An analytical model of inter-organizational relationships in project environment: A social network perspective

Um modelo de análise das relações inter-organizacionais em ambiente de projeto: uma perspectiva de rede social

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Abstract

To fulfill a project, there are varieties of organizations cooperating as a supply chain. Being in large numbers and diversity, the supply chain may result in complexity and uncertainty in managing the projects; although it provides the required resources to achieve project objectives. The more a project faces complexity, the higher attention is required to effective management of its inter-organizational relationship model. In the following study, the structure of relations between organizations in two Iranian petrochemical projects is studied and compared. Modeling methods and analysis are based on Social Network Analysis (SNA). After modeling the network structure of each project, the inter-organizational relationships model are analyzed and compared to the ideal model of Iranian National Petrochemical Company (NPC) and the results are presented. Finally some areas for further research are also discussed.

Keywords: Project management, project supply chain, inter-organizational relationship, social network analysis.

Resumo

Para cumprir um projeto, existe uma variedade de organismos de cooperação como uma cadeia de abastecimento. Sendo em grande número e diversidade, a cadeia de abastecimento pode resultar em complexidade e incerteza na gestão dos projetos, embora ela forneça os recursos necessários para atingir os objetivos do projeto. Quanto mais o projeto enfrenta a complexidade, maior atenção é necessária para uma gestão eficaz do seu modelo de relacionamento inter-organizacional. No presente estudo, a estrutura das relações entre as organizações em dois projetos petroquímicos iranianos é estudada e comparada. Os métodos de modelagem e análise são baseados na Análise de Redes Sociais (SNA). Após a modelagem da estrutura de rede de cada projeto, o modelo de relações inter-organizacionais é analisado e comparado com o modelo ideal da Iranian National Petrochemical Company (NPC) e os resultados são apresentados. Finalmente, também são discutidas algumas novas áreas de investigação.

Palavras-chave: Gestão de projetos, cadeia de suprimentos do projeto, relacionamento inter-organizacional, análise de rede social.

1. Introduction

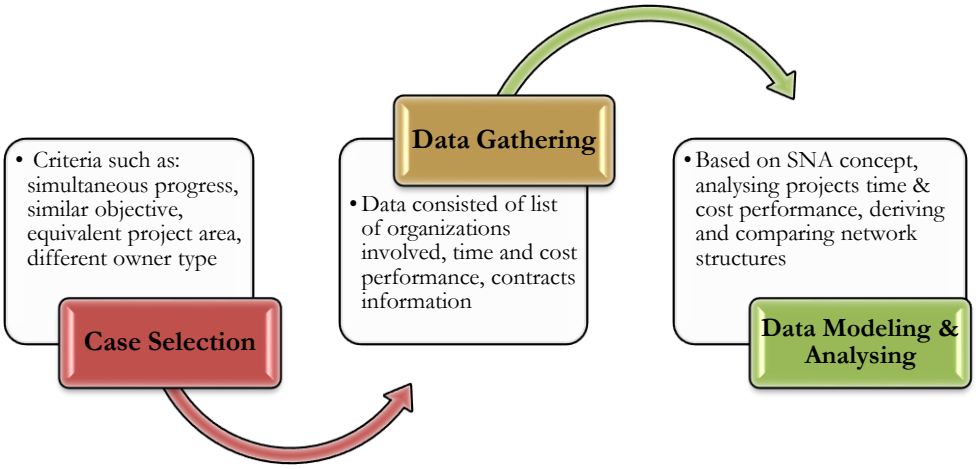
Nowadays, projects become an integral part of any business to handle the issues within organizations or creating the expected value for customers and stakeholders (Smyth & Pryke, 2008), (Walker & Rowlinson, 2008).To fulfill a project, there are varieties of individuals and organizations cooperating as a supply chain and creating the objected value, as in most cases the owner of a project has not sufficient resources and proficiency to do it solely(Fleming, 2003). Although diversity in a project's supply chain is necessary to achieve the objectives, it may result in complexity and uncertainty. Hence, achieving the project objectives may become a complete failure if relationships between involved organizations are not appropriately modeled and well-managed. The more complexity a project faces, the higher attention is required to effective management of inter-organizational relationships. The necessity of attention to project's supply chain and particularly the relationships between different organizations involved, have resulted to developing a new approach in project management entitled "relationship approach". In early project management approaches the primary focus is mostly on project itself, but the relationship approach put forward this issue that a project is designed, executed and managed by a network of individuals or organizations (Pryke & Smyth, 2006). As the result, the relationships between project supply chain or in a better word "project network" (of individual/ organizations) have a great impact on its efficiency and effectiveness as well as on the final value perceived by project stakeholders.

