Available online at www.CivileJournal.org

Civil Engineering Journal

Vol. 3, No. 10, October, 2017

A Proposal Model for Estimation of Project Success in Terms of Radial Based Neural Networks: A Case Study in Iran

Mahdi Asgari [a], Ali Kheyroddin [b], Hosein Naderpour [c*]

[a] *Ph.D. Student, Faculty of Civil Engineering, Semnan University, Semnan, Iran.*

[b] *Professor, Faculty of Civil Engineering, Semnan University, Semnan, Iran.*

[c] *Associate Professor, Faculty of Civil Engineering, Semnan University, Semnan, Iran.*

Received 27 August 2017; Accepted 20 October 2017

Abstract

For improving the conditions of project intended purpose and reaching high score in the project success, project Stakeholders (including employer, contractor, consultant and its users) try to comply with the implementation of project Critical Success Factors(CSFs) at the beginning of each project. This implementation is in two terms: economic and executive. Artificial neural networks are one of the new methods which have been developed to estimate and predict parameters by using inherent relationship among data. In this research, it tried to propose a model to determine the project success score by using radial basis neural networks. For reaching this purpose, firstly, the key indicators of project success (employer, contractor and consultant) among the main elements involved in the industry of macro-civil construction projects in Iran reviewed. Secondly, ten CSFs key project success indicators were recognized in five categories: (i) financial, (ii) interaction processes, (iii) manpower, (iv) contract settings and (v) characteristic nature of the project (based on conditions of the present research in Iran). Then, some projects were selected by random sampling of projects operated during the last 5 years in the country's Ministry of Energy. Among those projects, project information was collected by managers of large projects. After training the designed neural network, the project success model was provided based on an assessment of project objectives including factors of Scope, Time, Cost, and Quality of the projects. For facilitating other researches' use, the applied equation of the model was presented as well. Outputs, calculated by the proposed model, were in good agreement with the actual number of projects assessed in Iran. The results of this study may be used as a tool in implementing projects for the rapid assessment of achieving project goals' facilities.

Keywords: Project Success; Critical Success Factors (CSFs); Construction Projects; Radial Based Neural Networks; Iran.

1. Introduction

The success of a project is of the largest and most important objectives and concerns of managers and all those involved in a project which is somehow unifying the efforts of all team members of the project. Reviewing the success and failure factors of projects in construction projects is more sensitive due to the dynamic and changing nature of the construction industry in various stages of project implementation. But, determining the success factors of a project is a complex and relative concept which most of the experts have proposed different and sometimes contradictory definitions due to their nature and execution system and natural characteristics. On the other hand, the volume of construction activities is of the essential development factors of a country. Annually, trillions of dollars of investments in the public and private sectors of various countries, either directly or indirectly, are expended in civil and building infrastructure. A construction project is a combination of different events, planned or unplanned, during the life cycle of the project, and survives under the umbrella of the changes in their environment. Among them, there are factors that

* Corresponding author: naderpour@semnan.ac.ir

http://dx.doi.org/10.28991/cej-030924

are more important to the success or failure of a project. These factors are known as project success factors. In a definition, success factors of the project are expressed as "a set of environmental factors, facts or influential factors that can affect the output of the projects. These are factors that can accelerate a project or make it difficult. They can lead to the success or failure of the project but cannot be the basis for project evaluation [1, 2].

Based on this, Project Management Body of Knowledge (PMBOK) standard is a unique effort to deliver a series of products (output) in the defined Scope, Time, Cost, and Quality [3]. Projects include activities which should be carried out in the transparent scope and description of services, determined dates, with identified costs and determined quality; avoiding any of the four factors mentioned limits can lead to an unsuccessful and uneconomical project.

Defining a strategic framework that tactically examines the success of the project and identification of Critical Success Factors (CSFs) could be an important start point. As a result, the objectives of this assessment (1) are essential to identify the critical factors which overall determine project success (2) define and identify key CSFs of construction projects from the perspectives of different participants of the project with different goals. According to the actors in civil and forming CSFs for the project purposes such as scope, budget, schedule and quality, we can gain a better understanding of the project success. Management can take necessary steps to (1) avoid project failure (2) identify promising projects and keep track of them, and (3) identify the problematic areas of the project for undergoing necessary corrective actions

2. Research Background

2.1. Definitions of Project Success

Researching on the project success has attracted the interest of many researchers and specialists. Tuman (1986) defined the success of the project as having anything that can be a reason for hope, predicting all project requirements and having sufficient resources to meet the requirements in the appropriate mode [4]. In the same year, another definition was mentioned by De Wit. In the proposed definition, if a high level of satisfaction exists in terms of output and product of the project among key stakeholders including the main organizations, the project team and end users, it introduced as the overall success of the project [5].

In the following definition of project success, Ashley et al. (1987) suggest success as a consequence of better results, expected of the project (or normal level of project results), which is usually observed based on cost, schedule, quality, safety and satisfaction of participants. Since that time, safety is expressed a success factor [7]. Pocock et al. (1996), explained legal claims of the project as another indicator of the success of the project [8]. Wuellner (1990) claimed that a project is successful when it is performed on time and on budget with a reasonable profit margin [8].

In addition, it should meet expects of customers and produce a high-quality project or consulting services while it limited the professional commitments of the company to an acceptable level. Summary of the definitions (provided by different investigators about the success of the project) is presented in Table 1.

Table 1. Summary of Success Definitions

Reference	Definition of success
Tuman (1986)	All project requirements anticipated and needs met with sufficient resources, in a timely manner
De Wit (1986)	A project is considered an overall success if it: Meets the technical performance specifications or mission to be performed Results in high level of satisfaction concerning project outcome among: key people in parent organization key people in project team key users or clients of project effort
Ashley et al. (1987)	Results are better than expected or normally observed in terms of cost, schedule, quality, safety, and participant satisfaction
Pinto and Slevin (1987)	A successful project fulfils four criteria [9]: Completed on schedule (time) Completed within budget (cost) Achieved all goals originally set for it (effectiveness) Accepted and used by clients for whom project is intended (client satisfaction)
Wuellner (1990)	A successful project: Completes on time, within budget, and with an acceptable profit margin Satisfies client expectations Produces a high-quality design or consulting services Limits firm's professional liability to acceptable levels

Kerzner (1998)	The success of a project is defined in terms of five factors [10]: Completed on time Completed within budget Completed at desired level of quality Accepted by customer Customer agreeing to allow contractor to use customer as a reference
Low and Chuan (2006)	Sufficient focus on time, cost, and quality since such a definition entails a measurement of project success as too objective, difficult, and ambiguous due to disparity between project success and product success [11].

2.2. Critical Success Factors (CSFs)

The term CSFs, originally has been introduced by Rockart (1982) to define the number of activities that favourable results of which are necessary to achieve the objectives of project management [12]. In other words, CSFs are factors which help to predict the success of the project in addition to its durability [13, 14]. A new definition was explained by Ogunlana and Toor (2009). It said CSFs means a specified element that helps considerably to the success of the project and is a very important component for success. Hence, for checking and ensuring the success of the project, one must be able to identify the factors that affect the success and failure of the project first and foremost [15]. However, there is no general definition for CSFs or its evaluation.

