

Lean Thinking and E-Commerce as New Opportunities to Improve Partnership in Supply Chain of Construction Industries

Kaustav Kundu, Alberto Portioli Staudacher

Abstract—Construction industry plays a vital role in the economy of the world. However, due to high uncertainty and variability in the industry, its performance is not as efficient in terms of quality, lead times, productivity and costs as of other industries. Moreover, there are continuous conflicts among the different actors in the construction supply chains in terms of profit sharing. Previous studies suggested partnership as an important approach to promote cooperation among the different actors in the construction supply chains and thereby it improves the overall performance. Construction practitioners tried to focus on partnership which can enhance the performance of construction supply chains but they are not fully aware of different approaches and techniques for improving partnership. In this research, a systematic review on partnership in relation to construction supply chains is carried out to understand different elements influencing the partnership. The research development of this domain is analyzed by reviewing selected articles published from 1996 to 2015. Based on the papers, three major elements influencing partnership in construction supply chains are identified: ‘Lean approach’, ‘Relationship building’ and ‘E-commerce applications’. This study analyses the contributions in the areas within each element and provides suggestions for future developments of partnership in construction supply chains.

Keywords—Partnership, construction, lean, SCM, supply chain management.

I. INTRODUCTION

ALTHOUGH construction industry is a relevant segment of world-wide economy, it is still a complex and often underperforming sector [1]. The irregular cycles of demand and the dynamic nature of construction industry create high uncertainty and variability which lead to poor performance in terms of lead times, productivity, costs and planning efficiency [2]. Unlike other industrial sectors, the construction sector is very poorly integrated [3]. In the construction industry, the supply chain is more complex as compared with other industries [4] and it is very low repetitive due to the uniqueness of the products. Problems like adversarial relationships between project participants, profit maximization mentality of client-contractor are detrimental to the construction supply chains. Construction practitioners tried to remove adversarial inter-organizational relationships and fragmented business processes by using examples from other

industries but they need a better conceptual understanding of new and more systematic approaches [5].

Construction supply chains are networks of multiple organizations and relationships, which include the flow of information, the flow of materials, services or products, and the flow of funds between client, designer, contractor and supplier [6]. It is found that contract provisions are designed in such a way that they always favor the clients and put more pressure on contractors [4], [7]. These provisions often ignore difficulties of the different actors. The liabilities of the client and contractor are explicitly defined in the contract [8]. They don't want to share each other's responsibility. Moreover, projects generally involve one main contractor who relates to various subcontractors for the provision of components. Each subcontractor has different characteristics and scopes and this often results in conflicts and slowdowns of the workflow [9]. This type of relationship favors confrontation and adversity and hinders open communication and honesty among the actors in the construction supply chains [10]. Due to lack of synchronization of the activities carried out by the different actors in the construction process, there is huge variation in delivery times and work-in-process along the supply chains [3]. In order to avoid this problem, the relationship between the different actors has to be characterized by a high level of cooperation and transparency and by an effective communication [11].

There is extensive research dealing with quality and production planning issues in the construction supply chains. But organizational and strategic issues are often ignored [12]. Partnership is an attractive approach in the organizational level which can significantly enhance company performance by strengthening relationship among the different partners [13]. It is defined as a set of behaviors and practices, shared between actors that lead to win-win solutions. The main objective behind partnering or partnership is to fulfill a common goal while satisfying individual goal of each partner. It helps to improve quality and reduce conflicts among the different actors, thus creating an open and non-adversarial environment within the construction supply chains [14].

Depending on the time duration, partnership can be divided into 2 categories: project-based partnership and strategic partnership. Project based partnership refers to collaboration and operational integration to achieve better performances, like quality [15] or cost-reduction [16] at the short term level. At the conclusion of the project, the relationship is dissolved. There may be some best practices, with respect to process,

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quality, people and partners and environment, identified in the short-term level. However, due to the short-time of interaction, those practices will not be successful in their objectives and benefits. On the other hand, strategic partnership is a long-term commitment that spans several years and several projects. From the long term relationship, the partners can understand each other in a better way; they can learn from each other and easily adopt some of the best practices into their own work.

