Doctoral Thesis

Productive Relationships among Subcontract Teams in Construction Supply Chain

submitted in satisfaction of the requirements for the degree of
Doctor of Science in Civil Engineering
of the Vienna University of Technology, Faculty of Civil Engineering

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Dissertation

Produktive Beziehungen von Subunternehmern in der Versorgungskette von Bauprojekten

ausgeführt zum Zwecke der Erlangung des akademischen Grades eines
Doktors der technischen Wissenschaft
eingereicht an der Technischen Universität Wien Fakultät für
Bauingenieurwesen
von

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Wien, Februar 2011

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Acknowledgements

First of all I pay my gratitude to my supervisor Prof. Dr. Hans Georg JODL for his continuous support and encouragement throughout my doctorate studies. He has always been very kind in providing time for discussions related to my research work. I am also thankful of Prof. Dr. Alfred Taudes for his instructions and guidance in my research work. I feel honored, having carried out my studies under their invaluable guidance.

I also wish to express my thanks to “Institute of Interdisciplinary construction process management” for providing me office and allowing me to use other facilities of the institute. In addition, I wish to express my sincere appreciation to institute secretaries Gabriele VRBATKA, Waltraud WEIGEL and all Assistants in the institute for their help and cooperation during my four years study period.

I greatly acknowledge the financial support from Higher Education Commission of Pakistan through a scholarship under their scheme “Overseas Scholarship for PhD in Selected fields”. I also acknowledge partial financial support from “Institute of Interdisciplinary construction process management” in form of books and stationary. I am also thankful to Austrian Exchange Service (ÖAD) for their services in financial matters related to transfer of my scholarship. I also thank to my younger brother Irfan for his help in managing the matters on my behalf back in Pakistan.

I strongly admire the public facilities provided by city government of Vienna. Especially the children’s free school, subsidized children day care and health facilities. Public transport system in Vienna is also very efficient and comfortable which saved a lot of time during my daily traveling.

Finally and most importantly, I dedicate this dissertation to my family for their cooperation and support; especially to my loving wife Aisha for her encouragement and care. In spite of her own doctorate studies she always sacrificed her time for her family. I always enjoyed delicious meals cooked by

her. My children Haris and Sabrina were also source of motivation and relaxation for me. I really enjoyed weekend outings with them and their occasional activities in school and day care centre.

Vienna, February 2011 Rizwan NAZIR

Abstract

Construction industry contains many small and medium sized companies which depend on one another in a construction project. The practice of subcontracting is common in the construction industry; it has been observed that a major portion of any construction project is handed over to subcontractors by the main contractor. Subcontractors have to work simultaneously with other subcontractors during a construction project but real cooperative behavior among them is rare. The main contractor mainly acts as team leader or project manager of these subcontractors. Generally clients and developers consider big contractors, very important stakeholders in construction projects. Very little focus is paid to subcontractors and supplier which overall execute major portion of the project and they are the important part of construction supply chain. A problem which commonly arises in construction projects is that these subcontractors are contractually bound to the main contractor and not to one another while the construction process flows from one subcontractor to the other. Therefore it is necessary that these partner organizations have cooperative relationships with one another. These cooperative relationships will certainly prove very beneficial not only for these partner organizations but also for the main contractor and the client, whenever they will work together. The main focus of this study is Pakistan construction industry. In Pakistan construction industry, lack of cooperation is generally observed among participants, in construction projects.

In this thesis, previous literature has been reviewed to identify the necessity and nature of cooperation among subcontractors in the construction industry. An out come of a survey is also discussed. The survey was carried out in form of interviews/questionnaires among contractors and subcontractors working in construction industry of Pakistan. The purpose of survey was to investigate the relationships among main contractors and subcontractors. Development of suggestions to create cooperation among these parties during construction projects was also the aim of this survey.

In order to explore conditions for cooperation in construction supply chain, analytical modeling is carried out with the help of game theory. Game theory is an interesting process for analysis of competitive situations. The result of this analysis provides fundamental suggestions for cooperation among construction supply chain members.

In view of the literature research, survey findings and analytical modeling, a strategic model has been developed. Recommendations have been suggested in strategic model to achieve better coordination among different partners in construction projects.

Due to the increased role of subcontractors in construction projects, provision of balanced subcontract conditions have become very important. Subcontract conditions have been reformed and introduced in construction industry all over the world. Keeping in view the contract laws in Pakistan construction industry, standard subcontract conditions have been developed. These fundamental subcontract conditions will helpful in preparation of a balanced subcontract for any organization.

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Chapter 1
Introduction

Supply chain management is playing an important role in manufacturing and other consumer product industries so construction industry also can get benefits from it. The concept to lean construction also reveals the importance of management in such a way that the adverse factors should always try to be minimized. Due to the increased role of subcontracting in construction industry it will be beneficial if these different companies are kept in such an atmosphere of teamwork where they can produce maximum output. With the help of this integration certain problems can be avoided or reduced for example problems like delays, litigation, disputes at site, win-loose results and low quality.

The construction industry is different from the manufacturing industry in which repetitive processes take place while in the construction industry outputs vary in kind and scale. Each product has its own design and a unique process of construction. The construction process involves activities which overlap and interrupt one another. However, a large number of suppliers and sub-contractors are normally involved in construction projects, as it is the case in the manufacturing industry. Due to the nature of construction projects the activities of these subcontractors (SCs) overlap with respect to time and space.

Generally the construction industry contains sectors which are very diverse and comparatively very unstable too. The demands are very diverse and fluctuate, vary from project to project. Construction material production conditions remain uncertain. Wide rang of machinery, skills and specialists mostly required in short term project environment. Recently the increasing trend of subcontracting has increased the fragmentation in the construction industry [Dainty R.J. Andrew *et al*. (2001, vol.6)].

One prominent characteristic of the construction industry is the practice of subletting portions of a project to specialized subcontractors by a main

contractor (MC). As much as 75-80 % of the gross work done in the construction industry involves the purchasing of material and subcontracting services, when only considering new construction of large and complex facilities [Eriksson Erik *et al.* (2007)][Mathews Jasor *et al.* (2000)]. However, in spite of the subcontractor's large share of services, main contractors remain relatively unconcerned in their approach to them [Eriksson Erik *et al.* (2007)].

In the contract conditions like FIDIC red book and also in mostly public sector organizations it is mentioned that subcontractors should be nominated earlier or they should be engaged after the approval of client. But it has been observed that generally major portion of a construction activity is outsourced and main contractor usually claim it as its temporarily hired staff. One should accept this reality that in modern construction main contractor cannot provide all types of specialties and machinery by its own. Main contractor have to out source certain tasks to other specialists.

Subcontractors play a vital role in the construction industry. They are special contractors who are hired to perform specific tasks on a project. In spite of their vital role little is known about the actual terms of the working relationship that exists between subcontractors and the main contractor [Hinze Jimmie, Tracey Andrew (1994)]. A main contractor generally relies on a large number and variety of subcontractors while he tends to focus on management and coordination. To make matters worse, large numbers of the subcontracting firms are small and a pyramid structure of subcontractors is formed because of the multiple tiers of subcontractors. In Australia, for example, 94% of construction trades employ fewer than five people, and less than 1 per cent employs more than 20 people [Karim Khalid *et al.* (2006)]. As a consequence, most of these companies simply do not have the resources to adopt modern principles of quality management although their smaller size does provide them the flexibility to be able to adopt innovative methods. Further complications arise because the subcontractors are legally obligated to the main contractor, whereas the construction process flows from one subcontractor to the other [Karim Khalid *et al.* (2006)], as shown in Figure1.1. Some sort of coordination among subcontractors is beneficial for the project.

Cooperative relationships among subcontractors will certainly be productive for these partnering organizations and also for the client, whenever they will work together.

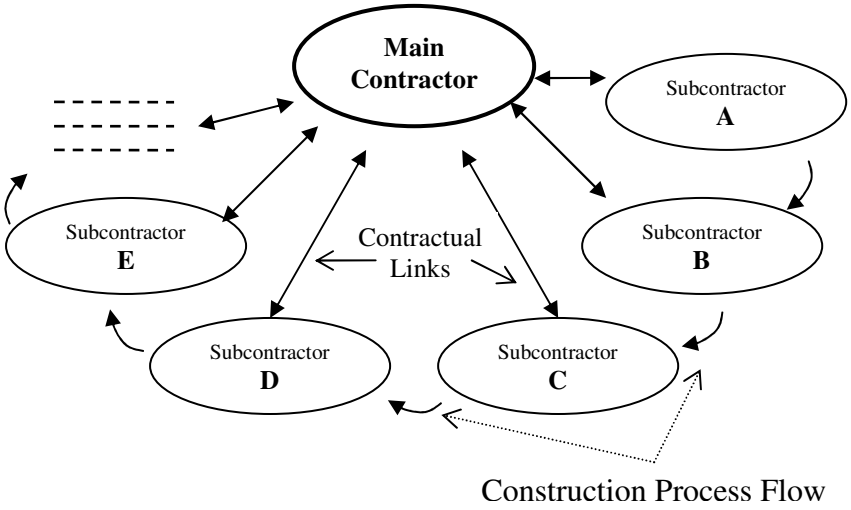


Figure 1.1 Contradiction between formal links and construction process flow

It is observed that major proportion of problems occur in that part of supply chain which consists of subcontractors and suppliers. Generally problems occur between main contractor & subcontractor and between subcontractor & subcontractor. Therefore in order to get full benefits of supply chain management, this portion should be focused for better supply chain management practices.

Figure1.2 shows the structure of a general supply chain of a construction project. It shows why it is important for main contractor to manage efficient links among subcontractors and suppliers in order to achieve good progress. The figure also gives an idea about how different parties are involved and depend on one another. The figure shows that the main contractor generally has some suppliers and also outsources different activities of project to subcontractors. These subcontractors may further have their own subcontractors and suppliers. In this way a multi layered structure is formed which includes different types of small and medium scale enterprises (SMEs).

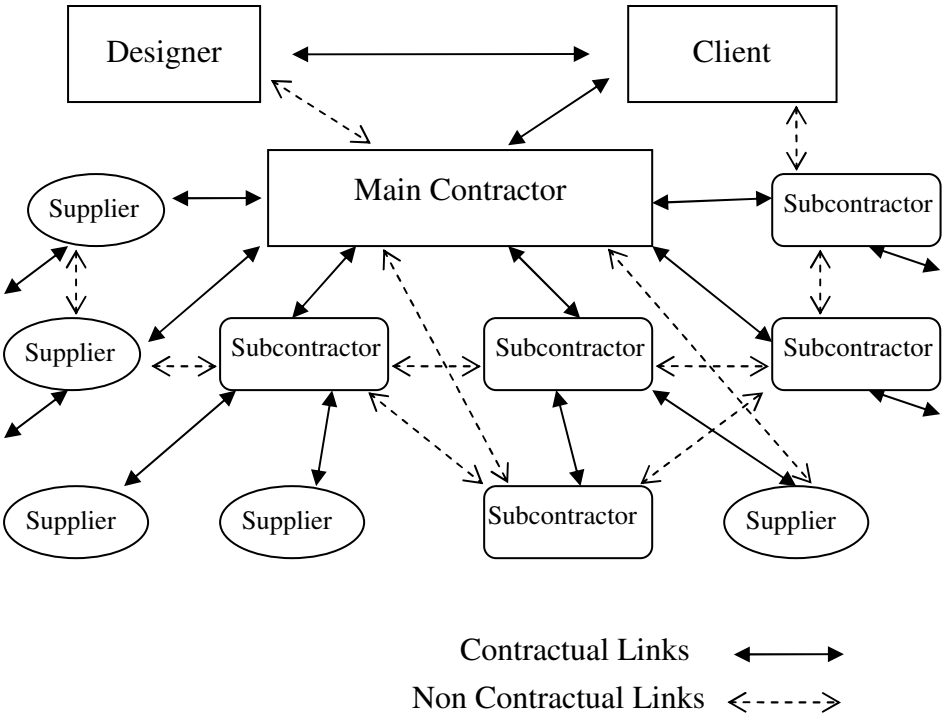


Figure 1.2: Links among different parties in a construction supply chain.

The links among these supply chain members can be divided in two categories. Contractual (vertical) links and non contractual (horizontal) links as shown in figure 1.2.

Supply chain management or supply chain integration in construction industry requires better relationships at different critical project interfaces such as client-contractor, consultant-contractor, contractor-subcontractor, and subcontractor-subcontractor. These interfaces of mutual relationships need to be explored to identify the barriers in supply chain management. In this study we will discuss the supply chain relationships among contractor-subcontractor and subcontractor-subcontractor. To keep a balance at each of above described interface, there should be proper contract conditions at each interface. As shown in figure 1.2 that supply chain member also have non contractual links therefore contract conditions are not enough. There should also be proper cooperative atmosphere through managerial practices.

In order to increase the subcontractors' contributions to innovation and value creation the actors should adopt a long-term perspective and actively work to establish an innovation-friendly climate [Eriksson Erik *et al.* (2007)]. In the construction industry, main contractors and subcontractors need to improve their performance in terms of quality, service and cost [Errasti Andre *et al.* (2007)]. As a consequence, increasing numbers of organizations are taking a critical look at their supply chain to gain the improvements they require. These facts raise the importance of the supply chain strategy in this sector. In the construction industry, there is always pressure upon subcontractors about the quality and they cannot afford high cost to achieve the required standards. To respond to these challenges subcontractors need to work in harmony with their partners.

The participation of different parties in the same project is one of the reasons for the unfavorable construction project outcomes (lack behind the schedule, cost overrun, defects and low quality). These parties are linked with one another due to the nature of construction process but contractually they are not bound with one another. They are generally independent organizations with different origins, objectives, management style, equipments and working techniques.

Therefore the subcontractors need to develop some kind of relationships with one another which will prove beneficial whenever they work together. The role of main contractor is important in this regard. Main contractor is overall administrator of construction site and responsible of selecting subcontractors and suppliers therefore its active involvement is necessary to make an efficient supply chain. Since the tasks of subcontractors are interrelated due to the nature of the construction industry therefore better coordination among subcontractors will increase the quality and speed of construction. In this way these developed coordination and relationships will certainly prove to be beneficial not only for theses subcontractors whenever they will work together but also for the main contractor and client.

Traditionally all the emphasis was on main contract and subcontract is considered as a mutual matter between main contractor and subcontractor.

However the surveys and studies about disputes and problems in construction industry show that the contractual relation between main contractor and subcontractor needs more attention. There is a need to develop balance subcontract conditions in order to reduce problems between main contractor & subcontractor and also between subcontractor and its subcontractor or supplier. The disputes related to subcontractors needs rapid resolution to maintain flow of funds and avoid interruptions in construction activities. Subcontractors being financially weak parties cannot work properly if their payments are pending for a long time due to disputes. Also it is unfair if balance of power is in favor of main contractor. Balance contract condition between financial strong main contractors and relatively weaker subcontractors can reduce the problems due to disputes.

When we talk about reducing problems and creating productive relationships among subcontractors in construction industry, then we have two major approaches to achieve this. One is contractual approach, it means by necessary reforms in contract conditions and legal system of construction industry. The other is through relationship management in order to improve horizontal relations in construction supply chain. In this study efforts in both of these directions have been carried out. Game theory is an important branch of mathematics in analysis of competitive situations. So analyses are also carried out with the help of game theory to explore the fundamental condition of cooperation among construction project teams.

Briefly the objective of this research is to generate information and guidelines in form of recommendations which facilitate in achieving cooperative and productive relationships in the operational stage of construction projects.

Chapter 2

Research objectives, Methodology and Structure

2.1 Research Objectives

The main objective of this study is to investigate how different construction firms involved in construction projects can reduce mutual problems due to non-cooperative behaviors. This will increase the quality and productivity of their out put. To achieve this objective main focus (in this study) is on improving their relationships by adapting managerial practices and also by creating balanced contractual and non-contractual conditions.

In this study the following aspects will be studied, observed and discussed in order to achieve the objectives.

1. Observe the structure of Supply Chain in construction projects.
2. Find out the nature of subcontractor's role in construction industry and their relationships with other supply chain members.
3. Study the nature of partnerships and alliances among supply chain members especially the subcontractors, in construction industry.
4. Identify the causes of poor relationships among subcontractors and also between main contractor and subcontractors.
5. Analyses of problems in construction projects especially the disputes among parties involved in construction projects.
6. Find out basic conditions for cooperation by analytical analyses with the help of "game theory"
7. Identify conditions to get better relationships among construction parties which may be beneficial for all construction supply chain members.
8. Discussion and analysis of current subcontract conditions and related reforms in view of reducing dispute and problems related to subcontractors.
9. Draw conclusions and suggesting recommendations for supply chain integration in construction industry.

2.2 Research Methodology

The study mainly consists of a literature review of previous related studies and related surveys, study of contract documents used in Pakistan construction industry and used internationally, Data collection (by interviews and questionnaire survey) from contractors and officials working in Pakistan construction industry and also international construction industries, data analysis and analytical modeling by game theory.

In order to get empirical data of the views of contractors and subcontractors working in construction industry a survey is carried out in Pakistan construction industry. Two separate questionnaires were prepared for contractors and subcontractors. The types of queries in both the questionnaires were same but the questions were described differently in some cases.

Other than the empirical data, basic cooperation conditions are also studied by cooperation theories. Robert Axelrod's famous competition [Axelrod Robert, 1984] for the game called "iterated prisoner's dilemma" is explored. Similar analyses are carried out for a simple construction project team.

Conclusions are drawn and recommendations are suggested in view of the reviewed literature, analytical and empirical research, which can be helpful to minimize problems related to subcontracting in construction industry.

2.3 Contents

Brief description of the parts and chapters of thesis

Part	*Chapter*	*Description*
	1 & 2	Introduction and structure of the thesis
Part 1	3,4,5,6,7&8	Review of related literature, presentation of theories and models
Part 2	9,10,11,12&13	Empirical studies and discussions of results
Part 3	14,15 &16	Analytical analyses with the help of "game theory"

Part 4	17,18,19,20&21	Recommendations and Conclusions: Recommendations in form of a Strategic Model and proposed basic subcontract conditions. Overall conclusions.

2.4 Definitions and Abbreviations

In this thesis the following definitions and abbreviations are used:

Main Contractor (MC):
Organization responsible to finally hand over the completed project to its client and it is customer of subcontractors.

Subcontractor (SC):
Organization engaged by main contractor to carry out activity/s of a construction project.

Contractor:
It refers to any firm participating in construction of a project. It may be a main contractor or subcontractor.

Subcontracting:
It is process of outsourcing activities of a project by its contractor to other independent organizations.

Supply Chain:
It is flow of material, equipments, services and information through different activities by different organizations in a construction project, from its conceptual stage to final finished form.

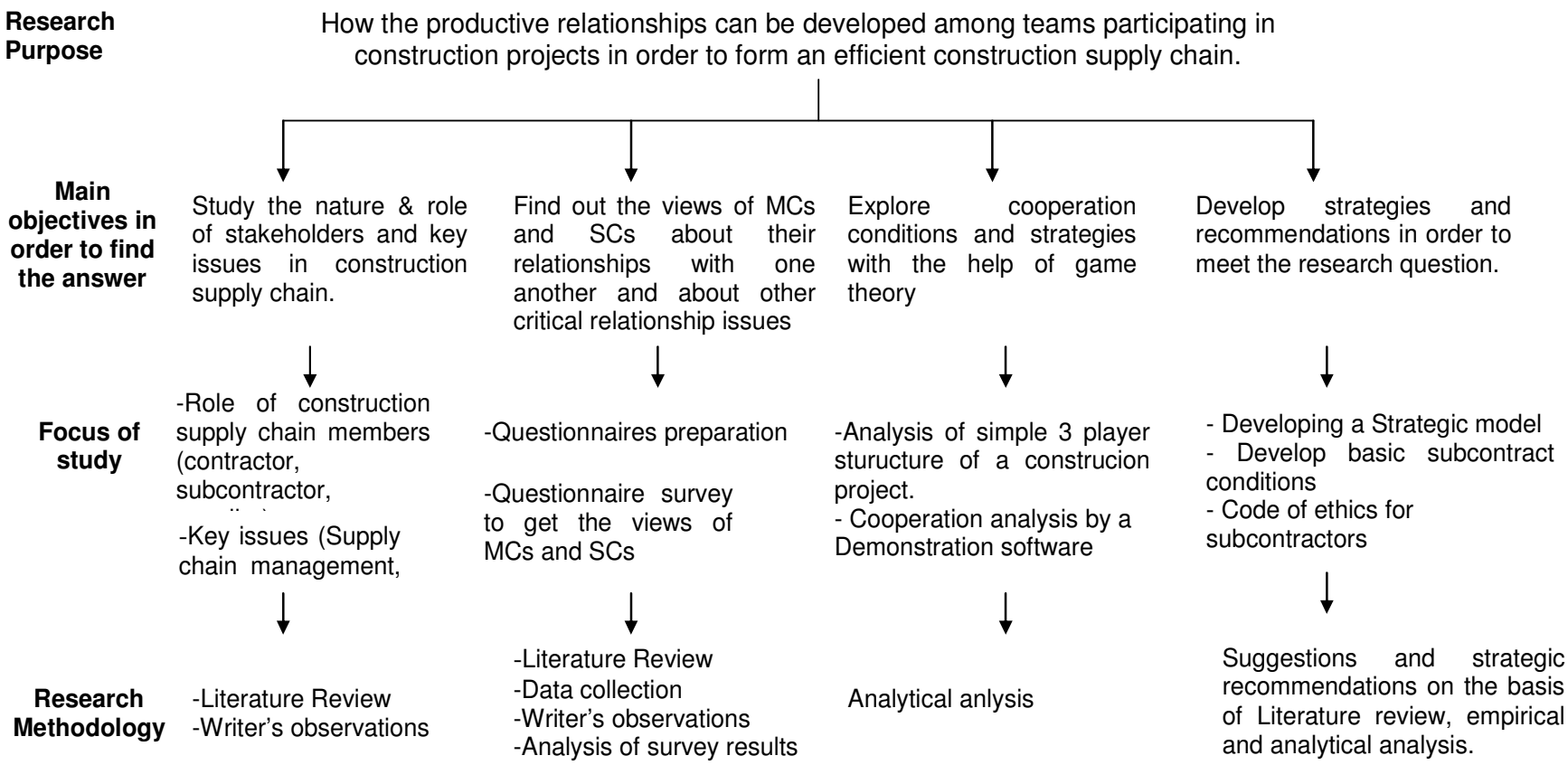
Supply Chain Management (SCM) or Supply Chain Integration:
It is the integration of different activities, involved in supply chain by improving the relationships and management techniques in order to achieve better results.

Subcontracting Chain:
It is a part of supply chain consisting of subcontractors and suppliers.

Sub-subcontractor:
If a subcontractor further outsources any work to another firm then this firm will be sub-subcontractor. In this study the sub-subcontractors are also described as subcontractors.

2.5 Research Description

The following structure gives a quick description about this thesis.



Part 1
Literature Review, Theories and Models

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Chapter 3
Construction Supply Chain

3.1 Introduction

Since different organizations generally involve in a construction project, therefore construction supply chain is a network of relationship among these partner organizations. In Construction projects these organizations include Client, Designer, Consultant, Main contractor, Subcontractors and Suppliers. The relationships among these include flow of materials, products, services, funds and information [Xue Xiaolong *et al.* (2005)].

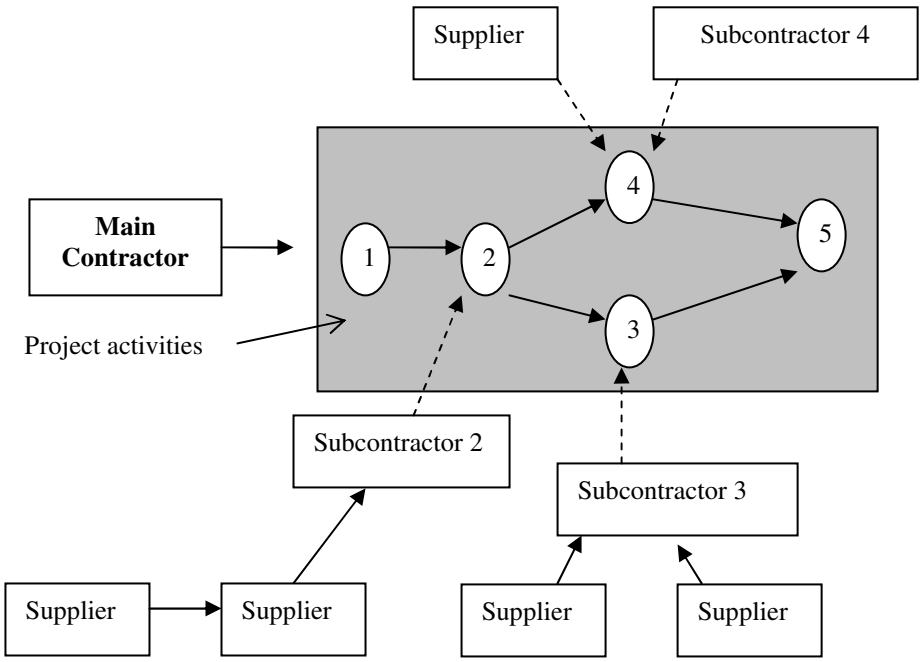

Figure 3.1: A simple view of the construction supply chain [O'Brien J. William *et al.* (2002)]

Figure 3.1 shows a simple view of construction supply chain. It demonstrates that the main contractor, who is responsible for the construction of a project, has sublet different activities of a project to different subcontractors. Activity 2 is being carried out by subcontractor2 who is getting material / equipments from a supplier and its supplier is further getting some material from another supplier. Activity 3 is being performed by

subcontractor3, who is getting material from two different suppliers. Similarly for activity 4, the main contractor engages a subcontractor, who is giving his services, but for the material the main contractor himself engages a supplier.

3.2 Formation of Links in Construction Supply Chain

Different types of companies are involved in construction industry varying in size and functions. If we see the relations of these companies in an ongoing environment then we see that each firm has different types of links with different other companies / individuals. These companies / individuals may be its customers or subcontractors. These relations or links are due to their current business, demand or services so in this way each firm is surviving and carrying out business in construction industry. This environment is shown in figure 3.2.

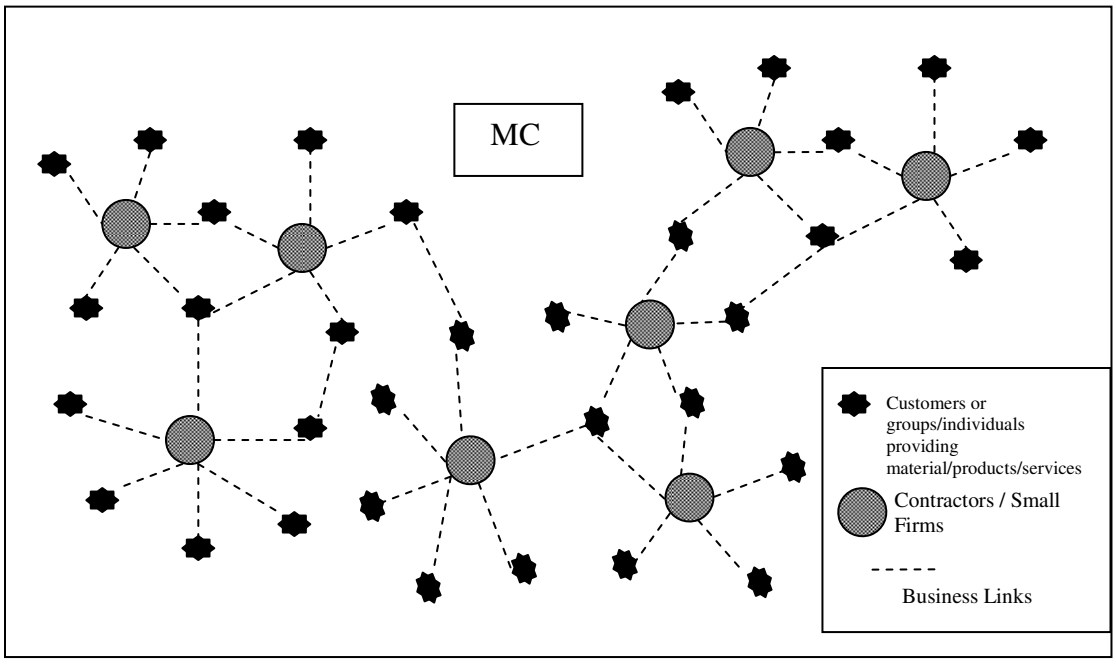

Figure 3.2: Small Firms/Subcontractors working in Industry according to their current business

When a main contractor gets a new construction project and due to this new project he needs the services of some subcontractors. Then it chooses subcontractors according to its requirement and choice from the existing

market. When main contractor form contractual links with its chosen subcontractors then these subcontractors started working for main contractor. If it is a big and relatively long duration project then due to their services for main contractor, their links with certain firms strengthened and with other becomes weak or finish. These new activated links are shown in solid lines in figure 3.3.

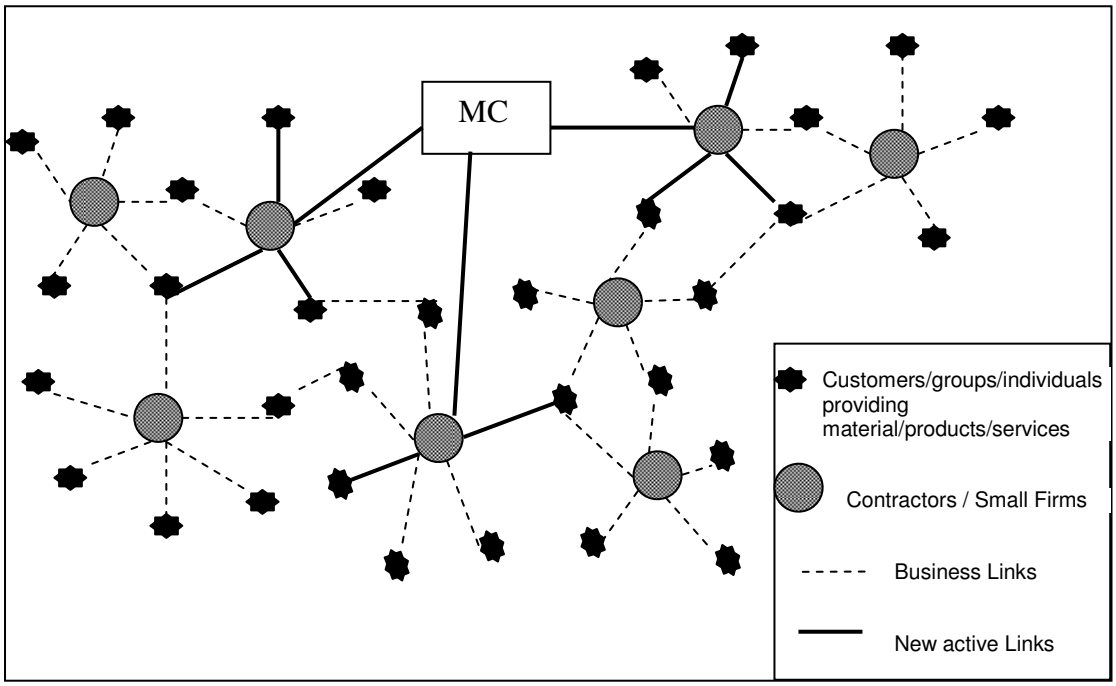

Figure 3.3: Formation of new contractual links among parties due to a new construction project.

If we isolate the firms involved in a project of main contractor then this structure is shown in figure 3.4 which is a theoretical multi layer structure. Actually these firm have other links with different customers and subcontractors which are not shown here and only links and participants due to a single project of a main contractor are shown. Other than this automatically developed vertical integrated chain a horizontal integrated atmosphere is also compulsory for a healthy and progressive construction site environment. All the parties involved in a project as shown in figure 3.4 usually have to work at same site one after the other or at same time. Therefore they should have characteristics of such adoptability and professional ethics which

enables them to form quick cooperative relations with their partner firms. These non-contractual relations are shown by dotted lines in figure 3.4.

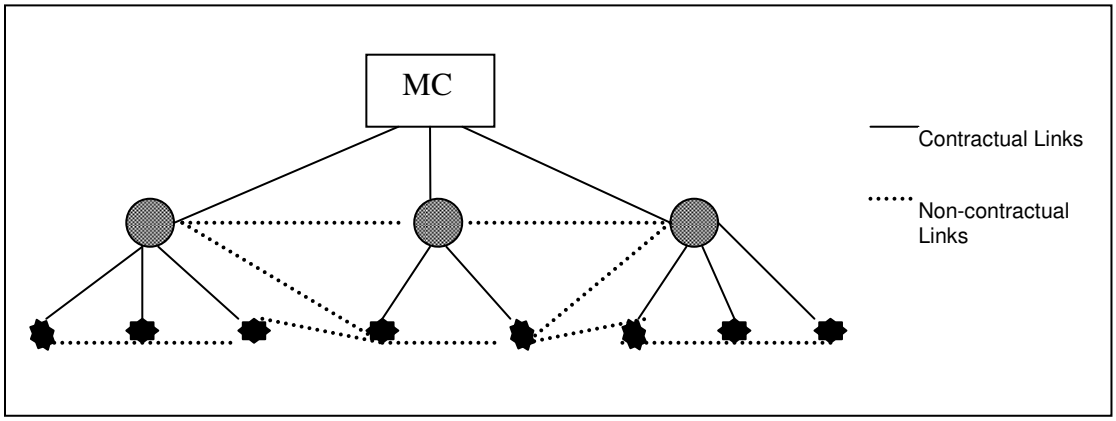

Figure 3.4: A group of construction teams is formed due to a new construction project.

3.3 Properties of Construction Supply Chain

Construction supply chain is a converging supply chain. All the materials and products are directed to the construction site and are utilized in constructing the facility and there is no out ward flow of product. It is contrast to manufacturing industry where the supply chain is not converging because raw material flows in and finished products flow out to different consumers/clients. These properties are shown in figure 3.5.

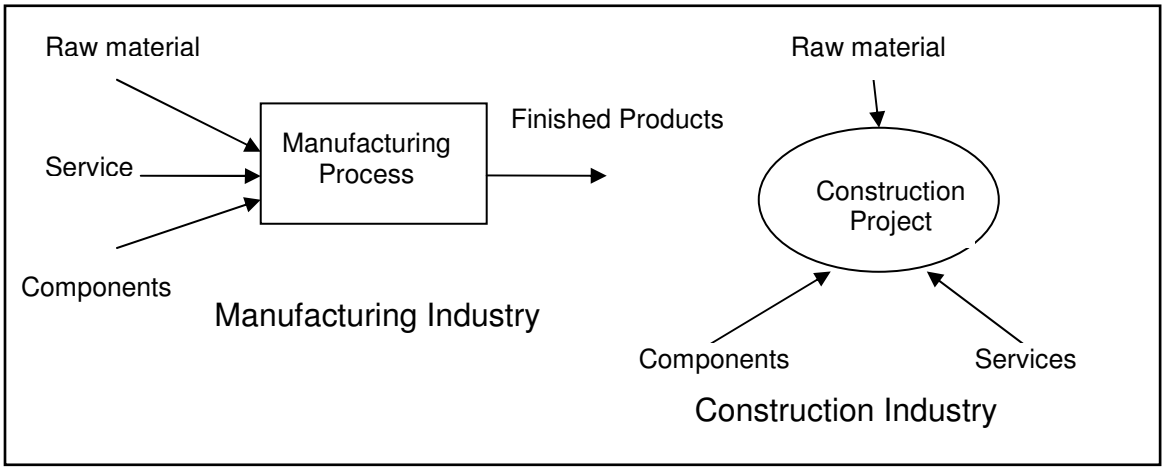

Figure 3.5 Simple diagrams showing converging nature of construction supply chain in contrast to manufacturing industry

Construction supply chain is generally a temporary supply chain. It normally exist for a single project therefore instability and fragmentation are more severe in construction supply chain than in other industries.

The structure of every supply chain in construction projects if different. It differs from project to project and there is hardly any repetition. [Vrijhoef Ruben, Koskela Lauri (2000)]

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Chapter 4

Supply Chain Management in Construction

4.1 Introduction

According to [McDermott P., Khalfan M.A Malik (2006)], Supply Chain Management (SCM) can be defined as *"network of different organizations, linked upstream and downstream in a chain, aiming to produce quality and value in the services and products for the end consumers through integrated processes and activities".*

SCM includes managing essential functions to form a series of interrelated flows and processes in order to fulfill the project requirements of cost, time and quality [Errasti Andre *et al.* (2007)]. When different organizations are involved, these principles are collectively called Supply Chain Management and deal with managing the flow of materials and information among various parties in the supply chain in order to create value for the client/customer [Errasti Andre *et al.* (2007)].

The concept of SCM was initiated and developed in manufacturing industry. The basic function of SCM is to realize the links in supply chain members and improve its control. The ultimate aim of SCM is to create win/win environment for partner organizations, achieve maximum out put improve performance and quality.

4.2 Importance of Supply Chain Management in Construction

Construction supply chain management offers new approaches to reduce the cost and increase the reliability and speed of construction. Supply chain management organizes the construction activities of autonomous production units (main contractor, subcontractors and suppliers) and seeks integration of these units. Applications of supply chain management (SCM) techniques in manufacturing industries have proved very successful and showed a lot of benefits [O'Brien J. William (1999)]. As subcontractors' and supplier's production comprise the largest value of project cost, supply-chain approaches may also have similar benefits in construction industry. Limited

studies in construction suggest that poor supply-chain design regularly increases project cost [O'Brien J. William (1999)]. In addition to this it is not only the cost that increases but projects also get delayed.

Construction Industry has been slow and reluctant in adopting the concept of SCM as compared to manufacturing industry. However it is observed that by adopting the concept of SCM different problems in traditional practices in the construction industry can be resolved. Early involvement of different parties of the project especially subcontractors and suppliers give rise to many useful suggestions and methods. This early involvement can avoid many unforeseen problems which may ultimately result in saving cost and time.

Supply chain management (SCM) is a very efficient procedure, which mainly focuses on the subcontractors and suppliers that comprise the largest value of project costs [O'Brien J. William (1999)]. Therefore effective supply chain management certainly improves the project performance.

The importance of SCM is realized in construction projects upon creation of a consistent balance among the variety of activities involved, for example services, purchasing, operations and logistics. The evidence suggests [Errasti Andre *et al.* (2007)] that organizations that have implemented SCM initiatives have achieved better results. SCM helps to improve product quality and human resource utilization as well as to reduce completion times and project/product costs. However, there are other techniques also that can increase an organization's ability to improve its performance.

4.3 Critical Issues in Construction Supply Chain Management

Fragmentation in construction industry can be explained as it is due to large number of participants in a construction project. In the construction industry the level of fragmentation is much high due to existence of large number of small and medium size firms (subcontractors and suppliers). Therefore integration becomes important in construction industry because of its fragmented nature. Large and complex project becomes more fragmented

because of large number of participants. The involvement of large number of participants is due to nature of construction projects, there is generally no barrier to enter in industry particularly in subcontracting business. Therefore many small companies come into existence trying their fortune in vast opportunities available in construction industry. In this way participants in a construction project comes from different back ground and with little or no skills & experience. Even these participants have different aims so it is difficult to manage everyone to play a positive role in project. Due to this type of environment the importance of integration in construction supply chain has increased. Figure 4.1 shows different components of construction supply chain which gives an idea about its complexity. Construction industry contains diverse types of supply chains which supply different type of materials and services to different clients.

Therefore there is necessity of partnerships, strategic alliances and productive relationships among these actors in industry which is mostly not realized and hence largely ignored. In large projects the supply chain consists of many subcontractors so better and cooperative relationships among them will help in aligning the supply chain which will certainly accelerate the activities. Supply chain relationships should extend beyond the simple exchange of materials or services, to integrate the design, distribution, marketing, and knowledge exchange between the parties [Dainty R.J Andrew *et al.* (2001, Vol. 6)]. However such relations did not prove much beneficial due to ignoring the small firms i.e. subcontractors and suppliers. It has been observed that dispute often occur between main contractor and subcontractors or among subcontractors. These disputes generate poor and hostile relationships among these parties which are likely to work together in future. Poor relations not only affect the current project but also not beneficial in future projects whenever these parties will work together. Consider a contractor who has good and strategic relations with its subcontractors and if its subcontractors also have good relationships among one another. Then this contractor due to these productive relationships definitely can reduce its costs and afford to lower its bid price in competitions.