Regardless of theory and empirical studies, success factors may also be identified by examining the actual projects. By taking the neural network approach, Chua et al. (1997) identified CSFs for the performance of construction budget [16]. They were limited to quantifiable aspects and details of completed projects in the United States. Also, Chua et al. (1999) identified 67 elements related to the success from a professional survey focused on the budget, schedule and qualitative objectives of the project [17]. It is reasonable to assume that the overall ranking of CSFs based on the involvement of participants in various projects will be different; hence it is considered as a study hypothesis. By forming CSFs for the purposes of the project (scope, budget, schedule and quality), the main players in construction projects can achieve a better understanding of the project success. On the other hand, the lack of sufficient and inclusive knowledge of project success factors makes controlling, monitoring, and performance of the projects difficult. Therefore, identifying effective factors which are important for the result of projects (depending on the type of projects) could provide a suitable framework for the evaluation of project outputs by managers and bosses and executives. Identification of factors in the success of the project can help to manage the appropriate allocation of resources over the life of the project as well [18].

According to the traditional projects, the potentially conflicting interests among stakeholders can also influence the success of an eco-city. The government and International cooperation are also important participants in an eco-city, which can facilitate the exchange of information and technical expertise on environment policy and innovation [19, 20]. Moreover, for identifying CSFs of eco-city and analyze the inter-relationship among them, Liu et al. opined that 'Clear definition and targets', 'conflicting interests among stakeholders', 'residents' behavior and awareness of environment protection and energy conservation' and 'management in operation stage of eco-city' were the most important CSFs for eco-city development in China [21].

Many developing countries face challenges to establish CSFs for public housing projects. Seven CSFs for PHPs in Nigeria is explained by Mukhtar et al. (2016) [22]. These factors were:

(1) Institutional framework for public housing,

(2) Availability of competent personnel,

(3) Effective project management,

(4) Good maintenance management practice,

(5) Appropriate design and good location,

(6) Effective housing finance system and

(7) Adequate political support.

Also, the promotion of Green Buildings (GB) became a global trend and the CSFs of GB investigated. Shen et al. (2017) presented the importance of 16 CSFs of green building industry in Thailand [23]. Using factor analysis, these CSFs of green building can be grouped into five categories, namely competence of project participants, integration of GB project team, technical and management innovation, external environment, and project characteristics. The results indicated that: 1) enhancing both competence of individual participants and integration of a project team are critical in fulfilling tasks of green building; 2) favourable global and local economic conditions can create new demand and supply of green buildings, and economic environment can greatly impact on the green building industry. Yang et al. (2017) created a list of CSFs for China's build-operate-transfer (BOT) projects to help the government and project companies to achieve success of BOT projects [24]. This assessment shows that ten top factors in ranking analysis could play a useful role in the phases of preparing, bidding, constructing, operating and transferring BOT projects, which may be helpful for project companies and the government when making decisions.

2.3. Consolidated Framework of CSFs for Construction Projects

Pinto and Mantel (1990) conducted his research on the causes of project failures for 97 projects identified as failed projects [25]. Sanvido et al. (1992) conducted a research to determine CSFs for construction projects by using data from interviewing with employers, architects, engineers, contractors [13]. Mohsini and Davidson (1992) investigated the effects of violations stimulating organizational variables on cost, time and quality of the project and identified the most important determinants among these variables [26]. In another study, Ahmed and Kangari (1995) reviewed factors which were understood as the most important factors by employers in contracting organizations [28]. By studding on 280 construction projects, the relationship between the project performance and alternative approaches for managing the contractor- employer relationship was studied by Larson (1995) [28]. In the case of contract investigation, By Alarcon and Ashley (1996), a method was proposed to model project performance [29]. Prolongation of construction time in Hong Kong investigated by Chan and Kumaraswamy (1997) [30].

A research has been conducted by Iyer and Jha (2005) to identify CSFs affecting the cost performance of the construction projects in India [31]. They reported coordination among project participants as the most important success factor for cost performance. Lam et al. (2008) investigated CSFs for construction projects with the method of construction and design [32]. They identified nature of projects, effective project management practices and adoption of new management approaches as critical success factors CSFs for design and construction projects. Based on the results of another study by Pakseresht and Asgari (2012), identification and ranking of the important factors of success in construction projects of Pars Garma Company was carried out using a questionnaire survey among the 58 members of the management staff, project managers and technical experts [33]. In the same year, with the aim of identifying critical success factors in public housing projects in Ghana and using the experiences of 13 specialists in the field of these projects, a study was conducted by Adinyira et al. [34].

In another study by Kog and Loh (2012), identification of CSFs conducted from the perspective of different specialists namely, civil and construction engineers, mechanical and electrical engineering, architects and monitoring devices [35]. After collecting expertise comments from 27 building industry specialists, based on the Analytic Hierarchy Process (AHP), 10 superior and important factors for project success of CSFs were identified. Hong and Lim (2013) discussed about identifying (CSFs) of construction projects in Singapore. They prepared questionnaire about 32 important factors in the success of the project and distributed them among 12 specialists with at least 10 years of experience as representatives of employers, contractors and consultants [36]. Factors affecting the success of construction projects in Malaysia (among 48 experts from contractors, consultants and developer companies) were examined by Yong and Mustafa (2013). They identified issues of the project manpower, commitment and communication of executive elements and management and control of project administrative process, were identified as the main topics contributing to success [37].

3. Artificial Neural Networks

Since of the processing way of the artificial neural networks is similar to the human brain functions and can have performances somewhat similar to the biological networks in learning, and extend this learning, the scope of research in this area continues to expand. The main idea of artificial neural networks is based on simulation of human's neural network. Neuron is the most important element of the processing in biological systems. There are more than 10 billion neurons in the human brain, each of which is linked to about other 10 thousand neurons and has created a dense structure. Each neuron contains input branches called dendrite, the main core and an output branch called axon. Axons of neurons are connected to the dendrites of other neurons at the synapse. When neurons become active, create electrochemical signals within its axon; this signal reaches other neurons via synapses and stimulates them. Each neuron becomes active when the total signals received by its body is exceeded a certain threshold. Figure (1) shows the overall structure and components of a neural neuron. According to various combinations of neurons and different learning rules, different networks are formed, one of the most useful of which in engineering sciences for nonlinear mapping, is the Radial Basis Neural Network (RBF) [38].

3.1. Structure Radial Basis Neural Network

Radial basis neural network was first used by Broomhead and Lowe (1998) as the stimulation function of neurons in the design of neural networks [39]. The next researchers demonstrated that RBF networks are very powerful approximation mechanisms. By having a sufficient number of neurons in the hidden layer; RBF networks are capable of approximating any continuous function with any degree of accuracy requirements. In the following figure, the general structure of RBF network is shown.