There are several elements like Lean approach, Relationship building and E-commerce applications which can influence partnership in the construction supply chains. But there is scarcity of research in identifying the particular areas within these elements. Therefore, an extensive literature review is carried out in order to understand better what has been done in those areas and to highlight promising future developments.

The objectives of this paper are as follows:

1. Investigate areas within different elements influencing partnership in construction supply chains.
2. Perform year wise analysis of literature over last 20 years to highlight the trend of identified areas within each element.

Literature review methodology for identifying main areas of partnership in construction supply chains is discussed in the next section.

II. LITERATURE REVIEW METHODOLOGY

A systematic literature review is done to identify the main areas of partnership in construction supply chains. Keywords related to partnership like "Lean", "collaboration", "construction", "modularization", "productivity", "contract", "supplier", "partnering", "procurement" and "partnership" have been used. Once papers were identified, the references were reviewed to assist in locating additional papers. This research produced lot of papers. Implementation of the further filter (mostly based on the analysis of the title, of the paper's keywords and of the abstract) led to 60 papers which are related to partnership in construction supply chains.

After going through the abstracts of these papers, it is found that partnership is influenced by several elements like Lean, Relationship building, E-commerce applications. Therefore, based on those elements, the literature is divided into three main categories:

- Lean approach – papers that primarily focus on suitability of Lean techniques in the process of construction supply chains.
- Relationship building – papers that primarily focus on trust, communication, organizational culture and mutual benefits among different actors in construction supply chains.
- E-commerce applications – papers that primarily focus on E-commerce applications like e-collaboration, e-procurement and IT applications in construction supply chains.

The categorization of literature with respect to different paper titles is shown in Table I.

According to categorization of literature as shown in Table I, there are 16 papers in "Lean approach", 32 papers in "Relationship building" and 12 papers in "E-commerce applications". These papers are then studied in details to identify potential areas within each category. Section III addresses the identified areas, exploring their influence on the partnership in the construction supply chains. The year wise literature analysis of different elements affecting partnership in construction supply chains for the last 20 years is explained in Section IV. Based on the literature, section V discusses the influence of E-commerce applications on partnership in construction supply chains. Finally, conclusion is drawn in Section VI.

III. PARTNERSHIP IN CONSTRUCTION SUPPLY CHAINS

This section describes the partnership in construction supply chains and its different aspects as revealed in the literature. There are different elements like Lean approach, Relationship building and E-commerce applications which can enhance this relationship (partnership) in construction supply chains. The different areas within each element are described in details in the following subsections.

A. Lean Approach

In this category, there are mainly two areas: Internal Lean view and External Lean view. Internal Lean view deals with the Lean techniques within the organization whereas External Lean view deals with the Lean implementation across the entire supply chain. Both areas are discussed below.

1. Internal Lean View

Internal Lean view deals with the firm's ability to see the value stream and to dispose its structure in order to be aligned with the flow [17]. This concept is strongly related to the department barriers' breakdown and to collaboration along the internal supply chain. The authors stated that people need to have a working identity and they try to identify themselves in a work position linked to a function (mechanical engineer or electrical technician), losing the whole view of the firms and the value stream flow. The effort of building a strong collaboration and partnership with partners has to be sustained by understanding the value of looking outside the single enterprise, but first of all companies need to build first a strong internal team [18], in fact internal collaboration is a fundamental issue, because it is the prerequisite to the external one [19]. As already stated, it is important to link internal collaboration, with external one, integrating processes and sharing information with customers and suppliers, avoiding larger organizational silos [20]. In order to achieve this objective, there are two fundamental instruments to achieve collaboration in the supply chain, downstream and upstream [21]: Customer relationship management that deals with collaborative demand planning, demand replenishment and shared distribution; Supplier relationship management that deals with supplier planning, production scheduling, collaborative design and collaborative transportations.