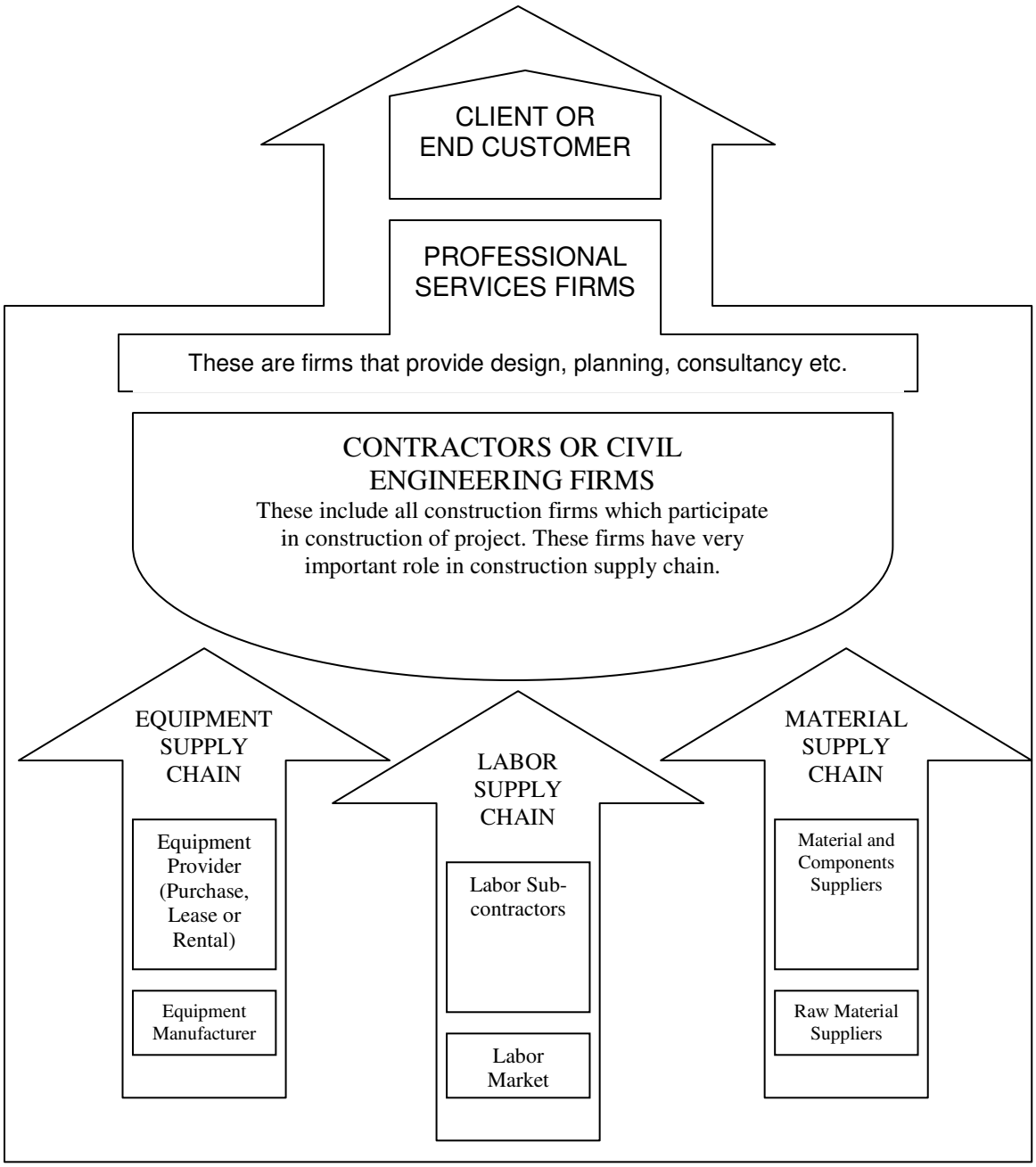

Figure 4.1: A construction supply chain and its components

4.4 How to Achieve Supply Chain Integration in Construction Industry

The managers and researchers in construction industry have adopted different procedures and recommended suggestions to achieve optimal level of supply chain integration.

One of the features of the integrated construction supply chain is that they are centrally coordinated and the relationship between firms is

maintained for the duration of a specific project. These chains are not only directed towards reducing un-necessary costs, but also towards sharing and transfer of expertise among all the supply chain members. [Vrijhoef Ruben Koskela Lauri (2003)] [McDermott Peter, Khalfan M.A Malik (2006)]

The question is that why the supply chain integration is important, the answer may be the integrated construction supply chain arrangements will help the supply chain members to work together in partnering environment for a long time. This will develop better working relationships and trust which will ultimately result in form of benefits for these participants and positive achievement for the construction industry.

4.5 Problems regarding Supply Chain Management in Construction Industry.

Poor SCM is mostly due to lack of coordination and communication among the participating organizations of a project. Some generally observed factors which result in creating barriers among supply chain members' relationships are listed below:

- Hostile attitude based on win/lose policy
- No long term relationship focus
- Non commitments (formal and informal)
- Poorly defined criteria for sharing of risks and benefits
- Lack of transparency and communication
- Behavioral and cultural obstacles

The ultimate effect of these problems results in form of cost overrun, time overrun, poor quality, defects, conflicts and disputes.

According to [Dainty R.J. *et al.* (2001, Vol. 19)], some subcontractors in Industry suspicious about SCM and they think it is a mechanism to ensure their short term financial contribution in the project in favor of the main contractor.

[Dainty R.J Andrew *et al.* (2001, Vol. 19)] based on their survey in UK construction industry, describe that companies that ignored to manage supply

chains were likely to be problematic. In his interviews to subcontractors he came to know that subcontractors generally have negative views about partnerships and supply chain management. They think that supply chain management is a process to ensure their share in taking the burden of short term financing of the project. Small parties other than the main contractor generally believe that in existing setup of supply chain management techniques, main contractor is benefited at the expense of other members. This is due to lack of trust between main contractor and its subcontractors/suppliers. He also observed that lack of trust among parties and negative attitudes as a result of competitive environment, are among the reasons which are causing hindrance in supply chain management in construction industry. He further suggested that construction industry is long way behind to be able to align its procedures and systems for integration in Supply chain.

[Vrijhoef Ruben, Koskela Lauri (2003)] after analyzing different case studies said that even in normal situations many problems exist which are often ignored or not realized. They further explain that most of these problems are realized at different stages from where these are originated. Therefore root cause of these problems can not be found in activities where these are encountered.

In spite of these inherited problems in construction supply chain, the alignment of the system towards adoption of SCM techniques is improving, construction industry started to realize the benefits of strategic partnerships among all the participants.

Subcontractors' lack of interest is due to their experiences, so main contractor and clients should realize the importance and abilities of subcontractors to add values in the project. Due to their experience and expertise these small organizations may prove innovative and add valuable contribution in the project. Main contractors should try to change their image by win-win relationships, fair payments and by due credit and praising the subcontractors for their contributions.

Chapter 5
Subcontracting

5.1 Introduction

The terms “subcontracting” or “subcontractor” does not have a specific definition; in construction industry subcontractors are generally the contractors and suppliers which are engaged by the main contractor to perform any particular job in a project. The facts are that subcontractors' outputs are not an end product but a part of the end product and subcontractors do not have direct contacts with the end customers (client).

According to the [European Commission (1997)]: “*When enterprises make complex products involving many different processes or when demand is too high or the products too specialized, they have the choice of doing the work themselves or getting others to do it for them. If they buy in specially made rather than standard products, this is known as subcontracting”.*

The dictionary of purchasing and supply management defines subcontracts as: *“Arrangement whereby a main contractor (or supplier) authorizes a second (or more) to undertake part of the order he has secured or subcontract for supplies outside the purchaser’s own production or because his production is overloaded”.*

The nature of subcontractors in construction industry is different from other small and medium scale enterprises (SMEs), in manufacturing industry. There are different forms of subcontractors in construction industry according to the nature of services for example, general contractor, general builder, material supplier, specialists(plumber, electrical contractors, painters, carpenters HVAC contractors) etc. These subcontractors provide important production and constructions services to the main contractors in their construction projects.

5.2 Nominated Subcontractors

Nominated Subcontractor is a Subcontractor

(a) who is mentioned in the contract between main contractor and client as a Subcontractor, or

(b) about whom the Engineer instructs the Contractor to employ as subcontractor. [FIDIC red book (1999)]

If the subcontractor is not nominated in contract then the prior consent of the engineer shall be obtained. According to the FIDIC contract clauses the contractor shall pay the nominated subcontractor the amounts which the engineer certifies to be due in accordance with the subcontract. If payment to contractor also includes an amount of work carried out by a nominated subcontractor, the engineer may request the contractor to provide reasonable evidence that the nominated subcontractor has received all amounts due in accordance with previous payment certificates.

5.3 Structure of Subcontracting Network

Subcontracting network may be represented by two basic structures according to the relationship among one another in supply chain. These structures are Star-shaped or Single layer structure and Tiered structure or Multi layered structure shown in figure 5.1.

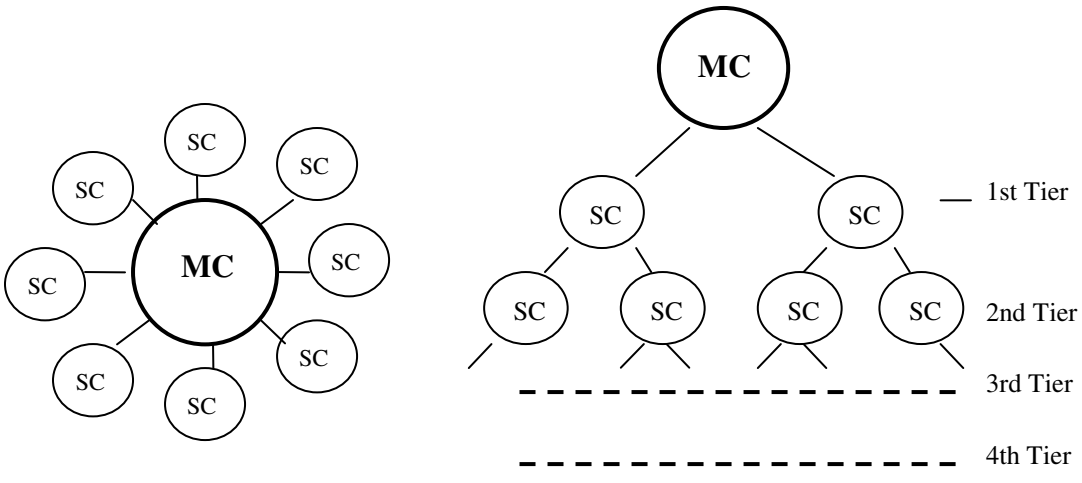

Figure 5.1: Single and multi tiered subcontractors' structures [Lehtinen Ulla (1998)]

The shape and type of structure depends upon the nature of the project and nature of links among the participants. Star-shaped structure is more flexible and capable to adopt a sudden change while the tiered structure is more rigid and it is developed form of star/single layer structure [Lehtinen Ulla (2001)].

According to [Lehtinen Ulla (2001)] some of the relative advantages of these structures are listed below:

Advantages of Star-shaped Structure

- It is flexible and any change can be accommodated easily.
- Perform better in cost competition.
- React better in uncertainty
- Perform better in availing opportunities.

Advantages of Tiered Structure

- It is more rigid and strong
- Better access to experience and knowledge
- Better flow of information
- Better distribution of profit and loss
- Confidentiality level is higher

The multi tiered subcontracting system is well developed in Japan's manufacturing industry. It started to develop after Second World War during the period of rapid economic growth the parent firms need to increase their production. In order to avoid the dangers and obstacles in rapid expansion they started to seek help of subcontractors by out sourcing the different tasks. So in this way the 1st tier of subcontractors was developed. These subcontractors of1st tier were small units which faced problems when the demand started to increase so they further tried to seek their own suppliers. They divided their jobs into small segments and got help of relevant experts to do these jobs for them. In this way 2nd and further tiers of subcontractors started to develop. Japan's automobile industry is a typical example of the development of tired structure.

5.4 Role of Sub-Contractors in Construction Industry

No project can be undertaken by a single organization without some degree of help and cooperation of others. Thus, in the construction industry the contractor normally seeks help of subcontractors. These subcontractors are given the responsibility of managing materials, providing labor and carrying out other activities. Generally, the main contractor and many subcontractors, operate within a project based system with the result that these organizations are increasingly developing horizontal and vertical integrated organizational structures [Errasti Andre *et al*. (2007)]. The process of out sourcing activities by main contractor provides opportunity to small firms to grow and compete. Additionally, subcontractors have to face the increased pressures of quality, service and cost by working in huge projects under their main contractor.

According to Nobbs [Mathews Jason *et al*. (2000)] the contribution of subcontractors to the total construction process can account for as much as 90 per cent of the total value of a construction project. In this way the responsibilities and opportunities for subcontractors have increased from traditional craft-based works. Therefore, main contractors concentrate their efforts on managing site operations rather than employing direct labor, managing materials and perform small specialist jobs to undertake construction work. Jamieson [Mathews Jason *et al*. (2000)] also attributed the increased use of subcontractors to the growing complexity of both the construction of buildings and the organizational relationships. Many subcontractors do not have the necessary expertise and experience to carryout work in such a way that it is satisfactory for their predecessor subcontractors and, as a consequence, subcontractors are unable to give their clients the service they require. As a result, projects are not only delayed but these subcontractors also suffer from low/no profit. Therefore, conflicts among these subcontractors often arise causing further problems for the main contractor. For subcontractors the job becomes more difficult due to the fact that many main contractors exploit subcontractors mainly to shift liabilities and risks towards them [Eriksson Erik *et al*. (2007)]. This kind of environment is

certainly not helpful for the development of innovations by subcontractors because subcontractors tend to adopt traditional practices rather than to take risk by trying something new. It can be rationalized that too much talent is therefore wasted because significant contributions of suppliers and subcontractors are not recognized, which otherwise lead to innovations. Through an integrated supply chain the skills of these actors can be assessed and utilized. Mutual cooperation and harmonization will help to facilitate improvements and innovation, securing project success and customer satisfaction. [Eriksson Erik *et al*. (2007)].

Agapiou [Mathews Jason *et al*. (2000)] concluded that subcontractors constitute important links within the construction supply chain and that partnering could help to improve the supply chain and reduce costs. Due to the increase involvement of subcontractors in large construction projects, the importance of management and selection of subcontractors is also increased [Tserng H. Ping, Lin H. Pao (2002)].

The poor relationships among subcontractors are also due to the traditional competitive tendering in which bidders bid on prices against each others. Furthermore, subcontractors are often divorced from the main contractor's decision-making processes [Eriksson Erik *et al*. (2007)]. Since subcontractors are hired by the main contractors after award of contract they mostly do not play any part in designing and planning of the project, although they are the agencies to carry out the activities of that project.

In recent years partnering arrangements have become popular in both construction and facilities management in order to transform the adversarial relationships into cooperative ones [Errasti Erik *et al*. (2007)]. However, partnering and its incentive schemes are most often focused only on relationships between client, main contractor and designer/consultants, and very rarely with suppliers and subcontractors. In cases where subcontractors are not involved in the partnering team the increased cooperation between client and main contractor hardly spreads to subcontractor level. Therefore it is beneficial that all key parties on whose activities overall project performance

depends should be included in the partnering team and the incentive schemes [Eriksson Erik *et al*. (2007)].

A change towards increase of cooperation among different subcontractors should also be initiated by clients for two reasons: first, clients often seem more interested than main contractors about retaining subcontractors' experience. This is because clients can appreciate value addition more than main contractors. Second, the relationships among different subcontractors depend upon the relationship between client and main contractor [Eriksson Erik *et al*. (2007)]. Clients' procurement procedures, including client recommendation and nomination of subcontractors to main contractors, thus heavily affect subcontractor integration [Eriksson Erik *et al*. (2007)]. To achieve a change towards more collaborative relationships between subcontractors the main contractor's and client's role is therefore critical. However, due to the traditional differences between them as result of competitions, integration and harmonization cannot be achieved easily and automatically. Hence, it seems important to increase the understanding about how to integrate subcontractors to increase the value addition and innovation [Eriksson Erik *et al*. (2007)].

A general perception of subcontractors is, they actually act as short term financer for the main contractor. Subcontractors execute different jobs in the project for main contractor and some times get paid by main contractor after he received his payment from client for that executed work. In this way main contractor do no invest by himself for works which are subcontracted to others.

5.5 Problems in Construction Industry Associated with Subcontractors

In huge projects, there are many subcontractors working under main contractors. It means the successful completion of the project also depends upon performance of subcontractors. Insufficient experience and capability of participating subcontractors can delay the project. The involvement of a large number of subcontractors in construction projects has increased the risk of

delays and unsatisfactory quality which may lead to inefficiencies in the construction industry. [Sambasivan Murali, Soon W. Yau (2007)] describe problems which commonly cause delay in construction projects. Some of these problems which are generally associated with subcontractors are:

5.5.1 Interruption in material supply

Shortages in basic materials like sand, cement, stones, bricks, and steel can cause major delays in projects. In those regions where prices of these materials often fluctuate depending on the demand, prices may suddenly increase due to high demand. Subcontractors are small companies in the majority of cases that cannot afford huge losses. Therefore, subcontractors responsible for supply or use these materials can not afford to purchase material at high rates. Consequently, they postpone or slow their activities until prices decrease or try to find other sources.

5.5.2 Labor quality

Generally subcontractors do not have permanent labor. They try to hire temporary labor according to the requirement. Moreover they try to find labor from nearby areas of the construction site. If it is expensive to employ large labor due to their residential expenditure at site or other reasons, the subcontractors try to employ as minimum labor. The quality and quantity of labor supply can have a major impact on the projects. So the temporarily hired cheap workers are generally untrained and have little or no experience of working in that kind of construction projects. Therefore their work quality is relatively low when compared to experienced laborers. The low quality and productivity of these workers have an adverse impact on the project progress and quality.

5.5.3 Equipment availability and failure

Many of the contractors do not own equipments that are required for some special tasks apart from generally utilized machinery. So they give the job to specialized subcontractors when required. During the periods when there are

many construction projects in progress, the equipments of these subcontractors are under heavy work load therefore it is not properly maintained. This lack of maintenance often results equipments failure causing the progress to be affected. Similarly, if these specialized subcontractors have many contracts at a time due to their specialized machinery then they cannot work in all projects at a time so they will manage to work one by one, which may cause delay of the projects.

5.5.4 Lack of communication between parties

Since there are many parties involved in a project (different types of subcontractors for different specialized jobs), the communication between the parties is very crucial for the success of the project because they have to work one after the other or simultaneously. Due to the improper establishment of communication channels between the various parties in the initial stage, problems may occur. Any problem with communication can lead to severe misunderstanding and therefore, delays in the execution of the project. These causes of delay can be minimized by better coordination among relevant subcontractors.

5.5.5 Disputes

Disputes among subcontractors or between subcontractor and main contractor may occur during the construction process. When there are a lot of parties involved in a project then disputes are most likely to occur. The disputes among subcontractors mainly occur due to the lack of communication and due to working practices which are not favorable for other parties. These disputes may lead to arbitration and litigation, which can cause delays in project completion.

Chapter 6

Evolution of Subcontracting in Construction Industry

6.1 General

Main contractors initially seek help of subcontractors to meet the increasing demand of their product/project. Main contractor focuses mainly on core activity and out source other tasks. There are different reasons for engaging subcontractors by main contractors. Some of these reasons are lack of sufficient capacity to meet the demand, need of specialists, technology, organizational changes, financial reasons, union avoidance, political and cultural reasons.

It is not feasible for a main contractor to have all kind of experts, skilled labor and machinery needed in different construction projects because it may not need all his staff in each project so the idle staff and machinery is an economic burden for him. On the other hand if it out sources different activities to specialists then it is more beneficial for him. The figure 6.1 shows two types of main contractors, MC1 has different types of staff groups which are needed in his construction activities but he do not need all the staff in every project so as a result some of its staff stays idle.

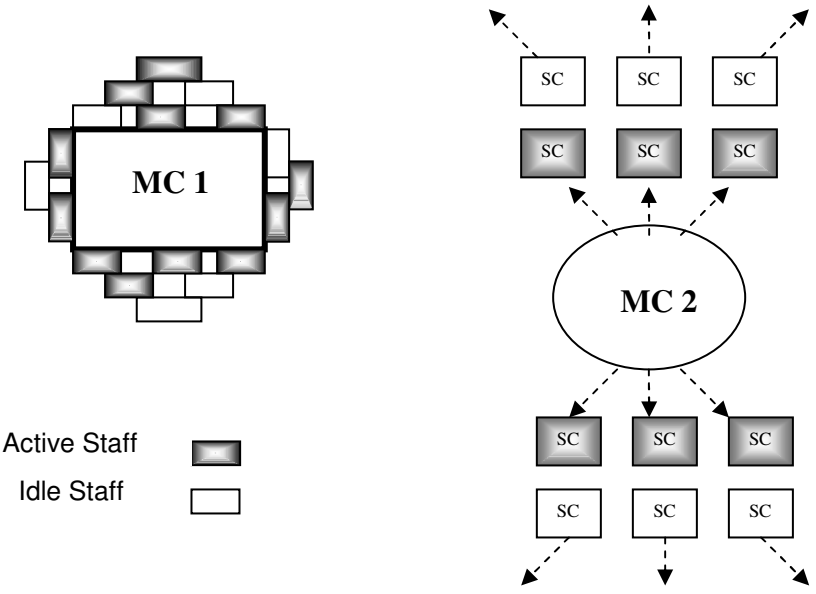

Figure 6.1: Comparison of main contractors who do not out source activities versus those who do.

Due to the economic reasons if MC1 may tries to use its idle staff in those activities for which they do not have much skills. Therefore the out put of MC1 will be inferior to those, who have services of specialized subcontractors.

The other main contractor MC2 only concentrates on core activities and out source other activities to subcontractors available in market; the other subcontractors which are not engaged by MC2 do not sit idle but seeks opportunities with other main contractors. So in this way MC2 avoid paying to idle staff and gets the services of experienced subcontractors who have developed innovative skills by working with different main contractors.

6.2 Development of Tiered Structure

In the initial phase the main contractors or original equipment manufacturer (OEM) started to get help by outsourcing some of its processes by engaging a number of subcontractors. In this phase the main contractor/OEM has direct relations with all the subcontractors as shown in figure 6.2 [Lehtinen Ulla (1997)]. It is actually a star shaped structure where all the subcontractors have contractual link to main contractor.

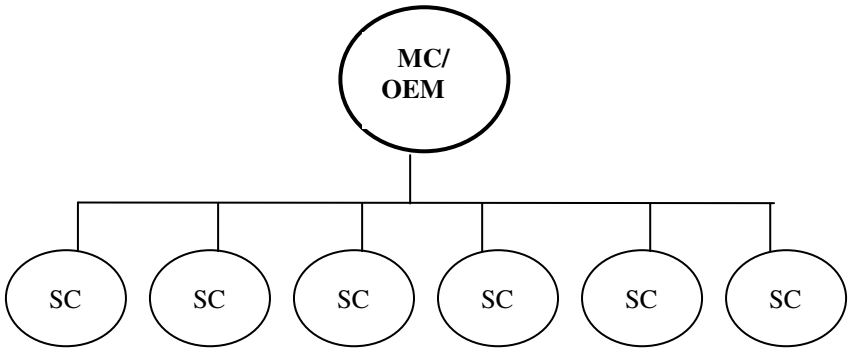

Figure 6.2: Main contractor has direct links with all its subcontractors [Lehtinen Ulla (1998)]

In the developing phase the main contractor/OEM started to reduce subcontractors to which it has direct relations. In this position the limited subcontractors have more responsibilities and work to do so they further get help of some subcontractors of their own. As shown in figure 6.3. At the initial

stages main contractor/OEM has direct relations to these 2nd tiered subcontractors also, in order to make sure the quality and sustainability of supplies. These types of multi layer relationship are indication of lack of trust of main contractor/OEM and lack of efficiency and experience of subcontractors.

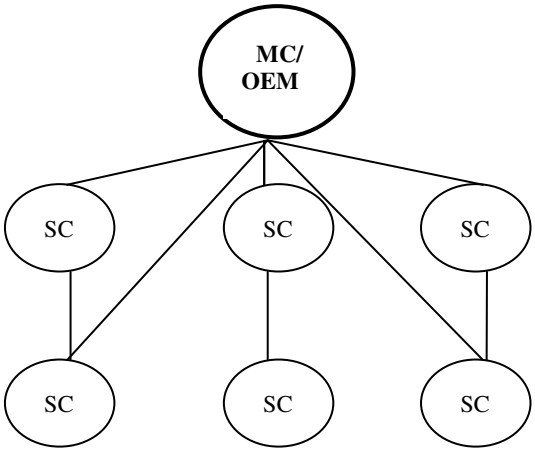

Figure 6.3: Developing stage of subcontractors' multi tiered structures. [Lehtinen Ulla (1998)]

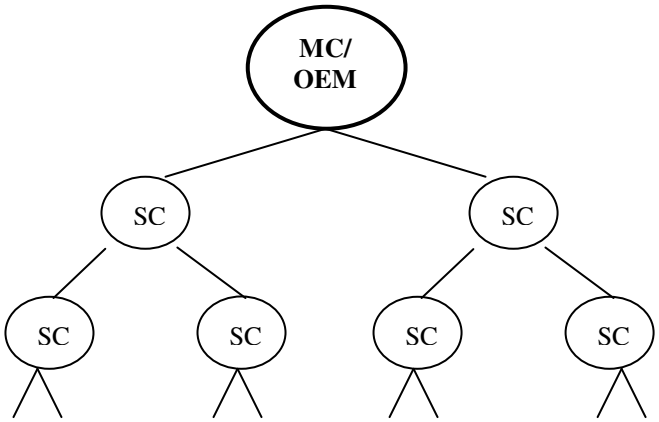

Figure 6.4: A developed form of multi tiered subcontractors' structure [Lehtinen Ulla (1998)]

With the passage of time and working together over a long period all the parties in different layers of the structure started to perform their role quite satisfactory. At this developed stage of tiered structure main contractor/OEM

only have direct contact with the 1st tier and similarly subcontractors in any tier only have direct relations with subcontractors of its next tiers as shown in figure 6.4.

The tiered structure is not well developed in industries of developing industries. Even in Europe it is not as developed as in manufacturing industry of Japan [Lehtinen Ulla (1998)]. Developing stage as shown in figure 6.3 exists when there is lack of trust and control among customer and subcontractor. Then the main contractors and subcontractors do not prefer to out source activities because of expected inefficiencies in quality and time. Due to this lack of control the main contractor/OEM have to interfere in operations of 2nd tier or even in further layers. While in well developed multi tiered structure the main contractor/OEM only have contact with 1st tier of subcontractors. A rigid and strong multi tiered structure normally developed when there is repetition of production of complex products over a long span of time. So these types of structures indicate mature and successful manufacturing industry. This structure indicates the industry, which started to grow due to increasing demand and then maintained its position in the market due to its continuous development and quality.

Since most of the subcontractors do not have capability and resources to expand themselves in order to meet the increased demand, the structure started to increase in number of subcontractors and layers, in this way multi tiered structure develops. This structure is also inherited, close and mutually benefited relations between main contractor- subcontractors and subcontractor-subcontractor in order to meet the increased demand and competition in market. Main contractors always try to modernize and facilitate their subcontractors. They provide them essential technical assistance and if necessary the financial help also.

According to [Hinze Jimmie, Tracey Andrew (1994)] the largest share of parts in the Japanese auto mobile case is so-called black box parts. These are parts designed by the supplier using their own technologies and expertise according to the requirements of clients.

6.3 Problems in Multi Tiered Subcontractors' Structure

Multi tiered structure in construction shows a consistent and developed construction activity. However there are some problems and draw backs also, these are:

- There is inefficiency in communication. Due to involvement of different organizations the lower tiers subcontractors do not fully aware of the instructions and demands of client. Similarly problems of lower tiered subcontractors can not be fully realized by main contractor or client.

- If any main contractor or any subcontractor fall in financial problem. It can not pay to its subcontractors then it affects all his lower tiered subcontractors.

- As for as subcontract conditions are concerned, there is not a single uniform subcontract adopted in a project. Each firm deals with its subcontractors with different subcontract conditions. Some times there is no written contract which some times causes disputes and work suspensions.

- Lower tiered subcontractors get lower rates due to the overhead charges of upper tiers subcontractors. Lower tiered subcontractors are usually small companies who employ skilled and semi skilled workers temporarily. These temporary workers some times not much experienced according to demand of work. In these circumstances lower tiered subcontractors can not perform according to required quality and efficiency.

6.4 Subcontractors' Growth / Development

It is a natural process that a subcontractor will gradually increase its volume of service or number of operations or both when ever there will be opportunity in industry. A subcontractor gradually develops, starting from a

simple opportunist to a specialized firm/subcontractor or even a main contractor. A small subcontractor after getting experience starts to increase the volume of its services and also starts to perform new services. In next stage it posses more labor, experienced supervisors and also starts purchasing related machinery in order to perform its job independently. Further more it starts to produce complete jobs independently as now it has its own skilled labor, technical staff, machinery and also control over supply of material due to development of links with material suppliers. In a growing industry it will grow large and then try to concentrate on core business and will out source some activities. This development is shown in figure 6.5. In this way subcontractor structure will gradually transform from single layer to multi layers.

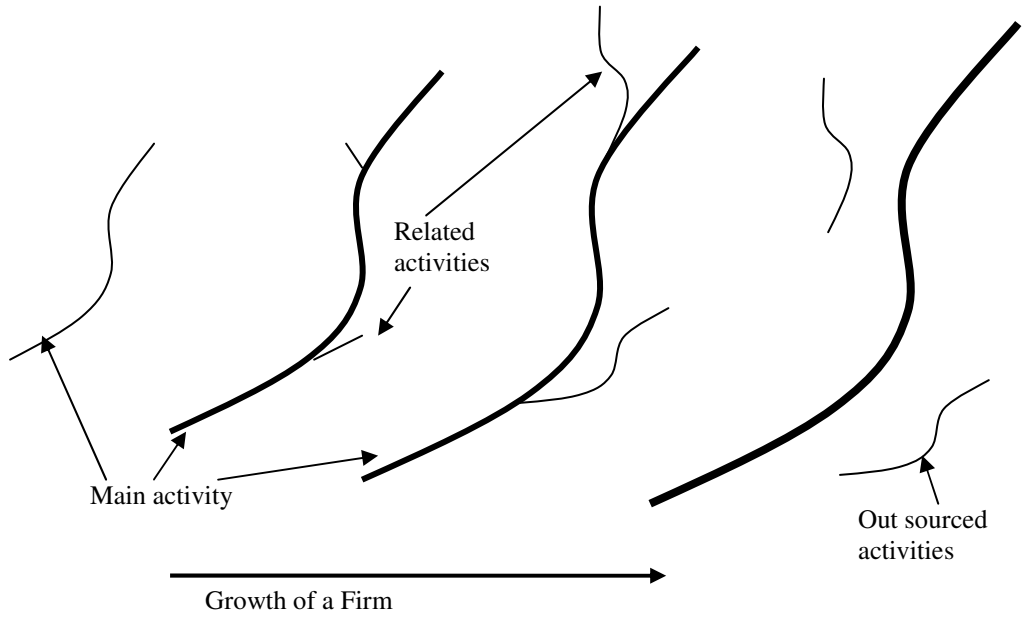

Figure 6.5: Gradual development of a subcontractor in a growing industry

6.5 Efficient Construction Team

The participation of subcontractors in a construction project can increase the efficiency. In this way multiple activities at same time is possible. Activities at different of site locations are also possible to carry out. If we consider a construction project carried out by a main contractor and different

subcontractors. The general form of cost-time curve also known as S-curve is shown in figure 6.6. Less expenditure at initial and final stages represents less number of activities and high expenditure at middle stage means more activities. If we draw a relation between time and number of activities then it will also be an S-curve.

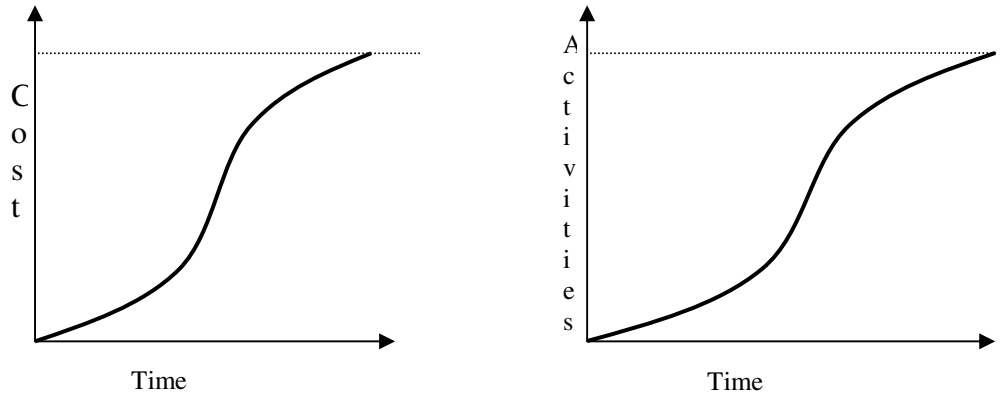

Figure 6.6: S-curves showing cost and activities against time

The slow pace of work at initial and final stages can also be increased by out sourcing the activities. The new improved curve is showing comparatively short project time as shown in figure 6.7.

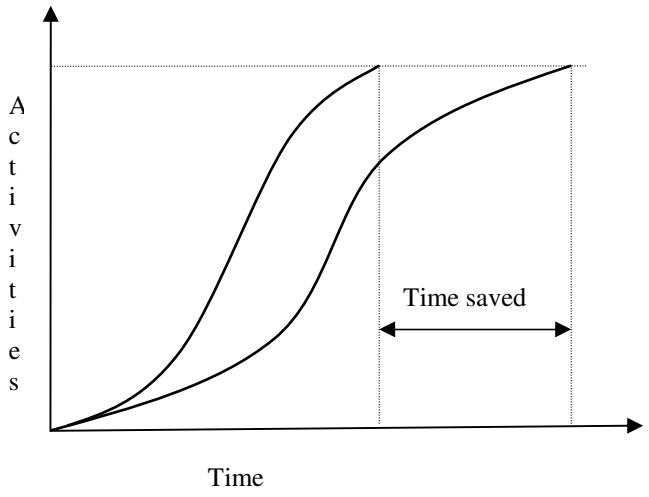

Figure 6.7: Comparison of ordinary and improved S-curve

Shifting responsibilities to different organizers and at differed locations can help to increase the number of activities at initial and final stages. Out sourcing activities to subcontractors can increase the efficiency due to following advantages:

- Better ability to share the site space
- Shifting of, site activities to alternate places/ outsourcing
- Increase of prefabricated items

6.6 Advantages and Disadvantages of Subcontracting

The increased role of subcontracting in construction industry has created some advantages and also there are some associated disadvantages.

Some of the advantages are

- Each firm concentrates on core task and out source the peripheral activities.
- Specialized approach has increased rather than performing multiple tasks.
- Risks and responsibilities are shared.
- Construction firms and specialists have more flexibility to work with different companies according to their preferences.
- The opportunities of development of innovative techniques have increased.

The associated disadvantages are:

- The increased number of construction firm in a project has made the management task more complex.
- The disputes and litigation among the firm has increased.
- The different types of contracts on behalf of main contractor with different subcontractors caused sense of exploitation and discouragement.
- The competitive bidding of main contractor for the selection of subcontractors some times creates price related issues and creates adverse relations among construction parties. Setting of unrealistic

targets by main contractor and also shifting risks and responsibilities in an unfair manner also creates barriers in the way of long term cooperation.

- In multi layered subcontractors structure there exist delay in paying the lower tiered subcontractors. It is common that main contractor pay to subcontractors when it gets paid. Similarly each layer of subcontractors gets payment for their completed work when their upper layer is paid. Therefore it takes time in flow of payment from main contractor to lower tiered subcontractors.

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Chapter 7

Alliances and Relationships in Construction Industry

7.1 Partnerships & Alliances

Partnering is defined by the Construction Industry Institute (CII) [Mathews Jason *et al.* (2000)] as "*a long-term commitment between two or more organizations for the purpose of achieving specific business objectives by maximizing the effectiveness of each participant's resources".* This needs to change traditional relationships in order to develop a shared culture without disturbing the organizational boundaries.

According to Bennet [Crowley G. Larry, Karim Ariful (1995)], "*partnering is a set of strategic actions that deliver marked improvements in construction performance. It is driven by a clear understanding of mutual objectives and co-operative decision-making by multiple firms all focused on using feedback to continuously improve their joint performance"*.

[Crowley G. Larry, Karim Ariful (1995)] defined partnering as ''*an organization implementing a co-operative strategy by modifying and supplementing the traditional boundaries separating companies in a competitive climate*''.

So in a partnering environment the traditional boundaries become less rigid and permeable for the flow of information across them which enhance cooperation and trust, in this way a mutual cooperative platform is created. However, to restrict this culture of shared information within certain limits, these partnered organizations also develop some boundaries which are not permeable and serve to shield particular interests of individual companies. The different organizations which undergo a partnership belong to the same industry so they are competitors of one another, (in projects) other than this (specific) alliance. If these enterprises make long term or strategic alliances then due to the necessity of the project and their own comfort they need to let their partners to have easier access inside the company. But this access is kept to a limit, since it is professionally necessary to keep their secrets because the other partners are after all their competitors out side the alliance.

During the project better coordination between one another eases interaction, enhances communication, encourages trust, and permits the participating organizations to directly interact with its counterpart. This interaction helps in sharing operational level ideas to resolve problems while working to accomplish common goals. Therefore the strict restrictions developed due to existing competitive culture also eases towards better relationships. In this way different parties work as a team for the completion of a single project by performing tasks for their individual goals. Matthew J. [Beach Roger *et al*. (2005)] identified different elements which are commonly raised in the partnering literature. These are: Goals and objectives; Trust; Problem resolution; Commitment; Continuous evaluation; Group working and teams; Equity; Shared risk; Win-win philosophy; and Collaboration/Co-operation.

In the construction industry saving of cost and achieving high quality may be achieved by closer collaboration during the design phase of the project [Errasti Andre *et al*. (2007)]. The firms which have to take part physically in the construction process can contribute better and add innovative ideas in the designing phase. This type of participation during the design period will be helpful in awareness and avoiding the problems which have to be faced in the construction phase. Generally, construction firms still do not really realize and are doubtful about the benefits that can be experienced by developing closer relationships with suppliers. On the other hand, they are concerned about the increased dependency as their supply base is reduced [Errasti Andre *et al*. (2007)]. Moreover, in construction industry it is being realized that these relations among the parties involved in a construction project are not fully satisfactory and that, by further improvement of these relationships parties could perform better [Errasti Andre (2007)]. Experts have described some of the problems of poor performance in construction industry such as: quality failures, increased costs, and delays in the project delivery process, due to misunderstandings and a lack of communication among the participants [Errasti Andre *et al*. (2007)]. [Lehtinen Ulla (2001)] describes that economic factors could be critical in determining the collaboration

requirements among companies in construction industry. [Chen T. Wei, Chen T. Tung (2007)] in a survey conducted in the Taiwan construction industry suggested 17 critical success factors (CSFs) of partnering. Then he grouped these CSFs into different categories and names them clusters. The four extracted clusters were named; collaborative team culture, a long-term quality focus, consistent objectives, and resource sharing. These four clusters have the most significant Influence on the output of the construction partnerships.

7.2 Strategic or Long Term Partnering

In the construction industry, partnerships may be short-term and project orientated or long-term and strategic in nature [Eriksson Erik *et al*. (2007)]. In strategic partnerships, participants are required to work through closer collaboration, which helps in formation of long term bonds among these participants. While in short-term or project based partnerships the parties try to achieve immediate project benefits rather than to develop long term cooperative strategies [Beach Roger *et al*. (2005)]. Buyer-supplier relationships take time to develop these relationships undergo a series of phases before changing from operational to strategic. These phases can be described as supplier, preferred supplier, supplier partner and strategic partner [Lehtinen Ulla (2000)]. In order to achieve maximum benefits and to minimise risks, there is need to work in a more collaborative atmosphere. This means companies should change their traditional business relations from conservative to sharing so that there should be improvements in the exchange of information, the development of closer cooperative relationships and ultimately, mutually beneficial project collaboration. These developments may also require deep cultural changes [Errasti Andre *et al*. (2007)]. As the competition in a market increases then the strategies also get modified to avail the opportunities. Strategic alliances become more efficient, it can also be realized by the following prediction by [Cox Andrew *et al*. (2006)].

"In the partnering perspective the future competition will be among supply chain vs supply chain and not among single firm against another. Those who

do not adjust themselves in partnering atmosphere will be over powered by those who adopt it".

7.3 Partnerships among Subcontractors in Construction Industry

In construction projects different subcontractors are being employed by the main contractor for his single project, these subcontractors may never have worked together on previous projects. This composition of subcontractors may invariably be changed in future projects of the same main contractor. This is due to the relationship of a subcontractor with the main contractor as well as type and location of the project [Hinze Jimmie, Tracey Andrew (1994)]. It means that these subcontractors should learn to work with different counterparts in different projects, which is possible by the development of instant ties which are helpful and beneficial for each other. In a construction project the subcontractors are contractually bound to the main contractor therefore, the main contractor is in a key position to organize all subcontractors and also help them to build better relationships among one another. [Maturana Sergio *et al*. (2007)] suggested methods which allow main contractors to help subcontractors to improve their performance by providing them periodic feedback. So this kind of performance record will also help the main contractor in selection of subcontractors based on their previous performance. This type of selection criteria helps in formation of collaborative relationships among those subcontractors that consistently perform well by working under the same contractor in different projects. Selection criteria based on previous performance will reduce site problems caused by subcontractors and will improve site performance. It will also help in the development of collaborative relationships among subcontractors and the main contractor.

Main contractors were generally criticized by subcontractors that they always more willing to accept the lowest bids irrespective to their strategic partners and those who offer some value added services. More over subcontractors generally not praised and encouraged for their innovative and value added services in the projects. This behavior is not helpful in making

them an integral part of construction supply chain. Most of the subcontractor's point of view is that they are not properly be given credit of praised for their value adding efforts. Moreover innovative methods and skills which they have developed by their own and then contributed in project, are not appreciated.

7.4 Benefits of Partnerships

Partnership improves communication between client and contractor which also reduces disputes and litigation. This will reduce legal and administration expenditure due to conflictions during and after the construction phase. Partnering improves the control over cost and physical activities which decreases the chances of cost and time overrun.

Partnering helps in creating win-win behavior among all actors involved in a project and it reduces the traditional rivalry. In this way the chances of getting financial benefits for all the parties increase. The quality of construction work also increases due to effective control and increased focus over the construction standards. More over it helps in reducing the chances of defects and increase quality standards. Better communication among all the parties in construction helps in creating an innovative atmosphere, the atmosphere which helps in developing new effective strategies and techniques, more over in creating better solutions for the problems.