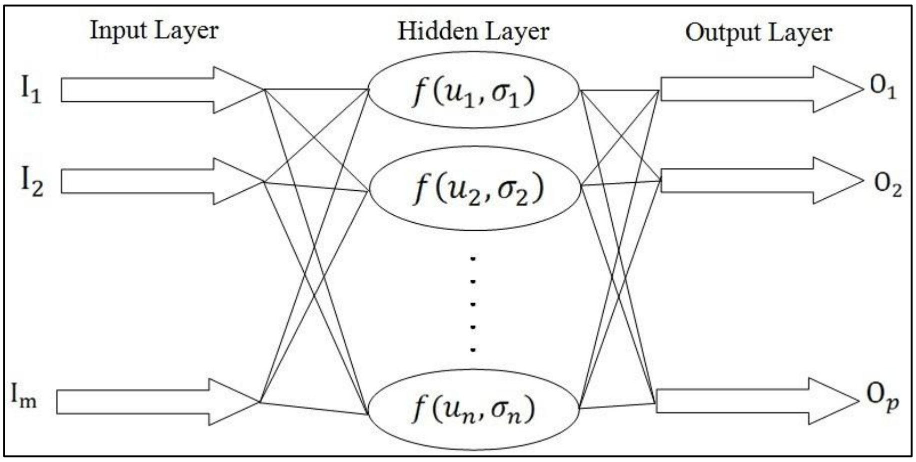

Figure 1. The overall structure of a RBF network

In Figure 1, each I_i represents one component of the input vector. Each σ_i represents the area in which the i^{th} neuron offers an acceptable and meaningful response, and u_i is a vector the elements of which are weights connecting each of the inputs with the i^{th} neuron. $f(i)$ is the excitation function of hidden layer neurons of an exponential Gaussian type as well. This excitation function is shown with equation 1. O_j is also network outputs which are produced by applying a linear excitation function to the signals sent from the hidden layer to the output layer.

$$f_i = e^{\left[\frac{-D_i^2}{(2\sigma^2)}\right]} \tag{1}$$

$$D_i^2 = (I - u_i)^T (I - u_i) \tag{2}$$

In equation 2, symbol T denotes vector transpose, and I is the input column vector. Each of communications shown in Figure 1 is established by a coefficient called weight. These weights are adjusted in the training process according to proper education rule. The number of hidden layers neurons is equal to the number of training pairs available in the training set. Also, the number of neurons in the output layer is equal to the number of components of the target vector. It should be explained that the training monitored using training pairs including input vector and the vector corresponding to the desired output, is conducted in a way that the difference between the actual outputs of the network and desired or objective outputs are minimized. In RBF network, the input layer weights do not require to be trained, and input matrix transpose is assigned as the first layer weight matrix. Weights of the second layer of RBF network are adjusted by the following supervised education act:

1. The input vector I_i of the training set is delivered to the network.
2. The Outputs of the hidden layer neurons are calculated and form the vector $f(i)$.
3. The network output vector O_j is calculated and compared with the target vector t_j.The second layer weight matrix w_{ij} is adjusted in order to reduce the difference of vectors O_j and t_j.To do this, the following formula is often used:

$$w_{ij}(n+1) = w_{ij}(n) + \eta(t_j - O_j)I_i \tag{3}$$

In the above equation, η is the learning rate coefficient and is usually much less than 1.

4. Steps 1 to 3 are repeated for each vector of the training set.
5. Steps 1 to 4 should be continued until the error reaches an acceptable level and at this point, the training ends. After training the network by providing it with input vectors, the output vectors simulated by the network can be received [34].

To stop the computations in a neural network, two criteria are considered: (i)the number of performed periods be more than a limit, and (ii) the amount of error calculated in the output, be lower than its limit value. In this study, to evaluate the results of the neural artificial network, the criteria of mean square error MSE and factor of the goodness of fit (R, the correlation coefficient) were used [35].

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(y_{actual_i} - y_{forecast_i})^2 \tag{4}$$

$$R = \frac{\sum x.y}{\sqrt{\sum(x^2).\sum(y^2)}} \tag{5}$$

In the above relations, y_{actual} is the actual value of the variable, $y_{forecast}$ is the predicted value of the variable, $\bar{y}$is the average value of the variable, n is the number of patterns, and $y = y_{actual} - \bar{y}_{actual}$, $y = y_{aforecast} - \bar{y}_{forecast}$.

4. Methodology

As mentioned in the previous section, factors associated with success used in the study, are mainly extracted from the results obtained by Chua et al. (1999) [17]. This may be explained as, by removing the potential discrepancies in terms of social, cultural, political or other differences which may cause abnormal results, these results have been used in construction projects in Iran. In this study, it has been focused only on the main actors of the project namely the employers, contractors and consultants rather than covering all project participants. Due to relatively lower influence of subcontractors, suppliers and manufacturers on the success of the project on all construction projects in Iran, these actors have been removed. To collect comments data, a semi-structured questionnaire was prepared interviewing with experts and scholars in the construction industry of development projects in Iran, by choosing 41 indicators affecting the success of the project, in 5 components as Table 2.

Table 2. 41 selected Success-Related Factors Considered in the Study

Project aspect	Success-related factor
Financial (8 Factors)	(1) adequacy of funding; (2) economic risks; (3) owner team turnover rate; (4) contractor team turnover rate; (5) consultant team turnover rate; (6) owner top management support; (7) contractor top management support; (8) consultant top management support
Interactive Processes (10 Factors)	(9) design complete at construction start; (10) constructability program; (11) report updates; (12) budget updates; (13) schedule updates; (14) design control meetings; (15) construction control meetings; (16) site inspections; (17) relationships; (18) common goal
Human Resource (8 Factors)	(19) project manager competency; (20) project manager authority; (21) project manager commitment and involvement; (22) capability of owner key personnel; (23) capability of contractor key personnel; (24) competency of contractor proposed team; (25) capability of consultant key personnel; (26) competency of consultant proposed team
Contractual Arrangements (5 Factors)	(27) realistic obligations/clear objectives; (28) motivation/incentives; (29) risk identification and allocation; (30) formal dispute resolution process; (31) adequacy of plans and specifications
Project Characteristics (10 Factors)	(32) impact on public; (33) constructability; (34) project size; (35) site limitation and location; (36) owner track record; (37) owner level of service;(38) contractor track record; (39) contractor level of service; (30) consultant track record; (41) consultant level of service;

Due to the sensitivity and importance of the study, the questionnaire was distributed among experts and prominent executives and government officials and investors of macro projects which have the sufficient experience, expertise and knowledge in the management of construction projects. A total of 175 questionnaires were collected and after analysing the data and eliminating invalid questionnaires, 137 questionnaires were finally studied and analyzed. The effective factor of success of the project was evaluated based on Friedman test. The results of this line of research were calculated to examine the efficacy of the top 10 indicators among the 41 identified indicators in this study and were compared with previous studies in different countries. Critical factors of success in the country of Iran along with comparison of CSFs identified in this study with previous studies are shown in Table 3. Based on the results of this section, factors of "Insertion of realistic commitments and description of services and purposes specified in the contract" and "professional competence of project manager client" are as factors selected in the previous researches among experts in different countries [6, 17, 35, and 30]. Also, due to much agreement between nature of Iran and Malaysia in terms of developing situation and shared spaces in construction projects in these countries, five indicators among the 10 key factors of the success of the project are in compliance. This compliance could be due to the developing situation in the two countries and sharing in the space of construction projects between the two countries.

