The Prospective of Artificial Neural Network (ANN's) Model Application to Ameliorate Management of Post Disaster Engineering Projects

RASHA A WAHEEB [1], KUSAY A WHEIB[2] , BJØRN S ANDERSEN [3], RAFEA AL-SUHILI[4]

[1]NTNU, Trondheim, 7491, Reconstruction & Projects dep. University of Baghdad, Baghdad, Iraq (first author's affiliation)

[2]Soil & water resources dep., University of Baghdad, Baghdad, Iraq, MI, United States (second author's affiliation)

[3]Mechanical and Industrial Engineering, NTNU, Trondheim, 7491(third author's affiliation)

[4]Civil Engineering, CCNY, New York, USA (fourth author's affiliation)

Preprint not peer reviewed

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

The Prospective of Artificial Neural Network (ANN's) Model Application to Ameliorate Management of Post Disaster Engineering Projects

Abstract

Currently and under the COVID-19 which is considered as a kind of disaster or even any other natural or manmade disasters, this study was confirmed to be important especially when the society is proceeding to recover and reduce the risks of as possible as injuries. These disasters are leading somehow to paralyze the activities of society as what happened in the period of COVID-19, therefore, more efforts were to be focused for the management of disasters in different ways to reduce their risks such as working from distance or planning solutions digitally and send them to the source of control and hence how most countries overcame this stage of disaster (COVID-19) and collapse. Artificial intelligence should be used when there is no practical solution for a problem occurring in a projects starting from individual self-development ending to the adaptation to information technology sector with a continuous posting in this world of information industry where as metaphor "needs is a cause of creativity". This study focuses on the use of artificial neural networks ANN to find a solution to issues in projects delays and furthermore when there is no physical or mathematical solution found so far. ANN's were used to build a model that helps in finding a solution for delays in some selected projects in Baghdad (as case study), and discussing the strategies of rebuilding plus delays in time and cost due to delay factors. 35 construction projects were chosen in Baghdad greater area, vary in sizes and types. Crew and laborers were targeted in sampling collection methodology basically throughout questionnaire forms of field survey as they were filled by them. ANN's helped in modelling delays factors to help decision makers in an appropriate management of projects. External factors which includes disasters mentioning COVID-19 as the most important disaster ever happened in the last decades, were the most important factor that caused delay in time and cost of projects implementation processes where this factor was controlling the other major factors such as contractor failure, redesigning, changing orders, security issues, low prices, besides weather issues and owner failure.

Keywords: construction projects, problems, post-disaster projects, ANN's, solutions, project risk management.

1. Introduction

Projects in Iraq or any other country are suffering from different factors of delay. Those factors vary in their importance also due to many reasons, some of those reasons are in common in different countries, and some are related to a certain country or situation of that country. Thus, the method of collecting data should be built due to the area these data are collected from.

Delays in engineering projects are the challenges often faced in the course of implementation. Delay is a common problem in building industry all over the world that affects development of the construction industry particularly and of the overall economy of countries generally. To improve performance of project it is important to study the problems of delay that affect the success of project [1] factors of delay differ from country to another in general, but in special cases there are some certain delay factors that addressed to that country and not found in another one, i.e., weather factors could be sever in some places while it could be no issue in another place on the globe as the geographic zone and climate distributed on the globe. The evaluation and scaling delay factors will then depend on the region of occurrence, and how to manage that will also depend on the circumstances of those regions. Processing these factors and their solutions using programmed analyses will enhance the outcomes of such project management where in this paper we are trying to simulate what machine conducts to reveal solutions as they were exhibited live where this framework could be open for more fields of science.

2. Literature review

The Iran-Iraq war of 1980 had damaged many construction projects and buildings, bridges, infrastructure etc. Nevertheless, Iraqi engineers reconstructed that in a shortage of time and economic cost because Iraqi economy status last years was very good compared to these current years followed with right planning and achieving in construction projects management. In contemporary times, the city has often faced severe infrastructural damage, most recently due to the 2003 invasion, and the subsequent Iraq civil war that lasted until December 2011. In recent years, the city of Baghdad has been frequently subjected to insurgency attacks, the matter that led to destroy more of the infrastructure in the country. Thus, some projects were started to build what was destroyed up or to establish a new project to contribute in improving life in Iraq [2].

Avoiding wars from occurring is the best way to prevent war-related disasters in the first place. Perceptibly, it is too late to prevent what occurred during the war between Iran and Iraq that led to an outbreak of hostilities later [3]. Similar situations are likely to arise in the future of this country (Iraq) especially after the collapse of the prior regime in 2003 and what followed of the wakened armed conflicts that delayed construction industry in all fields in Iraq ([4], [5]).

To understand reconstruction after disasters we must build the subversion resulted later, and rebuild the infrastructure in a process of urbanization under post war/disaster conditions [6[. Therefore, it is a definition in a scale minus, because it takes in consideration the rebuilding process of the destruction of the physical infrastructure only, and neglects the rest of the urban fabric components [7]. Which form the physical structure of a society, where the physical infrastructure is, in fact, a reflection of life cultural, social and economic history, technology, climate, and human activity [8]. [9], have discussed risk management strategies caused by COVID-19 pandemic related suspensions of many projects in middle east countries and especially in Iraq. Where the main focus was how to manage and run projects under COVID-19 circumstances. Their study confirmed that the lack in remote project management was the key factor that caused the main delays in projects besides the other studied factors.

It has been known that reconstruction strategies after the disaster is a group of processes and policies that are placed to cope with disasters and prepare them before those to occur [10] and meet the pressing needs during a disaster and the reconstruction of what was damaged by whether on a short or long-term level [11]. So that these policies are inclusive of all aspects of life which intending the rebuilding processes during or post disasters within other social, economic, cultural aspects, and these policies are different in nature from those that are placed in situations and normal conditions. Moreover, it means meeting the needs of the abnormal and unstable conditions[12].

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

[13] considered disaster management as public project management and defined 10 critical success factors (CFS) that must be taken into consideration in disaster management as follow, effective institutional arrangement, clear responsible governmental unit and authority line will speed up decision making in recovery. on a national level, specific governmental department and responsible unit must have fully authorization to manage disasters, coordination and collaboration.

Furthermore, [14] has developed key considerations in pots-disaster reconstruction, was based on Disaster Emergency Committee (DEC) member agencies' experience during post-tsunami reconstruction in Aceh. He arranged reconstruction process into three sections: planning, design and construction. The humanitarian disaster occurred after the 2003 in Iraq was a product of the war and all sabotage and violence actions related to this war were literally practiced in Iraq in different levels of the society [15]. Moreover, led to clog the construction industry in Iraq for different reasons that delay or hinder the whole process causing cost and time overrun when projects implemented under these circumstances [16].

In their study, [17] examined the causes of time delays and cost overruns in thirty post-disaster reconstruction projects in Iraq. Although the factors of delays have been studied in many countries and contexts, there are few data available from countries in light of the conditions that characterize Iraq during the past ten to fifteen years of wars and crises that have not been witnessed by humans before. The case study approach was used, with thirty building projects of various types and sizes selected for the Baghdad case study. Project data were collected for surveys that were used to build statistical relationships between time delay rates, cost and delay factors in post-disaster projects. The most important delay factors identified were contractor failures, redo designs and change orders, security issues, selection of low-price bids, weather factors, and owner failures. Some of them may be in line with findings from similar studies in other countries and regions, but some are unique and are only found in samples of projects for the case study Iraq, such as security issues and the selection of low-price bids. While many studies have examined the factors causing delays and cost overruns, this study provides unique insights into the factors that need to be considered when implementing emergency and post-disaster reconstruction projects in areas affected by war and terrorism.

Artificial Neural Networks (ANNs) are a nonlinear computational method. It is a mathematical model that uses artificial intelligence and that, like other models, aims to fully or approximately represent problems in a system [18], The application of ANN's in civil construction was earlier used in the beginning of 90's of the last century [19], where they suggested to this method to be used in the field of civil engineering industry and take the whole advantages out of it to predict the best solution for the problems which this field faces basically.

Thus, the purpose of this study came to invent models under ANN's approach to consolidate projects that face problems in implementation by knowing the effective factors of delay before they occur, and to estimate the actual cost and time necessary for project and avoiding the overrun in both terms of cost and time under severe conditions of post disasters projects.

In their study, [21] examined content analysis to identify 38 recurring cost overrun factors and 11 major causes in oil and gas construction projects. The factors that cause cost overruns have been categorized based on their common root causes. The Delphi method was used to verify this classification. Evidence from 12 construction projects in the oil and gas sector that experienced cost overruns was used to verify the results of this study. The results of this study may help workers in the project sectors to mitigate the risks of cost overruns in oil and gas projects and achieve their budget targets and not exceed them.

[22], focused in their study on developing a distinctive plan for emergency reconstruction projects and helping community leaders and planners educate the public about how informed decisions and choices affect the process of rebuilding and achieving a safer and more sustainable society, economic recovery; emergency planning recovery. In discussions and deliberations within communities and about post-disaster reconstruction policy, participants have many other interests to balance against concerns about natural hazards like earthquakes; floods or war. These emotional debates elicit an often fervent desire to perpetuate historical and unsafe development patterns and construction techniques versus a desire to use disasters as opportunities to rethink these patterns and practices and move away from unconscious decisions of the past. Intelligently balancing competing interests has always been at the heart of planning.

[23] devised a program to predict delays in construction projects and before the project reaches the stage of cash shortage and stoppage, to mitigate Hazard and to give a new method of risk management to make change in traditional stylish Risk assessment by using a real data form Iraq Case study. by using artificial intelligence networks through the questionnaires on which the program was built and which were distributed in projects and data collection through a distributed data collection survey conducted by the author. Mathematical data analysis was used to build a model to predict the change in time and cost of projects before construction began. Artificial neural network analysis was chosen as a mathematical approach. The most important factors identified that led to schedule delays and cost increases were contractor failures, re-designs of blueprints and change orders, security aspects, underbidding bids, weather factors, and owner failures. In their study, the researchers confirmed that using the ANN model for such a problem is an effective way to model this complex phenomenon.

[24] found that the use of the artificial neural network model is an important option for problems that projects may face and is expected to be an effective method for modeling this complex phenomenon in post-disaster emergency reconstruction projects.

3. Proposed approach

We assumed that delay in cost and time has difficulties to be predicted and solved, thus ANN's was chosen to reach a solution for them. Due to the development in the information technology and computer sciences recently, this branch of knowledge artificial neural networks "ANN's" has grown rapidly. This rise came to find solutions for complicated data analysis which is based on large sample size to find solutions for problems by modelling them using high computer languages and sophisticated algorithms [20]. The easiest way to represent ANN's principle is that they are simulating the human brain in solving problems in a primitive way. Definitely many processes occur inside the brain cells "neurons" to solve a problem then a solution comes out for them without knowing how that solution was made up. Signals between neurons are transferred though links where the strength of these links interpret how strong the relationship between neurons are.