Partnering also increase the trust among the parties and reduce the negative effects due to previous traditional rivalry. This improved trust plays very important role in effective supply chain management. Partnering reduces the client's staff, which needed to learn the project in detail before the start of construction in order to get better control over contractor. Partnering firms are more flexible to react in case of changes in construction of project and also efficiently adopt changes according to market needs. More over partnering firms react efficiently in case of any short term emergency situation during the construction process.

Partnering can save precious time which is normally wasted in selecting contractor and subcontractors it also helpful in reducing the design time and manage quick start of the project. It gives better control over the

project schedule. Partnering develops better long term relationships among the construction firms due to better communication, win-win atmosphere and trust. [Cox Andrew *et al*. (2006)]

Studies have proved that partnering in construction projects is beneficial. Partnering proves better results in case of common problems like cost overrun, time overrun, changes, claims and disputes. The results of two studies are shown here, which indicates benefits of partnering in construction projects.

TABLE 7.1 Project Performance Comparison 1 [Weston C. David and Gibson G. Edward (1993)]

Mean criterion	Partnered N = 16	Non-partnered N = 28
Cost change (%)	2.72	8.75
Duration change (%)	9.07	15.53
Change orders (%)	3.89	7.74
Claims cost (%)	0.67	5.01
Value engineering savings (%)	0.73	0.05
Mean contract award price (dollars)	10,368,643	11,448,745

TABLE 7.2 Project Performance Comparison 2 [Schmader J. Kelly (1994)]

Mean criterion	Partnered N = 39	Non-partnered N = 100
Cost change (%)	11.20	9.79
Duration change (%)	13.54	25.93
Change orders (%)	11.34	9.38
Claims cost (%)	0.04	0.57
Value engineering savings (%)	0.17	0.01
Mean contract award price (dollars)	11,190,681	4,887,601

7.5 Types of Relationships

There are different types of relations among the parties in construction industry for example relationships based on contract, expertise and mutual trust. Contractual relations are business relations in which parties work together only for the sake of their business under the conditions of a contract. There may be difference of objectives, opinions, company culture, working practice etc. This type of relations cannot prove to be strategic and long term relations.

In expertise relations the parties work with each other due to the special skills of others. If there is no alternative then these relations becomes compulsory for both parties or at least for one party. In this type of relations parties have to work together for one or more projects in spite of differences with each other.

The contractual and expertise relations may convert in to long term relations if the parties involved, finds each other helpful and create environment of mutual trust and professional responsibility. So these developed relations based on trust and friendship are long term and forms a group of companies which work efficiently due to cooperative relationships among one another when ever the have a chance to work together in a construction project.

In industries like automobile, food products and IT hardware, well structured vertically integrated supply chains exist having long term strategic relations among participating manufacturers and suppliers. The reason of these relations is that the demands of their products remain consistent or varies gradually both in terms of quantity and techniques. Contrary to that in construction industry projects are quite different from one another with respect to design, construction procedure, physical location and material required, for example multi-storey building, flyover, road, bridge, tunnel, dam etc. these projects are simple examples showing that these vary greatly in design, location, required skills and materials. Even if we consider one type of structure for example bridges even then each one will be different from other in all above described properties.

When an existing project finishes the main contractor and its subcontractors will seek new business, these existing links will fade and new links will develop with different firms or in some cases existing weak links will become stronger as results of new projects. The characteristics of these parties will help to develop horizontal integration by non contractual relations with one another in their next projects. Keeping in view the above described properties of construction industry it is obvious that self developed vertically integrated supply chains as in case of manufacturing industries, can not develop in construction industry.

In construction project large numbers of companies participate in one project which makes the construction supply chain a fragmented structure. Due to this fragmentation the main contractor can adopt the supply chain management policies like in manufacturing industry by trying to work with same subcontractors and supplier repeatedly.

7.6 Relationship Management

The studies reveal that it is necessary to change the traditional hostile relationships into positive and cooperative relationships among the different parties involved in a construction project. Relationship management is a way which gives cooperative atmosphere for all organizations working in a construction project, including subcontractors down in the supply chain. This participation of subcontractors gives rise to more productive relationships according to project objectives [Cheung Y.K Fiona., Rowlinson Steve (2007)]. They also concluded from case studies that leadership plays an important role in relationship management. Without the real efforts of senior management of organizations the relationship management is difficult to develop. [Cheung Y.K Fiona, Rowlinson Steve (2007)] describes that relationships among firms also depends upon the organizational culture. He categorizes organizational culture in three categories.

i) "*Task culture"* is found in organizations which works in a competitive market and where the project life is comparatively small. The organization comprised of a project team which changes from project to

project. Most of the participants are temporarily hired professionals or groups.

ii) "*Role culture"* exists in comparatively large companies where specialization and technical expertise are given due importance. Organizational structure does not change frequently in different projects. Professionals and specialists are not expected to abandoned or replaced frequently, they continue from project to project.

iii) "*Power culture"* is found in small organizations. Power is held by a single individual or a group. The single person/group form all the policies and his powers are beyond any title. Since maximum powers are held by head of company so this type of organizations are generally more flexible in risk taking and decision making.

Due to the competitive and hostile atmosphere among the organizations in construction industry, the move towards productive and collaborative relations requires some cultural change. Relationship management requires some change in current attitudes, which is an issue of organization management and requires education and trainings of staff. The change in industry culture and inter organizational relationship is a long term process. This change requires long term and consistent development in relations among the organizations which often work together in different construction projects.

Trust is an important factor in relationship management. In construction industry the organizations are more worried about their trade secrets and therefore do not open up to form joint ventures or long term relationships. In this case the top management is responsible to make policies regarding relationship management. Project management techniques and software's which can be used mutually by supply chain members will provide an effective platform for relationship development. Relationship management is also important in integrating the mismatched culture of different organizations.

Non-cooperative behavior of subcontractors may temporarily prove beneficial for them (not all in a construction project) but over all it causes negative effect on the project in form of delays, less profit, low quality and

defects. More over it badly affects the trust which is essential for long term relationship among these subcontractors. Non-cooperative behavior causes hurdle in creation of effective construction supply chain within the parties who often have to work together in the construction industry.

The unique nature of construction industry is also discouraging for relationship management. It is natural phenomena that long term relationship can only be achieved if there is continuity in relations. In construction sector the projects are unique and vary according to nature, location, construction procedure so subcontractors do not foresee continuity of relations with main contractor or with other subcontractors.

Commitment of leadership and special interest of senior members plays key role in pushing forward the relationship management efforts. All parties big and small should know the benefits of relationship management and also clearly understand the approach to move forward in this regard. The approach toward relationship management requires special emphasis on interest of top management, training and motivation of staff, understanding the long term benefits and special role assigned to effective members to act as facilitator.

Chapter 8
Construction Contracts

8.1 Introduction

A construction contract is a document which legally binds the two parties. Generally these parties are customer and builder. Customer and builder may vary such as client and main contractor, main contractor and subcontractor, subcontractor and sub-subcontractor. The main purpose of the contract it to control the relationships between the two parties, determine obligations and responsibilities for the parties. Construction contract also helps to make decisions in case of any unexpected problem arises.

In this chapter the issues related to subcontracting in construction contracts will be discussed. Construction contracts in Pakistan construction industry and internationally used construction contracts will be discussed especially contract conditions related to laws and management of subcontractors.

8.2 FIDIC Conditions of Contract

International Federation of Consulting Engineers (FIDIC) has published a series of contract documents according to the different types of construction projects. FIDIC has revised its contract documents after every few years according to the requirements. The changes are necessary to made because of the development and complexity of construction industry and to overcome the problems which are realized with experience. The different types of FIDIC contract documents according to the publication in 1999 are:

1. Condition of Contract for Construction, published in red cover page (known as FIDIC red book), this book is for building and engineering works designed by the employer. Generally in this type of contracts the contractor is given the responsibility to construct a project according to the design provided by the client. The design provided

by client may be in full detail or some times contractor has to design minor elements of civil, electrical or mechanical works.

2. Conditions of Contract for Plant and Design-Build, published in yellow cover page (known as FIDIC yellow book), this book is for the electrical and mechanical plants and for the design and execution of building and engineering works. Generally in this type of contracts the contractor provides the design of plant and other works according to the requirements of the client. The work may be a combination of electrical, mechanical and civil works. This contract book is replacement of previous FIDIC orange book and yellow book.

3. Conditions of Contract for EPC/Turnkey Projects, published in silver cover page (known as FIDIC silver book), in this type of contract the contractor is totally responsible of designing, construction and finishing till ready to operate condition (project ready to operate at turn of key). This is a new form of FIDIC contract.

4. Short Form of Contracts, published in green cover page (know as FIDIC green book). This book is recommended for building or engineering works or relatively small capital value. This is suitable for projects where relatively simple form of works. For works where a short form of contract is sufficient.

5. Form of Contract for Dredging and Reclamation Works, published in blue cover page (known as FIDIC blue book).

Other than these books FIDIC has published guides and publications for different construction related aspects. [FIDIC contract guide, (2000]

8.3 Construction Industry

Construction projects vary from simple materials and methods to high tech materials, machinery and complex interrelated systems. Other than the highly advanced materials and technology, any reasonable sized construction project contains complex organizational process. This complexity is due to the involvement of many types of specialists and professions contributing useful efforts in the project. Construction industry contains so many disciplines that some times it creates confusion about the limits of construction sector. [Murdoch John, Hughes Will (2008)] describe that the activities involved in construction industry are of such a wide range that the external limits cannot be clearly specified. The word construction also means different nature of projects for example it involves demolition, erection and repair of diverse type of structures. These structures may be residential buildings, commercial buildings, community building, sports halls, roads, motorways, bridges, towers, factories, rail roads, pipelines, underground construction, under water construction etc. Most of the construction firms restrict themselves in particular type of construction but large firms have different organizational setups for different type of constructions containing relevant expertise and professional. Therefore construction industry contains a diverse range of professionals, experts and suppliers. These participants have different kind of skills, belong to different organization and have different geographical origins and cultural background.

Keeping in mind all above properties of construction industry it seems difficult that a general contract document can be used in all type of construction projects.

Therefore contract documents sometimes seemed to be more generalized as compared to other legal documents. Due to this factor confusions arise during construction and disputes are a common practice in construction projects. Contract conditions also realize this deficiency and provide different systems to resolve disputes and confusions.

In the construction phase of a project there are generally three main stakeholders who are client, designer and builder or contractor. Since

Pakistan construction industry is the main focus of this study and in majority of public and private sector construction projects in Pakistan the project is designed by client or a separate designing organization and then it is awarded to a builder for construction. In international contract conditions like contract documents of FIDIC there are different types of contract documents for different conditions. For contract conditions in which project is designed by the client and then awarded to builder the FIDIC Red Book "Condition of Contract for Construction" is the relevant international contract document.

8.4 Subcontracts in Construction

When contractor out source one or more activities to a third party then this act is called subcontracting. The deal or contract between contractor and subcontractor is called subcontract.

In Pakistan construction industry some times subcontract is finalized by only a verbal deal. This verbal deal is normally described the general rate of subcontract work. Some times a very brief contract is signed which only describes the main features i.e. price, quantity, duration. In case of disputes these simple contract are not sufficient to resolve the matter. Like main contract, subcontract should also be a detailed document capable to address all possible conditions and outcomes.

In Pakistan different public sector organizations use their own standard contract documents. These contract documents are almost similar as far as general conditions of contract are concerned. But there is no standard subcontract used in Pakistan construction industry. There does not exist any standard form of subcontract. Therefore contractor and subcontractor try to avoid lengthy and time consuming contract document procedure. As a result very brief subcontracts are signed. These subcontracts usually cause no trouble and prove very efficient. In case of complex working conditions and disputes these brief subcontract are insufficient to resolve the disputes.

The general condition in main contracts about subletting or outsourcing activities by the builder/contractor states that contractor is not allowed to sublet any part or complete work to any other organization without the prior

permission of the client or client's representative other than the certain firm already mentioned and called nominated subcontractors.

Nominated subcontractors are those which are selected by client and contractor is asked to award subcontract to them. There may be different reasons for nomination of subcontractors. For example due to quality standards, special skills or if any part of project need long time then it is awarded by client very earlier or sometimes before the award of work to main contractor. Mostly in case of client's selected subcontractor, the main contractor is paid according to the cost of nominated subcontractor and it is called cost reimbursement. Some times contractor pays to nominated subcontractor from his own contract cost. Since the nomination is made by client so it also shifts the existing balance of risk responsibility between main contractor and client [Construction contracts, 2008].

Due to the increased role of subcontractors in construction industry the need of an effective subcontract document is essential. The construction industry of almost every developed country has introduced contractual conditions for subcontracting. Some recent and effective efforts in this case are discussed below.

8.5 FIDIC "Conditions of Subcontract"

FIDIC has published a test edition in 2009 for conditions of subcontracts. The title of book is "Conditions of Subcontract for Construction – for building and engineering works designed by the employer". This book describes the conditions of subcontracts for construction projects where the main contract is on the basis of FIDIC red book. The red book for subcontracts mainly consists of three parts.

Part 1 This part named "General Conditions of Subcontract" describes the general conditions which generally applicable to most of the subcontracts.

Part 2 This part is titled "Guidance for Preparation of Particular Conditions of Subcontract". This part describes the conditions

which are not applicable to every subcontract but applicable according to the particular project conditions.

Part 3 This part consists of different Forms (Subcontractor's offer, Contractor's acceptance and Subcontract agreement)

The FIDIC Red book is widely accepted in international construction industry, especially in international construction projects. FIDIC contract conditions proved very useful in international construction projects in developing countries. Mostly contract documents in developing countries do not have balanced construction laws for international contracts. FIDIC contract conditions are also used as standards in judgments of construction disputes. Even if these are not adopted in construction contracts, these serve as references.

The FIDIC conditions of subcontract are prepared and recommended to use back to back with the FIDIC Red Book "Conditions of Contract for Construction, for building and engineering works designed buy the employer". [FIDIC Red Book Subcontracts (2009)].

The FIDIC Contracts Committee was the principal director in the drafting of subcontract. This contracts committee comprised of Michael Mortimer-Hawkins (SwedPower, Sweden), K.B. Norris (consulting engineer, U.K.), and John Bowcok (Sir Alexander Gibb & Partners Ltd., U.K). Main drafting persons of "FIDIC conditions of subcontract" were two French lawyers, who are in private practice in Paris. [Seppala R. Christopher (1995)]

Other than the experts and lawyers mentioned above some international organization were also consulted for preparation of subcontract conditions. These organizations include World Bank, European Confederation of Construction Specialists, European International Contractors and International Bar Association. Three independent construction experts were also among the consultants. These consultants (external to FIDIC) were an engineer, a lawyer and an insurance expert [Seppala R. Christopher (1995)].

8.6 U.K. Housing Grants, Construction and Regeneration Act 1996

The Housing Grants, Construction and Regeneration Act 1996 (HGCRA, 1996) was introduced in U.K. on 1st may 1998. The Act consists of five parts containing 151 sections. This act consists of 89 pages and further 14 pages of schedules. Part II of the Act (Construction Contracts) is particularly interesting for this discussion. The most important aspect of the Act is introduction of adjudication.

In construction industry main contractor have dominant position as compared to subcontractors. Its dominant position is due to its authority on releasing payments, setting targets, instructions to subcontractors and due to its financial position. Most of the time subcontractors complain about the main contractor's exploitation. The dominant position of main contractor as compared to subcontractors gives them advantage in case of disputes. Financially strong contractor can afford to hire services of better lawyers and use other tactics in legal matters. Therefore subcontractors being a weaker opponent cannot get justice. The purpose of this Act was to keep a balance between contractor and subcontractor and to resolve disputes fairly. It provides a cheap and rapid dispute resolution through adjudication.

The part II of the Act focuses on two main aspects of subcontracting in construction industry

- Payment abuse
- Cheap & rapid dispute resolution by introduction of provision of adjudication.

8.6.1 Payment Abuse

Some important features about payments are discussed below. By introducing these provisions in the Act the complaints by subcontractors about payment abuses are certainly addressed.

- The Act introduced provision for interim / stage payment in case if the contract duration is more than 45 days. However the concerned parties

decide mutually about the amounts and intervals of these running payments.

- In case of non payment according to contract the suffering party will serve a notice within five days after the due date of payment. These notices will certainly favor subcontractors in case of payment abuse matters during dispute resolution process.
- The Act also give right of suspension of work in case of non payment. If the paying party does not pay according to due date without any withholding notice then aggrieved party can suspend work by serving at least seven days notice.
- The Act does not allow conditional payment (pay-when-paid) conditions. It only allows conditional payment when the paying (third) party becomes bankrupt [HGCRA, 1996].

  Pay-when-paid condition is widely used in construction industry. Contractors pay their subcontractor after they receive payment of that particular subcontract work from client. Pay-when-paid condition gives extra benefit to main contractors by shifting some of payment risks toward the subcontractors. Further more main contractors do not invest from their own but subcontractors act as short term financer for them. The Act has created a balance between contractor and subcontractor to restrict these kinds of conditional payment practices in construction industry.

8.6.2 Adjudication

Adjudication may be described as a process of dispute resolution where powers of making an interim decision are given to a third party individual called adjudicator. This Act gives right to any party involved in construction contract to refer to an adjudicator for a decision in case of dispute. According to 'HGCRA 1996' this decision is binding until it is settled in arbitration or litigation.

Some main provisions of the Act about adjudication are listed below:

- The Act makes this provision that any party can refer a matter to adjudicator in case of dispute.
- The adjudicator will make a decision within 28 days. Adjudicator may take further time up to 14 days if referring party agrees.
- The decision of adjudicator will be binding for both parties. It will be an interim decision which may be further settled by arbitration or litigation. The process of adjudication is not new and it is often practices in construction industry. In U.K. due to this Act, the decisions of adjudicator are now compulsion for both parties till it is further challenged by arbitration / litigation.
- For this adjudication provision of the Act it is necessary that both the parties must have a construction contract in writing between them.

The surveys and studies after implementation of this Act show that the adjudication has proved a revolutionary change in dispute resolution process.

Due to the effectiveness of compulsory adjudication in UK construction industry similar legislation is also made in other countries. Some similar legislative steps about compulsory adjudication in Australia, New Zealand and Singapore are listed below [Elliott F. Robert (2004)].

- The Building and Construction Industry Security for Payment Act 1999 No. 46 in New South Wales, which came into force March, 2000.
- The Building and Construction Industry Payments Act (BCIPA) in Queensland which came into force in October 2004.
- The Construction Contracts Act 2004 (No. 16 of 2004) in Western Australia came into force in January, 2005.
- The Construction Contracts Act 2002 (No 46 of 2002) of New Zealand, came into force in April, 2003.
- The Building and Construction Industry Security of Payments Act 2004 of Singapore came into force in April, 2005.
- The Malaysian Construction Industry Development Board is also working on “Construction Industry Payment and Adjudication Bill” introducing compulsory adjudication for the Malaysian construction industry.

8.7 Dispute Review Board

The Dispute Review Board (DRB) is widely used in United States on large construction projects. DBR consist of three neutral experts. The DBR is finalized before the start of construction. Each party selects a reviewer with the approval of other party and then these two reviewers select the third with approval of both the parties. DBR is provided with all compulsory documents e.g. contract documents and also regularly kept informed about project development.

When the two parties are not able to resolve the dispute then matter is brought to DRB. The decision of DRB is a non-binding. However it becomes effective by the provision in contract that DBR decision is admissible in further arbitration or litigation.

Part 2
Empirical Studies

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Chapter 9
Construction Disputes

9.1 Introduction

Main stakeholders in construction projects are Client, Designer, Contractor, Subcontractors and Suppliers. Conflicts and disputes are common in construction projects. There are many reasons of comparatively large number of disputes in construction industry.

- Stakeholders involved in construction project, temporarily work together (during the project only)
- Unique nature of each construction project.
- Uncertainty in working conditions
- Comparatively greater chances of risk involvement
- Huge amounts involved
- Temporary interaction of different parties having their own working practices, aims and targets.

In Pakistan construction industry it has been observed that disputes which are in litigation and arbitration, mostly between client and main contractor. Although there are lot of disputes occur between contractor and subcontractors. Subcontractors usually do not refer these disputes for arbitration or litigation. The reason is that subcontractors are small firms and cannot afford the higher costs involved in arbitration and legal proceedings. Some times the litigation charges are increased from the amount of claim. Major portion of amount of dispute is taken by legal advisers / lawyers. Due to these circumstances, if there is dispute between main contractor and subcontractor then subcontractors usually agree on lesser than they actually should deserve.

It has been observed that conditions are similar all over the world. In construction industries of UK and US the small firms can not afford the higher

costs of litigation and usually avoid it. In these circumstances the choices for subcontractors are:

- Try to resolve by mutual negotiation or
- Forget it

9.2 Dispute Resolution in Construction Projects

There is necessity to provide cheap dispute resolution and bring fair conditions among all stakeholders in construction projects especially for small dependant firms (subcontractors and suppliers). For this purpose several efforts have been done internationally. FIDIC has published a test edition "Conditions of Subcontract for Construction" in 2009. Government of UK has introduced "housing Grants, Construction and Regeneration Act 1996" in May 1998. Construction experts in United States has introduced concept of Dispute Review Board (DRB) in construction projects. Almost in every country efforts have been done in this regard.

Two basic efforts regarding problems of disputes in construction projects may be:

- Balanced and realistic contract conditions (Dispute avoidance)
- Cheap and efficient dispute resolution process (Dispute resolution)

According to the scope of this study the main focus is on disputes among main contractor and subcontractors. As discussed above that subcontractor being small firms generally try to resolve dispute by mitigation. Mostly subcontractors do not go for arbitration and litigation. Therefore the data available for the dispute cases through arbitration / litigation records does not reflect the realistic figures. However data regarding disputes, among contractor and subcontractors, referred for adjudication is available by some surveys in UK. After introduction of "HGCRA 1996" in May 1998 it was convenient for subcontractors to refer their disputes for resolution through adjudication. Therefore surveys carried out in UK about the disputes referred

for adjudication in construction projects, after introduction of “HGCRA 1996” reflect realistic figures.

9.3 Surveys about Adjudications in Construction Industry in UK

Surveys carried in UK about adjudications of disputes in construction projects after introduction of “HGCRA 1996” describes realistic facts. Some these surveys are listed below [Lynch R. Paul, 2002].

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- A survey carried out by lawyers of ‘Pinsent Masons’ (construction law firm UK). Data collected by Masons’ solicitors from participants of annual construction law conferences and information on the basis of about one hundred adjudication cases with which ‘Pinsent Masons’ was involved. [Carey Peter (2000)]

- The School of Engineering and Built Environment, University of Wolverhampton, U.K carried out a study based on questionnaire survey relating to different adjudication cases up to Sep. 2000 in UK. [Lynch R. Paul, (2002)]

- A questionnaire survey carried out by Liam Holder of JR Knowles in 2000. The survey carried out from main contractors, subcontractors and related professionals (engineers and solicitors). Total 500 questionnaires were distributed from which 159 were returned. Out of these returned questionnaires 44 were incomplete and results were compiled from 115 completed questionnaires. [Holder Liam (2000)]

- A series of reports on adjudication published by “School of Built and Natural Environment”, Glasgow Caledonian University, Glasgow, UK. Ten reports have been published from year 2000 to 2010 [Kennedy Peter *et al*. (2010)].

Some interesting analysis on the basis of these surveys, are shown here.

9.3.1 Distribution of parties involved in adjudication

The survey carried out by University of Wolverhampton shows the distribution of parties involved in adjudication cases. The observations are shown in figure 9.1a.

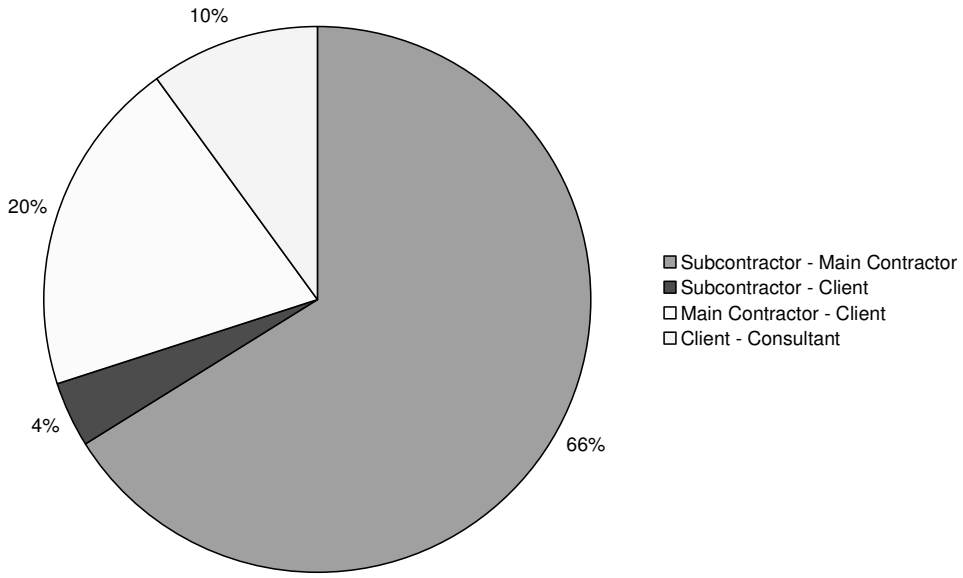

Figure 9.1a: Parties Involved in Adjudication (University of Wolverhampton)

Glasgow Caledonian University in its report No.10 [Kennedy Peter *et al* (2010)] has observed the following distribution as shown in figure 9.1b.

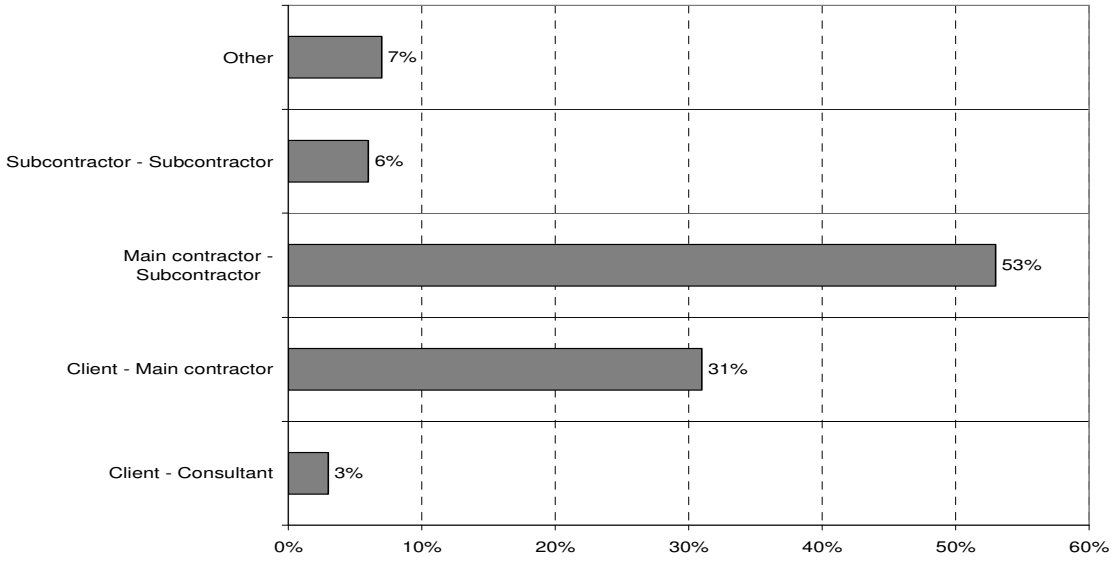

Figure 9.1b: Parties Involved in Adjudication [Kennedy Peter *et al* (2010)]

The above distribution shows that the main parties involved in construction projects disputes are main contractor and subcontractor. This result shows the importance of improvement or introduction of subcontract conditions in construction projects. It also indicates the importance of availability of cheap and rapid dispute resolution process.

9.3.2 Parties Referring for Adjudication

The survey carried out by Liam Holder of JR Knowles [Holder Liam (2000)] found about the parties referred for adjudication.

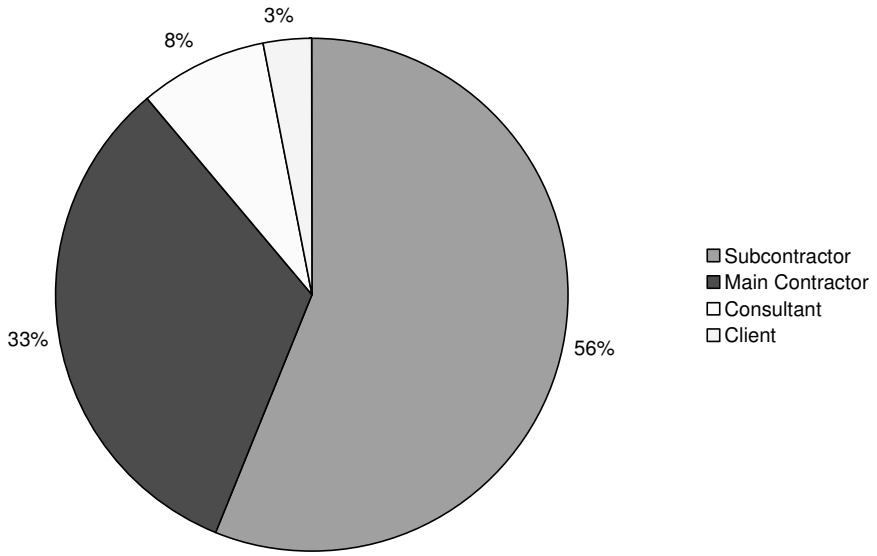

Figure 9.2: Parties Referred to Adjudication [Holder Liam (2000)]

The above distribution shows that the subcontractors are major group demanding disputes resolution. As described earlier that subcontractors complaint about payment abuses and other exploitations of main contractors. Therefore it indicates that when there is a choice of affordable dispute resolution process then small parties will be hopeful in case of disputes. More over financially stronger parties will not be able to exploit weaker partners in construction projects.

9.3.3 Main Issues of Disputes

Glasgow Caledonian University in its report No. 10 [Kennedy Peter et al, 2010], observed the distribution of different issues involved in disputes between main contractor and subcontractors as shown in figure 9.3a. In another survey carried out by the School of Engineering and Built Environment, University of Wolverhampton the nature of disputes in adjudication cases, is shown in figure 9.3b.

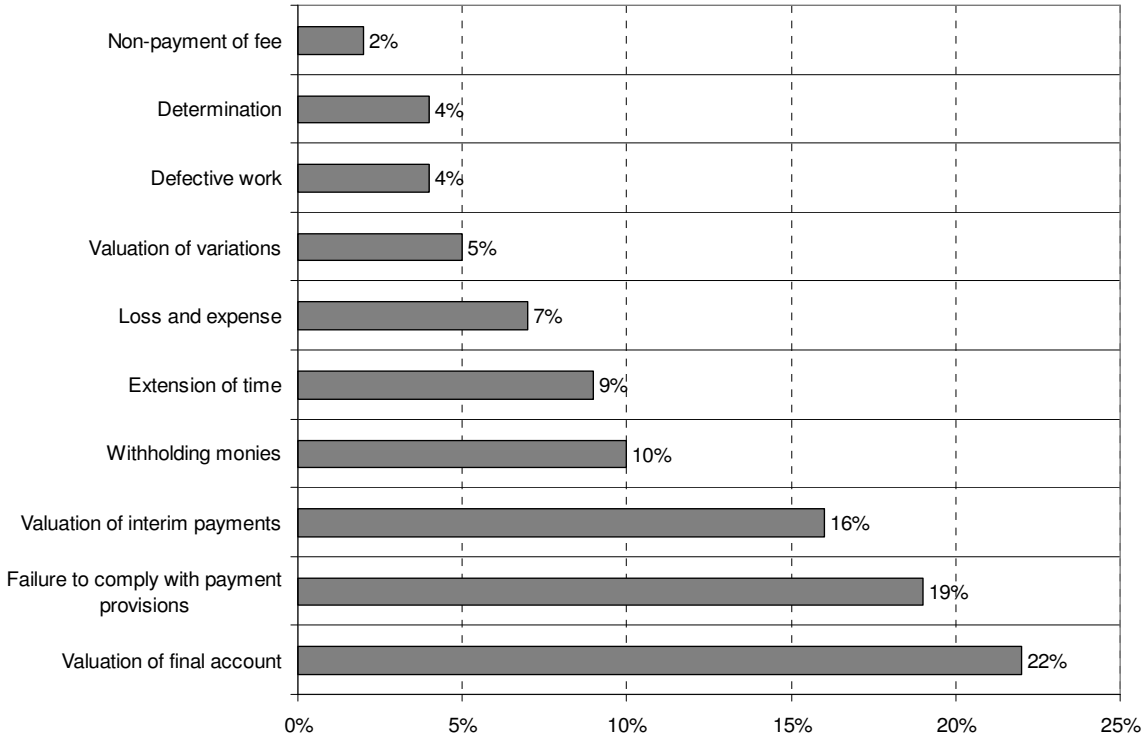

Figure 9.3a: Main issues in disputes [Kennedy Peter *et al.* (2010]

There are some statistical differences in both of these surveys. This is a normal situation. The statistical data of two different surveys may differ due to different factors. These factors may be method of survey, type and number of respondents, type of questions. However there is consistency in both the survey results. These results show that the main reason of disputes between main contractor and subcontractor is payment. It also indicates the importance of adjudication for resolving the payment related issues, cheaply and efficiently. Otherwise small contractors would not be able to challenge big

contractors due to huge cost involved in arbitration or litigation. Mostly subcontractors do not go for arbitration or legal proceedings and prefer to compromise on a reduced or no payment against their claim.

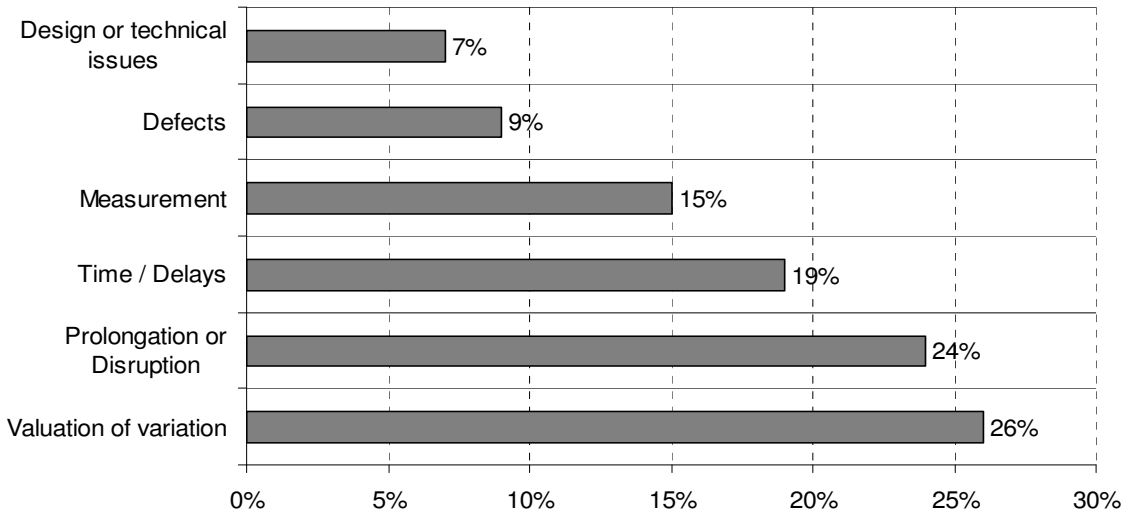

Figure 9.3b: Main issues in disputes (University of Wolverhampton)

9.3.4 When disputes are referred for adjudication

Glasgow Caledonian University in its report No.10 [Kennedy Peter *et al.* (2010)] observed that the disputes are referred for adjudication at following construction stages shown in figure 9.4a.

In another survey carried out by Pinsent Masons [Carey Peter (2000)] it was observed that the stages at which disputes are referred for adjudication are shown in figure 9.4b.

The results show that large numbers of disputes are referred for adjudication after physical completion of project. However a considerable proportion of disputes are usually referred to adjudicators during the construction phase. This shows how disputes cause bad relationships and also poor cooperation during the construction stage.

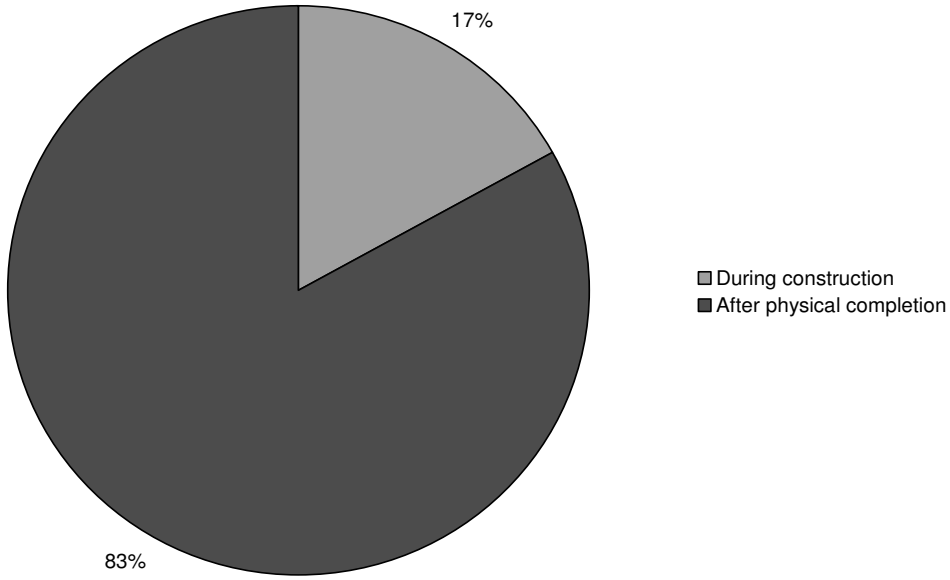

Figure 9.4a: Construction stage when Adjudication is initiated. [Kennedy Peter *et. al*. (2010)]

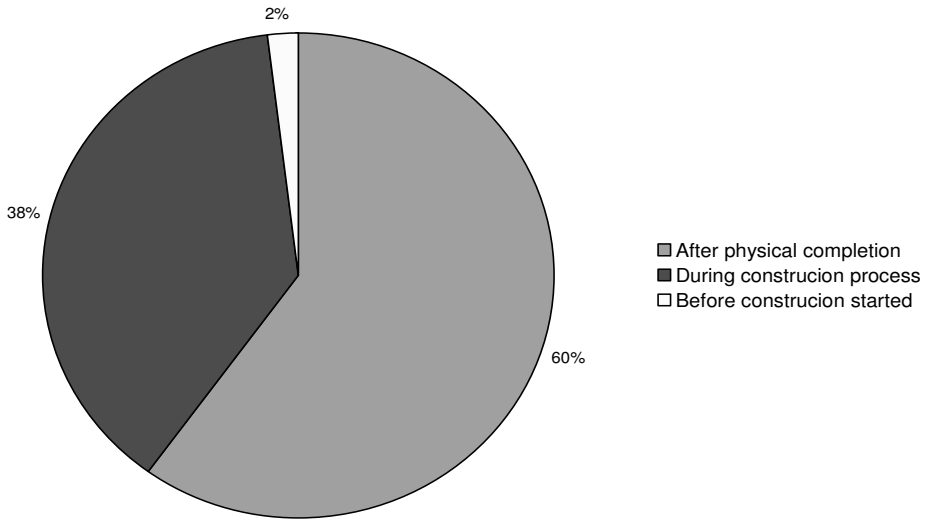

Figure 9.4b: Construction stage when Adjudication is initiated [Carey Peter (2000)]

Major proportion of disputes is brought to adjudicators after project completion. This does not mean that disputes occur at this stage. Disputes occurred during construction stages but both parties continue to concentrate on work rather than to abandon work and go for dispute resolution. Some times both parties negotiate and try to settle disputed matter till at the end. When these final negotiations are not settled mutually then they go for adjudication. It is shown earlier that major disputes are related to payment. These payment related matters realized or become intense during account closing and final payments. Therefore these payments related issues referred to adjudication after completion of project.

9.3.5 Price involved in dispute

The University of Wolverhampton in its survey observed the cost involved in disputes. The distribution of construction disputes according to different cost ranges are shown in figure 9.5a.

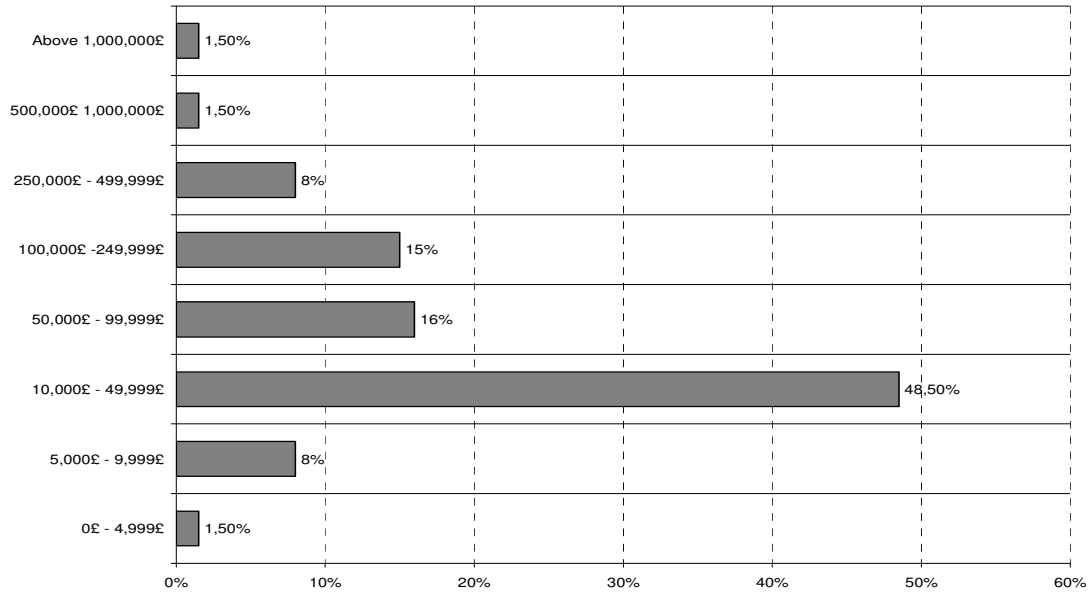

Figure 9.5a: Value of Disputes (University of Wolverhampton)

According to the survey carried out by Liam Holder of JR Knowles [Holder Liam (2000)] the range of cost involved in disputes is shown in figure 9.5b.