In this paper, the supply networks of two petrochemical projects are studied and modeled with the aim of deriving the pattern of relationships in each, comparing their structure to a presumed model and describing the impact of their network structure on their performance. Petrochemical projects are among the most complex projects which usually require the cooperation of a large number of organizations with different characteristics and proficiency. However reviewing the current literature on project management revealed that among various studies and papers concentrating on different dimensions of petrochemical projects, yet there is no specific work which focuses on their network structure and the way different organizations cooperate within the network.

The main contributions of this paper are: 1) studying the project supply chain from the "inter-organizational relationship" perspective which is an emerging project management approach and 2) focusing on petrochemical project's supply network which are among the most complex while neglected ones.

Figure 1 shows the steps of this research as well as the criteria, concepts and tools applied.

Figure 1 - The steps to conduct current research



The rest of the paper is organized as the following: after a brief introduction in first section, section 2 is focused on literature review by emphasizing on new perspectives in project management, section 3 discusses steps which are taken in this research as well as different derived models. The results of this study are presented in section 4, and section 5 finalizes the paper and introduces some areas for future research.

2. Literature review

In recent years the importance of project supply chain and its effective management is emphasized in academic areas. This focus results to emerging a new project management perspective called the "relationship management"which consider the project in a social context. The relationship approach emphasizes that as a project is the outcome of diverse individuals and organizations, the way they cooperate with each other has a significant impact on its overall performance and final delivery. Due to this fact, it is very important to effectively manage the relationships between different organizations constitute the project supply chain as well as other stakeholders.

There are various works and papers with focus on project supply chain from social perspective. Studying the current literature in this area reveal that most of the works are focused on construction industry ((London & Kenley, 2001), (Vrijhoef, Koskela, & Howell, 2001),(Akintoye, McIntosh, & Fitzgerald, 2000),(Dainty, Millett, & Briscoe, 2001), (Akintoye et al., 2000),(Briscoe & Dainty, 2005),(Chinowsky, Diekmann, & Galotti, 2008; Park, Jeong, & Han, 2009)) while other areas such as petrochemical projects are mostly neglected. In one hand, petrochemical projects are very complex and usually need huge investments; therefore it is vital to being performed in planned time, cost and quality. On the other hand, to perform this type of projects various organizations with different size and expertise are needed from engineering to commissioning and utilizing phases. As the result, effective management of SC co-operations is a major issue for the authorities. However, among the studies in this field there is no specific work which focuses on network structure and the way different organizations are cooperate within the network. As the result, this study focuses on identifying the structure of relationships in petrochemical projects networks.

In order to model and analyze supply networks, Social Network Analysis (SNA) is applied. SNA is an interdisciplinary area of research which focuses on a set of actors and relations between them which create a network. This methodology has a lot of different applications(Mueller, Buergelt, & Seidel-Lass, 2007) as it is flexible to define the actors from individuals to departments within an organization to organizations within a supply chain. SNA is based on graph theory and statistics and makes mathematical and graphical analysis possible(Knight & Ruddock, 2008). This methodology has recently become very popular in the area of project management too(Pryke & Smyth, 2006),(Smyth & Pryke, 2008).Some of primary concepts of SNA which are also considered in this study are summarized in Table 1.