This is exactly what happens in the ANN analysis, where figure 1 represents the layers of processes that happens in treating data under this approach. The first layer is the input vector layer where;

Answers of questionnaire forms represent the main data collection method to determine delays in time and cost later. Therefore, practicing these models, will definitely contribute in finding suitable solutions to avoid delay in projects and estimating them before they occur especially after these causes of delays being frequently happening in different projects while these projects are described as unique projects. And each one is totally different than the other. Moreover, that will optimistically help the constructional foundations to assess the current status before starting a project. Results have been discussed to explain how delay factors are acting then raising all reasons causing them and showing which factor was the most

Preprint not peer reviewed
This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

effective and which one was the least. Also, ANN's and regression models were tested to estimate delay in cost and time and showing the ability of using these models to estimate the needed time of implementation and the adequate cost that should be considered in the budget of the project with the

3.1 Artificial Neural Network analysis (ANN's)

The definition of intelligent neural networks is seeking a solution when problem exists and solution is absent. Neural networks are a computational strategy used in civil engineering works and other fields of knowledge, which is built on a wide data collection represented as neural units (neurons), somehow imitating the way an organic brain answers questions of research and solving a problem with large clusters of biological neurons connected by axons [25].

We assumed that delay in cost and time has difficulties to be solved, thus ANN's was chosen to reach a solution for them. Artificial Neural Networks (ANN's) have been used as a method in complicated problems finding solutions for them when these solutions are hard to find in the regular methods. As in this study, ANN's based built model was used as a method to find a solution for a complicated problem which is forecasting delay in construction projects under two different circumstances. Conventional conditions in Baghdad as a case study which is suffering from stress of many kinds of conflicts[1], and the other one is under emergency conditions especially after the violence activities occurred through the war against terror that forced people to immigrate from their places to other areas.

As to the previous definition of the ANN's, the model was built in this study is composed of three layers, input layer, hidden layer, and output layer. Input factors presenting the first layer is identified as (delay factors) to predict the output layer "third layer" of an efficiency product (Time and Cost) based where those products are then used to adjust an average time and cost gradient (ΔT and ΔC) of implementation for use on a specific project.

required quality. The model should consider the quality in determining the expected delay in cost, where the later should be determined due to some standard specifications following the Iraqi standard specification (ISS) that is originally derived from the American Society for Testing and Materials (ASTM).

[1] Such as post war remains, sectarian and civil war, terror and violence activities, and insecure society.

Preprint not peer reviewed

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

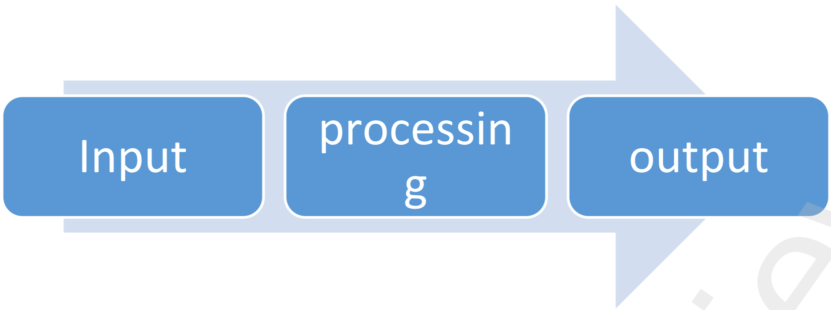


Fig. 1 ANN's work frame

The model used in this research is the Artificial Neural Network (ANN) approach. To review the concept find that they simulate the learning behavior of the human brain.

To illustrate this, we first need to imagine the basic neurobiological structure of the brain consisting of an estimated 1011 (100 billion) neurons, [26], neurons connected by electrical signals that are ephemeral pulses of electrical current in a cell wall or membrane. Synapses are those inner neural connections, which are refereed by electrochemical joints as they are located on branches of the cell called dendrites. Normally each neuron gets thousands of connections from other neurons, and therefore it constantly accepts a huge amount of internal signals that eventually reach the cell body. They are also combined together in a certain way to develop a weighted signal for the input and when the resulting signal exceeds some threshold value, a voltage pulse will be ignited or launched by the neuron in response. This signal is then transmitted to other neurons via branching fibers of neurons called the axon. [27].

However, since biological neural networks are then formed, artificial neural networks are modeled as a set of elementary computational entities represented by nodes, organized in a corresponding technique. The nature of the brain is designed to contain nearly as many neurons while artificial neural networks have much fewer nodes than the neurons in the brain. In addition, ganglia function much simpler than the neurons they represent. However, this will not prevent artificial neural networks from detecting brain-related properties that include learning and memory at different scale and amplitude. [26], [28],

[34] developed multiple linear regression models for preliminary cost estimating to be used by Alabama Highway Department (AHD) for long range cost forecasting. The total project cost per mile unit is the function of a list of probable independent factors representing line items, such as quantities of work items per distance unite (mile).

Thus, another model was built using statistical approach (SPSS 2010) where liner regression was tested for the collected data in two models, the first one to reveal the relationship between the actual and the planned time, and the second one was for the actual and planned cost.

These two models "equations" represent a liner regression of the form:

Y= a ± bX

Where: Y : the estimated time or cost (dependent variable)

X: delay factors (explanatory variable)

a: intercept (value of Y where X=0)

b: the slope of the line

[29] The node is the main component of the artificial neural network. [30] compared artificial neural network (ANN) with models, adaptive fuzzy neural inference system (ANFIS) models in a distribution system with non-deterministic inputs to reduce cost from the classical recharge model, finding that using ANN reduced cost by 34% while saving 36% of the cost using the ANFIS model, along with the newer model was able to modify the values of input and output variables a more robust solution.

Further development of this ANN model for construction project management is possible in some different fields such as manufacturing and design Similar ANN models have been successfully developed, for example the garment industry 11,

[31] developed three cost prediction models in order to determine an accurate cost for road maintenance. These models were developed in New Brunswick province for the period 1965–1994. According to these models and the historical review, they concluded that the funding of maintenance increased by 25% as compared to the original fund.

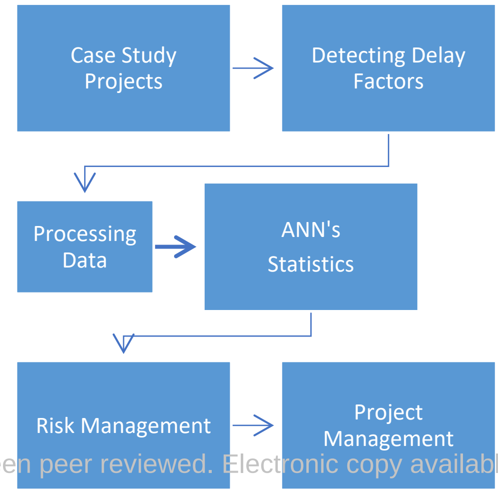
[32] developed a parametric cost-estimating model for highway projects by using a neural network approach to manage construction cost data. They presented two alternative methodologies to train network's weights: simplex optimization, and genetic algorithms.

multiple linear regression models for preliminary cost estimating of road construction activities as a function of project's physical characteristics such as terrain conditions, ground conditions and soil drill ability were developed by [33].

Correlation coefficients were also calculated to figure the strength of association of the observed data for X and Y.

Data included in these models were for the projects in the conventional and emergency status, where we put in out consideration that ANN's analysis wouldn't fit in emergency status because these projects are not suffering from delays because every step in conducting them was studied and implemented the way it should be, but their data were used in finding the regression relationship of predicting cost and time of implementation.

Projects in Iraq or any other country are suffering from different factors of delay, those factors vary in their importance also due to many reasons, some of those reasons are in common in different countries, and some are related to a certain country or situation of that country. The following flowchart shows the logical steps of conducting this study.



Preprint not peer reviewed
This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

4. Results and Discussion

4.1 Delay factors in relation to questionnaire results

Delay factors of this study were suggested to meet the characterization of those factors that cause shortage in construction project implementation and management. Beside the reviews survey. Field samples were represented by questionnaire and have also suggested that the main delay factors are occurring frequently in the surroundings of this case study (Baghdad city, Iraq). They are as shown below.

The major delay factors in construction projects that have been examined in the study are considered as in regular status. Where they are repeated somewhat in most construction projects all over the world in different rates of importance due to the conditions of the country such study is conducted in. The focus of this research is a major cause of twelve conventional construction projects factors explained in more details as follows :

1. Security status as the case study being suffering from severe security issues at the time of this study being conducted (S.S)..
2. Contractor failure in technical, administrative, and financial efficiency (Contractor failure/ Cont. F.).
3.Public holidays newly added after the war of 2003. (H.O).
4.Weak project management that coming from different reasons of owner failure (Owner failure/ O.F).
5. Redesigning and upgrading the original designs, sketches and plans of the project frequently (R.D).
6.Changing site location due to the different opinions of site selection. (C.S.P).
7. Conflicts over the land ownership and the lack of coordination between the owners of the project and the neighboring sites (DPP).
8. Consultant engineer failure who works for the employer (Cons. F).
9. Hauling business to lower prices (lower prices/ L.P).
10. Laboratory tests delay (L.T.D).
11. Weather factors (W.F) that include high temperature especially in summer and fall seasons, which reaches over 45 C^{o} in the shade, also rainfall in winter and spring time.
12. External factors (E.F) Such as the national power source shortage as Iraq infrastructure was destroyed after the war of 2003, also it might include manmade disasters such as diseases and break outs that might happen.

The previous factors were chosen due to two important references, the first one was the literature reviews that suggested different kinds of factors, while the second one was the results of questionnaire of those factors selected in poll questionnaire. Questionnaire form of that poll (table1) were distributed to employees and workers in the field of construction industry of different sectors official directories and offices in Baghdad area. Where they selected those 12 factors of delay as the most affecting factors in that field. These factors were rearranged according to their importance, ascendingly.

the main factors of delay in samples of construction projects that have been examined in the study for the conventional status (not being under the stress of emergency). Where they are repeated somewhat in most construction projects all over the world in different rates of importance due to the conditions of the country such study is conducted in. The focus of this research is a major cause of twelve conventional construction projects factors.

Table 1
Form 1 Delay projects data information form (Baghdad)

Delay projects data information form ((Baghdad))
1. Project name: treatment station
2. Foundation: Ministry of industry
3. Construction project type: chemical plant
4. Starting date: 01/04/2011
5. Contracting date: 10/01/2011
6. Project implementation period: 6 months
7. Project cost US $805457.2
8. Expected implementation date: 01/07/2011
9. Actual implementation date: 01/06/2012
10. Actual project cost: US $1264208
11. Working stop causes: fiscal budget delay
12. Warnings against contractor: 3 times

Preprint not peer reviewed

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

13. Additional periods: 13 months
14. Reasons to grant additional periods: system delay and security status
15. Delay penalties: (planned cost-actual cost)/ period of project * 100
16. Poor implementation: 15%
17. Notes: delay factors (system instruction and security status)

Table 1 showed survey form of selected projects were distributed in Baghdad city. Projects data was collected using 300 forms. These forms were filled out by employees working in the construction field and 250 forms were filled out, while 50 other forms were neglected because they were incompletely filled out, these 250 forms were representing 30 selected projects in Baghdad area that suffer from delay in conventional status, another five projects were chosen to represent projects under emergency conditions.

