=0.15), meaning on average there is no effect of job title on the perceived influence of different variables on project uncertainty

Table 9 The average perceived influence of project team characteristics (Author's Own Source)

Table 9	Sample size N	Average system characteristics M	Standard deviation SD
Project manager	8	3.28	0.63
architect	18	3.30	0.60
contractor	15	3.20	0.62

Based on the analysis displayed, we reject hypothesis 3 and conclude that there is no influence of job title on the perceived effect of different factors contributing to project uncertainty level.

According to the Ministry of Construction and Housing of Israel, the 2019–20 coronavirus crisis created a wide range of social, economic, health, educational, and more implications. In doing so, the State of Israel faces many issues that the decision-making of the matter will throw at the State of Israel in the short and long term. These issues include the issue of employment in the construction industry, while the Ministry of construction and Housing seeks to bring additional foreign workers into the industry to increase the volume of activity in the industry—a step that has many meanings, including answering the demand for housing units and the potential to generate growth throughout the economy, and the need for housing units and the development of the economy. The Ministry of Finance opposes the fear of reducing the employment of Israeli workers in the industry.

This study will call the attention of developers and project managers to factors that have the most significant impact on schedule deviations in construction projects in Israel. Given the small number of publications on this topic, the study's findings will also have implications for the construction set in the international arena. The publication of the

results can contribute to a deeper understanding of the phenomenon of schedule delays, to draw the attention of public construction clients, developers, project managers, planners, and contractors to the root causes of delays, thus leading to a reduction in the extent of schedule deviations in construction.

To sum up, in a dynamic world, which undergoes daily changes, and is characterized by scarce professional, experienced manpower, also experiencing issues of raw material supply at construction sites, as well as global changes affecting large organizations, agile methodologies are necessary to manage traditional construction projects, which will facilitate the project managers in reducing construction projects' uncertainty and risks, while increasing the likelihood of timely project completion.

Even though construction projects are still traditional, carrying out changes throughout the work is difficult, and even though construction projects are managed by means of traditional project management methods, such as the waterfall, flexible management methods such as AGILE and others are to be integrated into the work, so as to facilitate project managers' coping with the frequent changes brought by the construction branch.

The lack of construction workers, along with schedule exceptions in construction projects due to the impact of raw materials on the construction industry, as shown in the research literature review outlined in the study shown in this article, presents significant problems with delays in building schedules.

In a dynamic world, which undergoes daily changes and is characterized by a rare professional and experienced force, also experiencing issues of providing raw materials on construction sites, as well as global changes affecting large organizations, there is a need for quick methodologies to manage traditional building projects, which will allow project managers to reduce the uncertainty and risks of building projects, and to provide new building projects. Increasing the likelihood of completing the project in time.

Even though building projects are still traditional, it is difficult to make changes during work, and even though building projects are managed through traditional project management methods such as the fall of the water, flexible management methods such as AGILE and others in the work should be combined to make it easier for project managers to cope with the frequent changes that bring the construction industry.

This study will turn the attention of entrepreneurs and project managers to the most significant impact factors on schedule deviations in building projects in Israel. Given the limited number of publications on this issue, the research findings will also have implications for the construction set on the international stage. Publishing the results can contribute to a deeper understanding of the delays in the schedule, bringing attention to public construction customers, entrepreneurs, project managers, planners, and contractors to the root of delays, thus reducing the number of exceptions in the construction schedule.

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