Table 1 - A summary of social network analysis concepts and their definition(scott, 2000)

Concept	Definition
Actor	The nodes of a network which could be of a wide range from individuals to different organizations or countries.
Relation	The tie between actors in a network which can be of different types such as personal relations as well as formal relations between organizations or countries.
Centrality	Centrality shows the extent to which an actor is in the center of a network or reflects the degree of significance for each actor within a network

3. Methodology

To achieve the objectives of current study, a 3 step approach is applied as shown by Figure 1. In this section, the steps are discussed in more details.

3.1. Case selection

In the first step the cases to study were selected. As several and different petrochemical projects were in progress by Iranian National Petrochemical Company (NPC), some major criteria were considered to select between them. They are as the following:

1) Simultaneous progress
2) Similar objective (both project's objective was to implement petrochemical complex)
3) Equivalent project area
4) Different owner type (public vs. private)

With considering above criteria, several projects were studied and finally two projects were selected to perform the objected analysis. Table 2 summarizes the characteristics of each project.

Table 2 - Summary of two selected projects characteristics

Project Name	Project Area	Products	Project owner
A	15 ha	Methanol	Public sector
B	15.2ha	PVC, VCM	Private sector

3.2. Data gathering

After selecting the projects, some major data from each were gathered by means of studying related documents and several meeting and interviews with projects authorities. The type of data to be gathered should show the supply network overall structure as well as the project performance. Hence, the following data were collected from each project:

- List of organizations contributing in projects supply chains
- The role of each organization in projects supply chains
- Projects time and cost performance as shown by Table 3, Table 4, Table 5 and Table 6.

Table 3 - Time performance of Project A

	Difference between planned finish and actual finish	Difference between planned start and actual start
Engineering	153 days	95 Days
Procurement	580 days	120 Days
Construction and commissioning	365 days	110 Day
Total project	365 days	95 Days

Table 4 - Cost performance of Project A

	Cost variance
Engineering	5.7%
Procurement	29.9%
Construction and commissioning	41%
Total project	30%

Figure 2: The contract network structure of project A

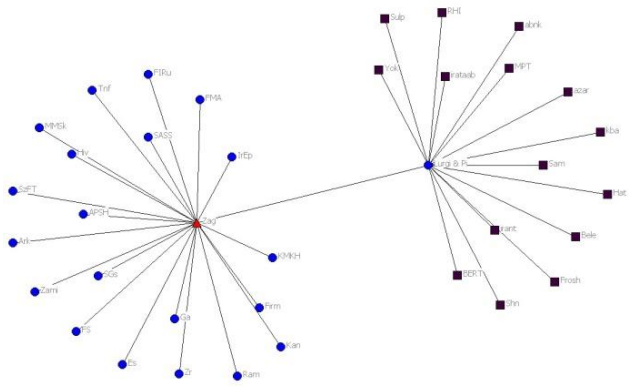


Table 5 - Time performance of Project B

	Difference between planned finish and actual finish	Difference between planned start and actual start
Engineering	390 days	243 days
Procurement	395 days	0
Construction and commissioning	365 days	341 days
Total project	365 days	243 days

Table 6 - Cost performance of Project B

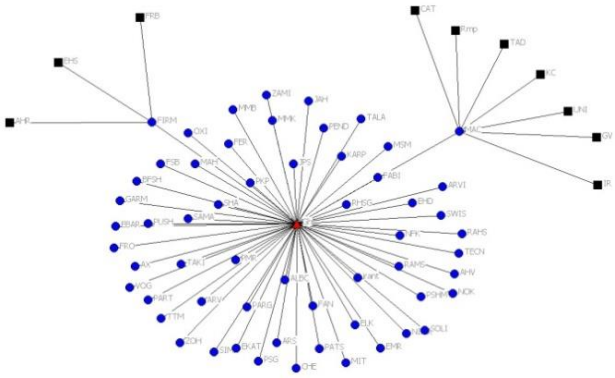
	Cost variance
Engineering	4.4 %
Procurement	37.29 %
Construction and commissioning	22.85 %
Total project	64.54 %

3.3. Data modeling and analysing

In order to model the projects networks, the organizations involved were considered as actors and the formal contracts between them considered as network links. The resulted contract network of each projects are drawn by Net-Draw and are shown in Figure 2 and Figure 3.

