

Research Article

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Supply chain collaboration within the Iranian construction industry

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Abstract: Collaboration is an important factor to succeed and increase the sustainability in project management and construction, especially in a construction supply chain (CSC) that includes multiple partners. Although, in recent decades, many changes have occurred in the construction industry, there are still many problems in this area. Therefore, research in this area becomes vital because collaboration is one of the best approaches to improve CSC performance. In this study, collaborative relationship has been found to be affected by three main factors: managerial, financial and structural. However, application of collaboration in Iran is still in its inception. This comprehensive research study focuses on suitable context for implementing the collaboration method. The methodology of this research is based on interviews and a review of previous research, which identifies critical factors and positive results of use in relation to collaboration. Results of this study improve our knowledge about the role of collaboration in a CSC's performance. Analysis of data shows that managerial factors have the most positive effects on the implementation of collaboration networks in CSCs, followed by financial factors and organizational factors.

Keywords: construction industry, supply chain, collaboration, sustainability

1 Introduction

The construction industry is one of the mainstays of the economy in many countries (Ngai et al. 2002). Furthermore, construction products have a large impact on any aspect of society (Bayliss et al. 2004). For these reasons, all human beings are directly affected by the processes and/or the products of the construction industry (Ngai et al. 2002). Supply chain in the construction industry is one of the most important issues in developing countries. Activities such as supply-and-demand planning, procurement, inventory control, distribution, delivery and customer service, which have been previously done at the level of the company are now transferred to the supply chain. Supply chain in the construction industry includes the hierarchical structure of client, general contractor, subcontractor, supplier and the consumer (Greaver et al. 1999). In this structure, the general contractor is at the highest level and the subcontractor and suppliers are located in the lower level. Information herein would be passing between different levels. In recent decades, basic steps have been taken to increase the efficiency of the construction industry (Vrijhoef et al. 1999). Due to the fragmented nature of construction, communication and coordination problems are common and these affect project performance and productivity (Li et al. 2000). Considering this fact, the construction supply chain (CSC), which is currently facing many challenges, needs more attention (Holton 2001).

There are many criticisms of the construction industry due to its association with disputes and due to weak customer-oriented behavior (Chan et al. 2003; Egan 1998; Latham 1994; Ng et al. 2002). According to the challenges in the CSC and the variety of work that has been done in this area, changes or moving from the traditional CSC to the cooperation model is essential (Dubois and Gadde 2000). Some of the recent changes faced by the construction industry are increased competition, limited resources, the need for more flexibility and faster response time in construction projects (Dikmen et al. 2008), client-contractor relationships (Bresnen and Marshall 2000)

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and increased complexity. Collaboration has been acknowledged by many researchers and practitioners for the past two decades as an innovative approach for supply chains in the construction industry, and it has become a management strategy for improving project performance and organizational relations (Dikmen et al. 2008).

This study uses a hybrid multiple-criteria decision-making (MCDM) model based on analytic hierarchy process (AHP) and fuzzy technique to prioritize effective factors and positive results. To achieve this, we have designed a fuzzy-AHP questionnaire and sent it to 36 experts in CSCs. Using the fuzzy-AHP mathematical model, causal relations and their prioritizations are determined. Then, the positive results are prioritized using pairwise comparison logic and fuzzy-AHP method. The collaborative approach could answer some of the requirements associated with the Iranian construction sector.

2 Background

One of the new approaches to success in the construction industry is collaboration. Collaboration is the process that allows companies to share their information, resources and responsibilities to plan, implement and evaluate activities in order to achieve a common goal. Nowadays, collaboration is one of the main features of a successful company and it helps units to obtain more appropriate decisions as well (London and Kenle 2001; Vrijhoef et al. 2002). A unit that cannot compete alone can combine its competitive advantages by cooperation with a supply chain and provide better services in the global market (Dainty et al. 2001; Khalfan et al. 2004).

