Identifying the Critical Communicational Factors Relations in EPC Projects: A DEMATEL Framework

Sara Sajedi
Amirkabir University of Technology
Industrial Engineering and Management Systems Department
Hafez Avenue
Tehran
Iran
Email: sarasajedi@aut.ac.ir

Naser Shams Gharneh
Amirkabir University of Technology
Industrial Engineering and Management Systems Department
Hafez Avenue
Tehran
Iran
Tel: +982164545363
Email: nshams@aut.ac.ir

Abstract

Considering that contractors are one of the main pillars of construction projects and also an important factor in converting resources into the final product, it is important to evaluate and select contractors and suppliers. The selection of a contractor for construction projects is primarily based on the lowest price, but many other factors, quantitatively or qualitatively, have great importance in choosing a contractor or supplier. In this paper, taking into account the construction companies of EPC, factors affecting to the selection of contractors and suppliers and their impact on each other are considered. This review is based on the DEMATEL method and by applying this approach, affected or effected factors are used to evaluate and rank the indicators in the selection of suppliers or subcontractors. Therefore, using this method, the main contractors in construction projects do not select suppliers or subcontractors in an intellectual way, and this choice will be based on indicators.

Keywords

Supply Chain Management, Supplier Performance Evaluation, EPC Projects

1. INTRODUCTION

The construction industry is one of the largest industries and has the highest GDP in each country[1]. Despite the size and impact of the construction industry in the economy, its acceptance rate for the supply chain is slowing down [2, 3]. The overall goal of supply chain management, the integrity of organizational units and the coordination of flow of materials, information and money are to improve the competitiveness of the chain [4-6]. In fact, supply chain management is a network management of tasks that are interconnected and geared towards meeting the needs of customers [7], But supply chain management in construction projects[1] is defined as: The strategic management of the flow of information, activities, tasks, and processes involve a variety of networks of independent organizations and communication paths (upward and downward) that cause the value from the completed project to its owner [8]. In the supply chain of construction projects, upstream activities are from the perspective of the main contractor, the project owner/owners and the design or engineering group that is preparing the construction process. Downstream activities also include suppliers and subcontractors that interact with the main contractor for construction work in the project, which requires a lot of coordination between the two sides of the project. In order to succeed in construction projects, among other competitors, the communication between the best supplier and subcontractor is necessary, but it should be said that usually, construction companies do not have an expert in identifying the supplier and the contractor and do not have a scientific method for selection, so do this only on the basis of the perception, but it is necessary to select the main contractors based on the predetermined indicators of their suppliers and evaluate them on the basis of scientific methods. As companies leave the market for various reasons, the main contractors must have alternatives to it, and, finally, the contractor must share information with the strategic suppliers [8]. Based on the extensive review of published works and interviews, the quality of the relationship between project owners, contractors and building construction consultants was defined and then presented seven strategies that included trust, commitment, cooperation, and communication as a feature Critical Issues for Quality Relations [9]. When trust, communication, commitment, mutual goals and continuous improvement were found among the key factors for establishing a successful relationship between project owners and major contractors in the project, According to the results obtained from the strategies used in construction projects, trust, communication, commitment, mutual goals, and continuous improvement of critical factors are for a successful job relationship between project owners and major contractors in construction [10-13],other important factors, such as teamwork, risk assignment and problem solving, play an important role in communications between main contractors and suppliers and / or subcontractors [14-16]. These findings indicate that in the construction sector, the critical factors that the interface between the main contractors and suppliers or subcontractors may differ from the main customers and contractors. Deciding to evaluate and select suppliers and subcontractors is a multi-criteria decision problem that is not usually complicated and structured, and can be solved by employing management tools, including Multi-Criteria Decision Making[2] and System Dynamics approach [17-20]. The main focus of this paper is on EPC[3] projects, in which all the activities necessary to run a project from the design and engineering stage to the procurement of goods and final construction will be borne by the contractor. In EPC projects, the main contractors should be included innovative design and procurement options to find the right balance between profit margins and inherent risks, and also they should overcome the massive problems in purchasing, transportation and equipment cost [21, 22]. In recent literature, the main relationship is often between project owners and contractors in construction projects [17],[23, 24]. These findings are likely to be different from the relationship between the customer and the main contractor as critical structural factors affecting the construction sector among main contractors and suppliers and/or subcontractor [25]. According to studies, today the type of application of EPC projects in construction is much more practical than traditional construction projects, and in many projects, construction projects have become internationally [4] significant and have grown dramatically have also been involved in recent years. Therefore, supply chain implementation in EPC projects is needed in order to be more profitable. Therefore, reviewing the literature will examine the impact indicators in managing the relationship between the main contractors and suppliers and/or subcontractors that affect the EPC projects. So, at first, the importance of these indicators in EPC projects is evaluated and then its impact on EPC projects will be reviewed.

