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Effects of Innovative Contracts into the Supply Chain performance in the Peruvian Construction Industry

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ABSTRACT

In today's business world, companies are forced to work in a very competitive environment. One way to succeed in this environment is the management of the supply chain. Therefore, Supply chain Management's techniques offer new approaches for companies looking to maintain their competitive advantages. This techniques demand trust, information sharing and coordination.

Contracts are important means of coordination between actors operating in the same supply chain. An adequate design of a contract can improve the supply chain performance and its study is advocated by many academics.

Construction is a particular industry in which the introduction of innovative management techniques has been slower. As a conclusion, relatively little is known about construction supply-chain management. However, the application of Supply Chain Management Techniques is expected to have an important impact in this industry, increasing the performance of the design, plan, and managing of construction projects.

This study presents an evaluation of the effects observed in the supply chain performance when non-traditional contracts are applied to the Construction Industry, specifically in the interface between the Main Contractor and the Concrete Supplier. This new approach is based on the Supply Chain Management methodology and the recommendations of the Supply Chain Council. The approach is presented in a case study with a comparison between two large construction projects with the same Client, one using this approach and one without, identifying the effects observed in the projects as a result of the implementation of this contract, and the gaps that should be managed in order to maximize the benefits that this type of contracts may have in the Construction Industry in a specially complex project as the one described.

Finally, the thesis project recommends some future needs in the Construction Industry, in order to plot a new theoretical base that allows the introduction of more and more contracts that consider the collaboration among the different actors as a mean for improving the competitive advantage of the supply chain against others in the same industry.

Keywords: Supply chain management; Innovative Contracts; Contractor; Supplier; Ready-mix concrete

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1. INTRODUCTION

Peru has been experiencing a sustained growing since the 90's, which is the result of the increase of economical incomes in most homes, bigger public and private investments and improvements in the financing in acquiring public housing (Econoblog, Enrique Huerta). The Construction industry is, after Mining, the most dynamic sector in the Peruvian economic expansion, growing yearly in rates over 10%. Nevertheless, the Peruvian companies have to adapt in order to continue to grow at such rates and facing the changing environment in which it finds itself.

Construction has always been a particular industry. Some of its characteristics have made the introduction of innovative management philosophies to flow slower than in other industries. However, more and more construction companies have recognized the potential benefits of some management philosophies such as Supply Chain Management (SCM).

The expectation in supply-chain management comes from its system perspective on production activities. Such perspective allows improved understanding of firms' production costs and capabilities (particularly under the uncertain and changing conditions that characterize modern construction sites) (O'Brien, 1998). In order to adapt to the changing conditions in modern construction, we should look for coordination among the different parties involved in a supply-chain. One of the tools used to make such coordination is contracts. Well-designed contracts can incentive the improvement of the supply-chain performance considering partnering and information sharing as crucial aspects for this improvement.

Academic and manufacturing commentators have recognized the positive impact that closer working relationships with suppliers can have on a product's quality (Womack and Jones, 10) whilst construction industry academics advocate the use of partnering to improve relationships (Egan, 178). However, most work undertaken in construction partnering has been main contractor (MC)-client based. Little has been mentioned about MC-supplier partnering, which represents an important opportunity for improvement. This study addresses this type of partnerships using innovative contracts as a strong tool to improve coordination between parties. These contracts do not look for one party's benefit, but that of the whole supply chain benefit. The context in which we want to apply this tool is within

the Peruvian construction industry, a constantly growing market that suffers from big gaps in applying progressive management theories.

After conducting an extensive literature review and evaluating the findings in the two case studies, it will be able to establish which were the effects of the introduction of these types of contracts in the construction industry, in particular in the Peruvian market. Also, we will suggest future study fields in order to increase the scant investigation made on this subject and the next steps in the implementation of supply-chain policies in Construction Companies.

2. LITERATURE REVIEW

In today's global business environment, satisfying the needs of customers with the best prices has become a crucial aim for companies to strive for. As competition among companies has been increasing, it is necessary to introduce new solutions for old problems. The introduction of new tools and techniques has been advocated for this purpose in many industries and specifically in the construction industry. One especially interesting methodology in such efforts is the Supply Chain Management (SCM). Contract design is an innovative tool used within SCM and it is the focus of this study. To have a deeper understanding of both, the literature review is divided in six sections. The first three give the definition of SCM, coordination within a Supply Chain (SC) and introduce the SCM practices in the Construction industry, showing some past studies about the effects of SCM on Construction and explaining the effect of partnering in SC performance. The following sections of the literature review are focused in The Construction Industry market in Peru, the use of contract within an SC and particularly in the Construction Industry.

2.1 Supply Chain Management

Many theories have been introduced in order to improve companies' performance. According to Akintoye et al. in recent times, the theory of purchasing and supplying operations has been widely studied under a variety of working conditions and for a number of reasons. Each of these focuses on different operations within an organization but SCM is the single most wide-ranging approach in its range of study in considering how firms utilize their suppliers' processes, technology, and capability to enhance competitive advantage (Akintoye et al., 160).

Quoting Christopher, Akintoye defined SCM as the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate customer (Akintoye et al., 160).

According to Kopczak and Johnson (Kopczak and Johnson, 2) "the term SCM conveys the idea of looking at the supply issue at the multi-company level (...) SCM is far more than just

order fulfillment. It encompasses all the processes from product generation through end-of-life recycling and disposal".

SCM has also been defined as the "design, planning, execution, control and monitoring of supply chain activities with the objective of creating net value, building a competitive infrastructure, leveraging worldwide logistics, synchronizing supply with demand and measuring performance globally" (APICS Dictionary).

The Council of supply chain Management professionals (CSCMP) defines SCM as "an integrating function with primary responsibility for linking major business functions and business processes within and across companies into a cohesive and high-performing business model. It includes all of the logistics management activities noted above, as well as manufacturing processes and activities with and across marketing, sales, product design, finance, and information technology" (Council of supply chain management professionals).

SCM encompasses the entire supply, rather than just the next part or level, and aims to increase transparency and alignment of the supply chain's coordination and configuration, regardless of functional or corporate boundaries (Cooper and Ellram, 15). This concept can be seen in Figure 1. The basic idea of SCM is to recognize the interdependency in the supply chain, and thereby improve its configuration and control based on such factors as integration of business processes (Vrijhoef and Koskela, 170).

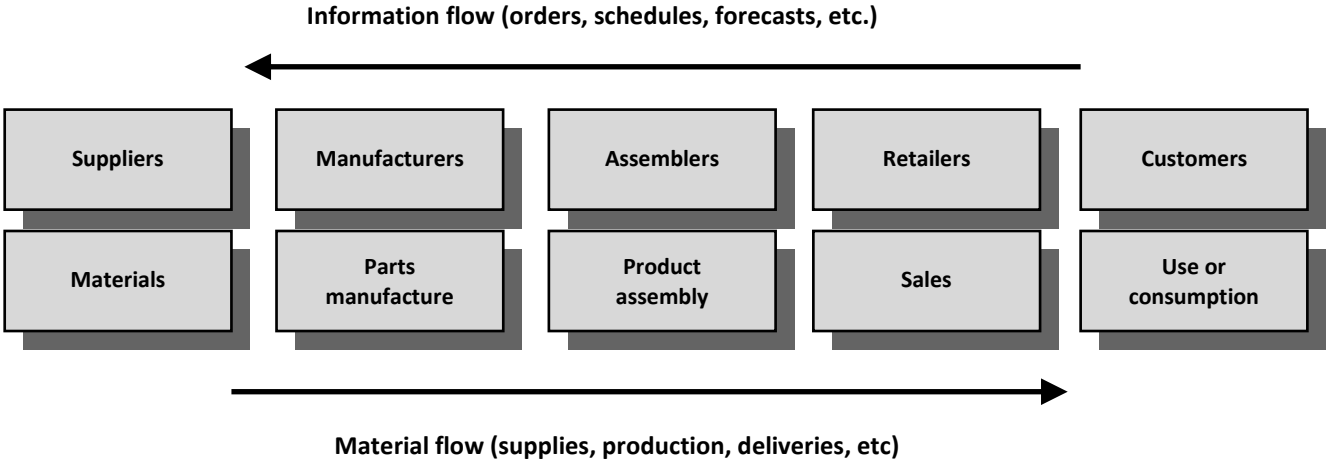

Fig. 2.1 Generic configuration of a supply chain in manufacturing

SCM is a concept originated in the manufacturing industry where the Just in time (JIT) system in Toyota was the first visible sign of it. After its emergence in the Japanese automotive industry, the concept of SCM has evolved throughout the years, resulting in an

independent management theory. According to some authors (Cooper and Ellram, 16), the shift from traditional ways of managing the supply chain towards SCM includes particular elements, as we can see in Table 1.

Characteristic differences between traditional ways of managing the supply chain and SCM		
Element	**Traditional management**	**Supply chain management**
Inventory management approach	Independent efforts	Joint reduction of channel inventories
Total cost approach	Minimize firm costs	Channel-wide cost efficiencies
Time horizon	Short term	Long term
Amount of information sharing and monitoring	Limited to needs of current transaction	As required for planning and monitoring processes
Amount of co-ordination of multiple levels in the channel	Single contact for the transaction between channel pairs	Multiple contacts between levels in firms and levels of channel
Joint planning	Transaction-based	Ongoing
Compatibility of corporate philosophies	Not relevant	Compatibility at least for key relationships
Breadth of supplier base	Large to increase competition and spread risks	Small to increase co-ordination
Channel leadership	Not needed	Needed for co-ordination focus
Amount of sharing risks and rewards	Each treated separately	Risks and rewards over the long term
Speed of operations, information and inventory levels	"Warehouse" orientation (storage, safety stock) interrupted by barriers to flows; localized to channel pairs	"Distribution centre" orientation (inventory velocity) interconnecting flows; JIT, quick response across the channel

Table 2.1 Differences between traditional ways of managing the Supply Chain and Supply Chain Management

There are some strategies for SCM including establishing permanent partnerships, evolution of the supply chain with the product life cycle, and information acquisition and sharing (Lin and Shaw, 211). Therefore, SCM is no longer taking place inside single companies but along a SC. In fact, according to some academics, the competition in business world is no longer taking place among single companies, but among supply chains (Christopher, 28). Hence, aligning companies' objectives becomes essential to improve supply chain performances and competitiveness.

How SCM has shifted business focus?

According to Kopczak et al. (Kopczak and Johnson, 4) SCM has resulted in six major shifts in business focus. Those shifts can be seen as following:

- Shift 1: From Cross-Functional Integration to Cross-Enterprise

Companies have shifted from integrating within their companies to integrating across companies as a way to coordinate and improve supply. Cross-companies have taken many forms such as the JIT in the automotive companies or the Vendor-Management Inventory programs in Wal-Mart and Dell Computer.

- Shift 2: From Physical Efficiency to Market Mediation

Companies that excel at SCM effectively manage two aspects of supply. The first is physical supply: the production and distribution of physical goods through suppliers, manufacturers, distributors and resellers to end customers. The second is market mediation: the matching of the quantity and variety of product supplied through the chain to that which is demanded.

- Shift 3: From Supply focus to Demand focus

While companies have continued to work on improving their supply processes, they also have renewed their efforts at demand management. Under SCM, operations people have been challenged to quantify better the impact of poorly understood and poorly managed demand on SC performance on sales (Bullwhip effect).

- Shift 4: From Single-Company Product Design to Collaborative, Concurrent Product, Process and Supply-Chain Design

In the early 1990s, companies began to recognize the influence that product design has on defining the supply chain and its performance. That understanding has led product designers to consider SCM issues during the early phases of product development. At the same time, companies have increased SC collaboration, the better to incorporate their partners' perspective into product design. The new approach to product design is termed *design for SCM.*

- Shift 5: From Cost Reduction to Breakthrough Business Models

The biggest successes in SCM are companies that have combined new and innovative SC's with new market approaches. Often the business breakthrough occurs in the following way: The company and chain focus initially on reducing cost. At some point, however, they discover that there is a bigger opportunity related to addressing a market need. They may

conceive of a different way to go to market that drives them to implement a new SC that, together with the new go-to-market strategy, creates better value for the customer, achieving superior financial results.

- Shift 6: From Mass-Market Supply to Tailored Offerings

Breakthroughs in information technology have made it possible to communicate with, understand and provide tailored service to individual customers or segments on an ongoing basis as means to increase loyalty, revenues and profits.

2.2 Coordination in Supply Chain Management

Supply chain coordination has become a critical success factor for SCM and effectively improving the performance of organizations in various industries. Coordination refers to the integration of different parts of an organization or different organizations in SC to accomplish a collective sect of tasks and to achieve mutual benefits (Xue et al., 413).

Coordination is "managing the dependencies between activities" (Malone and Crowston, 113). According to Xue et al., Wong et al. defined it as a mutually beneficial and well-defined relationship entered into by two or more organizations to achieve common goals. It also refers to the integration of different parts of an organization, or different organizations, in supply chain to accomplish a collective set of tasks and to achieve mutual benefits (Xue et al., 414).

The reason for uncertainties is that perfect information about the system cannot be secured. While every single member has perfect information about itself, uncertainties arise due to a lack of perfect information about other members. To reduce uncertainties, the supply chain member should obtain more information about other members. If the members are willing to share information and coordinate among each other, each of them will have more information about the rest. Therefore, the whole system's performance will be improved because each member can gain improvement from information sharing (Yu et al., 115).

However, we can see that worldwide in general, and in the Peruvian market in particular, SC partners still do not coordinate and do not share a common vision of the same situation. For

a number of firms, the cost evaluation is the best way to manage the SC. Consequently, according to Spekman et al. (Spekman et al., 635) a number of firms are sacrificing cost effectiveness, revenue enhancement, and customer satisfaction because they are unable to work effectively across the firms that comprise their SCs.

2.3 Supply Chain Management in Construction

2.3.1 Characteristics of Construction Supply Chains

In terms of structure and function, the construction supply chain is characterized by the following elements (Vrijhoef and Koskela, 171):

- It is a converging supply chain directing all materials to the construction site where the object is assembled from incoming materials. The "construction factory" is set up around the single product, in contrast to manufacturing systems where multiple products pass through the factory, and are distributed to many customers.
- It is, apart from rare exceptions, a temporary supply chain producing one-off construction projects through repeated reconfiguration of project organizations. As a result, the construction supply chain is typified by instability, fragmentation, and especially by the separation between the design and the construction of the built object.
- It is a typical make-to-order supply chain, with every project creating a new product or prototype. There is little repetition, again with minor exceptions. The process can be very similar, however, for projects of a particular kind (for example public housing).

2.3.2 Introducing the four roles of Supply Chain Management in Construction

The characteristics discussed above also have an impact on the management of supply chains. Four major roles of SCM in construction can be recognized, dependent on whether the focus is on the supply chain, the construction site, or both as it is shown in the figure 2.2.

In the first case, the focus may be on the impact of the SC on site activities. The objective is to reduce costs and duration of site activities. Here, the primary consideration is to ensure

dependable materials and labor flows to the site to avoid disruption to the workflow. This may be achieved by simply focusing on the relationship between the site and direct suppliers. The contractor, whose main interest is in site activities, is in the best position to adopt this focus. Improving measures in this role are focused in the field of logistics and should not be stressed only in cost considerations.

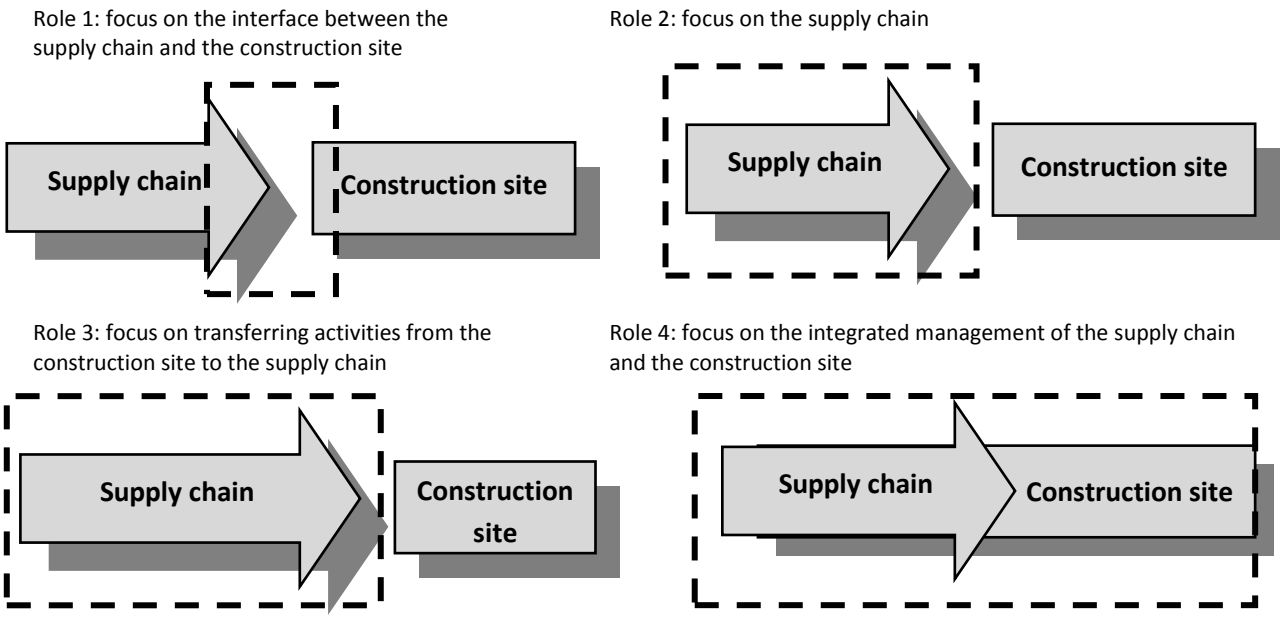

Figure 2.2 The four roles of supply chain management in construction (Vrijhoef and Koskela, 2000)

In the second case, the focus may be on the SC itself, with the goal of reducing costs, especially those relating to logistic management, lead-time and inventory. Material and component suppliers may also adopt this focus. When developing the SC, the trade-off between transportation, inventory and production costs should be kept in mind in order to achieve global improvement.

In the third case, the focus may be on transferring activities from the site to earlier stages of the SC. This rationale may simply be to achieve wider concurrency between activities, but this is not possible with site construction with its many technical dependencies. The target again is the reduction of the total cost and duration. Suppliers or contractors may initiate this focus.

In the fourth case, the focus may be on the integrated management and improvement of the supply chain and the site production. Thus, site production is included into SCM. Clients, suppliers or contractors may start this focus. We advocate for the use of this perspective.

Obviously the cases identified previously are not mutually exclusive, but are often used jointly. There could be a fifth important role namely managing the construction supply chain by facility, or real estate owners. They may well drive the management and development of the construction supply chain on which they are reliant for the continuation of their business.

2.3.3 Problems in Construction Supply Chain (CSC)

Although there have been many changes in the construction industry as a result of the development of technology and culture over the decades, CSCs do not seem to have changed much. Many problems still exist in CSC. According to O'Brien et al. the major problems are originated at the interfaces of different participants or stages involved in the CSC as shown in Figure 2.3.

Love et al. (Love et al., 427) noted the highly fragmented characteristics of the construction industry. For example, the separation of design and construction, lack of coordination and integration between various functional disciplines, poor communication, Etc., are the important impact factors causing performance-related problems, such as low productivity, cost and time overrun, conflicts, and disputes.

Palaneeswaran et al. (Palaneeswaran et al., 191) revealed the weak links in CSC as follows:

1. Adversarial relationships between clients and contractors (and between contractors and suppliers and subcontractors);
2. Inadequate recognition of the sharing of risks and benefits;
3. Fragmented approaches;
4. Narrow minded "win/lose" attitudes and short-term focus;
5. Power domination and frequent contractual non-commitments, resulting in adverse performance track records with poor quality, conflicts, disputes, and claims;
6. Prime focus on bid prices (with inadequate focus on life-cycle costs and ultimate value);

7. Less transparency coupled with inadequate information exchanges and limited communications;
8. Minimal or no direct interaction that foster sustainable long-term relationships.

