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Original scientific paper

The Investigation of the Role of RFID in Mitigating Delay Factors in Construction Projects

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Abstract: The examination of factors that delay construction projects is essential to project management. This study examined the effects of the potential delay factors on projects' completion time, using Radio-frequency identification (RFID) tools part of Internet of things (IoT) as a moderator variable in the model. A questionnaire-based survey was carried out and data from 466 respondents were collected from the population of four provinces in northern Iraq (Erbil, Sulaymaniyah, Duhok, and Halabja). Stratified random sampling was applied amongst the three groups of owners, supervisors, and contractors, and the resulting data were analyzed using factor analysis and structural equation modeling (SEM). The findings indicate that management-related issues had the strongest effect on the dependent variable, and the external issues had the weakest effect. Also, IoT technology negatively moderated between the independent and dependent variables. The research consequently suggests some mitigation strategies to reduce the delay factors in construction projects.

Keywords: construction projects; delay factors; RFID; IoT; moderator; focus group; pilot survey; Northern Iraq

1 INTRODUCTION

Delay in construction projects is a global issue [1]. In overcoming this challenge, there are many studies about managing, implementing, and controlling factors related to delays in construction project issues [2-5]. The majority of these studies show that most project implementation suffers from projects not being completed on time. For instance, the research that was done by Eliis and Thomas, [6] illustrated that 150 Highway projects in the USA experienced an average delay of 272 days. Likewise, based on Chartered Institute of Building (CIOB), more than 33% of Building projects and about 80% of engineering projects in the UK faced delays [7]. Also, in Asia, Prasad and Vasugi [8] claimed that out of 1257 construction projects, 22% suffered from a delay overrun in India in July 2017. Similarly, it is claimed that 62.7% of public buildings of university projects exceeded the average time in Nigeria [9]. Also, according to the Ministry of Municipal and Rural Affairs of Saudi Arabia in 2017, about 75% of public construction projects faced delays in completing projects on time [10]. In neighboring countries to Iraq, Arditi et al. claimed that 43.6% of public projects were delayed in Turkey [11]. Also, In Iran, based on Samarghandi et al., [12], all construction projects experienced an annual average delay of 5.9 months in 2016.

On the other hand, implementing construction projects differs from one country to another since each country has its own culture, economic growth, and policies [13]. Hence, the findings of previous studies are related to specific environments and geographical areas and cannot be used as a unified global construction framework. Considering this, the rationale of this study lies in the fact that delay factors and problems of the construction industry in the northern region of Iraq differ from those in other regions due to environmental, topographical, and technological differences between countries. To adapt the region's delay factors in construction fields with global issues, and to overcome these issues and fill the gap, both Focus group and Pilot survey to organize the questionnaire structure have been recommended as the first contribution in northern Iraq.

New technological tools can provide many opportunities for firms and industries to progress their work processes and achieve their project aims, i.e. RFID[1][14]. RFID is a technology that comprises unique tags, or transponders, readers or transceivers (Fig. 1). It has an antenna that lets the reader communicate via transponders. This technology emerged through the data exchange with electromagnetic signals to recognize and trace targets [14]. Combining RFID technology with building information modeling (BIM) via the sharing cloud data can monitor construction sites on time.

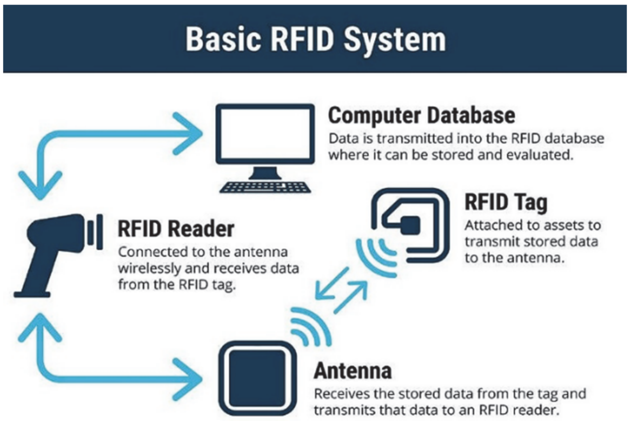

Figure 1 Basic working of RFID and tags

Moreover, The Autodesk Revit BIM program was applied to tracking RFID tags to tracking staff, materials, and equipment (Fig. 2) in the construction site [15]. In recent decades, the application of RFID technology has been developed in the construction sector by the "Core RFID" firm in 2009 and "Atlas RFID" company in 2017 [16].

In this regard, this study seeks to mitigate the delay factors based on our environmental region by applying Radio frequency identification (RFID) as part of the Internet of Things (IoT) [17, 18]. Contemporary literature

[1] tool is one of the most significant new technologies used in the construction industry and other sectors, such as manufacturing, transactions, and healthcare.

has looked at both the delay factors themselves and assessed the relationship between the independent variables and dependent variable(s). However, none have included RFID as a moderate variable within their conceptual models which is considered in this study as the second contribution. At the same time, the other moderate variables that have been used are intangible, including but not limited to the conceptual model presented by Zailani et al. [19]. Also, stratified random sampling has been applied during the distribution of the questionnaire between the population as the third contribution of the study.