Although there is conformity over the general concept of collaborating, there is considerable variation in the definition of collaboration levels (Fig. 1). Networking involves communication and information exchange for mutual advantage. A simple example of networking is the

case in which a group of entities share information about their experience by using a particular tool. Coordinated networking involves, in addition to communication and information exchange, aligning/altering activities, so that the final results will be more efficient. Cooperation involves not only communication, information exchange and adjustments of activities but also resource sharing for the achievement of compatible goals. Division of some labor (not extensive) among participants also helps in achieving cooperation. Collaboration is a more demanding process in which entities share information, resources and responsibilities to jointly plan, implement and evaluate a program of activities to achieve a common goal, therefore jointly generating value. This concept is derived from the Latin “collaborate” meaning “to work together” and can be seen as a process of shared creation; thus, it is a process through which a group of entities enhance the capabilities of each other. Coordination extends networking; cooperation extends coordination and collaboration extends cooperation. As we move along the continuum from networking to collaboration, we increase the amounts of common-goal-oriented risk taking, commitment and resources that participants must invest into the joint endeavor (Camarinha-Matos and Afsarmanesh 2006). The general purpose of enterprise collaboration is usually to maximize marginal profit or to hold the market punctuation, along with minimizing of negative impacts (Yoon et al. 2011).

Collaboration is an intentional property that derives from the shared belief that, together, the network members can achieve goals that would not be possible or would have a higher cost if attempted by them individually (Barabasi 2003; Dorogovtsev and Mendes 2003).

Through exploration into previous studies, Afsarmanesh proposed a framework for collaboration, whereby management mechanism, organizations involved and project dimensions can be evaluated for determining collaborating use (Afsarmanesh et al. 2006).

| | |
|---|---|
| ✓ | <i>Networking: Communication and information exchange is done for the benefit of both sides. At this level of collaboration, there is no common purpose and structure for sharing information and experiences to organize the timing and manner of participating institutions.</i> |
| ✓ | <i>Coordination: In addition to the exchange of information, parallel activities or variable activities are done.</i> |
| ✓ | <i>Cooperation: At this level of interaction, not only the exchange of information occurs, but also when different companies work together to achieve the same goals, they share their resources (including financial resources, manpower, etc.)</i> |
| ✓ | <i>Collaboration: collaboration concept refers to the process by which others are involved in the process. Therefore, when companies collaborate with each other, they reinforce their abilities. At this level they share information, resources and responsibilities to design, implement and monitor their activities.</i> |

Fig. 1: Definition of collaboration levels.

The review of previous studies indicated that there are some sub-factors in the major areas. For instance, for the managerial factor, project management capability (Rohaniyati 2009) (Mccord 2010) is the most important sub-factor. Some researchers emphasize on other subsets, including measurement and selection of subcontractor (Lehtonen 1998), leadership (Ahmad and Ullah 2013), project manager’s goal commitment (Rohaniyati 2009) and top management support (Akintoye et al. 2000). The second main factor is the organizational factor, which includes capability (Ahmad and Ullah 2013) and culture (Wong et al. 2004). The content of information is an important factor that affects communication. Information must be managed to bring in value. The quality of received information and the cost-effectiveness in obtaining the information determine the efficiency of a project partner. The third one is the financial factor, which in some studies is more important than the other items. The majority of the contractors like to have cost benefit in the relationship with a subcontractor (Akintoye et al. 2000). Therefore, subcontractors may hesitate to establish or maintain a relationship with a general contractor if the financial condition of the general contractor is questionable (Mccord 2010). On the other hand, general contractors should consider ways to expedite payments to subcontractors in order to enhance relations and gain favored pricing on bids (Mccord 2010).

There is a literature review background in this study regarding the advantages that collaboration provides for partners in the CSC. Collaboration significantly contributes to reduction of supply chain costs and time, as well as increase of quality. Expected benefits from relationship include improvement of efficiency and cost-effectiveness, increase of opportunities for innovations and continuous improvement of quality products and services (Lehtonen

1998). Collaboration allows the implementation of an on-site evaluation system.