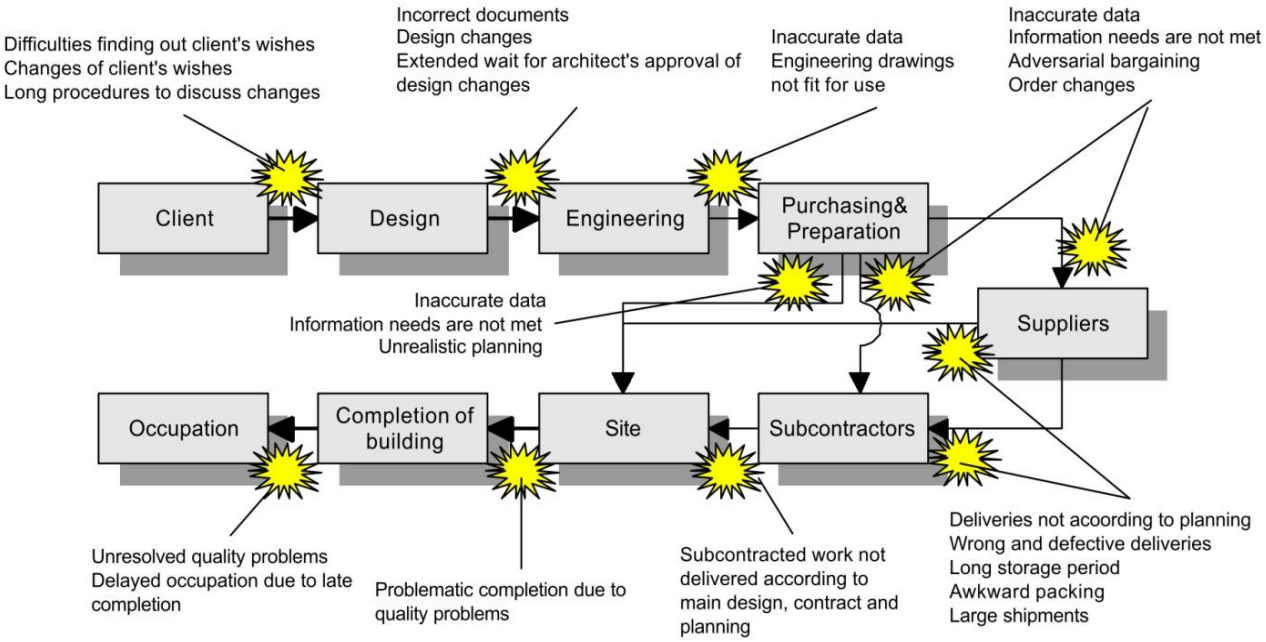

Figure 2.3 Problems in CSC (Vrijhoef et al., 186)

Realizing the perils of those approaches, several construction industry reforms were recommended and incorporated e.g. Latham, Chiang et al., and so on. These reports advocate restructuring and/or re-engineering the contracting and supplier-contractor-selection practices. In fact, formal contractual arrangements co-existing with non-legalistic mechanisms are said to be important in the current construction industry as means to overcome adversarial relationships between buyers and sellers (e.g. partnering and alliancing).

Long-term relationships not only improve cost and time performance, but also reduce conflict and claims. According to Palaneeswaran et al. (Palaneeswaran et al., 194), "Japanese organizations (as business partners) are strongly bound by keiretsu arrangements. The key characteristics of keiretsu are a) cross-holdings of shares and other assets (such as patents); b) multifirm production network; c) long-term relational contracting histories; d) joint R&D efforts; and e) exchange of skilled staff. These contracts with the fragmented nature, volatility and adversarial relationships among organizations are common in many western and other societies".

Palaneeswaran et al. (Palaneeswaran et al., 197) stated which would be the direction to overcome the CSC weak links. Some steps into this direction could be:

- Integration of concept design development and construction/maintenance with pre-selecting contractors and involving them from conception.
- Mostly two-way communications with plenty of opinion exchanges.
- Risk sharing, joint risk management
- Shared accountability responsibility
- Conflicts are sorted out in their initial stages. Constructive conflicts are give due significance by introducing amendments and changes (with renegotiations -if necessary). Destructive disputes are avoided with trusting relationships.
- Best value-based contractor selections, open and fair competition, transparent selection process, long-term qualifications, incentive arrangements with appropriate measuring scales.
- Integrity, flexibility, and less formal or informal attitude.
- Focus on value-chain aiming for long-term benefits.
- Influential, cooperative, integral and trusting.
- Performance should be as defined in the contract; potentials for performance beyond the contract.
- Performance track records given due significance (e.g. incentives and additional contracting opportunities).

The reinforcement of weak supply chain links to achieve harmonious operational equilibrium could be achieved through the strengthening of relational bonds. Some potential benefits of supply chain integration through reinforced relationships are:

- Reduced adversarial friction, fewer operational barriers and more productive co-operative efforts
- Less wastage of resource on procedures (e.g. additional checks/inspections) that do not add value
- Increased functional efficiencies through enhanced synergy and improved commitments by all parties involved.
- More efficient and effective responses for changes through improved relationships.

- Lower production and transactional costs.
- Reduced conflicts, disputes, and claims
- Enhanced performance and product quality.
- Increased competitiveness, profitability and harmony.

However, some potential "pitfalls" of excessive reliance on relationships to deliver the desired results are:

- "Good" relationships may lead to complacency and inefficiencies and could, thus, become "too cozy".
- Some accountability matters may be overlooked and the contractor may become complacent or may try to mislead/manipulate.
- Competition-driven efficiencies may not emerge.

It is expected that with the inclusion of innovative and collaborative contracts in construction, some of these problem will be directly addressed. O'Brien (O'Brien, 2) already stated in his study about the Durand Centre Case that the fragmented approaches in construction can lead to lose some improvement possibility. In this particular case the fact that contractor and owner did not share the same approach to the resource availability problem lead to loosing possible savings up to 70,000 pounds. This may be explained by the fact that the delay to steel fabrication was only addressed by the contractor with null participation from the owner and subcontractors and suppliers. We think that an integrated approach to this problem would have allowed a direct search of alternatives to find optimal responses to these changes. In the same study, implementing contracts that specify a more equal mechanism for paying for true cost of change would enhance trust and information sharing among firms, fostering long-term relationships.

Soosay (Soosay et al., 165) stated that the only way to overcome adversarial relationships between clients and contractors is to treat the supply chain as a single organization to break down barriers that hamper inter-organizational learning and innovation. Also, in that study Soosay (Soosay et al., 167) concluded that sharing knowledge and information leads to cost and service efficiency and better quality management. We believe that these processes of

information sharing can be included as part of a contract dealing with limited communication among the parties.

Akintoye (Akintoye et al., 162) studied the relationships between contractors and their suppliers and clients in the UK. In this study, 65% of the contractors have some form of collaboration/partnership agreement with one or more of their suppliers. Of these contractors 54% (35% from the total sample) held a contractual agreement. These low percentages reflect the persistence of adversarial relationship between contractors and suppliers that are, most of the times, originated by a lack of top management commitment with SCM policies. In order to deal with this problem it is suggested that "effective construction SCM calls for education and for a re-orientation of the industry" (Akintoye et al., 164).

Latham Report (Labor Government in Parliament) had recommended that separate parties in construction should work together in order to produce better work, higher productivity and a higher level of efficiency. According to Akintoye (Akintoye et al., 161), "Industry has been always dominated by competitive tendering and it is difficult to change people's attitude". This focus crash against the industry necessity of orienting cost evaluations to life-cycle costs and ultimate value.

A conceptual framework for integrated construction supply chain is recommended (Palaneeswaran et al., 200) in the next scheme:

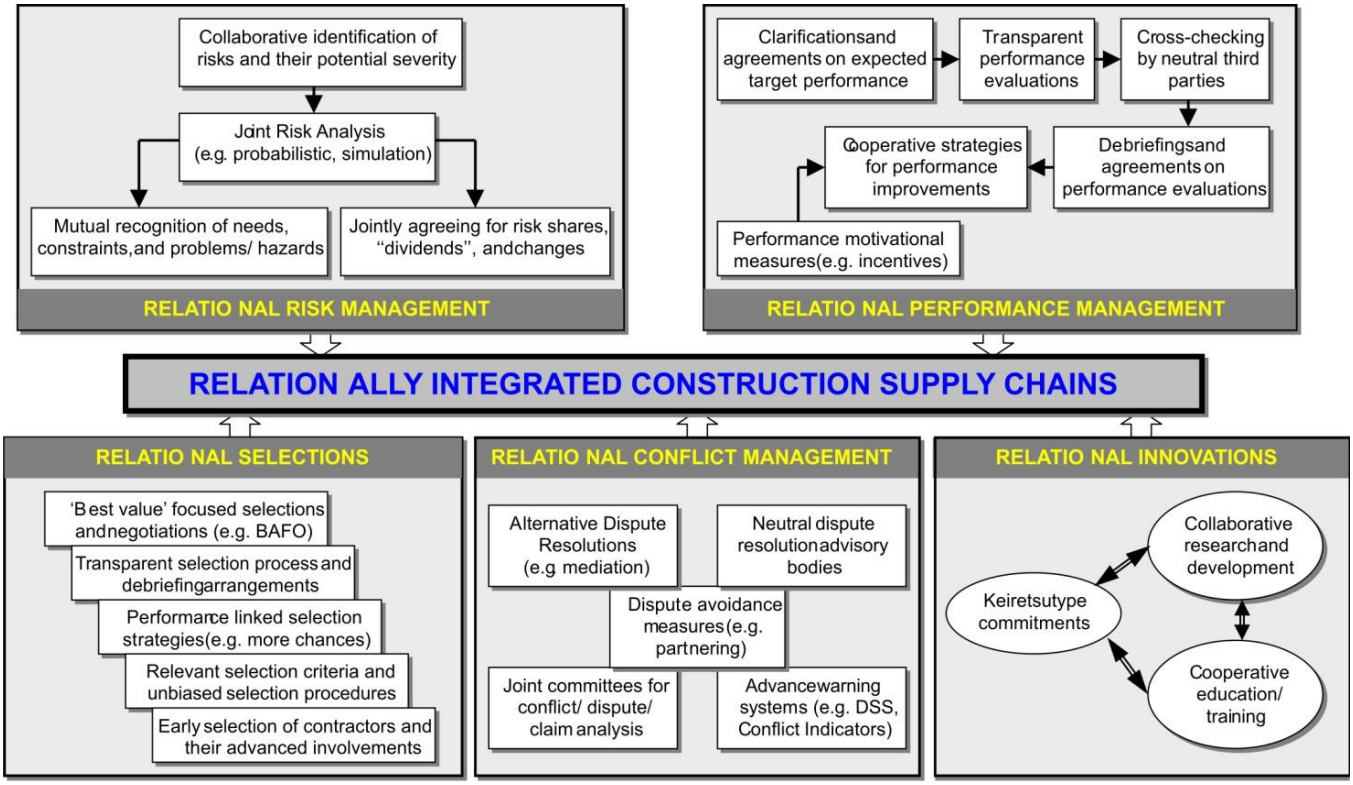

Figure 2.4 Conceptual framework for "relationally" integrated construction supply chains.

Based on the above, the present "relational integration" model is conceptualized to reinforce the "identified" weak links of CSC in the five "key" domains of:

a. Risk management: The relational risk management domain includes collaborative identification of risks, joint risk analysis, mutual recognition of needs/constraints/problems/hazards, and joint agreements on risk sharing/"dividends"/changes. Fully "committed" involvement from all the stakeholders (e.g. clients and contractors, financing bodies, consumers) -even from the project conceptualization stage- is useful for these reinforcements.
b. Contractor selection: Relational selection includes early selection of contractors, performance linked selection strategies, and best value focused selections and "structured" negotiation strategies (such as best and final offer). Well-structured, standardized and repeatable selection procedures that are unbiased and transparent are essential for these reinforcements.
c. Performance management: The relational performance management domain involves clear demarcation of target performance and agreements for performance,

unbiased and transparent performance evaluations including cross-checking by neutral third parties, and cooperative strategies for performance boosting.

d. Innovations: Relational innovations include collaborative research and developments, cooperative education and training arrangements, and "keiretsu" type business commitments.
e. Conflict management: Relational conflicts management reinforcements are considered to incorporate the establishment of "advance warning" systems and Decision Support Systems (DSS) for conflicts/claims/disputes (e.g. expert systems), joint committees for conflict/dispute/claim analysis, neutral dispute advisory bodies (e.g. Dispute Resolution Advisor, Dispute Review Board), dispute avoidance measures and alternative dispute resolution methods.

2.4 Construction Industry and Supply Chain Management in Peru

2.4.1 Historic Perspective

According to Ghio (Ghio, 25), competitiveness in Peruvian construction companies has suffered impacts through the years. In the 80's it was more profitable investing in being more competitive through contacts management, exchange rate management, Etc. Consequently, it generated a severe deterioration in the actual competitive level of Peruvian construction companies.

In the 90's, another scheme of competitiveness appeared. Many construction companies could not adapt to the new market conditions and disappeared. Others started a search of more efficiency with different levels of depth and results so far. However, in the later 90's another crisis struck Peru again and generated more changes in the competitiveness of the Peruvian market.

In the earlier 2000s Peruvian construction companies started to face this new crisis looking for systems that may improve competitiveness seeking more productivity and efficiency and from then, companies started the introduction of different innovative management theories such as Lean Construction, Supply Chain Management, and Just in Time.

2.4.2 Economic perspective

Peru faces, since the end of the last decade of the 20th century, a steady growth in the construction sector, mainly due to rising household incomes, higher public and private investment, both directly related with the economic growth and improved mortgages conditions for acquisition of public housing. Furthermore, large numbers of housing projects, mainly for low and lower middle class, have thrived because of the performance of popular housing programs such as "Techo Propio" and "Mi Casa" (Altamirano).

For the previous reasons, construction growth rates have been steadily over the 10%. Peruvian construction industry has expanded 15 percent in the second quarter of 2013, in respect to the previous year (Bloomberg News).

According to Fernando Ibárcena, the vice president of the Peruvian Construction Chamber (Capeco because of its initials in Spanish), the sector continues to see a strong demand, maintaining its dynamism and experimenting a greater demand for real-estate in general, shopping center, hotels and others, as much in Lima as in the provinces (Peruvian Times).

However, in order to maintain this positive trend, the construction industry in Peru needs to accomplish some basic goals in the following years:

- Increasing efficiency: Cost optimization and supply chain efficiency are two important means for companies to maintain competitive advantage without losing profitability.
- Mitigating issues: Usually, Peruvian companies do not focus on the risk management of their projects. A proper approach makes it possible for companies to be better prepared against the inherent uncertainty of construction projects and ensure the desired profit.
- Personnel qualification and management commitment: Construction companies' personnel in Peru lack adequate knowledge about the most modern management theories or do not incorporate them into their daily work because senior management is not aligned with these policies. Therefore, there is an important gap to be covered in the following years in this matter.

SCM responds to all the mentioned challenges above and it is a promise of performance improvement not only in the Construction Industry but in all the Peruvian market.

2.4.3 Industry main characteristics

The industry is very much fragmented and often criticized for poor performance. There are several possible reasons that have been argued as being the most important. First, this industry is comprised of a multitude of occupations, professions and organizations (Sommerville, 289). The owner employs consultant like architects and engineers to design the project. Most of the times, the owner also employs a consultant company to represent him/her in the construction site. This consultant company is, most of the times, named "Project Management". Sometimes the Project Management Company is also in charge of conducting the tender phase and of the evaluation of the tenders received in order to determine the project main contractor.

The main contractor will employ its own subcontractors as well as other subcontractor hired by the client and managed by the Project Management. Suppliers will supply the required materials either to the main contractor or directly to the subcontractors. The contractor, architect, engineers, suppliers, subcontractors, etc. have profit as their goal; the owner has the goal of minimum costs.

Regarding the formal companies' projects we can find some common characteristics, such as:

- Most of the projects have several changes in schedule and scope, even on well-run projects.
- Resource availability and poor site conditions affect real costs and limits on subcontractors and suppliers.
- Existing methods to manage changes in schedule and scope in the Peruvian companies do not account for the costs of capacity constraints or site conditions.
- Construction contracts that penalize for problems and contract solely for specific work at specific times, delay information sharing and provide no mechanism to explore costs and capabilities in a dynamic environment.

Xue (Xue et al., 416) have identified eight key construction business processes that are implemented within the CSC across organizational boundaries. This scheme responds also to the Peruvian industry. They are: project management, client service management, supplier relationship management, demand management, order fulfillment, construction flow management, environment management, and research and development. Figure 2.5 presents a schematic view of CSC.

2.4.4 Supply Chain Management in Peru

In 2013, the Peruvian magazine Semana Económica (Semana Económica, 3) conducted a survey about SCM in Peru. This study provides information about the practices followed by the SC executives in the main commercial and industrial companies in Peru. The main conclusion is that the efficiency level in SCM is very low in comparison to other countries and that the SCM presents big improvement opportunities because there is an important group of companies that are still in the first stage of their development. Therefore, they are in a potential risk state against more modern and efficient competitors and they are vulnerable to foreign menaces.

The main findings of this survey are:

- There are important development opportunities in SCM in Peru.
- There are not enough personnel in the Peruvian companies with SC knowledge.
- Outsourcing is a challenge for both, the providers of these services and the ones who demand these services.

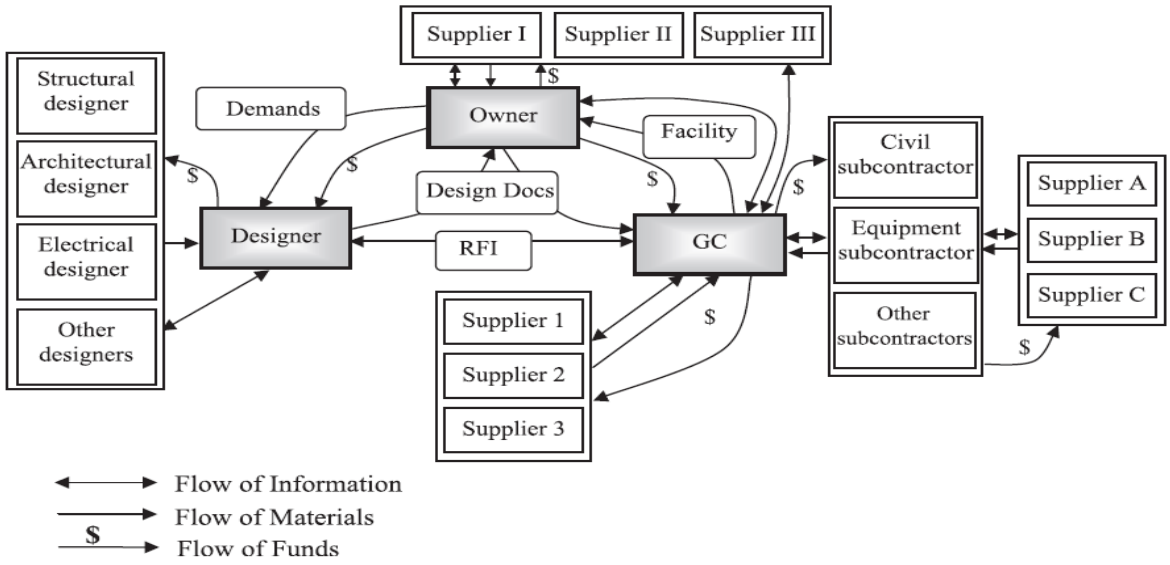

Figure 2.5 Model of Construction Supply Chain

The main challenges of SC in Peru, according to this study, are:

- To develop qualified personal through continuous training.
- To continue getting more space inside the organizations, consolidating the idea that SC is not only an operative department in a company, but also a part of the company's strategic core.
- To invest in technology, looking for new means to integrate SC's actors.
- To give more and more importance to the competition among SCs instead of competition among companies.

2.5 Contracts within a Supply Chain

According to Brun and Miragliotta (Brun and Miragliotta, 2) aligning companies' objectives becomes essential to improve supply chain performances and competitiveness. In this regard, one of the most important challenges of today's supply chains is to abandon the arm's length and adversarial approaches that have characterized SC relationships and companies' interfaces, in order to shift toward a new approach of co-operation amongst companies belonging to the same supply chain.