In these figures the red triangle symbolizes the project owner while blue circles and black are organizations involved in project, in a way that the former resembles organizations with direct contract with the owner while the owners and the latter are indirectly related.

Figure 3: The contract network structure of project B



Having modeled the contract network, in the next step the role of each actor in this network was analyzed. The analysis revealed that the major roles in the networks could be categorized as the following:

Vi: Vendors

Si: Suppliers which work based on order to make

Ei: Engineering consultants

Ci: Organizations responsible for construction and commissioning

MC: Management Contractor

EP: Organization responsible for engineering phase while managing vendors and suppliers too

By considering the above categories the structure of under-studied projects isidentified as depicted in Figure 4 and Figure 5.

Figure 4: The structure model of Project A

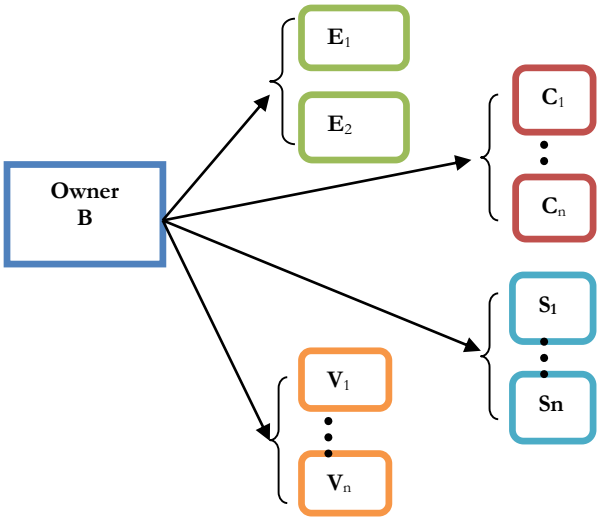
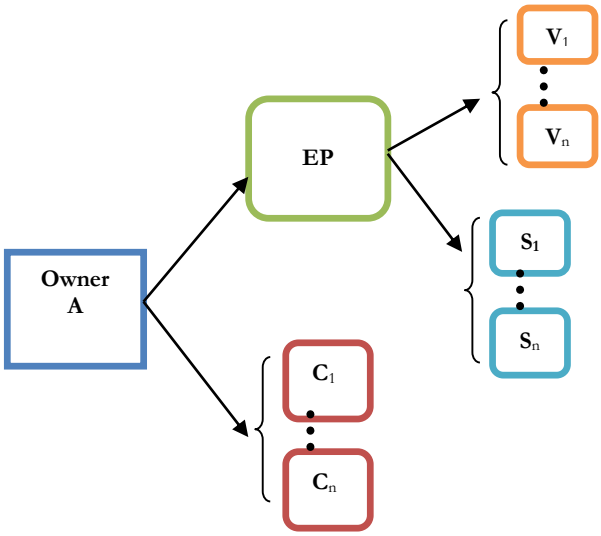
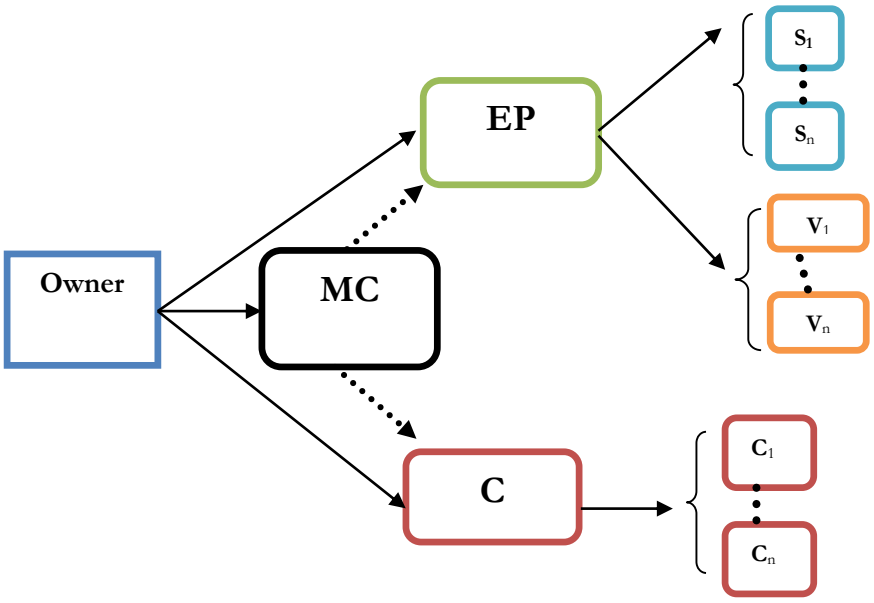