3 Methodology and framework

Application of collaboration in the Iranian construction industry is still in its inception. However, the key elements of collaboration can be observed in many projects. Some of the projects are called joint ventures, consortia, various forms of joint production and selling and so on (Vessal 2009). Therefore, they have used the collaborative approach. Because these are the only collaborative systems used in Iran, this research goes through the project management in these projects, interviewing and asking them to fill the questionnaire. The studied population includes the companies involved in the chain, such as client, consultant and contractor working in this area. Thirty-six experts (with titles of Project manager/Procurement manager/Executive managers) among them have been selected by random sampling. This research wants to increase awareness and knowledge of the companies by identifying these factors and ultimately helping to improve the supply chain performance in the construction industry. The following framework is presented through extensive review of literature on collaborative procurement, using interviews with experts and active project managers. The following framework shows the methodology of the research (Fig. 2).

3.1 Fuzzy–AHP questionnaire design

For evaluating the effective factors by the fuzzy–AHP method, it is necessary to define the criteria and

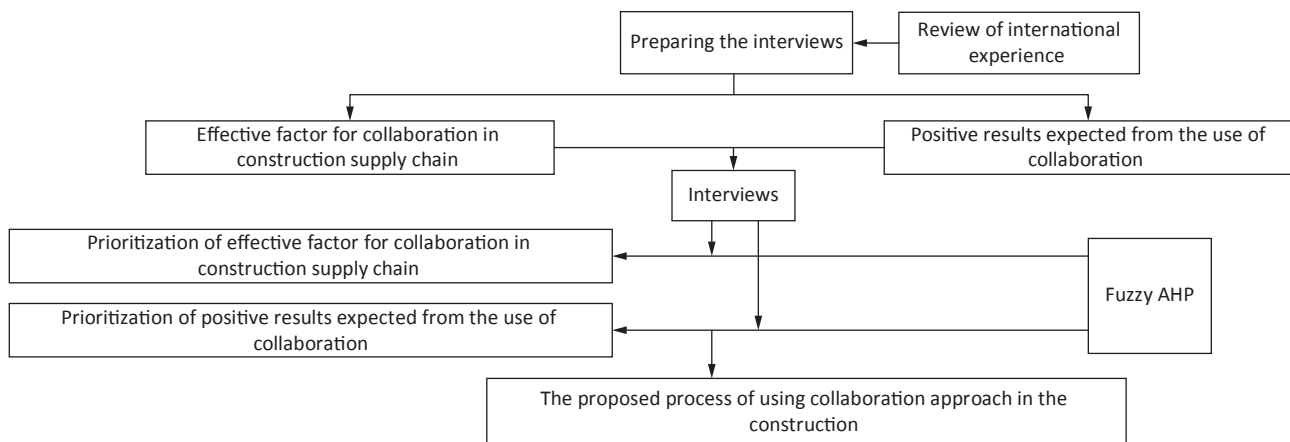


Fig. 2: Framework for collaboration in construction supply chain.

Tab. 1: Specific symbol of criteria and sub-criteria.

| Symbol | Factor | Symbol | Factor |
|----------------|------------|-------------------------------|---|
| A ₁ | Managerial | A ₁ B ₁ | Manager's commitment to the goals |
| | | A ₁ B ₂ | Manager's trust to share the information system |
| | | A ₁ B ₃ | Manager's justice and impartiality of communications with other members of the supply chain |
| A ₂ | Structural | A ₂ B ₁ | Existence of the culture of collaboration within the organization |
| | | A ₂ B ₂ | Knowledge, information and experience of employees |
| | | A ₂ B ₃ | Correct definition of the roles and responsibilities in the organization chart |
| A ₃ | Financial | A ₃ B ₁ | Spending money for use of updated information sharing system |
| | | A ₃ B ₂ | Use of financial resources to control and update project information |
| | | A ₃ B ₃ | Use of financial resources for training members (how to collaborate with each other) |