Table 3. Comparison of CSFs in different studies

CSFs	This study (2016)	Hong & Lim (2013)	Yong & Mustaffa (2012)	Kog & loh (2012)	chue et al. (1999)	Ashley et al. (1987)
political risks			*		*	
adequacy of funding;	*	*				
site limitation and location				*		
constructability			*	*	*	
realistic obligations/clear objectives	*		*	*	*	*
risk identification and allocation			*			*
adequacy of plans and specifications		*	*	*	*	
motivation/incentives			*	*	*	
project manager competency	*	*		*	*	*
project manager commitment and involvement				*	*	*
owner team turnover rate	*					
owner top management support	*	*				
owner level of service						
capability of contractor key personnel	*	*				
competency of contractor proposed team	*	*				
contractor track record	*					
contractor level of service	*					
capability of consultant key personnel		*				
schedule updates			*			
design control meetings			*			
construction control meetings			*		*	
site inspections		*	*		*	
common goal						
relationships	*					

After identifying the 10 critical factors of success of the project, with the aim of finding a predictive model of success of the project in Iran using the radial basis neural network, we proceeded to design a new questionnaire to gather the actual information on the success of the finished project in Iran. In this questionnaire, the information was designed in two parts, Part I: model input based on prediction of achieving percentage of 10 critical factors of success of the project in five categories of financial, human resources, interactive processes, features of nature, and the contract items. Part II: the purpose of the model based on evaluation of the realization of the Scope, Time, Cost, and Quality of the project with preliminary estimates at the beginning of the project based on definition of the success of the project in the standard PMBOK [3]. Since the accuracy of a model depends on the input data accuracy for network training, information needed to build the model and information of the construction projects of Ministry of Energy of Iran (completed over 5 years) were received from the ministry are shown in Table 4. Data of 80 projects were evaluated, and after removing the incomplete information, information of 56 projects was selected to build the model.

Table 4. A sample of the questionnaire

Project Target: Please complete the following information based on your project information.

Target	Questions	Answer
Scope	Was the project completed in accordance with the scope and description of the services (including the initial Scope of the contract and the changes approved by the employer contained in the additions)?	Yes□ No□
	If the answer to the above question is No, Pls mention amount of deviation of completed project scope with initial contract scope?	Under 25% □ between 25% and 50% □ between 50% and 75% □ above 75%□
Time	Time to start the project according to the contract: ……………… Mount	Real-time project start up: ……………… Mount
	Duration of project completion according to contract: ……………… Mount	Real-time completion of the project: ……………… Mount
Cost	Initial cost of project in the contract: …………………… Rial / Dollar The actual cost of the project at the time of completion of the project: ……………. Rial / Dollar	
Quality	Have the project processes and deliverables been implemented in accordance with the requirements and qualitative and technical standards set out in the contract and the additions?	Yes□ No□
	If the answer to the above question is No, Pls mention amount of deviation of completed project quality with initial predicted quality level in contract?	Under 25% □ between 25% and 50% □ between 50% and 75% □ above 75%□

Project Success Factor: During the implementation of the project, how much was the percentage of fulfilment of each of the following table based on the prediction of the above target.

Item	Factors evaluated	Very low (<20%)	Low (20%-40%)	Average (40%-60%)	High (60%-80%)	Very high (80%<)
Financial	Adequacy of funding, Owner top management support, Contractor top management support, owner turnover rate					
Human Resources	Capability of contractor key personnel, Competency of contractor proposed team, Project manager competency					
Human Resources	Capability of contractor key personnel, Competency of contractor proposed team, Project manager competency					
Project Characteristics	contractor track record, contractor level of service					
Contractual Arrangements	realistic obligations/clear objectives					
Interactive Processes	Relationships					

In this study, to simulate the structure of the artificial neural network and relating coding, the software MATLAB was used. In order to reach the success of the project using RBF neural network, the information of 56 development projects collected in the country of Iran, have been used for training and testing the network. Based on the information collected and the above description, 5 inputs of neural networks including scoring financial items, human resources, interactive processes, features of nature, and the contract items of each project were considered. The achievement level of each project objectives including scope, time, cost, and quality of the project with the estimation conducted at the time of the project start, were considered as 4 outputs of the neural network. The flow chart shown the estimation process of project success is presented in Figure 2.

Since the input values of the neural network have been scattered, and the possibility of lack of achieving the desired model due to scattering between the input data was expected, we limited input values in the range between zero and one through normalization by a division of all components of the input by their maximum. In the hidden layers of networks, a different number of neurons has been used and their optimal value has been determined to minimize error. Under the programming conducted, the number of hidden layers is begun with 1 and adding additional hidden layers continues until the increase in hidden layers does not affect the improvement of the error rate, which was selected as of 0.0159.

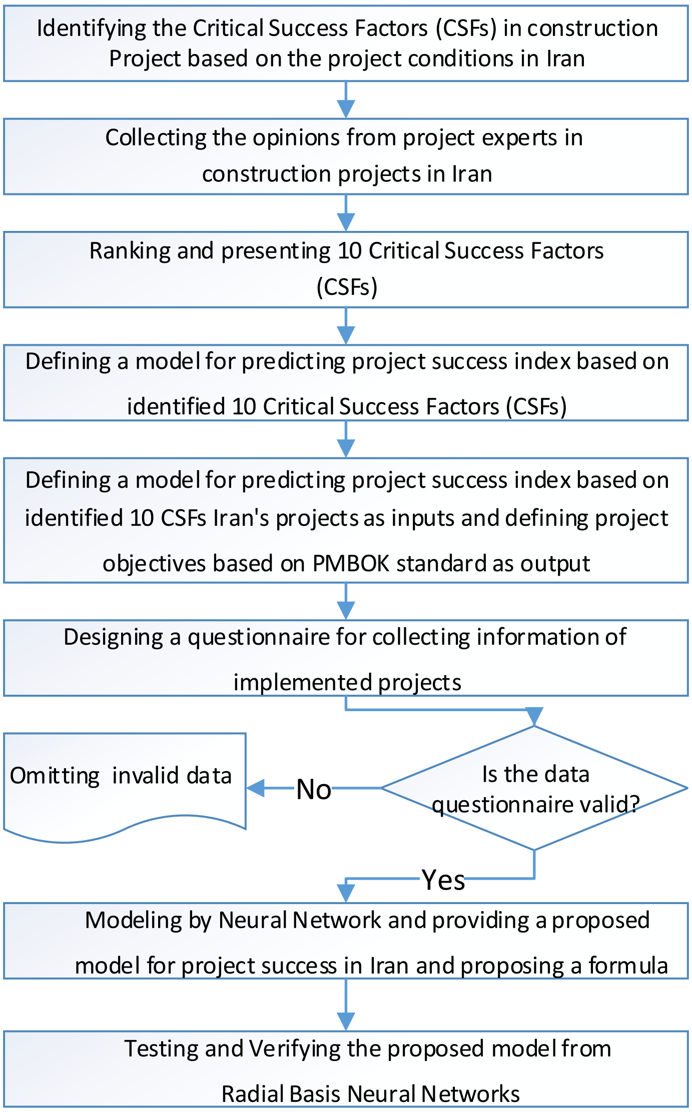

Figure 2. The flow chart of showing the process of the estimation of project success