[1] Construction Supply Chain Management (CSCM)
[2] Multi-Criteria Decision Making (MCDM)
[3] Engineering Procurement and Construction
[4] International engineering, procurement, and construction (IEPC)

This study, using the DEMATEL[5] method, for considering the influences of the effective factors to each other than from the review of the literature and, accordingly, make the effective factors more effectively.
In the second part, the relevant literature is analyzed in relation to the effective indicators for the success of EPC projects, and then, the methods performed are examined. The next part examines the research method used in this study, and finally, the results of this study will be examined.

2. LITERATURE REVIEW

Few studies have been conducted in traditional construction but interesting studies have been done on how different factors of supply chain relationships affect the relationship between project owners and main contractors, or between main contractors and/or subcontractors [26, 27]. Here are the factors that have the influence on the success of EPC projects.

2-1. Cooperation relationship

Fulford and Standing [28], Kanda and Deshmukh [29] and Thompson and Sanders [30] have shown that collaborative relationships often can be lead to Interaction, quick resolution of outstanding issues and overall project success[31-34].

2-2. Connect and share information

Both the quality and the quantity of shared information are important for the success of communication [9], [12], [35-39]. Effective joint communication, in particular bilateral communication [21], [28], [32]. Enabling partners to better understand each other's expectations, enabling buyers to better understand the supplier's capabilities and increasing the trust and relationships, and also solves the problems "as quickly and as low as possible without needs mediation and improves legal processes "[14] also promotes innovation[11]. So It is not surprising, therefore, that lack of communication among project partners often leads to distrust, weak relationships and low performance of the project [12].

2.3. Continuous improvement

Continuous improvement refers to efforts to improve the production process, services and processes associated with a long-term focus in an organization [40]. Continuous improvement to promote joint learning within and between organizations, among suppliers and their customers, has been used to extend positive outcomes to future projects and to avoid repetition of past mistakes [41-43].

2.4. Common goal

Most contractors and suppliers and/or subcontractors have conflicting objectives [30]. Due to the insistence of the main contractor to reduce prices, subcontractors and/or suppliers tend to suspect even the appropriate improvement plans proposed by the main contractors [44, 45]. Due to the ambiguity in the poor cooperation agreement, victory of one of the parties can lead to the loss of the other party [46], it can also lead to inconsistency, disagreement, and ultimately poor performance of the project [47]. On the other hand, when the main contractors and suppliers and/or subcontractors mutually share their goals with the potential outcomes, they increase the level of collaboration and improve the overall performance of the project [30], [33].

2.5. Solve the problem effectively

Effective problem solving involves creating a primarily warning system for identifying potential issues and using formal/informal feedback to identify opportunities for improving project performance, such a mechanism may be short-term for a single project or for a long-term for multiple project programs [21],[31]. A number of studies support joint problem solving and collective decision-making because problem-solving techniques are more useful in this case [33], [37], [48-50]. Therefore, it is logical that this factor also is taken into account in this study.

2.6. Fair risk allocation

Typically, a long and multi-level supply chain for EPC projects, which main contractors rely on suppliers and/or subcontractors to complete a successful project, poses further challenges in risk management [33], [51, 52] . A significant portion of the total budget is used to provide goods [17]. However, suppliers and/or subcontractors not only have the same ability but are not at the same uncertainty [53]. A number of studies have identified the

[5] DEMATEL (Decision Making Trial And Evaluation)

important role of fair risk allocation in the construction sector[9],[36], [54]. Therefore, the effect of this factor on managing relationships in EPC projects is reviewed.

2.7. Selection criteria for supplier and subcontractor

The recent supply chain literature and the Project Management Office indicate the importance of selecting a supplier and/or subcontractor [47], [55-57]. Deliverables and services are assigned as "customer-centric criteria" [48], and these criteria are widely used to select and evaluate suppliers and subcontractors [47], [58]. Hence, this study focuses on these two features, which will probably have a significant impact on the project results.

2.7.1. Reliability in delivery

In the field of procurement and construction projects, the ability of deliver primarily to the reliability of suppliers and /or subcontractors in order to provide products, materials, equipment, installation, repair and maintenance, technical knowledge and other services at the right time, It's in the right place and in the right amount [58-62]. Therefore, considering the important role that plays this index, it is necessary to be seen in EPC projects.

2.7.2. Services provided by suppliers and/or subcontractors

Services have been widely considered among the criteria used to select and evaluate supplier and/or subcontractor [55], [58], [63, 64]. It is recommended that the buyer's organization select a limited number of suppliers and/or subcontractors in accordance with the requirements and service capabilities of the supply chain in order to minimize processing costs, the time between ordering and receiving the customer, Risk and overall performance improvement [14], [32], [38], [65]. Therefore, due to the role and importance of services in EPC projects, this factor is also felt.