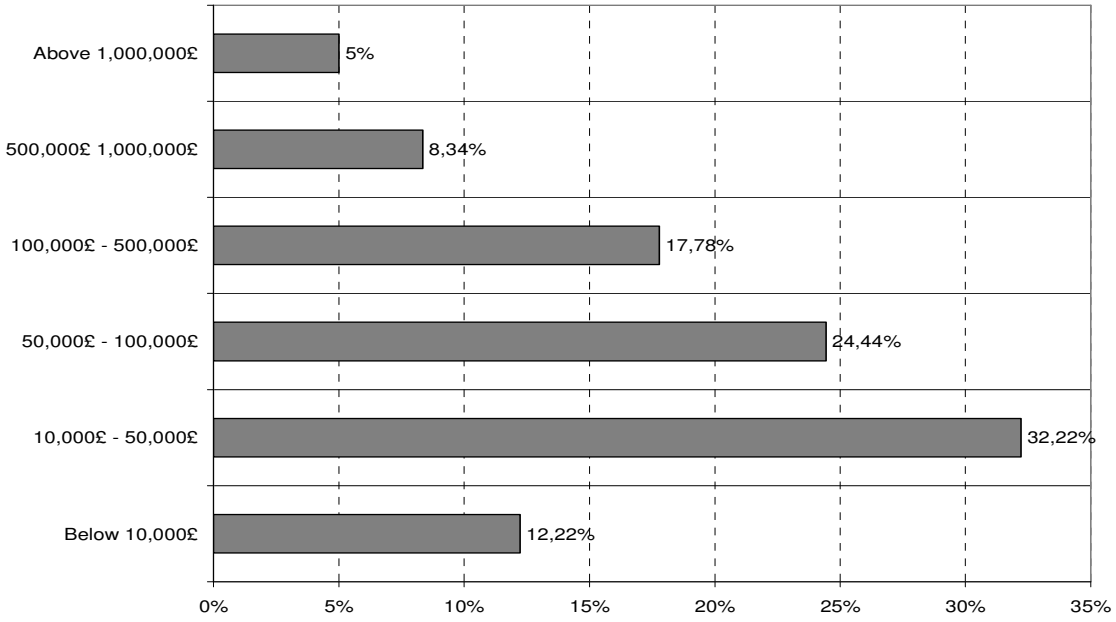

Figure 9.5b: Value of Disputes [Holder Liam (2000)]

Both the survey results shown above are consistent. These shows that cost involved in major portion of disputes referred for adjudication is less than £50,000. In view of the costs involved in construction activities these are low cost disputes. The reason of majority of low cost disputes is due to the type of parties involved. As it is shown in previous surveys that majority of disputes are between main contractor and subcontractor. Each construction project has several subcontractors and cost of subcontract work is obviously much lower than total project cost. Therefore the related disputes are also low cost disputes.

Another reason for low cost disputes is that referring party cannot afford high dispute resolution cost. Therefore for the disputes which have low costs involved the first choice of resolution is adjudication. The cases which are not referred for adjudication but directly referred to arbitration or litigation are not indicted in above surveys. For the disputes of high costs the parties go directly for arbitration or legal proceeding. The reason is that the adjudication is an interim decision and the referring party knows that due to high cost involved, it will ultimately be settled in arbitration / litigation. Moreover disputes of high costs are more complex in nature and referred party thinks that it is

beyond the expertise of adjudicator. The short decision making period (28 days) of adjudication is also considered not enough due to the nature and complexity of disputes. If there are some field tests, technical opinions and other observations are involved in fair judgment of dispute then adjudication obviously will not be the choice.

9.3.6 Acceptance of adjudication decisions

The provisions of adjudication in HGCRA 1996, proved a revolutionary step toward balancing the powers between main contractor and subcontractor. According to the Act the adjudicator's decision is a binding but it is an interim decision which ultimately will be settled by arbitration or litigation. It means if any party is not satisfied with the adjudicator's decision then it may challenge it. According to survey carried out by Pinsent Masons [Carey Peter (2000)] it was observed that most of the adjudication decisions were accepted as final decision and not challenged in courts. The figure 9.6 shows the result of this survey.

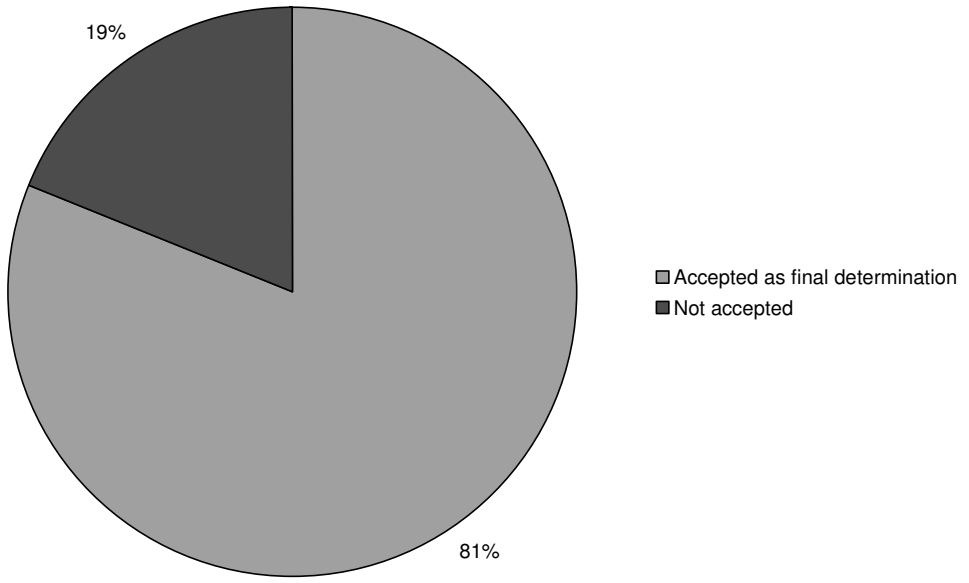

Figure 9.6: Adjudication decisions accepted or not. [Carey Peter (2000)]

One of the reasons of acceptance of adjudication decisions may be the cost of disputes. As it is indicated in previous survey results that majority of cases referred for adjudication were below hundred thousands pounds. Therefore high expenditures involved in litigation or arbitration have made it unfeasible to challenge the decision.

This survey outcome also shows the success of adjudication. Disputes involving relatively low costs and small contractors are settled cheaply. Therefore the provision of adjudication provides an opportunity to subcontractors to get rid of main contractor's exploitations.

9.3.7 Cost of adjudication

Liam Holder of JR Knowles [Holder Liam (2000)] asked in his survey about the cost involved in adjudication process. Most of his respondents were satisfied with the cost involved in adjudication. The survey result is shown in figure 9.7.

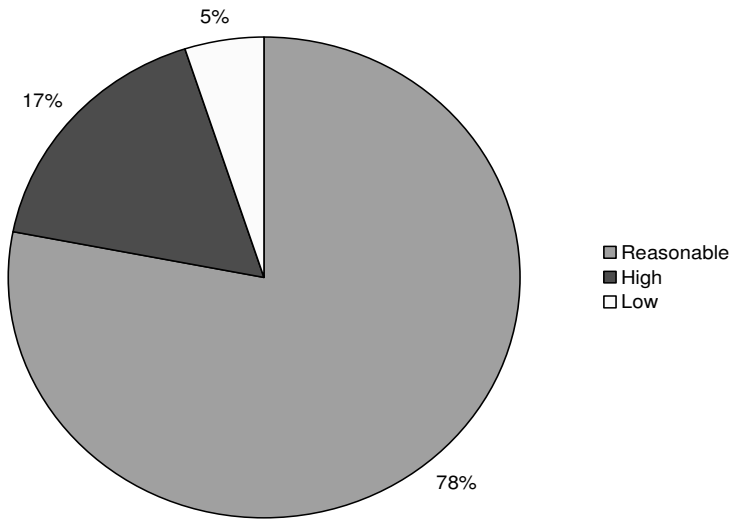

Figure 9.7: Cost of adjudication. [Holder Liam (2000)]

Holder further inquired to respondents about the cost of adjudication as compared to cost involved in dispute resolution before adjudication provision. The majority of respondents describe that cost is considerably cheaper than it

has to be paid in other dispute resolution processes. The out come of Holder's survey regarding this comparison is shown in figure 9.8.

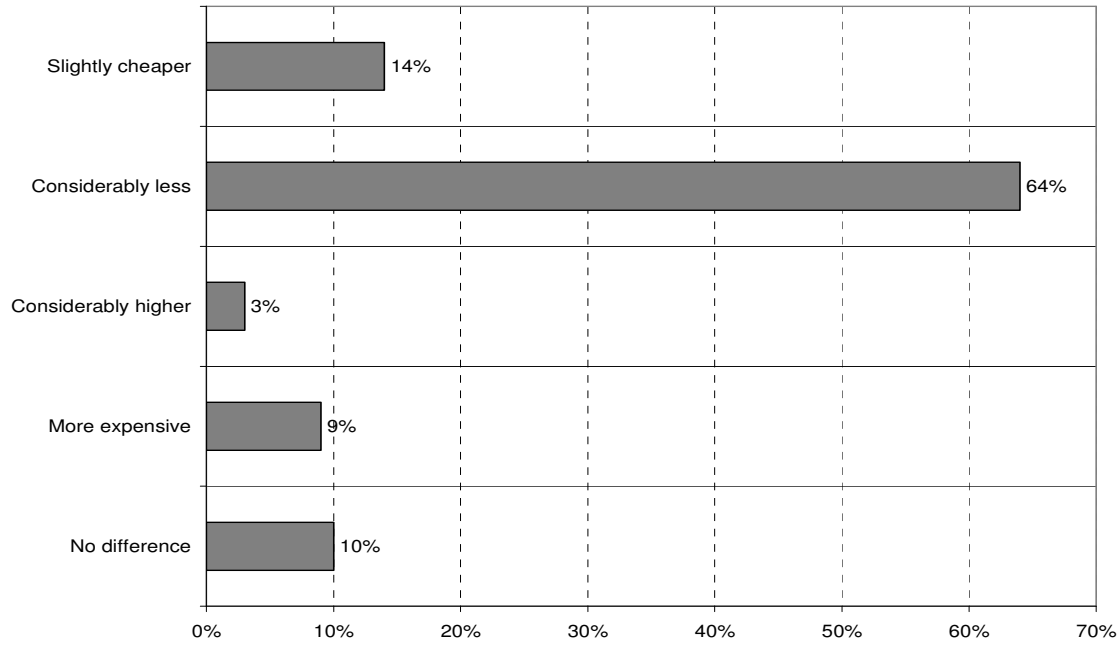

Figure 9.8 : Cost of adjudication as compared to previous costs. [Holder Liam (2000)]

The figures shown in above survey outcome are not surprising. It is obvious from the adjudication process. In alternate processes both the parties involved in disputes have to get services of legal experts to present their cases. Moreover the process may take many months till the final determination. Therefore the costs involved in arbitration or litigation processes are very high as compared to adjudication. In adjudication parties only have to pay to a single adjudicator for a limited period.

The survey shows that some respondent also thinks that adjudication is more expensive than the previous dispute resolution cost. It may be the opinion of small subcontractors who are usually involved in low cost disputes. Due to the high costs of dispute resolution they only relied on mitigation for their low cost disputes. Since mitigation costs much less so adjudication is comparatively expensive for them.

9.3.8 Trends of adjudication decisions

Glasgow Caledonian University in its report No.10 [Kennedy Peter *et. al*. (2010)] found that in most of the cases the adjudication decisions were in favor of referring party. The concerned result of survey is shown in figure 9.9.

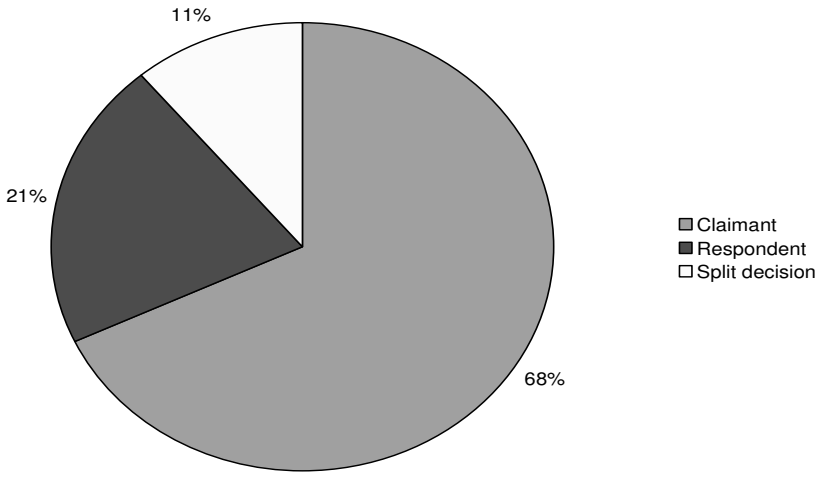

Figure 9.9: Trend of Adjudication decisions. [Kennedy Peter *et. al*. (2010)]

It does not simply mean that who ever refer for adjudication, will has more chance to win. Actually in construction projects the entire related parties do not like in involve in disputes and then further in expensive and time consuming resolution processes. Therefore only the aggrieved contractor, who has strong case, will refer for adjudication. Due to this reason the survey results show that most decisions are in favor of referring party. Another reason may be that referring parties takes their time for preparation before referring for adjudication. On the other hand defending parties have limited time for preparation.

9.4 Conclusions

Disputes can not be avoided in construction projects. Due to the complexity and uncertainty of construction process, the different parties involved often have disputes between them. Some times these disputes are settled mutually

or by mitigation and some times they need a neutral third party to decide. Usually many subcontractors are involved in construction projects; they get their payments from main contractor. Subcontractors often complain about payment abuses and other exploitations by main contractors. A rapid and cheap process of dispute resolution can reduce these complaints. As the subcontractors being comparatively small party cannot afford high dispute resolution costs. Therefore they have to accept main contractor's decision in case of difference of opinion.

"HGCRA 1996" by the introduction of adjudication has addressed this problem. This Act has played an important role in creating a balanced environment between weak 'subcontractors' and dominant 'main contractor'. Other than the provision of adjudication this Act also addressed some other subcontractor's problems. It has reduces the chances of payment abuse by addressing the issue like conditional payment and withholding payment. The surveys carried out after introduction of "HGCRA 1996" in 1998 showed a considerable improvement in construction industry of UK.

Disputes are a major issue in construction industry which needs to be addressed. Continuous efforts in form of reforms in construction contracts and related laws need to be done. Cheap and rapid dispute resolution process will help subcontractors in their survival and also their value added contribution in construction industry.

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Chapter 10
Questionnaire Survey

In order to get the views of actual actors involved in supply chain of construction projects a survey was conducted. The survey was conducted in Pakistan. The purpose of survey was not to make a quantitative data analysis but to collect information about the views of main contractors and subcontractors about the issues in SCM, specially the relationships between main contractor-subcontractors and subcontractors-subcontractors.

10.1 Survey Methodology

Since it was a qualitative survey and the quantitative data collection was not the purpose therefore it was not tried to increase the number of participants but keeping the number of participants low it was tried to make sure that the participant should understand the meanings of each question clearly. To achieve this target each participant was approached personally and every question was explained to the participant and then the comments were recorded. Mean while the observations and comments of participants about the related issues other than the questionnaire were also recorded.

Two questionnaires were prepared, one for the contractors and one for the subcontractors. The nature of information asked in both the questionnaires was same but these were described differently. Each questionnaire has two main parts. The purpose of first part was the collection of information regarding different types of issues among subcontractors and main contractors. The purpose of second part was only the collection of views about the importance of different factors acting as barriers and supportive for cooperation among subcontractors.

Since the major construction projects in Pakistan are financed by public sector and public sectors have their own enlisted contractors. This enlistment means only those contractors can participate in public sector projects bids which are prequalified by the respective government department. The survey was conducted in the major province of Pakistan, called Punjab.

Figure 10.1 shows the provincial distribution and major cities of Pakistan. Punjab is the largest province of Pakistan with respect to economy and population.

Figure 10.1 Map of Pakistan showing the Provinces

The main contractors and subcontractors of the largest provincial department in construction were approached. This provincial department is responsible for the construction and maintenance of the provincial roads, bridges and buildings. In the enlistment/prequalification process of this department there is no division between main contractors and subcontractors but the contractors are divided into classes, such as A, B, C, D in order to fix a maximum cost limit of construction projects for these contractors. The contractors are listed in respective category according to their experience, machinery, staff, and financial position. In this survey, contractors within the category “A” (no upper cost limit) and category “B” are surveyed as main contractors. While the contractors in category “D” which has lowest upper cost limit were treated as subcontractors because mostly these contractors work as subcontractors in large projects. Subcontractors also include those firms which are not enlisted

government contractors but these are small specialist firms which are being sublet work by contractors of public sector construction projects.

In order to make the survey more effective and getting the actual views of main contractors/subcontractors the questionnaires were translated in national language (Urdu). Different contractors in the three largest cities of province of Punjab (Lahore, Rawalpindi and Faisalabad) were approached personally by the author or author's representative. During the process of filling the questionnaires each questioned person was given explanation and exact meaning of each question by the author or author's representative. Total 68 contractors were questioned, 37 fall under category of main contractors and 31 are in Category of subcontractors.

10.2 Target Information in Questionnaires

The following information was tried to collect with the help of questionnaires.

- Procedures usually adopted by main contractors in order to select subcontractors for its projects.
- The preferences which are being mostly considered while selection of subcontractors.
- Trend of continuation with the same construction partners in different projects.
- Level of cooperation among subcontractors during the execution of construction project.
- Getting views of main contractors and subcontractors about some critical issues like payments, schedules and transfer of risks.
- Trend of long-term partnership among different construction firms (main contractors & subcontractors) who usually have to work together and the expected results of this kind of partnership.
- Influence of different factors which could prove as barrier to productive relationships among subcontractors.
- The level of importance of different factors which could be helpful in creating cooperative links among subcontractors.

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Chapter 11

Results of Survey (Part-1) and Discussion

For discussion each questionnaire is divided in two parts (I & II), chapter 11 discuss the part I and chapter 12 discuss the part II. Table 11.1 and table 11.2 show the question asked and views of contractors and subcontractors. The complete questionnaires and detail of answers are attached in appendices. As described earlier that the questionnaires were filled during personal interviews so there is no question about rate of return. There were five choices for each question and questioned person has to select one choice for each question. In order to get a combined view of answers, mean rating is also calculated. For the calculation of mean rating the following rating procedure is adopted:

The five choices were given rating numbers as following:

Every time / Very important = 5
Mostly / Important = 4
Often / May be = 3
Very few / Important to some extent = 2
Never / Not important at all = 1

So mean rating has the range from 1 to 5, if the value of mean rating is higher than the middle number (3) then it means that most answers are in favor of the question (yes) and low value shows that majority of views are against the question (no/never).

11.1 Questionnaire for Main Contractors (part I) and Results

Table 11.1

Questions for main contractors (part I) showing the views of 37 contractors:

Sr. No.	Question Statement	Mean Rating	Standard Deviation
1	Do you prefer to work with same Sub-Contractors (SCs), to whom you already have good experience in your different projects, irrespective of cost?	3.24	1.12

2	Do you think that selecting same Sub-Contractors (SCs) in your next projects is good for the successful completion of project?	3.11	1.26
3	Do you like to continue same team of SCs in your next project, who work comfortably with one another?	4.35	0.92
4	Do you prefer to try new subcontractor rather than your old co-partner SCs?	2.03	0.74
5	Do you think that by continuing the same team of SCs in next projects is helpful in producing productive relationship among them?	3.76	1.40
6	Do you realize that SCs Co-operate with one another during the project execution?	3.05	0.84
7	Do you think that non co-operation among SCs cause serious problems such as delay, low quality, defects.	4.08	0.86
8	Do you have to act as mediator in disputes among the SCs in your projects?	3.86	1.02
9	Do you conduct tendering/Bidding process while selecting SCs?	2.62	1.12
10	Do you select SCs without tendering/bidding just by verbal negotiations?	3.00	1.02
11	Do you prefer to have formal written agreement with your SCs.	4.05	1.19
12	Do you identify all the risks involved to the relevant Subcontractor?	4.16	1.03
13	Do you transfer all the responsibility of risks and damages to the relevant subcontractor?	2.46	0.83
14	Do you have some kind of partnership or cooperative relation with your SCs or Suppliers?	1.46	0.70
15	Do you think that if Main Contractor has partnership with some SCs and Suppliers then the services from them will be better and consistent?	2.62	1.28

11.2 Discussion over Main Contractors' Views

In question No.1 it is tried to access that whether main contractors give preference to cost while selecting a subcontractor or they consider other qualities also based on their previous experience. The result shows that selection criteria of contractors is although based to some extent on previous experience and reputation of subcontractor but major factor is the cost, it

means the lowest bid plays an important role in combination of other qualities of subcontractors.

When contractors were asked that continuing the services of the same subcontractor in different projects proves beneficial for the successful completion of the project then the most of the contractors think that usually continuation of same subcontractor/subcontractors does not effect the successful completion of the project however there was a view that experienced subcontractors proves better choice because of their relevant experience, higher reliability and better communication as compared to those who are new for the contractor.

When different subcontractors work in a project and those subcontractors, who show better coordination with other construction parities and show better mutual cooperation with other parties are most likely to be continued their services with the same contractor for being better choice of the main contractor. Contractors like those subcontractors who are cooperative with their copartners and create minimum problems. More over contractors are very reluctant to give preference to new subcontractor over a subcontractor who is already working with the contractor satisfactorily.

The general cooperative behavior of subcontractors with one another is not much encouraging in view of contractors. The general view of the contractors is that although the subcontractors cooperate with each other but not up to the level which could be very beneficial for the project and also for their future relation. Subcontractors do not willing to undergo a long-term partnership with other subcontractors but mainly focus on the current project and tries to maximize their profit and do not sacrifice profit at the cost of better relationship with their co-partners.

Since the main contractor is the only party who has contractual links with subcontractors during the execution of a project, therefore in case of disputes, tensions or non cooperative working behavior among subcontractors, the main contractor has to act as mediator among the concerned parties working in his project.

As for as the selection procedure of subcontractors by main contractor is concerned, there are different methods for example calling bid by general advertisement or calling bids among a few selected subcontractors, by verbal negotiations among few previous copartners or selection based on previous performance and links. Generally selection procedures without tendering/bidding process and just by mutual negotiations and bargaining are adopted by the contractors. However agreement in written form listing basic conditions of contract is a common practice, main contractors prefer to have a formal written contract with subcontractors although that they have more commanding position than the subcontractors during the project execution.

There are some issues which are likely to occur but usually not written in contracts between contractor and its subcontractors. The reason is that these issues are unexpected and the contract between contractor and subcontractors is usually very brief and simple which only describes the basic conditions. One of these issues is the transfer of the responsibility of risks. According to the statements of contractors, they always try to identify all expected risks, which may likely to occur during the execution of work of the relevant subcontractors. As far as the bearing of expenditure as a responsibility in case of occurrence of damage due to any risk is concerned, it has to be bear generally by the main contractor. How ever this is not the case every time if subcontractor is clearly warned about any expected risk and he did not carry out preventive measures in spite of contractor's warnings then in this case obviously subcontractor is held responsible. Main contractor usually have to take the responsibility of risks in case the risks are unexpected and beyond the capacity of subcontractor to bear it but in this case subcontractor also have to share in loss. Since subcontractors get their payments from main contractors so it is unlikely that subcontractors paid fully for their executed work if main contractor has to spend funds for any risk involved in this particular job. One of the reasons of taking the responsibility of risks is that the main contactor is the over all legal responsible of the project and if subcontractor is failed or not in a position to bear any out come of risk then main contractor is ultimately responsible.

When contractors were asked about their long term relationships with the subcontractors who usually work for them, then almost all of them said that they do not have any kind of partnership or long term relations to any subcontractor/supplier. A few contractors said that there are certain subcontractors which are repeatedly selected by them but it is only an informal relationship that both the parties prefer to work with each other but it is not in form of an agreement or joint venture.

This shows that there exists some very weak forms of long term relationship among few parties but parties are not bound to an agreement and prefer to work independently with freedom of choice.

When contractors were asked that "by having partnership with subcontractors/suppliers, a contractor can get better services from them", then some asked that it can prove very beneficial and some thought that it is not much important but majority was in doubt and not sure that this could prove beneficial or not. The reason is that they never under go this experience and phenomenon of long term partnerships. Long term partnership among parties in a construction supply chain, is very uncommon in Pakistan but the idea was interesting for them and their views were, "it may be very beneficial for contractor in order to get better and consistent services from his subcontractors and suppliers".

11.3 Questionnaire for Subcontractors (part I) and Results

Table 11.2

Questions for subcontractors (part I) showing the views of 31 subcontractors:

Sr. No.	Question Statement	Mean Rating	Standard Deviation
1	If MCs tries to select same team of Sub-Contractors (SCs) in his different projects then it will help in the successful completion of project?	3.65	1.21
2	Do you think that by continuing the same team of SCs in different projects is helpful in producing productive relationship among them?	3.77	1.16

3	Do you realize that SCs Co-operate with one another during the project execution?	3.42	0.87
4	Do you think that non co-operation among SCs cause serious problems i.e delay, low quality, defects.	4.29	0.92
5	Do the MCs carry out tendering/Bidding process for selection of SCs?	3.35	1.23
6	Do you prefer to have a formal written agreement with your Main Contractors (MCs).	4.19	0.82
7	Do you think that MCs selection procedure for SCs is fair?	3.55	1.16
8	Do you think that you are mostly given unrealistic time schedules by MC?	3.58	0.87
9	Do you get late/ incorrect payments from MC?	3.13	1.01
10	Do the quantity surveyors of MC fairly calculate your work done?	4.19	0.53
11	Do the MC expects from you more, than your expected Output and quality?	3.87	0.79
12	Do you get full technical, financial, operational support from the MC?	3.23	1.10
13	Does the MC identify all the risks involved in work to the relevant Subcontractors?	3.26	1.11
14	Do the MCs transfer all the responsibility of risks and damages to the relevant subcontractor.	3.26	1.08
15	Do you think that working conditions/environment are more in favour of MC during the execution of projects?	3.94	0.56
16	Do you have some kind of partnership or cooperative relation with your MCs.	2.42	1.19
17	Do you have some kind of partnership or long term relations with any other subcontractor or supplier?	1.65	0.70
18	Do you think it is important that Main Contractor should have partnership or alliance with SCs and Suppliers for better and consistent services from them?	3.03	1.09
19	Do you think that SCs/suppliers should have partnerships with each others to make an efficient team at construction sites?	3.84	0.63

11.4 Discussion over Subcontractors' Views

According to majority of subcontractors, continuing the same team of subcontractors in next projects by main contractor is better in successful completion of projects although some have opinion that it will not create any significant difference. As far as importance of continuing the same team of subcontractors in different construction project is concerned, in order to produce productive relationships among them then a clear majority of subcontractors was in the favor that it is very important factor in producing productive relationship among the parties involved in construction supply chain.

Most subcontractors think that they cooperate with their copartners during the construction phase, however some also think that in case of competition and individual benefit they normally care for their own interests and do not tend to cooperate with other parties involved in the same construction project. But unanimously most of them believe that cooperation with one another is a key factor to avoid bad circumstances and non cooperation certainly increases the chances of time over run, cost over run, decrease in individual profit, extra efforts, low quality and defective work.

Majority of subcontractors give opinion that main contractors select their subcontractors on merit although selection procedure may vary, some times contractor call bids and some times just select subcontractors according to subcontractors repute and their own previous experience of working with them. Mostly the subcontractors prefer to have a brief formal written contract with their contractor in order to avoid disputes and exploitation.

Main contractor is overall manager of construction project and also pays to its subcontractors. Some times the executed work is being paid to main contractor and then he paid to respective subcontractors for the same executed work. Therefore majority of subcontractors think that conditions are more in favor of contractor and they depend on their contractor even after their executed work is being paid by the client. Due to this advantage subcontractors think that some time they are exploited by late or inappropriate payments by their contractor. Most subcontractors agree that the

representative of main contractor measure their executed work fairly, the reason is that mostly it is a combine measurement by respective subcontractor and quantity surveyor of main contractor.

Subcontractors also complained that main contractors usually expect more from them than their capabilities and also the time schedule given by main contractor is often unrealistic. The reason is that main contractor mostly under the pressure to show rapid progress by client and also the rapid execution by subcontractors are in favor of main contractor, financially and also it creates good reputation by completing the work in time or prior to finish time. When subcontractors were asked about the help and support from main contractors during the construction of project then there was a mixed views some gave their opinion in favor of main contractors and some said that they are mostly left on their own and did not get financial and technical support from main contractors if needed.

As for as the identification and warning of involved risks is concerned the subcontractors also gave mixed type of opinions which means some times they are informed about the expected risks which are likely to occur during the execution of their works and some times they are not properly informed and warned for the expected risks. Most subcontractors said that they are often held responsible for the damage or extra work resulting from any unexpected condition during the construction so the main contractor saves himself from loss but the loss have to bear by the subcontractors.

Very few subcontractors told that they have some sort of long term partnership or cooperative relationships with main contractors but mostly said that they do not have long term partnerships with main contractors. As for as the long term relations or partnership with other subcontractors/suppliers are concerned all the answers were that they do not have this kind of relationships.

From the response of subcontractors it is clear that there is no trend of long term partnerships of subcontractors/Suppliers with other subcontractors/suppliers or main contractors but majority of subcontractors think that if main contractors have some kind of cooperative and long term

relations with subcontractors and suppliers then he can get better services from them. Majority of subcontractors are also in the favor that subcontractors and suppliers should also develop productive and long term relationships with one another in order to transform them into an efficient working team whenever they work in construction project.

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Chapter 12

Results of Survey (Part-2) and Discussion

During the literature review and discussions it was realized that there are certain factors which are considered relevant in terms of cooperative relationships among contractors/suppliers. So in the survey contractors were asked to give their opinion about the importance of these factors.

Table 12.1 shows the views about the importance of four factors which can act as barriers in creating productive relationships among parties in construction projects. Similarly Table 12.2 shows the views about the level of importance of seven factors which are generally considered as helpful in creation of cooperative environment among actors of construction projects. For each question there were four choices and the questioned person has to select one.

For simplicity the mean rating is calculated for each question, in order to calculate mean rating the following number criteria was adopted:
Very important = 4, Important = 3, Important to some extent = 2 and Not important = 1. So mean rating will vary form 1 to 4, mean rating higher than middle value (2.5) show more importance and lower values indicate less importance. The tables are arranged in descending order according to mean ratings.

12.1 Barriers to Productive Relationships

Table 12.1 shows the Importance of the factors which are considered as barriers to productive relationships among Subcontractors/Suppliers participating in different construction projects.

In the table 12.1 the highest rating is for “lack of interest of top management of companies” this shows the leading persons (owners and mangers) of construction companies do no take interest in creating cooperative relationship with other partners in construction projects. The reason is that they usually make a short focused, project based strategy.

Table 12.1: Relative importance of different factors (barriers for cooperation) (Views of 68 MCs/SCs)

Sr. No.	Factor Description	Mean Rating	Standard Deviation
1	Lack of interest of top management of companies.	3,06	0,82
2	Low commitment/interest toward enhancing cooperation from partners involved in a project.	2,87	0,75
3	Inappropriate organization structure of the construction firms involved.	2,85	0,81
4	Poor understanding of benefits of cooperation.	2,59	0,65

There aim is generally to complete their job in current project quickly and to get maximum profit. This project based strategy does not allow them to behave in a cooperative manner beyond a certain limit. It is the responsibility of leading members of construction companies to make policies which could help in long term relations with other counter parts. The staff of these companies then will show interest and commitment towards enhancement of cooperation with staff of other counter parts. Without the interest of top management the individual will not think in long term because each individual generally cares of his own job and then the interest of his company. Therefore in order to make a cooperative culture the trend should be set at personal level and for this top management have to make such environment in their companies. The lack of interest of leaders of a company is due to poor understanding of benefits of long term cooperation. As discussed earlier that in Pakistan the non consistent development funds due to political and economical reasons also is a factor that top management is short focused. Different small and large construction companies do not get chance to work with one another frequently over a long period in different projects.

Another reason which is also considered as an important barrier in cooperative construction culture is the organizational structure of the small and medium firms involved in construction projects. The managerial and technical staff of contactors frequently changes from project to project due to

various reasons. The main reason is also the non consistency in construction project opportunities. More over small firms which usually consists of 2 to 5 persons do not have any appropriate organizational structure. These small companies hire temporary staff/labor according to demand.

12.2 Creating Productive Relationships

Table 12.2 shows relative importance of different factors which are considered helpful in creating a co-operative environment among participants in construction projects.

Table 12.2: Relative importance of different factors (productive for cooperation)

(Views of 68 MCs/SCs)

Sr. No.	Factor Description	Mean Rating	Standard Deviation
1	SCs should be paid regularly according to agreement and their payments should not be held or delayed.	3,59	0,65
2	Selection of SCs should be based on previous experience but not on price.	3,57	0,58
3	MC should not put all the responsibilities (completion/risks) on respective subcontractor but should cooperate with them in case of problems.	3,38	0,62
4	Early selection of all SCs/Suppliers (before start of construction)	3,26	0,76
5	If subcontractor teams achieved their targets early or MC gets benefit by their good team effort then MC should give these parties some share in profit as incentive.	3,09	0,70
6	Establishing a joint project office for all project partners.	3,07	0,83
7	Main Contractor should establish joint objectives among groups of SCs rather than setting targets for each subcontractor.	2,35	1,05

One of the main reasons that cause poor relationship between contractors and its subcontractors is issues of payment. Subcontractors are generally small companies which do not financially sound and they also have temporary labor to which they have to pay daily or frequently. Therefore

subcontractors need the payment of their executed work regularly from their contractor. To pay the subcontractors, its contractor has to invest from his own and he cannot wait for the payment from his customer/client. Some contractors which are not in a financial position to pay their subcontractors usually wait until they receive payments from their customer/client. So they use their subcontractors as small investors for their project.

Contractors should consider all factors and lowest price should not be the only criteria for selection of subcontractors. In public departments of Pakistan it is generally compulsory for the departments to award the contract to lowest bidder as per rules but for the contractors it is not compulsory as they are independent organizations and can select any subcontractor according to their choice. The other factor which seems very important is that contractors should work in harmony with subcontractors and in case of any unforeseen factor contractors should support and help subcontractors because subcontractors being small companies can not bear the huge losses. If contractors try to put all the responsibility of risks on subcontractors then it causes disputes and bad relationships among these parties. Contractors also think that it is important that main contractors should select their team of subcontractors and suppliers in the beginning of the project so that each subcontractor and supplier could make strategies and selection of staff according to the other parties to which it has to work with. More over the experienced and old allies of main contractor can give valuable suggestions to main contractor regarding to the selection of other subcontractors/suppliers and in making of construction schedules which is satisfactory for all subcontractors and suppliers.

Subcontractors are small contractors who work for their customers under competitive rates. If main contractor gets a handsome profit due to the efficient subcontractors then it is very good gesture that main contractor should oblige these subcontractors by some financial incentives. The subcontractors should also behave similarly to their subcontractors. This type of encouragement will certainly improve the confidence of these subcontractors over the main contractor and also it will strengthen the

teamwork of subcontractors among themselves. The factors "establishing a joint project office" and "setting combine targets for a group of subcontractors" are considered relatively less important as compared to other factors.

12.3 Contractors' and Officials' Comments

During the survey contractors were asked to give their own comments about creation of productive relationships among parties in construction supply chain and about other related problems. Some of the comments made by contractors, subcontractors and departmental officials are presented here for the interest of the readers.

12.3.1 Subcontractors' Comments:

- During the execution of a construction project generally there is lack of coordination among construction firms working together in a project.
- It is not only the top management of companies that can create cooperative atmosphere, but main role is of the staff of the main contractor and subcontractor. The staff of all the construction companies working in a project plays an important role in mutual relations. Therefore it is an important that companies should encourage and train their staff through their company policies.
- Main contractor should exercise its key position in managing the subcontractor's chain. Main contractors can make their subcontractors and suppliers into an effective team by using monitoring and scheduling techniques properly and effectively.
- The staff of main contractor at site should be well aware about the problems of subcontractors. Therefore main contractor's staff should also try to help all the subcontractors in resolving their problems, rather than to leave them on their own.
- There should be regular joint consultation/meetings among main contractor and subcontractors in order to take care of all problems and to ensure required progress of work.

- Main contractors should not take advantage of competition among the subcontractors.
- Subcontractors should be paid according to a reasonable rate in order to achieve a good quality work from them.
- Subcontractors should also be answerable to client, in order to make them more responsible towards the project.
- Selection of subcontractors by main contractor should be made by considering all the factors and not only the cost.
- Main contractors do not treat all subcontractors uniformly which some times create disappointment in some neglected subcontractors. Main contractors should cooperate with all the subcontractors equally.

12.3.2 Main Contractors' Comments:

- Fairness among the parties is very important, especially in financial matters. Some times in public sector projects the funds from government are not released in time, then contractor should regularly pay its subcontractors and there should not be any obstruction in payments of subcontractors because these payment irregularities creates problems in relationships between main contractor and its subcontractors. It is important that contractor should be financially strong enough to bear the delay in payments from client without causing any effect on payments to subcontractors because this is necessary to maintain the fragile short term relation and to develop it in long term relations.
- Main contractor should give technical support to its subcontractors as usually subcontractors do not have sufficient technical staff to resolve the unexpected out comes during the construction.
- Main contractors usually face problems from their suppliers, major problem is due to inefficiency in supplies according to demand/agreement and also due to the supply of materials which some times fail to fulfill the quality standards and replacement of material causes delay and temporary hold in construction activities.

- When main contractor assigns same type of jobs to different subcontractors at different rates or if main contractor does not provide all the subcontractors of similar works the fair distribution of facilities (machinery, technical support) then it causes an unpleasant project atmosphere. It is very important for main contractor to remain fair about the uniformity in rates, payments and facilities provided to subcontractors.
- The disputes and hostile personal relationships among the staff or temporarily hired labor of subcontractors, working in a project is also an important factor which acts as barrier in positive relationship among these parties.
- Main contractors should be very vigilant while selecting subcontractors and, main contractors should also investigate the history of subcontractors other than bid price.
- Subcontractors should be provided all the required materials in time other wise they will have to face loss and then they will try to complete the work by compensating their loss at the cost of quality. This will create disputes between subcontractor and main contractor.
- Shortage of skilled workers or a specialized labor group also creates trouble in relations among the firms. Companies struggle to hire much needed skilled worker. Firms try to get services of the skilled persons who are already working with some other company by offering them more incentives so this struggle caused hostility and lack of trust among these companies.

12.3.3 Departmental Officials' Comments

- Some times contractors deliberately delay the construction projects to get certain advantages. For example in order to get cheap materials, machinery or labor. If the contractor has limited staff & machinery and it is executing multiple projects at same time. Then it tries to use its own resources one after the other rather than hiring new staff and machinery. Usually contractors got extension in completion time by

presenting excuses and by favourable behaviour of approving authorities. When contractor got the time extension then it also becomes eligible to claim the price escalation of materials. So contractors do not suffer loss due to delay of projects.

- Some times due to competition and scarcity of construction activities the contractor gave bid well below the departmental bid price. In public sector the lowest bidder have to be awarded the contract. So at very low price it is very difficult for the contractor to maintain all the required standards of construction projects. In this situation contractors try to compromise on quality and time in order to avoid loss.
- Contractors falsely show required number of professionals, machinery and funds during prequalification of public sector departments. Actually they do not have all the capabilities which are claimed by them in order to prequalify. Therefore there is usually lack of professionals from contractor's side. Departmental staffs have to struggle hard during the construction activities in order to achieve required quality standards.

  Some times the non-registered contractors use the name of registered contractors (with their consent) to bid for contracts. The reason is that contractors are registered in different categories according to their experience and capabilities. In public sector organization only pre-registered contractors are eligible to bid. Contractors of each category can bid for projects of certain amount. Lower category can only bid for low amount projects and only contractors in higher category are eligible to participate in bidding for bigger estimated amount projects. The contractors in lower category some times use the name of higher category contractors to get contract. This is done for some fee or other mutual favors.

Chapter 13
Survey Outlook

In this chapter some conclusions are drawn on the basis of survey and discussions with the contractors. These conclusions show the combined views of survey participants (main contractors & subcontractors). On the basis of survey results recommendations are also suggested.