As Iraq went through war circumstances and still passing through consequences of war action, as sectarianism violence, religious extremism, political affiliations, etc. all that led Iraq to go through emergency status, and all constructions projects occurred in that time would be considered as emergency status projects.

More than 90% of bridges in Anbar province, Iraq (for example) were totally destroyed. Few temporary bridges were built to replace them and those new built bridges are one side local made and materials, where they are just an emergency-built bridges, the money is granted by donor's countries so they have to be rebuilt to their original status projects to rebuild them.

Residential units and foundations are also destroyed where the whole infrastructure of the big cities of this province were totally destroyed by terrorist group to preve liberation forces to liberate these areas from their authority. The matter that looks very difficult to rebuild and reconstruct unless all efforts, funds and supports are gathered areas.

Here we can mention what happened to Iraq in early centuries when the Mongolian army invaded and destroyed it. Although what is happening NOWADAYS is even worse than what happened in that era.

Three emergency bridges were assigned in Ramadi transportation state of roads and bridges in the ministry of construction and housing. Mentioning Al-qasim, Abo-Faraj, Omar bin Abdulaziz, alternative bridges as emergency construction project. They were rebuilt by using a loan from the international bank of 4.300.000 million $ in one year of implementation and through the field visit, al Qasim bridge has been conducted and being used for public transportation after liberating these areas from the authority of terrorists groups.

Emergency projects were selected to be studied and compared to the conventional status projects as in table 2. It was simple to notice that the planned and actual time and cost in emergency condition projects were the same while in conventional condition, we have noticed big differences in cost and time as all mentioned before.

Table 2
Emergency projects with their costs and times

Project no.	Project Name	Contract Project time	Actual Project time	Contract Project cost	Actual Project cost
		Months		$ US	
1	22 Presidential Houses	6.0	24.3	45056000	55296000
2	Emigration office	15.2	18.2	1424400	1568400
3	Housing complex	36.5	39.5	76000000	84000000
4	Service office building	12.2	19.2	200000	240000
5	Karkh Traffic office	18.2	24.2	720000	880000
6	Ibn Sina hospital	3.0	27.0	7200000	11200000
7	Headquarters of the construction and housing department	12.2	14.2	1011984	1040000
8	Preparation of Ziggurat building	15.0	17.0	19002.77	19179.2
9	Department of burns at Yarmouk hospital	12.2	15.2	3200000	4000000
10	Temporary workshops	6.0	8.0	90515.2	92000
11	Additional buildings, College of Law, Mustansiriya University	23.2	29.2	2383690	2800000
12	Installation of complete washing machines in Baghdad Factory of Textiles	4.0	8.0	336000	353600
13	Rehabilitation of treatment station(zonal development plan	6.0	20.0	805457.2	1264208
14	The complementary phase of the classrooms project	3.0	8.0	224000	224000
15	Auditorium for College of education for women	2.5	2.7	96000	96000
16	College of Arts, university of Baghdad	24.0	32.0	2864000	3160000
17	Construction of space and communications building	4.0	9.2	1060925	1192000
18	The new headquarters building of the Ministry of Science and Technology	12.2	17.2	2800000	3000000
19	Engineering affairs building	18.0	27.0	1555048	1921001
20	Civil Defense Building	8.0	14.0	480000	494215.5

Preprint not peer reviewed

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

21	Gate of Baghdad – Hilla project	18.0	55.0	4856668	5196634
22	Gate of Baghdad – baquba project	18.0	46.0	4985209	5982250
23	Gate of Baghdad – Kut project	18.0	45.0	5224811	6269773
24	12 classrooms School in a Al-rashidiya project	4.0	28.0	567455.2	576000
25	Construction of the Mesopotamia building in Mahmudiya	6.0	42.4	630696.8	674844.8
26	Gate of Baghdad – Mosul project	18.0	55.0	5551249	5939836
27	Restoration and reinforcement of classrooms in Sumaya elementary school	4.0	12.2	157600	168000
28	Building a model 18 classrooms school complex in husseiniya.	5.0	5.7	837344	837344
29	Building a model school complex in Basmayah, Nahrawan area	8.0	8.0	1487200	1487200
30	Building a model 12 classrooms school complex in Mahmudiya	12.2	12.2	2400000	2400000
31	emergency project Baghdad	2.0	2.0	5120000	5120000
32	emergency project Erbil	2.0	2.0	5120000	5120000
33	emergency project Duhock	2.0	2.0	5120000	5120000
34	emergency project Sulaimaniya	2.0	2.0	5120000	5120000
35	emergency project karbala	2.0	2.0	5120000	5120000

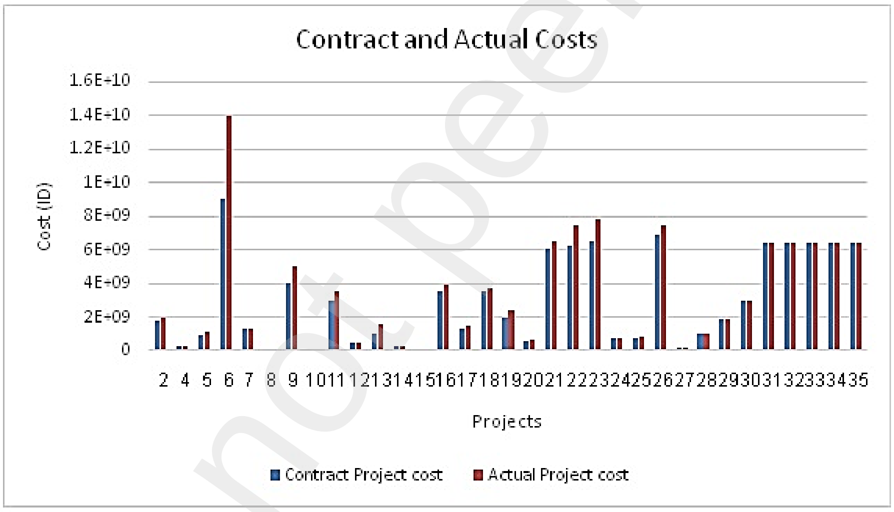
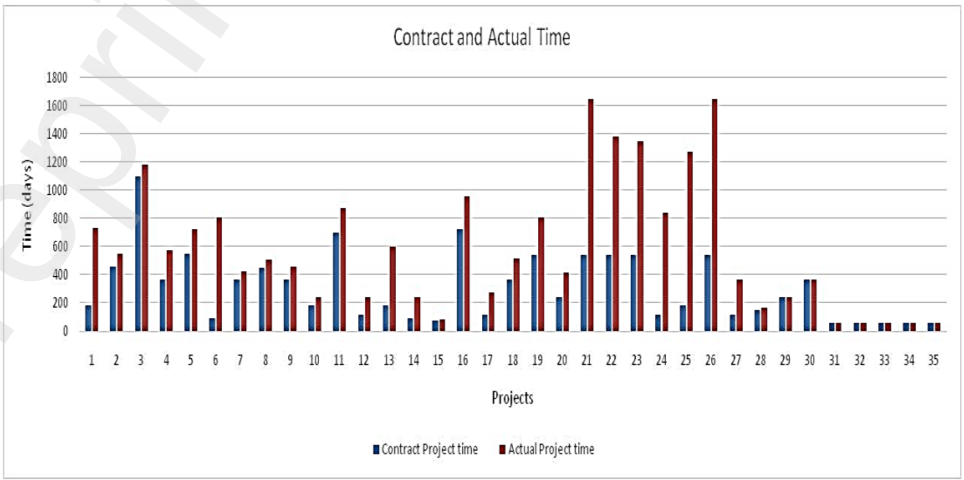


Fig. 2 contract and actual cost distribution histogram



Preprint not peer reviewed

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

Fig. 3 contract and actual time distribution histogram

Figure 2 shows the distribution histogram of the projects contract (planned) and actual costs. It emphasizes that the actual cost was always much higher than the contract one especially those projects of highly planned cost (project 6), also figure 3 shows the distribution histogram of the time of implementation (the contract and the actual one), where we can also see that all projects actual time was longer than the contract time. These differences in contract and actual cost and time were due to the delay factors. While we can see that the emergency projects are having the same cost and time of implementation for both the contract and the actual cost and time, and they are not witnessing any kind of delays because of the fixed cost and time specified for these projects that they supposed that they are not suffering from any delay factor.

4.2 Costs relationships

We investigated the regression model between the planned costs (C0) with the actual cost (C act.) for 28 of the implemental projects[2], as shown in fig. 4. This figure shows that these two costs (C0, Cact.) are very correlated to each other

($R^2 = 0.96$) and this relationship is described by the equation.

C act. = 1.2844(C0)-2E+8 ($R^2 = 0.96$)

Where C0 =planned cost

C act. = actual cost

We applied this equation as a feedback to determine the actual cost of the 28 projects included in forming this equation. It gave very close values to actual cost values. We also applied this equation to another two projects cost, that were not included in forming this equation, and it also gave a very close predicts to the values of the actual cost. That means this equation could be valid to predict the actual cost of any project if we know the planned cost that was originally put while bidding.

[2] The statistical model was built from the real data using the local currency (Iraqi Dinars IQD) but we transferred them to the US Dollar ($US) for more internationally understanding, assuming the factor of money exchange used is $1 US = 1250 IQD.