TABLE I
CATEGORIZATION OF LITERATURE

Paper title	Lean approach	Relationship building	E-commerce applications
A heuristic methodology for order distribution in a demand driven collaborative supply chain			
A review of the progress towards the adoption of supply chain management (SCM) relationships in construction			
Alliance contracting: adding value through relationship development			
An e-business model to support supply chain activities in construction			
An empirical investigation into supply chain management			
An Empirical Study of Information Flows in Multidisciplinary Civil Engineering Design Teams using Lean Measures			
An overview into the concept of partnering			
Behavioral aspects in construction partnering			
Communication risk and trust in construction projects: A framework for interdisciplinary research			
Consequences of competitive bidding in project-based production			
Constructing the team			
Construction industry productivity and the potential for collaborative practice			
Coordination mechanisms for construction supply chain management in the Internet environment			
Critical review of procurement method research in construction journals			
Defence sector procurement and supply chain relationships			
Designing Lean Supply Chains: A Case Study			
Developing the concept of supply strategy			
Effective applications of e-commerce technologies in construction supply chain: current practice and future improvement			
Efficiency versus effectiveness in construction supply chains: the dangers of "lean" thinking in isolation			
E-procurement in the Atlantic Canadian AEC industry			
Fairness in interorganizational project relations: norms and strategies			
Future proofing PPPs: Life-cycle performance measurement and Building Information Modelling			
Implementing supply chain partnering in the construction industry: Work floor experiences within a Dutch housing association			
Improving construction supply chain collaboration and performance: a lean construction pilot project			
Information procurement practices of key actors in construction supply chains			
Interdependence in supply chains and projects in construction			
Lean construction: arenas of enactment, models of diffusion and the meaning of 'leanness'			
Lean Management, Supply Chain Management and Sustainability: A Literature Review			
Managing subcontractor supply chain for quality in construction			
Multiobjective design of Work-In-Process buffer for scheduling repetitive building projects			
New trends on e-Procurement applying semantic technologies: Current status and future challenges			
On-Site Subcontractor Evaluation Method Based on Lean Principles and Partnering Practices			
Paradigm Shift in Main Contractor-Subcontractor Partnerships with an e-Procurement Framework			
Partnering Mechanism in Construction: An Empirical Study on the Chinese Construction Industry			
Planning for claims: an ethnography of industry culture			
Pre-construction project partnering: developing the process			
Problematic issues associated with project partnering — the contractor perspective			
Procurement Effects on Coopetition in Client-Contractor Relationships			
Procurement effects on trust and control in client-contractor relationships			
Project alliancing vs project partnering: a case study of the Australian National Museum Project			
Project partnering: Improving the likelihood of win/win outcomes			
Social e-business as support for construction e-procurement: e-procurement network dynamics			
Stakeholder management studies in mega construction projects: A review and future directions			
Strategic orientation in evaluation of supply chain activities			
Strategic Procurement Practices for the Industrial Supply Chain			
Supplier development initiatives and their impact on the consistency of project performance			
Supplier selection process in an integrated construction materials management model			
Supply chain management: a review of implementation risks in the construction industry			
Supply strategy and network effects - purchasing behaviour in the construction industry			
Supply-chain transparency within industrialized construction projects			
Survey of digital technologies in procurement of construction projects			
Swedish construction culture, management and collaborative quality practice			
The Collaborative Supply Chain			
The engineering or evolution of co-operation? A tale of two partnering projects			
The four roles of supply chain management in construction			
The nature and effectiveness of collaboration between firms, their customers and suppliers: a supply chain perspective			
The Research of E-commerce Supply Chain Construction in Chinese Small & Medium-sized Enterprises			
The rhetoric and reality of supply chain integration			
Understanding the meaning of collaboration in the supply chain			
Validating a model of cooperative procurement in the construction industry			

2.External Lean View

Collaboration is not only based on operational activity level, but also on tactical and strategic level, in the organization across the supply chain [21]. In fact, the process integration only at an operational level leads to limited benefits of integration [20]. Developing collaborative relationship requires a strong effort both internally and externally [22] and there is need for programs that sustain collaborative initiatives and that fight against the internal resistance to change [23]. But when Lean principles are applied beyond the industry into the entire supply chain, there may be potential conflict due to high levels of variability. The Lean approach is best suited for high volume low variety predictable demand with supply certainty. But for high variety and volatile supply chains, there should be more flexible system to tackle the unpredictable customer requirements. However, it is found that the Lean approach can add value to the customer by enhancing the capability of the resources so that they can better manage variability in market demand in an efficient manner [22].