13.1 Survey Conclusions

It is observed that there exists awareness among the contractors, subcontractors and suppliers that long term and strategic relations among them will certainly prove productive. But due to the nature and environment in Pakistan construction industry, such relations could not develop. The long term relations are rare among construction supply chain members working in public sector than those in private sector construction projects. One of the reasons is that there is not any consistency in public sector works due to non consistence release of funds to departments responsible for developing works. The major reasons of this non consistency are government's financial condition and political influences. In Pakistan construction industry as far as mega projects are concerned, major part consists of public sector projects, such as construction of roads, bridges, irrigation / drainage systems, dams and barrages.

Generally in a construction site the construction teams (contractor, subcontractor and suppliers) do not seem to be cooperative with one another and concentrate on their own business and benefits. It shows the lack of professional ethics which are required to be developed in these parties for more productive relations. In case of disputes among subcontractors, the main contractors have to act as mediator so it is in a position to set some professional practices for smooth running to construction processes.

Lowest bid is an important criterion in selecting subcontractors but main contractors should also concentrate in making and efficient team. Selection should be made according to a wide criterion other than the lowest

bid. Therefore main contractors should make a database for subcontractors and regularly record their performance so that while selection of subcontractors their monitored properties could be considered. It will make it possible to select best team according to the required conditions of every project.

General perception of subcontractors is that they are being exploited by main contractors and there is lack of trust not only between main contractor and subcontractors but among subcontractors themselves also. In order to create more effective supply chain the existing active communication circle consisting of main contractor, consultant/designer and client should be expanded and subcontractors should also be included. It will help to create more trust worthy atmosphere among main contractor and its subcontractors. In this way subcontractors will not feel vulnerable and can concentrate better on their professional practices. It has been observed that mostly subcontractors are annoyed due to the exploitation of main contractors, regarding the payments of executed works. The process of payments to subcontractors should be fair and efficient because it can create a sound trust among subcontractors over their contractor. A uniform procedure of payments by contractors for all the subcontractors will not create or increase any hostility among subcontractors.

In Pakistan construction industry, the quantity of construction projects fluctuates according to the availability of development funds. When there are enough funds available then number of public sector projects increases. In this situation many construction parties (contractors, subcontractors, suppliers) rushed in due to demand and to avail the opportunities. When developing funds suddenly decrease due of political or any other reasons, these organizations have to find new business in other public and private sectors. So there is not a good environment for these parties to develop mutual long term relations. Major part of the construction supply chain generally consists of the services of subcontractors and suppliers therefore productive relations among subcontractors / suppliers are main key of construction supply chain management.

The non consistency in construction industry in not only in Pakistan but it is every where in the world so it is a characteristic of this industry that demands of products (construction projects) fluctuate in quantity and nature. If a road is being constructed in an area then it will accelerate different type of industries as compared to another project like hydro power plant. It is all over the world that construction industry does not have consistency like manufacturing industry. This is why the SCM in more challenging in construction industry because there does not exist a consistent environment to work together over a long time. There is awareness about the benefits of cooperation among subcontractors and main contractors but individual interests are more attractive than mutual cooperation.

13.2 Recommendations

On the basis of previous empirical studies some recommendations are drawn, which are enlisted here.

i. Major proportion of disputes occurred during construction projects are between main contractor and its subcontractors. Therefore efficient dispute resolution system should be developed. Subcontractors being weaker party should not face any disadvantage in dispute resolving system.

ii. Special consideration should also be given to dispute avoidance. Contract conditions, professional ethics and trainings should focus on cooperation, and exploitive behaviors should be discouraged.

iii. Continuity in relations is considered very important but the nature of construction industry does not helpful in continuity of relations. Special efforts need to be done to promote continuity in relations.

iv. Partnerships among contractors are considered very important in increasing productivity but there is not trend of partnerships among contractors. Bidding conditions and other construction industry regulations should be amended to promote partnerships and joint ventures.

v. Top management of construction companies can play an important role to promote cooperation. The administrators and mangers of these firms should be aware of the benefits of the mutual cooperation and they should adopt necessary policies and working procedures in this regard. Especially the small subcontracting firms which are usually governed by a person/owner should be convinced to promote cooperative trends among the staff.

vi. The dominant role of main contractor should also be reduced. Subcontractors should not be exploited in form of payment abuses and transfer of risks and responsibilities unfairly towards subcontractors.

vii. Before start of the physical construction process and during the construction main contractor and all important subcontractors should work like a team. Frequent interactions right from the beginning can contribute towards productive and cooperative relations.

Part 3
Game Theory and Cooperation Analyses

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Chapter 14

Cooperation Strategies and Construction Projects

14.1 Introduction

In mathematics the game theory is an important method for analysis of competitive situations. These competitive situations are called games. The subject of "game theory" has two main purposes. One is the description of behavior of players, which they adopt in competitive situations. Second is to suggest players the best way to play. It means to find out the best strategy (behavior) for player in competitive situations. In the following sections we will discuss cooperation in "Game Theory" and analyze a simple 3-player construction supply chain structure.

14.2 Cooperation Theory

14.2.1 Prisoner's Dilemma

Robert Axelrod in his famous book "The Evolution of Cooperation" [Axelrod Robert (1984)] discussed the conditions for cooperation in detail. Axelrod used the famous Prisoner's Dilemma game to study the cooperative behaviors among individuals. His model of Iterated Prisoner's Dilemma is a famous study in cooperation strategies in which players have multiple encounters with other players. The payoff matrix of Prisoner's Dilemma is shown in Table 14.1.

Table 14.1: Payoff matrix of Prisoner's Dilemma [Axelrod Robert (1984)].
Each cell shows payoffs of player1 and player2 respectively.

		Player 2	
		Cooperate	Defect
Player 1	Cooperate	3 : 3	0 : 5
	Defect	5 : 0	1 : 1

Payoffs in table14.1 explain that if both players will cooperate with each other then they will get 3 points each. If both defect each other then both will get 1 point each. When one player cooperates and other defects then the defector will get 5 points and the one who cooperate will get no point. So there is temptation in defection if other is cooperative. When player1 cooperate the best strategy for player2 is to defect, similarly when player 1 defects then best strategy for player2 is again to defect. It shows that the Nash Equilibrium (NE) in this case is Defect vs Defect (1:1). So both players will defect in order to play safe. But the dilemma is that they can get more points if both cooperate to each other.

Robert Axelrod arranged a competition; experts all over the world were invited to submit their strategies to play "Iterated (repeated) Prisoner's Dilemma". There were different strategies from most simple i.e All D (always defect), All C (always cooperate) to complex type of strategies. The winner strategy was a relatively very simple one consisting of a short program (code). It was "tit for tat" (TFT), which states "*cooperate in first move and then play the same (cooperation or defection) which opponent has played in previous move"*. TFT won the first round and then a second competition was carried out by Robert Axelrod. In the second round he announced the result of first round. Even then the TFT won the 2nd round also.

14.3 Cooperation Analyses in Construction Projects

To analyze cooperation strategies in construction projects we consider a simple 3-player structure of a construction project. Consider a construction project in which main contractor (MC) also sublets work to two subcontractors (SC) as shown in figure 14.1.

The division is such that part of the work is carried out by main contractor and remaining is equally distributed among two subcontractors. Further for simplicity we consider that every player (MC or SC) have only two strategies. One is to Cooperate (C) and other is Don't cooperate (D). In contradict to Prisoner's Dilemma, we have changed the "Defect" strategy to "Don't cooperate" because in our case the defector cannot be offered any

incentive. More over to make the things simple there are no levels in cooperation. Each player has only two options Cooperate or Don't cooperate.

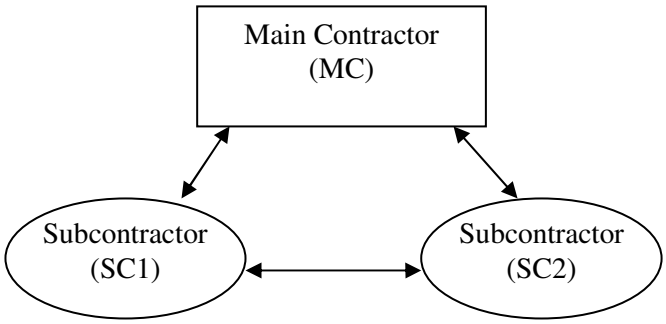

Figure14.1: A simple structure of participants of a construction project

It is a very simple model as we discussed in earlier parts that construction supply chain consists of many subcontractors and suppliers forming many hierarchical layers. In actual, behaviors are also not so simple like we adopt here as "cooperate" or "do not cooperate". Cooperation also can be categorized in different levels. During the construction project if a party cooperates with other then it will cost him very less as compared to benefit for the other party. Therefore in our supposed payoff values we tried to make it more realistic and set the condition that value of receiving cooperation is considerably larger than the cost of cooperating with others.

For calculation of payoffs (gain and lost) we consider the following conditions:

- When a player is being cooperated by other it receives 3 points (+3) for each cooperation.
- When a player himself cooperates to any other he looses 1 point (-1) for each cooperation.
- When a player Don't cooperate then it neither receive nor loose any point (0).

Unlike the payoffs of "Prisoner's Dilemma" in this case there is no temptation for defection. There is no third party which can get benefit for

players' defections and offer them rewards. In this case the only advantage of defection (not cooperating) is that the player can save the efforts/expenditures which it has to exercise in case of cooperation with others.

In order to make the payoff more realistic we consider that when subcontractors will cooperate among themselves then it will also beneficial for the main contractor. Main contractor is overall responsible for the project so if subcontractors will achieve their targets (which are actually set by main contractor) then main contractor will also be benefited. Therefore we also set following additional conditions.

- When one subcontractor Cooperate to other subcontractor then MC also gets 1 point (+1).
- When both subcontractor Cooperate to each other then MC gets 2 points (+2)

Table 14.2: Different combinations of strategies and corresponding payoffs

Strategies Combinations				Payoffs				
Sr. No.	MC	SC1	SC2	MC	SC1	SC2	Total	Client
1	C	C	C	6	4	4	14	5
2	C	C	D	2	1	6	9	2.75
3	C	D	C	2	6	1	9	2.75
4	C	D	D	-2	3	3	4	0.5
5	D	C	C	8	1	1	10	4.5
6	D	C	D	4	-2	3	5	2.25
7	D	D	C	4	3	-2	5	2.25
8	D	D	D	0	0	0	0	0

Table 14.2 shows the payoff calculation for each player with different strategy options. If there are three players and each player has two strategy options then there will be total eight combinations. The client also wants the benefit of each player in order to boost the construction industry. So Client's benefit is also calculated by considering 50% of MC's payoff and 25% of

subcontractor's payoffs {0.5 (MC's payoff) + 0.25 (subcontractor's combined payoffs)}.

14.3.1 Nash Equilibrium

Nash equilibrium named after the person (John Forbes Nash) who proposed it. Nash Equilibrium gives a stable condition of strategies in game theory. If each player is playing with its strategy and the combination in which no player can get additional benefit by changing its strategy while other players' strategies remain same. The combination of these strategies and corresponding payoffs are Nash equilibrium.

The Nash equilibrium in the payoff conditions of table 14.2 is determined and different combinations in this regard are shown in table 14.3.

Table 14.3: Determination of Nash Equilibrium

Cells show the payoffs of SC1 : SC2 : MC respectively.

		MC: C		MC: D	
		SC2: C	SC2: D	SC2: C	SC2: D
SC1: C		4 : 4 : 6	1 : 6 : 2	1 : 1 : 8	-2 : 3 : 4
SC1: D		6 :1 : 2	3 : 3 : -2	3 : -2 : 4	0 : 0 : 0

In table 14.3 it is visible that the best strategy for SC1 is D, best strategy for SC2 is also D and best strategy for MC is also D. The outcome is similar as in case of Prisoner's Dilemma. The best strategy for each player is Don't cooperate, irrespective to the strategies of other players. So if all the players go for "D" then no one will get any payoff as shown in table 14.2. On the other side the best option for all players is when all of them cooperate. If

everyone goes to play safe then all of them will play “D”. If there is situation that every one is sure that if it goes for “C” then other will also do the same then in this situation the choice for every player will be “C”. For client the best situation is also when every one is playing “C”. Although the payoff of client is also close to maximum when MC is playing “D” and SCs play “C” but it will not better choice for client. The reason is that client wants benefit for every player, more over if SCs have to face “D” then next time they will not go for “C” which is discouraging for the client. From the results in table 14.2 we can predict that if the game is played repeatedly then players will go for cooperation. More over it is better to teach and motivate every player to cooperate with everyone.

14.3.2 Mixed Strategies

Now we also consider situations in which players using mixed strategies instead of a generalised strategy. These mix strategies are described below:

M_{cd} : Subcontractor play C with main contractor and D with subcontractor

M_{dc} : Subcontractor play D with main contractor and C with subcontractor

M_1 : Main contractor playing C with one subcontractor and D with other

Using these strategies the different combinations are shown in Table 14.4 along with corresponding payoffs.

Table 14.4: Different combinations of mixed strategies and corresponding payoffs.

Strategies			Payoffs				
MC	SC1	SC2	MC	SC1	SC2	Total	Client
C	C	M_{cd}	5	1	5	11	4
C	D	M_{cd}	1	3	2	6	1.75
D	C	M_{cd}	7	-2	2	7	3.5
D	D	M_{cd}	3	0	-1	2	1.25
C	C	M_{dc}	3	4	5	12	3.75
C	D	M_{dc}	-1	6	2	7	1.5
D	C	M_{dc}	5	1	2	8	3.25
D	D	M_{dc}	1	3	-1	3	1

M_1	C	C	7	4	1	12	4.75
M_1	C	D	3	1	3	7	2.5
M_1	D	C	3	6	-2	7	2.5
M_1	D	D	-1	3	0	2	0.25
C	M_{cd}	M_{dc}	2	5	2	9	2.75
D	M_{cd}	M_{dc}	4	2	-1	5	2.25
M_1	M_{cd}	M_{dc}	3	5	-1	7	2.5
C	M_{cd}	M_{cd}	4	2	2	8	3
D	M_{cd}	M_{cd}	6	-1	-1	4	2.5
M_1	M_{cd}	M_{cd}	5	2	-1	6	2.75
C	M_{dc}	M_{dc}	0	3	3	6	1.5
D	M_{dc}	M_{dc}	2	2	2	6	2
M_1	M_{dc}	M_{dc}	1	5	2	8	2.25
M_1	M_{cd}	D	2	2	0	4	1.5
M_1	M_{cd}	C	6	5	-2	9	3.75

The result of mixed strategies shows that there is no better combination than the combination when all players play C as in table 14.2. This result can also be verified by using another property of game theory called Characteristic Function.

14.4 Characteristic Function and Coalitions

The maximum payoff of a coalition is called characteristic function (υ). A coalition is guaranteed to be able to choose a joint strategy by which they can get at least a total payoff, equal to characteristic function (υ). [Moris Peter 1994]. Now we form different coalitions and then compare their payoffs using characteristic function (υ).

In our structure shown in figure 14.1 consider a coalition of two subcontractors. In the Table 14.5 the different combinations of strategies for this coalition are shown. The payoffs of coalitions are sum of the all players' payoffs. Coalition is a row player and MC is column player. In each column the first number is coalition's payoff and 2nd number is MC's payoff.

Table 14.5: Different strategies combinations and payoffs of coalition (SC1 & SC2) and MC

Cells shows payoffs of Coalition and MC respectively

	MC			
SC1 & SC2	C		D	
C,C	8	6	2	8
C,D	7	2	1	4
D,C	7	2	1	4
D,D	6	-2	0	0

In another combination we form a coalition of MC and one subcontractor while second subcontractor is playing alone. The payoffs of this combination are shown in table 14.6.

Table 14.6 Different strategies combinations and payoffs of coalition (MC & SC1) and SC2.

Cells shows payoffs of Coalition and SC2 respectively

	SC2			
MC & SC1	C		D	
C,C	10	4	3	6
C,D	8	1	1	3
D,C	9	1	2	3
D,D	7	-2	0	0

For calculation of characteristic function (υ) bi-matrices of payoffs of each player/coalition are formed and then characteristic functions (υ) are calculated. The values of these calculated characteristic functions (υ) are given below.

υ (SC) = 0

υ (MC) = 0

υ (SC1 & SC2) = 2

υ (MC & SC1) = 3

υ (SC1, SC2, MC) = 14

υ ( ) = 0

In above values of characteristic functions, the value 0 does not mean that no payoff but it is a comparative number, 0 means less than 1 and greater than (-1). Value of characteristic function can be negative.

The above values of characteristic functions show that:

- The highest payoff is only possible when all players make a coalition.
- When the players play alone they will get minimum payoffs
- When a subcontractor makes coalition with main contractor it is more beneficial than making a coalition with other subcontractor.

As it has been explained in early part of this dissertation, that subcontractors have contractual links with main contractors but not with other subcontractors. It is very beneficial to develop cooperation among subcontractors. From the characteristic functions it seems that subcontractor will prefer to make coalition with main contractor as compared to other subcontractor. Therefore in a construction project we can get additional benefit by developing cooperation among subcontractors. Maximum payoff is only possible when all parties are cooperating with each other.

14.5 Shapley Values

Shapley value is another solution concept in "game theory", to assess the importance of a player in a coalition. It takes into account a player's contribution to the success of the coalition to which it belongs to [Morris Peter (1994)]. Consider a player P_i belongs to a coalition S and characteristic function is υ then

$$\mu (P_i, S) = \upsilon (P_i, S) - \upsilon (S - \{ P_i \}) \quad \text{--- Eq. 14.1}$$

The number μ describe the amount of contribution of P_i in coalition S by joining it. These numbers (μ) will be used in calculating shapely values. Considering the characteristic functions as in section 14.4, μ values are calculated as below:

Calculations of μ values for SC1

There are four possible coalitions of SC1, which are:
(SC1) , (SC1, SC2) , (SC1, MC) , (SC1, SC2, MC)

μ (SC1, SC1) = υ(SC1) - υ( ) = 0 – 0 = 0

μ {SC1, (SC1, SC2)} = υ(SC1, SC2) - υ(SC2) = 2 – 0 = 2

μ {SC1, (SC1, MC)} = υ(SC1, MC) - υ(MC) = 3 – 0 = 3

μ {SC1, (SC1, SC2, MC)} = υ (SC1, SC2, MC) - υ(SC2, MC) = 14 – 3 = 11

Similarly the values of μ for SC2 will also be the same as for SC1

Calculations of μ values for MC
There are four possible coalitions of MC, which are:
(MC) , (MC, SC1) , (MC, SC2) , (MC, SC1, SC2)

μ (MC, MC) = υ(MC) - υ( ) = 0 – 0 = 0

μ {MC, (MC, SC1)} = υ(MC, SC1) - υ(SC1) = 3 – 0 = 3

μ {MC, (MC, SC2)} = υ(MC, SC2) - υ(SC2) = 3 – 0 = 3

μ {MC, (SC1, SC2, MC)} = υ (SC1, SC2, MC) - υ(SC1, SC2) = 14 – 2 = 12

The shapely value (Φ) can be calculated by following formula

$$\Phi_i = \sum_{Pi} \frac{(N-n)!(n-1)!}{N!} \mu(Pi, S) \qquad \text{--- Eq. 14.2}$$

'N' is total number of players
'n' is number of players in coalition under consideration (*S*)

Substituting the values for μ in Eq. 14.2
Since there are four possible coalitions containing SC1 so there will be four terms in this case

$$\Phi_{SC1} = \left(\frac{2!\times 0!}{3!}\times 0\right)+\left(\frac{1!\times 1!}{3!}\times 2\right)+\left(\frac{1!\times 1!}{3!}\times 3\right)+\left(\frac{0!\times 2!}{3!}\times 11\right)$$

$$\Phi_{SC1} = 0+\frac{1}{3}+\frac{1}{2}+\frac{11}{3}=4.5$$

Similarly $\Phi_{SC2} = 4.5$

$$\Phi_{MC} = \left(\frac{2!\times 0!}{3!}\times 0\right)+\left(\frac{1!\times 1!}{3!}\times 3\right)+\left(\frac{1!\times 1!}{3!}\times 3\right)+\left(\frac{0!\times 2!}{3!}\times 12\right)$$

$$\Phi_{MC} = 0+\frac{1}{2}+\frac{1}{2}+4=5$$

The results show that shapely value for main contractor is greater than shapely values of subcontractors. It means the contribution of main contractor to coalition is more than that of subcontractors'. More over it also indicates the strong position and greater bargaining power of main contractor. There is not much difference between shapely values of subcontractor and main contactor showing subcontractors' roles are not much less than main contractor's role.

Shapely values are important in estimating the importance of different players before making coalitions. It helps in setting contract conditions and distribution of work so that no player can have relatively huge importance in coalition. Therefore it will help in reducing the exploitation in coalitions.

14.6 Essential and Inessential Games

In an N-person game if the set of all players $S = \{ P_1, P_2, P_3 \ldots . P_N \}$ then the value of characteristic function of coalition of all player (υ (S)) will be

$$\upsilon(S) \geq \sum_{i=1}^{N} v(\{Pi\})$$

If $$\upsilon(S) = \sum_{i=1}^{N} v(\{Pi\})$$

Then the game is called inessential game. In case of inessential game there is no advantage of formation of coalitions. In our case above the value of υ for coalition of all the players is 14 and sum of individual values of υ is 0.
Therefore it is essential game because:

$$\upsilon(S) > \sum_{i=1}^{N} v(\{Pi\})$$

Therefore in our case the game is essential and formation of coalition is beneficial than playing alone.

Chapter 15
Cooperation among Subcontractors

15.1 Introduction

In previous chapter a simple construction project structure was analysed. In that structure the payoff of main contractor was different from subcontractors. In a construction project there is only one main contractor and several subcontractors. In order to analyze the interactions of subcontractors among themselves we now consider only subcontractors. When we consider the subcontractors then the payoff conditions for every player will be same. An interesting software "Axelrod Tournament Demonstration Software" is very helpful in this analysis. We will use "Axelrod Tournament Demonstration Software" to analyze the subcontractors' interactions with one another. A brief description of this software is described below.

15.2 Axelrod Tournament Demonstration Software

This Demonstration Software is designed such that user can host his/her own tournament. The software is licensed as open source freeware under the GNU Public License, copyright Chris Cook, 2006. There is a pool of 16 different strategies (e.g Always Cooperate, Always Defect, Random, Tit for Tat, etc.) and user can assign any strategy to a single or more players. Players of each strategy can be assigned a user's defined payoff matrix. Different payoff matrices can be assigned to players of each strategy. There is option to select number of iterations from 1 to 100. One iteration means one player will play with every other player once. It means there will be N (N-1)/2 matches in one iteration. Each player plays "iterations x (N-1)" matches in whole tournament. The user can also view the result of the tournament in graphical and tabular form.

15.3 Subcontractors' Relationship Analysis

Consider a project structure in which a main contractor has many subcontractors. Now we consider the relationship among subcontractors only.

Such a structure is shown in figure 15.1. Consider the interaction of two subcontractors, the payoffs are the same as we are using earlier. If a player will cooperate to other it cost him -1 and the player who is receiving cooperation will get +3. The payoffs are shown in table 15.1.

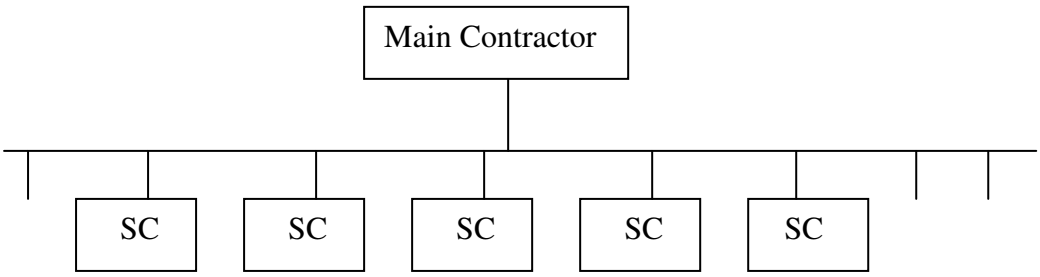

Figure 15.1 A simple subcontractors' structure

Table 15.1: Payoff Matrix of two subcontractors.

Each cell shows payoffs of column player and row player respectively

		SC2	
		C	D
SC1	C	2 : 2	-1 : 3
	D	3 : -1	0 : 0

Now consider that this construction project has sufficient duration and subcontractors have many encounters among themselves.

15.3.1 Tournament Series 1

There are 16 different strategies in the Axelrod Demonstration Software. We consider an even distribution and every strategy is assigned to one player. In this way there are 16 players. The payoffs were set as in table 15.1 for each player. A number of tournaments were conducted by changing the number of

iterations (1, 2, 3, 4, 5, 10, 20, 30, 40 and 50). In “1 iteration” tournament the position of TFT is 8th. As the number of iterations increased the TFT improved its position. In the tournaments with 5 iterations and onward TFT has started winning. As the number of iterations increases the difference of payoff of TFT from other players also increased. The results are shown in table 15.2. The detail results of tournament series 1 are shown in appendix C.

Table 15.2: Results of Tournament series 1

Tournament	Iterations	No. of Players	No. of Strategies	Position of TFT
1	1	16	16	8
2	2	16	16	5
3	3	16	16	5
4	4	16	16	2
5	5	16	16	1
6	10	16	16	1
7	20	16	16	1
8	30	16	16	1
9	40	16	16	1
10	50	16	16	1

15.3.2 Tournament Series 2

In the payoff matrix in table 15.1, the safe strategy is to play “All D”. In the tournament series 1 we have seen that the winner is TFT provided that there are sufficient numbers of repetitions in mutual encounters of each player. In previous 3 player case shown in table 15.2 the situation is similar. The whole group will get maximum when all of them play “All C” (always cooperate), but the best strategy for an individual player is to play “All D” in any situation.

In order to compare the negative behaviour (All D) and TFT according to our payoff matrix situation a second series of tournament was conducted. Axelrod Demonstration Software was used again and this time the strategies

"All D" and TFT were compared. 10 players with strategy "All D" were played against varying number of TFT players. The number of iterations were kept constant as 20. As the number of TFT players starting form 1, reached 2 they started winning and continue to win comprehensively as their number increase. The results of tournament series 2 are shown in table 15.3. It shows that a group of small number of TFT is required to overcome the large number of "All D" players. The average payoff of TFT increases as the number of TFT players increases. On other side the average payoffs of "All D" players also increases (but much less as compared to TFT) as number of TFT increases although the number of "All D" remains constant. If the numbers of players with strategy TFT are less than a certain number then they will get fewer payoffs than "All D". Detail result of tournament series 2 are shown in appendix D.

Table 15.3: Payoffs of varying number of TFT vs "10 All D" players

Tournament	Iterations	Number of Players		Average Payoffs		Difference
		TFT	All D	TFT	All D	TFT – All D
1	20	1	10	-0.05	0.015	-0.065
2	20	2	10	0.136	0.027	0.109
3	20	3	10	0.292	0.038	0.254
4	20	4	10	0.423	0.046	0.377
5	20	10	10	0.921	0.079	0.842

According to Axelrod" [Axelrod Robert (1984)], in a group of all defectors if the numbers of TFT are at least 5% then TFT will score higher than all defectors. Table 15.3 shows that TFT starts wining when they are 20% of the "All D", it is because when they are less that 20% there is only one TFT player. So the minimum possible group is 2 players, which is 20% of "All D". It means a small group of cooperatives (playing TFT) can survive in majority of defectors. In a large number of defector players if only one player cooperate then it can not survive because it will not receive any cooperation. But a small cluster of cooperatives can survive if they reciprocate to defection and cooperation accordingly.

15.4 Main Contractor and Subcontractors' Relationship Analysis

In section 15.3 the analysis is carried out among subcontractors and main contractor was not included. Now we carry out analysis by including main contractor in a team of subcontractors by using Axelrod's Demonstration Software. A drawback of this software is that we can not assign different payoff matrices to players having same strategy. In our case the payoff matrix for main contractor is different than that for subcontractors. Therefore it is not possible to carry out analysis (by Axelrod's Demonstration Software) if one or more subcontractors have same strategy as main contractor is assigned.

15.4.1 Tournament Series 3

In previous analyses we found that the safe strategy according to Nash Equilibrium is "All D" but on the other hand the most successful strategy is "TFT". Now we carry out analyses by considering a team of six subcontractors, three of them play "All D" and three play "TFT". This structure is shown in figure 15.2. We carry out tournament series 3 which consist of two tournaments. In one tournament main contractor play "TFT" and in other tournament main contractor play "All D". The analysis is carried out in two phases. In first phase the interactions among subcontractors are analysed by "Axelrod's Demonstration Software" and in 2nd phase effect of main contractor's participation is added after wards. For this purpose a spread sheet in Microsoft Excel is created. These spread sheets for these two tournaments can been seen in appendix E.

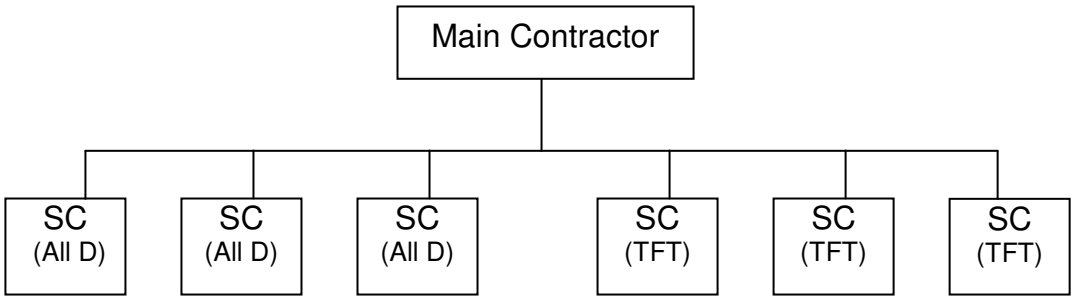

Figure 15.2 A simple structure for tournament series 3

In both the tournaments the analyses are carried out by 5 iterations. The reason for 5 iterations is that "TFT" is not effective in low iteration tournament and by increasing the number of iterations there were chance of mistakes as partial analysis is carried out manually. The results of these two tournaments are shown in table 15.4. In tournament 1 main contractor play "TFT" and in tournament 2, main contractor play "All D".

Table 15.4: Comparison of the results of tournament series 3

Tournament 1

Player	Strategy	Payoff	
		Total	Avg.
MC	TFT	66	2,20
SC 0	TFT	27	0,90
SC 1	TFT	27	0,90
SC 2	TFT	27	0,90
SC 3	All D	12	0,40
SC 4	All D	12	0,40
SC 5	All D	12	0,40

Tournament 2

Player	Strategy	Payoff	
		Total	Avg.
MC	All D	48	1,60
SC 0	TFT	17	0,57
SC 1	TFT	17	0,57
SC 2	TFT	17	0,57
SC 3	All D	9	0,30
SC 4	All D	9	0,30
SC 5	All D	9	0,30

Tournament series 3 also shows the success of "TFT". Main contractor gets higher payoffs when play "TFT" as compared to the playing "All D". The payoff of all the subcontractors increased when main contractor played "TFT" as compared to when main contractor played "All D". The reason is obvious; when main contractor plays "TFT" then "TFT" subcontractors get more payoffs from main contractor in each interaction with him. The payoff of "All D" subcontractors also increases because each of them also gets single cooperation from main contractor in their first interaction with him.

15.5 Conclusions and Recommendations

- The success of TFT is due to its property that it does not exploit others and it judges the other player's strategy and plays accordingly.
- Continuity of interactions is necessary for development of cooperation.
- When a cooperative strategy is established in a group and all players starts cooperating with one another then this group can resist an invasion of non cooperative, only due to its reciprocity action. It is a

basic principal for a stable cooperative strategy that if an invader strategy tries to exploit cooperatives then it should be unprofitable for the invader.

- The strategy “All D” is evolutionary stable irrespective of the probability of continuation. On the other hand TFT in only evolutionary stable if there is sufficient large probability of continuation of relations.
- There should be recognition ability about the reputation of other players. One of the successful properties of TFT is that it recognizes the other player by its history.

The strategy “All D” seems more stable but if we consider the real world examples then it is revealed that cooperation is necessary for survival of species. Consider a colony of ants or honey bees. When an invader attacks their colony then a group defends the colony by endangering their lives. When a honey bee stings it can not survive similarly defender ants also have greater chance to die in case of strong invader. The best strategy for these defenders is to play safe and try to save their lives. If every one saves its life then there will be no resistance for invaders. A small incentive (saving its own life) is not much beneficent because in this case whole colony will die. A small benefit today generating a big loss tomorrow is not an evolutionary stable strategy. On the other hand sacrificing small benefits for big benefit tomorrow is evolutionary stable. The behavior of ants and honey bees is a real word example.

Cooperation is also visible in other animals. Wolves, wild dogs and lions hunt in groups. If one animal does not hunt with its group it will have less chance of injury and even then it will get food. If all the animals of the group adopt this strategy then no one will hunt and they will die of hunger. So cooperation is necessary for their survival. It is the cooperative behavior due to which these species have survived. It shows that their cooperative strategy is evolutionary stable strategy. If we consider an individual animal then it seems that by non cooperative behavior the animal has more chances of survival but actually it is not.

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Chapter 16
Realistic Behaviors and Cooperation

16.1 Introduction

In previous chapters of this part the combinations of different strategies and characteristics of a good strategy were discussed. Actually that was the analysis of different strategies. In these analyses we assume that a party adopted a constant strategy. Once a party have choose a strategy to play then it stick to it in whole game. This behaviour is not realistic. In actual conditions an individual or a group rethinks after each interaction and can play different strategy in its next moves according to the conditions. Now we will take help of "game theory" to study the sustainable cooperation by analysing the individual behaviour and related conditions.

16.2 Lame Duck Effect

As defined by Wikipedia "*A lame duck is an elected official who is approaching the end of his or her tenure, and especially an official whose successor has already been elected."* The Lame Duck Effect is that "when a person's role is going to be finish it undermines his/her ability to cooperate". This is also called "end effect".

It has been discussed earlier that by increasing the number of interactions cooperation can be established. If there is only "one iteration game" then players will not cooperate but try to play safe strategy. In our payoff case as in table 15.1, if there is only single iteration game the players will not take risk to cooperate. If one cooperates and other defects then it will be loss for co-operator and there are no further moves to reciprocate. In finite interaction game the last move is actually a single interaction game because there will be not further move. In last move of the game every one will play safe (Defect). Similarly in 2^{nd} last move every one also defect and it will continue and every one will defect in whole game. This process is called "backward induction" or "unravelling from the back". Suppose in a game there are repeated interactions among the two players. If there are 100 interactions

then at 100th move players will play safe and defect. Similarly on 99th move they will also defect and it will continue it means they will not cooperate.

Repeated interactions cannot create cooperation if there is finite number of interactions. This discussion explains that a known end (absence of future) will not promote cooperation.

16.3 Effect of Punishment on Defection

Consider a single move game then defection is more attractive than cooperation because there is more gain in defection. A general relationship below (Eq. 16.1) describes the condition when cooperation will be preferred over defection.

$$\underset{\text{(today)}}{[\text{Gain in Defection}]} \leq \underset{\text{(tomorrow)}}{\left| \text{Value of relationship after cooperation} \right| - \left| \text{Value of relationship after defection} \right|} \quad \text{Eq. (16.1)}$$

If there is no future interaction or player does not give any importance to future relationships then the right hand side of equation 16.1 will be zero. It means there is benefit in defection and players will go for defection. According to equation 16.1, cooperation will be induced if value of future cooperative relationships will have more value than benefits of defection today. If there is no future interaction then right side of equation 16.1 can be increased by introduction of punishment. If the loss due to punishment is greater than gain in defection then the incentive to defect can be reduced.

Now consider the interactions of two players. The cooperative condition according to equation 16.1 can be expressed as in equation 16.2 below by using the payoffs as we assume in table 15.1 earlier.

$$\underset{\text{(today)}}{[\text{Gain in Defection}]} \leq \underset{\text{(tomorrow)}}{[\text{Payoff to play C-C}] - [\text{Payoff to play D-D}]} \quad \text{Eq.(16.2)}$$

Inserting the payoffs as in table 15.1 in Eq. 16.2:

$$[\,3 - 2\,]\ \text{(today)} \quad \leq \quad [\,2\,] - [\,0\,]\ \text{(tomorrow)}$$

$$1\ \text{(today)} \quad \leq \quad 2\ \text{(tomorrow)}$$

This result indicates healthy signs for cooperation if there is possibility of future interaction. If the chance of future interaction is very less even then we can create cooperative conditions by introducing the punishment for defection. If loss due to punishment is greater than the temptation of defection the defection can be avoided.

Now the question is that how this punishment can be assured. One method of punishment is the reciprocation but if there is no future interaction then no reciprocity possible. The solution is to introduce a compulsory third party punishment. As it is a normal case in construction industry, if a party violate the contract then it is answerable to court or mediators. But we have described earlier that there is no contractual relationships among subcontractors in a construction project. If there is no contract then there is no possibility of a compulsory third party punishment in case of defection.

16.4 Cooperation in Non-Contractual Relations

As discussed in previous section that a third party punishment for defection is possible when the parties have an agreement/contract between them. In construction projects the subcontractors involved in a project are not contractually bound to one another. Therefore no third party punishment can intervene to ensure cooperative behaviour. In this situation the only punishment is the reciprocity. The reciprocation is possible if there is probability of future interaction. The incentive of cooperative relationships in future can provide incentive for cooperation today.

16.4.1 Provocation

In non contractual relationships among subcontractors if a party defect to other then a series of continuous defection starts. The defection creates

hostility among both the parties and they do not cooperate again. A single defection provokes the opponent and non cooperative behaviour starts. Under these circumstances the equation 16.2 can be written in form of equation 16.3 as below:

$$\text{Gain in Defection} \leq \delta\,[(\text{Payoff to play C-C (forever)}) - (\text{Payoff to play D-D (forever)})] \quad \text{Eq.16.3}$$

δ is probability of continuation in future, its value will be less than 1 because there is possibility that tomorrow may not occur. Value of payoff today is higher than the value of same payoff tomorrow because there is element of doubt that tomorrow may not occur.

By substituting the payoffs as in table15.1, in the equation 16.3 we get:

$$[3-2] \leq \delta\,[(\text{Payoff of value 2 (forever)}) - (\text{Payoff of value 0 (forever)})] \quad \text{Eq. (16.4)}$$

Value of 2 forever = 2 + 2 (tomorrow) + 2 (day after tomorrow) and so on

Probability of occurrence of tomorrow is δ

=> Value of 2 forever (X) = $2 + \delta 2 + \delta^2 2 + \delta^3 2 + \delta^4 2 + \ldots$.

=> $X = 2 + \delta 2 + \delta^2 2 + \delta^3 2 + \delta^4 2 + \ldots$.

=> $\delta X = \delta 2 + \delta^2 2 + \delta^3 2 + \delta^4 2 + \ldots$.

=> $X - \delta X = 2$

=> $X = 2/(1-\delta)$

Substitute this value of X in equation 16.4 we get

$[3-2] \leq \delta\,[\,2/(1-\delta) - (0)\,]$

=> $1 \leq \delta\,[\,2/(1-\delta)\,]$

=> $1 - \delta \leq 2\delta$

=> $1 \leq 3\delta$

=> $\delta \geq 1/3$

If the temperament of parties is provocative such that a single defection triggers the non cooperation then the cooperation can sustain if the probability of continuity of relationship is at least 1/3. This value of probability (1/3) is not a general number but it depends upon the value of payoffs. We will use this value only for comparison under same payoff conditions.

16.4.2 Self Realization

In previous section we analyze that if the probability of continuity is at least 1/3 then it can create sustainable cooperation. But this type of behaviour is not reliable. If the value of probability of continuity is greater than 1/3 even then an unintentional defection or a misunderstanding can trigger defection for ever.

Now we use the similar analysis to estimate the probability value for condition that in case of a defection parties can turn again toward cooperation. Equation 16.2, under these conditions of one time defection, can be written as shown below in equation 16.5.

$$[3-2] \leq \delta \left| \begin{array}{c}\text{Payoff of value} \\ \text{2 forever}\end{array} - \begin{array}{c}\text{Payoff of value 0 tomorrow} \\ \text{and then 2 forever}\end{array} \right| \quad \text{Eq. (16.5)}$$

$$\Rightarrow \quad 1 \leq \delta\left[\left(\frac{2}{1-\delta}\right)-\left(\frac{2\delta}{1-\delta}\right)\right]$$

$$\Rightarrow \quad 1 \leq \frac{2\delta}{1-\delta}(1-\delta)$$

$$\Rightarrow \quad 1 \leq 2\delta$$

$$\Rightarrow \quad \delta \geq 1/2$$

This result shows that under the given payoff condition, parties can turn back to cooperation after one time defection if the probability of continuity is at least 1/2.

This probability value is greater than the value as in provocative condition. It means by increasing the value of probability of continuity, cooperation can be established even after a defection. Cooperation under this condition is more reliable than the previous condition because now an

unintentional defection or misunderstanding can not trigger defection. It shows that by increasing the probability of continuity we can get a sustainable cooperation.

16.5 Conclusions and Recommendations

- The nature of construction industry gives rise to “lame duck effect” due to its non-consistency. The existence of future, in relationships is necessary for cooperation. As the probability of continuity in relations increases cooperation gets better and better.
- Punishment on defection is also a process to decrease the non-cooperative behaviours. Punishment decreases the benefits of selfish behaviours in relationships. In this way the defection in response of cooperation does not remain an attractive move even for the short sighted selfish players.
- Punishment can only work if the conditions of contract/agreement are well balanced. Such as no party could exploit other.
- Efficient dispute resolution system is also necessary for effective punishment. Proper punishment to the deserver is necessary to discourage contract violations.
- Punishment can only be exercised effectively if there is contract or agreement between the parties. Actually in construction projects there exists lot of interactions among parties which are not bound in any kind or contract/agreement. In these conditions selfish behaviours can not be punished. In these kinds of relationships the best condition to promote cooperation is continuity in relations.
- The construction industry some times can not ensure continuity in relations. If the continuity of relationships between same parties is not possible then one can also explore the chain-relationships. One contractor works in a project with few contractors and in next project works with other contractors so there is chain of relationships. Reputation of a contractor plays very important role for other players to

deal with it. Reputation can play a role in the environment which not only record the behaviour of contractors but also make it possible for others to know about its behavioural history.