Preprint not peer reviewed

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

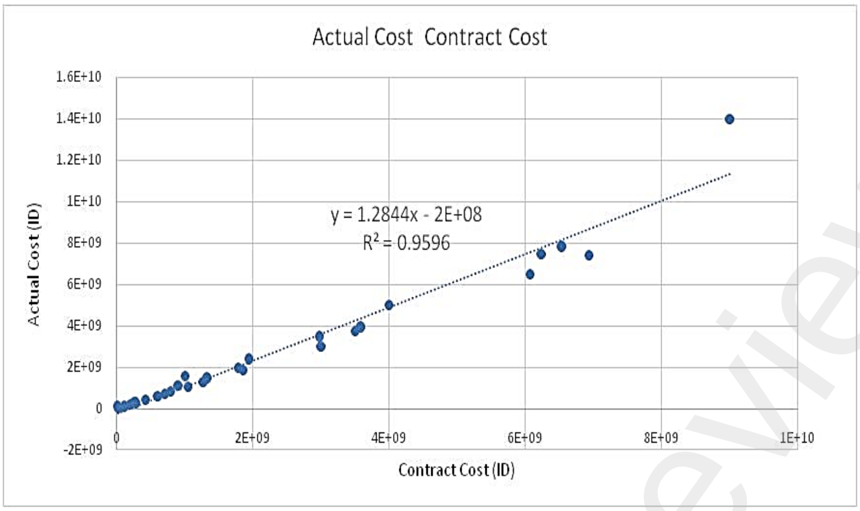


Fig. 4 Actual and planned (contract) cost

Table 3
Actual and planned costs feedback

Project no.	Project Name	Contract Project time	Actual Project time	Contract Project cost	Actual Project cost	measured cost (feedback)
		Months		$ US		
1	22 Presidential Houses	6.0	24.3			57709926.4
2	Emigration office	15.2	18.2	1424400	1568400	1669499.36
3	Housing complex	36.5	39.5			97454400
4	Service office building	12.2	19.2	200000	240000	96880
5	Karkh Traffic office	18.2	24.2	720000	880000	764768
6	Ibn Sina hospital	3.0	27.0	7200000	11200000	9087680
7	Headquarters of the construction and housing department	12.2	14.2	1011984	1040000	1139792.25
8	Preparation of Ziggurat building	15.0	17.0	19002.77	19179.2	-135592.8458
9	Department of burns at Yarmouk hospital	12.2	15.2	3200000	4000000	3950080
10	Temporary workshops	6.0	8.0	90515.2	92000	-43742.27712
11	Additional buildings, College of Law, Mustansiriya University	23.2	29.2	2383690	2800000	2901611.95
12	Installation of complete washing machines in Baghdad Factory of Textiles	4.0	8.0	336000	353600	271558.4
13	Rehabilitation of treatment station(zonal development plan	6.0	20.0	805457.2	1264208	874529.228
14	The complementary phase of the classrooms project	3.0	8.0	224000	224000	127705.6
15	Auditorium for College of education for women	2.5	2.7	96000	96000	-36697.6
16	College of Arts, university of Baghdad	24.0	32.0	2864000	3160000	3518521.6
17	Construction of space and communications building	4.0	9.2	1060925	1192000	1202651.813
18	The new headquarters building of the Ministry of Science and Technology	12.2	17.2	2800000	3000000	3436320
19	Engineering affairs building	18.0	27.0	1555048	1921001	1837303.549
20	Civil Defense Building	8.0	14.0	480000	494215.5	456512
21	Gate of Baghdad – Hilla project	18.0	55.0	4856668	5196634	6077903.866
22	Gate of Baghdad – baquba project	18.0	46.0	4985209	5982250	6243002.182

Preprint not peer reviewed
This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

23	Gate of Baghdad – Kut project	18.0	45.0	5224811	6269773	6550747.506
24	12 classrooms School in a Al-rashidiya project	4.0	28.0	567455.2	576000	568839.4589
25	Construction of the Mesopotamia building in Mahmudiya	6.0	42.4	630696.8	674844.8	650066.9699
26	Gate of Baghdad – Mosul project	18.0	55.0	5551249	5939836	6970024.318
27	Restoration and reinforcement of classrooms in Sumaya elementary school	4.0	12.2	157600	168000	42421.44
28	Building a model 18 classrooms school complex in husseiniya.	5.0	5.7	837344	837344	915484.6336
29	Building a model school complex in Basmayah, Nahrawan area	8.0	8.0	1487200	1487200	1750159.68
30	Building a model 12 classrooms school complex in Mahmudiya	12.2	12.2	2400000	2400000	
31	emergency project Baghdad	2.0	2.0	5120000	5120000	
32	emergency project Erbil	2.0	2.0	5120000	5120000	
33	emergency project Duhock	2.0	2.0	5120000	5120000	
34	emergency project Sulaimaniya	2.0	2.0	5120000	5120000	
35	emergency project karbala	2.0	2.0	5120000	5120000	

The equation could be used by both sectors, the governmental and the private. Where in most contracts, the process of bidding is to accept low prices, therefore there will be some consequences resulted from low prices bidding that reflected by fraud and quality manipulations when the contractor may show while carrying out and here it could give the key to determine actual cost of any project.

4.3 Time relationships

We also investigated the regression of the contract time and the actual time of implementation (fig 5) as a trial to predict the actual time when the contract time is fixed.

There was a high correlation between both durations of implementation (R^2=0.92)

Moreover, this relationship was described by the equation.

$T_{act.} = 1.0738 \times T0 + 94.75$ (R^2=0.92)

Where T act. = actual time of implementation

T0 = the contract time.

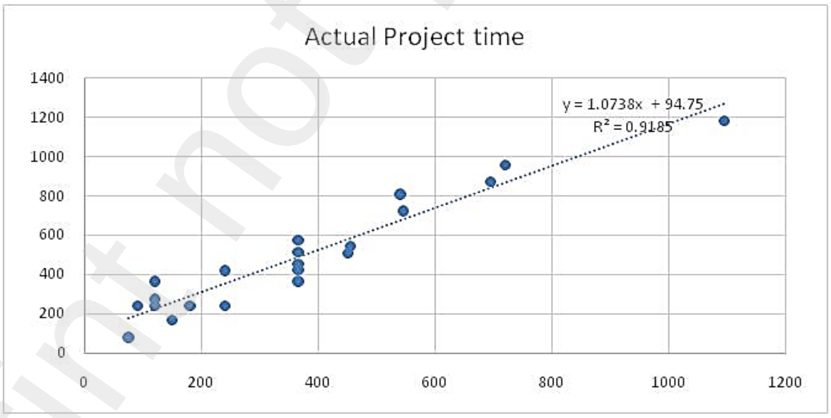


Fig. 5 actual and contract time

Table 4
Actual and contract times feedback

Project no.	Project Name	Contract Project time	Actual Project time	Contract Project cost	Actual Project cost	measured time (feedback)
1	22 Presidential Houses	6.0	24.3			
2	Emigration office	15.2	18.2	1424400	1568400	19.44
3	Housing complex	36.5	39.5			42.35
4	Service office building	12.2	19.2	200000	240000	16.22

Preprint not peer reviewed

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

5	Karkh Traffic office	18.2	24.2	720000	880000	22.67
6	Ibn Sina hospital	3.0	27.0	7200000	11200000	
7	Headquarters of the construction and housing department	12.2	14.2	1011984	1040000	16.22
8	Preparation of Ziggurat building	15.0	17.0	19002.77	19179.2	19.27
9	Department of burns at Yarmouk hospital	12.2	15.2	3200000	4000000	16.22
10	Temporary workshops	6.0	8.0	90515.2	92000	9.6
11	Additional buildings, College of Law, Mustansiriya University	23.2	29.2	2383690	2800000	28
12	Installation of complete washing machines in Baghdad Factory of Textiles	4.0	8.0	336000	353600	7.45
13	Rehabilitation of treatment station(zonal development plan	6.0	20.0	805457.2	1264208	
14	The complementary phase of the classrooms project	3.0	8.0	224000	224000	6.4
15	Auditorium for College of education for women	2.5	2.7	96000	96000	5.8
16	College of Arts, university of Baghdad	24.0	32.0	2864000	3160000	29
17	Construction of space and communications building	4.0	9.2	1060925	1192000	8
18	The new headquarters building of the Ministry of Science and Technology	12.2	17.2	2800000	3000000	16.2
19	Engineering affairs building	18.0	27.0	1555048	1921001	23
20	Civil Defense Building	8.0	14.0	480000	494215.5	12
21	Gate of Baghdad – Hilla project	18.0	55.0	4856668	5196634	
22	Gate of Baghdad – baquba project	18.0	46.0	4985209	5982250	
23	Gate of Baghdad – Kut project	18.0	45.0	5224811	6269773	
24	12 classrooms School in a Al-rashidiya project	4.0	28.0	567455.2	576000	
25	Construction of the Mesopotamia building in Mahmudiya	6.0	42.4	630696.8	674844.8	
26	Gate of Baghdad – Mosul project	18.0	55.0	5551249	5939836	
27	Restoration and reinforcement of classrooms in Sumaya elementary school	4.0	12.2	157600	168000	8
28	Building a model 18 classrooms school complex in husseiniya.	5.0	5.7	837344	837344	8
29	Building a model school complex in Basmayah, Nahrawan area	8.0	8.0	1487200	1487200	11
30	Building a model 12 classrooms school complex in Mahmudiya	12.2	12.2	2400000	2400000	16
31	emergency project Baghdad	2.0	2.0	5120000	5120000	
32	emergency project Erbil	2.0	2.0	5120000	5120000	
33	emergency project Duhock	2.0	2.0	5120000	5120000	
34	emergency project Sulaimaniya	2.0	2.0	5120000	5120000	
35	emergency project karbala	2.0	2.0	5120000	5120000	

This equation was tested as a feedback (table 4) for some projects and it gave a close value of the predicated time of implementation to the actual time besides we also tested this equation for some projects that not included in forming the equation itself, and it gave a close estimates to the actual time of implementation.
This equation then could be used to determine the actual time of projects implementation when the planned time is fixed in the contract itself.

The difference between the predicted time that is almost equal to the actual time, and the contract time (planned) is caused due to the delays factors that were studied in earlier paragraph.

Analysis of variance showed that there was no significant deference between the planned cost (C0) and the actual cost (C act.), where most contractors were committed to their prices they submitted to conduct the work, with some variation or extra cost in spite of the non-significance of it . While there was a highly significant differences between the contract times (T0) and the actual time (Tact.), ($p<0.01$). Which confirms that most contractors are not committed to the time of implementation due to factors of delays suggested in this study, the matter that lead the beneficiary to apply penalties of time shifting.
These empty cells were not use in building model equation but they gave a close value as a feedback.

4.4 ANN's and Statistical model building

A quick look at the results showed how delay factors played an important role in cost and time delays. Hence, the statistical methodology gave results for arranging the delay factors in such

Preprint not peer reviewed

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

a way that the factors affecting cost and time delay were studied. If we look at the model that was built for this study, we can see that delay factors can affect cost and time delays directly.

This models can be used in engineering projects to predict delay ratio and additional cost before the deadline of project in time and before approaching to the financial shortage. There are two plans to keep in mind in this case before starting the project itself. The first is to shift the cost of the project to approach the cost predicted by this model and in that case there will be no or less shortage in cost, also adjusting the time specified for the project and in this case, therefore, time delay could be eliminated. The second plan is to control the delaying factors as much as possible as the port can do, the shortfall of cost and time will also be reduced. This form can be used by the owner and contractor. They can use it to predict the additional cost and time to consider when awarding the bid. Here he will put all possibilities in the plan before bidding, and he can also negotiate with the beneficiary for better results. This model has been designed primarily for the beneficiary before even assigning the bid to any contractor and including the terms of contracts that include estimating the true cost and the schedule of the successful project at the end.