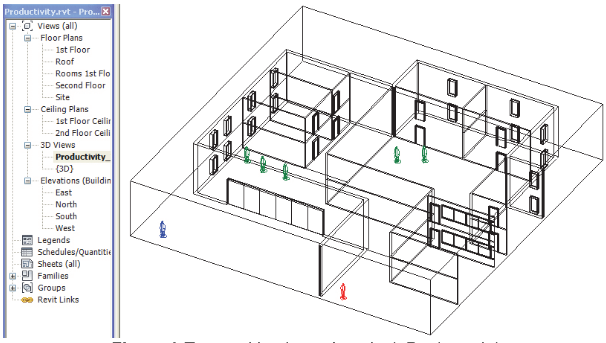

Figure 2 Tag tracking in an Autodesk Revit model

The remainder of the study is organized as follows: Section 2 reviews the literature; Section 3 provides the data and research methodology; Section 4 and 5 provide the data analysis and the factor analysis respectively. Section 6 tests the research hypotheses, and Section 7 concludes the work.

2 LITERATURE REVIEW

The majority of the historical and contemporary literature focuses on analyzing the delay factors without any perspective given to the relationship between the independent and dependent variable(s) [20, 21]. In the interest of applicability, relevancy, and contextual importance, our focus is on the last decade's literature, but covering an array of methods and approaches, not limited to RII and the Risk Matrix highlighting the lack of perspective given to the variables' relationship. For instance, Jahanger [22] conducted a study and found that the construction projects in the capital of Iraq (Baghdad) suffered from these top ten delay factors: (1) differences and errors in drawing documents, (2) inadequate scheduling and planning of the project by the executor, (3) weak site monitoring and administration by the contractor, (4) weak qualifications of the technical staff of the contractor, (5) insufficient and ambiguous details in the design documents, (6) weak design team experience, (7) inadequate investigations for data gathering before design, (8) financing problems of the contractor, (9) inappropriate or outdated building methods, and (10) unskilled laborers. The author argued that poor project management caused the factors mentioned above [22].

Another study in Iraq as a whole (excluding Northern Iraq) investigated the 65 most crucial delay factors. Security-related issues, governments verifying regulations and bureaucratic orders, official and non-official holidays, and the government's tendering system, changes of design by the owner, changes of design by the consultants, delays in payment by the government, problems in the local community, and the owner's inadequate construction experience, local and global economic conditions were the top 10 most significant factors [23].

Similarly, a study that was completed in Pakistan identifying 27 delay factors in construction projects and grouping them into seven main clusters (client-related, contractor-related, consultant-related, material-related, labor and equipment, contracts, and external factors) was left with 10 delay factors as their outcome from the initial twenty-seven [24].

In Egypt, authors gathered 293 delay factors and categorized them into 15 groups which then became these ten main delay factors: the owner’s financial difficulties, shortages of equipment, inefficient contractor experience, shortages in construction materials, equipment breakdowns, design mistakes made by the designers, soil investigations, poor subcontractor implementation, reworking due to changing orders or design changes, and poor site management and control by the contractor [25].

In the case of Cyprus, Vacanas and Danezis [26] highlighted several delay factors. They ranked them in order of importance: consultant changes and variations, lack of payment to contractors, project mismanagement by contractors, the indecisiveness of owner in relation to design selection, financial difficulties faced by contractors, and insufficient experience of contractors as the most significant global delay factors.

As well, in Saudi Arabia, the author arranged 50 causes of delay into four groups: causes of delay before awarding the tender, causes of delay whereas awarding the tender, causes of delay after awarding the tender, and general causes of delay. Among the top 20 causes of delay determined by the RII, the most significant was determining the abilities of each contractor before awarding the contract to the lowest bidder [10].

Also, fifty-nine delay factors were categorized into nine groups. The outcome of this analysis process determined the five most significant delay factors: slow-changing orders, unrealistic contract durations, slow variations in orders in extra quantities, delays in payment for the performed work, and ineffective planning and scheduling by the contractors [27].

Important to note is the case of Nigeria; having determined the delay factors of the finances and payment arrangements, it was found that improper contract management, shortages of materials, and price fluctuations were the most prevalent causes of delays that cost overruns for a highway project in Nigeria [28].

Most important is Saudi Arabia with 73 delay factors; *change order* was the most serious cause of delay in enormous construction projects in Saudi Arabia [7].

Some studies grouped the delay factors of construction projects into main clusters, such as project-related, practice-related, participant-related, and procurement-related (4P), [29].

After looking at the bulk of research on the topic presented, it can readily be seen that while the authors provide prompt analysis on the delay factors themselves, they shed little to no light on the relationship between the independent variables and dependent variable(s). Understanding the relationship between these variables, being it negative or positive, is crucial in determining the best mitigation process to address the delay factors present. Some researchers uniquely used interviews to find the specific delay factors that were neither mentioned in any previous study nor formed as questionnaires. The authors focused on common factors recorded by the NVivo software during British interviews and captured the results [30]. While other researchers applied System dynamics (SD) and the Decision-Making Trial and Evaluation Laboratory (DEMATEL) methods to analyze 58 delay factors [31].