Tab. 2: Linguistic scale for importance (Fuzzy AHP).

| Triangular fuzzy scale | | | Linguistic scale for importance |
|------------------------|---|---|---------------------------------|
| u | m | l | |
| 3 | 1 | 1 | Equally preferred |
| 5 | 3 | 1 | Moderately preferred |
| 7 | 5 | 3 | Strongly preferred |
| 9 | 7 | 5 | Very strongly preferred |
| 11 | 9 | 7 | Extremely preferred |

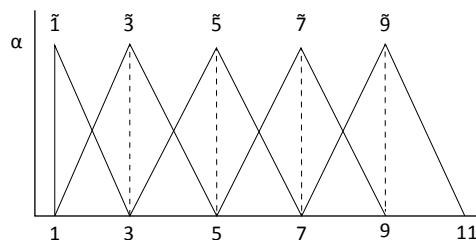


Fig. 3: The membership function of the fuzzy number.

sub-criteria. This study uses nine evaluation criteria and symbols as shown in Table 1. The questionnaire is based on pairwise comparison to evaluate the effective factors and positive results, where scores of one to five represent no influence, low influence, normal influence, high influence and very high influence, respectively (Cheng and Mon 1994). The linguistic scale for importance (fuzzy-AHP) and the membership function of the fuzzy number are shown in Table 2 and Figure 3.

The reliability of the questionnaire is measured using the inconsistency rate. For data obtained from paired comparisons of factors affecting the collaboration in collaborative supply chain management and the positive results obtained by using it, the inconsistency rates obtained are 0.05 and 0.07, which are <0.1. Hence, the reliability of the questionnaire assessment is favorable.

3.2 Calculation process of fuzzy-AHP method

The fuzzy-AHP technique can be viewed as an advanced analytical method developed from the traditional AHP. Despite the convenience of AHP in handling both quantitative and qualitative criteria of multiple-criteria decision-making problems based on the decision maker's judgments, the fuzziness and vagueness existing in many decision-making problems may contribute to the imprecise judgements of decision makers in conventional AHP approaches (Aggarwal and Singh 2013). Cheng and Mon's extent analysis method is used to evaluate fuzzy pairwise comparisons (Cheng and Mon 1994). Extent analysis approach is explained in details in the following steps:

Step 1: Design the hierarchical structure (shown in Table 1)

Step 2: Set up the pairwise comparison matrix with triangular fuzzy numbers

Step 3: Transform triangular fuzzy numbers into the triangular fuzzy number's α -cuts

Step 4: Set up Matrix A with optimism index (λ) (Eq. 1):

$$\tilde{a}^{\alpha}_{ij} = \lambda \tilde{a}^{\alpha}_{ju} + (1 - \lambda) \tilde{a}^{\alpha}_{ijl} \quad \forall \lambda \in (0, 1) \quad (1)$$

After specifying the fuzzy number, in this step, we attempted to moderate the cut of fuzzy numbers by taking $\lambda = 0.5$. So, it is possible to calculate the weight of the main criteria by using the average of rows.

Step 5: Normalize the above matrix and divide each element by the sum of the column entries (Eq. 2)

$$a_{ij \text{ normal}} = \frac{a_{ij}}{\sum_{i=1}^n a_{ij}} \quad (2)$$

Step 6: Rewrite the matrix with different values of α .