Project no.	CTF	HO	RD	CSP	DPP	OF	SS	LTD	CSF	EF	WF	LP	Planed Time	Actual Time	Planed Cost	Actual Cost
1	0.7	0.3	0	0	0	0	0.1	0	0	0	0	0.2	6	24.3	45056000	55296000
2	0	0	0.5	0.5	0	0	0.2	0	0	0	0	0	15.2	18.2	1424400	1568400
3	0	0	0.3	0	0.5	0	0.1	0	0	0	0	0.5	36.5	39.5	76000000	84000000
4	0	0	0.7	0	0.3	0.5	0	0	0	0	0	0	12.2	19.2	200000	240000
5	0.3	0	0.2	0	0	0	0.7	0	0	0	0	0	18.2	24.2	720000	880000
6	0	0	0.6	0	0	0	0.3	0	0	0	0	0.4	3	27	7200000	11200000
7	0	0	0	0	0.5	0	0	0	0	0	0	0.4	12.2	14.2	1011984	1040000
8	0	0	0.8	0	0	0	0.3	0	0	0	0	0	15	17	19002.77	19179.2
9	0	0	0.6	0	0	0	0.1	0	0	0	0	0.5	12.2	15.2	3200000	4000000
10	0	0	0	0.9	0	0	0	0	0	0	0	0	6	8	90515.2	92000
11	0	0	0.4	0	0	0.8	0	0	0	0	0	0	23.2	29.2	2383690	2800000
12	0.5	0.5	0	0	0	0.3	0.2	0	0	0.3	0	0.2	4	8	336000	353600
13	0.5	0	0	0	0	0.5	0.1	0	0	0	0	0	6	20	805457.2	1264208
14	0	0.5	0.3	0	0	0.2	0.1	0.2	0.2	0	0	0.2	3	8	224000	224000
15	0	0	0	0	0	0	0	0	0	0	0.4	0	2.5	2.7	96000	96000
16	0	0	0	0	0	0.6	0.3	0	0	0	0	0	24	32	2864000	3160000
17	0	0	0.6	0	0	0.5	0	0	0	0	0	0	4	9.2	1060925	1192000
18	0	0.4	0	0	0	0	0	0.5	0	0	0.2	0	12.2	17.2	2800000	3000000
19	0.4	0.3	0	0	0	0.3	0	0	0	0	0	0.2	18	27	1555048	1921001

Table 5
Delay factors

Contractor failure = Cont. F	Security status =S.S	External factor =E.F
New holidays =H.O	Consultant failure =Cons. F	Weather factor =WF
Redesign =R.D	Delay preparation position =D.P.P	
Change site position =C.S.P	Laboratory test delay =L.T.D	
Owner failure =O.F	Low price =L.P	

Preprint not peer reviewed

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

20	0	0.3	0.5	0	0	0	0	0	0	0	0.4	0	8	14	480000	494215.5
21	0.5	0	0.4	0	0	0	0.4	0	0	0.2	0	0.1	18	55	4856668	5196634
22	0.3	0	0.6	0	0	0	0.3	0	0	0.3	0	0.2	18	46	4985209	5982250
23	0.6	0	0.3	0.4	0	0	0.2	0	0	0	0	0	18	45	5224811	6269773
24	0.6	0	0	0	0.3	0	0.1	0	0	0	0	0	4	28	567455.2	576000
25	0.6	0	0.2	0	0	0	0.2	0	0	0.2	0	0	6	42.4	630696.8	674844.8
26	0.4	0	0	0	0	0	0.5	0	0	0	0	0.2	18	55	5551249	5939836
27	0.8	0	0	0	0	0	0.2	0	0	0	0	0.4	4	12.2	157600	168000
28	0	0	0	0	0	0.2	0	0	0	0	0	0	5	5.7	837344	837344
29	0	0	0	0	0	0	0	0	0	0	0	0	8	8	1487200	1487200
30	0	0	0	0	0	0	0	0	0	0	0	0	12.2	12.2	2400000	2400000

Table 6
Delay projects with their delay factors weights

4.5 ANN's analysis interpretation:

Actual time in relation to delay factors:

An artificial neural network analysis was conducted to find out how the actual time was affected by the delay factors chosen in this study. One input layer represents the actual time that should be affected by the delay factors, one output layer was suggested by this test, and two hidden layers were selected to conduct the mathematical processes in the ANN's analysis to increase the accuracy of outputs. Figure (6) shows these three layers in a network diagram.

Preprint not peer reviewed

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

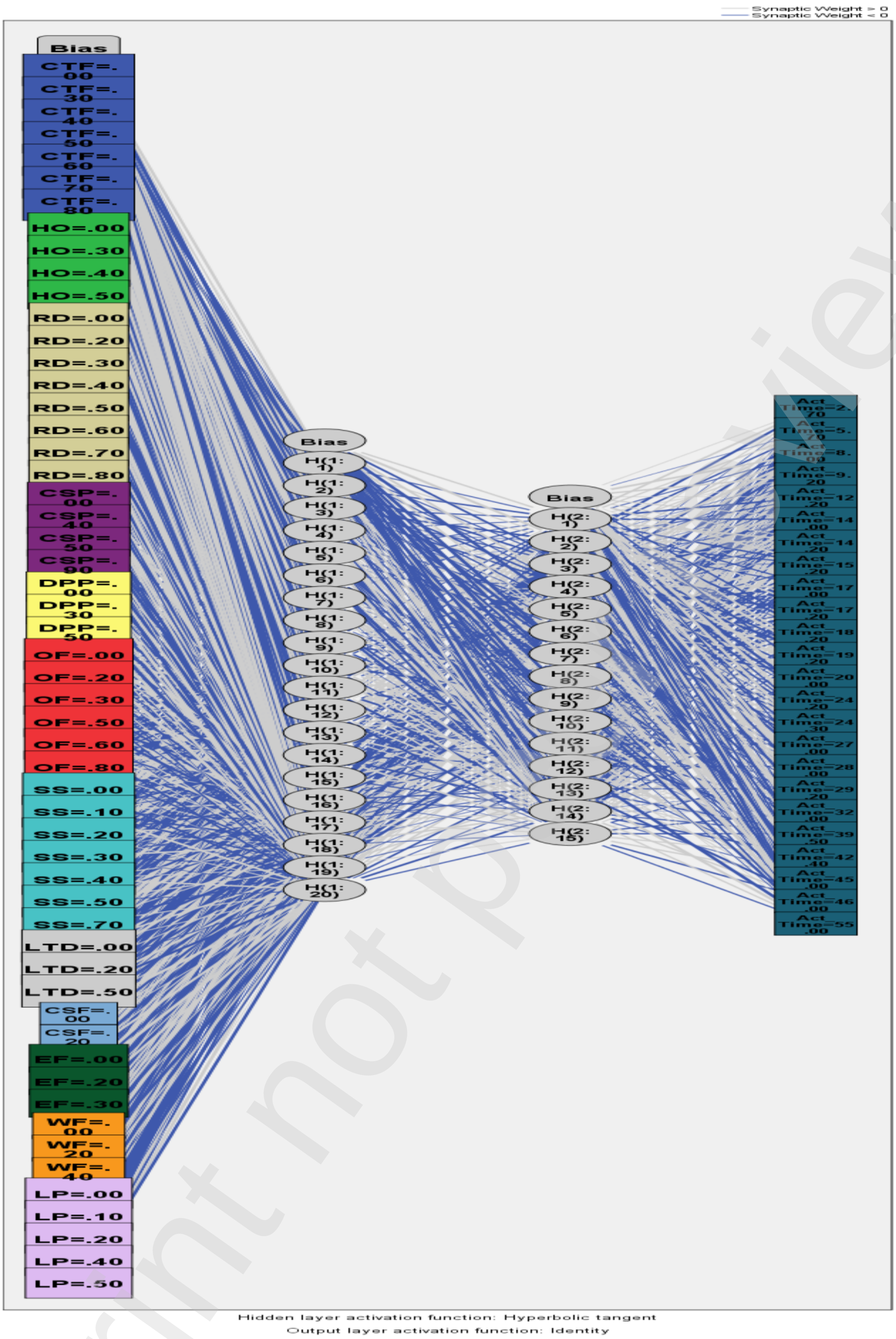


Figure 6 network diagram of actual time delay in relation to delay factors

The model summery (table 7) showed that the sum of squares errors was 7.298 which refers to a good prediction of this ANN's model to find out the importance of the factors affecting the actual time of implementing the project under the stress of delay factors where the percentage of incorrect prediction was 10.0%, in another meaning, the accuracy of this mathematical model was 90.0% accurate which is considered as a high accuracy percentage for prediction.

Table 7
Model summery of the actual time ANN's analysis

Training	**Sum of Squares Error**	**7.298**
	Percent Incorrect Predictions	10.0%

Preprint not peer reviewed

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

Stopping Rule Used Training Time	Maximum number of epochs (100) exceeded 0:00:00.11

Dependent Variable: Act. Time

The figure (7) of specificity and sensitivity of the model also showed a high percentages of specificity of the model in the meanwhile, the sensitivity of the model showed high values as well, which also confirm the significance of using ANN's analysis in predicting delay factors affecting the actual time of implementation under uncontrolled project management circumstances.

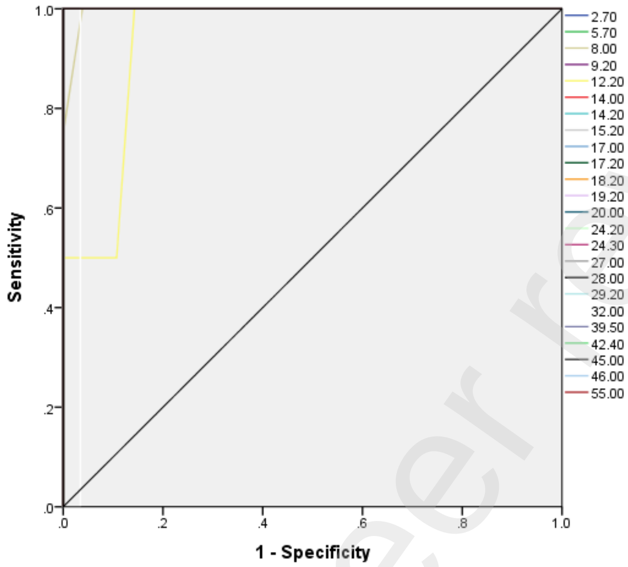
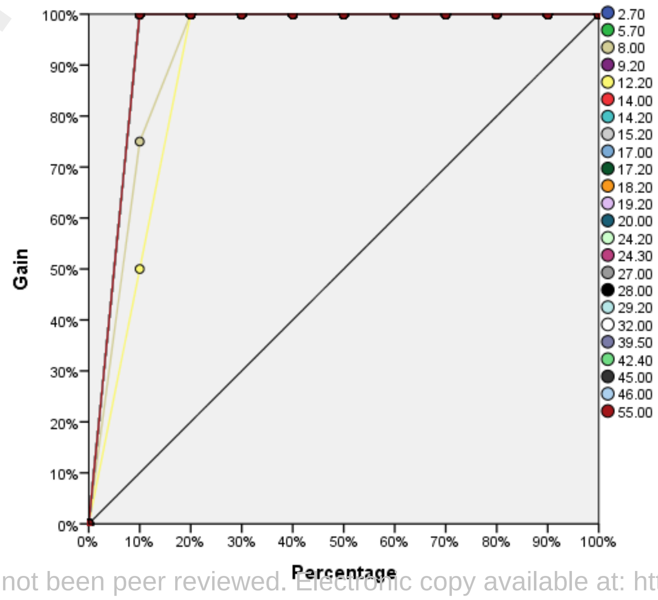


Figure 7 specify and sensitivity percentage diagram of actual time affected by delay factors

Gain percentages diagram (figure 8) shows that there was a high percentages of gain were reached up in a low percentages of importance, which refers to that the gain in this analysis was revealed in an early stages of prediction, almost under 20% of

the whole prediction process. Also, the gain curve describes how accurate the delay factors in interpreting the actual delay in time, as long as the curve is far from the centroid diagonal line and that is an evidence that the prediction model is accurate in term of gain.