Yilmaz [3] utilized Factor analysis with both branches of EFA (Exploratory Factor Analysis) and CFA (Confirmatory Factor Analysis) to explore and confirm the independent variables, and RII (Relative Importance Index) applied to rank the factors based on their importance to analyze 31 delay factors.

Data of 37 construction companies were analyzed by Rashid [32] and he grouped the cause factors into seven groups, including contractors, clients, consultants, labor and equipment, material, design, and general environment. He categorized the factors as the independent variables to determine their effects on the construction projects. In this study, the author found that contractor-related factors had the highest impact on delays in construction projects in Pakistan.

The main idea of the underlying model of the current study has been built by combining the proposed models of some seminal research such as Zailani et al. [19], Khan and Gul [33], and Rashid [32]. On the other hand, utilizing RFID for tracking the progress of the projects, but not along with a model, has been investigated in almost all sectors of research fields including healthcare, transportation, retail, and food industry [34] or in the construction industry [35]. It is worth mentioning that in all the above-mentioned research, the RFID has been leveraged as an indicator of project management and an illustrator of project initiatives being delivered or completed on time. That is, none of the available studies exploited the RFID within the conceptual model. But in this study, RFID has been put into a model where it acts as a moderator variable between independent variables and the dependent variable (finishing projects on time).

2.1 Types of Monitoring Project Sites and Tracking

There are two methods for monitoring an object's localization (materials, staff), i.e., Radio Frequency (RF)-based technologies and non-RF-based technologies. For RF-based localization technologies, the concentration is on using GPS techniques, RFID localization, and (WLAN) wireless local area networks. Non-RF-based technologies, however, focus on laser localization, ultrasonic localization, audio-visual localization, and infrared localization to finding the situation of targets at the site of projects [36]. RFID technology enables the site supervisor to locate materials for construction in the shortest time with accuracy (about one to a few meters) for managing critical materials, equipment, and vehicles [37].

2.1.1 Tracking of Concrete

A supervisor evaluates the acquisition order from the concrete manufacturer and determines the trucks and their identification (ID) for delivery purposes. The project supervisor attaches the RFID tags on the truck to record information pertinent to the concrete mix and the admixture times of loading, the job site address, etc. The read-write reader placed on the truck tag is used to transfer data relevant to the concrete order from the company monitor to the tag. When the truck leaves, the supplier sends electronic information to the project site or consumer. This is related to the departure time, mix specifications, and truck ID. When the concrete mixture truck arrives at the project site, a fixed reader at the entrance scans and reads all the information on the tag attached to the truck; a credible example of checking and comparing information on the tag was illustrated [38].

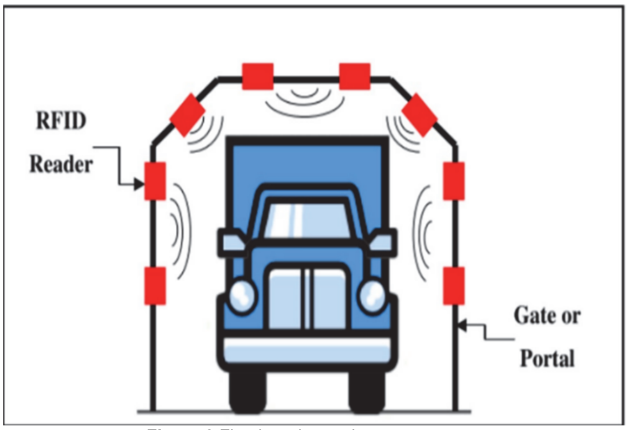

Figure 3 Fixed reader on the entrance gate

This was related to the previous purchasing order. When the truck leaves, the reader at the site entrance gate reads the tag attached to the truck and sends to the supplier the information regarding the truck's departure time, and arranges some other order for that truck (Fig. 3).

2.1.2 Asphalt Tracking

Based on the European OSYRIS (open system for road information support), projects that use IT infrastructure support asphalt laying and compacting performance. The eight main stages of material tracking are as follows:

1. providing the ingredients (aggregates, binders, fillers, etc.) to the asphalt mixer plant,
2. storing the ingredients in tanks or alternatives,
3. carrying the ingredients from storage to the mixing tool,
4. making components by grading and mixing the material batching,
5. carrying out the materials produced by the mixing firm,
6. receiving the products at the project-laying site;
7. laying the ready asphalt, and
8. compacting the laid asphalt.

Monitoring and tracking points 5 and 6 is significant for the current research because it has applied RFID and GPS simultaneously [39]. In this system, communication between whole departments works based on magnetic waves. Further, both computer systems are fixed in the batching asphalt and on the paver roller as the RFID reader and its antenna. All information (asphalt temperature, weight, date, time, mix design, etc.) pertinent to the batching of materials was captured and transmitted to the mix plant tag. This tag adhered to the asphalt truck. The data were transferred to the project site. When the truck loaded asphalt to the paver's hopper, the data were read and downloaded into the OSYRIS computer (reader in the RFID system) of the paver (Fig. 4).