Figure 5: The structure model of Project B



In the next step, the standard structure recommended by NPC was also investigated as a basis for better analysis. This structure is shown by Figure 6.

Figure 6 - The recommended structure of NPC



And finally some particular analyses were done by means of popular SNA software called UCINET v.6 to derive networks characteristics and statistics as shown by table7 and table8.

4. Main results

4.1. Lack of empowerment

Studying the project networks showed that in both projects the centrality of project owner were higher than other organizations, (A: 0.583, B: 0.853 according to Table 7 and Table 8) which reflects that the owners did not empower to other organizations. This made the whole network highly depended on their owners which may results to some difficulties if the owner has not enough experience and proficiency in performing the project or if some internal problems emerge. This fact was shown in performance of project B where several changes in top management results to low performance of project in it lifecycle regarding time and cost.

4.2. Not trusting management contractors

Comparing to standard structure recommended by NPC (Figure 6), in both understudied projects the role of management contractor is neglected. As the management contractors act as an interface between project owners and other organizations, in many cases they limit the authorities of owners. However, this transfer some of project risks from owner to another organization and the owner would be able to focus on responsibilities other than executing the projects such as marketing and strategic planning. But not using management contractors in both projects may have some reasons such as the general culture of not trusting management contractors or lack of qualified organizations for acting this role in this industry.

Table 7 - Multiple centrality measures project A

Treat data as: Undirected
Type of scores to output: Normalized Centrality Measures