Preprint not peer reviewed
This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

Figure 8 Gain diagram of actual time as affected by delay factors

Then after, the independent valuable importance was measured and normalized, where table (9) and figure (9) show the normalized importance of each delay factor in controlling the actual time of implementation. Results showed that LTD was the highest factor affecting the delay in time, and the importance of factors were ranked due:
LTD>SS>CFT>OF>LP>DPP>CSP>HO>RD>FF>WF>CSF.

The importance showed in table (8) shows the percentage of each factor in the interpretation the model, where LTD interprets 0.102 of the model while the interpreting 0.043, 0.067, 0.077, 0.079, 0.082, 0.083, 0.087, 0.09, 0.093, 0.098, 0.099 of CSF, WF, EF, RD, HO, CSP, DPP, LP, OF, CTF, SS respectively as the sum of these estimations should reach a value of 1.

Table 8
Independent Variable Importance in term of actual time

Delay factors	Importance	Normalized Importance
CSF	0.043	42.50%
WF	0.067	65.80%
EF	0.077	75.70%
RD	0.079	77.30%
HO	0.082	80.00%
CSP	0.083	81.70%
DPP	0.087	85.00%
LP	0.09	88.80%
OF	0.093	91.60%
CTF	0.098	96.00%
SS	0.099	97.10%
LTD	0.102	100.00%

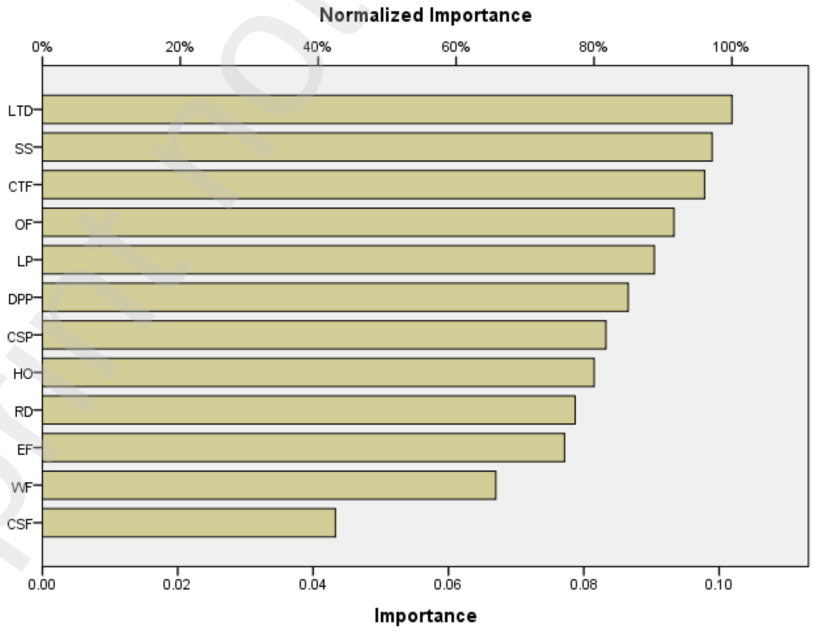


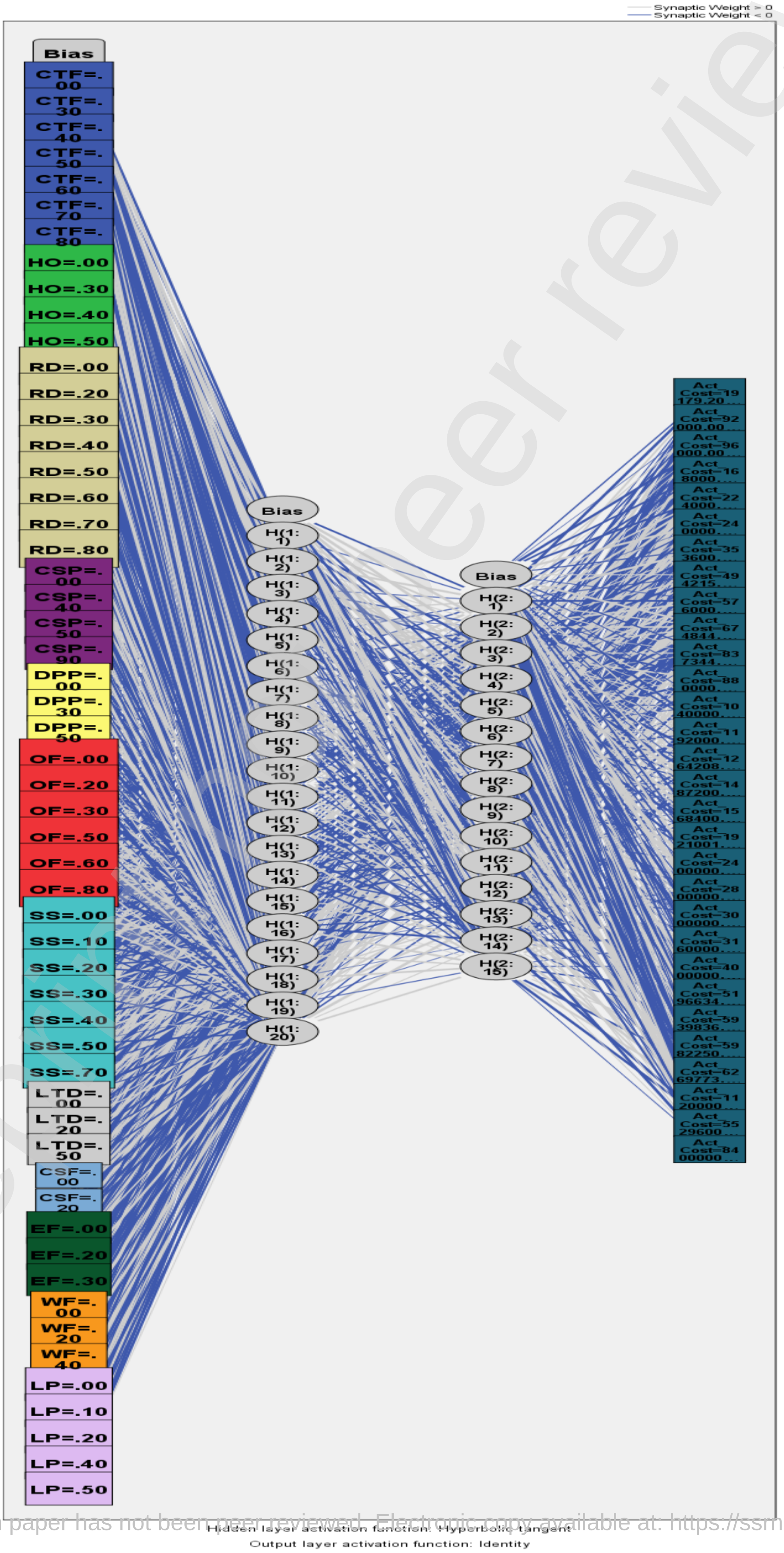
Figure 9 normalized importance of delay factors in term of actual time

Preprint not peer reviewed

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

4.6 Actual cost in relation to delay factors:

An artificial neural network analysis was also conducted to find out how the actual cost was affected by the delay factors chosen in this study. One input layer represents the actual time that should be affected by the delay factors, one output layer was suggested by this test, and two hidden layers were selected to conduct the mathematical processes in the ANN's analysis to increase the accuracy of outputs. Figure (10) shows these three layers in a network diagram.



Preprint not peer reviewed

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

Figure 10 network diagram of actual cost delay in relation to delay factors

The model summery (table 9) showed that the sum of squares errors was 9.281 which is also refer to a good prediction of this ANN's model to find out the importance of each factor affecting the actual cost of implementation under the stress of delay factors where the percentage of incorrect prediction was 16.7%, in another meaning, the accuracy of this mathematical model was 83.3.0% accurate which is considered as a high accuracy percentage for prediction.

Table 9
Model summery of the actual cost ANN's analysis

Training	**Sum of Squares Error**	**9.281**
	Percent Incorrect Predictions	16.7%
	Stopping Rule Used	Maximum number of epochs (100) exceeded
	Training Time	0:00:00.09

Dependent Variable: Act.Cost

The figure (11) shows the specificity and sensitivity of the model. it obviously pointed a high percentages of specificity of the model in the meanwhile, it showed high values of sensitivity as well, which also confirm the significance of using ANN's model in predicting delay factors affecting the actual cost of implementation under uncontrolled project management circumstances.

Preprint not peer reviewed
This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

Figure 11 specify and sensitivity percentage diagram of actual cost affected by delay factors

Gain percentages diagram (figure 12) shows that there was a high percentages of gain were reached up even in a low percentages of importance, which refers to that the gain in this analysis was revealed in an early stages of prediction, almost under 10% of the whole prediction process. Also, the gain curve describes how accurate the delay factors in interpreting the actual delay in cost, as long as the curve is too way far from the centroid diagonal line which means higher accuracy of the model in term of gain**.**

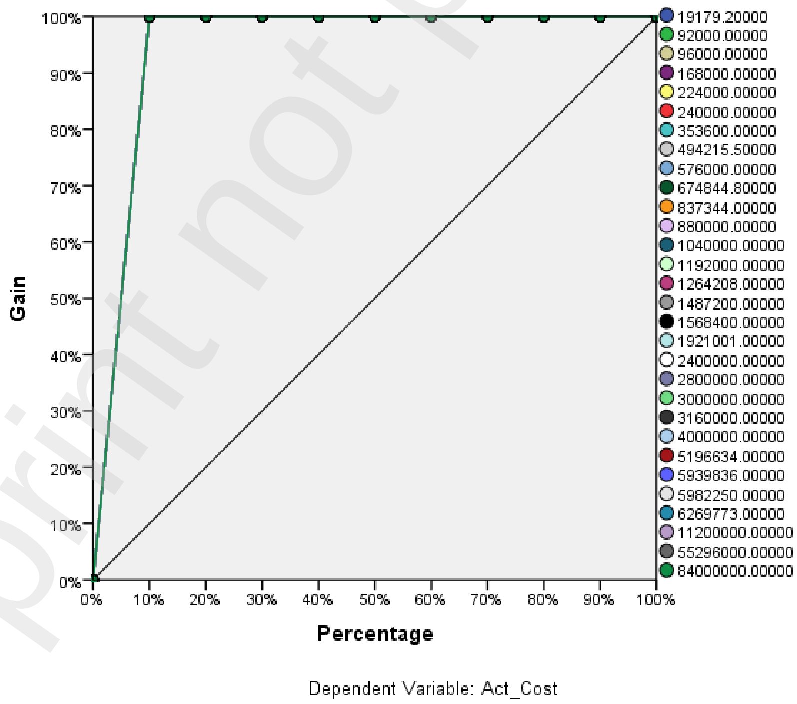


Figure 12 gain diagram of actual cost as affected by delay factors

Preprint not peer reviewed

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

The independent variable importance was measured and normalized, where table (10) and figure (13) show the normalized importance of each delay factor in controlling the actual cost of implementation. Results showed that RD was the highest factor affecting the delay in term of cost, and the importance of factors were ranked due: LTD>SS>CFT>OF>LP>DPP>CSP>HO>RD>FF>WF>CSF.