Adopting cross-functional activities permits to destroy boundaries between organizations, that restrict information sharing and collaborations between partners [24]. But the vast majority of supply chain metrics are internal measurement [5] that is inappropriate to a supply chain view [25]; the complexity of overlapping supply chain is the main barrier to develop a unique metric [5].

B. Relationship Building

This category is particularly important because without relationship, partnership cannot exist. There are four major areas in this category: Trust, Effective communication, Organizational structures and culture, and Mutual benefits among different actors. These areas are discussed below.

1.Trust

In order to reach to a higher degree of value creation and excellence along the supply chain, it is necessary to obtain full knowledge of the partner. However, in a variable and risky contest like construction, it is not possible to achieve full knowledge of all the aims and intentions of the actors of the supply chain. Trust plays an important role to overcome this deficiency [26]. For a more radical and profound change and evolution, a spontaneous approach is required, which can only be reached through trust [27]. Control is often present in contracts but, contract incompleteness and opportunism are a high risk in such complex context as construction. If there is too much control, it reduces trust and fails to improve relationships in the long run.

Trust is an ambiguous and complex phenomenon and researchers have concentrated on diverse aspects of trust and processes of trust development [28]. In an effort to bring together the elements most frequently cited in works from various theoretical perspectives, a definition is given in [29], "Trust is a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behavior of another". Thus, trust is regarded as a

psychological state, not a behavior, and it is not equivalent to co-operation. Cooperation is the product of trust, even if it does not necessarily require trust; it may also be induced by coercion. However, trust is considered vital to bring about farther reaching co-operative processes [8]. If trust is present, people can spontaneously engage in constructive interaction without pondering what hidden motives exchange partners might have, which is formally responsible for problems, or the risks of disclosing information [30]. Trust also has direct costs for building trust, potential costs for breach of trust and costs of inefficiency related to excessive trust [10]. This enables long term profitable collaborations, but there are some risks of trust, which should be mitigated through proper control.

2.Effective Communication

Next important area is effective communication. During the project development, it is important to introduce alignment and communication across the entire supply chain [31]. There is significant improvement in performance through sharing information in supply chain [32] and it is at the basis of JIT system. In fact, establishing direct communication between customer-supplier and other actors' permits all participants to involve at the start of the project and keeps them informed about the evolution of the project [33]. A more open, frequent, and accurate exchange of information would permit companies to ensure ongoing improvement. Sharing up-to-date information between participants reduces errors and time delays and consequently facilitates more effective and efficient productivity, ultimately improving collaboration and teamwork [32].

3.Organizational Structures and Culture

The organizational culture is an integral part of any comprehensive approach to management theory and practice. Every supply chain has to be featured by different strategy, culture, leadership style and different requirements from the stakeholders [34]. As partnership may suggest for another way of working, change in organizational structures and culture is very important [35] in the construction supply chains. However, organizations don't have specific ideas about how to accomplish this change in culture. How to make culture receptive to radical technological and organizational improvements is still a big challenge. The project leader's self-reflection could make them more aware of the changes and therefore help to change in behavior in the organization.

Culture is defined as a complex system which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society [35]. In the construction industry, the main contractor has favorable cash flow due to interim payment by clients, combined with delays in payment to sub-contractors and suppliers. The contractors make the situation more complex by a tendering strategy. In this strategy, it involves submitting tenders at expected prices but the ultimate price of the job will be decided by claims. Claims should be carefully planned and the expected return should be calculated with a degree of accuracy otherwise the contractor would render a negative

profit if the quantities are changed [36]. This strategy of planning for claims forbids smaller contractors to enter into the market at tender stage. There will be conflicts between contractors and clients and this will create a negative image for the industry. Moreover, sometimes clients will often refuse or make delayed payments but contractors need to maintain positive cash flow in order to maintain profitability. Therefore, they try to withhold payments from sub-contractors and suppliers.