2.8. Trust

Conscience is widely used as an important indicator of communication in the supply chain [9] [13] [31] [36] [42]. However, due to mistrust in the construction sector, most contractors are often pushing for optimal quotes, and suppliers and/or subcontractors try to keep cost information to themselves, fearing that contractors may end the margin of profit in their favor in the future [16] [38] [60]. But if the relationship of trust between partners is created, it can lead to closer cooperation, lower transaction costs, and the risk of the supply chain and improve project performance [13] [28] [46]. So with regard to the literature review, mutual trust can be significant and important in construction.

2.9. Measure project results

The three basic principles of cost, time, and quality are mainly used by most stakeholders to evaluate the results of construction projects [66, 67]. In general, time measurement is presented with aspects of project duration, for example, filling time, construction time, construction speed, time variation, and so on. Measuring the cost with total cost of ownership, which is not limited to the total amount of the bid, includes the costs of changes, amendments, or legal claims, and with the estimation of unit costs, the percentage of net changes, total final cost, etc., the total cost can be measured by the size Made. Typically, the quality of construction in the industry is more measured by the success of the project because it attracts attention [59]. Cost, time and quality are also generally used effectively in communication research in the supply chain of construction [15] [68, 69].

3. METHOD

In this research, a DEMATEL technique is used to examine the effect of factors on each other on EPC projects. DEMATEL technique uses one of a variety of decision-making methods based on paired comparisons using expert judgments in extracting the factors of a system and systematically structuring them by applying the principles of graph theory, using a hierarchical structure of factors in the system with affected or effected interactions. In such a way as to express the effect of these relations as numerical scores. The DEMATEL methodology is used to identify and investigate the relationship between criteria and inter-network relationships. Because the directional graphs can better illustrate the relationships between the elements of a system, this technique is based on graphs that can divide the factors involved into two causative and causal groups, and their relationship as a structural model understandable. DEMATEL technique was generally developed to study the very complex global issues. DEMATEL is also used to construct a sequence of supposed information. As the severity of the communication is evaluated as a reward, it traces back their important feedback and accepts non-transferable relationships. Considering interconnections; the advantage of this approach to network analysis technique is its clarity and

transparency in reflecting interactions between a wide ranges of components. So that professionals can more fluent in expressing their opinions about the effects (direction and severity of effects) between criteria. It should be noted that the matrix derived from the DEMATEL technique (internal communication matrix) actually forms part of the super matrices. In other words, DEMATEL technique does not work independently, but as a subsystem of a larger system such as ANP. The structuring of complex factors in the form of cause and effect groups is another subject discussed in this technique. This is one of the most important functions and one of the most important reasons for its extensive use in problem-solving processes. By deconstructing a wide range of complex factors in the form of impaired cause groups, the decision maker in a more appropriate context will understand the relationship. This makes it more aware of the place of the factors and the role played by mutual interaction.
The DEMATEL technique includes the following steps:

- Formation of a Direct Contact Matrix (M): When using multi-viewpoint, we use the simple average of the comments and form M.
- Normalize the direct relation matrix: N = K*M
  Which in this formula k is calculated as follows; first, the sum of all rows and columns is calculated. The reciprocal of the largest number of rows and columns is k.

$$k = \frac{1}{\max \sum_{j=1}^{n} a_{ij}}$$

- Calculate the complete communication matrix $T = N \times (I - N)^{-1}$
- Create causal chart:
  The sum of the elements of row (D) for each factor indicates the extent of its effect on other system factors. (Effect of Variables)
  The sum of column elements (R) for each factor indicates the extent of its impact on other system factors. (Variable Effectiveness)
  Therefore, horizontal vector (D + R) is the amount of impact and effect of the agent in the system. In the other word, the greater the amount (D + R) of a particular factor, the more interacting with other system factors. Vertical Vector (D-R) shows the power of each agent's influence. In general, if (D-R) is positive, the variable is a causal variable and, if negative, is considered an effect.
  Finally, a Cartesian coordinate system is mapped. In this machine, the axis is longitudinal (D + R) and the transverse axis is based on (D-R). The position of each agent is determined by the point to the coordinates ((D + R), (D-R)). In this way, a graphic diagram will also be obtained.

Proposed Analytical Steps
The analytical process seen in this article is in the following steps: Each step is the basis of the next step.
The first step is to examine and identify the effective factors in EPC projects. These indicators are based on extensive literature reviews.
Step Two: At this stage, direct matrices (Matrices of Paired Comparisons between Criteria) are collected, then the interrelationships of the criteria are evaluated by expert opinions. Each matrix expert has a direct relationship and interaction between experts is inevitable.
Step 3: When the matrix collection process is complete, we normalize the matrix. At this stage, the numbers in this matrix are between zero and one, but it should be noted that its sum is not necessarily equal to one.
Step Four: Now we make the matrix (I-N), in which "I" is equal to the unit vector, and "N" is the matrix that is made in the previous step.
Step Five: Here we reverse the resulting matrix and then multiply the matrix N in the matrix, it should be noted that this is a multiplication of matrices.
Step 6: At this point, we write the sum of each row and each column, sum the row is D, and sum the column is R, then calculate (D-R) and (D + R). In (D + R), the largest factor (the largest number) is the factor that has the most interaction with the rest of the factors, and the lowest number will have the least interaction with the rest. But in the (D-R), the largest factor is known as the most effective factor and the smallest factor as the most effective factor. Of course, no calculations should be done manually and will be performed with Excel software due to the size of the calculation. It should also be taken into account that DEMATEL is a multi-criteria decision that identifies the relationship between criteria and sub-criteria and the importance of them, but does not provide a ranking between criteria and only gives us the relationship between criteria.