The importance showed in table (10) shows the percentage of each factor in the interpretation the model, where LTD interprets 0.109 of the model while the interpreting 0.044, 0.064. 0.076, 0.077, 0.079, 0.085, 0.086, 0.089, 0.089, 0.094, 0.108, 0.109 of CSF, WF, LTD, DPP, EF, LP, CSP, CTF, HO, SS, OF respectively as the sum of these estimations should reach a maximum value of 1.

Table 10
Independent Variable Importance in term of actual cost

Delay factors	Importance	Normalized Importance
CSF	0.044	40.30%
WF	0.064	58.80%
LTD	0.076	69.60%
DPP	0.077	70.90%
EF	0.079	72.60%
LP	0.085	78.00%
CSP	0.086	78.60%
CTF	0.089	81.30%
HO	0.089	81.50%
SS	0.094	86.40%
OF	0.108	99.10%
RD	0.109	100.00%

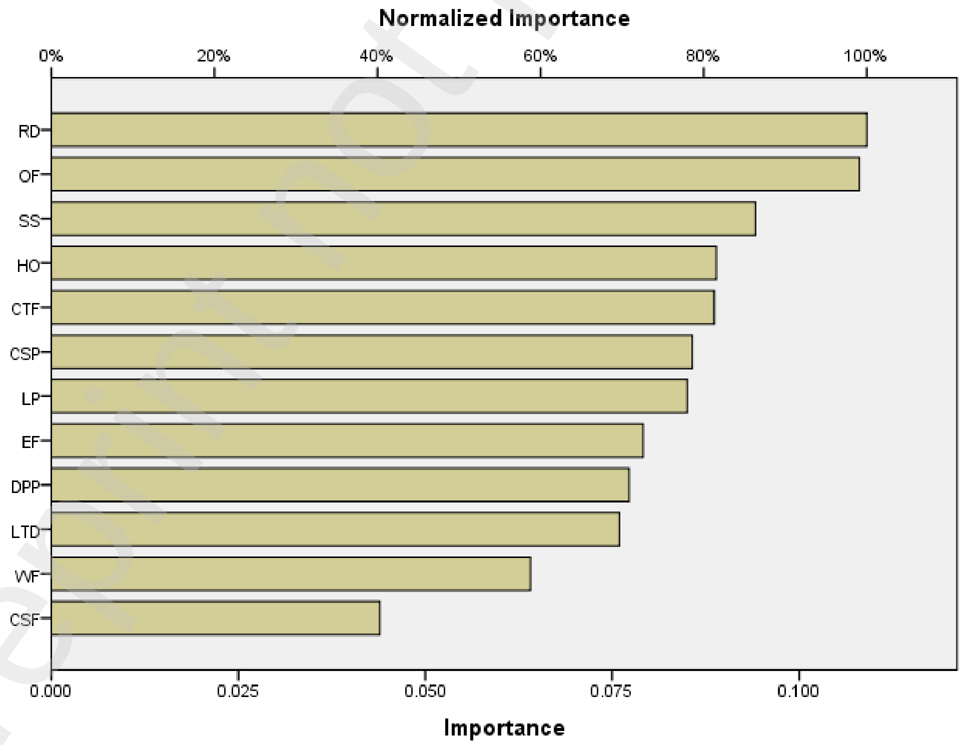
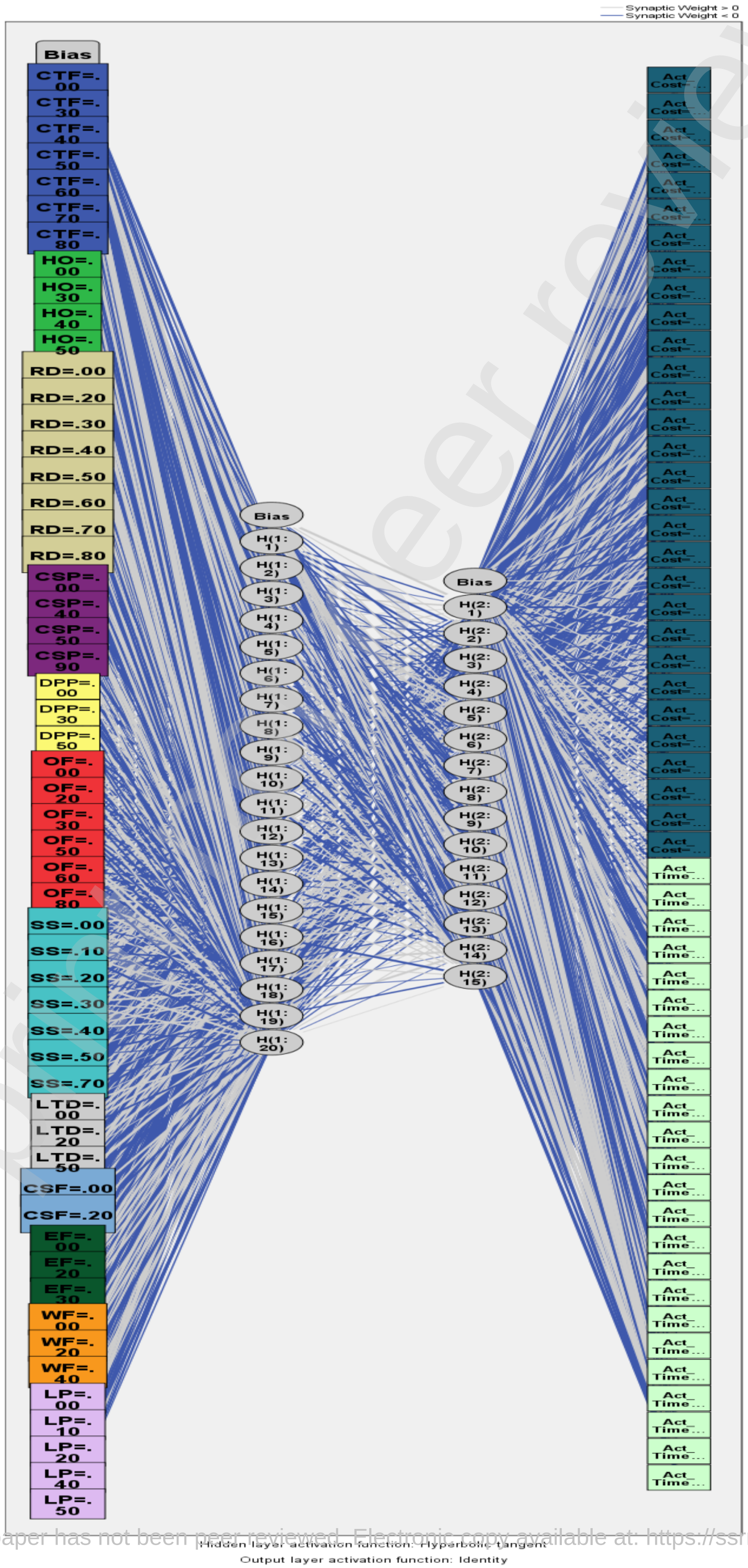


Figure 13 normalized importance of delay factors in term of actual cost

Preprint not peer reviewed
This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

4.7 Actual time and actual cost in relation to delay factors:

After testing the actual time and actual cost in term of delay factors controlling them, another ANN's test was conducted for both actual time and actual cost in term of delay factors selected in this study. The network diagram (figure 14) showed the same layers in designing the model of how delay factors affect actual time and cost. It consisted of three layers, the first layer was the input layer which included the dependent layer of actual time and cost with the independent delay factors that control them. The second layer was the hidden one that consisted of two layers to increase the accuracy of the model and predictions. While the third layer was the output layer which includes all the results that describe the importance of the independent factors that control the actual time and cost.



Preprint not peer reviewed

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

Figure 14 network diagram of actual time and cost delay in relation to delay factors

The model summery (table 11) shows that the sum of squares errors of the model which was 20.471. we noticed that the sum square errors were increased when actual time and cost was interacted in term of delay factors, although this value was not high to reject the model as it was confirmed by the percentages of incorrect predictions for the categorical dependents actual time and actual cost as 20.0% and 27.7% respectively and in an average of accuracy of incorrect predictions values are representing an average of accuracy of 76.7% of the model which is considered as significant as the other previous models suggested for each actual time and actual cost separately.

Table11
model summery of the actual time and cost ANN's analysis

Training	**Sum of Squares Error**		**20.471**
	Average Percent Incorrect Predictions		23.3%
	Percent Incorrect Predictions for Categorical Dependents	Act_Cost	20.0%
		Act_Time	26.7%
	Stopping Rule Used		Maximum number of epochs (100) exceeded
	Training Time		0:00:00.14

The independent variable importance was measured and normalized as they affect the combined actual time and cost. Table (12) shows that the most affecting delay factor in term of combined actual time and cost of implementation in project management plan was the CSF where this factor interpret 0.114 of the model while other factors interpret 0.059, 0.065, 074. ,0.077 , 0.078,.0.078,.0.084,.0.087, 0.088, 0.088, 0.108 of DPP, HO, OF, LTD, EF, LP, WF, SS, CTF, CSP, RD respectively, as the sum of these estimations should reach a maximum value of 1. Also the normalized importance analysis confirmed that the CSF was the highest factor that affected delay in time and cost. Figure (15)

Table 12
Independent Variable Importance in term of actual time and cost

Delay factors	Importance	Normalized Importance

Preprint not peer reviewed

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

DPP	**.059**	**51.9%**
HO	**.065**	**56.9%**
OF	**.074**	**65.1%**
LTD	**.077**	**67.2%**
EF	**.078**	**68.7%**
LP	**.078**	**68.7%**
WF	**.084**	**73.9%**
SS	**.087**	**76.0%**
CTF	**.088**	**77.2%**
CSP	**.088**	**77.3%**
RD	**.108**	**94.4%**
CSF	**.114**	**100.0%**

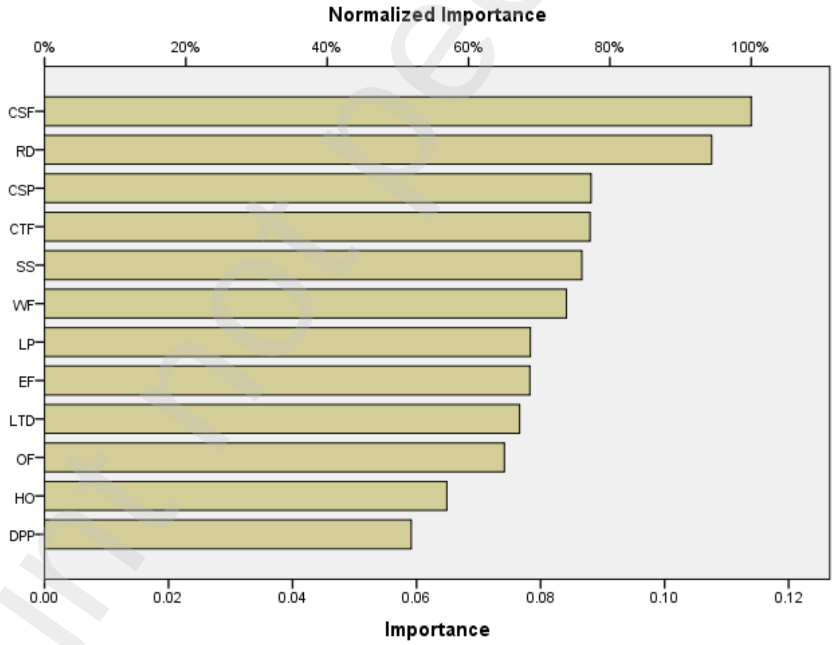


Figure15 normalized importance of delay factors in term of actual time and cost

5. Conclusion

Some facts were revealed in this study, as it provides a summary of the stages of project management and reflects an impression of the implementation processes that a project manager may go through. The model that was built according to the research field study may touch the reality of construction projects, find practical solutions, and outline the causes of delay. It is aimed with the model created to represent the project before starting from the first preparation stage, such as the feasibility study and preliminary designs to help decision makers control delays in time and cost. Focus on working with the iron triangle foundation of time, cost and quality which is the first step and reference for any project to begin.