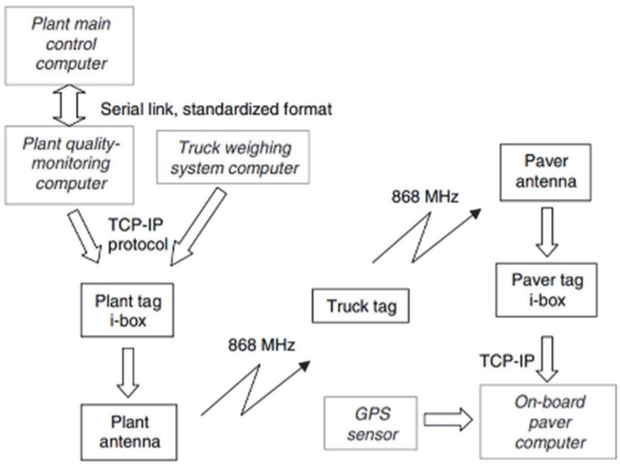

Figure 4 Structure of OSYRIS (Open System for Road Information Support) with its data tracking system

Fig. 4 illustrates the somatic structure and data track system. The traceability system component includes the plant tag, antenna, truck tag, paver antenna, and paver tag. These components are connected to the plant quality control computer equipped with related software, the paver computer, and the GPS on the truck and paver. The benefits of applying the Open System for Road Information Support (OSYRIS) system are relevant to both the short-term and the long-term. In the short term, savings will be achieved for contractors by using intelligent tracking for equipment such as pavers and rollers.

Moreover, this system based on RFID technology reduces the need for traditional tests and continuously provides quality management for managers. Additionally, it can save time and reduce the error risk through timely tracking the paving process. For a long period of time, the saved information will be enriched by the OSYRIS documentation. Thus, the costs saved and dangers avoided will be useful for the next phases of the road life cycle, such as rehabilitation and repair.

2.1.3 Tracking of Personnel with RFID

Beyond materials, the tracking of resources such as laborers and tools should be controlled in construction projects. In many situations, the laborers should be evaluated by a supervisor. Many project staff will not stop working and may move the project site simultaneously. To control the worker's activities, they can apply an RFID that records the labor movement and working time [40]. Also, applying a Wi-Fi RFID tag can connect to the wireless system such as laptop, and sometimes the RFID Tags record each objective regularly from 1 to 10 seconds that need to be tracked [41]. Some technologies used for tracking staff in construction projects include the Global Positioning Systems (GPS) and radio frequency (RF) systems. Some researchers illustrated the requirements for the automatic identification of staff sign-ins using a sign-in project implemented via markers in a construction site [42]. An RFID technology system was improved to use inside a project site to automatically gather the staff's location data periodically. Knowing the number of hours laborers work, the total wasted time daily, and the reasons for wasting time in the project have crucial roles in achieving the project's aims. This position information can be changed with staff inputs by utilizing algorithms. With this method, RFID tags adhere to construction components, and stuff would transport the individual items with RFID readers. These readers record the information from all the tags that the workers or staff have in hand or embedded in hats, clothes, or shoes. By downloading this information daily, stuff's location is calculated [43].

3 METHODOLOGY

3.1 Data collection

Within the existing body of research, it was found that there were 131 delay factors preventing construction projects from coming to fruition [44]. With that in mind, when constructing the questionnaire, a pilot survey was executed to shorten this list, given the limited time and resources available in addressing all of these delay factors as potential reasons for construction projects being setback in the region. During the pilot survey, 26 experts aided in condensing this list by removing 103 factors that they found were the least important, leaving 28 delay factors as the focus for the remainder of the study.

After that, two focus groups were created to further cover these 28 delay factors. Within the first focus group, a panel discussion was initiated consisting of 10 representatives (2 representatives from each cohort on the panel)) including government officials, project managers, contractors, the ministry of finance, and the planning ministry. During the debate, the participants blamed one another for the delays in the construction projects that had taken place within the last 2-3 decades. As a result of this panel discussion, 13 new delay factors (specific to the region) emerged, which were not included in the initial list of 131 delay factors. This process brought the new list total to 41 (28 + 13). Furthermore, a second focus group, consisting of 12 experts, was initiated to identify independent variables comprising resource-related issues, management-related issues, regulation-related issues, and external issues to be used within the main questionnaire. Using stratified random sampling among the population of four provinces (Erbil, Sulaymaniyah, Duhok, Halabja), with a focus on three strata of respondents (government, supervisors, and contractors), these 41 delay factors were then used to construct the questionnaire to be distributed to assist in finding the relationship between the independent variables and dependent variable. The 466 questionnaires received responses and were thus answered by the population with stratified random sampling.