More recently, Lee (Lee, 1) states that the most important characteristics of a successful supply chain are agility, adaptability, and the alignment of companies' objectives. The

alignment of objectives between actors is a necessary condition to create a competitive supply chain; in the author's opinion, in order to achieve this in a supply chain, companies have to share risks, costs, and benefits of doing business together. A collaborative relationship between a supplier and its customer therefore includes:

- The alignment of competitive objectives: this means that the two actors are focused on the same Critical Success Factors and do invest on improving the operative conditions, which will, in turn, result in an improvement of their competitive strength. The most effective way to do this (Narayanan and Raman, 1) is to establish incentives able to modify the actors' behavior;
- The sharing of risks and cost of collaboration: this requires proper measures to assess the costs and risks of the supply relationship, and suitable tools to distribute them between the parties;
- The sharing of the benefits resulting from the collaboration: as before, this requires to jointly assess the benefits and to distribute them no more according to the traditional bargaining power approach, but for instance considering the amount of unhedged risks, or the value that each actor brings into the relationship.

The challenge is therefore to design some mechanisms that could help in achieve all the three targets above. Such mechanisms can be either explicit, as transfer payments between parties, or implicit, like a joint commitment on the improvement of performances. Ballou (Ballou et al., 8) states that there exists a need to share the benefits of coordination between parties, using either formal or informal mechanisms, as a fair distribution of benefits can strengthen the relationship between companies.

One of the most suitable tools to strive for a collaborative supply chain is the re-design of supply contracts (Cachon, 230; Narayanan and Raman, 1), i.e. of the contract framework that regulates the operative and economic conditions of the supply flows. The re-design of the supply contracts must be done considering possible misalignment in actors' behavior, related to the characteristics of the industry in which each actor operates and the actual needs of the customers served. Schneeweiss (Schneeweiss et al., 44) argues that two different contracts can lead to very different behaviors in a customer-supplier relationship. The authors points out that a contract must be designed in a way that anticipates the operational behavior of actors, which means that the contract should induce companies to behave in a way that is optimal for the whole supply chain.

Narayanan and Raman (Narayanan and Raman, 94) agree on the importance of objectives and incentives alignment between supply chain actors. The authors emphasize the importance of a correct design of contractual incentives between actors; the design should push towards the alignment of the SC by influencing the way payments are made between companies. In their opinion, the redesign of contractual incentives can be a really powerful tool and they are easily implemented and monitored.

There are several categories of contracts for actors' coordination within a SC. Each of them is specialized in certain characteristics of the product/service, clients, Etc. Given that the focus of this study is the relation between two actors (supplier and contractor), we will use the classification provided by Cachon and Lariviere (Cachon and Lariviere, 31) which is described below:

- **Wholesale price.** The producer sets the unit product price to be paid by the customer (for example a distributor) and it does not change. This is the classical contract, where the risk is fully held by the distributor.
- **Quantity discount.** The price for the distributor is decreasing according to the quantity of products exchanged. In this case, the distributor will have some incentives in increasing inventories in order to satisfy possible higher demand. The producer will give up part of the unit profit for higher volumes;
- **Buy back.** The distributor pays a fixed price per unit bought, but the producer has to pay a certain amount for the unsold units which can be returned. Thanks to the buyback price, the distributor will have incentives in increasing stocks, being partially protected on the total ordered quantity (the buyback price is usually lower than the full purchase price);
- **Quantity flexibility.** The distributor pays a fixed price per unit bought, but the producer has to pay back the same price for the unsold units above an agreed threshold. This is very similar to the buyback contract, but in this case the distributor is fully protected on part of the ordered quantity (above the threshold);
- **Revenue sharing.** The producer sets a fixed price for the product sold to the distributor; such price is lower than the wholesale price. A percentage of the revenues obtained by the distributor through those products' sales is then given to

the producer. Also in this case, the distributor will have an incentive in increasing its inventory;

- **Sales rebate.** The producer sets a fixed price for the product up to a specific volume. Above this volume, the distributor has a discount x for each additional unit bought. In case the distributor incurs in large stock-outs (over an agreed threshold), the distributor must pay to the producer the same amount of money x. It is a complex decision for the distributor to balance the risk of buying too many units of product and the risk of facing stock-outs to be paid back to the producer.
- **Capacity reservation.** The distributor commits to buy a number of units and the producer commits to provide them. If the final order is for a smaller than promised quantity, the distributor has to pay a fee (pay to delay) or the full price (take or pay) for the difference in quantity. If the final order is for more units than agreed, additional units will be sold at a higher price.

In addition to these typologies there are other alternatives, for example back-up agreements and advanced booking discounts, which might be considered as slight modifications of the previous ones. All these contracts, but the wholesale price, support coordination and risk and benefit sharing among two players. They are applicable when the unit marginal cost for production is lower than the unit marginal revenue; which happens quite frequently (Cachon, 2003). Another issue must be taken into account, namely the administration costs; different contract agreements present different costs to be correctly managed. The sales rebate contract, for example, is a complex and effective way of sharing stock-keeping and stock-out risks, but it requires precise and reliable information about sold volumes at the point of sale.

Considering the above mentioned contract types, it is evident that contracts are powerful coordination means. For example, a contract like the revenue sharing is able to align objectives (both suppliers and customer are struggling to maximize the final sales of the product), share risks (because the supplier offers a reduced price to incentivize the customer - e.g. a retailer - to increase the product availability) and benefits (as told by the name itself, profits are shared between customer and its suppliers).

2.6 Contracts in the Construction Industry

In most of the developed countries, there is a surprising amount of standardization in the contracts used in building constructions. As an example, we can say that The American Institute of Architects (AIA) and the Associated General Contractors (AGC) provide standard forms of contracts that are used by many buyers as general conditions for private-sector building (Bajari and Tadelis, 390). An advantage of these documents is that the central clauses are well understood in the industry, and there exists a significant body of case law on the interpretation of the contract conditions.

While there are many forms of alternative contractual arrangements used in the industry, cost-plus and fixed-price contracting appear to be the most commonly used. Fixed-price contracts in the private sector tend to be awarded through competitive bidding, while cost-plus contracts are frequently negotiated between a buyer and contractor. Occasionally there are cost incentives in cost-plus contracts that reward (or penalize) contractors for having actual costs below (or above) a cost target that is set at the start of the contract. Cost-incentive contracts are not the industry standard because of difficulties with implementing incentives in the face of changes.

A leading problem is the difficulty in establishing fair and equitable cost targets. Any changes due to design failure, buyer priorities, goals, or other factors beyond the contractor's control will require a renegotiation of incentive provisions and cost targets. As a consequence, the working relationship between the buyer and contractor can suffer. Ashley and Workman cited by Bajari and Tadelis (Bajari and Tadelis, 390) claim that, at a minimum, project engineering must be 40-60% complete to establish reasonable cost and schedule targets. In a survey of contractors and buyers, Ashley and Workman report that only 12% of the respondents use contracts with cost incentives. They also report that incentives on time-to-completion, commonly referred to as liquidated damages, appear to be more commonly used than incentives on costs.

Three kinds of conditions that allows to face contracts risks are: 1) Conditions that transfers risks to the customer, releasing the contractor ("hold harmless" treaty, hardship conditions, special risks); 2) Conditions that transfers risk to third parties, releasing the contractor or limiting his responsibility (assurance held by the owner, assurance held by the contractor); and 3) Conditions that reduce or limit risk (grace period in fine applications, understanding

fine as "precautionary payment" of the damages; maximum limit for contractual responsibility, usually not more than the profit percentage; exclusion from particular burdens coming from unforeseeable situations).

A typical set of documents in the contract includes, but is not limited to, bidding documents, general conditions of the contract, specifications, drawings, and reports of investigations of physical site conditions. The general conditions define the roles of the owner (buyer), consultants (architect(s) and engineer(s)), supplier, and contractor, describe the warranty, provide provisions for dispute resolution, outline procedures for adjusting the design and how the payment will be changed, among other provisions. The drawings are also considered a part of the contract documents. The drawings should be sufficiently clear and accurate so that if the contractor conforms to them, a well-constructed product will arise.

Additionally, the law in many countries has recognized that contractors are entitled to fair compensation for changes to the blue-prints and specifications in a fixed-price contract. Consequently, in a fixed-price contract, the MC will not be willing to perform duties beyond those to which he is contractually bound without additional compensation. Two contractual procedures are used to adjust compensation in fixed-price contracts: change orders and change directives.

A change order is a written amendment to the contract that describes additional work the contractor must undertake and the compensation he will receive (including also the calculation mechanism for it). The work and the conditions in a changer order are generally determined by negotiation between the parties. If the parties are unable to reach an agreement, in some contracts the consultant has the power to issue a change directive, which is described as a written order asking for a necessary change in the project and whose inclusion in the project is of an urgent nature. In other contracts, when there is no agreement between the parties in the negotiation, dispute resolution mechanisms are used. It is common to include clauses about it in the contracts and the more common mechanism used is the arbitration award from an expert of a renowned institution.

Usually the type of contract to be used depends on how the parties want to distribute the project risks. In all construction projects risk are inherent and according to Peckiene (Peckiene et al., 889) "the more important the role the parties play in the development and

successful completion of the project, the greater the risks they have to carry. Shifting the risk onto one of the parties to a construction contract agreement is inequitable and unreasonable". Although, studies emphasize looking for equitable risk allocation, the task of allocations of risks among parties lies in the hand of one party only (the one with bigger bargaining power, usually the project owner or buyer).

2.6.1 The Peruvian Case

In the Peruvian industry there is more and more attention to the contract design, considering the same two types of contracts already mentioned as the most used ones. The fixed-price contracts in Peru are divided in three sub-types, as follows: Lump sum, Unit price and Turn-key. In the case of cost-plus contracts, in Peru we only have the cost-plus fee contract.

The Lump sum contract is the contract in which the contractor, supplier or subcontractor is in charge of delivering a construction project (or part of it), a supply or a service, according to a well-defined scope and a fixed total amount of money. This amount of money can only be changed due to alterations in the scope or initial conditions in the project. This type of contract can be used for the overall construction projects, as well as a specific part of it, or for the provision of a material or a service. It is used mainly when the work scope, magnitude and quality are well-known and the project is reasonably defined in base of technical specifications and blue-prints.

The Unit price contract is the type in which the contractor, supplier or subcontractor is in charge of delivering a construction project (or part of it), a supply or a service, according to fixed unitary prices. These unitary prices are defined according to initial conditions or characteristics in the project and a provisional calculated quantity of work, supply or product to be delivered. Once finished the works included in the contract, the definitive amount of performed and approved works are calculated and paid according to these unitary prices. This type of contract can also be used for the total or partial project, material and/or services. It is used mainly when the work dimension is not well-known, but its characteristics are typical.

The Turn-key contract is used only for the delivery of a project (or part of it) and it is the type of contract in which the contractor or subcontractor commits himself to deliver the

project completely finished and in working condition, asking for this concept a fixed amount, paid in fixed quotas. In this type of contracts the contractor, or subcontractor, assumes possible problems or mistakes in the project and is not allowed to ask for additional sums like in the other two types of contracts. It is used when both the scope and amount of the works are well-known and there is not much uncertainty on them.

On the other hand, a cost-plus contract (also known as a cost reimbursement contract) is a contract in which a contractor is paid for all of its allowed expenses to a set limit plus additional payment to allow for a profit. This type of contract contrast with the fixed-price contract, in which the contractor is paid a negotiated amount regardless of incurred expenses. Generally, the most usual contract type in Peru is the cost plus fixed fee, in which the contracts pay a predetermined fee that was agreed upon at the time of contract formation. However, sometimes the contract cost-plus incentive fee has been used, looking for cost savings in the construction projects.

Usually, current contractual relationships are mainly based on confrontational situations that reflect the level of trust (or mistrust) in the contractual documents. This traditional scheme is always responsible to the increase of the total cost of a specific project. The risk allocation can be linked to the type of chosen contract as shown in Table 2.2.

2.7 Ready-mix concrete

Concrete is a very common construction material. Projects ranging from a single family home to a high-rise building may all need concrete for their foundation, slabs, columns, beams, walls, etc. to be constructed. In urban settings, the task of delivering concrete more often than not has been delegated to ready-mix batch plants and contractors have to rely on the timing and reliability of their service. Although this set-up puts the contractor´s project somewhat at the mercy of the batch plant, most batch plants perform at their very best to meet their customers´ schedules. On-time delivery is part of the product they sell (Tommelein and Li, 99).

The interplay between contractors and batch plants is interesting. On one hand, the contractor must order a large enough quantity, sufficiently long ahead of time to ensure available batch plant capacity and timely delivery service in order to maximize the productivity of their delivery crew. On the other hand, the batch plant tries to time its

deliveries so that all projects are served according to the contractors´ needs and the plant in a way that leaves with little idle time. This balancing act between the two parties is not always achieved due to the nature of the concrete and the nature of the production systems being used. In addition to the contracts and batch plants, this balancing act also involves the suppliers of raw materials to the batch plant, crews on site that erect formwork and tie reinforcing bars in preparation for concrete placement, as well as others (Tommelein and Li, 100).

	Risk holder		**Advantages**		**Disadvantages**	
Type of contract	**Buyer**	**Seller**	**Buyer**	**Seller**	**Buyer**	**Seller**
Fixed-price						
Lump sum		X	Early cost certainty, minimizing his risk and with more flexible financing options	High margins according to the risk. Avoid owner excessive intervention in project execution	Premium cost due to contractor's contingency and risk and limited ability to make design changes without onerous change order process	Maximum risk strategy with exposure to market demand and escalation
Unit price		X	Works can be initiated without having a finished project. Flexibility in the increasing of work volume.	There are no risks in case of increasing the work volume. Contractor may increase profits if manages resources efficiently	It is very important to define the specifications of the works to be performed, including an extensive quality control	Maximum exposure to prices and supply market risk. Probable performance problems due to delays in project blue-prints and specifications deliveries
Turn-key		X	Cost certainty. Resources can be allocated in controlling the quality of the works included	High margins with almost zero intervention of the owner in the project execution	Low power in choosing preferred subcontractors and products for the project	If the initial estimate was wrong, contractor is the only responsible for exceeding the budget.
Cost-plus						
Cost-plus fixed fee	X		Maximum flexibility on project scope and schedule	Minimal risk exposure and certainty of cost exposure with predictable revenues	Full risk exposure and lack of cost certainty (limiting financing options)	Low margin and low value-added work with competitive bidding shaving margins further

Table 2.2 Links between risk allocation and contract type. Advantages and disadvantages

2.7.1 Nature of concrete

Although batching and delivering concrete are common tasks, they are driven by many material-specific considerations (Tommelein and Li, 100):

Concrete is a perishable material: Concrete consists of coarse aggregates, fine aggregates, cement, and water, plus admixtures if specified. Aggregates, cement, and admixtures separately can be stored for long periods of time. Concrete itself, though, is a perishable material. Once water has been added to the mix of dry materials, concrete only has a mere hour and half or so (unless retarders are used) before the hydration process will form a gel that, if disrupted, would jeopardize the ultimate strength of the concrete. Hence, fresh concrete leaves little room for variability in terms of time for delivery and placement after water has been added.

Three main factors that affect the availability and distribution of concrete are:

- Concrete, is a custom specified material: Designer, usually civil/structural engineers, performing the structural calculations for a project, determines the strength and other quality requirements of the required concrete mix for concrete. They may specify a concrete mix design or performance and then leave it up to the batch plant to propose a design that meets the specifications. Different mixes may be needed in different quantities on a single project because of different uses of the concrete (e.g., shear wall vs. foundation slab) and a priming mix is needed prior to pumping. Not all projects require a uniquely designed mix, however. Standard mixes are specified for instance, by government agencies for public works, such as sidewalk and road paving. Accordingly, most batch plants have an on-line database with recipes for hundreds if not thousands of mixes that they can load to program their facility. This makes it easy not only to add new mixes or find those that meet an engineer´s requirement, but also to name them based on customer preferences.
- Availability of ingredients: While finding a suitable mix recipe may be easy, a batch plant may not stock all aggregate types of admixtures in quantity or at all (e.g. color additives). When given the project specifications, the contractor must recognize when special ingredients are needed and notify the batch plant in a timely manner so that it will have enough lead time to obtain them.

- Material type: This information can change the focus of the supply contract. There are three general types of materials in construction: made to stock (MTS), made to order (MTO), and engineered to order (ETO) as shown in the next table:

Made to Stock Commodities	Made to Order Specialties	Engineered to Order Custom-Bespoke
Suppliers make these products to stock based on projected market demand	Suppliers have standard product that are made once customer orders are received	Suppliers engineer and make these products based on customer orders. The first step in the process is engineering
Consumables (e.g. nails, fixings) PPE, Hand tools & Replacement for small tools	Concrete, Rebar	(e.g. rebar cages, MEP modules, structural steel, cladding)

- Table 2.3 General material types (Arbulu and Koerckel, 4)

For made-to-order and engineered-to-order materials (such as concrete) the approach for managing the SC should incorporate the definition, design, and implementation of material management systems to pull material through the value stream with appropriate work-in-process levels in the SC. This approach proposes pulling materials to project sites according to site demand on a just-in-time basis reducing the possibility of accumulating physical inventories on site. We will study this approach in the next chapter.

2.7.2 Concrete production system

The production system for concrete is governed by the plant operator´s equipment, the contractor´s placement method, and of course, their individual schedules as well as the coordination between them. Today´s ready-mix batch plants are fully automated and computer controlled, so ingredients can be measured and mixed on demand and in virtually no time. This makes it possible to batch one truckload at a time, and load one truck after another, with a different mix each time if required.

A plant´s batching capacity is usually larger than its delivery capacity. The batch time is on the order of a few minutes; by contrast, the cycle time for a truck, including the load time, may be on the order of 30 minutes up to an hour or two. A quick, deterministic calculation based on a 2-minute load time and 30-minute truck cycle time yields 15 trucks possibly being served by the plant; a 1-hour cycle yields 30 trucks. Because of the significant variability in cycle time, the batch plant will be idle at times when waiting for trucks to

return, while trucks will experience 'bunching' at other times when having to line up at the plant.

Trucks as well as the plant itself tie up a lot of capital; they are the fixed cost to the operator. Drivers' and operators' pay, truck operating costs, as well as materials are the variable cost. A batch plant operator will, thus, vary the actual number of drivers working on any given day and vary their work hours to meet demand (e.g., for delivery at night or on a weekend day). Delivery, therefore, tends to be the limiting capacity factor. Other factors affecting plant capacity are availability of materials and space to clean out trucks. However, in normal operating conditions, these will not govern.

The main challenge for cost-effectively and reliably batching and placing concrete lies in scheduling. At the time a contractor calls in an order to a batch plant, many unknowns remain to be revealed. How a batch plant and the contractor handle these unknowns can be the determining factor for making or losing money.

The basic characteristics of a concrete production system are (Tommelein and Lin, 101):

- Delivery capacity: Determined by the number of trucks and drivers that service the batch plant.
- Demand fluctuation: Demand for concrete fluctuates throughout the day, week and year.
- Placement size: Large placements require uninterrupted supply of concrete in order to avoid unplanned construction joints. To achieve continuity of delivery, plant and site must communicate in real time to realize when a placement is being delayed and to prevent trucks from queuing up at the site (pull mechanism).
- Total quantity order of a specific mix: Raw materials for the batch plant are typically restocked daily. Extra deliveries can be arranged if the need so dictates.
- Delivery cycle and location: Since concrete should be poured no later than ninety minutes after the addition of water, travel from the batch plant to a site should not take much more than half an hour or so. A plant's operating radius therefore tends to be limited based on the nature and condition of haul roads.
- Contractor ordering and Timing of Delivery: As noted, the contractor must plan and prepare for the arrival of the concrete. When a contractor calls for a concrete delivery, he needs to be ready to place that concrete once it arrives. However, same

day orders for delivery at a specific time can seldom be guaranteed by a plant due to limited delivery capacity. On-time delivery of concrete is essential to a contractor. If a truck arrives early, the concrete placement crew may not yet be ready. Trucks are expected to spend some time on site during off loading, but the contractor will be charged for standby time beyond a few minutes per cubic yard delivered. Worse, gelling concrete may lose its window for placement and the entire load may have to be disposed of. If a truck is late, the crew may stand around waiting.