4. RESULTS

This section discusses the approach used in the DEMATEL analysis in this study.

I. The first step is to list the factors:

DEMATEL methodology collects views and contributions from project owners /contractors through the mental storm and group methodology in relation to the impact of factors extracted from the literature review. To keep confidentiality, the names of specialists will not be published in this article.

Table 1 - Proposed measurement criteria

Factors	Symbol
The relationship of collaboration	A
Communication and information sharing	B
Continuous improvement	C
Common goal	D
Effective problem solving	E
Fair risk allocation	F
Supplier selection criteria And Subcontractor	G
Reliability in delivery	G
Services provided by suppliers and /or subcontractors	G
Trust	H
Measurement of Project Results	I

II. Step Two: Create a Direct Relationship Matrix

This stage of DEMATEL analysis is to analyze the relationship between the invoices. According to the agreement of the main contractors, relations in the direct relationship matrix are identified in Table 2. In this table, attention is paid to knowing how to encourage a particular benchmark for others. Here are the average opinions of the experts (project managers) from the three sustainable construction companies of the Sazeh Paydar (consisting of 4 main contractors and 11 subcontractors),Sabz Andishan (consisting of 3 main contractors and 7 subcontractors) and Royal Sazeh Structures (including 5 main contractors and 9 contractors) which, an EPC project organizer, who has sufficient experience in evaluating suppliers and subcontractors in various projects.

Table 2 - Creating a Direct Relationship Matrix

	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
A	0.00	1.33	4.00	2.67	2.33	1.67	4.00	4.00	3.00
B	3.67	0.00	0.00	1.00	0.00	1.67	3.00	1.33	0.33
C	3.33	4.00	0.00	4.00	4.00	3.33	4.00	3.00	1.33
D	4.00	3.33	1.00	0.00	0.67	3.00	2.67	1.33	2.33
E	3.67	4.00	3.00	3.00	0.00	2.67	4.00	2.33	0.00
F	2.33	3.67	3.33	3.00	1.00	0.00	4.00	3.33	0.00
G	4.00	2.33	3.33	3.67	1.33	3.33	0.00	4.00	2.33
H	3.00	3.00	2.67	2.00	2.00	3.00	3.00	0.00	2.67
I	2.33	3.33	3.67	3.33	2.67	4.00	4.00	3.67	0.00

III. Step Three: Obtain an Internal Affiliation Matrix

At this point, the extracted results from Excel software are presented with consideration of the inputs previously examined. This step is achieved after normalization. The criteria are, respectively the relationship of collaboration (A), communication and information sharing (B), continuous improvement (C), common goal (D), effective problem solving (E), fair risk allocation (F), supplier selection criteria And Subcontractor: Reliability in Transformation, Services Provided by Suppliers and / or Subcontractors (G), Trust (H), Measurement of Project Results (I).

Table 3 - Relationship vector and relative (relative importance) for cause and effect group for suppliers

	R	D	R+D	R-D
A	0.16644132	0.227149811	0.39359113	-0.06070849
B	0.082477015	0.251892915	0.33436993	-0.1694159
C	0.271498107	0.189291509	0.460789616	0.082206598
D	0.166035695	0.206192537	0.372228231	-0.04015684
E	0.222958356	0.123985938	0.346944294	0.098972418
F	0.19753921	0.214575446	0.412114657	-0.01703624
G	0.213223364	0.283937263	0.497160627	-0.0707139
H	0.180773391	0.195375879	0.37614927	-0.01460249
I	0.249323959	0.057869118	0.307193077	0.19145484

Table 4 - Complete matrix

	A	B	C	D	E	F	G	H	I
A	-0.0928	-0.0407	0.0784	0.0175	0.0317	-0.0235	0.0578	0.0722	0.0657
B	0.0978	-0.0321	-0.0438	-0.0010	-0.0224	0.0283	0.0689	0.0041	-0.0174
C	0.0174	0.0558	-0.0811	0.0665	0.1046	0.0401	0.0425	0.0251	0.0002
D	0.0846	0.0663	-0.0247	-0.0599	-0.0117	0.0565	0.0224	-0.0194	0.0519
E	0.0477	0.0750	0.0485	0.0400	-0.0428	0.0296	0.0612	0.0109	-0.0473
F	0.0008	0.0673	0.0705	0.0467	-0.0050	-0.0682	0.0718	0.0596	-0.0461
G	0.0611	-0.0016	0.0505	0.0596	-0.0054	0.0462	-0.1047	0.0704	0.0370
H	0.0311	0.0362	0.0324	0.0009	0.0294	0.0427	0.0223	-0.0768	0.0623
I	-0.0206	0.0255	0.0584	0.0356	0.0455	0.0627	0.0415	0.0490	-0.0485