- It has been seen that safer strategy does not mean the most successful strategy. As in previous chapters the safer strategy for player was to defect but players can get more benefits by cooperation. Therefore to start cooperation it is necessary that players should be taught and encouraged to cooperate with others. If all the dealing parties leave their safer strategy and turn towards cooperation then no one will be in loss.

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Part 4
Recommended Strategies and Conclusions

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Chapter 17

Strategic Model

Improving the Relationships among Construction Supply Chain Members

17.1 General

Construction industry has been considered backward as compared to other manufacturing industries in adopting latest management practices. However construction industry has showed great interest in adopting project management techniques. Modern project management techniques are considered essential for the successful completion of construction projects. As for as supply chain management and relationship management are considered, construction industry is generally lacking behind from manufacturing industries. Especially in Pakistan construction industry the concepts of supply chain management and relationship management are new. The leading public and private developers and contractors does not considered cooperation among project fellows, as an important issue which may be critical in successful completion of their projects. Although Pakistan construction industry is facing some serious issues like cost overrun, time overrun and disputes among construction teams in most of the construction projects. One of the important reasons of above described issues is the lack of coordination and poor relationships among participating teams e.g. main contractor, subcontractors and suppliers. Large construction projects are not a single organization's show but actually different types of firms as subcontractors are usually involved in carrying out different construction activities. Out sourcing different activities by main contractor to different specialist firm is now a days a common practice not only in Pakistan but all over the world.

Therefore due to the current problems in Pakistan construction industry there is need of better cooperation and productive relationships among supply chain members. In order to deal with this issue a strategic model has been proposed, keeping in view the necessity and characteristics of Pakistan

industry; however it may be applicable all over the world especially in developing countries. Recommendations for cooperation have been suggested on the basis of empirical findings and analytical analyses as described in previous sections.

The sections below describe the strategic model to improve the relationships among supply chain members of construction projects. The practical importance and the recommendation for its implementation are also suggested.

17.2 Model Development Process

Development of a strategic model to improve the relationships among supply chain members in Pakistan construction industry require an overall examination of practices in construction projects especially the issues related to subcontracting. After examining the issues need to be improved, recommendations are suggested on the basis of empirical and analytical findings, carried out in this research. This examination particularly emphasis on some important aspects of construction industry as described below:

a. Business environment of the industry i.e bidding process and project execution.
b. Administration, regulation and legal environment of industry.
c. Present situation of implementation of project management techniques and related training of professionals in construction industry.
d. Trend and practices of subcontracting (outsourcing project activities to third party)
e. Level of innovation in management of subcontracting and related issues.
f. Cooperative culture and practices in the construction industry.
g. Management culture related to safety, quality, cost and time issues in the construction industry.
h. Present practices and culture related to risk management in construction projects.

i. Financial disbursements practices in the construction industry.
j. Disputes and litigation among supply chain members of construction projects.

"Game theory" is a well known branch of mathematics to analyze the competitive situations. Cooperation conditions are explored with the help of analytical modeling by "game theory".

To get the actual picture empirical studies also carried out. For data collection, to assess the issues related to relationships and other problems faced by supply chain members, the contractors and subcontractors of province of Punjab were focused. A major government developing agency in province of Punjab which manages all provincially financed developing projects related to roads, bridges and buildings, is the client of these focused contractors.

The study initially focused on overview of the problems related to subcontracting by review of Pakistani and international literature. The views of the key stakeholders (main contractors and subcontractors) in Pakistan construction industry were also assessed about key issues through interviews and questionnaire survey. It is tried to consider the ground realities associated with related issues. In addition of literature review and empirical data collection, analyses are also carried out by analytical modeling with the help of game theory.

The ultimate objective was the development of a strategic model, which can suggest effective recommendations to promote productive relationship in the construction industry. The model was developed and refined through an extensive investigation of the industry to achieve practical significance in reducing problems of construction projects in Pakistan.

17.3 Model Description

This section explains the basic objective of the model. The objective is also described in form of Vision and Mission of model.

17.3.1 Aim of the Model

The main objective of the proposed model is to create productive relationships by improving cooperation among contractors and subcontractors in construction projects. The model especially focuses on Pakistan construction industry. However it is applicable to any construction industry in the world especially in developing countries. Its aim is to improve conditions during the execution phase of construction projects by managing all the participants in the project. Implementation of strategies has been suggested which are successful in developed countries and also in other industries related to subcontractors' management. The model aims to make the Pakistan construction industry successful by overcoming its problems. Especially problems related to fragmentation in industry. The model also aims to provide opportunities to small contractors with out the fear of exploitation of big contractors in large construction projects.

17.3.2 Vision and Mission of the Model

To improve the construction industry so that it can overcome some of serious problems like non-cooperative relationships and disputes. A construction project culture needs to be developed which is free of professional hostility among participants and can exhibit better teamwork.

Keeping in mind the above description, a vision of this model has been described. This vision is expected to provide direction for necessary development and implementation of desired recommendations in order to achieve its objectives. The public and leading private institutions should promote this vision to all the stakeholders in the construction industry in order to get its desired benefits.

Vision of the Model

The model aims the construction industry to be a leading, progressive, and innovative through its cooperative and productive environment during construction.

The mission is to develop construction industry of Pakistan/Developing countries. So that it could deliver high quality products and can contribute in country's economy by successful completion of development projects. The construction industry should overcome its issues related to teamwork management during the physical execution of the projects in order to lead the industry towards its vision.

Mission of the Model

To recommend strategies so that big and small contractors in Pakistan construction industry can develop a mutually productive and cooperative project environment. All the participants in construction projects should think and act collectively to overcome their mutual problems.

The key elements in the mission and vision statements are explained as under:

Leading

The construction industry will not only overcome some of its traditional problems but it will further achieve such achievements and set examples for other industries. It will also provide inspiring role in economic development of the country.

Innovative

The construction industry will become an innovative industry by providing its stakeholder (small and large firms) a cooperative and encouraging environment. Competitive as well as balanced (in terms of powers and risk sharing) conditions can make construction industry innovation friendly.

Progressive

A qualified and skillful workforce in an encouraging and cooperative environment will certainly grow and achieve its targets. If construction industry provides opportunities and encourages individuals and collective efforts then the industry will naturally creates more opportunities. In this way industry will not only economically and technically develop but it will also help other key sectors of country's economy.

Cooperative and productive

Not only in Pakistan but all over the world the construction industry consists of different kinds of firms and these firms have their roots in other sectors also so that the boundaries of construction industry cannot be clearly defined. In this kind of situation it is obvious that the more the cooperation among these firms the more productive they will be.

Participants

It includes all the stakeholders in the construction project especially client, main contractor and its subcontractors which includes medium and small size firms, specialists and material and equipment suppliers.

17.4 Strategic Model

The proposed model mainly consists of two major components as below:

1. Strategic Thrusts; this component identifies the important areas to be focused for this model on the basis of empirical and analytical analysis.
2. Recommendations for improvement; explains how to achieve desired performance for different strategic thrusts in construction industry.

17.4.1 Strategic Thrusts

In view of the survey outcome and analytical analysis by "game theory" some important aspects to achieve "vision and mission", have been identified which are named strategic thrusts. These strategic thrusts are listed below:

1. Increase the probability of future interactions
2. Make cooperation more beneficent than defection.
3. Teach and motivate contractors to cooperate.
4. Improve reciprocity in construction industry.
5. Improve conditions and abilities for formation and recognition of reputations.
6. Improve contractual conditions especially for subcontracting
7. Motivate to develop and adopt best ethical and professional practices.

Description of these strategic thrusts is given below:

Strategic thrust1: Increase the probability of future interactions:

If there is no interaction in future then defection will be more beneficent and cooperative behaviour will not pay. There are two conditions to enlarge the future interactions. One is to increase the durability and 2nd is to make the interactions more frequent. Consider different broader types of construction fields, the different groups of each field normally stick to their special construction field. It means the member of each group interact within the group in different projects. If the members of groups are less then there will be more frequent interactions. Members of a small group interact more frequently than members of a large group. Moreover the element of recognition of others will be more in small groups as there will be fewer strangers.

The interactions can be increased by creating such an atmosphere during the construction project that one interaction could be divided in several small interactions.

Strategic thrust 2: Make cooperation more beneficent than defection:

It has been proved earlier that non-cooperation seems more attractive than being cooperative. If there is some kind of punishment for defectors such that defection becomes more costly than cooperation then no one will defect. It is easy to say but these conditions are not as easy to create. Punishment for defection is possible if there is agreement or contract between parties. Then a third party (mediator) will decide the level of defection/violation and suggest punishment. In construction projects the subcontractors do not have any contract with one another. Subcontractors only have contract with main contractor. In relationships among subcontractors there are two possibilities, one is short term benefit of defection and the other is benefits of a long term cooperative relationships.

It has been discussed earlier that short term incentive of defecting today are actually less beneficent than long term effect of cooperation. So the realization of this reality of benefit can make the parties to understand that cooperation is more beneficent than defection.

Strategic thrusts 3: Teach and motivate contractors to cooperate:

From the payoffs in table 15.1 it is clear that the best strategy for a player in any situation is to defect. The reason is that there are chances that other may defect. Defection is more attractive if continuity of relations is not clear. If there is continuity in relations and it is assured that other player will cooperate then the chances of a party to cooperate, will increase. More over if the party is also realized that short term benefit of defections is less than overall benefit of cooperation then it is sure that the party will cooperate because overall there is loss in defection. Therefore teaching and training of organisations' management as well as staff is necessary to promote cooperation.

Due to the unique nature of construction projects one can realize that there should be some kind of working practices for all the participating organisations. So that by adopting these working practices, each party involved can create a helpful and progressive atmosphere for other participants. These practices or norms should include responsibilities, sharing

of risks, compromises, cooperation, working style, sharing of limited resources and space. Better cooperation among the critical members of construction project can be achieved in this way as naturally it is difficult to achieve satisfactory cooperation if there are not many chances of continuity of relations among these firms in recent future.

Generally there are different construction firms involve in a project as main contractor outsources some activities to different subcontractors. These different subcontractors have to share same space and there activities also depend or affect one another. Therefore their issues with one another can not be managed by contract because they are only contractually bound with main contractor but not with one another. This strategic thrust suggests introducing and encouraging practices to increase better cooperative relationships among these firms that often have to work in large projects with other small and medium scale companies.

Strategic thrusts 4: Improve reciprocity in construction industry:

In Axelrod tournament the winner strategy “tit for tat” is a reciprocity strategy. It plays defection against defector and cooperation against cooperator. It gives punishment to defectors. In construction projects when different construction companies interact with one another then playing “tit for tat” has many complications. It creates hostility among construction firms. Some times a small unintentional incident can create never ending hostility. If the defection receives no punishment then it will pay to defector, more over it will encourage other parties that defection pays.

The punishment from a third party is important to reduce retaliation similar to the role of police in a society. The use of balanced construction contracts and effective dispute resolution methods can serve this purpose to some extent. The problem is that all the parties in a construction project are not bound in a construction contract. Therefore there should be some rules or ethics to act as guidelines for measuring cooperative behaviours. There should be also some kind of central authority to decide about the level of non cooperative behaviour and enforce necessary punishment.

Strategic thrusts 5: Improve conditions and abilities for formation and recognition of reputations:

We have seen that the best strategy has two basic characteristics. It is cooperative initially and it reciprocates accordingly. For reciprocating reaction there should be recognition ability. For reciprocation the parties should distinguish between those who respond to the cooperative behaviours and those who do not respond positively. Effective information and communication system in construction industry can help in this regard.

Although information and communication system plays important role in post construction stage as it has helped in accelerating the modification, review and approval processes. The use of information and communication system may be very beneficial for main contractors in managing the subcontractors' activities and their performances in project. The objective of this strategic thrust is to modernize the construction industry in Pakistan and to provide it some platform to manage construction related records effectively.

Strategic thrust 6: Improve contractual conditions especially for subcontracting:

For smooth relations between contractor and subcontractor a balanced subcontract conditions are necessary. In Pakistan construction industry there is no standard subcontract. Some big contractors have developed their own brief subcontract conditions under which they sublet their works. Since these type of subcontract can not be a balanced unless these are developed by neutral experts. Some times a contractor sublet similar type of works to different subcontractors under different rates and conditions which creates troubles. A contractual relationship can only be effective if contract conditions are well balanced between both the parties. Therefore there should be some kind of standard conditions for subletting the works to subcontractors.

In Pakistan the general impression of construction industry is a backward and unfriendly. Subcontractors often complain of exploitation of their customers meanwhile main contractors also complain about the non professional approach of subcontractors. This strategic thrust emphasizes on

introduction and reforms of legal and regularly structure in construction industry. Due to lack of this structure especially at subcontractors' level the disputes and unfavorable outcomes are common.

Strategic thrust 7: Motivate to develop and adopt best ethical and professional practices:

In case of non-contractual relationships among subcontractors the probability of selfish behavior increases. In this case professional and ethical practices play important part in promoting cooperative relationships. Proper human resource management is necessary in promoting these ethics.

Although subcontracting is a common phenomena in construction projects but there is need for proper professional practices in this regard especially in public sector. Lack of professionalism is a serious problem in Pakistan construction industry, especially in small construction firms. Inconsistent construction development and lack of continuity of relations are major reasons due to which the professionalism in construction industry can not develop as compared to other industries. The aim of this strategic thrust is to introduce professionalism in construction community through administration of the companies. The administrators/owners of construction firms should be guided and trained so that they could align their efforts and policies to improve professional mind set of their staff.

In Pakistan construction industry the use of labor as compared to machinery is higher in comparison to developed countries. The availability of cheap labor has decreased the innovative skills in construction industry. Due to poverty and unemployment cheap labor is abundantly available and this labor also does not object on unpleasant working conditions. This environment is discouraging for skill and qualified workers. Construction firm should produce attractive conditions for skilled and experienced labor in order to create a professional and productive workforce. Professional training opportunities should also be provided to improve the skills and qualifications of available local labor.

17.4.2 Strategic Recommendations

Construction industry plays an important role in any country's national economy. In Pakistan construction industry especially at provincial level the public sectors are major developers. Therefore the strategic recommendations for this model include policies at government level and steps to be taken by important stakeholders.

Recommendations for Strategic Thrust 1: Increase the probability of future interactions:

Some important project management practices are discussed here that can play important role in increasing interactions among construction firms involved in construction projects.

a) *Combine Schedule Controlling*

Main contractor's planners or planning firms generally do not critically and deeply consider the working procedures of subcontractors. As a result the project planning schedule can not be followed by all the subcontractors of the construction project. This schedule may cause difficulties and hindrances for some subcontractors. It is obvious that schedule prepared with the participation of all concerned participants will be more effective and truly represent the construction procedure which can be followed by all the participants. Preparation of a combine schedule and then continuous monitoring with this schedule will increase the interactions among participants of construction project. It will also reduce the chances of delays, site disputes, claims and litigations. It will also avoid duplicate efforts as some times separate schedules and reports have to be prepared according to different external and internal requirements.

There may be different approaches to create a combine schedule but some basic steps are suggested here.

The schedule planner (main contractor, planning firm or client) should provide a pattern or guide lines to all participants to prepare the schedule. The subcontractors should be communicated about their as well as other participants' scope of work.

Each subcontractor will prepare his own schedule of work and will also communicate the main contractor about expected constraints and those activities of other participant which can affect its progress. Each participant should deeply observe the schedule prepared by others and in case of suspected constraints it should be mutually amended. After these preparations main contractor will prepare combine schedule and all the participants will observe it and it will be further amended if needed. Combined schedule preparation meeting should be arranged for this purpose.

This mutually developed schedule will increase coordination among subcontractors. More over the constraints and issues will become clear and effected party can take remedial measures in advance. This schedule will be constantly updated and amended during the periodic meetings of the construction parties. Recording progress will be easier and duplicate efforts will be reduced. The start and finish dated of different activities will be more realistic. A realistic schedule prepared with consultation of all the participants will help the main contractor and clients to estimate the cash flow, material and labor requirements at different stages so it will help in reducing different financial, social and cultural issues also.

b) Continuous Evaluation

By making series of evaluation during a project means evaluating and displaying several small interactions instead of a single evaluation at the end of the project. In some condition it is not necessary that subcontractors involved in a project may work with the same main contractor again for example when a main contractor works in another country. Therefore evaluation of

subcontractors at the end of the project will not be beneficial. In this kind of situation main contractor should mark the instant performance during a project. The recorded performance by periodic evaluation process should be displayed in a visual manner on a chart. This chart should be installed in its office to have a single glance understanding about the performance of every participant. A simple chart showing this type of performance detail is shown in table 17.1. It will not only help the main contractor's managerial staff about the necessary efforts to be done but also motivate subcontractors to perform better and a sort of healthy competition will develop among them.

Table 17.1: A Simple Performance Chart of Subcontractors during a Project

Good (✓) : Satisfactory (–) : Poor (✖)

Sub Contractor Description	Progress according to Schedule	Quality	Site installations	Site Cleanliness	General behavior	Over All
SC A (Earth work)	–	✓	✖	✓	✖	–
SC B (Concreting)	✓	–	✖	–	–	–
SC C (Steel Fixer)	✖	✓	–	–	–	–
SC D (Sanitary)	–	–	✖	✓	✓	✓
SC E (Tile fixer)	✖	✓	–	–	–	–
SC F (Painter)	–	–	–	✖	✖	✖

The performance record made by continuous monitoring will help the subcontractors to overcome their week points. This type of performance record will become a data base for main contractors to be used in prequalification of subcontractors and suppliers in their future projects. If we consider the details of all the subcontractors and suppliers involved in a project then there will be some participants which worked for very short span of time. Some have

very insignificant impact on project or on others through their performance. So these subcontractors are not necessary to be included in the performance monitoring list. Only the critical subcontractors and suppliers should be closely monitored and invited in regularly arranged meetings. Regular meetings of all key participants will help to inform the subcontractors about their performance and future preferences. A continuous feed back will help the subcontractors to improve their performance according to the expectations of others. In this way some of the project uncertainties caused by subcontractors can be avoided. Monitoring and evaluation practice will also encourage the subcontractors to seek for different innovative means in order to become more productive. Therefore it will motivate them to develop cooperative relations with one another to improve their performance. The non-cooperatives could be identified earlier and directed to perform better.

c) Construction projects are short term in nature and all the participating parties cannot continue their relations with one another during their next projects. A contractor engages different subcontractors and suppliers in its different projects due to location and nature of the project. In these conditions continuity in relations is difficult to achieve. Therefore a group based practice needs to be developed to form an integrated supply chain in short time. By keeping the number of related professionals less, the number of mutual interactions can be increased. The subcontracting firms should be registered according to requirement of industry and main contractors should sublet work to registered subcontractors only.

Recommendations for Strategic Thrust 2: Make cooperation more beneficent than defection:

a) Subcontractors often complain about the exploitation of main contractors in form of payments, risk transfer and deserved credit. Therefore it is much important to balance the powers between main contractor and subcontractors so legal and contractual reforms in this regards should be done. In Pakistan the general contract document of public sector do not contain sufficient contract conditions for subcontracting, it means responsibilities of main contractor towards subcontractors are not clearly defined in contract documents. Balanced contract conditions and efficient dispute resolution system can ensure punishment to defectors.

b) The adoption of partnering in public sector projects should be introduced. Provision of partnering in contract documents should be made and there should be also efforts on exploring the contractual partnering.

c) Incentive can change the traditional approaches in construction projects. Some incentive like new introduction of new procurement approaches such as “target cost contracting” and “guaranteed maximum price” approaches. These kinds of approaches may be selected and explored according to the requirements of each construction project. The initiative of introduction of these kinds of new approaches should be started by public sector and also private sector should be encouraged to adopt new contacting approaches because it is easier for private sector because they are more flexible in administrative and financial matters than public sector. By experiencing new contracting approaches their will be improvement in inter firm communication and payment practices.

Recommendations for Strategic Thrust 3: Teach and motivate contractors to cooperate:

a) The leading stakeholders of construction industry should provide opportunities of training and learning to new comers at educational institutes, according to the current demand.

b) Training and education should be continuous phenomena in construction firms. Practice of in house training should be introduced in construction firms. In-house training and learning opportunities should be part of evaluation criteria for construction firms.

c) Awareness should be created to invest on human capital. Contractors should introduce professional trainings and evaluation systems for generation and categorization of supervisors, technicians and skilled workers. The trained and skillful professionals should be kept intact with high wages and better working conditions. As it is observed that lot of professionals and skilled workers of Pakistan construction industry, have migrated in Middle East because of better wages.

d) The teaching staff of technical institutions should also provided the facility of practical experience in industry and the professionals in the industry should also teach in technical institutions so that the training and education should meet the current requirement of the construction industry.

e) *Risk Management*

A proper criterion of sharing of risks also increases cooperation. Sharing and managing responsibilities in case of risks also play important role in mutual relationships. The practice of risk

management is not properly adopted in Pakistan construction industry. It is observed that disputes over responsibility of risk transfer often occur among contracting firms involved in a project. Therefore it is important to develop awareness for importance and benefits of risk management practice in construction community to promote cooperation. It is also observed there is lack of realization of risk management at organizational and individual level therefore formal and informal training and education is necessary in this regard. By reducing project risks the problems of cost and time overrun can be reduced and also there would certainly improvement in quality and safety.

Some important steps regarding proper practice of risk management are suggested as below:

i. Most of the project risk evolved during project development and design stage therefore it is important to involve contractors in development stage for realistic risk management.
ii. Contractors should be introduced to develop and implement policies related to risk management.
iii. Subcontractors should also be aware of the benefits of risk management. Main contractor should play their role and demand risk management plans from subcontractors.
iv. Contractors and subcontractors should realize the responsibility and benefits of risk management and required strategies should be adopted. They should also allocate funds for hiring and training of their professionals for proper risk management.
v. All the parties during the project should be involved in risk management and related meetings should continuously be arranged to update related efforts.

vi. It is always important for contractors and subcontractors to foresee the sources and occurrence of risks rather than planning the consequences of impact.

vii. Contractors should develop proper risk monitoring and response by improving their capabilities.

viii. After introduction of risk management the level of risk maturity should be gradually improved and contractors can make themselves safer against risks.

ix. Clients in construction industry of Pakistan can play a major role in introduction and adoption of risk management practices because clients have a driving role on policies and finance.

x. Insurance as risk transfer is rarely practiced in Pakistan construction industry. Transfer of risks by insurance should be introduced by clients and contractors through contractual reforms and insurance companies should also offer special insurance policies in construction industry to increase the insurance trend.

f) *Relationship management*

Some important issues are discussed here which can play an important role in improving mutual cooperation among different firms in construction industry. It is important for chief executives and manager to adopt these practices through their company policies for more productive construction supply chain. Some important issues in relationship management are discussed under:

i) Strategic policies:

Contactors should focus on long term relations and develop vision and mission statements by considering future relations and customers. Creation and encouraging the culture of continuous learning and sharing knowledge in all categories of staff needs special focus.

ii) *Partnership:*

In Pakistan mostly public sectors works are awarded on low bid basis to single pre qualified contacting firms. This environment is not encouraging for partnering. Studies have proved that partnering in construction projects shows better outcomes than non-partnered projects. Amendments should me made in project awarding practices in order to allow contractors to participate in bids collectively in form of partners or joint ventures.

iii) Trust Building:

Trust take long time to build but can be shattered as a result of only one bad incident. To build trust start to share information, help counterparts and avoid trust avoiding activities such that creating hurdles for others at construction sites and hiring the staff of others in case of shortage. Try to have transparency in all dealings with other firms working along with.

iv) *Look beyond financial benefit:*

Good relations with other companies are more beneficial than short term advantages. Companies should look to strengthen their links with their counterpart firms. Sharing of rewards and risks are more beneficial and it creates a win-win environment. Cooperative culture will be beneficial for firms working together in cost control, avoiding unforeseen losses and creation of innovative atmosphere.

v) *Cooperative network:*

Building long term partnership with those companies which can provide help and skill in which you are lacking will be certainly beneficial. This kind of network will have natural ability of cooperation. It will not only provide the opportunity to train the staff of each other but also encourage the companies to work

together in future by increasing their dependency and trust over one and other.

vi) *Team work:*

Construction firm which work like a team will have more value for the clients or main contractors. Subcontractors try to strength their relations on individual and collective levels to increase their output and reduce hurdles like disputes, shortage of skilled workers and equipments. With a good team work the participating firms will have more chance to get work with better terms and conditions.

vii) *Attract and grow:*

A network of firms working together successfully will also attract other firms to join. In this way the network can enlarge itself by inviting the firms which it really needs. So this enlargement will increase the network ability to perform.

viii) *Financial disbursement management:*

Suppliers and subcontractors get their payments from main contractor therefore main contractor should be fair in paying to its subcontractors. There are problems due to exploitation of subcontractors by main contractors due to delayed or reduced payments. More over all the subcontractors should be equally treated in financial matters. If some subcontractors are given preference then other may feel discouragement.

ix) *Behavior and fairness:*

Front line staff of contractors should treat subcontractors fairly and should be trained to have communication and working relationship skills. For example quantity surveyor, who measures the work of subcontractors for payments and scheduling and monitoring staff of main contractor involved in progress

monitoring and setting up targets for subcontractors often criticized by subcontractors for their unfair behavior. Realistic approach should be adopted by main contractor to avoid these kinds of complaints.

Recommendations for Strategic Thrust 4: Improve reciprocity in construction industry:

a) There should be reforms in contract conditions of public sector regarding subcontracting. In public sector there is need of proper control over subcontractors' works. This control can be improved by introducing tender requirements for main contractors to submit plan of out sourced activities and their management and monitoring schedule.

b) Since in each major construction project several construction firms are involved (contractors, subcontractors, suppliers) so there are often disputes and litigation took place. These disputes not only financial burden for contractors but also it delays the construction process. Although the arbitration system is defined in contract document but it needs to be make more effective and rapid. By observing the recent disputes resolution process, reforms should be made in following aspects:
   i. Criteria for nomination of arbitrators.
   ii. Code of ethics (transparency, fees, confidentiality) and mechanism for nominated arbitrators.
   iii. The time to time improved arbitration mechanism should also be included in standard contract conditions.
   iv. Introduction of new and improved dispute resolution processes such as adjudication.

Recommendations for Strategic Thrust 5: Improve conditions and abilities for formation and recognition of reputation:

a) Improved data base of registration and grading of subcontractors according to their skill and capabilities. Reforms also required to avoid adverse effects of subletting such as total or excessive subletting. Obligations of main contractors and subcontractors should be defined and practiced.

b) Database of supervisors and skilled workers should be maintained at each firm level and also by collective database system. It will also help in job continuity for sincere and skill workers as their jobs are temporary and project based. So their services can be hired by other construction firms when existing project finishes.

c) In most of the public sector organizations the only criteria for awarding contract is price competition. There is significant need to give due credit to quality, safety, and other added values by the contractors. Rule and regulations needs to be revised to take care of these factors and current performance should be the significant factor than the price.

d) Pakistan Engineering Council (PEC) is organization responsible for registration of engineers and contractors. Due to the diversity of construction activities PEC should have close ties with public sector construction developers and also with leading private contractor organizations for effective control and evaluation of contracting firms.

e) In order to control small firms which work as subcontractors, PEC should also register site supervisors. Contractors should make bound to register their site supervisors and only firms with

registered supervisors allowed to work as subcontractor with other firms.

f) By registration of different types of professionals and skilled workers the availability of required number of certified manpower in any project or activity can be assured. More over proper control in this regard can be achieved by effective data base.

g) *Communication and information system*

Pakistan construction industry is backward from other industries in adopting information technology (IT). Although big construction firms are adopting IT at individual level but its proper use in construction industry still needs special efforts. The main reason is that in each projects several small and medium construction firms are usually involved which do not have IT experts so at project level IT has not been properly adopted.

i) IT training should be done during the projects, main contractors and large construction firms should adopt IT procedures jointly with small contractors in order to train and encourage them.
ii) The wider use of modern management and communication methods needs to be introduced in construction industry. A recommended procedure is to set priority areas for introduction of IT such as project scheduling and monitoring.
iii) Tendering and bidding procedures can also be improved by use of IT. Online issuance and submission of tender documents and online bidding processes will eliminate unfair means. This practice will also reduce hostility and rivalry among contractors during tendering and bidding process which will benefit in better relationships among members of construction industry.

Recommendations for Strategic Thrust 6: Improve legal and contractual conditions especially for subcontracting:

a) There is no any standard subcontract document in any public sector department in Pakistan. It is much important for major developers to prepare document for subcontract conditions and main contractors should be forced to undergo this subcontract conditions in all of their subcontracts. Sufficient guidelines in this regard are available in standard subcontract documents of FIDIC and JCT (Joint Contracts Tribunal, UK). Fundamental conditions for a subcontract are also described in next chapters.

b) Contractors often complained about un-necessary obstacles and difficulties in pre-construction, during construction and post construction phases. For example site clearance & acquisition, getting NOCs, certifications, interference of external agencies, payment and audit procedures, changes and modifications, release of guaranties and securities. Due to these difficulties contractors cannot perform up to their capabilities and pay full attention to construction activities. Reforms should be made to legal and administrative procedures to minimize these difficulties.

Recommendations for Strategic Thrust 7: Motivate to develop and adopt best ethical and professional practices:

a) The major clients like public sector organizations should introduce professional ethical practices. The contractors associations should also take steps to create proper ethical behavior among staff and among subcontractors at construction site. The public sector departments and organizations like Pakistan Engineering Council (PEC) should introduce codes of ethics and motivate construction

firms also to introduce and practice their code of conduct during onsite operations.

b) Unstable political environment in country also effects construction industry. Steps should be taken to minimize the political involvement in developing projects.

d) To solve the corruption and transparency problems in construction industry legal reforms should be made e.g reforms according to the guidelines of FIDIC construction contracts. Moreover public sector departments should improve their administrative competency and reduce the effect of political interference.

e) *Avoiding delays and its consequences:*

Time is money and it is very precious in construction projects because in time construction of a project is the first stage of any development. Construction project plays an important role in economy after its completion. In time completion of any developing project boosts the economy while delay causes losses and inconvenience for public. A delay in completion of construction project is a very common problem in Pakistan construction industry. In a construction project the delay due to one contractor also affects others so it causes disputes among contractors working on a construction project. Some recommendations are suggested here to reduce this problem.

i. Early involvement of contractor in design and planning phase is important to avoid delays. Similarly main contractor should also involve its subcontractors and especially suppliers earlier to insure the supply and availability of materials, equipments and services.
ii. Since each construction project is different from other due to its location, requirements and method of construction. Therefore it

is very important that experts in participating firms should exercise innovative construction methods to meet with the critical situations in construction industry. Mutual understanding and relationships can provide better environment for problem solving practices.

iii. Change in construction methods according to the availabilities of materials, equipments and labor with the early discussion of related participating contractors and suppliers is very important. It is also important to manage close and early interaction with the locals to get information about problems due to local circumstances such as special local & physical conditions, social, cultural and economic factors.

f) *Effective control over quality of material and services*

Due to fragmentation in construction industry supply of materials, skilled labor and specialists are from different organizations and sources. Poor and unsatisfactory quality in construction is a major problem especially in developed countries as it is observed in Pakistan.

i) It is difficult for small firms to develop their products / materials and train their staff according to latest technology. Therefore cooperative relationships can be improved by sharing and exchanging the information and techniques.

ii) Poor quality materials, negligence at site and poor coordination among different parties are also the causes of poor and hostile relationships among contractors. Suppliers should be convinced and helped in producing materials of required standards; subcontractors should be helped so that they can provide efficient and high quality services.

iii) Client's commitment toward quality achievement is most important. Contractors should also generate awareness to their staff about quality through training and motivation.

iv) Use of construction machinery and proper equipments should be encouraged. Government should also take step in financing and leasing of construction machinery and also by reducing taxes on construction machinery. Local industries should be encouraged to manufacture and repair construction machinery and spare parts.

v) There is need to introduce more prefabricated items and general construction and safety equipments. Public and private sector clients should encourage the wider use of precast items and also use of proper construction equipments to minimize the quality related issues.

vi) Construction companies should work with close ties to other contractors working in same project and should set combined targets in order to harmonize their efforts and avoid re-works.

g) Since each construction project is unique and complex therefore a cooperative atmosphere can be achieved by a general code of ethics in form of rules and project specific practices. These rules and practices can be set by mutual negotiations and discussions of subcontractors and main contractors on the basis of their past experiences. These can be changed or modified for each project according to conditions. For this, the main contractor and all subcontractors which are working in the initial stage and those who have to work in later stages should arrange meetings before start and during the project.

Chapter 18

Fundamental Conditions for Construction Subcontract

18.1 Introduction

In part 3 it is described that reciprocity or punishment is necessary to establish cooperation. In order to establish reciprocal condition in construction industry it is necessary to have balance contract conditions. In Pakistan there is no standard subcontract in any construction related organization. Different public sector departments have their own contract documents for their particular construction projects. Even in these contract documents the described subcontract conditions are very brief and insufficient to deal with the subcontracting issues. In this section some basic conditions are described which are usually required for a standard subcontract in construction industry. For smooth progress of construction activities it is essential to establish a balance contractual relationship between contractor and subcontractor. The following section describes the basic provisions for a subcontract. This basic subcontract conditions described in this chapter will provide a guide line to different organizations in preparation of subcontract condition for their projects.

Preparation of a detail subcontract document takes considerable time. Therefore in order to avoid delay, some times subcontracted work has to be started before the finalization of all the conditions. This is because there is no standard subcontract to be adopted. Preparation of a detail subcontract document requires a team of experts. Subcontractors or even contractors can not afford to hire required legal and professional experts for preparation of detailed subcontract conditions.

Some times one contractor sublet similar activities of same project to different subcontractors under different contract conditions. In this case subcontractors think the contractor has biased behavior.

Keeping in view the outcome of survey in Pakistan construction industry a general layout of a subcontract is formed. In this layout general

issues in subcontracting are highlighted and possible contract conditions are described.

The general issues in this subcontract are according to problems and necessity of Pakistan construction industry. However these fundamental guidelines can be adopted for preparation of condition of subcontracts in other parts of the world. Detail descriptions of subcontract conditions can be included by each organization according to its specific conditions and requirements. A subcontract describes the contractual rules between main contractor and its subcontractor or between subcontractors and sub-subcontractor.

18.2 Basic Information in Subcontract

A subcontract should describe the basic information needed to manage all matters related to subcontract work. Subcontract should also help in smooth dealings, related to the responsibilities and chain of command among different tiers of subcontractors. Some basic information is listed below:

a) Subcontract should clearly define basic trades and terms i.e. Employer, contractor, subcontractor, main contract, subcontract work, construction site, completion period.

b) Names and details of subcontractor, main contractor and employer

c) Important mile stones and duration of subcontract work.

d) Reference to main contract conditions related to subcontract work. It means clearly mentioning the clauses of main contract which are applicable to the subcontract work.

18.3 Contractor's General Obligations

Contractor should clearly guide subcontractors and provide all necessary information about subcontract works to avoid misunderstandings. Main issues

regarding contractor's obligations should be clearly listed in subcontract. These issues should include following aspects:

a) Description of obligations on behalf or the contractor regarding to subcontract work.

b) Demarcation of construction site, access to site, provision or sharing of construction facilities with subcontractors e.g. construction materials, machinery, construction plants, technical help.

c) Fair and unbiased distribution of payments and facilities towards all the subcontractors. Managing the matters among subcontractors.

d) Take care of subcontract works beyond the subcontractor's responsibilities.

18.4 Subcontractor's General Obligations

Subcontract should ensure good performance from subcontractor. Value added and innovative practices should be encouraged. One of the fundamental purposes of subcontract is to made subcontractor aware about the main obligations on its behalf. These obligations are described with the help of the following aspects:

a) Obligations regarding execution and maintenance of subcontract work.

b) Maintaining complete and accurate record of subcontract work and making this record available to contractor.

c) Working according to the requirements and related instruction of the subcontract work.

d) Carry out the necessary design (if required in case of some special works) related to that particular subcontract work.

e) Co-operation with other subcontractors as per instruction of contractor.

f) Avoiding the total subletting of subcontract work or subletting any part of subcontract work without consent of the contractor.

g) Responsibility to behave according to ethical practices generally adopted in local construction industry, during execution of subcontract work.

18.5 Start and Completion of Subcontract Work

a) Starting date should be clearly mentioned to avoid misunderstandings. It should be conveyed by contractor in writing and should be confirmed by subcontractor.

b) A reasonable preparation time should be given to subcontractor to start work. After receiving the written instructions the subcontractor, within an appropriate duration as mentioned, must start the subcontract work.

c) The completion date or the period within which, work is required to be completed, should be mentioned clearly in subcontract.

18.6 Extension in Completion Time

Subcontractor should have facility of extension in completion time due to unavoidable or special circumstances. Subcontractor should convey in writing to contractor well in time if extension in time is required. Circumstance under which subcontractor should be entitled of time extensions are listed below:

a) Reasons of delays in completion of subcontract work are similar to those conditions under which extension of time is allowed in main contract.

b) In case of variations, revised instruction, delay in payments or temporary suspension in subcontract work by main contractor.

c) Delays due to disputes between contractor and subcontractor if subcontractor's argument is proved valid.

However if subcontractor is entitled of time extension under subcontract conditions then assessment of extension should be justified by subcontractor and agreed by contractor.

18.7 Payment

Subcontract should ensure balanced and timely payment conditions. Clear provisions should be described in subcontract about periodic payments, release of retention money, compensation in case of late payments. Important provisions are listed below:

a) Conditions to determine, when periodic and final payments will be due.

b) Time limits and cost limits for successive payments.

c) Fair criteria for detention and deduction of payments.

d) Period for release of securities or retention amount.

e) Advance notice in writing to subcontractor in case of withholding or deductions in payment.

f) Compensation or interest in case of delayed payments to subcontractor.

18.8 Delay and Penalties

a) Conditions for deductions in subcontractor's payments and assessment of liquidated damages should be clearly mentioned in subcontract.

b) In case of liquidated damages imposed by contractor due to delay in completion of subcontract work then advance notice in writing should be made.

18.9 Claims

Subcontractor should submit notice in writing to contractor in case of any claim. The written notice of claim should be supported by relevant documents and evidence. Notice of claim should be served within reasonable time.

18.10 Instructions and Variations

a) Subcontractor should comply with the contractor's instructions related to subcontract work, subject to

   i) If subcontractor is informed in good time

   ii) Instructions are not out of subcontractor's capabilities and other limitations described in subcontract.

Instructions and variations (addition, reduction, omission or modification of subcontract work) should be conveyed in writing with detail instructions and supported reasons.

b) General rules for evaluation and assessment of variations / instructions should be described in subcontract.
Instructions and variations may be assessed:

i) By rates of added and omitted items as in subcontract.
ii) By fair assessment of prices of new items (not in subcontract)
iii) According to working hours or days decided by both parties.

Contractor should confirm the assessment of variation within suitable period. If it is not possible due to shortage of time then a mutually agreed amount may be paid subject to the adjustment in later stage or in final payment after the assessment of variation.

18.11 Transfer of Property

Transfer of material, construction machinery / plant or other items related to subcontract works should be clearly mentioned in subcontract. Conditions of transfer should be according to the similar provisions in main contract.

18.12 Indemnity

The conditions and extent of indemnity provided to subcontractor should be clearly stated. Fair extent of indemnity is that the responsibilities and liabilities of subcontractor under its subcontract work should be proportionate to contractor under its main contract. However the additional risks, responsibilities and administrative expenses of main contractor should be taken in account.

18.13 Insurance

The extent of insurance coverage that subcontractor supposed to have, should be clearly described in subcontract. Insurance coverage for employees, loss due to third party, loss due to natural disasters or other expected risks related to subcontract work should be mentioned.
Some important aspects which should be mentioned are:

a) Detail of risks for that subcontractor must have insurance coverage.

b) Type of insurance under which main contractor has coverage.

c) Agreed amount which is to be deducted from subcontractor if subcontract work is insured under insurance policy of main contractor.

18.14 Liability due to Maintenance and Defects

The period for which subcontractor is responsible to carry out maintenance and rectification of defects should be stated in subcontract. A fair allowance for expected wear and tear should be taken in account.

The liability period for subcontract work should be according to the type of that work. It may or may not be related to maintenance period of main contract depending on the nature of subcontract work.

18.15 Termination of Subcontract by Main Contractor

Main contractor should serve written notice to subcontractor in case of termination of its services. Conditions under which main contractor can terminate subcontractor's services should be described in subcontract in detail. Some general conditions of subcontractor's default are given below:

a) Failing to start subcontract work without acceptable reasons.

b) Abandoning the subcontract work.

c) Lagging behind the required progress for considerable long duration, in spite of contractor's notices.

d) Failing to achieve the required construction standards described in subcontract.

e) Failing to comply with the contractor's instructions under the subcontract.

f) Failing to proceed according to obligations in subcontract.

g) Subletting any part of subcontract work without contractor's consent.

h) Subletting the entire subcontract work.

i) Failing to achieve financial obligations in spite of timely payment from contractor or if subcontractor becomes bankrupt.

After issuance of termination notice from contractor the rights and obligations of both parties should also be described.