In Northern Iraq as the federal system, supervisors are not independent practitioners, but rather considered civil service employees (civil servants are government employees) either a member of the Kurdistan engineers' syndicate (KES) or Kurdistan engineers' union (KEU) in the Kurdistan Region. As of 2020, after consulting the head offices of the three groups of the surveyed population (government, supervisors, and contractors), the total number of members came to 41208, with 3670 contractors, and 37538 is a sum of both government employees (owners, and supervisor). So the number of each supervisor and owners is equal to half of 37538 and 18769 and supervisors. The latter figure is inclusive of KES (18488) and KEU (19050) members. From the 41208 members, 466 were surveyed, 70 more than the required 396 sample size within the Yamane formula [45], as the following:

$$n = \frac{N}{1 + Ne^2} \tag{1}$$

where n is the sample size, N is the total Population, and e is the margin of error. So, having in 95% confidence level (e = 0.05), the sample size will be:

$$n = \frac{41208}{1 + 41208 \times (0.05)^2} = 396 \tag{2}$$

Based on strata random sampling, the minimum Sample

Size (SS) should meet the following criterion:

$$SupervisorSS = \left(\frac{Supervisors'Population}{TotalPopulation} \right) \times n$$

Supervisors' Population = Owner's Population, and equal to:

$$\frac{37538}{2} = 18769$$

Thus,

$$Supervisor\ SS = \left(\frac{18769}{41208} \right) \times 396 = 180$$

As mentioned above, the Owner sample size will get a similar value in the study region which should equal 180.

Similarly, the Contractor Sample Size should follow Eq. (3):

$$\left(\frac{Contractors'Population}{Total\ Population} \right) \times n$$

Therefore, the sample size for the Contractor should be more than:

$$\left(\frac{3670}{41208} \right) \times 396 = 36$$

Table 1 Number of questionnaires gathered from three Strata

Status of job	Frequency
Supervisor	206
owner	181
Contractor	79
Total	466

As shown in Tab. 1, the number of all correctly returned questionnaires are more than required and acceptable.

3.2 Conceptual Model

Combining two conceptual models comprising Zailani et al. [19], and Khan and Gul [33] covered the idea of the current conceptual model. A description of this particular framework contributes two methods to a research report since it first identifies the investigation variables and then clarifies the interactions among the variables [46].

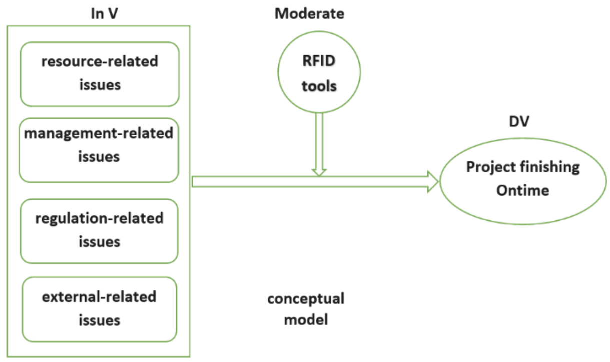

Figure 5 Conceptual model

In this model (Fig. 5), according to the focus group and pilot survey, the independent variables are:

(1) Resource-related issues:

Resource-related variables are described as an entity having crucial roles in project activities, such as financing, materials, equipment, and manpower [47]. In this model, regarding the second focus group, the financing delay factors are issues related to payments and to the difficulties that contractors and government faced as well as shortages of cash in the bank, etc. Manpower delay factors are factors related to a shortage of experience, knowledge, and personnel at the project site.

(2) Management-related issues:

Based on the second focus group, Management delay factors are some factors related to managing projects from contractors, governorates, and supervisors, such as delay in decision making, poor planning and monitoring of the projects, and communications between parties, and so on.

(3) Regulation-related issues:

For the regulation factors, regarding the second focus group, some factors have been mentioned that are related to government that either improper regulations are the cause of delay factors, such as: problem in payment to contractor method, limitation in tendering and awarding the project and calcification of company's level system or lack of following up for regulation such as pre-selling the project instead of implementation, applying a typical map or details to multiple areas and corruption and bribery duration of construction time, etc.

(4) External related issues:

External factors are some factors whose occurrences are beyond the control of the project managers and play a direct and crucial role in gaining the project aims [48]. In this model, as mentioned in the second focus group, these factors can be divided into the political, economic, socio-cultural, and natural. For instance: economic sanction from central government, unforeseen site condition, raining and severe weather conditions on job site, interference and resistance of residents or powerful individuals (military and official persons, head tribes) in the performance of the project, and some others.

The moderate variable is:

(1) Internet of Things (IoT):

RFID tool as the part of IoT has been applied to tracking materials, staff, and monitoring project site, as the moderator variable in the model.

The dependent variable is:

(1) Finishing the project on time:

Timely finishing of the project is the only factor for measure the dependent variable has defined in the model [44, 48].

4 DATA ANALYSIS

In this section, 466 questionnaires were completed via statistical sampling in northern Iraq. Descriptive and inferential statistics were applied to analyze the questionnaires by the SPSS and LISREL statistical software. To conduct descriptive statistics, the general characteristics of the statistical sample are described using tables of frequency distribution, frequency percentage, bar and circle diagrams, as well as statistical indicators. Descriptions such as the mean, standard deviation, skewness and elongation describe the variables presented in this research's structural model. At the inferential statistical level, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) are performed on the research questionnaire, and a Kolmogorov-Smirnov test (*k-s* test) is used to test the normality of the statistical distribution of the variables presented in the structural model of this research. The structural and theoretical models are evaluated in line with the data observed in the statistical sample studied by the use of the Goodness Fit Statistics and research hypotheses via the structural equation modeling (SEM) method, ANOVA, and the Friedman Test.