- Accuracy in Order Quantity: Accuracy in order quantity is important. Batch plants charge contractors for everything they order. This includes, of course, the excess concrete remaining in trucks that return to the plant once a placement has been completed, but also, when no more concrete is needed, the remainder of the same-day order that gets cancelled prior to mixing. Contractors may, thus, tend to order a little less than what they actually expect to need and count on being able to get an extra truck on short notice should one be needed in the process of finishing a placement. This requires real-time communication with the batch plant and, of course, works only if a plant is willing to mobilize quickly and able to deliver such extras. The game is tricky for the contractor as concrete delay may result in difficult bonding between concrete layers. Shortage of concrete will result in unwanted construction joints that may jeopardize strength, water-tightness, appearance, or durability of the concrete.

3. METHODOLOGY OF THE STUDY

3.1 Methodology Design of the Study

According to Phuah (Phuah, 3), there are four basic steps in the definition of the methodology design of a research study:

- Research Method Election
- Problem Definition
- Theoretical framework
- Data collection methodology

3.1.1 Research Method Election

There are two main research methods: Quantitative (Collection and analysis of numerical data to describe the phenomenon of interest) and Qualitative (Collection, analysis and interpretation of comprehensive data to gain insight into a particular phenomenon of interest). We can see the main characteristics of both methods in the following table:

	Quantitative Research	**Qualitative Research**
Type of data collect	Numerical data	Non-numerical narrative and visual data
Period of data collection	Shorter period	Longer period
Research problem	Hypothesis and research procedures stated before	Research problems and methods evolve as understanding of topic deepens
Manipulation of context	Yes	No
Research procedures	Relies on statistical procedures	Relies on categorizing and organizing data into patterns to produce a descriptive, narrative synthesis
Participant interaction	Little interaction	Extensive interaction
Underlying belief	We live in a stable and predictable world that we can measure, understand and generalize about	Meaning is situated in a particular perspective or context that is different for people and groups; therefore, the world has many meanings

Table 3.1 Research methods overview

In the particular case of this study, the method is qualitative and we will look to interpreting the results of the data obtained. According to Bygrave (Bygrave, 8), a qualitative approach encourages the development of practical and theoretical understanding, as well as the generation of new and alternative theories or concepts. In this case, the data was collected from participants in their working environment using semi-structures interviews, documents

analysis and direct observation. These techniques allowed the capture of data rich in detail about the research problem, and give the researcher flexibility to explore additional issues raised by the participants.

Regarding the particular qualitative method chosen, the election was the case study from which we will get non-numerical narrative and visual data. The environment and context of the cases will not be manipulated (non experimental). The use of two cases contributes by giving more reliability to this study's findings, since with the comparison someone can establish the range of generality of a finding or explanation. Apart from their exploratory value, the cases provide a base to identify key events and actors, linking them to a causal chain, which is going to be used in the Theoretical Framework.

According to O'Brien (O'Brien, 3), qualitative studies allow the implementation of contracts that specify an equitable basis to pay for the true cost of changes, enhancing trusts and information sharing among firms. According to Vrijhoef and Koskela (Vrijhoef and Koskela, 173) the comparison of case studies results in better understandment and justification of the results achieved in an SCM research. Furthermore, case studies allow finding the root causes of the symptoms of the SCM problems. According to Eisenhardt (546), "one strength of theory building from cases is its likelihood of generating novel theory. Creative insight often arises from the juxtaposition of contradictory or paradoxical evidence".

The research procedures look to describe the "Effects of the innovative contracts into the Supply Chain performance in the Peruvian Construction Industry" and for common understandings that will emerge to give meaning to SC's actors' interaction (the main contractor and the concrete supplier). The Peruvian construction market has been chosen because of our previous experience in this market and the promises of improvements that SCM brings with itself.

3.1.2 Problem Definition

Every research project starts with the perception of a problem, meaning the existence of a void in some subject's knowledge. In our particular case, the problem is the lack of knowledge about the effects of contracts within an SC in the construction industry, specifically in the Peruvian market.

The author considers that the study of this matter is especially important because of four reasons:

- Construction Industry in general, the Peruvian one in particular, has been slower than other industries in introducing the use of innovative management methods. This initiative is even more interesting because of the importance of this project in Lima.
- Construction companies in Peru are continuously growing, but there is strong competition among them and with foreigner companies. Therefore, they need to find means to maintain competitive advantages improving their cost and quality performances, in a context where the companies have to respond to more exigent customers.
- Being a new study field, this study can provide new or future researching needs in order to complement the required knowledge in SCM in construction.
- This study can provide basis for new initiatives regarding other Peruvian construction companies, therefore, increasing the quality of their management practices.

3.1.3 Objectives and Investigation Limitations

3.1.3.1 Objectives

The main objective of this study is to ask whether SCM practices in general, and contract design in particular, have positive effects in cost and quality performance in construction projects, specifically in the Peruvian construction projects. By focusing in the interface between suppliers and contractors we pretend to gain an insight into how each one views the SC processes and practices.

There are also secondary objectives in this study, such as:

- Provide new researching needs in the application of SCM in the Peruvian Construction Industry.
- Provide basis for performance improvement plans in Construction Companies in order to maintain their competitive advantages against foreigner companies.

3.1.3.2 Limitations

Because of the lack of research in this field, this study lacks of quantitative records and models that could enrich and ground the content and the conclusions of the research. This

study is also constrained by the limited development in the contract design literature, especially in the construction industry. Furthermore, being this one of the first initiatives in this subject, there is a limited validity of the study because it is necessary to have a bigger sample to obtain richer conclusions.

3.2 Theoretical Framework

The theoretical framework is the research's part that bases theoretically the study. It is formed by the principles, hypothesis, and theories that describe the phenomena related to the problem. The framework is the result of the statements related to the research problem, caused by one or more existent theories.

3.2.1 Concepts definition

We find necessary to define some basic terms for the study:

- Supply Chain: According to BusinessDictionary.com, it is the entire network of entities, directly or indirectly interlinked and interdependent in serving the same consumer or customer. It is comprised of vendors that supply raw material, producers who convert the material into products, warehouses that store, distribution centers that deliver to the retailers and retailers who bring the product to the ultimate user. Supply chains underlie value-chains because, without them, no producer has the ability to give customers what they want, when and where they want, at the price they want. Producers compete with each other only through their supply chains, and no degree of improvement at the producer's end can make up for the deficiencies in a supply chain, which reduces the producer's ability to compete.
- Supply Chain Management: According to the CSCMP, SCM encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, SCM integrates supply and demand management within, and across, companies.
- Coordination: According to the Oxford Dictionary, it is the organization of the different elements of a complex body, or activity, so as to enable them to work together effectively. It is a cooperative effort resulting in an effective relationship.

- Contract: According to the APICS dictionary, it is an agreement between two or more competent people or companies to perform or not perform specific acts or services, or to deliver merchandise. A contract may be oral or written. A purchase order, when accepted by a supplier, becomes a contract. Acceptance may be in writing or by performance, unless the purchase order requires acceptance in writing.

3.2.2 Hypothesis formulation

A hypothesis is an assumption, a postulation in affirmative character to answer the question set by the problem. It is a tentative proposal to solve the problem, it has to be contrasted with the reality and, therefore, it has to be measurable.

In the specific case of this study the hypothesis is "the higher the coordination acknowledged by an innovative contract, the better the performance results within a SC in the Peruvian construction companies".

3.2.2.1 Variables

Variables are the aspects, characteristics or properties of a phenomenon that have the capacity of assuming different quantitative or qualitative values. The relations that these variables set will be used to formulate the hypothesis in which one variable could be independent (cause) whilst the other one will be dependent (consequence).

In the case of this study, the independent variable would be the degree of involvement of innovative contracts and SCM, and the consequence would be the resulting benefits in a construction project.

3.2.3 Elements of a Contract

Although there are significant differences in the specific wording and details, the structures of contracts used in purchasing products and services are fairly standard and have a number of common attributes. These attributes are established by a firm´s legal counsel and then are modified for different types of suppliers, products, and services. The important point to remember is that contracts establish the terms and conditions by which two parties agree to conduct business. They define the type of relationship and pave the way for ensuring that both parties come away with mutual benefits. As such, it is always better to spend more time in negotiations to ensure that the right terminology, measures and requirements are

spelled out in detail and agreed to. If both parties are clear about how they will work together, the likelihood that there will be problems is reduced significantly (Monczka et al., 501)

Following the introduction, there are several numbered sections (called “clauses”) that describe the different sets of conditions that the parties agree to follow. The following is an example of a specific contract between two companies (Monczka et al., 502):

- Definitions: This section defines all the important terms contained within the contract and is important so everyone understands exactly what each term means.
- Scope of Agreement: This section defines what is in and out of scope.
- Purchase orders: This section outlines the relationship between the agreements and any other purchase orders issued by the company to the supplier
- Supply and delivery: This clause specifies the terms for supply and delivery of the product or service. For instance, the lead times stipulated between order placement and delivery and what happens if the supplier does not deliver in time
- Specifications, quality, and health, safety, and environment: This clause describes method of manufacture and quality requirements, and may include language specific to terms of quality and charges for delivery of off-specification products or services.
- Payment: This section may specify terms that determine how or if prices will be adjusted over the course of the contract and how the payments will be done.
- Liability: This clause can sometimes be a contentious clause and generally specifies who is responsible if there are injuries or damage, over the course of the contract, and any damages to be paid. This may also include insurance requirements and sub supplier issues as they arise.
- Force majeure: This clause describes the course of events that occurs if there are unforeseen events such as earthquakes or hurricanes that prevent a supplier from fulfilling its obligations to the buyer.
- Effective date and termination: This clause states when the contract becomes effective, when it terminates, and any agreements relating to the conditions for contract extension beyond the termination date.
- Intellectual property: This clause specifies conditions regarding who owns any intellectual property that comes out of the agreement.

- Assignment and contracting: This clause stipulates whether the supplier can assign its rights described in the agreement to another party, and whether subcontracting is permissible
- Confidentiality: This clause ensures that all information, technology, and so on shared between the parties remains confidential and is not shared with other customers or suppliers.
- Statistics: This clause provides guidelines regarding what type of reporting statistics and measures the supplier must provide to the buyer on a regular basis, clearly defined.
- Key performance indicators and compensation: This clause provides specific details on how the supplier´s performance will be measured and if any compensation will be awarded by the supplier to the buyer if these defined levels of performance are not maintained.
- Notices: This clause establishes where bills, invoices, notices, and other documents should be sent, as well as the key contact person at the buying and supplying company to whom to direct all questions and issues concerning the relationship.
- Severability: This clause describes how an issue will be addressed if a portion of the agreement is void or unenforceable, and which court of law will resolve the difference.
- General: Any other general business principles.
- Governing law: This clause stipulates the court of law where any disputes will be settled. This clause may also stipulate the use of arbitration or other forms of conflict resolution.

3.2.4 Contracts within Supply Chain Management

According to APICS (American Production and Inventory Control Society), a contract is "An agreement between two or more competent persons or companies to perform, or not to perform, specific acts or services or to deliver merchandise. A contract may be oral or written. A purchase agreement, when accepted by a supplier, becomes a contract. Acceptance may be in writing or by performance, unless the purchase order requires acceptance in writing".

Furthermore, in opinion of Lariviere a contract in a supply chain is an agreement between parties to transact, imposes obligations, assigns decision rights (who is responsible for what) and includes plans for contingencies (maybe explicit in the contract or not, jurisdictionality in contracts, acceptable deviations in the contracts, etc.). He emphasizes the question of how contracts between parties affect their abilities or their incentives in order to carry out supply chain actions.

On the other hand, Shum (Shum, 3) underlines the necessity of studying the stability of coordinating contracts in supply chains. However, due to competition not all coordinating contracts are achievable. Shum claims that robust contracts are possible only when supplier (seller) and retailer (buyer) engage in long-term relationship.

3.2.5 Relational Management

According to the conceptual framework defined in the figure 2.4 (Palaneeswaran et al., 17) we can define several aspects in which we can analyze the construction supply chains in operational basis as follows

- Relational Risk Management
- Relational Performance Management
- Relational Selections
- Relational Conflict Management
- Relational Innovations

3.2.5.1 Relational Risk Management

This domain includes issues such as collaborative identification of risks, joint risk analysis, mutual recognition of needs/constraints/problems/hazards, and joint agreements on risk sharing/"dividends"/changes. Fully "committed" involvement from all stakeholders is useful for these reinforcements.

The rationale behind this domain is that as the interconnections of the enterprises in the network make them dependent on each other, it can be useful to partially share the risk management process and to develop a mutual assessment on how to manage the risks in a particular process. Consequently, risk identifications must take into account the dependencies on other organizations (Hallikas et al., 49).

According to Hallikas et al. (Hallikas et al., 50) "increased co-operation of companies in a manufacturing network causes transfer of risks between companies; it may decrease some risks and increase others". No generic and complete assessment on risks management can be given, as they are always dependent on the circumstances of each network, company, branch and economic status or cycle.

Risks of the companies are related to their objectives. The main objective of the owners is usually that the company should be profit-making. In addition, the company may have other objectives, like growth or future position, and the time range evaluated may be different for different companies. However, management of profitability is also usually needed to survive and to achieve other possible objectives. Hence, it is of the utmost importance in a Supply Chain to coordinate the objectives of the parties involved in a contract and how these objectives influence the management of risks within the SC.

In the construction industry in Peru this domain is given by the interaction among the different actors in the supply chain as showed in figure 2.5. In the particular case of the two case studies this interaction is settled between the general contractor (GC) and the concrete supplier (CS). They both recognize own and shared risks and work together in order to find solutions. This way, the GC and CS identify the productivity (understood as the amount of time used for producing a unit of production- m3 of concrete), supply quality, and timeliness as especially important and that it is risky not to control them.

As a product of the appropriate risk management, it is expected to appear benefits which should be divided in correspondence of the risk degree managed by each party within the network. This benefit issuing should incorporate an initial recognition of needs, constraints and problems. Not all the parties within the chain can manage in the same level the risks and their effects.

3.2.5.2 Relational Performance Management

Performance management begins in each party with purposes and objectives, which are expressed in the key success factors. The key success factors (KSFs) are those activities, attributes, competencies, and capabilities that are seen as critical pre-requisites for the success of organizations in their industry at a certain point of time (Thompson and Strickland).

On the basis of these factors, some key measures are taken at different levels in both organizations included in a supply chain. These measures should be linked to some target values in order to continuously evaluate the performance of companies within the supply chain. This performance assessment must be unbiased and transparent, including neutral third parties' participation.

As a consequence of these performance evaluations in the SC, some rewards (financial and/or non-financial) should be defined. These rewards can be positive (rewards) or negative (penalties). Also it is important to define cooperative strategies for performance improvements of the parties included in the SC, in order to allow both parties in the agreement to reach these rewards.

There are some basic requisites to provide trustability to the performance management within the SC. The main one is an adequate management of the information flows in the network. They are the binding agent that keeps the whole chain together. Feedback information flows are omnipresent in contemporary organizations.

In the Peruvian construction industry this performance management is related to the productivity measurement. In the case of the GC of the two case studies, he measures the productivity as the labor units by cubic meters poured in the project. He compares the output of this measurement with the initial planned amount and therefore will obtain any deviation from the initial project assumptions. In the case of the CS, he measures the productivity as the time that any concrete truck should be expected to wait before starting to pour concrete (assuming that after this starting point the pouring process will be continuous). Another possible measure of CS performance can be the calculation of the time from departing the concrete company facilities to the project and then returning back. However, as a good deal of time related to this measurement is related to the transit of the unit in the streets (which can be affected by many circumstances, from traffic jams to public demonstrations and streets works) it is a measurement not always considered to evaluate the concrete supplier productivity.

3.2.5.3 Relational Selection

Relational selection includes early selection of contractors, performance linked selection strategies, best value focused selections and "structured" negotiation strategies (such as

"best" and "final" offer). Well-structured, standardized and repeatable selection procedures that are unbiased and transparent are essential for these reinforcements.

Yang and Chen citing Choy et al. claim that selecting suppliers only on the basis of evaluators' personal experiences is neither effective nor scientific, due to the inherent risks of subjective judgment and a lack of systematic analysis (Yang and Chen, 927). Hence, it is necessary to establish a procedure that can be used to systematically integrate qualitative and quantitative criteria to evaluate and select from a list of potential suppliers.

Although the "relational" improvements in culture, trust, relations, sharing and commitments will provide supply chain reinforcements, any over-reliance on such relationships could become too "cozy" with, for example, inefficiencies and accountability matters being "swept" under a "relational carpet." Thus, relevant improvements/upgrades in the relational integration among stakeholders, as well as appropriate parallel reinforcements in more binding "bonds", such as enhancements in contractual safeguards, are also essential for the longevity and continuity of obtaining best value and benefits from relational supply chain integration (Palaneeswaran et al., 202).

Nevertheless, the ability to develop an adequate and exhaustive supplier selection is not always possible. Sometimes it can be influenced by the bargaining power of big suppliers, capacity of competitor suppliers and even political issues. In the particular case of the Peruvian concrete production sector, one player controls the 50% of the total volume of the ready-mixed concrete, and in the Lima area the same actor controls over the 85% of the market.

As we can see, we will not always have many options for the suppliers' selections but we can still enforce criteria selections to be fulfilled by the concrete suppliers. Also, we can follow negotiations conducting to best value contracts and improvement of the project output by early involvements of the suppliers in the project.

3.2.5.4 Relational Conflict Management

Conflict management is a central task for members of a network, especially when the parties in the network do not share the same objectives. Because conflict is so central to organizational groups, conflict management efficacy may contribute significantly to the SC overall performance. With low levels of conflict management efficacy, the network will be unable to perform effectively.

Relational conflicts management reinforcements are considered to establish Decision Support Systems (DSS) for conflicts/claims/disputes, joint committees for conflict/dispute, claim analysis, neutral dispute advisory bodies, dispute avoidance measures and alternative dispute resolution methods.

Protagonists of an SC should see conflicts as a mutual problem that needs common consideration and solution (Alper et al., 627). Therefore, they should work for mutually beneficial solutions, understanding that they can pursue their interests as they pursue the interests of others. These expectations lead to a full exchange of diverse ideas and perspectives that are combined into effective, mutually advantageous solutions (Alper et al., 627).

In the concrete ready-mix sector, the biggest supplier has a strong bargaining power and exerts influence in the mechanisms for solving disputes. They even include some aspects on which they do not admit claims (differences from theoretical to real volumes of poured concrete). However, they do recognize the necessity of taking it into account with neutral dispute resolution bodies. In the private contracts the preferred institution is the "Centro de Arbitraje de la Cámara de Comercio de Lima" (Lima's Commerce Chamber's Arbitrage Center). The GC also seeks to install joint committees for conflict/dispute management with some very important supplies (for example with concrete suppliers for dams and asphalt suppliers for highways) but this is not a widespread practice.

The performance of the relational conflict management in construction can be measured by the number of claims (solved and unsolved) in a project, non-conformity reports issued (depending on the quality of the supply), and even in the amount of resources outside the project used for dispute management. Unfortunately, there is not much stored data about conflict management in Peru to build a valid conclusion about the level of this dimension in the construction industry.

3.2.5.5 Relational Innovations

Relational innovations in a supply chain are defined as new (or improved) methods for governing buyer-seller interactions. Numerous aspects, such as trust, loyalty and market segmentation determine the existence of relational innovations in a supply chain. Previous studies have identified trust and commitment as critical elements in buyer-supplier relationships and alliances. Collaborative tools also transform how supply chain partners

interact with each other. Communication channels, such as the Internet have changed the way information is exchanged, but without a structured approach to collaboration it may not have the same impact on relationships as would be the case if collaborative methods were used to plan supply chain activities (Cassivi, 250).

Relational innovations are related to the mutual efforts for researching and improving their processes and products. These efforts should be directed in order to develop all the parties included in an SC. For this mutual benefit a cooperative education and training is necessary. A clear example of this type of relation is the keiretsu structure in which a group of companies are linked by economic interests. In this structure, there is a central company that helps other companies to coordinate efforts and improve their performance and afterwards split the benefits from this collaboration. It is a supply chain that improves the efficiency in the overall production processes.