18.16 Termination of Subcontract by Subcontractor

Subcontractor should also be allowed to terminate subcontract in case of default from contractor's behalf. In this case subcontractor should serve notice to contractor with reasonable time limit. Conditions of contractor's default should be clearly described in subcontract. Typical conditions for which contractor can be considered default, are listed below:

a) Contractor fails to start work of main contract without any acceptable reasons.

b) Contractor abandons the main contract.

c) Failing to pay subcontractor as per agreement without reasonable excuse.

d) Failing to fulfill financial obligations or becoming bankrupt.

In case of serving termination notice from subcontractor the rights and obligations of both contractor and subcontractor should also be described in detail.

18.17 Termination of Main Contract

a) If main contract between contractor and client is terminated due to any reason then contactor can also terminate subcontract. Subcontract should be terminated by a prior written notice to subcontractor.

b) If subcontract is terminated due to termination of main contract then conditions of payment to subcontractor should be clearly mentioned in subcontract. Subcontractor should be entitled of receiving payment for its services. Some basic conditions of payment are listed below:

   i) On the basis of assessment of work done by subcontractor.

   ii) Assessment of temporary work or mobilizing efforts done by subcontractor related to subcontract work.

   iii) Material which is brought at site by subcontractor.

   iv) Cost of transport, fixing and removal of construction plant or machinery if brought / fixed at site.

18.18 Disputes

There should be provisions to resolve disputes between contracting parties. Both contracting parties should have access to request for dispute resolution process.

Arbitration is most common and effective dispute resolution method in construction industry. However some alternate options should also available such as adjudication and mediation. Most of the subcontractors are small

organizations and can not afford high cost for dispute resolution process. Proper adjudication provision can prove an effective and cheap dispute resolution method.

18.19 Bond and Sureties

The condition of deposit of any amount as performance bond should be optional depending upon the nature of subcontract work. The amount should be according to the type of risks involved.

In case it is necessary to exercise this option then the conditions of release and amount of performance bond should clearly described. The amount should be fair and it should not be an excessive financial burden for subcontractor.

18.20 Governing Law

As it is general condition for all contracts that local laws are governing laws. Subcontract should also be according to regional and national law as in case of main contracts. Regional or national law should be governing law.

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Chapter 19
Critical Problems and related Subcontract Conditions

19.1 General

The standard form of subcontract in previous section describes an over all structure of subcontract. However during the survey in Pakistan construction industry and study of literature about construction industry all over the world, it was observed that there are certain issues which are very critical in subcontracting. Therefore these critical issues need detail description. These critical problems and the recommended contract condition in detail are described in this section. These contract conditions are not specific to Pakistan construction industry or a particular department but equally applicable to any construction activity at any place. These conditions can easily be adopted into a subcontract by any organization under its own specific working conditions.

Some critical issues which should be addressed in subcontract are listed below.

1) The obligations of both the parties (main contractor and subcontractor should be defined.
2) Completion time of subcontract work and if needed the targets for certain important activities should be clearly mentioned. The criteria for extensions in completion time should also be defined.
3) Variations and periodic instructions from main contactor are a common phenomenon in subcontract works. Payment, extension in completion time and other issues related to variations and instructions should be addressed.
4) Payment to subcontractors is a critical issue. Therefore criteria for periodic and final payments, release of securities and bonds should be clearly addressed.

5) Procedure for settlement of disputes should be part of the subcontract to avoid legal complications later on.
6) Main contractor and subcontractors are part of a team working in a construction project. Instruction should be included, related to their role in the construction project, especially working practices and behavior with other project fellows.
7) All the conditions related to equipments, machinery and materials should be defined.
8) Some times there are minor issues which become very important in certain conditions so these minor issues need also to include in subcontract conditions according to their importance. For example environmental issues, Disposal of waste materials, communication routes, staff accommodation.

A general condition for any subcontract is that it should be in coordination with main contract. The main rights and obligations in main contract should also reflect in subcontract. The reason is that, subcontractors should also work under similar conditions as main contractor. However due to the unexpected out comes at construction sites main contractor and subcontractor may change the condition in subcontract at any time. It means subcontract should not be a rigid document and there should be flexibility as result of mutual negotiations. It is sometimes necessary due to variant site and other relevant conditions.

The contract documents used in public sector in Pakistan are generally client oriented. Contractors are kept under more obligations than international construction contract standards. The reason is that contractors some times cause loss to government due to inefficiency of financial sectors, law enforcement agencies, judiciary and legal system and also due to political involvement. Therefore conditions in public sector documents some time seems biased but these also provide necessary security to client. On the other hand same kinds of conditions are not necessary to include in subcontracts. This can alter the balance of powers between main contractor and

subcontractor. At level of subcontracts the same kind of security in favor of main contractor is not necessary. On the other hand the inefficiency of system as described above can affect subcontractor rather than main contractor. The reason is that in case of disputes, subcontractors usually can not compete with main contractors due to main contractor's relatively strong financial and political position. For drafting a subcontract, these critical issues in subcontracting are described here in detail in following sections.

19.2 Main contractor – Subcontractor, Obligations & Relationships

Problem:

Subcontractors usually complain about the tough and unrealistic demands of the main contractor. Subcontractors usually suppose that main contractor often stretch them unnecessarily and demand early completion and higher quality standards beyond their capabilities. Subcontractors consider that these conditions are exercised to create an extra pressure on them and to enforce penalties and deductions.

Similarly Main contractor complain about the non cooperative behaviors of subcontractors in meeting the quality standards and schedules of his work. Due to these types of non performance he often has to bear losses due to some remedial measures in later stages for subcontract works.

In Pakistan public sector organizations, main contractor is kept under extra obligations. Similar obligations should not reflect in the subcontract. Subcontract should exhibit balance between two parties. It has been observed that subcontractors already complaint about main contractors' exploitation in construction projects.

Recommendations:

a) Incorporation of main contract conditions in subcontract has many limitations. For example it is not easy to decide which provisions of main contract should be included in subcontract and which are not.

Since this can cause disputes because it may happen that portion of main contract included in subcontract is not sufficiently described.

The problem can be dealt with the access of main contract to the subcontractors other than the prices of main contractor. Contractor should make the main contract along with all provisions, available to subcontractors. With this condition it can be supposed that subcontractors have full knowledge of main contract (other than the contractor's prices)

b) There may be absence of specific provisions in subcontract about a particular subcontract work. In this situation subcontractor should responsible to all obligations of main contractor as described in main contract related to that particular subcontract work.

It means if there are not special conditions in the subcontract about any subcontract work. The subcontractor supposed to carry out related tasks (design, execute, remedial measures of defects if any etc.) under the conditions related to that specific work in main contract.

In case of non performance and breach of subcontract the obligations and penalties should be similar as in main contract between contractor and client. For example if subcontractor breaches the subcontract then main contractor can demand the damages and loss for which main contractor is responsible under main contract due to subcontractor's action. Main contractor can recover damages from subcontractor's due bills or the damages will become due to the subcontractor.

As for as liquidated damages are concerned these depend upon the nature of subcontractor's work. In this case related provisions can be made in subcontract.

If subcontractor's work is on the critical path of the contractor's work then the late completion of subcontract work will certainly affect to the main contractor. In this case contractor will deduct damages or loss according to the liquidated damages it has to pay under main contract. On the other hand if main contractor can provide extension in

completion time of a subcontract work such that it does not affect its schedule because of non critical activity then liquidated damages should be avoided.

c) Subcontractors should also abide by all the instructions which client/ engineer give to main contractor related to that particular subcontract work. If subcontractor receives any direct instructions form client / engineer then he should inform the contractor before complying.

d) If contractor receives any complaint or claim form client related to subcontract work, the contractor should inform subcontractor immediately. Subcontractor should perform all remedial measure and provide all necessary information to contractor in order to settle the issue with client.

Problem:

Sub- subcontract: It means the work subcontracted by subcontractor.

Recommendations:

a) Like conditions in main contract, subcontractors should not be allowed to outsource fully or partially the subcontract work to any other firm without the consent of contractor.

b) However subcontractors should not be required to get consent of contractor for minor and predefined issues such as:
   - Hiring and firing of labor
   - Suppliers and subcontractors which are mentioned in subcontract for supply or material or to carry out any activity.

19.3 Extension of Completion Time for Subcontract Work

Problem:

During the execution of construction projects some times due to the circumstances extra time is required to complete certain activity. In case of

extension in time for any subcontract work the main contractor can provide required time to subcontractors if justified. The critical situation arises if the particular subcontract is on the critical path of the main contractor's work. In this case it is pure matter of mutual negotiations between the subcontractor and main contractor keeping in view the circumstances.

Recommendations:

In Subcontract it should mention that under which conditions the subcontractors is entitled of getting time extension. There are certain obvious conditions under which the subcontractor is entitled to get time extension.

a) If subcontractor requires time extension for an activity which is on critical path of main contract and main contractor is entitled to get time extension for that work under his main contract. In this case subcontractor is also entitled to get time extension if contractor is entitles too.

   In this case the extension in completion time for subcontractor should not be exceeded than the extension which main contractor gets from client.

   Main contractor should also inform the subcontractors about all the time extension that it already has availed from client which can affect the subcontractor's time extension period.

   There may be certain unavoidable circumstance for which subcontractor needs time extension. But for which main contractor is not entitled for time extension under main contract. In this case Main contractor will request client (or Engineer) for extension in time due to those particular circumstances. If client agrees for time extensions then subcontractor is also entitled of time extension.

   Subcontract should also mention that subcontractor should notify the contractor for any time extension request well in time. So that contractor can submit a proper request to client well in time according to main contract.

b) Subcontractor should provide detailed schedule of its subcontract work to contractor. This schedule will help in monitoring subcontractor's work and also providing justification for any time extension request by subcontractor. If any subcontractor's schedule clashes with another subcontractor's schedule then matter should be brought under contractor's notice, well in advance.

19.4 Variations and Instructions

Problem:

Sometimes there are necessities to make some changes in a work which is awarded to a subcontractor. These changes may be related to the scope of work or method of execution of work. Mostly in standard form of subcontracts, provisions are made that contractor can make this kind of variations if necessary. The reason of this provision is that main contractor may be asked by client for certain variations or due to the site conditions some changes may become necessary.

Subcontractors usually obey instructions and variations but some times problem occurs when:

- The variation makes severe stress on subcontractor's resources.
- The extra work is beyond the subcontractor's capability and expertise.
- The subcontractor is not properly compensated for any variation.

Recommendations:

a) In subcontract, variations should be defined i.e which work will be considered as variation. Variation may be addition, reduction or alteration in work. It can also be change in standards of materials or finished products. In case of any additional work or varied work which is not in the provision of subcontract the contractor should ask subcontractor to submit its price. Normally this kind of variation is in benefit of subcontractors. Subcontractors usually provide price and

after necessary negotiations the subcontractor starts working on varied work. However subcontractors should not be made bound to do this if they have justified reasons.

b) Minor instructions are usually a routine procedure at construction sites and these instructions do no affect subcontractors. Subcontractors usually, should suppose to comply with all the instructions of main contractor which are related to design, procedure, and scope of subcontract work.

However if instruction causing a considerable change in amount of work (addition or omission), causing delay or creating strain on subcontractor's resources. Then prior negotiations and compensations should be carried out. In this later situation instruction should be conveyed in written form.

19.5 Payments to Subcontractors

Problem:

Payment to subcontractors by main contractor is one of the critical issues in subcontracting. There may be several factors in payment issues to subcontractors.

- Contractor does not pay to subcontractor in time.
- Contractor does not pay full.
- Contractor itself not paid by the client for that particular subcontract work.
- Contractor is unable to pay due to its financial conditions, bad intensions or breach of contract with client.
- Due to dispute between subcontractor and main contractor.

To understand the problem properly we should first know about the risks involved in payment to main contractor from client. In most of the

conditions and in “FIDIC Red book” the following risks in payment are mentioned, contractor should assume these risks in payment.

- Due to any reason the Engineer is late in certifying contractor’s payment statements.
- Engineer does not certify or partially certify the payment statements.
- The employer, even after certification of engineer can not pay in time.
- The employer disagrees to engineer’s recommendations and refused to pay.
- The employer is unable to pay due to its financial conditions or biased intensions.

These risks are usually passed on to subcontractors according to their subcontract work. Subcontractors also have to face additional risks which are due to the main contractors. Main contractors usually pay to subcontractors when they received the payment of subcontract work from their client. This “pay when paid” policy is in favor of contractors and subcontractors have to suffer due to this trend.

Recommendations:

a) Contractors usually get periodic payments on basis of the completed works or material brought at site. A simple way to deal with subcontractor’s payments may be that contractor should pay all the subcontract works which are paid to main contractor. To ensure this client or engineer can also demand all the subcontractors’ bill statements, whose work is included in contractor’s bill statement. Further client should also demand the proof of previous payments to subcontracts included in previous bills.

   The condition of “pay when paid” should be provided in subcontract only if necessary. Conditional payments should be defined in subcontracts in such a way that subcontractors should not be exploited by main contractors.

b) Withholding of subcontractor's payments by main contractor is a common cause of dispute. If contractor wants to hold payment of any subcontract work due to any objection then it should only withheld the payment concerned to that objectionable work not that subcontractor's whole payment.

   When contractor decide to withheld payment of any subcontract work then it should inform the concerned subcontractor in writing about the cause of withholding payment. This written notice should be conveyed earlier to the date when subcontract work is due to be paid to subcontractor.

c) If subcontract's payment is delayed due to late payment to contractor form its client. In this case if main contractor is eligible of getting interest against the amount which is delayed by employer under the main contract then in this case subcontractor should also eligible to get its share. It means when contractor do not pay to subcontractors due to "pay when paid" condition. Then contractor received interest form client against late payment then the amount of interest should also be paid to subcontractors according to their subcontract work.

   In main contract if there is condition that contractor will be paid any described amount of interest against any late payment by client then similar clause should also be included in subcontract. If contractor gets its payment in time and then due to any reason it does not pay its subcontractor whose work also involved in this paid amount. Later if subcontractor found not responsible then contractor should also pay interest to subcontractor for delay.

   In any case if main contractor receive any interest on its due payments then it should pass on this benefit to subcontractors also whether it is mentioned in subcontract or not.

d) Payments of any additional or special works which are not included in contract but necessary to carry out, are additional payments. If there is

a claim of any additional payment by the subcontractor then he should submit it to contractor. The contractor should submit related claim to client and exercise all his efforts in perusing the client. In case the claim of additional payment is rejected by client / engineer then main contractor should not have any liability to pay to subcontractor.

If the subcontractor's claim of additional payment is due to the fault of contractor then in this case contractor should be liable to pay agreed amount to subcontractor irrespective of the compensation from client. For example if main contractor other than the fault of client, fails to provide subcontractor agreed conditions, such as:

- Failing in handing over the site in time
- Physical obstructions caused by contractor.
- Failing to provide in time drawings, machinery or material to subcontractor according to the subcontract.

19.6 Settlement of Disputes

Problem:

The most controversial situation arises when some sort of dispute arises between contractor and subcontractor. If disputes can not be settled amicably in early stage then it causes serious problems. Problems like financial loss for both the parties, delays and in extreme case breach of subcontract. When a dispute arises between contractor and subcontractor, first the two parties tries to settle it by them. If the parties involved in dispute can not settle it amicably the intervention of third party is necessary.

Recommendations:

a) Like main contract, subcontract should also specify the rules to settle disputes. Some basic recommendations in this regard are:
   - First of all representative of both the parties should negotiate and try to resolve the matter (negotiation).

- Client or Engineer may also be given the responsibility to settle the dispute in a specific period of time (mitigation).
- If dispute can not be settled in specific time or any party challenges the decision then the next stage is to go for adjudication / arbitration / litigation.
- If contractor and subcontractor belong to different countries then they may agree on international arbitration for their dispute.
- If both parties belong to same country then they may proceed to their local arbitration procedure or legal courts.

b) In case a dispute arises between contractor and client under main contract and disputes undergoes in arbitration. If one or more subcontractors are involved in the work which is under dispute between contractor and client then main contractor may ask related subcontractors to provide assistance.

   Situations in which, payment or any other benefits of one or more subcontractors are also involved in the dispute between main contractor and client. Then in this case subcontractors should also responsible to provide any kind of assistance needed by main contractor including sharing in expenditures of adjudication / arbitration / litigation.

c) Even after the introduction of subcontract there are chances that small companies will not get desired benefits. The reason is that in case of arbitration or litigation the main contractors have advantage because of their professional and financial dominance. Therefore special attention is required to keep the cost of dispute settlement, affordable for small subcontractors. There is need to introduce adjudication and other cheap dispute resolution procedures.

19.7 Co-operation at Construction Site

Problem:

In construction sites some times space and other resources are limited and many subcontractors work at same time. In these conditions subcontractors struggle for space / resources required to perform their activities. Generally the subcontractors already working at construction site do not show desired flexibility in sharing space / resources with those subcontractors joining later on. These situations some times create disputes and hostile behavior among subcontractors. The work also may get delayed due to some subcontractors who are not provided space / resources required to perform desired output.

Recommendations:

a) Contractor should not provide any subcontractor any space exclusively at construction site if other subcontractors also need to use that space for their activities.

b) Subcontractors should have to share the space at construction site with contractor or other subcontractors according to instruction of contractor or subcontractors mutual consent.

c) The subcontractor should abide by the contractor's instructions regarding sharing and co-operating with contractors and other subcontractors in order to provide every subcontractor equal opportunity to carry out their activities. Subcontractor should also cooperate as per contractor's instructions with the client's personnel and other public sector agencies involved in project.

   If any contractor's staff or subcontractor has complaint regarding non co-operation then contractor should be informed. Contractor should resolve the matter at the earliest by negotiating with the related parties.

d) Contractor or any subcontractor should not try to recruit staff member of other subcontractors or contractor without the consent of the respective employer.

e) Contractor should appoint a representative to deal with the subcontract works and similarly subcontractors should also appoint their representative to deal with contractor and other subcontractors. In case there is language barrier among parties then the representative should be fluent in a common (mutually decided) language. The representatives should permanently reside at construction site during their related activity.

19.8 Equipments, Machinery and Materials

Problem

In cases contractors have to provide material or equipments to subcontractors then some complaints arise. Subcontractors complaint about the late or inappropriate supply of material / equipments and machinery. Similarly contractors complaint about the mishandling of machinery and equipments by subcontractors.

Recommendations:

a) Provision of Equipment, Machinery and Material
   - If according to subcontract any material, machinery or equipments are to be provided by contractor. The subcontractor should notify contractor well advance to ensure the availability.
   - Contractor is bound to give appropriate compensation or time extension in case of late supply of material / machinery.
   - At the time of handover of materials or machinery the representative of both parties should inspect the material/ machinery to ensure the quality, quantity and functionality.

b) Handling of Equipment, Machinery and Material
   - After the hand over of material / machinery the subcontractor should be responsible for proper use and take care.
   - Materials, equipments and machinery should be used and operated according to contractor's instructions.
   - Subcontractor should be responsible for damage to material / machinery in case he is failed to abide by the contractor's instructions.

c) Fixing and Removal of Equipment and Machinery
   - Subcontractor should not install or remove any machinery / plant (other than the vehicles transporting material and staff) at construction site without the contractor's permission.

19.9 Miscellaneous

There are several other issues which seem minor but usually cause trouble if not dealt properly. If these issues are likely to involve then these should also be included in subcontract conditions. Some of these issues are listed below:

a) Temporary space for subcontractor's office/ accommodation. Subcontractors working in project for comparatively long durations need building for their administrative activities. Subcontractors some times need space for accommodation of their staff and labor.
b) Electricity supply needed to perform subcontract work.
c) Water supply for Subcontractor's residential staff and for their construction activities.
d) Description about waste water disposal, i.e. method, treatment, location of disposal.
e) Dumping of excavated material or other waste materials.
f) Use of communication routes. If construction site is away from any existing road the contractors have to build special (paved or unpaved) road and bridges for movement of staff,

materials and machinery. If subcontractors use these roads for their material carrying vehicles or other machinery then it can cause wear and tear to roads. Proper description about use and maintenance of communication roads should be included in subcontract if needed.

g) Site clearance after the completion of subcontract work.

h) Insurance of subcontractor's work and its staff.

i) Safety of contractor's and other subcontractors' work, staff, material, machines. Safety of public and private property.

j) Environmental and pollution issues.

Chapter 20
Code of Ethics for Subcontractors

20.1 Introduction

In big construction projects many subcontractors usually involved in construction project. It is obvious that these subcontractors have to interact with one another during their work. They have to work one after the other or at same time. Every subcontractor has its separate subcontract with main contractor. Subcontractors do not have any contractual relationship with one another. It is also observed that the interaction of subcontractors with each other is for short period. There are very few chances of continuation in relations therefore the level of cooperation among subcontractors is naturally not satisfactory. By increasing the mutual cooperation among subcontractors the output can be increased.

In this section some important recommendations are suggested to develop a code of ethics for subcontractors. During a construction project any subcontractor may affect other subcontractors in different ways. Some important issues which generally caused trouble among subcontractors are pointed out and related solutions are also discussed. These ethics and practices should be discussed in the combined project meetings. Subcontractors should align their company policies according to these ethical practices and should train and instruct their staff accordingly. Main contractors should also encourage and instruct subcontractors to adopt these professional practices.

20.2 Recommendation for Code of Ethics

1. The procedure of work which one subcontractor adopts may cause hurdles for other subcontractor/subcontractors.

The working procedure of a subcontractor should not cause any disturbance to other subcontractors. During a construction project the subcontractors are not responsible to only their own work but each

subcontractor is a member of project team. Subcontractors should also responsible to take care of the smooth operation of other subcontractor's activities.

Some times delay in completion of one subcontractor's work severely affects the progress of other subcontractor. For example in construction of road, if one subcontractor is constructing road and another is constructing bridges. The method of bridge construction or delay in bridge completion can cause the communication barrier for road subcontractor. Similarly the construction procedure of road subcontractor can affect the transport of material and machinery for bridge subcontractor.

Each subcontractor should adopt a working style which causes least trouble and maximum productivity for others. In case of contradiction among subcontractors about the working method the main contractor should play its role. A mutual solution can be sorted out by mutual negotiation of main contractor and concerned subcontractors.

A subcontractor should be responsible to take necessary action if its work is causing trouble to other subcontractors or may cause trouble to those subcontractors, who have to work after its work. The concerned subcontractors and main contractor should mutually decide the procedure which is most appropriate and acceptable. There are chances that concerned subcontractors may not be able to agree on a solution by themselves. The reason is that one has to sacrifice on its most convenient working style and other may be not fully satisfied with the change which 1st subcontractor is willing to make. In this case main contractor should play its part and instruct both the parties by an evenly balanced decision.

2. The quality or nature of a subcontractor's product or its workmanship is not acceptable for other.

In construction projects it is normal practice that one subcontractor's work depends upon the materials or products supplied by other subcontractors. In this case the efforts and quality of the work of the subcontractors (in upper layer of multi tiered structure) also depends upon the

out put of other subcontractors (at lower layer of multi tiered structure). A simple example is in building construction the work of painter is greatly depends upon how the wall has been plastered.

An early interaction of these subcontractors whose work can affect each other is necessary to avoid troubles later on. A good practice is that, subcontractors at higher layers should instruct the lower layer subcontractors about their requirements. Subcontractors should also discuss the working methods, working schedules of each others and criteria for supply of materials / products.

3. If same space is to be shared by more than one subcontractor.

Subcontractors working at the same space at same time should work in cooperation with each others. Procedures can be adopted by their mutual decisions according to nature of their works. Subcontractors can avoid conflicts by slightly changing their working styles and schedules. Different time span can be chosen by mutual consents.

4. If same resources are to be shared by more than one subcontractor.

Some times subcontractors have to face trouble in sharing of human or other natural resources. If resources are limited and two or more subcontractors need these resources for their construction activities then prior regulation in this regard is necessary. Concerned subcontractors with the involvement of main contractor and other concerned parties can finalize a sharing policy.

5. If main contractor provides material / machinery and it is to be shared by more than on subcontractor.

During a construction project, subcontractors some times face disputes over the sharing of material or machinery provided by main contractor. According to nature of subcontracts some time two or more subcontractors are provided same kind of material by the contractor. Subcontractors should

make a proper distribution plan with the main contractor according to nature and importance of work of each subcontractor.

In case some machinery is to be provided by main contractor to two or more subcontractors then again proper schedule and sharing plan should be finalized among concerned subcontractors and main contractor. Subcontractors should show flexibility in possession of machinery and should cooperate with other subcontractors in case of emergency situations or changing priorities.

6. In case of utilization of same communication routes by more than one subcontractor.

When construction sites are in remote areas then roads are built specially for logistics. Contractor, subcontractors and suppliers need these communication roots continuously during their working period. Sharing of these communication routes also need proper cooperation among users. Building separate road for any subcontractor is expensive, time consuming and some times impossible due to geographic conditions. All the users of a common communication route should develop a combine schedule to ensure maximum uninterrupted traffic on the common route.

7. Staff of each subcontractor should be fully aware of the cultural and religious values of others.

In Pakistan the cultural and religious differences among labor/staff of subcontractor is often observed. If the staff of subcontractors do not aware or respect the values of others then serious disputes may occur. In mega projects staffs of contractor and subcontractor usually live at construction sites in temporary accommodations for several months or years. Disputes among staffs can cause delays or held up in construction activities. Senior administration should properly instruct and guide their staff members to understand and respect the values of others.

For example in Pakistan the labor from Northern and Western area usually work in central and southern parts. These people have strong cultural

values and men works and their women stays home. These people do not want their women to interact or work with strangers. On the other hand there are also gypsy labor groups who have totally different culture. Their women work along with their men. It has been observed that without proper awareness and respect of values of other, cultural diversity may some time causes serious disputes. Some times staff members belong to different religions and their daily life practices and habits contradict each other.

8. In case any worker of a subcontractor is hired by other subcontractor without consent of its previous employer.

Some times when skill workers or labors are not available according to demand then subcontractors struggle to find the required staff. In this competition subcontractors some times try to hire staff of other subcontractors with out their consent. This type of acts also creates disputes and lack of trust among subcontractors. Subcontractors should behave like good professionals and try to avoid these kinds of practices.

20.3 Recommendation for Implementation

Main contractors should take more responsibility in developing working practices/codes and then directing all the subcontractors to abide by these mutually decided working practices. When these helpful professional and ethical practices will be common and acceptable for all teams in the business then the disputes and conflicts will also be reduced.

The requirement of these construction practices may vary according to the construction process. The construction process is usually different for each project but there are major categories for which construction processes are almost similar. For example construction of roads, buildings, bridges, hydraulic structures etc. For these different categories construction processes will be different but for each category the processes will be quite similar. Generally subcontractors prefer to work in one kind of projects, for example the subcontractor of road construction will normally prefer to work in road projects because he has the related experience, machinery and trained

workers. In this way the teams of subcontractors will be different for each category. Different working practices can be developed among these different teams of subcontractors, because subcontractors of each category most likely have the chance of working together and requirements of activities in each category will also be quite similar.

These working practices will be helpful in creating cooperative relationships among subcontractors. Each subcontractor is an independent company, who is not legally bound to his counterparts not only in different projects but also in a single project. So these above discussed practices will tie them in such a relationship which will automatically be created whenever they work together. When cooperative relationships will develop among the subcontractors of the construction industry then this will also reduce a wide range of problems and disputes in construction projects. It is important to know that disputes among participants may occur often during construction projects, which are neither beneficial for those involved nor for other participants and the project itself. Furthermore, a more helpful atmosphere for lean construction will be created.

Chapter 21
Conclusions

21.1 General

This study explores the benefits of co-operative relationships of key supply chain members in construction industry by extending the traditional partnering of Client, designer and contactor to some important stakeholder which are subcontractors/suppliers. It is analysed how it is more beneficial for all stakeholder, if this important class known as subcontractor (subcontractors) is also integrated in construction supply chain and by development of cooperative relationships among these small organisations.

The practice of subcontracting has increased in the construction industry and major portion of a project are carried out by subcontractors. These subcontractors may be material supplier, labor supplier, specialized in carrying out different construction activities or manufacturer of construction related products.

It is normal practice that the main contractor usually hires 20 to 30 subcontractors during his construction project. Some of these subcontractors have to work simultaneously with one another and some have to work one after the other. In both the situations their finished work and working style affect the other. While working together they have to work in the same space at the same time and the way one is carried out its activities may either ease or hamper the work of others. So it is always beneficial for the project that each subcontractor should work in a style which is not only productive for him but also it should create maximum facilities and minimum hindrances for other subcontractors. But this kind of synergistic working environment is only possible when all these subcontractors have experience of working together continuously. This condition of working together continuously is not possible because every construction project is different from one another. Therefore main contractor's preferences and requirements for the selection of subcontractors are different for each project. Subcontractors of a project will

have to work with different counterparts and main contractors in each of their future construction projects. An important factor to create trust is the creation of such environment and behaviour that supply chain members take care of one another.

21.2 Professional Expertise and Innovations

Each construction project requires different types of materials, machinery and special skills. One contractor can not purchase all types of machinery and hire all types of experts. Therefore due to the increased demand of different type of specialists in construction projects, contactors find it easy to outsource different activities to specialists and concentrate on core activity. In this way firms and individual concentrates on particular activities and associated professional skills. By outsourcing different activities contractors minimise the hiring and firing of staff and also paying to those employees whose services are not required temporarily. Keeping in view these facts it can be said that the increasing trend of subcontracting in construction industry is a healthy sign. It makes construction industry flexible, efficient and has increased the opportunities of development of innovative techniques. The chance of development of innovative techniques increases, when each small unit perform independently as compare to that atmosphere where they are under the instructions of same management in every project.

Long term relationships among participating organizations can help in product development and innovations. Introduction of new construction techniques is difficult to initiate by a single company but an efficient team consisting of different types of specialized organisations can do it. For example shift of some site activities to manufacturing locations and introduction of prefabricated items. When subcontractors work under different contractors then they can learn and are able to introduce new and efficient methods in place of traditional practices. These types of efforts can decrease the construction time and also increase the quality.

21.3 Productive and Strategic Relationships

It is general awareness that co-operation certainly proves beneficial. There is an old saying that “one and one make eleven”. In this research co-operation among parties of construction supply chain, means to explore the practices by which productive relations can be developed among these partners and finding the reasons which causes barrier to this co-operation.

When we talk about creation of cooperative relations among subcontractors it does not mean that something new is expecting to be created among these actors. It is obvious that when different firms work for a single goal then there must be good relationship among them, otherwise they can not work together successfully. These mutual relationships may be due to contract, trust, mutual benefits, sense of responsibility etc. In order to get good cooperation, we should reduce the factors which create poor relationship among construction parties.

The importance of achieving lean construction can not be denied in current competitive world economy, which means reducing waste in construction process. Waste may be explained as waste of material, efforts and time. Progress to achieve lean construction can also be increased with the help of reducing waste by improving the working relationships through management practices.

The culture of long term partnership also called strategic partnering can be achieved by consistently improving the mutual relationships. The focus of managerial practices, on reducing the factors which causes adverse relationships and strengthen the practices which creates cooperation, will be called the creation of cooperative / productive relations among construction parties. Briefly we can say it is an effort to increase and decrease certain practices and attitudes by management process in order to get better results.

Over all the effective relationship management requires special interest of leadership, motivation, training and education of staff. Mutual cooperative culture can be effectively developed by continuous interest and training at top and individual level in all the organizations in construction industry.

21.4 Analytical Analyses by Game Theory

Analyses of cooperation conditions by game theory give solution about two main issues. 1st it describes the outcome of a strategy, when a player adopt it to play with other players. 2nd it helps in deciding which strategy, a player should adopt in certain conditions. In “iterated Prisoner’s Dilemma” game the different strategies are combinations of two actions, cooperate and defect (do not cooperate). In this analysis it is supposed that when a player adopts a strategy then it sticks to it in whole tournament which does not describe realistic behavior. Generally analyses by game theory give important solutions in many social and economic problems. The strategies defined in game theory analyses are generally simple and hypothetical as in case of “iterated Prisoner’s Dilemma” game. These strategies some times can not depict the actual behaviors especially behaviors and strategies of groups of individuals. Although competitive analyses by game theory give fundamental conditions for cooperation but real solution also needs detail behavioral study.

The strategies adopted by subcontractors in construction industry or in other industries, are not as simple to define and then analyze by game theory. These small construction firms change their strategies according to the conditions. Competitive and economic conditions in construction industry and social and cultural values of staff are major factors to shape their behaviors. Some times individual behaviors are totally contradictory to the strategy of its organization.

21.5 Role of Main contractor

Supply chain management helps in coordinating the resources such as flow of material & finances, efficient communication and services (labor and machinery) sharing. Failing to achieve supply chain integration/management means failing to get benefits, which otherwise could be achieved due to added values, contributed by small firms such as subcontractors and suppliers. Small organizations are more likely to under go a short term partnering process as compared to large companies which are more formal in collaboration. Subcontractors being small firms can easily adopt a different working

environment. Therefore it is necessary for main contractors to take initiative to create cooperative relationships among subcontractors.

Generaly the relationships among members of construction supply chain, especially among contractors and subcontractors, lack in mutual trust and fairness. These poor relationships often create litigation and other unsatisfactory outcomes i.e poor distribution of profit, delay, poor construction quality. It is common observation that there are cooperative relationships among client, contractor and designer/consultant. Due to increased role of subcontractors, it is important that all participating firms including subcontractors should form a joint project team.

The main contractor has a separate contract with its subcontractors other than its own contract with its client. The price which contractor pays to its subcontractor for a particular job is often less than that which it gets from its client. The reason between this cost differences is the organizational charges and other unforeseen expenditures which contractors have to meet with. Due to this cost competition contractors try to get maximum saving from this cost difference to increase their profit. Due to these efforts construction partners frequently changes from project to project, which creates adverse effects in development of long term relations / cooperation among supply chain members.

If contractors only keep in mind the lowest bid as major criteria for selection of subcontractors then it is possible that they can get unsatisfactory performances. In this way frequently changed subcontractors to increase savings can prove more expensive because of the defects and quality problems created by subcontractors. Main contractor being overall responsible, ultimately have to face all the problems. To avoid the selection of such subcontractors, contractors should adopt an evaluation system for its subcontractors and these evaluations should be recorded and considered for selection of subcontractors in future projects.

If evaluation is done at the end of the project then it can only be considered in future projects. The subcontractors who are not likely to work with the same main contractor in future will not care about this type of

evaluation. Main contractor also can not get much benefit for this evaluation. So evaluation should be a continuous process during the project and all the participants should be informed about every one's progress. There should be mutual meetings in order to get better results in view of this continuous evaluation process. There should be some rewards and penalties, announced by main contractor to motivate subcontractors. The frequent mutual meetings will help in acknowledging and praising the positive efforts of subcontractors, which will also motivate other partners and will develop a positive competition. These sessions at regular intervals also help in conveying the warnings and then ultimately enforcing penalties to non serious subcontractors. As it is observed that although penalties exists but these are hardly enforced, which encourage the lazy and ignorant subcontractors.

Another problem which also has to be faced by contractors is that subcontractors usually have poor administrative capacity in planning, preparing progress reports and other document management procedures. Subcontractors mostly do not have expertise or tools to work in accordance to the main contractor's information, planning and monitoring system. Main contractors who have better expertise and also well aware of their requirements can manage to do the job on subcontractor's behalf. Main contractor can assign the required experts not only to work on behalf of subcontractors but also train and encourage them to learn these methods. When subcontractors will become aware of the importance of these tools then they will automatically be encouraged to train their own staff accordingly. It is obvious that main contractors will prefer those subcontractors who can work in according to main contractor's planning, monitoring and information sharing tools. This benefit will motivate other supply chain member to get the necessary expertise in order to work in accordance to their contractors and other counterparts.

21.6 Professional and Cultural Issues in Subcontractors' Interactions

Subcontractors also act as short term financer for the main contractors. The increased involvement of subcontractors provides an economic buffer to main

contractor. Due to this reason subcontractors feel that supply chain management is a process which will further facilitate main contractors and subcontractors will not get much benefit.

Development of mutual trust is an important factor which can enhance some key co-operative issues like sharing information and operational co-operation. An atmosphere of trust, operational & administrative co-operation and sharing information will not only minimise problems but also can reduce the duplication of certain efforts, for example site investigations, forecasting and fixing/removal of site installations.

Struggle for skilled workers / experts, which are in shortage always creates tension among construction firms. This problem can only be deled with, in a mutually negotiable environment and development of harsh relations due to this, can be avoided.

A tiered structure provides a reliable supply chain but its development is a long term process and unlike manufacturing industry it is difficult to develop an isolated tiered structure in construction industry due to non consistent nature of construction industry. So in order to create a short term reliable structure a group-based approach should be developed. This approach will help to create a vertically and horizontally integrated structure during the project, among firms which did not work with one another previously.

For example it is observed in Pakistan that some times the specialized labor group has a distinct culture which can cause trouble when other subcontractors of the project do not familiar to their customs. Some examples are “brick maker labor” (poor families doing this job from generation to generation), “earth excavation labor” (strong and hard working labor from northern parts of country, working in central and southern parts), “road work labor” (families generally living as gypsies). Their distinct culture is normally due to the cultural back ground from where they originally belong to.

21.7 Subcontract Conditions and related Legal Issues in Construction

As the number of specialized services in construction projects increasing so involvement of subcontractors are also increased. This has increased the necessity of balanced subcontract conditions. As there are standard contract documents used in construction projects at international and regional level so there is also need of standard subcontracts. Subcontractors often complain about main contractor's exploitations. Therefore balanced subcontract conditions are required to deal with this problem. Keeping in view the problems in subcontracting FIDIC has also published "subcontract conditions" to be used back to back with its contract documents. Similarly subcontracts have been introduced in construction industries of many countries. New Acts also have been introduced to address the problems i.e. "HGCRA 1996" in UK.

In developing countries such as Pakistan there is no standard subcontract used in public sector construction related organizations. Large contracting firms have developed some general documents for outsourcing different works for their own use. As the involvement of subcontractors is also increasing in Pakistan construction sector therefore some reforms are also necessary. In contract documents, conditions for outsourcing activities should be addressed in detail. The increased role of subcontractors in construction industry is not properly realized. Standard subcontract documents should be introduced and also contractors are forced to outsource works by using these standard subcontracts. Dispute resolution systems should also be reformed, keeping in view the benefits of small construction firms. Since subcontract works are relatively short duration works as compared to main contract so a fast and cheap dispute resolution process will certainly help in addressing the problems and grievances or subcontractors.

21.8 Recommendations for Future Research

In this research work the recommendations for cooperative and productive relationships among subcontractors have been suggested. The bases of these recommendations are study of subcontractors' role in construction projects, analytical cooperation analyses and views of representatives of

contractors and subcontractors firms. More realistic and effective recommendations can be suggested by studying the interaction behavior of construction companies. A detail study of the individual and group behavior of subcontractors' staff is necessary to suggest effective organizational reforms to establish cooperative relationships.

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Appendix A

Questionnaires

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Questionnaire for Main Contractor

Note: *This Questionnaire will only be used for a study purpose. The name of person/firm is only for record maintenance and will not be mentioned in study.*
Name and designation of person carrying survey:_____
Name and description of Contractor/Firm answering the questions._____
Please Mark (✓) at the relevant option.

Part I

1. Do you prefer to work with same Sub-Contractors (SCs), to whom you already have good experience in your different projects, irrespective of cost?

   Every time *Mostly* *Often* *very few* *Never*

2. Do you think that selecting same Sub-Contractors (SCs) in next projects is good for the successful completion of project?

   Yes absolutely *Mostly* *Often* *very few* *No*

3. Do you like to continue same SCs in your next project, who work comfortably with one another?

   Yes *Mostly* *Often* *very few* *Never*

4. Do you prefer to try new subcontractor rather than your old co-partner SCs?

   Yes *Mostly* *Often* *very few* *Never*

5. Do you think that by continuing the same team of SCs in next projects is helpful in producing productive relationship among them?

   Yes absolutely *Mostly* *Often* *maybe* *Never*

6. Do you realize that SCs Co-operate with one another during the project execution?

   Always *Mostly* *Often* *very few* *Never*

7. Do you think that non co-operation among SCs cause serious problems i.e delay, low quality, defects.

   Yes *Mostly* *Often* *very few* *No*

8. Do you have to act as mediator among the disputes of SCs in your projects?

   Yes every time *Mostly* *Often* *very few* *Never*

9. Do you conduct tendering/Bidding process while selecting SCs?

Yes every time *Mostly* *Often* *very few* *Never*

10. Do you select SCs without tendering/bidding just by verbal negotiations?

Yes every time *Mostly* *Often* *very few* *Never*

11. Do you prefer to have formal written agreement with your SCs.

Yes every time *Mostly* *Often* *very few* *Never*

12. Do you identify all the risks involved to the relevant Subcontractor?

Yes every time *Mostly* *Often* *very few* *Never*

13. Do you transfer all the responsibility of risks and damages to the relevant subcontractor.

Yes every time *Mostly* *Often* *very few* *Never*

14. Do you have some kind of partnership or cooperative relation with your SCs or Suppliers?

Yes with all *with most of them* *about half* *with few* *with none*

15. Do you think it is important that Main Contractor should have partnership or alliance with SCs and Suppliers for better and consistent services from them?

Very important *important* *may be* *to some extent* *not important*

Part II

16. What are the barriers to productive relationships among Subcontractors/Suppliers involved in a construction project? Mark relevant option.

(a) Lack of interest of top management of companies.

Very important *important* *may be* *not important*

(b) Poor understanding of benefits of cooperation.

Very important *important* *may be* *not important*

(c) Inappropriate organization structure of construction firms involved.

Very important *important* *may be* *not important*

(d) Low commitment toward enhancing cooperation from partners involved in a project.

Very important *important* *may be* *not important*

(e) Any other reason do you think is important. Please write.