Organization	Degree	BonPwr	2Step	ARD	Eigenve	Between
. 1	0.583	23.485	1.000	0.792	0.898	0.810
. 2	0.028	2.986	0.444	0.421	0.114	0.000
. 3	0.028	2.986	0.444	0.421	0.114	0.000
. 4	0.028	2.986	0.444	0.421	0.114	0.000
. 5	0.028	2.986	0.444	0.421	0.114	0.000
. 6	0.028	2.986	0.444	0.421	0.114	0.000
. 7	0.028	2.986	0.444	0.421	0.114	0.000
. 8	0.028	2.986	0.444	0.421	0.114	0.000
. 9	0.028	2.986	0.444	0.421	0.114	0.000
. 10	0.028	2.986	0.444	0.421	0.114	0.000
. 11	0.028	2.986	0.444	0.421	0.114	0.000
. 12	0.028	2.986	0.444	0.421	0.114	0.000
. 13	0.028	2.986	0.444	0.421	0.114	0.000
. 14	0.028	2.986	0.444	0.421	0.114	0.000
. 15	0.028	2.986	0.444	0.421	0.114	0.000
. 16	0.028	2.986	0.444	0.421	0.114	0.000
. 17	0.444	14.324	1.000	0.722	0.544	0.667
. 18	0.028	4.891	0.583	0.444	0.188	0.000
. 19	0.028	4.891	0.583	0.444	0.188	0.000
. 20	0.028	4.891	0.583	0.444	0.188	0.000
. 21	0.028	4.891	0.583	0.444	0.188	0.000
. 22	0.028	4.891	0.583	0.444	0.188	0.000
. 23	0.028	4.891	0.583	0.444	0.188	0.000
. 24	0.028	4.891	0.583	0.444	0.188	0.000
. 25	0.028	4.891	0.583	0.444	0.188	0.000
. 26	0.028	4.891	0.583	0.444	0.188	0.000
. 27	0.028	4.891	0.583	0.444	0.188	0.000
. 28	0.028	4.891	0.583	0.444	0.188	0.000
. 29	0.028	4.891	0.583	0.444	0.188	0.000
. 30	0.028	4.891	0.583	0.444	0.188	0.000
. 31	0.028	4.891	0.583	0.444	0.188	0.000
. 32	0.028	4.891	0.583	0.444	0.188	0.000
. 33	0.028	4.891	0.583	0.444	0.188	0.000
. 34	0.028	4.891	0.583	0.444	0.188	0.000
. 35	0.028	4.891	0.583	0.444	0.188	0.000
. 36	0.028	4.891	0.583	0.444	0.188	0.000
. 37	0.028	4.891	0.583	0.444	0.188	0.000

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Table 8 - Multiple centrality measures project B

Treat data as: Undirected; Type of scores to output: Normalized Centrality Measures

Organization	Degree	BonPwr	2Step	ARD	Eigenve	Between
.1	0.853	48.789	1.000	0.926	0.998	0.985
.2	0.015	6.371	0.853	0.483	0.131	0.000
.3	0.015	6.371	0.853	0.483	0.131	0.000
.4	0.015	6.371	0.853	0.483	0.131	0.000
.5	0.015	6.371	0.853	0.483	0.131	0.000
.6	0.015	6.371	0.853	0.483	0.131	0.000
.7	0.015	6.371	0.853	0.483	0.131	0.000
.8	0.015	6.371	0.853	0.483	0.131	
.9	0.015	6.371	0.853	0.483	0.131	
.10	0.015	6.371	0.853	0.483	0.131	
.11	0.015	6.371	0.853	0.483	0.131	0.000
.12	0.015	6.371	0.853	0.483	0.131	0.000
.13	0.015	6.371	0.853	0.483	0.131	0.000
.14	0.015	6.371	0.853	0.483	0.131	0.000
.15	0.015	6.371	0.853	0.483	0.131	0.000
.16	0.015	6.371	0.853	0.483	0.131	0.000
.17	0.015	6.371	0.853	0.483	0.131	0.000
.18	0.015	6.371	0.853	0.483	0.131	0.000
.19	0.015	6.371	0.853	0.483	0.131	0.000
.20	0.015	6.371	0.853	0.483	0.131	0.000
.21	0.015	6.371	0.853	0.483	0.131	0.000
.22	0.015	6.371	0.853	0.483	0.131	0.000
.23	0.015	6.371	0.853	0.483	0.131	0.000
.24	0.015	6.371	0.853	0.483	0.131	0.000
.25	0.015	6.371	0.853	0.483	0.131	0.000
.26	0.015	6.371	0.853	0.483	0.131	0.000
.27	0.118	7.298	0.956	0.551	0.149	0.197
.28	0.015	6.371	0.853	0.483	0.131	0.000
.29	0.015	6.371	0.853	0.483	0.131	0.000
.30	0.015	6.371	0.853	0.483	0.131	0.000
.31	0.015	6.371	0.853	0.483	0.131	0.000
.32	0.015	6.371	0.853	0.483	0.131	0.000
.33	0.015	6.371	0.853	0.483	0.131	0.000
.34	0.015	6.371	0.853	0.483	0.131	0.000
.35	0.015	6.371	0.853	0.483	0.131	0.000
.36	0.015	6.371	0.853	0.483	0.131	0.000
.37	0.015	6.371	0.853	0.483	0.131	0.000
.38	0.015	6.371	0.853	0.483	0.131	0.000
.39	0.015	6.371	0.853	0.483	0.131	0.000