5 FACTOR ANALYSIS

5.1 Exploratory Factor Analysis (EFA)

In exploratory factor analysis (EFA), the researcher examines the empirical data to identify the indicators and their relationships. There is no predetermined model for exploratory analysis that can be structured, modeled, or hypothesized. The researcher uses exploratory analysis to explore the factors that justify the interdependence between the variables. This method is a case when a researcher does not have sufficient prior empirical evidence to formulate a hypothesis about the number of infrastructural factors in the data. Therefore, exploratory analysis is significantly considered as a method for theory formulation and production rather than a theoretical testing method. In this study, the research questionnaire is designed to identify the components and infrastructural factors of the questionnaire using exploratory factor analysis (EFA) and the Linear Structural Relations (LISREL) statistical software. A sampling adequacy test was performed before the exploratory factor analysis. In the exploratory factor analysis, the Kaiser-Meyer-Olkin (KMO) index and the Bartlett test demonstrated in Tab. 2 were used to test the number of samples' adequacy.

LISREL (linear structural relations) is a proprietary statistical software package used in structural equation modeling (SEM) for manifest and latent variables. It requires a reasonably high level of statistical sophistication.

Table 2 KMO index results and Bartlett test results

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.926
Bartlett's Test of Sphericity	Approx. Chi-Square	7793.144
	Df	1081
	Sig.	0.001

The research questionnaire's retesting coefficient was calculated in the SPSS software, and the results are demonstrated in Tab. 3. All the coefficients obtained for each factor in the questionnaire, and the total research questionnaire at an error level of 5%, are significant (Sig < 0.05). This indicates the desired reliability of the research questionnaire.

Table 3 Retesting coefficient of the research questionnaire based on 30 samples

Questionnaire factors	Retesting Coefficient	Sig
Resource-related issues	0.811	0.001
Management-related issues	0.822	0.001
Regulation-related issues	0.618	0.001
External-related issues	0.732	0.001
Finishing project on time	0.613	0.001
Internet of Things	0.710	0.001
The whole questionnaire	0.805	0.001

In the structural model, the analysis of the structural relationship between structures relies on the covariance matrix. In the first step, the covariance matrix is calculated as demonstrated in Tab. 4. Tab. 4 shows that there is a negative and significant relationship between resources, management, regulation, and external-related issues concerning finishing the construction project on time. It is found that there is no significant relationship between external-related issues and finishing construction projects on time. There is a significantly positive relationship between the Internet of Things and finishing a project on time.

Table 4 Covariance matrix of structures present in the structural model of this research

Variable	Resource-related Issues	Management-Related Issues	Regulation-Related Issues	External-related Issues	Finishing Project On time	Internet of Things
Resource-related issues	1					
Management-related issues	−0.033	1				
Regulation-related issues	0.097	0.034	1			
External-related issues	0.023	−0.078	0.061	1		
Finishing project on time	−0.51**	−0.61**	−0.43*	−0.35*	1	
Internet of Things	0.021	0.031	0.039	0.044	0.41*	1

** Correlation is significant at a 0.01 level

* Correlation is significant at a 0.05 level

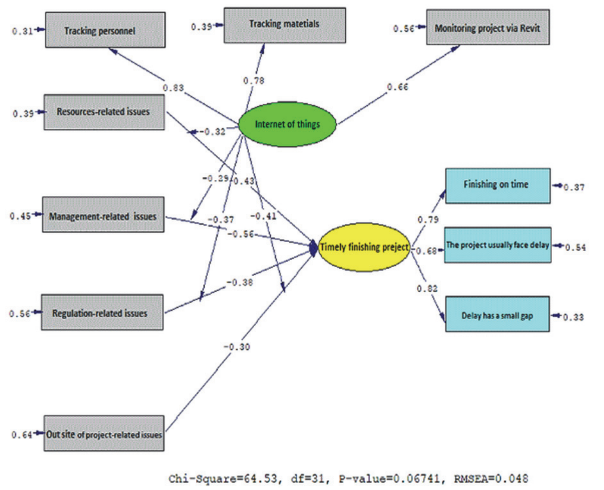

Figure 6 Fitting the structural model of the research in the standard estimation mode

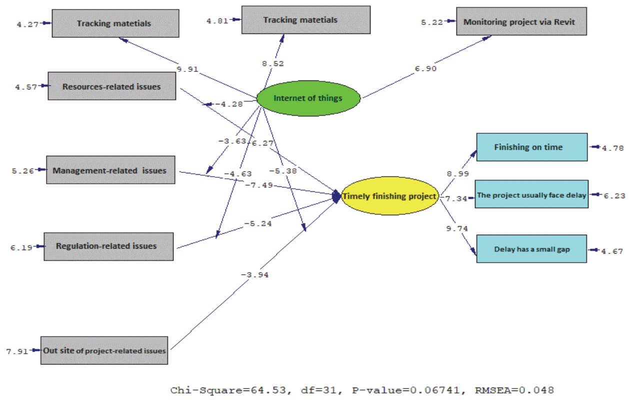

Figure 7 *t*-test

Figs. (6) and (7) demonstrate the fits of the structural and conceptual models of this research in the LISREL software in line with the standard estimation mode and the *t*-test, respectively.