5. Description of Results

With the aim to build a prediction model for the success of the project in Iran, by radial basis neural network, it was proceeded to conduct the coding and analysis of data collected. In the program written for the production of neural networks, 4 outputs of scope, time, cost, and quality of the project were calculated with 4 distinct networks based on 5 parameters. The results of implementing the program on 56 projects in Iran, including correlation coefficient gained by comparing the calculated outputs with actual value outputs and the error rate calculated by Mean Square Error (MSE), are given in Table 4.

Table 4. Regression results and the calculated error

Item	Results
Scope	0.79642
Time Each Regression	0.820531
Cost	0.689667
Quality	0.96155
Total Regression	0.808977
Total Performance (Mse)	0.015671

In Figure 3, the number of Epochs calculated to achieve errors of trained data under the amount set as 0.0159, is shown and in Figure 4, the correlation coefficient obtained (Total Regression) of the trained network, and also histogram of network errors is shown in Figure 5.

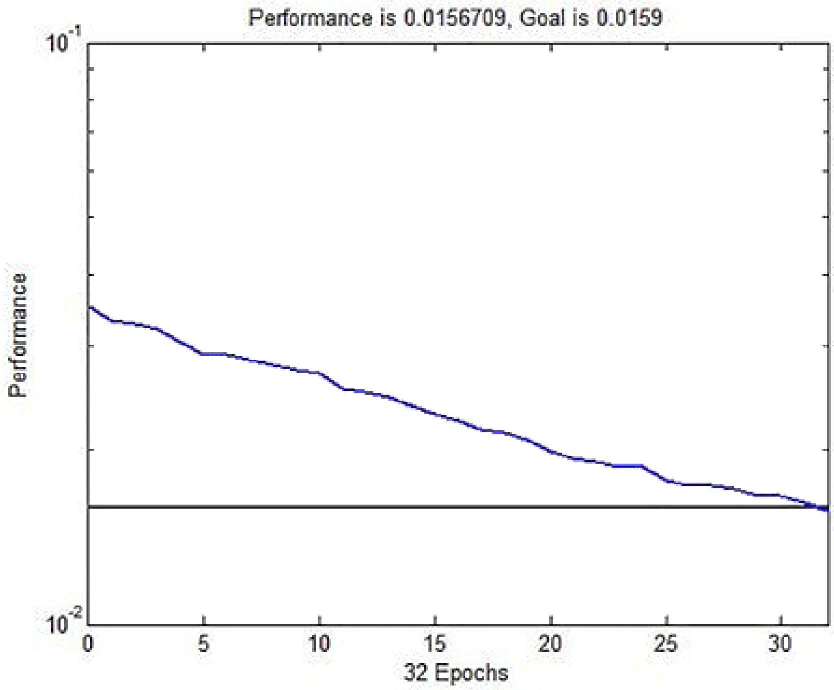

Figure 3. Number of network epochs

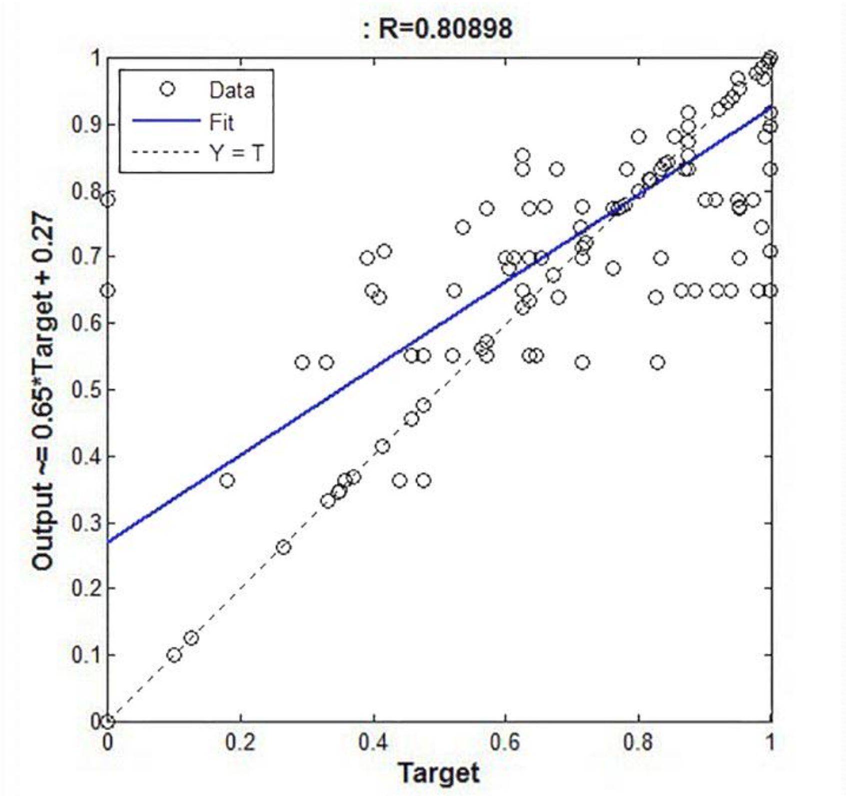

Figure 4. Obtained correlation coefficient (Total Regression) of network training data