With increase in subcontracting, the construction industry now concentrates mainly on transaction costs rather than the organization costs [36]. The incidence of claims is often highly opportunistic, in situations of specialist information and with major presence of asset specificity. There are several different kinds of reasons for claims like poor weather conditions or the site of production is new for each project. But organizational conditions like mistakes in calculating quantities, bad planning and ineffective communication are the most vital reasons for claims. There are three kinds of pressure, which lead to inadequate design in the public sector. Firstly, due to pressure from the government, consultants have to accept the lowest tender. Secondly, at the end of the financial year, inflexible budgetary arrangements force the organization to spend the remaining money instead of losing it. Thirdly, the numerous stakeholders can create continuous pressure on the organizations that can lead to uncertainty as to the requirements of the design.

Culture is usually a covering concept, which intends to strengthen industry members' own accounts of industry activities against external analytic distortion. It enables the organizations to focus on major features like the predictability of claims and their utility in both proactive and reactive planning by contractors in a holistic manner. The main pillar behind any culture is its familiarity with its participants [37]. Knowledge sharing that a culture disseminates among its members often leads to best practices which help the partners to survive for a longer time. Therefore, it can be said that although culture may become dormant but able to revive itself when conditions become more favorable.

4. Mutual Benefits among Different Actors

In partnership, each actor tries to look into its own benefits. Therefore, mutual benefits need to be investigated properly before making any partnership. Firms, in their journey towards partnership, have to select a small number of strategically important customers and suppliers [38], to ensure successful collaboration. Because customers have different needs and expectations and are disposed to pay different prices, segmentation is fundamental. Supply chain segmentation is based on the concept that a unique supply chain can't satisfy all the kind of customers [39], for this reason, it is important to differentiate supply chain in accordance with customers' specific needs [38]. Segmentation helps firms to tailor service offerings, targeting the specific customer's requirements, by identifying their long-term requirement and expectations [40]. Moreover, supplier relationship management is critical to face competitive pressures, sustainability and risk, to achieve cost

efficiency in order to be cost competitive, to develop closer relationships with key suppliers who can provide the expertise necessary to develop innovative new products and successfully bring them to market [41]. It has been shown that integration of operations with suppliers can improve firm performance [39]. An additional benefit of cross functional, collaborative relationships with key suppliers is the ability to co-create value [40]. Due to the limited amount of resources, it is not possible to fulfill the unlimited wants and needs of customers and suppliers [38]. Therefore, it is important to allocate time strategically and resources to customers and suppliers that are most important to the company's success to ensure a sustainable profit. Once the different supply chains have been identified, it is then possible to manage better the relationships with customers and suppliers.

Apart from customer and supplier relationships, mutual benefits can also be observed from relationships between other actors of the construction supply chains. It is found out in the literature that contractors and clients are always in competition regarding procurement related issues. But both the parties will be mutually benefitted if they cooperate with each other [42]. In most of the projects, the main contractor strongly depends on a number of subcontractors. The contractor can give some incentives to the subcontractors so that they will be concerned about the quality from which contractor will obtain benefit [15].

C. E-commerce Applications

Nowadays, internet plays an important role in our daily life. Therefore, internet-based applications or E-commerce applications are becoming popular in almost all types of industries. There are 3 major areas influencing partnership in construction supply chains: IT Applications, E-procurement and E-collaboration which are discussed below.

1. IT Applications

With the advancement in information technology (IT), most of the businesses become online. However, IT applications are not widely investigated in the construction industry [43], [44]. All activities related to collaborative procurement have to be supported by IT systems. Information sharing is fundamental both vertically and horizontally in the channel [45]. Information sharing in buyer-supplier relationships can occur in three ways: Vertical information sharing, Horizontal information sharing and Information dissemination. Information sharing is not enough; firms should keep their attention on quality and transparency of information in the supply chain. In this way, it is possible to eliminate limited visibility and improve integration [6]. The benefits of communication are not solely visible on site operations, but also on a corporate and strategic level, where it is possible to develop jointly a building concept from the early stages.