In the Peruvian construction industry this dimension is not given enough value. The collaborative research and development is a common practice in many big general contractors in Europe, USA and Asia, nevertheless, this approach has not reached Peru yet. There were some isolated efforts made by two of the main Peruvian GC in the past ten years but not much has been improved on this matter since this programs started. We took part on one of this programs and this one in particular was merely an exploratory project that could not be established due to the opposition of some middle-level managers, who were reluctant to cooperate or train the suppliers because of lack of trust in alliances.

3.2.6 Mutual Benefits in a contractual relation

3.2.6.1 Benefits

According to the Merriam-Webster Encyclopedia Britannica Company, benefit is "a good or helpful result or effect". The Oxford Dictionary defines it as "an advantage or profit gained from something". In the specific case of this thesis the benefits are not only economical; they can also be intangible, such as improving relations and establishing long term relationships

According to Williamson (Williamson, 219) the foundation of relational contracting is recognition of mutual benefits and "win-win" scenarios through more cooperative

relationships between the contracting parties. Relational contracting principles underpin various approaches, providing the means to sustain and improve ongoing relations in long and complex contracts by adjusting processes that are more transaction-specific or of an ongoing administrative kind.

There has already been mentioned some potential benefits of supply chain integration such as reduced adversarial friction (with fewer operational barriers and more productive cooperative efforts), less wastage of resources on procedures that do not add value, increased functional efficiency, and so on and so forth. Also, there are some pitfalls related to the adoption of SC integration, such as "good" relationships may lead to complacency and inefficiencies and competition-driven efficiencies may not emerge, among others.

However, it is important to translate these expected benefits into operational indexes in order to make it possible to monitor their performance along the supply chain and within the companies forming the supply network.

3.2.6.2 Benefits with relational contracting practices

Authors recognize the existence of driving forces behind the change from transactional contracting practices to relational contracting practices. On the other hand, there are also restraining forces against making the desired change. Let's focus first in the driving forces.

The driving forces for such change, according to Palaneeswaran (Palaneeswaran et. al, 199) are:

- Strident calls for dramatic improvements and excellence, especially in the current convulsed worldwide market
- Value of continuous relationships which has been highlighted along this study and is claimed as a very important issue by many researchers.
- Greater satisfaction in the parties and minimizing conflicts/disputes/claims, due to the continuous mutual efforts and communication within the network.
- Improved productivity and product quality through enhanced harmony, not only for one of the parties but for all within the supply chain.
- Value for money with total value chain focus and potentials for lesser transaction costs.

- Shared risks, responsibilities and benefits with supply chain integration, overcoming shortcomings of incomplete contracts through "win-win" governance.

The restraining forces against changing to relational contracting practices are:

- Stringent procedures and lack of rules and regulations.
- Lack of direct incentives and cultural inertia.
- Difficulties in recognition and reluctance to change due to doubts/worries about the impact on competition.
- Focus on immediate/short-term benefits and fragmented project-specific objectives.
- Risk transferring and power domination attitudes.

In particular in the Peruvian construction industry the focus on the benefits of improvements in contracting practices within a Supply Chain are focused on improved productivity and shared risks, responsibilities and benefits from the supply chain. However, we believe that given the introduction of foreign companies in the Peruvian market, soon national construction companies will look for improvements, leading to excellence and more value for money translating in lesser transaction costs, making companies more competitive to face the foreign competence.

3.2.7 Benefits Measurement factors

The factors in which the benefits of supply-chain focused contracts can be measured in this study are productivity, timeliness, quality, and continuous improvement need.

3.2.7.1 Productivity

Productivity is a ratio of production output and resources input. The measure of productivity is defined as a total output per one unit of a total input. In the construction industry, the output is usually expressed in weight, length, or volume, and the input resource is usually in cost of labor or man-hours. There are many standards available in the construction industry for contractors as reference values for purposes of construction cost estimation. In fact, every medium big-sized contractor company usually takes records on its productivity measurements in the most important activities they perform.

In the construction industry, these output measurements can be difficult and complex, owing to the extreme heterogeneity of construction projects. For this reason, some

governmental institutions prefer not to publish labor productivity data, taking into account the low confidence in the reliability of the price indexes used to estimate real output.

Contracts that focus on improving the supply-chains also receive improvements in productivity by lowering uncertainty in the supply chain, varying site conditions and improving the flow of materials and information through the different stages and actors in a project.

In the Peruvian construction companies, productivity is measured in the opposite way, as the ratio of labor input to output (hh/m3, hh/Kg, hh/m2). It is important to point that productivity measures can be on-site and off-site (for example in the production of pre-cast concrete elements).

Independently of the complexity of the supply chain, variability can be expressed as the Percentage Plan Complete (PPC). This index is defined by the Lean Construction Institute as a measure of how well the planning system is working, calculated as the number of assignments completed on the day stated divided by the total number of assignments made for the day. It is believed that a high (above 90%) percentage of PPC is a sign of high productivity in projects in which there is no excess of resources used. In fact, this index is complementary to the productivity ratios, because in a project with high performance it is not only necessary to have adequate productivity ratios, but also high percentage of PPC. Only after an adequate combination of both aspects one can conclude that the project is going well in production performance basis.

3.2.7.2 Timeliness

One of the biggest risks in construction projects is not fulfilling the owners' requirements. On the contrary, most requirements and, indeed, most of the projects accomplish them. However, many construction projects lack meeting the schedules requirements. The reasons for this issue can be many, from poor activities planning practices to fortuitous events of force majeure. Most of the times, the resultant delays in the deliveries of the projects are affected by penalties according to some clauses included in the contract.

Sometimes, the delays observed in a construction project can be related to a supplier's performance. This is especially critical when the supply is specialized and, therefore, only one supplier can provide it or it requires a complicated import process. This can be observed

in the Peruvian industry when the supplies come from other countries and, previous to its arrival, the supplier's design effort before starting the production and delivering is required.

In construction projects timeliness is measured according to one main criterion: The S-Curve and the Deviations between the original Master Schedule Plan and the Actual Schedule. An S-Curve resembles the logistic function and its function is to describe the growth of a variable in terms of another variable (usually the time). In the specific case of construction projects, this curve shows the growth of executed activities in the project (measured in terms of money) along the project duration. The deviations in the measurement of this index are showed in the differences between the planned and the actual S-Curve.

In controlling the schedule, the project manager should use the schedule baseline. It is important to update the schedule baseline, as any deviation is included in the project, such as changes or delays. Calculating the deviation from the Baseline, the project manager can identify positive or negative trends, to which he can then react. An additional tool to control the project timeliness is the inclusion of benchmarks or control points related to the finalization of specific activities (such as the completion of the concrete structure in a determined floor in a building, or the start-up of a system in an electromechanical project). All these benchmarks should be included from the beginning in the project contract from the beginning of the project.

3.2.7.3 Quality

According to Hendrickson, the most important decisions regarding the quality of a completed facility are made during the design and planning stages rather than during construction. It is during these preliminary stages that component configurations, material specifications and functional performance are decided. Quality control during construction consists largely of insuring conformance to this original design and planning decisions. With the attention to conformance as the measure of quality during the construction process, the specification of quality requirements in the design and contract documentation becomes extremely important. Quality requirements should be clear and verifiable, so that all parties in the project can understand the requirements for conformance.

While conformance to existing design decisions is the primary focus of quality control, there are exceptions to this rule. First, unforeseen circumstances, incorrect design decisions or changes desired by an owner in the facility's function may require re-evaluation of design

decisions during the course of construction. While these changes may be motivated by the concern for quality, they represent occasions for re-design with all the attendant objectives and constraints. As a second case, some designs rely upon informed and appropriate decision making during the construction process itself. For example, some tunneling methods make decisions about the amount of shoring required at different locations based upon observation of soil conditions during the tunneling process. Since such decisions are based on better information concerning actual site conditions, the facility design may be more cost effective as a result.

In the construction projects in Peru, the quality of activities' output is measured according to national and international regulations. There are many institutions worldwide that provide tolerances and minimum (and maximum) specifications that must be met by a construction output. These institutions are commonly oriented to one specific field. For example ACI (American Concrete Institute) make available regulations applied to concrete design, construction, and materials; while NFPA (National Fire Protection Association) provides codes and standards to reduce the worldwide burden of fire and other hazards on the quality of life.

One of the most important quality indexes in a construction project in Peru is the result of the compression test on cylindrical specimens. The method for sampling and testing these specimens is complete detailed both in ACI standards and ASTM (American Society for Testing and Materials). To guarantee the structural safety in a project it is necessary to execute a continuous control that ensures that the quality of the concrete supplied meets the requirements defined during the design stage.

3.2.7.4 Continuous improvement

Continuous improvement (or Kaizen, in Japanese) is a long-term approach to work that systematically seeks to achieve small, incremental changes in processes in order to improve efficiency and quality. This improvement can be applied to any kind of work and it was first used in manufacturing and programming. When applying relational contracts in a supply chain, it is necessary to set performance targets. Meeting these targets in the long term implies to count with some continuous improvement practices. As a result, the overall project performance is improved and good practices appear in the daily work.

Although construction is different from manufacturing (because its products are unique) essentially repeat sub products which can be continually improved but, more importantly, the process of construction is itself repetitive in its essentials from project to project. Taking into account this repetitiveness we can tackle the study of inefficiencies, obtaining a potential for more systematized and integrated project processes in which waste in all its forms can be reduced and both quality and efficiency improved.

In the Peruvian industry, some clauses in contracts include continuous improvement clauses. We took part of a mining project in which the main contractor was asked, in the contract, to fulfill a minimum productivity measurement but along the project continuous there were some productivity targets to reach by the main contractor. However, this practice is not a common one and it is only used in some contracts.

3.2.8 Ready-mixed concrete (RMC) SC characteristics

RMC has played an important role in enhancing construction performance. However, its advantageous features are not always realized. Failure to deliver RMC on time can result in subsequent construction delays or even make delivered concrete useless, if the time threshold for concrete hardening has exceeded. On the other hand, in some cases, too many truck mixers simultaneously queue up to be unloaded on-site; this results in time being wasted, time that could have been used to serve other construction sites (Park et al., 44) .

Supplying RMC in an efficient and economical manner depends greatly on the distance between the batch plant and the construction site. At the operational level, truck mixer scheduling and raw material logistics within the batch plant are critical to ensure timely and economical supply.

RMC supply performance is also heavily influenced by factors that are under the contractor's control (e.g. concrete placing work). Park citing Smith indicates that the contractor has an even greater influence over the RMC supply process than the supplier (Park et al., 44) Moreover, Park citing Anson and Wang says that as long as smooth concrete work is ensured, contractors tend not to be as concerned about truck mixers idling on-site (Park et al., 44). As a result, RMC suppliers are faced with the challenge of supplying RMC in a timely and cost-effective manner.

In dealing with RMC productivity issues, previous studies have recognized the importance of proper truck mixer scheduling. For example, Bernold (Bernold, 178) argued that an appropriate time interval for truck mixer would ensure the desired productivity. However, empirical studies by Anson and Wang (Anson and Wang, 124) demonstrated that is difficult to supply RMC in a timely manner because of the limited number of truck mixers and unpredictable traffic conditions. Meanwhile, Wang (Wang et al., 179) considered the arrival pattern of truck mixers as the most important factor in determining RMC productivity, while Chua and Li (Chua and Li, 198) emphasized the responsiveness of RMC productivity to changes in site conditions.

It has also been noted in the literature that contractors and RMC suppliers have different perspectives on RMC delivery performance. Park expressed that Smith (Park et al., 45) focused on the cost tradeoff between the contractor and supplier and suggested reducing the arrival rate of truck mixers to minimize the supplier's operational losses.

RMC production involves the deployment of labor and plant resources, handling of raw materials that make up concrete, transportation of materials to the batch plant, and storage of materials at the plant. This study is focused on the process from the truck on standby to the unloading on the construction site and the afterwards return to the concrete plant.

According to Park (Park et al., 45) the performance of truck mixers varies, depending on the type of concrete placement methods used on-site. Before leaving the plant, each batch of delivery must go through the slump test to ensure that the ready mixed concrete has correct workability. In this study the average duration of the slump test is 2.81min. When arriving at the site, in the same study, truck mixers queue up for 20.76 min on average. The average time to unload concrete from the truck mixer is 15.91 min, ranging from 9.24min (direct pour) to 25.90 min (wheel barrow). As a result it takes an average of 88.60 min to deliver one batch of RMC. In the next table we can see the outputs on the truck mixer performance. Being the truck mixer the critical element in the ready-mixed concrete supply, it is important to show the truck mixer cycling, as we can see in figure 3.1.

When enough resources are provided to perform a job, outflow can be measured by dividing the level of the stock by the average time taken to reside in the stock. On the other hand, outflow can also be determined by the associated resource capacity or by managerial decisions.

In the same study, the simulations revealed that the mixer truck's unloading speed at the site has a significant and direct impact on the performance of RMC delivery (assuming that the concrete supplier is working flawlessly).

Type of unloading	Avg queuing time on-site (minutes)	Avg time to unload (minutes)	Avg time to return (minutes)	Avg time taken for delivery (*) (minutes)
Crane and skip	29.94	20.05	24.92	103.81
Wheel barrow	22.77	25.90	20.50	93.59
Tremie pour	12.01	9.50	24.44	74.60
Pump pour	16.96	13.85	21.67	79.72
Direct pour	12.06	9.24	24.67	74.08
All types	20.76	15.91	23.96	88.60

(*) It includes dispatching interval, time to position, time to load mix, time for slump test, time to haul, queuing time on-site, time to unload, and time to return

Table 3.2 Truck mixer performance

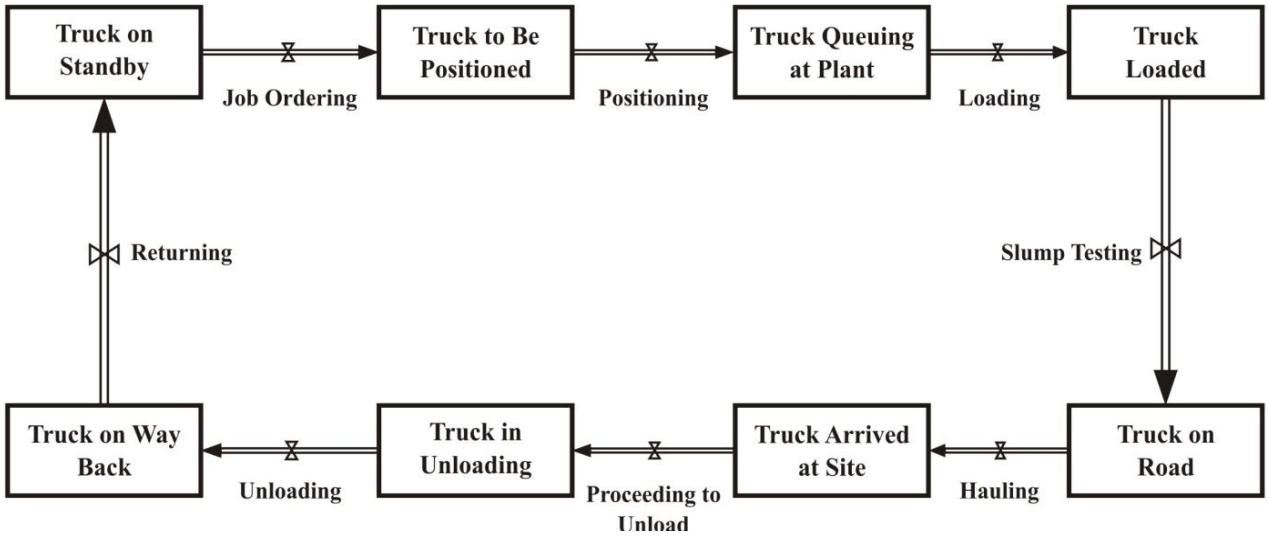

Figure 3.1 Truck mixing cycling (Park et al., 48)

3.3 Data Collection Methodology

It is the operative part of the research and answer to how we are going to investigate, how we are going to pick the data, with which instruments, etc. It is the stage in which we program the transference from the theoretical work to the practical one.

In this stage we have to establish the population from which we should gather the data. The population is the collective with which we will conduct the research, which can encompass all the elements (universe) or just a fraction of them (sample).

3.3.1 Data Collection Techniques

This section should provide a description of the procedure that we are going to conduct in order to obtain the needed information for the hypothesis verification. The conclusions validity will depend of the quality of the data obtained. We should determine the sources and techniques used in the acquisition of data (e.g. documents, direct observation, focus groups, interviews, questionnaires, Etc.). Among the techniques to be used in this study we have the documents' analysis (contracts, tenders, cost management reports, Etc.), direct observation (actors' behavior observation related to their role in the SC), SC's actors interviews (representatives of both supplier and contractor about the SC, comparing both study cases with and without innovative contracts in the project), pictures and videos, Etc.

3.3.1.1 Interviews

It is important for the research not only to know which are the requirements of the MC or the suppliers, but especially the requirements of the MC according to the supplier's view and the requirements of the supplier according to the main contractor's view. On this perspective it is better to use interviews. For the interview there will be a list of topics on which the interview will be conducted and the target will be to get the opinion, ideas, doubts and thoughts of the representatives of both companies about SC and SCM. The interviews will be individual and they will aim for senior-level participation.

A total of 13 interviews will be conducted in both companies with senior and middle managers and construction project personnel. The personnel to be interviewed can be seen in the next table 3.4.

All responses to questions will be recorded using, when possible, a recorder. Answers to questions will be then incorporated to a computer database. This database will allow answers to questions to be recorded in a systematic way that, in turn, will facilitate overall identification of those issues that were found to be most prevalent.

Firm	Organization structure	Main functions	Main products	People interviewed
Unicon	Part of a large company group	Ready-mix concrete supplying	Ready-mix concrete supply and pumping	Operations manager, Sales manager, Plant manager, Project coordinator (4)
Livit	Subsidiary of a multinational corporation	General contractor	Housing, malls, mining facilities	Project Construction Manager (1), Building Division Manager (1), Logistic Department Chief (1), CEO (1), Cost Control Chief (1), Production Engineers (4)

Table 3.4 Overview of people interviewed

3.3.1.2 Direct observation

Field notes, as a product of direct field observation, are an important means of accomplishing an overlap of data analysis with data collection. As described by Van Maanen (Van Maanen, 35), field notes are an ongoing stream-of-consciousness commentary about what is happening in the research, involving both observation and analysis preferably separated from one another.

According to Eisenhardt (Eisenhardt, 539), "one key to useful field notes is to write down whatever impressions occur, that is, to react rather to sift out what may seem important, because it is often difficult to know what will and will not be useful in the future". Additionally a second key for successful field notes is to push thinking in these notes by asking questions related to what the researcher is learning with these notes.

In this study, we will conduct observation of the concrete works in the field and the interaction between the concrete suppliers' representatives in the project and the project staff.

3.3.1.3 Documents Review and Analysis

This technique is also a powerful tool in qualitative studies. There are some advantages related to its use, such as obtaining comprehensive and historical information, less biased about information, often more reliable, and valid. Nevertheless, some cons can be linked to its use, such as data restricted to what already exists and cannot be generalized to several cases.

In this study in particular we are looking to analyze the contracts included in the case study, as well as other reports and documents generated within the SC formed by the MC and the

concrete supplier. In this way we could know which were the most valued insights in the SC for both parts.

3.3.2 Data processing

It consists in handling mathematically the data in order to reach conclusions related to the stated hypothesis. For this purpose, we should first check the information (quality control). The processing can be done manually or using informatics tools. We should analyze the data obtained comparing the hypothesis with the research results so as to confirm, or not, the validity of the hypothesis.

4. THE COMPANIES

As already mentioned, the thesis is conducted in the Peruvian Construction Market. The SC studied consists in the interaction of a major Peruvian Contractor Company, Grupo Livit S.A. (Livit), and the biggest ready-mix concrete supplier, Unicon de Concreteras S.A. (Unicon). Therefore it is necessary to describe both companies.

4.1 Grupo Livit S.A.

In 1995 in Peru, Constructores Interamericanos S.A.C. (Coinsa) is founded by the Grupo Internacional Fierro (IF). Coinsa is a construction company focused in the Real Estate and Malls and Mining Construction. IF is a Spanish group with operations related to the industrial and financial areas in Spain, United States, Central and South America. In Peru, Banco Interamericano de Finanzas (BIF) is the token investment of IF.