As shown in Tables 3 and 4, the significant pattern of the main factors and the sub-criteria is obtained. In order to

Tab. 3: The significant patterns of the main factors and the sub-criteria of managerial factor.

| A_1 | A_2 | A_3 | Alpha | A_1B_1 | A_1B_2 | A_1B_3 | Alpha |
|-------|-------|-------|-------|----------|----------|----------|-------|
| 0.489 | 0.240 | 0.270 | 0.1 | 0.477 | 0.255 | 0.267 | 0.1 |
| 0.492 | 0.237 | 0.269 | 0.3 | 0.485 | 0.252 | 0.262 | 0.3 |
| 0.494 | 0.236 | 0.269 | 0.5 | 0.491 | 0.250 | 0.258 | 0.5 |
| 0.495 | 0.235 | 0.268 | 0.7 | 0.495 | 0.235 | 0.268 | 0.7 |
| 0.496 | 0.236 | 0.267 | 0.9 | 0.498 | 0.248 | 0.252 | 0.9 |
| 0.496 | 0.236 | 0.266 | 1 | 0.499 | 0.248 | 0.251 | 1 |

Tab. 4: The significant patterns of the sub-criteria of organizational factor and financial factor.

| A_2B_1 | A_2B_2 | A_2B_3 | Alpha | A_3B_1 | A_3B_2 | A_3B_3 | Alpha |
|----------|----------|----------|-------|----------|----------|----------|-------|
| 0.343 | 0.344 | 0.311 | 0.1 | 0.301 | 0.321 | 0.377 | 0.1 |
| 0.343 | 0.346 | 0.310 | 0.3 | 0.298 | 0.322 | 0.379 | 0.2 |
| 0.342 | 0.348 | 0.308 | 0.5 | 0.296 | 0.322 | 0.380 | 0.3 |
| 0.342 | 0.349 | 0.308 | 0.7 | 0.295 | 0.322 | 0.382 | 0.4 |
| 0.341 | 0.352 | 0.306 | 0.9 | 0.294 | 0.321 | 0.383 | 0.5 |
| 0.341 | 0.353 | 0.305 | 1 | 0.293 | 0.321 | 0.385 | 0.6 |

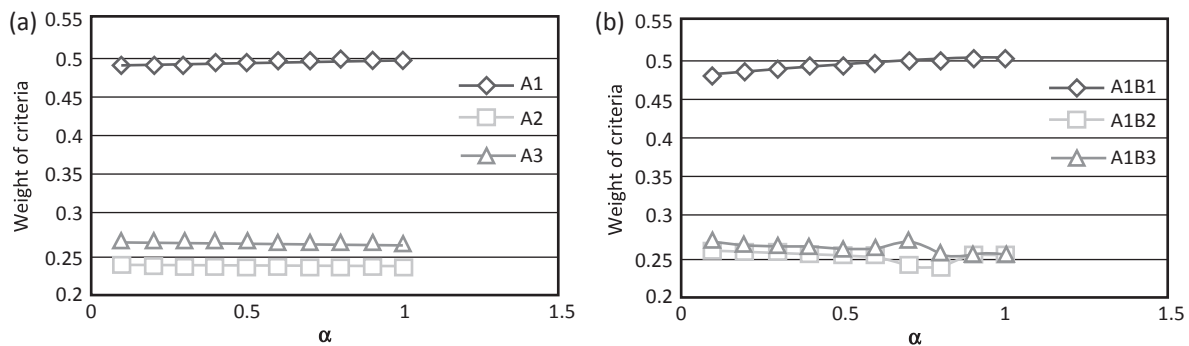


Fig. 4: Prioritization of main factors affecting the use of collaboration (a) and prioritizing the sub-criteria of managerial factor (b).

speed up the calculation process for a large number of collected questionnaires, a computer software (MATLAB) has been used.

4 Research findings

The fuzzy-AHP analysis [Fig. 4(a) and 4(b)] shows that the managerial factor aggravates other factors. Consequently, if these factors are improved, then the following derived factors such as organizational and financial factors will be facilitated. Combining these results, the prioritizations of the fuzzy-AHP method prove that managerial factors have the maximum impact on application of collaboration in Iran’s construction industry. The second challenge is structural factors, and the third one is summarized under financial factors in training and technical fields [Fig. 5(a) and 5(b)].