Organization	Degree	BonPwr	2Step	ARD	Eigenve	Between
.40	0.015	6.371	0.853	0.483	0.131	0.000
.41	0.015	6.371	0.853	0.483	0.131	0.000
.42	0.015	6.371	0.853	0.483	0.131	0.000
.43	0.015	6.371	0.853	0.483	0.131	0.000
.44	0.015	6.371	0.853	0.483	0.131	0.000
.45	0.015	6.371	0.853	0.483	0.131	0.000
.46	0.015	6.371	0.853	0.483	0.131	0.000
.47	0.015	6.371	0.853	0.483	0.131	0.000
.48	0.015	6.371	0.853	0.483	0.131	0.000
.49	0.015	6.371	0.853	0.483	0.131	
.50	0.015	6.371	0.853	0.483	0.131	0.000
.51	0.015	6.371	0.853	0.483	0.131	0.000
.52	0.015	6.371	0.853	0.483	0.131	0.000
.53	0.015	6.371	0.853	0.483	0.131	0.000
.54	0.015	6.371	0.853	0.483	0.131	0.000
.55	0.059	6.740	0.897	0.512	0.138	0.087
.56	0.015	6.371	0.853	0.483	0.131	0.000
.57	0.015	6.371	0.853	0.483	0.131	0.000
.58	0.015	6.371	0.853	0.483	0.131	0.000
.59	0.015	6.371	0.853	0.483	0.131	0.000
.60	0.015	0.959	0.118	0.357	0.020	0.000
.61	0.015	0.959	0.118	0.357	0.020	0.000
.62	0.015	0.959	0.118	0.357	0.020	
.63	0.015	0.959	0.118	0.357	0.020	
.64	0.015	0.959	0.118	0.357	0.020	0.000
.65	0.015	0.959	0.118	0.357	0.020	
.66	0.015	0.959	0.118	0.357	0.020	
.67	0.015	0.886	0.059	0.342	0.018	
.68	0.015	0.886	0.059	0.342	0.018	0.000
.69	0.015	0.886	0.059	0.342	0.018	0.000

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Principal Eigenvalue was: 7.62830917282679

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4.3. Not using leader organizations

The lack of empowerment to other organizations is also clear in other activities of projects in both networks. Regarding the recommended structure by NPC, it is suggested that in every area of project execution such as procurement and construction a specialized organization act as leader. This leader may direct sub organizations to fulfill project needs. But studying the understudied projects showed that they tend to centralize most of the activities. However, the centralization tendency is higher in project A as this project is a public one and project B was done by a private owner.

5. Conclusion

In this study the supply networks of two Iranian petrochemical projects were studied and the results were discussed. It should be noted that the aim of this study is to

show and report the co-operation structure in selected projects in order to give a better understanding of projects supply networks and prescribing the optimized model of supply networks in petrochemical projects are not within its objectives. The results of this study are useful to academics, petrochemical authorities and organizations involved in this industry. Academically, this study could be considered as a basis for further research in the area of project network analysis as this issue is an emerging approach in the area of project management and particularly in petrochemical projects. In this study, contracts are used as links between network actors, but contract relationships are not the only relation between the organizations, and there are other relations such as financial transactions, information flows etc. Modeling and studying these networks would show beneficial information about project networks. Apart from considering organizations as network actors, the network between individuals could be defined in future studies and some relations such as trust and social affiliation could be studied to have a broader view of project network. From managerial perspective, this study shows lack of empowerment as well as lack of trust on management contractors which requires more managerial concentration and planning to change the current culture while training qualified organizations to take the required responsibilities.

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