IF operates in Peru since 1961 with Fosforera Peruana S.A. and it involves the following firms:

- Fosforera Peruana S.A.
- Destileria Peruana S.A.C.
- Iberoamericana de Plásticos S.A.C.
- Agroinper S.A.
- Farmex S.A.
- Innova Andina S.A.
- Sensoria S.A.C.

As important milestones in Coinsa's history we can say that, in 1996, Coinsa started the construction of its first big project "Condominio Tres Marías" and, in 2010, Coinsa finished the first Peruvian building with the Green Building Certification: Platinum Plaza. In 2006, Coinsa Venezuela is founded, focused mainly on real state. In 2012 Coinsa opened an office in Colombia and finally, in 2013, looking for internationalization, Coinsa changed its name to Grupo Livit S.A., as part of its strategy to become an important player in markets such as the Colombian, Venezuelan, Costa Rican, and Guatemalan by the 2020.

4.2 Union de Concreteras S.A.

In 1996, Union de Concreteras S.A. (Unicon) is created as a result of the merger of the two main supplier of ready-mix concrete in Peru: Copresa and Hormec. In 1997, Unicon signed a strategic alliance with Synthetic Industries, world leader in the development and fabrication of polypropylene and metallic fibers. In 2000, Unicon made an alliance with MBT and opened the MBT-Unicon plant, created to produce and supply the Peruvian construction market with additives and chemicals for construction.

In 2010 Unicon, as part of its growth strategy, bought 50% of the shares of Entrepisos Lima S.A.C., a Peruvian company focused on the prefabrication of concrete structures, towards building and infrastructure. In 2011, Unicon acquired First Industries Peru S.A., the second most important ready-mix concrete supplier, reinforcing its leadership in the Peruvian market. In 2012, Unicon led the creation of the Peruvian Association of Ready-Mix Concrete Suppliers (ASPECON, Asociación de Fabricantes de Concreto Premezclado Peruano), grouping the main companies in this sector and looking for the technical improvement of concrete construction in Peru.

Unicon is part of the holding Grupo Económico UNACEM that also owns the two biggest Peruvian Cement Producers: Cementos Lima S.A. and Cemento Andino. Unicon is also part of the Green Building Council in Peru and has 9 plants in the Province of Lima and 8 plants outside Lima (http://www.unicon.com.pe/principal/categoria/acerca-de-unicon/1/c-1).

5. LOOKING FOR AN OPTIMAL SUPPLY CONTRACT

As we have seen, there commonly exists the adversarial standpoint between main contractors and their suppliers. Usually, choosing the lowest cost for each supplier is the most common practice, even though; it cannot guarantee the lowest cost for the whole value-stream. It is said that seeking for long-term relationships with supplier allows them to better customize the service to the main contractor. Having a major, long-term client may also help to reduce some other costs related to bank financing (Schniederjans, 200).

It is necessary that the contracts within a construction project look for equilibrium. This supply chain equilibrium was conceptualized by Palaneeswaran (Palaneeswaran et al., 199) by making a comparison with an analysis of forces. In this model the strength of supply chains depends on (a) the "resultants" of "push" and "pull" forces; (b) reinforcing "relational" bonding forces, and (c) "pre-stressing" contractual/non contractual motivators. Recoverable elastic deflections/deformations could occur due to stresses within acceptable limits (e.g. conflicts, warnings for bad performance) and permanent plastic deformations may result if the system is stressed beyond the yield points (e.g. unresolved disputes, and breaches of contract leading to litigation). Nevertheless, important SC deflections could be controlled within certain "permissible" limits through structured arrangements depending on the specific environment in which the SC is situated.

In the previous chapters, we stated that SC management tools and mechanisms depend strongly on the cultural diversities of the environment in which the SC is placed. Hofstede analyzed cultural diversity and their relations based on many dimensions. With these dimensions and some ethical and legal considerations, they classified the cultures in different aspects, one of them, being how the cultures behave while negotiating, finding two main clusters:

- High context cultures, where people look for establishing a relation before doing business. Negotiations are reflexive and paused and many times the oral agreement is more important that the actual signing of the contract. The cultures embracing this style are the Asians (especially Far East ones) and Eastern Europeans.
- Low context cultures, where business is the central aspect (not relations). Experience and past-performance of the parties is highly valued. Some examples of these cultures are the American, British, Nordic, and German.

In the specific case of Latin Americans, we can say that we are in a medium position closer to low context cultures due to the strong contact with Anglo-American cultures. However, in some smaller cities this context can be closer to high context. This study is referred to two big companies in Peru; consequently, the low context approach is the preferred one.

5.1 A First Attempt: Real Plaza Salaverry (RPS)

According to some authors innovative contracts in a Supply Chain are those that alter the performance of the Supply chain. Those contracts apply to any industry and any link between two levels in a supply chain (e.g. supplier-manufacturer or manufacturer-distributor). It does not matter whether the asset produced at the upstream level is rented at the downstream level or sold outright, or whether demand is stochastic or deterministic (Cachon and Lariviere, 31). There are some common characteristics in any Innovative contract (Cachon, 3):

- It has to coordinate the supply chain. Ideally, the optimal actions should achieve a unique Nash equilibrium.
- It has sufficient flexibility to allow for any division of the supply chain´s profit among the firms, therefore, it can allocate rents arbitrarily.
- It is worth adopting. Although, coordination and flexible rent allocation are desirable features, contracts with those properties tend to be costly to administer, As a result, the contract designer may actually prefer to offer a simple contract even if that contract does not optimize the supply chain´s performance. A simple contract is particularly desirable if the contract´s efficiency is high and if the contract designer captures the lion´s share of supply chain profit.

It is not the case but, when developing international contracts, both parties should pay particular attention to the following details:

- Forum selection: In the event of a dispute, where would the arbitrations forum for resolving the dispute take place?
- Choice of law: The parties to an international contract should agree on the contract law that will govern the contract in the event of a dispute.
- Payment: What currency will be used to make payments under the contract?

- Language: The contract should specify the official language to be used in the contract, as translations are not exact.
- Force majeure: it is common in international contracts to excuse performance when events that make it impossible to fulfill the contract´s performance take place.

With the parameters described by Cachon (Cachon, 3) we are going to analyze the focus that all the actors in the Supply chain give to an Innovative Contract.

5.1.1 Contract´s Background

First, it is notorious that no matter the level (Construction managers, production chiefs, production engineers) in the Construction Company the knowledge about SCM is limited. In fact just one of the interviewees in Livit had some knowledge about it. However, everybody believes in the importance of including innovative contracts for some subcontractors and suppliers. On the other hand, in the concrete supplier the level of knowledge of SCM is high, having even one of the interviewees a master degree on it. Therefore, it is not strange that the proposal for including an innovative contract in the concrete supply in the project came from the supplier.

Second, it is a common belief that the supply performance depends also on the closeness of the plant which the project is provided from. Unicon divides its projects on sectors regards on the project's location. Furthermore, some plants have better performances than others.

Third, it is a common belief that the degree on which the project is defined and the attitude of the Project Manager Consultants. In fact, Unicon's representatives mentioned that in their opinion the reliability in the on-site concrete pouring and the frequency between mixer trucks is highly dependent on the Consultants.

However, everybody agrees on that the most important factor for applying this type of contracts is the companies' willingness to plan, do, check and change their procedures on the basis of the performances' measures.

5.1.2 Basic aspects in a proposed innovative contract

Both, contractor and supplier's representatives mentioned some aspects as basics for an innovative contract. These aspects are the following ones:

- To establish clear and fair measure mechanisms for both, rewards and punishes (not only monetary). The contractor representatives declared that the mechanisms were

proposed by the supplier and some were some unclear in their opinion. Also, they highlighted that there was no procedure of how to manage the claims against the supplier.

- To establish, from the project kick-off, the plant(s) where the project will be supplied from. An important requisite for this aspect is to have a clear idea of the concrete volumes, shifts, timeframe and sectors in the project.
- To have both, contractor and supplier, organizational cultures oriented to productivity and innovation. The innovative contract was proposed to other two Peruvian companies (one before and one after RPS) but both companies rejected it because it meant extra efforts in controlling daily and weekly performances. Furthermore, inside the contractor personal there were some engineers with a negative attitude towards planning and controlling, resulting of a combination of lack of interest and knowledge. These problems were overcome with training and continuous reinforcement (supervision, weekly feedbacks, Etc.).
- To define communications liaisons between both companies. In the case of RPS, Unicon assigned a full-time liaison with permanent communication with the Unicon's Delivery and Planning Department. On the other hand, Coinsa designed a full-time engineer who was the only one allowed to ask for concrete and the responsible for delivering the concrete schedules and volumes for the project.
- To incorporate as a requisite, meetings in which every company communicates to all its members the procedures , mechanisms and targets in the contract in order to align the objectives within all the organizations. In fact, one of the biggest criticisms that some members in the contractor was that they did not know which the contract´s purpose was in the first place.
- Whether the project has or not an own batching plant. Logically, concrete pouring performances vary when the concrete source is inside the project. This study aim is the supply from external batching plants, because this is the most common case in the Peruvian construction industry.

Additionally, there are some other aspects that cannot be managed by both parties and that should be considered such as:

- Traffic: It is very difficult to predict the actual conditions of traffic in Lima. In fact, several public construction projects along the city (because the proximity of local elections) make even more difficult to control the traffic.
- Consultant Company Procedures: These procedures may dramatically vary from one company to the next one and even within the same company. Therefore, it is very difficult to predict the degree of positive/negative influence of the consultancy over the project. Generally, Construction Companies allocate resources to deal with this uncertainty, incorporating waste to the supply chain. In this regard, Unicon expressed that on average 40% of the projects have late start or annulments of daily concrete pouring. Most of these delays or annulments are directly linked to the consultant company procedures. Consequently, projects 'costs increase to cover this inefficiency. In our opinion the only manner in which this drawback can be overcome is on the means of incorporating the Consultants to the coordination chain between Supplier and Contractor, showing as an incentive possible savings in the project.
- Other suppliers 'interaction: In Salaverry, most of the structure was made on pre-stressed slabs. These precast elements are supposed to speed the project construction up. However, in Lima there are many suppliers and the one chosen for Salaverry did not have enough capacity for dealing with the project, creating delays in the construction sequence. These delays impacted the frequency of concrete pouring and the overall project performance.

5.2 Proposed Innovative contract:

An effective contracting strategy and consistent process would require the support and agreement of many internal stakeholders. In fact, there should be some target benefits on the contracting strategy, such as more efficient operations, improved parties´ relationships and better communication/information flow. Hence, managing contracts in a global environment continues to be a major source of problem, misunderstanding, and poor execution (Monczka et al., 499).

Many companies seek to resolve this issues through a process known as "preventive contracting", which involves spending more time in the initial contracting stages to fully understand stakeholders requirements, expectations, and repeated communication of

expectations, in order to gain a full understanding of elements, “it usually cost less to avoid getting into trouble than to pay for getting out of trouble” (Monczka et al., 499).

In this part we are going to analyze every clause of RPS´s contract comparing it with the contract in Real Plaza Venturosa (RPV), a fairly traditional contract, and establish were we think we can introduce changes. It is important to mention that a prerequisite for having these contracts is the willingness of both parties to work together overcoming the adversarial relationships between them.

- **Clause 1:**

This clause is introductory and on it, it is explained which the signing companies are and what is their background. This clause is typical in every construction contract. In a traditional contract this clause is not included.

- **Clause 2:**

In this clause it was described the contract objective, in this case the premixed concrete supply. This clause is usually neglected in the traditional contracts.

- **Clause 3:**

In this clause it was explained how the supply planning is performed. It is established when the project should require for concrete in order to ensure the supply.

In the traditional contract the requisitions´ terms were different and there were differences in the procedure that were improved in the new contract.

- **Clause 4:**

In this clause, it was included the contract term. It depends on every contract and it can vary in case of not-fully-defined projects. This clause is usually included in the supply contracts with not much detail.

- **Clause 5:**

In this clause was expressed the contract amount and which items were included in the contract (labor, materials, equipment, testing, contingencies, Etc.).

Because in the traditional contract the total concrete volume is roughly estimated, this clause is usually neglected.

- **Clause 6:**

In this clause, it was expressed the number of work sectors and whether the project will be considered as one or every sector will have a different planning. It is also included the down

payment agreed between the parties. In RPS, the 30% of the total amount covered possible cement cost increments. We believe that, when possible, it should be included this payment because it diminishes the uncertainty in the project. Finally, in this clause it is included the invoicing procedure.

In RPV's contract, usually there is not detail about number of work sectors and whether each of these sectors will have a different planning and, therefore, requisitions. Consequently these aspects are usually neglected and managed informally.

Additionally, contractors do not give down payment for concrete supply. Hence, traditional contracts include information about how much the concrete price would increase because of variations in the price of fuel and cement on terms of the compressive strength.

- **Clause 7:**

In this clause it was described the supplier´s obligations. This clause was different from traditional contracts in the sense that incorporates a sub clause with the possibility of the contractor of claiming extra cost because of the supplier bad performance. Some years ago (for example in RPV) Unicon paid to the contractor because of its deliveries 'delays, but three years ago, Unicon had used its strong bargaining power to avoid this kind of liabilities. However, in RPS, Unicon has admitted the possibility of being responsible of damages to the contractor.

We believe that this clause should incorporate Unicon´s obligation of issue weekly reports on concrete pouring performance in the project. These reports should be not only quantitative but also qualitative. These reports should be made by the Unicon liaison in the project, which inclusion in Salaverry was praised for both parties. It is important that this liaison arrives to the project from the beginning and stays until the structure finishes.

Finally, we believe that this clause should incorporate as Unicon´s obligation to transmit their expertise in concrete practices and technologies to the contractor in successive meetings, especially in the beginning of the project. This way, the concrete headquarters gain a closer approach to the project that will improve the interaction with the contractor personnel and will improve the communication degree. Unicon had already made it in several projects, but it should be included in the contract in order to ensure its application in every project.

As it was mentioned before, this clause is usually neglected and Unicon refused any possible liability.

- **Clause 8:**

In this clause it was described the contractor´s obligations. This clause started with the payment and invoicing characteristics, very important matter for the supplier. However, the most interesting parts are the ones that incorporate how the concrete requisitions should be conducted. It is very important the sub clause in which it was established the timeframe needed for the requisition (two weeks) and the maximum percentage of variability between the volume required and the volume confirmed the previous day of the pouring.

All these procedures must be reinforced over the time. It was observed in both parties that the planning quality diminished in the later stages of the project, probably because of the shift of the main focus in the project, from the concrete structures to the finishing stage. In RPS the 90% of the concrete requisitions and 70% of pumping equipment requisition were efficiently fulfilled by the supplier, the rest of the requisitions were somehow not.

Additionally, as in the previous clause this clause incorporated penalties in case the contractor does not meet the mixer truck frequencies agreed in the requisition.

Finally, it described the safety conditions that the contractor should provide for the normal operation of the concrete supplier. Unicon´s representatives also mentioned that it is very important that the contractor establishes from the beginning the space that the mixer trucks would have on-site. In some project, especially in Lima´s financial district, the available space is very limited but studying this aspect from the beginning allow both parties to work on finding a suitable solution on this regard.

In RPV's contract, this is a strong clause with much detail to protect the supplier from the contractor´s inefficiencies. However, this focus neglects the collaborative approach and increase the controversial relation between the parties.

- **Clause 9:**

In this clause, some general supply conditions were described. For example, it was described which codes apply for the supply and the procedure for the requisition (through phone calls or emails). Finally, it incorporated how much of the volume confirmed one day before can be modified (in this case 10% if the variation comes from the contractor and 5% if the variation comes from the supplier). Unicon mentioned that in order to improve these procedures they are implementing a call center for closer attention to the projects, with personnel qualified to the complaints´ management.

In a traditional contract, these supply conditions are also described but the range variation is lower and, therefore, this clause shows low flexibility in the contract that was previously mentioned as a basic characteristic of an innovative contract. The requisition procedures are very similar but the terms for doing so are different.

We believe that this clause should incorporate the necessity of coordination meetings. The meetings frequency should depend on the project complexity, timeframe, location, Etc. These meetings should be accompanied with continuous feedback from both parties. This feedback would need some formats and procedures for communication. These formats have been already developed for RPS but they should be adapted for every project.

Finally, these meetings should not be held only in the upper levels of the supply chain but especially in the operational level. In fact one complain in the contractor lower organization levels was that they did not know the overall procedure held in the project until it was already signed and about to be implemented.

- **Clause 10:**

In this clause, the project special supply conditions were described. In this clause the RPSC incorporated the waiting on-site time (TEO because its initials in Spanish). The TEO in this project was defined in 20 minutes (on average Unicon stated that a mixer truck waits before bee poured 33 minutes in Lima´s construction projects). This value was defined on the basis of some benchmarking conducted by Unicon with other concrete producers in Latin America. According the actual TEO in the project, it is established a discount per cubic meter and how this discount would be managed in the invoicing process. However, we noticed that Unicon did not study that the TEO value can vary from 12 to 30 minutes, depending on the type of concrete pouring (Park and Kim, 46). This value should be defined in the beginning in the project as should be a characteristic of every project. Furthermore, this value definition should be made for both parties and how this value is measured should be known for both parts. A complaint from the contractor was the precision of the GPS system (which it is used to confirm the mixer truck arrival to the project location) was about 60m and that in some parts of Lima 60m can be a matter of 10 minutes or even more because of the traffic conditions. Unicon stated that this value can be (and will be) improved but that 20m (distance between points now) is not practical.

Another important aspect in this clause was the inclusion of Unicon´s liaison in the project. This person can be a full time or part time, depending on the characteristics of the project.

In the case of Salaverry this person was at full time. The suppliers' early involvement makes easy the project construction and some constructability and productivity issues can be covered increasing the performance of the project.

Also, this clause incorporated the conditions for the use of pumping equipment in the project. Previously, the general impression in the contractors was that the concrete deliver department and the pumping equipment department were dissociated. In fact, Unicon acknowledged that these two departments were previously included in different business units. Now, they both depend on the Operations unit and they participated in every meeting held in the project between supplier and the contractor.

In a traditional contract, this clause is usually neglected and there are neither special conditions for supplying nor full-time / part-time liaison in a project.

Finally, we think that this clause should incorporate the available pouring timetables (which can widely vary depending on the location of the project) and the pumping equipment required for the project (which can be a very decisive aspect for the success of a project, especially when there is no much available space for mixer trucks).

- **Clause 11:**

This clause referred to the impossibility of transferring or subcontracting the concrete supply in the project. Unicon was chosen for the project because its capacity for dealing with a project such as RPS, so transferring the contract must be avoided in any case. This clause is usually neglected in traditional contracts.

- **Clause 12:**

This clause explained that the supplier must communicate directly with the contractor and not with the project owner. This because the contract modality between the owner and the contractor (in RPS lump sum). If the construction contract would be turn-key we believe that it is necessary an interaction between the three parties: contractor, owner and supplier. This clause is usually neglected in the traditional contracts but, it is understood that in any case the communication should be direct between the contractor and supplier.

- **Clause 13:**

This clause explained the causes in which one of the parties can ask for the contract resolution and the procedures to be performed before the actual resolution. In a traditional contract, this clause is not included and it is only mentioned that any delay in the contractor

payment can originate a claim from the supplier for financial costs, calculated using the TAMEX and/or TAMN indexes.

- **Clause 14:**

This clause explained which cases could be considered force majeure and, therefore, do not apply to the penalties 'application. In a traditional contract, this clause is usually neglected.

- **Clause 15:**

This clause talked about the responsibility of the supply and which codes apply to it. Also, it clarifies the provider responsibility during his operation on-site. This clause is, in a traditional contract, more detailed about the codes that apply to the supply. In this case, we think that the traditional contract is more complete than the innovative one.

- **Clause 16:**

This clause dealt with the confidentiality and how the supplier should managed the information (blue prints, specifications, schedules, Etc.) received from the contractor for the concrete supply in the project. This clause is not included in a traditional contract.

- **Clause 17:**

This clause dealt with the parties' waiver in their contract´s rights. It establishes that even one of the parties has not exerted its right on a specific contract clause it does not mean that this party has renounced to its right on this clause. It is typical in the construction contracts. This clause is not included in a traditional contract.