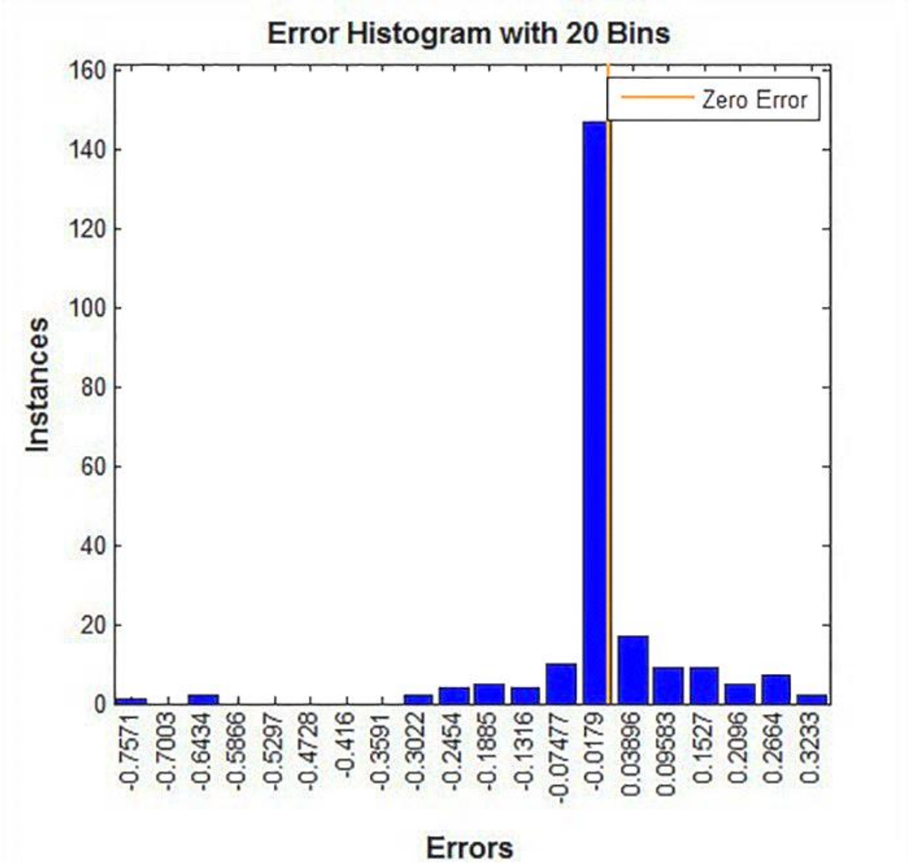

Figure 5. Histogram of network errors

5.1. Proposing Method for Determining the Score of the Success of the Project

According to the results in the previous section, the outputs calculated by the proposed radial basis neural network show a good agreement with actual values of projects reviewed. Because of the complex network computations for evaluating basic data of each project, the neural network has been used to produce and provide an equation for determining the rate of success, based on calculation pattern. These complex network computations are the financial information, human resources, interactive processes, features of nature, and the contract items via weight and transfer functions within neural network and complexities involved in determining the success score of the project. This pattern is presented as follows:

$$n = \|w_1 - p\| \quad (6)$$

$$\mathrm{y_1} = \mathrm{e}^{-(\mathrm{n} * \mathrm{b_1})^2} \quad (7)$$

$$\mathrm{PSI} = \mathrm{w_2} * \mathrm{y_1} + \mathrm{b_2} \quad (8)$$

Given that in the success prediction model, radial neural network conducts the calculations in two layers. So the equation has 2 weighting matrices and 2 bias matrices of layers 1 and 2. In the above equation, w_1 is the first layer weight matrix, p is the matrix of input data including 5 indicators of financial, human resources, interactive processes, features of nature, and the project contract items, b_1 is the first layer bias matrix, w_2 is second layer weight matrix, b_2 is bias matrix of the second layer, $PSI(Project\ Success\ Index)$ is the score matrix of the success of the project calculated based on 4 output factors including the scope, time, cost, and quality of the project, and $\|w_1 - p\|$ means calculation of the distance between the weights and inputs from the following relationship:

$$\|dist\| = \|w_1 - p\| = \sqrt{\left(w_{1_{1,1}} - p_1\right)^2 + \left(w_{1_{1,2}} - p_1\right)^2 + \cdots + \left(w_{1_{1,i}} - p_i\right)^2} \quad (9)$$

(A) Weight of the first layer including a matrix of 32 rows and 5 columns, are given in Table 5.

(B) Weight of the second layer including a matrix of 4 rows and 32 columns, are given in Table 6.

(C) Bias value of the first layer including a matrix of 32 rows and 1 column; all amounts of rows are considered as 0.832555.

(D) Bias value of the second layer including a matrix of 4 rows and 1 column, are given in Table 7.

Table 5. Weight of the first layer

	1	2	3	4	5
1	0.777778	1	0.777778	0.777778	0.714286
2	0.111111	1	0.777778	0.555556	1
3	0.333333	0.777778	1	0.555556	0.714286
4	1	0.777778	0.777778	1	0.428571
5	0.777778	1	0.555556	1	0.714286
6	0.777778	1	0.555556	1	0.714286
7	0.777778	1	1	0.555556	1
8	0.555556	0.777778	1	0.777778	1
9	0.777778	0.777778	1	1	1
10	1	0.555556	0.555556	1	0.428571
11	0.555556	0.555556	0.555556	0.777778	0.714286
12	1	1	1	0.777778	0.714286
13	1	0.555556	0.555556	0.555556	0.714286
14	0.555556	0.777778	0.777778	0.777778	1
15	1	0.777778	0.777778	0.555556	0.714286
16	0.555556	0.555556	1	0.777778	1
17	1	0.555556	0.555556	0.777778	0.428571
18	1	0.555556	0.777778	0.777778	0.714286
19	1	0.777778	0.777778	1	1
20	1	0.555556	0.555556	0.777778	1
21	0.777778	0.777778	1	0.777778	0.714286
22	1	0.777778	0.555556	0.777778	0.714286
23	1	0.777778	0.777778	0.777778	0.714286
24	1	0.777778	0.777778	0.777778	0.714286
25	1	0.777778	0.555556	1	1
26	1	0.555556	0.777778	1	0.714286
27	1	0.555556	0.777778	1	0.714286
28	1	0.555556	0.555556	1	0.714286
29	1	0.555556	0.555556	0.777778	0.714286
30	1	0.555556	0.555556	0.777778	0.714286
31	1	0.777778	0.555556	0.777778	1
32	1	0.777778	0.777778	0.777778	1
5	0.777778	1	0.555556	1	0.714286
6	0.777778	1	0.555556	1	0.714286
7	0.777778	1	1	0.555556	1
8	0.555556	0.777778	1	0.777778	1
9	0.777778	0.777778	1	1	1
10	1	0.555556	0.555556	1	0.428571
11	0.555556	0.555556	0.555556	0.777778	0.714286
12	1	1	1	0.777778	0.714286
13	1	0.555556	0.555556	0.555556	0.714286
14	0.555556	0.777778	0.777778	0.777778	1
15	1	0.777778	0.777778	0.555556	0.714286
16	0.555556	0.555556	1	0.777778	1
17	1	0.555556	0.555556	0.777778	0.428571
18	1	0.555556	0.777778	0.777778	0.714286
19	1	0.777778	0.777778	1	1
20	1	0.555556	0.555556	0.777778	1
21	0.777778	0.777778	1	0.777778	0.714286
22	1	0.777778	0.555556	0.777778	0.714286
23	1	0.777778	0.777778	0.777778	0.714286
24	1	0.777778	0.777778	0.777778	0.714286
25	1	0.777778	0.555556	1	1
26	1	0.555556	0.777778	1	0.714286
27	1	0.555556	0.777778	1	0.714286
28	1	0.555556	0.555556	1	0.714286
29	1	0.555556	0.555556	0.777778	0.714286
30	1	0.555556	0.555556	0.777778	0.714286
31	1	0.777778	0.555556	0.777778	1
32	1	0.777778	0.777778	0.777778	1