Results stress the need to rehabilitate and re-evaluate owners and contractors to ensure financial efficiency and specialization in project implementation and to withdraw the hand of any part that fails to exceed the restrictions and qualifications reported

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

by the Ministry of Planning, Housing and Construction. The Ministry of Planning should also review all the rules, laws and legislations dealing with implementation to prevent the increase in high-rise funds for construction projects that will be implemented by unqualified contractors, along with following the procedures of directing invitation of bidding for long standing expects besides, international wellknown companies. Therefore, it is necessary to focus on the qualification of contractors at various levels, because the contractors are the implementers and the real reason for the delay in time and cost, through holding workshops and lectures to educate them in the field of bidding and the implementation of better contracts under the circumstances of the country they are implementing the projects in. Building test laboratories are also supported and improved. Also, encouraging the private sectors to open their own certified laboratories, activating rules and legislation that guarantee the rights of engineers and project managers and giving them confidence to support their decisions. In addition to allowing oversight committees and integrity sponsors to investigate instances of any inconvenience. Furthermore, reporting cases of corruption and fraud in construction project works. following accurate steps towards choosing the appropriate designs and plans for the projects before starting implementation.

Preparing accurate and complete Bills of Quantities (BOQ) to avoid falling into the corner of delay. The enactment of a new law obligating executing companies not to sell contracts to more than one subcontractor. Depending on the low-price bids, if only these bids cover the real cost of the construction project to avoid any foreseeable delays during the implementation of the project.

Considering the skills and qualifications of an Executive Engineer with more than five years of experience to be referred and registered as an Affiliate Engineer supervising the meticulous implementation of projects. In addition to testing more factors and upgrading the model according to the implementation time and the nature of construction projects. One of the main external factors causing the delay was the lack of energy. Thus, power plants should be considered one of the first projects to be taken care of, starting with the termination of investment contracts with reputable companies and the withdrawal of contracts to reputable companies.

[35] built an application that can be used in difficult cases and sudden circumstances during the pandemic and post-disaster state, which can be the development of digital risk management and mitigating the difficult impact of the epidemic through the improvement of IT and IoT that can be fine by finding initial solutions and make the world like a digital city that could be managed by the network.

The use of artificial intelligence (ANN) to predict and identify appropriate solutions to the problem of delays in construction projects is extremely important for all countries to reduce and mitigate crises and properly manage risks and move in the right direction, therefore, focus must be upon managing risks accurately and employing technologies and information technology in the field of disaster management and mitigation as much as possible. Work must be done digital project management.

As for this study, it is possible to go with building mathematical models and artificial intelligence to solve a specific problem that may face any project in all aspects of business sectors. The use of the model that was created according to ANN's in this study is a way to avoid delays in time, also, avoiding the increase in cost and to maintain the balance of the project until completion. Circumstances may differ from country to another.

Future Studies should be done to focus on the delay factor that were found in this study in more details to make sure all the reasons that participate in making these delay factors and controlling time and cost in construction projects.

Other factors and sub factors, out of what this study covers should be under the scenario of the future works. For instant, external factors could be studied in more details, such as power shortage and the infrastructure of the case study country (Iraq), Training and developing the technical engineering team of the beneficiaries following real and well prepared programs where these teams should be tested and evaluated by higher committees to decide if they are technically and practically qualified enough, Supporting and improving construction tests laboratories on a national level and opening more branches in different areas and provinces. Also, encouraging private sectors in the construction industry, as well as provoking the use of the in situ laboratories that certified by governmental institutions to avoid bias and fraud of sampling that might occur while translocating samples to different places for tests, Statistical analysis has also given a precise estimates of delay in time and cost therefore the model built under this methodology could also be used to forecast delay in time and cost. Testing more factors and upgrading the model according to the time of conducting and the nature of construction projects, the necessity of reviewing channels that all projects pass through to screen them to keep quality control of time and cost because time is considered as money in the market and keeping the planned time is a goal for this study.

Data availability statement: data that supports is available by the corresponding author upon reasonable request, when applicable and permission of third party.

Preprint not peer reviewed

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

[1] Salunkhe AA, Patil RS. Identification of critical construction delay factors. International Journal of Latest Trends in Engineering and Technology. 2014 Mar;3(4):256-61.
[2] Karsh E. The Iran–Iraq War 1980–1988. Bloomsbury Publishing; 2014 Jun 6.
[3] Helm D, Hepburn C. Carbon contracts.
[4] Roberts L, Lafta R, Garfield R, Khudhairi J, Burnham G. Mortality before and after the 2003 invasion of Iraq: cluster sample survey. The Lancet. 2004 Nov 20;364(9448):1857-64.
[5] Gawande A. Casualties of war—military care for the wounded from Iraq and Afghanistan. New England Journal of Medicine. 2004 Dec 9;351(24):2471-5.
[6] Awotona A, editor. Rebuilding sustainable communities after disasters in China, Japan and beyond. Cambridge Scholars Publishing; 2014 Jun 2.
[7] Habitat UN. Habitat III issue paper 22—informal settlements. New York: UN Habitat. 2015.
[8] Baradan B (2006) Analysis of the post-disaster reconstruction process following the Turkish Earthquakes, 1999. In: GROUP IR (ed) International conference on post-disaster reconstruction meeting stakeholder interests. University de Montreal, Florence.
[9] Waheeb RA, Wheib KA, Andersen BS, Al-Suhiili R. Impact of Pandemic SARS COVID-19 on Different Construction Project Management: Problems and Solutions. Public Works Management & Policy. 2022 Jul 7:1087724X221113579.
[10] Laframboise MN, Loko MB. Natural disasters: mitigating impact, managing risks.
[11] Perry RW, Lindell MK. Preparedness for emergency response: guidelines for the emergency planning process. Disasters. 2003 Dec;27(4):336-50.
[12] Saunders WS, Becker JS. A discussion of resilience and sustainability: Land use planning recovery from the Canterbury earthquake sequence, New Zealand. International journal of disaster risk reduction. 2015 Dec 1;14:73-81.
[13] Moe TL, Pathranarakul P. An integrated approach to natural disaster management: public project management and its critical success factors. Disaster Prevention and Management: An International Journal. 2006 May 1;15(3):396-413.
[14] Da Silva J. Key considerations in post-disaster reconstruction. 2010.
[15] Bassil Y. The 2003 Iraq war: operations, causes, and consequences. Journal of Humanities and Social Science. 2012 Nov;4(5):29-47.
[16] Bekr GA. Causes of delay in public construction projects in Iraq. Jordan Journal of Civil Engineering. 2015;9(2).
[17] Waheeb RA, Andersen BS. Causes of Problems in Post-Disaster Emergency Re-Construction Projects—Iraq as a Case Study. Public Works Management & Policy. 2022 Jan;27(1):61-97.
[18] SILVA L, REIS G, MANCINI MC, CALÇADA LA. Determinação do coeficiente global de transferência de massa na secagem de sementes de agrião e agrião d'água em leito fixo e leito fluidizado: modelo a duas fases. Revista Universidade Rural. 2004:1-2.
[19] Moselhi O, Hegazy T, Fazio P. Neural networks as tools in construction. Journal of construction engineering and management. 1991 Dec;117(4):606-25.
[20] Bisht D, Jain S, Raju MM. Prediction of water table elevation fluctuation through fuzzy logic & artificial neural networks. International Journal of Advanced Science and Technology. 2013 Feb;51(2):107-20.
[21] Esmaeili I, Kashani H. Managing Cost Risks in Oil and Gas Construction Projects: Root Causes of Cost Overruns. ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part A: Civil Engineering. 2022 Mar 1;8(1):04021072.
[22] Schwab J, Topping KC, Eadie CC, Deyle RE, Smith RA. Planning for post-disaster recovery and reconstruction. Chicago, IL: American Planning Association; 1998 Dec.
[23] Waheeb RA. Identification of Delay Causes in Construction Projects and Emergency Reconstruction"Iraq as a case study".
[24] Waheeb RA, Andersen BS, Suhili RA. Using ANN in emergency reconstruction projects post disaster. International Journal of Engineering Business Management. 2020 Nov 19;12:1847979020967835.

References

Preprint not peer reviewed

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813

[25] Hill T, Marquez L, O'Connor M, Remus W. Artificial neural network models for forecasting and decision making. International journal of forecasting. 1994 Jun 1;10(1):5-15.
[26] Cross SS, Harrison RF, Kennedy RL. Introduction to neural networks. The Lancet. 1995 Oct 21;346(8982):1075-9.
[27] Gurney ME. The use of transgenic mouse models of amyotrophic lateral sclerosis in preclinical drug studies. Journal of the neurological sciences. 1997 Oct 1;152:s67-73.
[28] Cheng B, Titterington DM. Neural networks: A review from a statistical perspective. Statistical science. 1994 Feb 1:2-30.
[29] Lu L, Renals S. Probabilistic linear discriminant analysis with bottleneck features for speech recognition. InFifteenth Annual Conference of the International Speech Communication Association 2014.
[30] Okwu MO, Adetunji O. A comparative study of artificial neural network (ANN) and adaptive neuro-fuzzy inference system (ANFIS) models in distribution system with nondeterministic inputs. International Journal of Engineering Business Management. 2018 Apr 19;10:1847979018768421.
[31] Christian J, Newton L. Highway construction and maintenance costs. Canadian Journal of Civil Engineering. 1999 Aug 1;26(4):445-52.
[32] Hegazy T, Ayed A. Neural network model for parametric cost estimation of highway projects. Journal of construction engineering and management. 1998 May;124(3):210-8.
[33] Mahamid I, Brul A, Bruland A. Preliminary cost estimating models for road construction activities.
[34] Bell WR. Applying time series models in forecasting age-specific fertility rates.
[35] Waheeb RA. APP innovation to Control Projects Risks Management during Crises. EAI Endorsed Transactions on Internet of Things. 2022 May 20;8(30):e1-.

Preprint not peer reviewed

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=4180813