- **Clause 18:**

This clause stated that both parties have agreed on the previous clauses and that every previous communication between the parties has been replaced by the contract and its appendages. This clause is not included in a traditional contract.

- **Clause 19:**

This clause established where the parties should receive the formal communications needed in the development of the contract. This clause is not included in a traditional contract.

- **Clause 20:**

This clause established who both parties' representatives for formal communications are when they are required in the contract and their contact data (email, phone number and address). This clause is not included in a traditional contract.

- **Clause 21:**

This clause established the procedure for controversy resolution and the applicable code for it. It also designates the institution in charge for the resolution and how this institution´s payment will be managed. We believe that this clause should incorporate the inclusion of some joint Committees to Manage Disputes within the parties. These committees should act in the early phase of the conflicts in order to avoid that they maximize and endanger the parties 'mutual trust.

In fact, both parties acknowledge that disputes are to be avoided and that effective communication, common objectives and mutual trust are important for the project success.

This clause is not only neglected in traditional contracts but also it was understood as a source of conflicts when it should be the total opposite.

- **Appendix**

The contract incorporated as appendixes the concrete volume per sector and concrete compressive strength (f´c). It also incorporated the purchase order for every sector and other general concrete supply conditions. In our opinion the appendix should incorporate some other important information such as sectors layout, expected pouring concrete volumes.

To sum up, following the classification provided by Cachon and Lariviere (Cachon and Lariviere, 31) RPS's contract is a hybrid of revenue sharing, wholesale price. On the other hand, RPV's contract meets the basic characteristic of a wholesale price contract. In the next chapter, we will analyze the effect of the RPS's concrete supply contract.

5.3 Effects in projects due to Innovative contracts.

As we already mentioned it is important for us to test our hypothesis "the more SCM techniques are used, in this case contracts, the better the project performance". There are four main aspects in which this project performance can be measured:

5.3.1 Productivity

The positive effect that the innovative contract brought to the project was clear in RPS. With similar structural setting, the same project owner and similar short terms we expected to

obtain similar productivity results. However, as we can see in the Table 5.1, there was an improvement in all the concrete-related activities.

As we already mentioned, there is an indirect measurement of productivity: PPC index. It can be seen that in both projects the PPC index was almost the same. It was expected that PPC index in RPS was higher than RPV´s. However, there could be two reasons for that. On the one hand, the PPC level was calculated only for the first five months of the project. After the fifth month, the project staff stopped calculating it. It was believed that the PPC level after the 5th month would be better because the project team knows each other better. On the other hand, the PPC level was influenced by the Consultant Company in charge of managing the project the first three months. After the 3rd month, there was a meeting in which the criteria for approving the concrete pouring started to change and after that moment, there was more accuracy in the planning activities.

Productivity Ratios			
Description	**Unit**	**Perform (HH/unit)**	
		Venturosa	**Salaverry**
Columns concrete	HH/m3	1.70	1.42
Slabs and beams concrete	HH/m3	2.11	1.49
Foundations concrete	HH/m3	0.80	0.78
Columns formwork	HH/m2	1.69	1.43
Slabs and beams formwork	HH/m2	3.75	2.52

Table 5.1 Productivity ratios in Venturosa and Salaverry

5.3.2 Timeliness

As already mentioned, one of the biggest risk in construction is not meeting project's terms. In our case studies this factor was tested. In RPS, in particular, the improved effect of including innovative contracts in a project was not achieved. On the contrary, this project ended with 10 days of overall delay. On the other hand, RPV, the other case study, finished on time.

There could be some reasons for this. First, RPS was a project in which there were major modifications. These modifications undoubtedly impacted on the project term. Second, RPV was located in a district in which there is no limitation in working hours. On the contrary,

because its location, RPS had limited working hours and it was an issue from the projects beginning.

Real Plaza Venturosa						
Week	Weekly PPC			Cumulated PPC		
	Planned activities	Performed activities	PPC (%)	Planned activities	Performed activities	PPC (%)
Week 0	32	24	75%	32	24	75.0%
Week 1	33	25	76%	65	49	75.4%
Week 2	37	28	76%	102	77	75.5%
Week 3	33	24	73%	135	101	74.8%
Week 4	28	21	75%	163	122	74.8%
Week 5	35	27	77%	198	149	75.3%
Week 6	40	30	75%	238	179	75.2%
Week 7	36	28	78%	274	207	75.5%
Week 8	38	29	76%	312	236	75.6%
Week 9	38	29	76%	350	265	75.7%
Week 10	45	34	76%	395	299	75.7%
Week 11	48	36	75%	443	335	75.6%
Week 12	43	32	74%	486	367	75.5%
Week 13	42	35	83%	528	402	76.1%
Week 14	40	29	73%	568	431	75.9%
Week 15	35	25	71%	603	456	75.6%
Week 16	76	46	61%	679	502	73.9%
Week 17	128	118	92%	807	620	76.8%
Week 18	134	115	86%	941	735	78.1%
Week 19	210	187	89%	1,151	922	80.1%
Week 20	195	183	94%	1,346	1,105	82.1%
Week 21	248	188	76%	1,594	1,293	81.1%
Week 22	201	161	80%	1,795	1,454	81.0%
Week 23	183	127	69%	1,978	1,581	79.9%
Week 24	184	145	79%	2,162	1,726	79.8%
Week 25	207	171	83%	2,369	1,897	80.1%
Week 26	279	221	79%	2,648	2,118	80.0%
Week 27	62	55	89%	2,710	2,173	80.2%
Week 28	56	51	91%	2,766	2,224	80.4%
Week 29	60	53	88%	2,826	2,277	80.6%
Week 30	50	45	90%	2,876	2,322	80.7%
Week 31	84	75	89%	2,960	2,397	81.0%
Week 32	89	87	98%	3,049	2,484	81.5%
Week 33	120	103	86%	3,169	2,587	81.6%
Week 34	77	50	65%	3,246	2,637	81.2%
Week 35	66	64	97%	3,312	2,701	81.6%
Week 36	75	70	93%	3,387	2,771	81.8%
Week 37	12	12	100%	3,399	2,783	81.9%

Table 5.2 PPC index in Real Plaza Venturosa

Another source of delay was the subcontractors' action. Specifically, the glasses subcontractor had a delay of more than two weeks cause by an excessive workload in its plant. This was until the end of the project, the biggest concern on staff members and it could not be solved despite of the contractor's efforts.

Real Plaza Salaverry						
Week	**Nº Planned activities**	**Nº Performed activities**	**Nº Planned accum activities**	**Nº Performed accum activities**	**Weekly PPC**	**Accum PAPC**
Week 0	19	16	19	16	84.2%	84.2%
Week 1	16	2	35	18	12.5%	51.4%
Week 2	10	9	45	27	90.0%	60.0%
Week 3	11	10	56	37	90.9%	66.1%
Week 4	11	10	67	47	90.9%	70.1%
Week 5	10	10	77	57	100.0%	74.0%
Week 6	17	13	94	70	76.5%	74.5%
Week 7	18	14	112	84	77.8%	75.0%
Week 8	18	17	130	101	94.4%	77.7%
Week 9	19	19	149	120	100.0%	80.5%
Week 10	20	8	169	128	40.0%	75.7%
Week 11	20	17	189	145	85.0%	76.7%
Week 12	19	17	208	162	89.5%	77.9%
Week 13	19	18	227	180	94.7%	79.3%
Week 14	19	18	246	198	94.7%	80.5%
Week 15	19	19	265	217	100.0%	81.9%

Table 5.3 PPC index in Real Plaza Salaverry

At some point, project staff members acknowledged that the lack of benchmarks and control points prevented them from realizing the schedule baseline's deviation.

5.3.3 Quality

Concrete quality in construction is an attribute that is the result of the several stages in the concrete supply. From the concrete supplier bidding process to the control of hardened concrete' properties, every stage is very important to concrete quality in a project. In this study the focus of the concrete quality starts in Transporting and Receiving Concrete and finishes with the Evaluation of Hardened Concrete. We are going to analyze each of these phases in RPS.

- Transporting and Receiving Concrete

In RPS, Unicon's delivery system allows to monitor and control the truck mixer's location all the time. Monitoring the location of concrete mixers trucks is an effective way to ensure the plastic state of the concrete inside the truck. Traceability is also very important. It is very important that every truck can be identified with basic information such as origin plant, time in which the concrete was batched and the truck number. With all this information the receiving on-site concrete procedure is quite simple. In both projects, RPS and RPV, this information was included in every dispatch because it is part of Unicon's normal operational procedures.

- Measurement and Acceptance of Plastic Concrete

Essentially, there are some testing requirements for plastic concrete such as slump, air content and unit weight. Commonly, only the first one is performed in most of the construction projects. Only in some special projects the other two are also performed. Additionally, the last criteria for concrete on-site acceptance is the verification that concrete does not have more than one and half hour from batching when it is about to pour.

RPS had a better performance in this aspect than RPV. In RPS there were only two cases in which the concrete contained in the mixer truck did not meet the slump design requirements. On the contrary, in RPV there were several cases in which the concrete arriving to the project did not meet the slump requirements. In that case, the contractor decided many times to reject mixer trucks. There can be two explanations for this difference; either the batching quality controls in plant have improved or the contract, and the procedures established in the contract, eased the improvement of concrete quality performance. The available data did not allow us to conclude which one is.

Regarding to the waiting time, there were some isolated cases in RPS in which the maximum time was surpassed. On the contrary, in RPV there were several cases in which the maximum time was surpassed originating the rejection of truck mixers, with losses for both supplier and contractor (depending on which was responsible for the rejection.

Finally, in neither of the two cases, RPS and RPV, did the concrete fail to meet the specified strength.

- Evaluation of hardened concrete properties

Essentially, the concrete acceptance is given by the result of the compressive strength test (an average of two cylinders) to meet the specified strength. Additionally, other structural acceptance criteria are the Hardened Air Void System, the Rapid Chloride Permeability, the Linear Shrinkage and the Modulus of Elasticity. Only the first one is performed in the Peruvian construction projects, especially when the structure is in constant contact with water or whenever there are cycles of freezing and thawing. Finally, another practical acceptance criterion is given by the hardening of concrete eight hours after being poured.

On this behalf, the quality level of supply in both projects was high. In particular, RPV presented two problems of forge retard (poured concrete remained in plastic state after 24 hours of discharged) in two concrete slabs, that were quickly solved after better controlling additive proportions while batching. In both projects, the specifications were similar, regulated by the ACI code.

To summarize, there was an improvement in quality in the concrete supply but this improvement was minor. In our opinion, the quality improvement was minor because supply quality is more to the supplier culture and processes than of the type of contract.

5.3.4 Continuous Improvement

Both companies, Unicon and Livit, embrace Lean Construction philosophy. Continuous improvement in Lean Construction means involving everyone in the organization, including managers and workers, and every process and department within the organization. A systematic approach is to identify and eliminate waste, especially during the critical path, through continuous improvement. Therefore, focus on learning is a requisite for continuous improvement. Another source of continuous improvement comes from building long-term relationships within the SC. Good relationships between SC's actors can help the SC go smoothly and produce continuous improvement.

Between both case studies, a planning and controlling improvement was observed. However, as already described, continuous improvement needs a longer term for being observed. Only after long-term relationships we will able to study all the effects of

innovative contracts in the construction projects' continuous improvement. Hence, this study cannot establish adequately this effect in a construction project.

5.4 Suggested Improvements for Future Innovative contract:

Our opinion is that it is already demonstrated that there cannot be a "best practice" approach to construction procurement contracts. On the contrary, "best practice" must involve an organization and its buyers understanding all the factors previously outlined to select appropriately from among the complex range of sourcing and relationship management approaches that are available to select from in a specific exchange transaction (O'Brien et al., 279).

To simply argue in construction management that there is always one sourcing or procurement approach (partnering or alliancing) that constitutes "best practice" is clearly nonsense. There are a range of sourcing and relationship management approaches that can be adopted by buyers to procure all types of construction goods and services. On the contrary, competence requires that organizations and their buyers undertake five steps (O´Brien et al., 268):

- First, a construction buyer must properly segment their activities and expenses profile to understand the nature of the demand profile (regular, serial, irregular, Etc.) they possess, and the types of power resources this provides them with to leverage value from the supply market.
- Having understood their demand profile, a buyer of construction goods and services must then understand what the nature of the supply market is (this implies understanding the relative power and leverage of suppliers in the market).
- Having understood the power and leverage situation for the particular projects and/or construction activities, a buyer has to understand the opportunity costs and risks of pursuing any of the six sourcing and six relationship management options available to them.
- Having understood the opportunity costs and risks of these options, the buyer must then decide which of the available commercial outcome is feasible, and seek to test in the market to what extent each of the available options is the most desirable given current market circumstances.

- Having selected the options for market testing, a buyer must then select the most appropriate approach through a rigorous and robust approach to market testing and contractual negotiation and award.

What all of this implies is that there can be no panacea for construction procurement, and that a strategic approach to construction procurement management involves a commitment to understanding the appropriateness of a range of complex sourcing choices under very different power and leverage. Only by understanding from first principles what these options are under particular power and leverage circumstances, can an appropriate approach to construction procurement be developed.

This means that all of the relationship management options available may be appropriate for construction buyers to use. It also implies that the construction procurement strategy for some organizations will have to be very different to that of other organizations, which possess very different demand and supply and, therefore, power and leverage circumstances within which to operate.

Next, some of the strategic sourcing and relationship management options that arise from these different types of demand scenarios are described (O´Brien et al., 281):

- If demand is similar because of standardized design and specification, and projects and activities can be undertaken either in a consecutive or overlapping manner, then a number of preferred suppliers may be selected to deliver requirements through long-term collaborative relationships.
- If projects and activities have a unique aspect and are irregular, then it is unlikely that a buying organization will be able to standardize design and specification, and as a result, short term and relatively ad hoc and adversarial arm's length relationship and sourcing options are likely to be adopted.

Whether the design and specification is standardized or not, it is evident that the nature of regularity involves two separate variables: the regularity of workload and the regularity of relationship. Given this distinction, it is clear that the appropriate management of construction expenditure and supplier relationships may vary based on the nature of the regularity of the demand and supply variables that have to be managed:

- For one-off projects with different suppliers it is likely that reactive sourcing approaches (such as supplier selection) based on adversarial and opportunistic short-term relationships are likely to be appropriate.
- When there are one-off projects with preferred suppliers it is possible for opportunistic and adversarial reactive sourcing approaches to be adopted that include supplier selection and supply chain sourcing.
- For those with an ongoing portfolio with different suppliers it is possible to be both reactive and proactive, but the proactive sourcing approach would probably only extend to supplier development activities.
- When there is an ongoing portfolio with preferred suppliers it is also possible to pursue both reactive and proactive approaches, but there may be scope for both supplier development and supply chain management approaches.

Given this, it is evident that simplistic generalizations about what is the appropriate way to manage construction procurement, and what a strategic approach implies, must be avoided at all costs. Organizations within the construction industry face very different demand and supply, and power and leverage, circumstances. As a result, competence in the development of procurement strategies requires that buyers and suppliers understand what is appropriate given the circumstances they are in.

The only way in which a buyer or a supplier can understand whether or not it is possible to undertake reactive or proactive source is through the understanding of the power regime that exists within a particular supply chain network. These power attributes can be shown in the following matrix (Figure 5.1).

We think that this approach should be incorporated in supply contracts. Contractual relationship can offer incentives or disincentives for SC participants to view the project holistically and strive to meet the projects' objectives; they can drive or stifle work structuring efforts (O'Brien, 6-19). Some tools for developing this strategy can be (Arbulu and Ballard, 9):

- Use of a web-based tool designed based on the Last Planner System (LPS) to control production on site on a daily basis increasing workflow reliability, therefore reducing demand variability.

- Link the web-based production control tool with the material management process. This way the products can be pulled from suppliers.

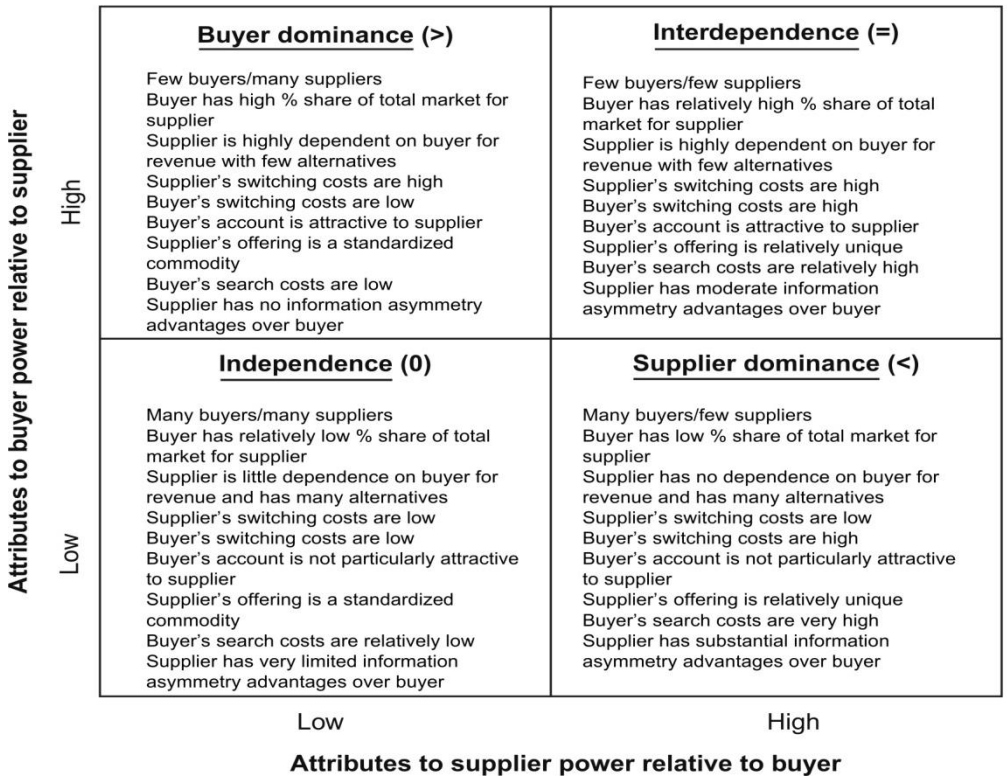

Figure 5.1 The power matrix: the attributes of buyer and supplier power (O'Brien et al., 12-8)

In order to monitor supply performance through these tools, project stakeholders must agree to work with automatic reports for concrete demand, concrete deliveries, volume of concrete/delivered by day, volume of concrete ordered/delivered by pour qualities, Etc.

Therefore, it is important to include in contracts the use of these shared web-based tools. Unicon has already started some efforts on this direction. Contractors should align efforts with Unicon and consolidate this tool as an innovative tool for managing variability. Implementation can be done through a workshop with project leadership and stakeholders involved in the concrete ordering process with the objective of providing a final review of the overall materials management approach. Separate implementation workshops should be scheduled with project managers and engineers from the different site teams to review rules, roles and responsibilities (O'Brien et al., 158). Once the implementation process is over, project leadership should continuously monitor the performance of the concrete supply to ensure results.

It was demonstrated that the inclusion of a supplier liaison or coordinator in a project is worth it. This liaison should not only coordinate the requisitions. He should also monitor key performance indicators (KPI) of concrete supply performance showing cubic meters of concrete planned on the one-day look-ahead, cubic meters placed, cubic meters cancelled, and the cubic meters of unplanned placement. These graphs provide very important information to the project and can be the initiator of the continuous project improvement. Consequently, the KPIs and their monitoring must be included in the contract.

There are important factors to consider when negotiating with a supplier over contract type, such as market uncertainty, long-term agreements, degree of trust between buyer and seller, process or technology uncertainty, supplier´s ability to impact costs and total monetary value of the purchase. Depending on these factors the desirability of using fixed-price and cost-based contract can vary as we can see in the Figure 5.2 (Monczka et al., 512).

In our opinion in supply contracts, long-term contracts should be pursued. Long-term contracts are contract purchases that are made on a continuing basis for a specified or indefinite period of time, typically exceeding one year. However, it is not always possible to achieve a projects' continuity that allow subscribing this kind of contracts. The advantages and disadvantages of such contracts can be seen in the Figure 5.3.