17. Please evaluate the different techniques as under, which are important to create a collaborative project climate. (mark relevant option)

(a) Selection of SCs should be based on previous experience but not on price.

Very important *important* *possible* *may be* *not important*

(b) Establishing a joint project office for all project partners.

Very important *important* *possible* *may be* *not important*

(c) Early selection of all SCs/Suppliers (before start of construction)

Very important *important* *possible* *may be* *not important*

(d) Main Contractor should establish joint objectives among groups of SCs rather than setting targets for each subcontractor.

Very important *important* *possible* *may be* *not important*

(e) If subcontractor teams achieved their targets early or MC gets benefit by their good team effort then MC should give these parties some share in profit as incentive.

Very important *important* *possible* *may be* *not important*

(f) MC should not put all the responsibilities (completion/risks) on respective subcontractor but should cooperate with them in case of problems.

Very important *important* *possible* *may be* *not important*

(g) SCs should be paid regularly according to agreement and their payments should not be held or delayed.

Very important *important* *possible* *may be* *not important*

(h) Any other suggestion, which do you think important for this purpose. Please write,

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Questionnaire for Subcontractors/Suppliers

Note: *This Questionnaire will only be used for a study purpose. The name of person/firm is only for record maintenance and will not be mentioned in study.*

Name and designation of person carrying survey:_____

Name and description of Contractor/Firm answering the questions._____
Please Mark (✔) at the relevant option.

Part I

18. If MCs tries to select same Sub-Contractors (SCs) in different projects then it will help in the successful completion of project?

    Yes absolutely *Mostly* *Often* *very few* *No*

19. Do you think that by continuing the same team of SCs in different projects is helpful in producing productive relationship among them?

    Yes absolutely *Mostly* *Often* *maybe* *Never*

20. Do you realize that SCs Co-operate with one another during the project execution?

    Always *Mostly* *Often* *very few* *Never*

21. Do you think that non co-operation among SCs cause serious problems i.e delay, low quality, defects.

    Yes *Mostly* *Often* *very few* *No*

22. Do the MCs carry out tendering/Bidding process for selection of SCs?

    Yes every time *Mostly* *Often* *very few* *Never*

23. Do the you prefer to have formal written agreement with your Main Contractors (MCs).

    Yes every time *Mostly* *Often* *very few* *Never*

24. Do you think that MC's selection procedure for SCs is fair?

    Yes every time *Mostly* *Often* *very few* *Never*

25. Do you think that you are given unrealistic time schedules by MC?

    Yes every time *Mostly* *Often* *very few* *Never*

26. Do you get late/ incorrect payments from MC?

Yes every time *Mostly* *Often* *very few* *Never*

27. Do the quantity surveyors of MC fairly calculate your work done?

Yes every time *Mostly* *Often* *very few* *Never*

28. Do the MC expects from you more, than your max. Output and quality?

Yes every time *Mostly* *Often* *very few* *Never*

29. Do you get full technical, financial, operational support from the MC?

Yes every time *Mostly* *Often* *very few* *Never*

30. Do the MC identifies all the risks involved in work to the relevant Subcontractors?

Yes every time *Mostly* *Often* *very few* *Never*

31. Do the MCs transfer all the responsibility of risks and damages to the relevant subcontractor.

Yes every time *Mostly* *Often* *very few* *Never*

32. Do you think that working conditions/environment are more in favour of MC during the execution of projects?

Yes every time *Mostly* *Often* *very few* *Never*

33. Do you have some kind of partnership or cooperative relation with your MCs.

Yes with all *with most of them* *about half* *with few* *with none*

34. Do you have some kind of partnership or long term relations with any other subcontractor or supplier

Yes with all *with most of them* *about half* *with few* *with none*

35. Do you think it is important that Main Contractor should have partnership or alliance with SCs and Suppliers for better and consistent services from them?

Very important *important* *may be* *to some extent* *not important*

36. Do you think that SCs/suppliers should have partnerships with each others to make an efficient team at construction sites?

Very important *important* *may be* *to some extent* *not important*

Part II

37. What are the barriers to productive relationships among Subcontractors/Suppliers involved in a construction project? Mark relevant option.

(a) Lack of interest of top management of companies.

Very important *important* *may be* *not important*

(b) Poor understanding of benefits of cooperation.

Very important *important* *may be* *not important*

(c) Inappropriate organization structure of construction firms involved.

Very important *important* *may be* *not important*

(e) Low commitment/interest toward enhancing cooperation from partners involved in a project.

Very important *important* *may be* *not important*

(e) Any other reason do you think is important. Please write.

38. Please evaluate the different techniques as under, which are important to create a collaborative project climate. (mark relevant option)

(c) Selection of SCs should be based on previous experience but not on price.

Very important *important* *possible* *may be* *not important*

(d) Establishing a joint project office for all project partners.

Very important *important* *possible* *may be* *not important*

(c) Early selection of all SCs/Suppliers (before start of construction)

Very important *important* *possible* *may be* *not important*

(d) Main Contractor should establish joint objectives among groups of SCs rather than setting targets for each subcontractor.

Very important *important* *possible* *may be* *not important*

(e) If subcontractor teams achieved their targets early or MC gets benefit by their good team effort then MC should give these parties some share in profit as incentive.

Very important *important* *possible* *may be* *not important*

(f) MC should not put all the responsibilities (completion/risks) on respective subcontractor but should cooperate with them in case of problems.

Very important *important* *possible* *may be* *not important*

(g) SCs should be paid regularly according to agreement and their payments should not be held or delayed.

Very important *important* *possible* *may be* *not important*

(h) Any other suggestion, which do you think important for this purpose. Please write,

Appendix B

Detail Result of Questionnaires Answers

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Questionnair and Result (Main Contractor) Part I

Sr. No.	Question Statement	Answers					Mean Rating	Standard Deviation
		Yes / Everytime	Mostly	Often	Very few	Never		
1	Do you prefer to work with same Sub-Contractors (SCs), to whom you already have good experience in your different projects, irrespective of cost?	5	10	11	11	0	3,24	1,12
2	Do you think that selecting same Sub-Contractors (SCs) in next projects is good for the successful completion of project?	7	6	8	16	0	3,11	1,26
3	Do you like to continue same SCs in your next project, who work comfortably with one another?	21	9	6	1	0	4,35	0,92
4	Do you prefer to try new SC rather than your old co-partner SCs?	0	2	3	26	6	2,03	0,74
5	Do you think that by continuing the same team of SCs in next projects is helpful in producing productive relationship among them?	14	10	6	4	3	3,76	1,40
6	Do you realize that SCs Co-operate with one another during the project execution?	1	9	18	9	0	3,05	0,84
7	Do you think that non co-operation among SCs cause serious problems i.e delay, low quality, defects.	13	14	10	0	0	4,08	0,86
8	Do you have to act as mediator among the disputes of SCs in your projects?	11	13	10	3	0	3,86	1,02
9	Do you conduct tendering/Bidding process while selecting SCs?	1	7	11	13	5	2,62	1,12
10	Do you select SCs without tendering/bidding just by verbal negotiations?	0	16	5	16	0	3,00	1,02
11	Do you prefer to have formal written agreement with your SCs.	18	8	6	5	0	4,05	1,19
12	Do you identify all the risks involved to the relevant Subcontractor?	19	6	11	1	0	4,16	1,03
13	Do you transfer all the responsibility of risks and damages to the relevant SC.	0	4	11	20	2	2,46	0,83
14	Do you have some kind of partnership or cooperative relation with your SCs or Suppliers?	0	0	3	11	23	1,46	0,70
15	Do you think it is important that Main Contractor should have partnership or alliance with SCs and Suppliers for better and consistent services from them?	Very important	Important	May be	Important to some extent	Not important at all	2,62	1,28
		2	8	8	12	7		

Questionnair and Result (Sub Contractor) Part I

Sr. No.	Question Statement	Answers					Mean Rating	Standard Deviation
		Yes / Everytime	Mostly	Often	Very few	Never		
1	If MCs tries to select same Sub-Contractors (SCs) in different projects then it will help in the successful completion of project?	11	6	6	8	0	3,65	1,21
2	Do you think that by continuing the same team of SCs in different projects is helpful in producing productive relationship among them?	8	15	4	1	3	3,77	1,16
3	Do you realize that SCs Co-operate with one another during the project execution?	2	15	8	6	0	3,42	0,87
4	Do you think that non co-operation among SCs cause serious problems i.e delay, low quality, defects.	17	8	4	2	0	4,29	0,92
5	Do the MCs carry out tendering/Bidding process for selection of SCs?	6	11	4	8	2	3,35	1,23
6	Do the you prefer to have formal written agreement with your Main Contractors(MCs).	12	15	2	2	0	4,19	0,82
7	Do you think that MC's selection procedure for SCs is fair?	8	10	4	9	0	3,55	1,16
8	Do you think that you are given unrealistic time schedules by MC?	4	14	9	4	0	3,58	0,87
9	Do you get late/ incorrect payments from MC?	4	6	11	10	0	3,13	1,01
10	Do the quantity surveyors of MC fairly calculate your work done?	8	21	2	0	0	4,19	0,53
11	Do the MC expects from you more, than your max. Output and quality?	6	17	6	2	0	3,87	0,79
12	Do you get full technical , financial, operational support from the MC?	5	8	7	11	0	3,23	1,10
13	Do the MC identifies all the risks involved in work to the relevant Subcontractors?	5	9	6	11	0	3,26	1,11
14	Do the MCs transfer all the responsibility of risks and damages to the relevant SC.	5	6	14	4	2	3,26	1,08
15	Do you think that working conditions/environment are more in favour of MC during the execution of projects?	4	21	6	0	0	3,94	0,56
16	Do you have some kind of partnership or cooperative relation with your MCs.	3	2	7	12	7	2,42	1,19
17	Do you have some kind of partnership or long term relations with any other subcontractor or supplier?	0	1	1	15	14	1,65	0,70
18	Do you think it is important that Main Contractor should have partnership or alliance with SCs and Suppliers for better and consistent services from them?	Very important	Important	May be	To some extent	Not important	3,03	1,09
		5	4	9	13	0		
19	Do you think that SCs/suppliers should have partnerships with each others to make an efficient team at construction sites?	4	18	9	0	0	3,84	0,63

Questionnaire Result Part II (Combined result of MCs and SCs)

Importance of the factors which are considered as barriers to productive relationships among Subcontractors/Suppliers involved in a construction projects. (Views of 68 contractors/subcontractors)

Sr. No.	Description	Answers				Mean Rating	Standard Deviation
		Very important	Important	May be	Not important		
1	Lack of interest of top management of companies.	22	31	12	3	3,06	0,82
2	Low commitment/interest toward enhancing cooperation from partners involved in a project.	12	38	15	3	2,87	0,75
3	Inappropriate organization structure of the construction firms involved.	13	37	13	5	2,85	0,81
4	Poor understanding of benefits of cooperation.	6	28	34	0	2,59	0,65

Evaluation of the importance of different factors which are helpful in order to create a co-operative project climate among contractors, subcontractors and suppliers. (Views of 68 contractors/subcontractors)

No.	Description	Answers				Mean Rating	Standard Deviation
		Very important	Important	May be	Not important		
1	SCs should be paid regularly according to agreement and their payments should not be held or delayed.	45	19	3	1	3,59	0,65
2	Selection of SCs should be based on previous experience but not on price.	42	23	3	0	3,57	0,58
3	MC should not put all the responsibilities (completion/risks) on respective SC but should cooperate with them in case of problems.	31	32	5	0	3,38	0,62
4	Early selection of all SCs/Suppliers (before start of construction)	30	27	10	1	3,26	0,76
5	If SC teams achieved their targets early or MC gets benefit by their good team effort then MC should give these parties some share in profit as incentive.	20	34	14	0	3,09	0,70
6	Establishing a joint project office for all project partners.	22	33	9	4	3,07	0,83
7	Main Contractor should establish joint objectives among groups of SCs rather than setting targets for each SC.	10	24	14	20	2,35	1,05

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Appendix C

Results of Tournament Series 1

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1 Iteration Tournament

Player 16
Strategies 16
Matches 120

	Agent Type	Agent Count	Games Played	Result Frequency				Total Payoff	Avg. Payoff
				C-C	C-D	D-C	D-D		
+	Tit For Tat	1	15	10	5	0	0	15	1
+	Tit For Two Tats	1	15	9	6	0	0	12	0.8
+	Spiteful	1	15	10	5	0	0	15	1
+	Joss	1	15	7	4	3	1	19	1.267
+	Tester	1	15	0	0	10	5	30	2
+	Pavlov	1	15	9	6	0	0	12	0.8
+	Mistrust	1	15	0	0	10	5	30	2
+	Prober	1	15	8	7	0	0	9	0.6
+	Soft Majority	1	15	10	5	0	0	15	1
+	Hard Majority	1	15	0	0	11	4	33	2.2
+	Random	1	15	4	5	5	1	18	1.2
+	All C	1	15	10	5	0	0	15	1
+	All D	1	15	0	0	11	4	33	2.2
+	PerCD	1	15	8	7	0	0	9	0.6
+	PerCCD	1	15	9	6	0	0	12	0.8
+	PerDDC	1	15	0	0	11	4	33	2.2

BACK FORWARD

20 matches complete

2 Iterations Tournament

Player 16
Strategies 16
Matches 240

	Agent Type	Agent Count	Games Played	Result Frequency				Total Payoff	Avg. Payoff
				C-C	C-D	D-C	D-D		
+	Tit For Tat	1	30	18	7	3	2	38	1.267
+	Tit For Two Tats	1	30	20	10	0	0	30	1
+	Spiteful	1	30	17	8	3	2	35	1.167
+	Joss	1	30	16	6	2	6	32	1.067
+	Tester	1	30	3	6	10	11	30	1
+	Pavlov	1	30	16	8	4	2	36	1.2
+	Mistrust	1	30	4	6	10	10	32	1.067
+	Prober	1	30	10	5	12	3	51	1.7
+	Soft Majority	1	30	17	8	3	2	35	1.167
+	Hard Majority	1	30	4	7	11	8	34	1.133
+	Random	1	30	12	8	6	4	34	1.133
+	All C	1	30	21	9	0	0	33	1.1
+	All D	1	30	0	0	14	16	42	1.4
+	PerCD	1	30	10	5	11	4	48	1.6
+	PerCCD	1	30	20	10	0	0	30	1
+	PerDDC	1	30	0	0	14	16	42	1.4

BACK FORWARD

240 matches complete

3 Iterations Tournament

Player 16
Strategies 16
Matches 360

	Agent Type	Agent Count	Games Played	Result Frequency				Total Payoff	Avg. Payoff
				C-C	C-D	D-C	D-D		
+	Tit For Tat	1	45	24	12	5	4	51	1.133
+	Tit For Two Tats	1	45	31	12	1	1	53	1.178
+	Spiteful	1	45	23	10	5	7	51	1.133
+	Joss	1	45	21	11	6	7	49	1.089
+	Tester	1	45	3	7	17	18	50	1.111
+	Pavlov	1	45	25	10	4	6	52	1.156
+	Mistrust	1	45	5	8	16	16	50	1.111
+	Prober	1	45	10	5	17	13	66	1.467
+	Soft Majority	1	45	23	14	5	3	47	1.044
+	Hard Majority	1	45	5	8	16	16	50	1.111
+	Random	1	45	15	5	8	17	49	1.089
+	All C	1	45	32	13	0	0	51	1.133
+	All D	1	45	0	0	17	28	51	1.133
+	PerCD	1	45	13	17	11	4	42	0.933
+	PerCCD	1	45	21	9	11	4	66	1.467
+	PerDDC	1	45	3	12	14	16	36	0.8

BACK FORWARD

360 matches complete

4 Iterations Tournament

Player 16
Strategies 16
Matches 4800

	Agent Type	Agent Count	Games Played	Result Frequency				Total Payoff	Avg. Payoff
				C-C	C-D	D-C	D-D		
+	Tit For Tat	1	60	31	14	10	5	78	1.3
+	Tit For Two Tats	1	60	40	16	1	3	67	1.117
+	Spiteful	1	60	30	9	7	14	72	1.2
+	Joss	1	60	28	12	10	10	74	1.233
+	Tester	1	60	6	12	21	21	63	1.05
+	Pavlov	1	60	31	14	7	8	69	1.15
+	Mistrust	1	60	7	15	20	18	59	0.983
+	Prober	1	60	11	15	20	14	67	1.117
+	Soft Majority	1	60	33	14	7	6	73	1.217
+	Hard Majority	1	60	11	11	17	21	62	1.033
+	Random	1	60	27	17	11	5	70	1.167
+	All C	1	60	43	17	0	0	69	1.15
+	All D	1	60	0	0	21	39	63	1.05
+	PerCD	1	60	15	15	23	7	84	1.4
+	PerCCD	1	60	26	19	12	3	69	1.15
+	PerDDC	1	60	3	12	25	20	69	1.15

BACK FORWARD

480 matches complete

5 Iterations Tournament

Player 16
Strategies 16
Matches 600

	Agent Type	Agent Count	Games Played	Result Frequency				Total Payoff	Avg. Payoff
				C-C	C-D	D-C	D-D		
+	Tit For Tat	1	75	40	17	11	7	96	1.28
+	Tit For Two Tats	1	75	51	18	1	5	87	1.16
+	Spiteful	1	75	34	10	10	21	88	1.173
+	Joss	1	75	26	18	18	13	88	1.173
+	Tester	1	75	8	14	28	25	86	1.147
+	Pavlov	1	75	33	18	11	13	81	1.08
+	Mistrust	1	75	10	15	23	27	74	0.987
+	Prober	1	75	15	15	24	21	87	1.16
+	Soft Majority	1	75	41	18	7	9	85	1.133
+	Hard Majority	1	75	11	12	21	31	73	0.973
+	Random	1	75	24	15	17	19	84	1.12
+	All C	1	75	51	24	0	0	78	1.04
+	All D	1	75	0	0	27	48	81	1.08
+	PerCD	1	75	18	27	22	8	75	1
+	PerCCD	1	75	34	26	11	4	75	1
+	PerDDC	1	75	4	11	27	33	78	1.04

BACK FORWARD

600 matches complete

10 Iterations Tournament

Player 16
Strategies 16
Matches 1200

	Agent Type	Agent Count	Games Played	Result Frequency				Total Payoff	Avg. Payoff
				C-C	C-D	D-C	D-D		
+	Tit For Tat	1	150	60	39	35	16	186	1.24
+	Tit For Two Tats	1	150	103	29	3	15	186	1.24
+	Spiteful	1	150	64	9	22	55	185	1.233
+	Joss	1	150	47	34	38	31	174	1.16
+	Tester	1	150	15	27	46	62	141	0.94
+	Pavlov	1	150	82	30	15	23	179	1.193
+	Mistrust	1	150	24	36	42	48	138	0.92
+	Prober	1	150	20	33	48	49	151	1.007
+	Soft Majority	1	150	73	34	21	22	175	1.167
+	Hard Majority	1	150	28	28	32	62	124	0.827
+	Random	1	150	49	37	32	32	157	1.047
+	All C	1	150	103	47	0	0	159	1.06
+	All D	1	150	0	0	45	105	135	0.9
+	PerCD	1	150	30	45	55	20	180	1.2
+	PerCCD	1	150	55	50	31	14	153	1.02
+	PerDDC	1	150	9	36	49	56	129	0.86

BACK FORWARD

1200 matches complete

20 Iterations Tournament

Player 16
Strategies 16
Matches 2400

	Agent Type	Agent Count	Games Played	Result Frequency				Total Payoff	Avg. Payoff
				C-C	C-D	D-C	D-D		
+	Tit For Tat	1	300	117	80	76	27	382	1.273
+	Tit For Two Tats	1	300	196	59	10	35	363	1.21
+	Spiteful	1	300	107	10	42	141	330	1.1
+	Joss	1	300	72	46	55	127	263	0.877
+	Tester	1	300	30	56	88	126	268	0.893
+	Pavlov	1	300	148	61	34	57	337	1.123
+	Mistrust	1	300	48	64	68	120	236	0.787
+	Prober	1	300	36	66	83	115	255	0.85
+	Soft Majority	1	300	154	60	36	50	356	1.187
+	Hard Majority	1	300	58	49	55	138	232	0.773
+	Random	1	300	83	74	82	61	338	1.127
+	All C	1	300	210	90	0	0	330	1.1
+	All D	1	300	0	0	78	222	234	0.78
+	PerCD	1	300	53	97	110	40	339	1.13
+	PerCCD	1	300	118	92	62	28	330	1.1
+	PerDDC	1	300	18	72	97	113	255	0.85

BACK FORWARD

2400 matches complete

30 Iterations Tournament

Player 16
Strategies 16
Matches 3600

	Agent Type	Agent Count	Games Played	Result Frequency				Total Payoff	Avg. Payoff
				C-C	C-D	D-C	D-D		
+	Tit For Tat	1	450	182	113	109	46	578	1.284
+	Tit For Two Tats	1	450	303	79	12	56	563	1.251
+	Spiteful	1	450	162	10	64	214	506	1.124
+	Joss	1	450	118	75	86	171	419	0.931
+	Tester	1	450	45	85	133	187	404	0.898
+	Pavlov	1	450	217	92	52	89	498	1.107
+	Mistrust	1	450	74	100	104	172	360	0.8
+	Prober	1	450	46	85	131	188	400	0.889
+	Soft Majority	1	450	220	91	63	76	538	1.196
+	Hard Majority	1	450	77	66	96	211	376	0.836
+	Random	1	450	106	138	90	116	344	0.764
+	All C	1	450	316	134	0	0	498	1.107
+	All D	1	450	0	0	118	332	354	0.787
+	PerCD	1	450	82	143	162	63	507	1.127
+	PerCCD	1	450	162	138	106	44	504	1.12
+	PerDDC	1	450	34	116	139	161	369	0.82

BACK FORWARD

3600 matches complete

40 Iterations Tournament

Player 16
Strategies 16
Matches 4800

	Agent Type	Agent Count	Games Played	Result Frequency				Total Payoff	Avg. Payoff
				C-C	C-D	D-C	D-D		
+	Tit For Tat	1	600	254	140	135	71	773	1.288
+	Tit For Two Tats	1	600	396	104	18	82	742	1.237
+	Spiteful	1	600	226	10	81	283	685	1.142
+	Joss	1	600	174	105	130	191	633	1.055
+	Tester	1	600	59	115	178	248	537	0.895
+	Pavlov	1	600	287	124	71	118	663	1.105
+	Mistrust	1	600	104	149	155	192	524	0.873
+	Prober	1	600	64	124	162	250	490	0.817
+	Soft Majority	1	600	281	107	89	123	722	1.203
+	Hard Majority	1	600	104	91	134	271	519	0.865
+	Random	1	600	135	176	120	169	454	0.757
+	All C	1	600	418	182	0	0	654	1.09
+	All D	1	600	0	0	150	450	450	0.75
+	PerCD	1	600	105	195	220	80	675	1.125
+	PerCCD	1	600	217	188	130	65	636	1.06
+	PerDDC	1	600	40	155	192	213	501	0.835

BACK FORWARD

4800 matches complete

50 Iterations Tournament

Player 16
Strategies 16
Matches 6000

	Agent Type	Agent Count	Games Played	Result Frequency				Total Payoff	Avg. Payoff
				C-C	C-D	D-C	D-D		
+	Tit For Tat	1	750	298	190	186	76	964	1.285
+	Tit For Two Tats	1	750	496	132	22	100	926	1.235
+	Spiteful	1	750	267	10	99	374	821	1.095
+	Joss	1	750	158	146	175	271	695	0.927
+	Tester	1	750	74	163	239	274	702	0.936
+	Pavlov	1	750	377	146	86	141	866	1.155
+	Mistrust	1	750	131	168	173	278	613	0.817
+	Prober	1	750	76	160	209	305	619	0.825
+	Soft Majority	1	750	310	130	117	193	841	1.121
+	Hard Majority	1	750	141	113	137	359	580	0.773
+	Random	1	750	163	201	161	225	608	0.811
+	All C	1	750	521	229	0	0	813	1.084
+	All D	1	750	0	0	186	564	558	0.744
+	PerCD	1	750	128	247	271	104	822	1.096
+	PerCCD	1	750	276	234	163	77	807	1.076
+	PerDDC	1	750	48	192	237	273	615	0.82

BACK FORWARD

6000 matches complete

Appendix D

Results of Tournament Series 2

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TFT Players 1
All D Players 10
Iterations 20
Matches 1100

Agent Type	Agent Count	Games Played	Result Frequency				Total Payoff	Avg. Payoff
			C-C	C-D	D-C	D-D		
Tit For Tat	1	200	0	10	0	190	-10	-0.05
All D	10	2000	0	0	10	1990	30	0.015

TFT Players 2
All D Players 10
Iterations 20
Matches 1320

Agent Type	Agent Count	Games Played	Result Frequency				Total Payoff	Avg. Payoff
			C-C	C-D	D-C	D-D		
Tit For Tat	2	440	40	20	0	380	60	0.136
All D	10	2200	0	0	20	2180	60	0.027

TFT Players 3
All D Players 10
Iterations 20
Matches 1560

Agent Type	Agent Count	Games Played	Result Frequency				Total Payoff	Avg. Payoff
			C-C	C-D	D-C	D-D		
Tit For Tat	3	720	120	30	0	570	210	0.292
All D	10	2400	0	0	30	2370	90	0.038

TFT 4
All D Players 10
Iterations 20
Matches 1820

Agent Type	Agent Count	Games Played	Result Frequency				Total Payoff	Avg. Payoff
			C-C	C-D	D-C	D-D		
Tit For Tat	4	1040	240	40	0	760	440	0.423
All D	10	2600	0	0	40	2560	120	0.046

TFT Players 10
All D Players 10
Iterations 20
Matches 3800

Agent Type	Agent Count	Games Played	Result Frequency				Total Payoff	Avg. Payoff
			C-C	C-D	D-C	D-D		
Tit For Tat	10	3800	1800	100	0	1900	3500	0.921
All D	10	3800	0	0	100	3700	300	0.079

Appendix E

Results of Tournament Series 3

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MC Play TFT

Game Settings:
Iterations 5

Game Results:		SC1					SC2						Payoffs: To MC due to SC vs SC		To SCs From MC		To MC from SCs		To MC due to MC's C			Total Payoffs		
Round	Iteration	Player1	Type1	Move1	Payoff1	Value1	Player2	Type2	Move2	Payoff2	Value2	Class	SC 1	SC2	SC1	SC2	SC1	SC2	sc1	sc2	T	SC1	SC2	MC
1	1	3	All D	FALSE	0	0	5	All D	FALSE	0	0	Mutual_Defection	0	0	3	3	0	0	-1	-1	-2	3	3	-2
2	1	1	Tit For Tat	TRUE	-1	-1	5	All D	FALSE	3	3	Sucker_Temptation	1	0	2	0	3	0	-1	0	-1	1	3	3
3	1	0	Tit For Tat	TRUE	-1	-1	3	All D	FALSE	3	3	Sucker_Temptation	1	0	2	0	3	0	-1	0	-1	1	3	3
4	1	4	All D	FALSE	0	0	5	All D	FALSE	0	3	Mutual_Defection	0	0	3	0	0	0	-1	0	-1	3	0	-1
5	1	3	All D	FALSE	0	3	4	All D	FALSE	0	0	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
6	2	3	All D	FALSE	0	3	5	All D	FALSE	0	3	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
7	2	4	All D	FALSE	0	0	5	All D	FALSE	0	3	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
8	1	0	Tit For Tat	TRUE	2	1	1	Tit For Tat	TRUE	2	1	Mutual_Cooperation	1	1	2	2	3	3	-1	-1	-2	4	4	6
9	1	2	Tit For Tat	TRUE	-1	-1	3	All D	FALSE	3	6	Sucker_Temptation	1	0	2	0	3	0	-1	0	-1	1	3	3
10	2	0	Tit For Tat	FALSE	0	1	3	All D	FALSE	0	6	Mutual_Defection	0	0	2	0	3	0	-1	0	-1	2	0	2
11	1	0	Tit For Tat	TRUE	-1	0	5	All D	FALSE	3	6	Sucker_Temptation	1	0	2	0	3	0	-1	0	-1	1	3	3
12	2	0	Tit For Tat	FALSE	0	0	5	All D	FALSE	0	6	Mutual_Defection	0	0	2	0	3	0	-1	0	-1	2	0	2
13	1	1	Tit For Tat	TRUE	-1	0	3	All D	FALSE	3	9	Sucker_Temptation	1	0	2	0	3	0	-1	0	-1	1	3	3
14	3	4	All D	FALSE	0	0	5	All D	FALSE	0	6	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
15	2	2	Tit For Tat	FALSE	0	-1	3	All D	FALSE	0	9	Mutual_Defection	0	0	2	0	3	0	-1	0	-1	2	0	2
16	1	2	Tit For Tat	TRUE	-1	-2	5	All D	FALSE	3	9	Sucker_Temptation	1	0	2	0	3	0	-1	0	-1	1	3	3
17	3	2	Tit For Tat	FALSE	0	-2	3	All D	FALSE	0	9	Mutual_Defection	0	0	2	0	3	0	-1	0	-1	2	0	2
18	3	0	Tit For Tat	FALSE	0	0	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
19	2	0	Tit For Tat	TRUE	2	2	1	Tit For Tat	TRUE	2	2	Mutual_Cooperation	1	1	0	2	0	3	0	-1	-1	2	4	4
20	1	1	Tit For Tat	TRUE	2	4	2	Tit For Tat	TRUE	2	0	Mutual_Cooperation	1	1	2	2	3	3	-1	-1	-2	4	4	6
21	1	0	Tit For Tat	TRUE	2	4	2	Tit For Tat	TRUE	2	2	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
22	4	4	All D	FALSE	0	0	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
23	1	2	Tit For Tat	TRUE	-1	1	4	All D	FALSE	3	3	Sucker_Temptation	1	0	0	0	0	0	0	0	0	-1	3	1
24	2	3	All D	FALSE	0	9	4	All D	FALSE	0	3	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
25	2	1	Tit For Tat	FALSE	0	4	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
26	2	2	Tit For Tat	FALSE	0	1	4	All D	FALSE	0	3	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
27	4	0	Tit For Tat	FALSE	0	4	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
28	1	1	Tit For Tat	TRUE	-1	3	4	All D	FALSE	3	6	Sucker_Temptation	1	0	0	0	0	0	0	0	0	-1	3	1
29	3	0	Tit For Tat	TRUE	2	6	1	Tit For Tat	TRUE	2	5	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
30	4	0	Tit For Tat	TRUE	2	8	1	Tit For Tat	TRUE	2	7	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
31	2	2	Tit For Tat	FALSE	0	1	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
32	2	1	Tit For Tat	TRUE	2	9	2	Tit For Tat	TRUE	2	3	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
33	1	0	Tit For Tat	TRUE	-1	7	4	All D	FALSE	3	9	Sucker_Temptation	1	0	0	0	0	0	0	0	0	-1	3	1
34	3	2	Tit For Tat	FALSE	0	3	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
35	3	1	Tit For Tat	TRUE	2	11	2	Tit For Tat	TRUE	2	5	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
36	2	1	Tit For Tat	FALSE	0	11	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
37	4	2	Tit For Tat	FALSE	0	5	3	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
38	4	2	Tit For Tat	FALSE	0	5	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
39	2	0	Tit For Tat	FALSE	0	7	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
40	3	2	Tit For Tat	FALSE	0	5	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
41	4	1	Tit For Tat	TRUE	2	13	2	Tit For Tat	TRUE	2	7	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
42	5	1	Tit For Tat	TRUE	2	15	2	Tit For Tat	TRUE	2	9	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
43	3	0	Tit For Tat	FALSE	0	7	3	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
44	3	1	Tit For Tat	FALSE	0	15	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
45	5	0	Tit For Tat	FALSE	0	7	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
46	4	1	Tit For Tat	FALSE	0	15	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
47	3	1	Tit For Tat	FALSE	0	15	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
48	5	0	Tit For Tat	TRUE	2	9	1	Tit For Tat	TRUE	2	17	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
49	3	3	All D	FALSE	0	9	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
50	2	0	Tit For Tat	TRUE	2	11	2	Tit For Tat	TRUE	2	11	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
51	5	1	Tit For Tat	FALSE	0	17	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
52	3	3	All D	FALSE	0	9	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
53	5	2	Tit For Tat	FALSE	0	11	3	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
54	5	2	Tit For Tat	FALSE	0	11	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
55	3	0	Tit For Tat	FALSE	0	11	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
56	4	2	Tit For Tat	FALSE	0	11	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
57	5	2	Tit For Tat	FALSE	0	11	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
58	4	0	Tit For Tat	FALSE	0	11	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
59	5	0	Tit For Tat	FALSE	0	11	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
60	4	3	All D	FALSE	0	9	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
61	4	3	All D	FALSE	0	9	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
62	4	1	Tit For Tat	FALSE	0	17	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
63	5	3	All D	FALSE	0	9	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
64	5	1	Tit For Tat	FALSE	0	17	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
65	4	0	Tit For Tat	FALSE	0	11	3	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
66	5	3	All D	FALSE	0	9	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
67	2	1	Tit For Tat	FALSE	0	17	3	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
68	5	0	Tit For Tat	FALSE	0	11	3	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
69	3	0	Tit For Tat	TRUE	2	13	2	Tit For Tat	TRUE	2	13	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
70	3	1	Tit For Tat	FALSE	0	17	3	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
71	4	1	Tit For Tat	FALSE	0	17	3	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
72	5	4	All D	FALSE	0	9	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
73	5	1	Tit For Tat	FALSE	0	17	3	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
74	4	0	Tit For Tat	TRUE	2	15	2	Tit For Tat	TRUE	2	15	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
75	5	0	Tit For Tat	TRUE	2	17	2	Tit For Tat	TRUE	2	17	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
													24	15										

Agent Roster:

0	Tit For Tat	SC
1	Tit For Tat	SC
2	Tit For Tat	SC
3	All D	SC
4	All D	SC
5	All D	SC

Abstract of results

Player	strategy	Payoff: Total	Payoff: Avg.
MC	TFT	66	2,20
0	TFT	27	0,90
1	TFT	27	0,90
2	TFT	27	0,90
3	All D	12	0,40
4	All D	12	0,40
5	All D	12	0,40

Game Settings:
Iterations 5

MC play All D

Game Results:		SC1					SC2						Payoffs											
													To MC due to SC vs SC		To SCs From MC		MC from SCs		To MC due to MC's C			Total		
Round	Iteration	Player1	Type1	Move1	Payoff1	Value1	Player2	Type2	Move2	Payoff2	Value2	Class	SC 1	SC2	SC1	SC2	SC1	SC2	SC1	SC2	T	SC1	SC2	MC
1	1	3	All D	FALSE	0	0	5	All D	FALSE	0	0	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
2	1	1	Tit For Tat	TRUE	-1	-1	5	All D	FALSE	3	3	Sucker_Temptation	1	0	0	0	3	0	0	0	0	-1	3	4
3	1	0	Tit For Tat	TRUE	-1	-1	3	All D	FALSE	3	3	Sucker_Temptation	1	0	0	0	3	0	0	0	0	-1	3	4
4	1	4	All D	FALSE	0	0	5	All D	FALSE	0	3	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
5	1	3	All D	FALSE	0	3	4	All D	FALSE	0	0	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
6	2	3	All D	FALSE	0	3	5	All D	FALSE	0	3	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
7	2	4	All D	FALSE	0	0	5	All D	FALSE	0	3	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
8	1	0	Tit For Tat	TRUE	2	1	1	Tit For Tat	TRUE	2	1	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
9	1	2	Tit For Tat	TRUE	-1	-1	3	All D	FALSE	3	6	Sucker_Temptation	1	0	0	0	3	0	0	0	0	-1	3	4
10	2	0	Tit For Tat	FALSE	0	1	3	All D	FALSE	0	6	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
11	1	0	Tit For Tat	TRUE	-1	0	5	All D	FALSE	3	6	Sucker_Temptation	1	0	0	0	0	0	0	0	0	-1	3	1
12	2	0	Tit For Tat	FALSE	0	0	5	All D	FALSE	0	6	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
13	1	1	Tit For Tat	TRUE	-1	0	3	All D	FALSE	3	9	Sucker_Temptation	1	0	0	0	0	0	0	0	0	-1	3	1
14	3	4	All D	FALSE	0	0	5	All D	FALSE	0	6	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
15	2	2	Tit For Tat	FALSE	0	-1	3	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
16	1	2	Tit For Tat	TRUE	-1	-2	5	All D	FALSE	3	9	Sucker_Temptation	1	0	0	0	0	0	0	0	0	-1	3	1
17	3	2	Tit For Tat	FALSE	0	-2	3	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
18	3	0	Tit For Tat	FALSE	0	0	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
19	2	0	Tit For Tat	TRUE	2	2	1	Tit For Tat	TRUE	2	2	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
20	1	1	Tit For Tat	TRUE	2	4	2	Tit For Tat	TRUE	2	0	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
21	1	0	Tit For Tat	TRUE	2	4	2	Tit For Tat	TRUE	2	2	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
22	4	4	All D	FALSE	0	0	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
23	1	2	Tit For Tat	TRUE	-1	1	4	All D	FALSE	3	3	Sucker_Temptation	1	0	0	0	0	0	0	0	0	-1	3	1
24	2	3	All D	FALSE	0	9	4	All D	FALSE	0	3	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
25	2	1	Tit For Tat	FALSE	0	4	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
26	2	2	Tit For Tat	FALSE	0	1	4	All D	FALSE	0	3	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
27	4	0	Tit For Tat	FALSE	0	4	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
28	1	1	Tit For Tat	TRUE	-1	3	4	All D	FALSE	3	6	Sucker_Temptation	1	0	0	0	0	0	0	0	0	-1	3	1
29	3	0	Tit For Tat	TRUE	2	6	1	Tit For Tat	TRUE	2	5	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
30	4	0	Tit For Tat	TRUE	2	8	1	Tit For Tat	TRUE	2	7	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
31	2	2	Tit For Tat	FALSE	0	1	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
32	2	1	Tit For Tat	TRUE	2	9	2	Tit For Tat	TRUE	2	3	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
33	1	0	Tit For Tat	TRUE	-1	7	4	All D	FALSE	3	9	Sucker_Temptation	1	0	0	0	0	0	0	0	0	-1	3	1
34	3	2	Tit For Tat	FALSE	0	3	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
35	3	1	Tit For Tat	TRUE	2	11	2	Tit For Tat	TRUE	2	5	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
36	2	1	Tit For Tat	FALSE	0	11	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
37	4	2	Tit For Tat	FALSE	0	5	3	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
38	4	2	Tit For Tat	FALSE	0	5	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
39	2	0	Tit For Tat	FALSE	0	7	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
40	3	2	Tit For Tat	FALSE	0	5	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
41	4	1	Tit For Tat	TRUE	2	13	2	Tit For Tat	TRUE	2	7	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
42	5	1	Tit For Tat	TRUE	2	15	2	Tit For Tat	TRUE	2	9	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
43	3	0	Tit For Tat	FALSE	0	7	3	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
44	3	1	Tit For Tat	FALSE	0	15	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
45	5	0	Tit For Tat	FALSE	0	7	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
46	4	1	Tit For Tat	FALSE	0	15	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
47	3	1	Tit For Tat	FALSE	0	15	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
48	5	0	Tit For Tat	TRUE	2	9	1	Tit For Tat	TRUE	2	17	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
49	3	3	All D	FALSE	0	9	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
50	2	0	Tit For Tat	TRUE	2	11	2	Tit For Tat	TRUE	2	11	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
51	5	1	Tit For Tat	FALSE	0	17	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
52	3	3	All D	FALSE	0	9	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
53	5	2	Tit For Tat	FALSE	0	11	3	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
54	5	2	Tit For Tat	FALSE	0	11	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
55	3	0	Tit For Tat	FALSE	0	11	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
56	4	2	Tit For Tat	FALSE	0	11	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
57	5	2	Tit For Tat	FALSE	0	11	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
58	4	0	Tit For Tat	FALSE	0	11	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
59	5	0	Tit For Tat	FALSE	0	11	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
60	4	3	All D	FALSE	0	9	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
61	4	3	All D	FALSE	0	9	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
62	4	1	Tit For Tat	FALSE	0	17	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
63	5	3	All D	FALSE	0	9	4	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
64	5	1	Tit For Tat	FALSE	0	17	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
65	4	0	Tit For Tat	FALSE	0	11	3	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
66	5	3	All D	FALSE	0	9	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
67	2	1	Tit For Tat	FALSE	0	17	3	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
68	5	0	Tit For Tat	FALSE	0	11	3	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
69	3	0	Tit For Tat	TRUE	2	13	2	Tit For Tat	TRUE	2	13	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
70	3	1	Tit For Tat	FALSE	0	17	3	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
71	4	1	Tit For Tat	FALSE	0	17	3	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
72	5	4	All D	FALSE	0	9	5	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
73	5	1	Tit For Tat	FALSE	0	17	3	All D	FALSE	0	9	Mutual_Defection	0	0	0	0	0	0	0	0	0	0	0	0
74	4	0	Tit For Tat	TRUE	2	15	2	Tit For Tat	TRUE	2	15	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
75	5	0	Tit For Tat	TRUE	2	17	2	Tit For Tat	TRUE	2	17	Mutual_Cooperation	1	1	0	0	0	0	0	0	0	2	2	2
													24	15										

Agent Roster:

0	Tit For Tat	SC
1	Tit For Tat	SC
2	Tit For Tat	SC
3	All D	SC
4	All D	SC
5	All D	SC

Abstract of results

Player	strategy	Payoff	
		Total	Avg.
MC	All D	48	1,60
0	TFT	17	0,57
1	TFT	17	0,57
2	TFT	17	0,57
3	All D	9	0,30
4	All D	9	0,30
5	All D	9	0,30