6 TESTING THE RESEARCH HYPOTHESES

The research hypotheses were tested using structural equation modeling (SEM), one-way analysis of variance (ANOVA), and the Friedman Test. For each path in the structural model, the t statistic's value is compared with the critical values of 1.96 and −1.96. If the values calculated by the software are between the two numbers, the desired path at an error level of 5% is not significant. Otherwise, the desired path at an error level of 5% is significant.

6.1 The First Hypothesis Test

H1: resource-related factors negatively impact finishing the project on time. Figs. (6) and (7) in Tab. 5 demonstrate the results of the structural equation modeling for testing the first hypothesis. The standard coefficient of the impact of the resource-related factors for finishing the project on time is −0.43. The statistical value of *t* (−6.27) is smaller than the critical value of −1.96 (*t*-value < −1.96). This means that the impact of resource-related factors on finishing the project on time is negative and significant at a 5% error level. By increasing the resource-related factors to the level of the standard deviation, finishing the project on time is reduced to 0.43 standard deviation. This value (R^2) is equal to 0.185, which means that a total of 18.5% of the variance in finishing the project on time is directly explained by resource-related factors. Thus, the first research hypothesis is confirmed with an accuracy of 95%.

Table 5 The results of the structural equation modeling were used to test the first hypothesis

Path	Standard Path Coefficient	*t*-value	R^2
The impact of resource-related factors on finishing the project on time	−0.43	−6.27	0.185

6.2 The Second Hypothesis Test

H2: management-related factors negatively affect finishing the project on time. Figs. (6) and (7) in Tab. 6 demonstrate the results of structural equation modeling for testing the second hypothesis.

Table 6 SEM to test the second hypothesis

Path	Standard Path Coefficient	*t*-value	R^2
The impact of management-related factors on finishing the project on time	−0.56	−7.49	0.314

The standard coefficient of the impact of management-related factors on finishing the project on time is −0.56. The statistical value of *t* (−7.49) is smaller than the critical value of −1.96 (*t*-value < −1.96). This means that the impact of management-related factors on finishing the project on time is negative and significant at a 5% error level. By increasing the management-related factors to the level of the standard deviation, finishing the project on time is reduced to 0.56 standard deviation. The value R^2 is equal to 0.314, which means that a total of 31.4% of the variance for finishing the project on time is directly explained by management-related factors. Thus, the second research hypothesis is confirmed with an accuracy of 95%.

6.3 The Third Hypothesis Test

H3: regulation-related factors negatively affect finishing the project on time. Figs. (6) and (7) in Tab. 7 demonstrate the results of the structural equation modeling for testing the third hypothesis.

Table 7 The results of the SEM to test H3

Path	Standard Path Coefficient	*t*-value	R^2
The impact of regulation-related factors on finishing the project on time	−0.38	−5.24	0.144

As demonstrated, the standard coefficient for the path of the impact of regulation-related factors in finishing the project on time is −0.38. The statistical value of *t* (−5.24) is smaller than the critical value of −1.96 (*t*-value < −1.96). This means that the impact of regulation-related factors on finishing the project on time is significantly negative at a 5% error level. By increasing the regulation-related factors to the level of the standard deviation, finishing the project on time is reduced to 0.38 standard deviation. This value is equal to 0.144, which means that regulation-related factors directly explain a total of 14.4% of variance to finishing the project on time. Thus, the third research hypothesis is confirmed with an accuracy of 95%.

6.4 The Fourth Hypothesis Test

H4: External-related factors negatively impact finishing the project on time. Figs. (6) and (7) in Tab. 8 demonstrate the results of the structural equation modeling for testing the fourth hypothesis.

Table 8 SEM to test the fourth hypothesis

Path	Standard Path Coefficient	*t*-value	R^2
The impact of external-related factors on finishing the project on time	−0.30	−3.94	0.09

As demonstrated, the standard coefficient for the impact of the external project-related factors on finishing the project on time is −0.30. The statistical value of *t* (−3.94) is smaller than the critical value of −1.96 (*t*-value < −1.96). This means that the impact of the external-related factors to finishing the project on time is negative and significant at a 5% error level. By increasing the external-related factors to the standard deviation level, finishing the project on time is reduced to 0.30 standard deviation. This value is equal to 0.09, which means that the external-related factors directly explain a total of 9% of the variance for finishing the project on time. Thus, the fourth research hypothesis is confirmed with an accuracy of 95%.