Table 5 - Binary matrix

	A	B	C	D	E	F	G	H	I
A	0	0	1	0	1	0	1	1	1
B	1	0	0	0	0	1	1	0	0
C	0	1	0	1	1	1	1	1	0
D	1	1	0	0	0	1	1	0	1
E	1	1	1	1	0	1	1	0	0
F	0	1	1	1	0	0	1	1	0
G	1	0	1	1	0	1	0	1	1
H	1	1	1	0	1	1	1	0	1
I	0	1	1	1	1	1	1	1	0

In the table below, which is the final table, effects are examined. If each of the calculations in Table 4 is greater than the mean, 1, otherwise it becomes zero and indicates that it has no effect. For example, the cooperative relationship (A) is effective on continuous improvement (C), but it does not affect the allocation of fair risk, or trust (H) affects all factors and only affects the common purpose (D). The effectiveness of each of the factors expressed as zero and one is shown in the graph below.

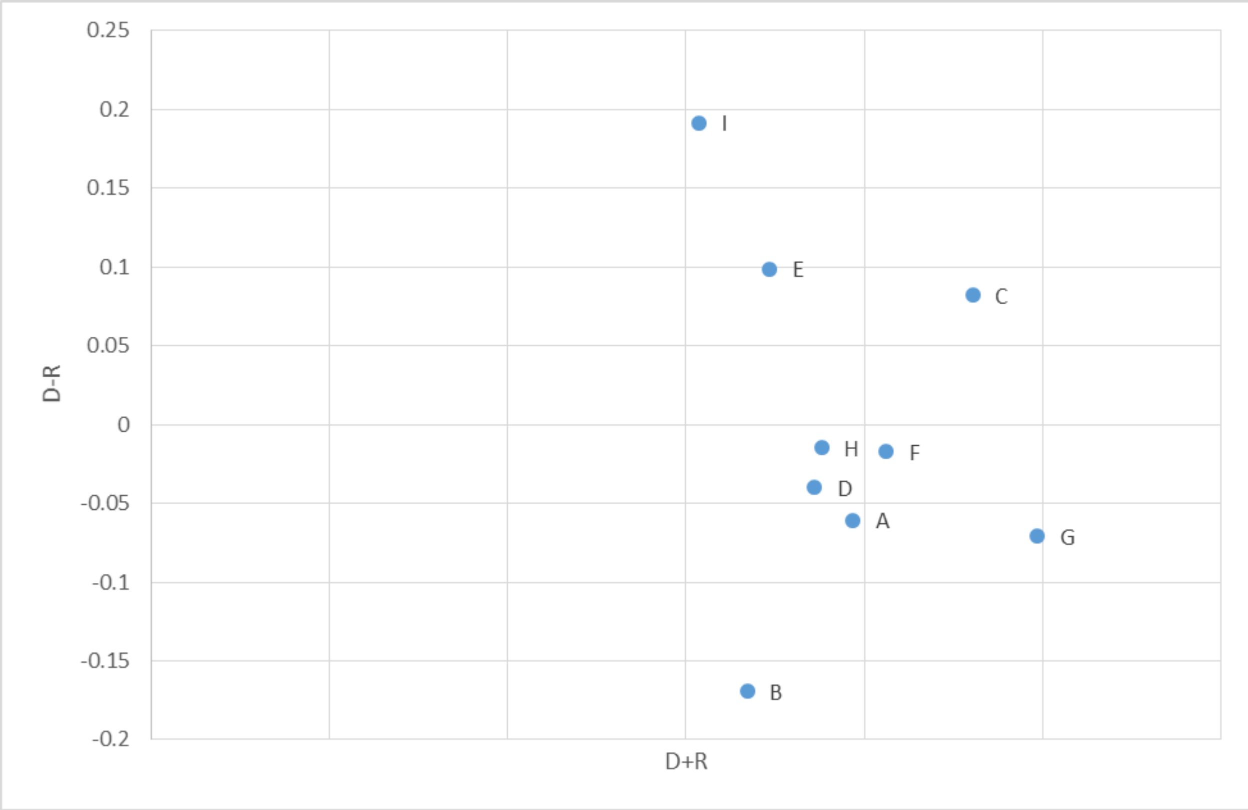

Figure 1-Cause Diagram

5. CONCLUSION

Considering that EPC construction companies do not have specific criteria for choosing a supplier or subcontractor, in this research, using the DEMATEL method, effective and affective factors for evaluating and ranking factors in choosing suppliers or subcontractors are identified. Therefore, using this method, the main contractors do not choose suppliers or subcontractors, and this choice will be based on indicators. The research was carried out in three major construction companies and it was observed that the choice of the supplier or subcontractor was carried out safely, which also resolved many of the problems of selecting suppliers or subcontractors. It is suggested that future selection of models for selection of selected projects be presented.