Table 6. Weight of the second layer

	1	2	3	4	5
1	11.37908	-48.2688	20.70924	4.430618	0
2	174.2264	56.7239	-23.4365	-46.5828	0
3	-148.744	172.3306	14.18215	451.6676	0
4	-72.8781	42.22722	64.72442	35.44455	0

	6	7	8	9	10
1	-52.9597	27.68877	-226.934	15.28806	9.161208
2	-112.048	73.20061	-101.519	157.8903	229.9944
3	168.6326	12.4639	462.2543	107.1073	-844.127
4	50.99962	32.77235	-240.765	211.1623	-13.0823

	11	12	13	14	15
1	-78.3536	-152.695	-186.227	264.6857	-46.7532
2	76.90341	-3.6556	352.6333	-200.806	-262.126
3	258.9485	791.9049	680.5056	-758.258	155.447
4	-11.702	184.8903	99.22319	-20.1142	27.38111

	16	17	18	19	20
1	-1.53298	-131.973	-235.527	-37.5558	-118.549
2	115.699	-105.448	616.5856	62.25126	67.10251
3	24.86913	934.0224	3226.222	1473.974	279.4879
4	94.50327	110.1218	185.4458	-228.525	68.44574

	21	22	23	24	25
1	115.4817	-32.0405	282.5846	0	43.26259
2	-138.141	15.91389	316.8026	0	36.55726
3	-448.034	1010.436	-2867.38	0	-1836.84
4	-113.574	111.5013	-410.548	0	101.0808

	26	27	28	29	30
1	-0.9016	0	-203.306	726.3539	0
2	-468.689	0	330.3383	-1005.69	0
3	-1807.77	0	3220.218	-5014.91	0
4	4.31448	0	87.87746	-389.683	0

	31	32
1	-195.094	133.7199
2	224.5495	-377.972
3	2102.001	-1405.55
4	17.40668	72.97125

Table 7. Bias value of the second layer

	1
1	25.66556
2	-15.9879
3	-106.772
4	-26.0681

5.2. Using the Proposed Model

For testing the proposed model and implementing program written in MATLAB, three other projects completed by the Department of Energy were randomly selected and investigated after the construction of the network. The projects included the installation of Irankhah 63 kV substation connections, construction project of access roads to the control dam of irrigation and drainage network plan of Chamshir, and governance and maintenance of drinking water facilities of the city of Neyshabour. All three projects have been exploited in the last 5 years. Information on each project was collected from project manager employers of all three projects as completed questionnaire forms. In the time of completing the questionnaires, all 3 project managers presented their project information together with the success grade of implementation of any project without the awareness of the designed model for calculating the success score of the project. Similar to section 5, information of three projects is entered in this project. After entering the information in the designed neural network, the correlation coefficient obtained in the assessment of the proposed success model presented (Total Regression Test) was calculated at a rate of 0.8689, and the error rate calculated by the Mean Square Error (MSE), (Total Performance Test) as 0.01088. In Figure 6, the correlation coefficient obtained (Total Regression) of the testing network.

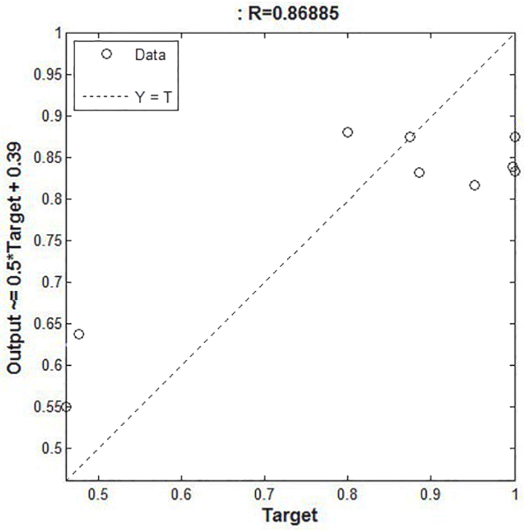

Figure 6. Obtained correlation coefficient (Total Regression) of network testing data

6. Conclusion

This study was conducted to present a model to predict the success score of the project. For achieving this goal, we used radial basis Neural Network. The proposed model has been designed and presented based on studies and researches conducted in two stages including identification of factors relating to the success of the project and gathering the data of the exploited projects In Iran. As in the first phase, studies conducted to identify the success factors of the project, despite the general agreement on (CSFs) of the project. But due to geographical conditions of each region and conditions governing the space of the construction projects, there are no single factors among different countries. In this regard, and according to the project implementation status of Iran, 10 critical success factors of the project were recognized and selected among the 41 factors in previous studies based on researches conducted and performing semi-structured interviews with experts and top specialists in the construction industry of Iran, from the view of employers, consultants and contractors, in 5 categories of 1- financial, 2- interactive processes, 3-human resources 4- contract settlement, and 5-characteristics of the nature of the projects. In the second stage of the investigation, information on the development projects exploited by project managers was collected through the Department of Energy. The data collected consist of two parts: a) the realization scores of 10 critical success factors of the as the model input and b) the realization of the objectives of the project according to the PMBOK, including Time, Scope, Cost, and Quality of the project (collected by the designed questionnaires) [3]. After reviewing the information and using the neural network, the model for determining the score of project success was designed. Then, this model was evaluated by 3 other projects' models. There was a good compliance of the output values (calculated by the model with actual values). In this regard, the applied equation for use by other researchers was presented.

This research can create practical applications for project leaders, which can exploit the results as guidelines for the formation of CSFs according to the customer's order and specifications for building projects. They can also compare the success factors identified in this study with real success factors in projects conducted in the past. This can be the use of a healthier knowledge management process and can be used more as a baseline for the formation and implementation strategies to increase performance. With a focus on predictive modeling of project success score in this study, project teams have better opportunity to access to important improvements in the performance of their projects and thereby, guarantee a promising future.

7. Acknowledgements

The authors would like to thank Ministry of Energy of Iran, which generously support for data collection for this research.

8. References

[1] Udwadia, F. E. & Trifunac, M. D. Ambient Vibration Test of Full Scale Structures, Proc. of the 5th World Conf. On Earthquake Engineering, Rome, pp, 1973.

[2] Lim, C. S., and M. Zain Mohamed. "Criteria of project success: an exploratory re-examination." International journal of project management 17, no. 4 (1999): 243-248.

[3] Project Management Institute. Guide to Project Management Body of Knowledge: PMBOK 5th edition, 2012.

[4] Tuman, J. "Success modeling: A technique for building a winning project team, Proc.", 18th Annual Seminar/Symposium, Project Management Institute, Montreal, Canada, (1986): 29–34.

[5] De Wit, A. Measuring project success: An illusion, Proc., 18th Annual Seminar/Symposium, Project Management Institute, Montreal, Canada, 13–21, 1986.