IT is fundamental to sustain efficiency of planning activities; however IT tools are largely directed within a single business function, within a single firm, and they are also directed at execution of traditional construction tasks and are not explicitly directed towards supply chain practice [6]. There

is a class of hardware coupled with complementary software tools like 'Building Information Modeling' that improve the productivity and help track construction equipment and material at the construction site and/or through the construction supply chains.

2. E-Procurement

In industries other than construction, adaptation of e-procurement systems has produced huge pool of information related to both use and implementation. It is found in the literature that e-procurement enables the procurement process to be more efficient and effective. It has an impact on overall firm performance. The benefits for implementing e-procurement are: an increase in process quality, reduced procurement cost, user satisfaction, increased responsiveness, improved customer service, product innovation, market expansion, reduction in purchasing cycle time, reduction in staff time and managerial effectiveness [43]. But the empirical studies fail to provide complete list of benefits and associated costs for each specific industry. Although the value of IT investments is a hot topic in most of the industries, research shows that most construction firms are unaware about the benefit of IT investments and how does implement them for procurement purposes. Some authors tried to benchmark value derived from the e-procurement implementation in the construction industry with manufacturing industries based on certain criteria [46]. Those criteria include business unit, supply chain structure, business attitude, process type, process complexity, category of products, maturity of technology infrastructure, and flexibility of technology infrastructure.

Most of the existing E-commerce applications in the construction supply chains are web-based applications that facilitate real-time communication and collaboration. Although there is some progress in e-procurement in construction, still extensive research needs to be carried out to address issues like integration of different procurement activities into a single system such that procurers can adopt to manage the entire construction procurement lifecycle [47].

3. E-Collaboration

E-collaboration encourages the use of electronic technologies among the actors beyond market transactions. Literature shows that e-collaboration is one of the latest areas by which the relationship between suppliers and original equipment manufacturers is optimized via the Internet. It is an enterprise-spanning cooperation which is considered to be vital during the execution of the construction project. It enables coordination of various supply chain activities and decision-making processes [43]. In the current Web-based supply chain environment, it acts as an important player in achieving a sustainable competitive edge. In e-collaboration, there is mutual exchange of information among different members in the supply chain. Apart from information sharing, it also provides opportunities for collaborative planning and new product development. There is easy exchange of product forecasts and replenishment plans among supply chain partners. New plans that meet market demand are developed

in a timely and effective way. Successful implementation of e-collaboration helps to enhance the overall efficiency of the construction supply chains as well as customer satisfaction. Year wise literature analysis of different elements affecting partnership in construction supply chains is described in the next section.

IV. LITERATURE ANALYSIS

After categorizing the literature of partnership in construction supply chains into different elements, the literature is analyzed over time to obtain better view of different areas within each element. All the literature for the different elements for the last 20 years (1996-2015) is considered for the analysis. The trend of literature over time is studied as shown in Table II.

TABLE II
TREND OF LITERATURE OVER TIME

Years	Topics		
	Lean approach	Relationship building	E-commerce applications
1996		1	
1997			
1998		2	
1999	1		
2000	1	2	
2001		1	1
2002		6	
2003		2	
2004	1	2	
2005	2	1	
2006	1	2	2
2007	1	1	1
2008		1	
2009	1	2	
2010	4		1
2011		2	
2012	1	1	
2013			1
2014	2	3	4
2015	1	3	2

From Table II, it is observed that papers are evenly distributed over years in the first two elements "Lean approach" and "Relationship building". But for "E-commerce applications", almost 60% papers belong to the last 5 years.

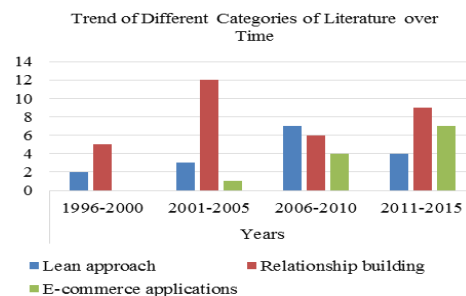


Fig. 1 Trend of different categories of literature over time

With the rapid development of IT technology, there is increasing focus of E-commerce applications like e-procurement, e-collaboration in construction supply chains which is clearly seen in Fig. 1. Then, each element is drilled down and it is found out that each element can be further subdivided: Lean approach – Internal Lean view, External Lean view; Relationship building – Trust, Effective communication, Organizational structures and culture, Mutual benefits among different actors; E-commerce applications – IT Applications, E-procurement, E-collaboration.