References

1. Cheng, J.C., et al., *A service oriented framework for construction supply chain integration.* Automation in construction, 2010. **19**(2): p. 245-260.
2. Akintoye, A., G. McIntosh, and E. Fitzgerald, *A survey of supply chain collaboration and management in the UK construction industry.* European Journal of Purchasing & Supply Management, 2000. **6**(3-4): p. 159-168.
3. Gadde, L.-E. and A. Dubois, *Partnering in the construction industry—Problems and opportunities.* Journal of purchasing and supply management, 2010. **16**(4): p. 254-263.
4. Stadtler, H., *Supply chain management and advanced planning––basics, overview and challenges.* European journal of operational research, 2005. **163**(3): p. 575-588.
5. Tabrizi, B. and J. Razmi. *A stochastic programming based approach for supply chain network design under uncertain processing costs*. in *The 11th Asia Pacific Industrial Engineering and Management Systems Conference*. 2010.
6. Chopra, S. and P. Meindl, *Supply chain management. Strategy, planning & operation*, in *Das summa summarum des management*. 2007, Springer. p. 265-275.
7. Thomas, D.J. and P.M. Griffin, *Coordinated supply chain management.* European journal of operational research, 1996. **94**(1): p. 1-15.
8. Benton, W. and L.F. McHenry, *Construction purchasing & supply chain management*. 2010: McGraw-Hill New York.
9. Jelodar, M.B., T.W. Yiu, and S. Wilkinson, *A conceptualisation of relationship quality in construction procurement.* International Journal of Project Management, 2016. **34**(6): p. 997-1011.
10. Black, C., A. Akintoye, and E. Fitzgerald, *An analysis of success factors and benefits of partnering in construction.* International journal of project management, 2000. **18**(6): p. 423-434.
11. Cheng, E.W. and H. Li, *Construction partnering process and associated critical success factors: quantitative investigation.* Journal of management in engineering, 2002. **18**(4): p. 194-202.
12. Ng, S.T., et al., *Problematic issues associated with project partnering—the contractor perspective.* International Journal of Project Management, 2002. **20**(6): p. 437-449.
13. Bastan, M., et al., *Sustainable development of agriculture: a system dynamics model.* Kybernetes, 2017.
14. Beach, R., M. Webster, and K.M. Campbell, *An evaluation of partnership development in the construction industry.* International Journal of Project Management, 2005. **23**(8): p. 611-621.
15. Humphreys, P., J. Matthews, and M. Kumaraswamy, *Pre-construction project partnering: from adversarial to collaborative relationships.* Supply Chain Management: An International Journal, 2003. **8**(2): p. 166-178.
16. Meng, X., *The effect of relationship management on project performance in construction.* International journal of project management, 2012. **30**(2): p. 188-198.
17. Ahmadvand, A.M., et al., *Analysis of Tehran construction and demolition waste management with System Dynamics Approach.* Asian Journal of Research in Business Economics and Management, 2014. **4**(8): p. 234-242.
18. Bastan, M. and L. Azizi Baraftabi. *The effect of HSE programs on time and cost of construction projects: An analysis based on System Dynamics methodology*. in *The 1st International Conference on Industrial Engineering, Management and Accounting, Tehran, Iran*. 2016. University of Applied Science and Technology.
19. Bastan, M., M. Mosaed, and F. Kashef. *Dynamic Analysis of Housing Cost Changes in Tehran*. in *The 9th International Conference on Industrial Engineering (IIEC2013), Tehran, Iran*. 2013. K.N. Toosi University of Technology.