[6] Ashley, D. B., Laurie, C. S., and Jaselskis, E. J. "Determinants of Construction Project Success", Proj. Manage. J., 18(2), (1987): 69–79.

[7] Pocock, J. B., Hyun, C. T., Liu, L. Y., and Kim, M. K. "Relationship between project interaction and performance indicator", J. Constr. Eng. Manage., 122(2), (1996): 165–176.

[8] Wuellner, William W. "Project performance evaluation checklist for consulting engineers." Journal of Management in Engineering 6, no. 3 (1990): 270-281.

[9] Pinto, Jeffrey K., and Dennis P. Slevin. "Critical factors in successful project implementation." IEEE transactions on engineering management 1 (1987): 22-27.

[10] Kerzner, H. In search of excellence in project management, Wiley, New York, 1998.

[11] Pheng, Low Sui, and Quek Tai Chuan. "Environmental factors and work performance of project managers in the construction industry." International journal of project management 24, no. 1 (2006): 24-37.

[12] Rockart, J. F. "The changing role of the information systems executive: A critical success factors perspective", Sloan Manage. Rev., 24(1), (1982): 3–13.

[13] Sanvido, V., Parfitt, K., Guveris, M., and Coyle, M. "Critical Success Factors for Construction Projects", J. Constr. Eng. Manage., 118(1), (1992): 94–111.

[14] Ghosh, B. C., Liang, T. W., Meng, T. T., and Chan, B. "The key success factors, distinctive capabilities, and strategic thrusts of top SMEs in Singapore", J. Bus. Res., 51, (2001): 209–221.

[15] Toor, Shamas-ur-Rehman, and Stephen O. Ogunlana. "Construction professionals' perception of critical success factors for large-scale construction projects." Construction Innovation 9, no. 2 (2009): 149-167.

[16] Chua, D. K. H., Y. C. Kog, P. K. Loh, and E. J. Jaselskis. "Model for construction budget performance—Neural network approach." Journal of Construction Engineering and Management 123, no. 3 (1997): 214-222.

[17] Chua, David Kim Huat, Yue-Choong Kog, and Ping Kit Loh. "Critical success factors for different project objectives." Journal of construction engineering and management 125, no. 3 (1999): 142-150.

[18] Ahadzie, D., Proverbs, D., and Olomolaiye, P. "Critical Success Criteria for Mass Housing Building Projects in Developing Countries", International Journal of Project Management, 26(6), (2007): 675-687.

[19] Joss, Simon, and Arthur P. Molella. "The eco-city as urban technology: Perspectives on Caofeidian international eco-city (China)." Journal of Urban Technology 20, no. 1 (2013): 115-137.

[20] Khanna N, Fridley D, Hong L. "China's pilot low-carbon city initiative: a comparative assessment of national goals and local plans". Sustainable Cities Soc., 12, (2014):110–121.

[21] Junying Liu, Sui Pheng Low & Lin Fei Wang. "Critical success factors for eco-city development in China", International Journal of Construction Management, (2017), DOI: 10.1080/15623599.2017.1351731

[22] Mukhtar, M.M., Amirudin, R.B., Sofield, T., Mohamad, I.B. "Critical success factors for public housing projects in developing countries: a case study of Nigeria", Environment, Development and Sustainability Journal, (2016), DOI: 10.1007/s10668-016- 98432.

[23] Shen, W., Tang, W., Siripanan, A., Lei, Z., Duffield, C.F., Wilson, D., Hui, F.K.P., and Wei, Y. "Critical Success Factors in Thailand's Green Building Industry", Journal of Asian Architecture and Building Engineering., (2017) Vol. 16, No. 2, p. 317-324.

[24] Yang, J., Nisar, T. and Prabhakar, G. P. "Critical success factors for build-operate-transfer (BOT) projects in China", Irish Journal of Management, (2017), http://eprints.uwe.ac.uk/28453.

[25] Pinto, Jeffrey K., and Samuel J. Mantel. "The causes of project failure." IEEE transactions on engineering management 37, no. 4 (1990): 269-276.

[26] Mohsini, R. A., and Colin H. Davidson. "Determinants of performance in the traditional building process." Construction Management and Economics 10, no. 4 (1992): 343-359.

[27] Ahmed, Syed M., and Roozbeh Kangari. "Analysis of client-satisfaction factors in construction industry." Journal of Management in Engineering 11, no. 2 (1995): 36-44.

[28] Larson, Erik. "Project partnering: results of study of 280 construction projects." Journal of management in engineering 11, no. 2 (1995): 30-35.

[29] Alarcon, Luis F., and David B. Ashley. "Modeling project performance for decision making." Journal of Construction Engineering and Management 122, no. 3 (1996): 265-273.

[30] Chan, D. W. M., and Kumaraswamy, M. M. "A Comparative Study of Causes of Time Overruns in Hong Kong Construction Projects", Int. J. Project Manage. 15(1), (1997), 55–63.

[31] Iyer, K. C., and Jha, K. N. "Factors Affecting Cost Performance: Evidence from Indian Construction Projects", Int. J. Project Manage. 23(4), (2005): 283–295.

[32] Lam, E. W. M., Chan, A. P. C., and Chan, D. W. M. "Determinants of Successful Design-Build Projects", J. Constr. Eng. Manage., 134(5), (2008): 333–341.

[33] Pakseresht, A. and Asgari, G. "Determining the Critical Success Factors in Construction Projects: AHP Approach", Interdisciplinary Journal of Contemporary Research in Business, 4(8), (2012): 383–393.

[34] Adinyira, E., Botchway, E., and Kwofie, T. E. "Determining Critical Project Success Criteria for Public Housing Building Projects (PHBPS) in Ghana", Journal of Engineering Management Research, 1(2), (2012): 122-132.

[35] Kog, Y. C. and Loh, P. K. "Critical Success Factors for Different Components of Construction Projects", J. Constr. Eng. Manage., 138(4), (2012): 520–528.

[36] Hwang, B. G., and Lim, E. S. "Critical Success Factors for Key Project Players and Objectives: Case Study of Singapore", J. Constr. Eng. Manage., 139(2), (2013): 204–215.

[37] Yong, Y. C., Mustaffa, N. E. "Critical Success Factors for Malaysian Construction Projects: An Empirical Assessment", Journal of Construction Management and Economics, 31(9), (2013) 959-978.

[38] Kaveh, A., and Iranmanesh, A. Artificial Neural Networks in Optimization of Structures, Housing and Development Research Center of Iran, 1999.

[39] Broomhead, D.S. and Lowe, D. Multivariable Functional Interpolation and Adaptive Networks, Complex Systems, Vol. 2, pp 1998, 321-355.

[40] Wasserman, P. D. Advanced Methods in Neural Computing", USA: Prentic Hall Company, Van Nostrand Reinhold, New York, 1993.

[41] Kisi, O. Multi-layer perceptions with Levenberg–Marquardt training algorithm for suspended sediment concentration prediction and estimation, 2004.