Using the positive results of collaboration in previous studies, we divided them into three main groups:

- A: complete the project up to the cost of contract
- B: maintain the agreed quality of the project
- C: complete the project up to the time of contract.

The final weight of each of these positive results of collaboration in a CSC by fuzzy-AHP is shown in Fig. 6.

Because achievement of goals is affected by the top manager’s policies, the first step for improving the managerial factor is management’s commitment to the goals. This change is the result of the recognition that changes in concepts require moving forward to a more collaborative approach. Concept changes involve changes in beliefs in the project and the organization environment. This aim would be possible only through the promotion of the cultural level of individuals. Organizational changes need change in the management field, including management commitment to the goals, manager’s trust in sharing the

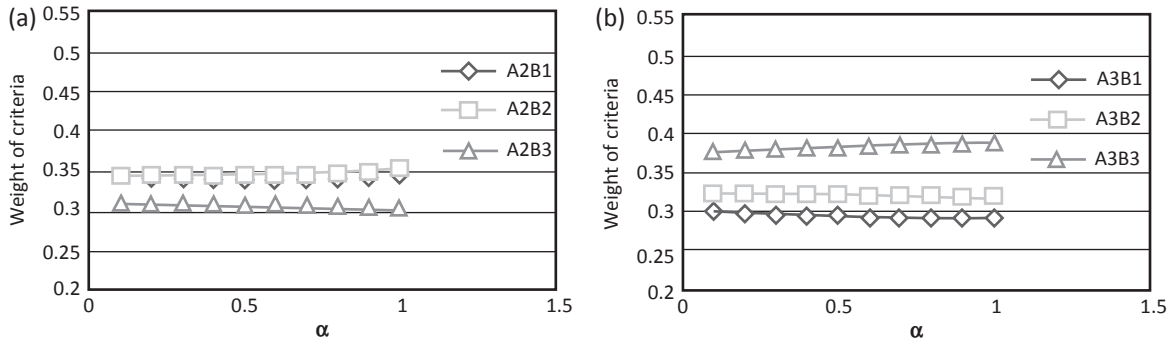


Fig. 5: Prioritizing the sub-criteria of structural factor (a) and prioritizing the sub-criteria of financial factor (b).

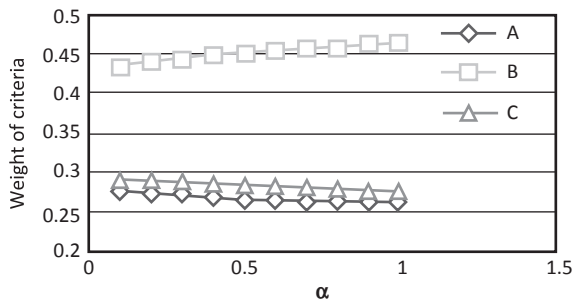


Fig. 6: Prioritization of the exceptive positive results from the use of collaboration.

information system, manager's justice and impartiality of communications with other members of the supply chain. So the leadership must demonstrate the required behaviours. Jointly working on developing project norms can also strengthen project norms (Ashcraft 2011). These recommendations guide the effective factors of collaboration. In the next stage, positive results are important. This result involves three fields, including cost, time and quality. By improving the quality of projects through partnering, there is a more competitive atmosphere that motivates organizations to look at collaboration as an appropriate way to cover their defects and shortages. In many projects, contractors and consultants do not have any prospective program for continuous collaboration and only focus on the project's short-term benefits. Therefore, modifying and editing some of the contractual provisions will pave the way for the adoption of integration and collaboration. Finally, in more collaborative systems, the CSC members themselves participate as a part of partnering.

5 Summary and conclusions

Collaboration between project partners – from the first idea of the project– is fundamental for sustainability

and any global optimization of a construction project. Without an efficient collaboration process, each partner is limited to optimization of efficiency only in his or her own field of responsibility. In this research, through an extensive literature review, a questionnaire for large contractor firms in the construction industry presented a conceptual framework for assessing the applicability of collaboration in the region. We have summarized the essential context for overall assessment in three categories, including managerial, financial and structural factors.