6.5 The Fifth Hypothesis Test

H5: The Internet of Things positively moderates the impact of (a) resource-related issues, (b) management-related issues, (c) regulation-related issues, and (d) external-related issues on the project finishing on time. Figs. (6) and (7) in Tab. 9 demonstrate the results of the structural equation modeling for testing the fifth hypothesis. As demonstrated, the standard coefficient for the path of the impact of the Internet of Things on the relationship between resource-related factors and finishing the project on time is −0.32. The statistical value of t (−4.28) is smaller than the critical value of −1.96 (*t*-value < −1.96), which means that the impact of the Internet of Things on the relationship between resource-related factors and finishing the project on time is negative and significant at a 5% error level. By increasing the Internet of Things to the level of the standard deviation, the relationship between resource-related factors and finishing the project on time is reduced to 0.32 standard deviation. This value is equal to 0.102, which means that a total of 10.2% of the variance of the relationship between resource-related factors and finishing the project on time is directly explained by the Internet of Things. Thus, with 95% accuracy, the Internet of Things moderates the relationship between resource-related factors and finishing the project on time. The results show that the standard coefficient for the path of the impact of the Internet of Things on the relationship between management-related factors and finishing the projection time is −0.29. The statistical value of *t* (−3.63) was smaller than the critical value of −1.96 (*t*-value < −1.96), which means that the impact of the Internet of Things on the relationship between management-related factors and finishing the project on time is negative and significant at a 5% error level. By increasing the Internet of Things as much as the standard deviation, the relationship between management-related factors and finishing the project on time is reduced to 0.29 standard deviation. This value is equal to 0.084, which means that a total of 8.4% of the variance of the relationship between management-related factors and finishing the project on time is directly explained by the Internet of Things. Thus, with 95% confidence, the Internet of Things moderates the relationship between management-related factors and finishing the project on time.

Table 9 SEM to test the fifth hypothesis

Path	Standard Path Coefficient	*t*-value	R^2
The impact of the internet of things on the relationship between resource-related factors and finishing the project on time	−0.32	−4.28	0.102
The impact of the Internet of Things on the relationship between management-related factors and finishing the project on time	−0.29	−3.63	0.084
The impact of the Internet of Things on the relationship between regulation-related factors and finishing the project on time	−0.37	−4.63	0.136
The Impact of the Internet of things on the relationship between external-related factors and finishing the project on time	−0.41	−5.38	0.168

The results demonstrate that the standard coefficient for the path of the impact of the Internet of Things on the relationship between regulation-related factors and finishing the project on time is −0.37. The statistical value of *t* (−4.63) is smaller than the critical value of −1.96 (*t*-value < −1.96), which means that the impact of the Internet of Things on the relationship between regulation-related factors and finishing the project on time is negative and significant at a 5% error level. By increasing the Internet of Things as much as the standard deviation, the relationship between regulation-related factors and finishing the project on time is reduced to a 0.37 standard deviation. This value was equal to 0.136, which means that the Internet of Things directly explains a total of 13.6% of the variance of the relationship between regulation-related factors and finishing the project on time. Thus, with 95% accuracy, the Internet of Things moderates the relationship between regulation-related factors and finishing the project on time. The standard coefficient for the path of the impact of the Internet of Things on the relationship between the external-related factors and finishing the project on time is −0.41. The statistical value of *t* (−5.38) is smaller than the critical value of −1.96 (*t*-value < −1.96), which means that the impact of the Internet of Things on the relationship between the external-related factors and finishing the project on time is significantly negative at a 5% error level. Furthermore, by increasing the Internet of Things to the level of the standard deviation, the relationship between the external-related factors and finishing the project on time is reduced to 0.41 standard deviation. This value is equal to 0.168, which means that the Internet of Things directly explains a total of 16.8% of the variance of the relationship between the external-related factors and finishing the project on time. Thus, with 95% confidence, the Internet of Things moderates the relationship between the external-related factors and finishing the project on time.

Thus, the fifth research hypothesis is confirmed with an accuracy of 95%.

7 CONCLUSION

When summarizing the research and applications on the topic of delay factors within the construction industry, the most historically implemented approach has been to simply look at the delay factors themselves. But over time, a more modern approach has been to further analyze not only the delay factors themselves but also the relationship between independent variables (as the delay factors) and the dependent variables (finishing projects on time) within the conceptual model in deciphering mitigating processes for any delay factors present, given the respective context. Still, the varying practices have neglected to utilize tangible tools as moderating factors, instead choosing to focus more on intangible options. Yet, the results from this study have shown (Tab. 9) that applying the IoT (especially RFID in the case of Northern Iraq, which can be a replicable example) in construction projects reduces the impact of independent variables (i.e., resource-related, management-related, regulation-related, and external-related factors) on the dependent variable (finishing on time) of construction projects. The cornerstone of this research has been not to do away with the existing research and approaches but to add RFID as a moderate variable within the conceptual model. In doing so, RFID would control the relationship between the independent variables and the dependent variable(s). The desired result is a decrease in the negative impact the independent variables have on the dependent variable(s).

Based on the completed analysis, management-related factors have the strongest effect on finishing projects on time. This effect can be controlled by applying IoT technology, particularly RFID (Tab. 6). For instance, some factors connected to management-related variables that can be monitored by applying IoT technologies include poor relationships (communication and coordination) between parties, the absence of a supervisor or consultant on the project site, and monitoring of the site by contractors (staff and materials). Additionally, this process can be implemented by embedding a tracking device (RFID tags) in the clothing, work hats, or shoes of staff on the project site. After extensive research and application, with a focus on the case of Northern Iraq, it has been found that RFID, acting as a moderator variable between the independent variables and the dependent variable(s), can have the desired impact on the relationship of the variables, causing construction projects to be finished in a timely fashion.

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