20. Khoshneshin, F. and M. Bastan. *Analysis of dynamics of crisis management in the earthquake and performance Improvement using system dynamics methodology*. in *The 10th International Conference on Industrial Engineering (IIEC2014), Tehran, Iran*. 2013. Tehran University.
21. Dainty, A.R., S.J. Millett, and G.H. Briscoe, *New perspectives on construction supply chain integration.* Supply chain management: An international journal, 2001. **6**(4): p. 163-173.
22. Vrijhoef, R. and L. Koskela, *The four roles of supply chain management in construction.* European journal of purchasing & supply management, 2000. **6**(3-4): p. 169-178.
23. Briscoe, G. and A. Dainty, *Construction supply chain integration: an elusive goal?* Supply chain management: an international journal, 2005. **10**(4): p. 319-326.
24. Kadefors, A., E. Björlingson, and A. Karlsson, *Procuring service innovations: Contractor selection for partnering projects.* International Journal of Project Management, 2007. **25**(4): p. 375-385.
25. Pal, R., P. Wang, and X. Liang, *The critical factors in managing relationships in international engineering, procurement, and construction (IEPC) projects of Chinese organizations.* International Journal of Project Management, 2017. **35**(7): p. 1225-1237.
26. Chen, W.T. and T.-T. Chen, *Critical success factors for construction partnering in Taiwan.* International Journal of Project Management, 2007. **25**(5): p. 475-484.
27. Deutsch, M., *Constructive conflict resolution: Principles, training, and research.* Journal of social issues, 1994. **50**(1): p. 13-32.
28. Fulford, R. and C. Standing, *Construction industry productivity and the potential for collaborative practice.* International Journal of Project Management, 2014. **32**(2): p. 315-326.
29. Kanda, A. and S. Deshmukh, *Supply chain coordination: perspectives, empirical studies and research directions.* International journal of production Economics, 2008. **115**(2): p. 316-335.
30. Thompson, P.J. and S.R. Sanders, *Peer-reviewed paper: partnering continuum.* Journal of Management in Engineering, 1998. **14**(5): p. 73-78.
31. Brahm, F. and J. Tarzijan, *Relational Contracts and Collaboration in the Supply Chain: Impact of Expected Future Business Volume on the Make-or-Buy Decision.* Journal of Supply Chain Management, 2016. **52**(3): p. 48-67.
32. Broft, R., S.M. Badi, and S. Pryke, *Towards supply chain maturity in construction.* Built Environment Project and Asset Management, 2016. **6**(2): p. 187-204.
33. Du, L., et al., *Enhancing engineer–procure–construct project performance by partnering in international markets: Perspective from Chinese construction companies.* International Journal of Project Management, 2016. **34**(1): p. 30-43.
34. Meng, X., *Assessment framework for construction supply chain relationships: Development and evaluation.* International Journal of Project Management, 2010. **28**(7): p. 695-707.
35. Ab Talib, M.S. and A.B. Abdul Hamid, *Application of critical success factors in supply chain management.* International Journal of Supply Chain Management, 2014. **3**(1).
36. Doloi, H., *Key Factors of Relational Partnerships in Project Management*, in *Handbook on Project Management and Scheduling Vol. 2*. 2015, Springer. p. 1047-1061.
37. Monczka, R.M., et al., *Success factors in strategic supplier alliances: the buying company perspective.* Decision sciences, 1998. **29**(3): p. 553-577.
38. Zhao, Z.-Y., et al., *Corporate social responsibility for construction contractors: a China study.* Journal of Engineering, Design and Technology, 2016. **14**(3): p. 614-640.
39. Dainty, A.R., G.H. Briscoe, and S.J. Millett, *Subcontractor perspectives on supply chain alliances.* Construction Management & Economics, 2001. **19**(8): p. 841-848.
40. Bhuiyan, N. and A. Baghel, *An overview of continuous improvement: from the past to the present.* Management decision, 2005. **43**(5): p. 761-771.
41. Babaeian Jelodar, M., T.W. Yiu, and S. Wilkinson, *Assessing contractual relationship quality: Study of judgment trends among construction industry participants.* Journal of Management in Engineering, 2016. **33**(1): p. 04016028.