ENVIRONMENTAL CONDITION	FIXED-PRICE CONTRACT	INCENTIVE CONTRACT	COST-BASED CONTRACT
High component market unicertainty	Low	Desirability of use ⟷	High
Long-term agreements	Low	⟷	High
High degree of trust between buyer and seller	Low	⟷	High
High process/technology uncertainty	Low	⟷	High
Supplier's ability to affect costs	Low	⟷	High
High dollar value purchase	Low	⟷	High

Figure 5.2: Desirability of using contracts under different conditions

POTENTIAL ADVANTAGES	POTENTIAL DISADVANTAGES
Assurance of supply	Supplier opportunism
Access to supplier technology	Selecting the wrong supplier
Access to cost/price information	Supplier volume uncertainty
Volume leveraging	Supplier forgoes other business
Supplier receives better information for planning	Buyer is unreasonable

Figure 5.3: Potential advantages and disadvantages of long-term contracts

However, in order to avoid potential disadvantages of long-term contracts, we think that innovative contracts must include specification of the overall business requirements required by the supplier. The acceptance test criteria should be specified before issuing the contract, so that both parties completely understand how the supply is expected to perform.

To summarize, there is no such thing like a "recipe" for designing an innovative supply contract. It is necessary previously to perform an extensive analysis which output should be the comprehension of spending profile, nature of the supply and the power and leverage equilibrium within the SC. Afterwards, it is necessary to understand the nature of the regularity of the demand and supply variables to be managed (regularity of demand, variability of supplier, Etc.). Long-term contracts and relationships within a SC are desirable but not always possible, especially due to the high variability demand in the industry.

Only after such analysis, a procurement manager can face the supply contract design. We advocate to incorporate the use of web-based tools such as the one described by Arbulu (Arbulu and Ballard, 5). These tools allow monitoring the project's variability and implementing improvement measures. Finally, we think that innovative contracts must incorporate the use of KPI's regarding the concrete supply.

5.5 Future needs of research in SCM in the Construction Industry

As a result of the extensive review of existing literature, we recommend some fields in which more research is still required regarding SCM within the Construction Industry:

- It is necessary to study more about partnering in construction. More attention needs to be paid to identify the conditions that encourage or inhibit partnering in practice. These conditions can be economic, institutional, technical and organizational (Bresnen and Marshall, 235). The present status of collaboration in construction is mainly empirical.
- It is necessary to study the impact and effect that cultural environment can have on the collaboration agreements between parties. It is clear that in the Peruvian society the implementation of SCM practices need to be founded in formal agreements, such as contracts. However, the literature review tells us that the agreement type is influenced by the context type of the culture. Most of the contract background used in this study is based on European countries' studies and those studies should be contrasted with Latin American studies.
- According to the study conducted by Semana Económica, SCM in Peru is in its early stages. In the construction industry what is known about SCM is even less, therefore, it is necessary to conduct a research about the degree of knowledge in the industry, especially in the biggest companies.
- As already mentioned, it is necessary to apply all the concepts used in the innovative concrete supply contract in other supplies. We think that another material in which the application of these approaches could be important is the preassembled steel reinforcement.
- This research (and most of the researches reviewed) has been focused on the private projects. It would be interesting to investigate the effects of collaboration in public projects, integrating not only supplier and contractor, but also owner in the SC improvement efforts.
- SCM need to be studied with more detail for subcontractors. We could not find many research papers about SCM in subcontractors outside European and Asian countries. Training and developing subcontractors in SCM seems to be bringing more advantage for companies than just price bidding.
- Cost and performance modeling of subcontractor and supplier production should be studied, in order to better understand the SC performance with econometric measures of firms.

- Game theoretic design of contracts should be analyzed, to support SC performance that can generate criteria to improve SC performance.

6. CONCLUSIONS

- From construction process to finished product, the construction industry has a very unique nature. Every project is a different product and, therefore, every contract for every supply has to incorporate project peculiarities. To copy solutions from other industries does not solve observed problems, but rather create frustration in both parties. Even though, collaborative and long-term relationships focus are advised, they are not always feasible and an extensive analysis before the contract design is necessary.

- SC collaboration and management has been used in many industries to gain competitive advantage. In the global environment, only companies with competitive advantages will succeed. Hence, SC will allow for rebranding and repositioning within the Peruvian Construction Industry.
- Although learning is currently perceived as important, the type of learning being undertaken does no match the competencies and the cultural changes needed for such a complex, multi-factor and dynamic innovation. A further indication of the limited understanding of the scope and complexity of the innovation needed in collaborative contracts is the low importance given by the respondent to external support in SC´s performance improvements.
- Effective truck mixer scheduling is critical to ensure high ready-mix concrete supply performance; it has been a challenge for suppliers to align different perspectives for it to become achievable. However, with more contractors interested in ensuring no interruptions in concrete placing and in obtaining discounts by helping to reduce suppliers´ operational losses, it is believed that there is a big opportunity for improvement.
- The effort already developed in the concrete supply contract should be used also in other supplies that are very important for the projects. In particular, we think that it should be used for steel supply, especially for preassembled steel reinforcement.

- Contractors should see contracts as a possible mean to improve the project constructability and reduce waste. In fact, we think that early supplier involvement in the project can improve the design of the concrete formwork system and improve the handling and transportation operations on site (mostly related to site layout problems and to the use of inadequate equipment).
- Both financial and nonfinancial waste originated by a poor contract must be measured. On the one hand, financial measures are necessary to support decision making and it could be used to investigate the economic impact of waste. On the other hand, nonfinancial measures are important to identify the causes of waste at the operational control level. Once we have identified both we can perform an efficient feedback that allows improvements in supply contracts.
- In the United Kingdom it was observed that there was a high correlation between the time of publication of the Latham Report and the increase number of partnership arrangements in the construction firm´s supply chain. We think that any singular effort on behalf of the Peruvian Government in that direction may have the same effect.
- Open tendering is outdated, the modern trends calls for partnership not only with the project owners but especially with the suppliers. The challenge is how to implement successful supply chain collaboration; the contract can be a mean for doing so. A common justification for competitive bidding approach in contracting is that it reduces the risk of ad hoc selection and corruption. However, we believe that for complex projects this approach may have higher costs.
- In developing countries, such as Peru, the biggest problem to apply these philosophies is the widespread ignorance of supply chain. Appropriate training and education, at all levels of the industry, are required to overcome these barriers.
- To successfully implement these innovative contracts in Construction, it is important to sink the message that the objective of SCM is to create the most value not solely for any one company but for the entire supply chain network. On the basis of the interviews, it would appear that this message has not yet reached the industry.
- An important aspect of contractual arrangements is their ability to accommodate adaptation, thus creating a tradeoff between transaction costs that are due to

change and incentives to reduce costs. Innovative contracts are aligned with this idea, providing incentives for cost reduction and incentives for flexibility.

- Balancing the benefits obtained for some members at the detriment of others is the SCM´s challenge. This will require inexpensive ways to measure and report costs and other data, share information about the level of benefits and reallocate the benefits that put some channel members in a worse position as a result of their cooperation.
- To establish problem solving procedures and provisions for continuous improvement in contracts, it is necessary to have procedures to control cost, meeting schedule, and technical performance. Likewise, it needs to avoid expensive litigation procedures. Hence, engaging in collaborative and partnering activities is well worth the investment of time and money.
- The findings suggest the value of projects participants meeting before the project begins, to identify actual areas of problem as early as possible areas in which problems may occur. This is likely to help focus the participants 'attention to critical areas and reduces potentially costly misunderstandings. Moreover, not only should potential problems be flagged, but it is more important that participants establish ground rules in advance to solve conflicts and disagreements. The key is to prevent small problems from becoming large ones that may jeopardize the working relationship between the parties.
- Innovative contracts can bring about improvements in the design process, communication and constructability, thus, they have the potential to improve the levels of productivity and quality attained on site. As working relationships between SC´s actors become closer, technology transfer will also increase, providing organizations with limited resources the opportunity to obtain expert skills from their collaboration with their partners.
- CSCs are plagued with several defects originating from deficiencies such as short-term probity, fragmented approaches, low-bid selections, etc. Such detrimental SC defects could be rectified by the introduction of relational bonds. These bonds require multilateral communication, impartiality, transparency, mutual trust and open and fair competition.

- While the literature suggests that there is a reluctance to share key information among partners, many of these fears subside if partners share similar values and a common vision. Such information sharing heightens the alignment between partners effective SCs share learning among partners rather than worry about knowledge expropriation.

7. REFERENCES

7. 1 Bibliographic

Ashley, D.B. and Workman, B. W. (1986), *Incentives in Construction Contracts,* Austin, USA: Bureau of Engineering Research of University of Texas at Austin.

Christopher, M. (1992), *Logistics and Supply Chain Management,* London, England: Pitman.

Ghio, Virgilio (2001), *Productividad en Obras de Construcción,* Lima, Peru: Fondo Editorial de la Pontificia Universidad Católica del Perú.

Hendrickson, C. (2000), *Project Management for Construction, 2nd Edition,* Pittsburgh, USA: Prentice Hall.

Hofstede, G. (1980). *Culture's consequences: International differences in work-related values*. Beverly Hills, USA: Sage.

Latham, Michael (1994), *Constructing the Team,* London, United Kingdom: HSMO. Report to the UK government.

Monczka, R., Handfield, R., Giunipero, L., Patterson, J., *Purchasing and Supply Chain Management (4th Edition),* Mason, Ohio, USA: South-Western Cengage Learning.

Schniederjans M.J., Schniederjans D.G., Schniederjans A.M. (2010), *Topics In Lean Supply Chain Management*, Singapore, Singapore: World Scientific Publishing.

Thompson, A., Strickland A.J. (1999), *Strategic Management 11th Edition.* Boston, USA: Irwin Mc Graw Hill.

Van Maanen, J. (1988), *Tales of the field: On writing ethnography,* Chicago, USA: University of Chicago Press.

Williamson, O.E. (1985), *The Economic Institutions of Capitalism: Firms, Markets, Relational Contracting*, New York, USA: Mc Millan.

Womack, J.P. and Jones, D.T. (1996), *Lean Thinking: Banish Waste and Create Wealth in Your Corporation,* New York, USA: Simon&Schuster.

7.2 Hemerographic

Akintoye, A., McIntosh, G., Fitzgerald, E. (2000), *A survey of supply chain collaboration and management in the UK construction industry, European Journal of Purchasing &Supply Management 6 (2000),* pp. 159-168.

Alper, S., Tjosvold, D., Law, K. (2000) *Conflict Management, Efficacy, and Performance in Organizational Teams, Personnel Psychology,* Issue 53 (3), pp.625-642

Anson, M., Wang, S. (1998), *Performance of concrete placing in Hong Kong buildings, Journal of Construction Engineering and Management,* Issue 124 (1998), pp. 116-124.

Bajari, P. and Tadelis, S. (2001), *Incentives versus transaction costs: a theory of procurement contracts, The Rand Journal of Economics,* Volumen 32, No. 3, pp. 387-407

Ballou, R.H., Gilbert, S.M., Mukherjee, A. (2000). *New Managerial Challenges from Supply Chain Opportunities*. *Industrial Marketing Management*, Volume 29, pp.7-10.

Bernold, L. (1989), *Simulation of non-steady construction processes, Journal of Construction Engineering and Management*, Issue 115 (1989), pp. 163-178.

Bresnen, M. and Marshall, N. (2000), *Partnering in construction: a critical review of issues, problems and dilemmas, Construction Management and Economics,* Issue 18 (2000), pp. 229-237.

Brun, A. and Miragliotta, G. (2010), *The use of supply contracts as supply chain coordination means: interpretative model and empiric validation, pp. 1-13*

Bygrave, W. (1989), *The entrepreneurship paradigm (1): a philosophical look at its research methodologies*, *Entrepreneurship Theory and Practice,* Vol. 14 No. 1, pp. 7-26.

Cachon, G.P. and Lariviere, M.A. (2001), *Contracting to Assure Supply: How to Share Demand Forecast in a Supply Chain*, *Management Science,* No. 51 (1), pp. 30-44)

Cachon, G.P. (2004), *The Allocation of Inventory Risk in a Supply Chain: Push, Pull, and Advance-Purchase Discounts Contracts, Management Science,* Issue 50 (2), pp. 222-238.

Cassivit, L. (2006), *Collaboration planning in a supply chain, Supply Chain Management: An International Journal,* Volume 11, Issue 3, pp. 249-258

Chiang, Y.H., Tang, B.S., Leung, W.Y. (2001), *Market Structure of the construction industry in Hong Kong, Construction Management and Economics,* Volume 19, Issue 7, pp. 675-687

Chua, D., Li, G. (2002) *RISim: resource-interacted simulation modeling in construction, Journal of Construction Engineering and Management ,* Issue 128 (2002), pp. 195-202.

Cooper, M. C. and Ellram, L. M. (1993), *Characteristics of Supply Chain Management and the Implications for Purchasing and Logistics Strategy, International Journal of Logistics Management,* Vol. 4 Issue 2, pp. 13-24.

Eisenhardt, Kathleen M. (1989), *Building theories from Case Study Research, Academy of Management Review*, October 1, 1989, Vol. 14 No. 4, pp. 532-550.

Hallikas, J., Karvonen, I., Pulkkinen, U., Virolainen, V., Tuominen, M. (2004) *Risk management processes in supplier networks, International Journal of Production Economics,* Volume 90, Issue 1 (2004), pp. 47-58.

Kopczak, L.R. and Johnson, E. (2003), *The Supply-Chain Management Effect, MIT Sloan Management Review,* Spring 2003, pp. 1-14

Larson, E. (1997), *Partnering on Construction Projects: A study of the relationship between partnering activities and project success, IIEE Transactions on Engineering Management,* Vol. 44, N°2, May 1997,

Lee, H.L. (2004) *The triple-A Supply Chain.* Harvard Business Review, September-October.

Lin, F. and Shaw, M. J. (1998), *Reengineering the order fulfillment process in supply chain networks, The International Journal of Flexible Manufacturing Systems,* Issue 10, pp. 197-229.

London, K. and Kenley, R. (2001), *An industrial organization economic supply chain approach for the construction industry: a review, Construction Management and Economics*, Issue 19, pp. 777-788.

Love, P., Irani, Z. and Edwards, D. J. (2001), *A rework reduction model for construction projects, Engineering Management,* Volume 51, Issue 4, pp. 426-440

Malone, T.W., and Crowston, K. *The Interdisciplinary study of coordination, Computing Surveys,* Volume 26, 1 (1994), pp. 87-119.

Narayanan, V.G., Raman, A. (2004) *Aligning Incentives in the Supply Chains. Harvard Business Review.* November 2004, pp. 94-102

O'Brien, W. J. (1998), *Construction Supply-Chain Management: A Vision for Advanced Coordination, Costing, and Control, pp. 1-7*

Palaneeswaran, E., Kumaraswamy, M., and Ng, T. (2003), *Formulating a Framework for Relationally Integrated Construction Supply Chains, Journal of Construction Research,* Vol. 4, No. 2 (2003) pp. 189-205.

Park, M., Kim W., Lee, H., Sangwon, H. (2010), *Supply chain management model for ready mixed concrete, Automation in Construction,* Issue 20 (2011), pp. 44-55.

Peckiene, A., Komarovska, A., Ustinovicius, L. (2013), *Overview of Risk Allocation between Construction Parties*, Procedia Engineering, Volume 57, 2013, Pages 889-894.

Schneeweiss, C., Zimmer, K., Zimmermann, M. (2004), *The Design of Contracts to Coordinate Operational Interdependencies within the Supply Chain*, *International Journal of Production Economics*, Issue 92, pp. 43-59.

Semana Económica and Ipsos Apoyo (2013), *Al inicio del Camino: Primer estudio sobre la situación del Supply Chain Management en el Perú, pp. 1-21*

Sommerville, J. (1994) *"Multivariate barriers to total quality management within the construction industry", Total Quality Management,* Vol. 5, No. 5, 1994, pp. 289-298.

Soosay, C. A., Hyland, P.W., and Ferrer, M. (2008), *Supply chain collaboration: capabilities for continuous innovation, Supply Chain Management: An International Journal 13/2,* pp. 160-169.

Spekman, R. E., Kamauff, J. W., Myhr, N. (1998), *An empirical investigation into supply chain management: A perspective on partnerships, International Journal of Physical Distribution & Logistics Management,* Vol. 28, Issue 8, pp. 630-650.

Vrijhoef, R. and Koskela, L. (2000), *The four roles of supply chain management in construction, European Journal of Purchasing&Supply Management 6 (2000),* pp. 169-179.

Wang, S., Teo, C., Ofori, G. (2001), *Scheduling the truckmixer arrival for a ready mixed concrete pour via simulation with @Risk, Journal of Construction Research,* Issue 2 (2001), pp. 169-179.

Xue, X., Li, X.; Shen, Q. and Wang, Y. (2004), *An agent-based framework for supply chain coordination in construction, Automation in Construction 14 (2005),* pp. 413-430.

Yu, Z., Yan, H., Cheng, T.C.E. (2001), *Benefits of information sharing with supply chain partnerships, Industrial Management & Data Systems,* Volume 101, issue 3, pp.114-121.

Yang, C., Chen, B. (2004) *Supplier selection using combined analytical hierarchy process and grey relational analysis, Journal of Manufacturing Technology Management,* Volume 17, Issue 7, pp. 926-941.

7. 3 Master and Doctoral dissertations

Shum, W. (2007), *Effective contracts in Supply Chains,* Doctor of Philosophy in Operations Research, School of Management, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA.

7.4 Conferences

Arbulu, R., Ballard, G. (2004), *Lean Supply Systems in Construction,* Proceedings IGLC-12, July 2004, Helsingor, Denmark.

Arbulu, R., Koerckel, A. (2005), *Linking Production-level Workflow with Materials Supply,* Proceedings IGLC-13, July 2005, Sidney, Australia.

O'Brien, W., London, K., and Vrijhoef, R. (2002), *Construction Supply Chain Modeling: A Research review and interdisciplinary research agenda,* Proceedings IGLC-10, Aug. 2002, Gramado, Brazil.

Tommelein, I. and Li, A. (1999), *Just-in-time concrete delivery: Mapping alternatives for vertical supply chain integration,* Proceeding IGLC-07, July, 1999, Berkeley, California, USA.

Vrijhoef, R., Koskela, L., Howell, G. (2001), *Understanding construction supply chains: an alternative interpretation,* Proceedings IGLC-09, Aug. 2001, Singapore, Singapore.

7.5 Web

APICS DICTIONARY (2014) consulted in www.apics.org [20-04-2014]

BLOOMBERG NEWS (2013), Quigley, J., consulted in http://www.bloomberg.com/news/2013-08-23/peru-gdp-growth-accelerates-on-construction-and-manufacturing.html [20-04-2014]

COUNCIL OF SUPPLY CHAIN MANAGEMENT PROFESSIONALS (2014), consulted in http://cscmp.org/about-us/supply-chain-management-definitions [20-04-2014]

ECONOBLOG (2012), Enrique Huerta Berríos, consulted in econoblognet.blogspot.com [20-04-2014].

ENCYCLOPEDIA BRITANNICA (2014), consulted in http://www.merriam-webster.com/ [20-04-2014]

LARIVIERE, MARTIN (2014), consulted in http://hstalks.com/main/view_talk.php?t=2444&c=250 [21-04-14]

OXFORD DICTIONARY (2014), consulted in www.oed.com [20-04-2014]

PHUAH, JOEY (2012), *Overview of Research Methodology, consulted in* http://www.slideshare.net/JoeyPhuah/overview-of-research-methodology, [21-04-2014]

PERUVIAN TIMES (2004), consulted in http://www.peruviantimes.com/23/construction-industry-seen-posting-double-digit-growth/20044/).

THE BOOM OF THE CONSTRUCTION INDUSTRY IN PERU (2013), Manuel Altamirano, consulted in http://www.slideshare.net/E-DAY/manuel-ppt [20-04-2014]

UNICON WEB PAGE (2014), consulted in http://www.unicon.com.pe/principal/categoria/acerca-de-unicon/1/c-1 [21-04-2014]

7.6 Report

UNITED KINGDOM. LABOR GOVERNMENT IN PARLIAMENT (1998). *Rethinking construction.* London, United Kingdom: HSMO.