The fuzzy–AHP analysis shows that in Iranian construction projects, managerial factors are more important than other factors. Consequently, if these factors are improved, then the following factors such as financial and structural factors will be facilitated. Combining these results, the prioritization in the fuzzy–AHP method proves that managerial factors have the maximum impact on collaboration in Iran's CSC. The second challenge is financial factor and the third one is summarized in structural factors. Because collaboration is affected by the level of management, the first step for achieving this goal is managerial substructure reformation. This aim would be possible only through the promotion and strengthening of management commitment to the goals, followed by manager's trust in sharing the information system and manager's justice and impartiality of communications with other members. On the other hand, financial changes need implementation of innovative tools, updating of project information and frequent meetings to achieve better cooperation. The third step is structural change. This change is the result of the recognition of collaboration. Changes in concepts require moving forward to a more collaborative approach. Structural changes involve changes in culture of cooperation within the organization, experience of employees and the correct definition of the roles and responsibilities in the organization chart.

The results of this study improve our knowledge about the essential context of using collaboration in CSCs. The challenges that the construction industry has faced in recent years have led experts to use the collaboration network as an innovative approach for CSC. The main goal of the modern CSC can be stated to be the coordination and integration of all logistics activities.

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Appendix 1

Questionnaire: Supply chain collaboration within Iranian construction industry

The questionnaire used to identify and prioritize the factors affecting the use and understanding of the interaction between members of the supply chain of the construction industry chain probed the advantages of using interactivity in construction.

First Part:

1. Public Profile of Participant:

Age.....

Degree of Education.....

Company Rating.....

Work Experience.....

Position.....

Second Part:

In this part of the questionnaire, we write the main factors and sub-factors of collaboration in a construction supply chain. Please compare them. To what extent do you think that one of them is more important than another?

| Managerial | 9 | 7 | 5 | 3 | 1 | 3 | 5 | 7 | 9 | Managerial |
|---|---|---|---|---|---|---|---|---|---|---|
| Manager's trust in sharing the information system | | | | | | | | | | Manager's commitment to the goals |
| Manager's justice and impartiality of communications with other members of the supply chain | | | | | | | | | | Manager's trust in sharing the information system |
| Manager's commitment to the goals | | | | | | | | | | Manager's justice and impartiality of communications with other members of the supply chain |
| Structural | 9 | 7 | 5 | 3 | 1 | 3 | 5 | 7 | 9 | Structural |
| Knowledge, information and experience of employees | | | | | | | | | | Existence of the culture of collaboration within the organization |
| Correct definition of the roles and responsibilities in the organization chart | | | | | | | | | | Knowledge, information and experience of employees |
| Existence of the culture of collaboration within the organization | | | | | | | | | | Correct definition of the roles and responsibilities in the organization chart |

| Financial | 9 | 7 | 5 | 3 | 1 | 3 | 5 | 7 | 9 | Financial |
|--|---|---|---|---|---|---|---|---|---|--|
| Use of financial resources to control and update project information | | | | | | | | | | Spending money for use of updated information sharing system |
| Use of financial resources for training members (how to collaborate with each other) | | | | | | | | | | Use of financial resources to control and update project information |
| Spending money for use of updated information sharing system | | | | | | | | | | Use of financial resources for training members (how to collaborate with each other) |

Third Part:

In this part of the questionnaire, we write the positive results of using collaboration in the construction supply chain. Please compare them. To what extent do you think that one of them is more important than another?

| Positive results | 9 | 7 | 5 | 3 | 1 | 3 | 5 | 7 | 9 | Positive results |
|------------------|---|---|---|---|---|---|---|---|---|------------------|
| Higher Quality | | | | | | | | | | Lower Cost |
| Lower Time | | | | | | | | | | Higher Quality |
| Lower Cost | | | | | | | | | | Lower Time |