42. Carrillo, P., *Lessons learned practices in the engineering, procurement and construction sector.* Engineering, Construction and Architectural Management, 2005. **12**(3): p. 236-250.
43. Salmasnia, A., M. Bastan, and A. Moeini, *A robust intelligent framework for multiple response statistical optimization problems based on artificial neural network and Taguchi method.* International Journal of Quality, Statistics, and Reliability, 2012. **2012**.
44. Hartmann, A. and J. Caerteling, *Subcontractor procurement in construction: the interplay of price and trust.* Supply chain management: an international journal, 2010. **15**(5): p. 354-362.
45. Tavakoli, H. and M. Bastan. *A Holistic View to Performance Measurement: An Integrated Approch of Balanced Scorecard And Analytic Hierarchy Process*. in *The 1st International Conference on Industrial Engineering, Management and Accounting, Tehran, Iran*. 2016. University of Applied Science and Technology.
46. Larson, E., *Project partnering: results of study of 280 construction projects.* Journal of management in engineering, 1995. **11**(2): p. 30-35.
47. Tang, W., C.F. Duffield, and D.M. Young, *Partnering mechanism in construction: An empirical study on the Chinese construction industry.* Journal of Construction Engineering and Management, 2006. **132**(3): p. 217-229.
48. Cheng, E.W., H. Li, and P. Love, *Establishment of critical success factors for construction partnering.* Journal of management in engineering, 2000. **16**(2): p. 84-92.
49. Meng, X., *The role of trust in relationship development and performance improvement.* Journal of Civil Engineering and Management, 2015. **21**(7): p. 845-853.
50. Ho, W., et al., *Supply chain risk management: a literature review.* International Journal of Production Research, 2015. **53**(16): p. 5031-5069.
51. Liu, J., X. Zhao, and P. Yan, *Risk paths in international construction projects: Case study from Chinese contractors.* Journal of Construction Engineering and Management, 2016. **142**(6): p. 05016002.
52. Zsidisin, G.A., A. Panelli, and R. Upton, *Purchasing organization involvement in risk assessments, contingency plans, and risk management: an exploratory study.* Supply Chain Management: An International Journal, 2000. **5**(4): p. 187-198.
53. Manu, E., et al., *Trust influencing factors in main contractor and subcontractor relationships during projects.* International Journal of Project Management, 2015. **33**(7): p. 1495-1508.
54. El-Sayegh, S.M., *Risk assessment and allocation in the UAE construction industry.* International journal of project management, 2008. **26**(4): p. 431-438.
55. Ho, W., X. Xu, and P.K. Dey, *Multi-criteria decision making approaches for supplier evaluation and selection: A literature review.* European Journal of operational research, 2010. **202**(1): p. 16-24.
56. Nair, A., J. Jayaram, and A. Das, *Strategic purchasing participation, supplier selection, supplier evaluation and purchasing performance.* International Journal of Production Research, 2015. **53**(20): p. 6263-6278.
57. Yeo, K. and J. Ning, *Integrating supply chain and critical chain concepts in engineer-procure-construct (EPC) projects.* International Journal of Project Management, 2002. **20**(4): p. 253-262.
58. Luzon, B. and S.M. El-Sayegh, *Evaluating supplier selection criteria for oil and gas projects in the UAE using AHP and Delphi.* International Journal of Construction Management, 2016. **16**(2): p. 175-183.
59. Eshtehardian, E., P. Ghodousi, and A. Bejanpour, *Using ANP and AHP for the supplier selection in the construction and civil engineering companies; case study of Iranian company.* KSCE Journal of Civil Engineering, 2013. **17**(2): p. 262-270.
60. Kotula, M., et al., *Strategic sourcing supplier selection misalignment with critical success factors: Findings from multiple case studies in Germany and the United Kingdom.* International Journal of Production Economics, 2015. **166**: p. 238-247.
61. Ulubeyli, S., E. Manisali, and A. Kazaz, *Subcontractor selection practices in international construction projects.* Journal of Civil Engineering and Management, 2010. **16**(1): p. 47-56.

62. Weber, C.A. and L.M. Ellram, *Supplier selection using multi-objective programming: a decision support system approach.* International Journal of Physical Distribution & Logistics Management, 1993. **23**(2): p. 3-14.
63. Amid, A., S. Ghodsypour, and C. O'Brien, *A weighted max–min model for fuzzy multi-objective supplier selection in a supply chain.* International Journal of Production Economics, 2011. **131**(1): p. 139-145.
64. De Boer, L., E. Labro, and P. Morlacchi, *A review of methods supporting supplier selection.* European journal of purchasing & supply management, 2001. **7**(2): p. 75-89.
65. Forsythe, P., *Monitoring customer perceived service quality and satisfaction during the construction process.* Construction Economics and Building, 2015. **15**(1): p. 19-42.
66. Chan, A.P. and A.P. Chan, *Key performance indicators for measuring construction success.* Benchmarking: an international journal, 2004. **11**(2): p. 203-221.
67. Ling, F.Y.Y., et al., *Drivers and barriers to adopting relational contracting practices in public projects: Comparative study of Beijing and Sydney.* International Journal of Project Management, 2014. **32**(2): p. 275-285.
68. Wang, X. and J. Huang, *The relationships between key stakeholders' project performance and project success: Perceptions of Chinese construction supervising engineers.* International Journal of Project Management, 2006. **24**(3): p. 253-260.
69. Mokhtari, H., A. Salmasnia, and M. Bastan. *Three Dimensional Time, Cost and Quality Tradeoff Optimization in Project Decision Making*. in *Advanced Materials Research*. 2012. Trans Tech Publications.

Biographies

Naser S. Gharneh is an Associate Professor in the Industrial Engineering and Management Systems Department at Amirkabir University of Technology (AUT) where he has been a faculty member since 1993. Naser has been a member of the research faculty since 2000. He is the Industrial Engineering and Productivity Research Centre Director at AUT. Naser completed his Ph.D. at UMIST in the UK and his master and undergraduate studies at AUT. His research interests lie in the areas of Industrial Engineering and Financial Management. He has collaborated actively with other research centres in several other disciplines of Education Management and Productivity. Naser has been the Director of Iranian Students in the UK and Ireland from 2002 to 2007. He has stablished many academic links between Iranian and UK Universities. Naser has served on more than thirty conference and workshop program committees since 1990. For additional information see: http://www.aut.ac.ir/official/main.asp?uid=nshams

Sara Sajedi is currently Master of Science Student in Industrial Engineering at Amirkabir University of Technology (AUT).