For better understanding, further analysis of the literature over 5 years' time bucket is carried out. As papers are collected from 1996 to 2015, 4 buckets are considered. The distribution of the papers over years is shown in Tables III-V.

TABLE III
SUBCATEGORIES OF LEAN APPROACH OVER TIME

Topics		Topics	
Years	Internal Lean view	Years	External Lean view
1996		2006	1
1997		2007	1
1998		2008	
1999		2009	1
2000		2010	2
2001		2011	
2002	1	2012	1
2003		2013	
2004	1	2014	2
2005	2	2015	1

In Table III, it is seen that instead of internal Lean view, more focus is given on external Lean view in construction supply chains in recent years. In Lean approach, from the period (1996-2000), there are 2 papers on external Lean view. These papers mainly discuss about how the construction industries can connect to the external environment using Lean techniques. For the period (2001-2005), there are 4 papers on internal Lean view. These papers mainly focus on the inter-organizational Lean culture. For the period (2006-2010), there are 4 papers on external Lean view and only one paper on internal Lean view. For the period (2011-2015), there are 4 papers on external Lean view and only one paper on internal Lean view. From 2006 to 2015, there are more papers on external Lean view than on internal, focusing mainly on the interaction of internal and external actors of the construction supply chain using Lean culture. This signifies that construction industries should focus on end to end supply chain in order to obtain maximum benefits from Lean culture.

In Table IV, it is observed that extensive research is carried out in mutual benefits among different actors in Relationship building category. From the period (1996-2000), there are two papers on Trust, two papers on Organizational structures and culture and one paper on Mutual benefit among different actors. In this period, more focus is given on Trust and Organizational culture related issues in Relationship building. For the period (2001-2005), there are 4 papers on Trust, one paper on Effective communication, 4 papers on Organizational

structures and culture and 3 papers on Mutual benefits among different actors. During this period, although more focus is still on Trust and Organizational structures and culture, there is emergence of literature on Effective communication and Mutual benefits among different actors. For the period (2006-2010), there are 2 papers on Trust and 4 papers on Mutual benefits among different actors. In this period, more focus is on Mutual benefits among different actors. For the period (2011-2015), there are one paper on Trust, two papers on Effective communication, one paper on Organizational structures and culture and 5 papers on Mutual benefits among different actors. During the last 5 years, Mutual benefits among different actors outstands the other areas. This signifies that Trust and Organizational structures and culture are more important in the period (1996-2005), Effective communication is little bit studied but Mutual benefits among different actors is most significant in the recent years.

TABLE IV
SUBCATEGORIES OF RELATIONSHIP BUILDING OVER TIME

Years	Topics		
	Trust	Effective communication	Mutual benefits among different actors
1996			1
1997			
1998	1		1
1999			
2000	1		1
2001		1	
2002	2		2
2003	2		
2004			1
2005			1
2006			2
2007	1		
2008			1
2009	1		1
2010			
2011		1	1
2012			1
2013			
2014		1	2
2015	1		1

From Table V, it is observed that more importance is given on E-procurement. In E-commerce applications, from the period (1996-2000), there is no paper because nobody can imagine of such kind of applications in the construction industry. For the period (2001-2005), there is only one paper on E-procurement. This period observes the appearance of E-commerce applications in construction supply chain. For the period (2006-2010), there is one paper on IT Applications, two papers on E-procurement and one paper on E-collaboration. During this period, E-commerce applications creep into the construction supply chain in order to enhance partnership. For the period (2011-2015), there are one paper on IT Applications, 5 papers on E-procurement and one paper on E-collaboration. It is observed that the trend in research for E-

commerce applications increases within last 5 years, especially in the field of E-procurement. This signifies the importance of E-commerce applications in partnership in construction supply chains in today's world.

Some of the features of E-commerce applications in partnership found in the literature are discussed in details in the next section.

TABLE V
SUBCATEGORIES OF E-COMMERCE APPLICATIONS OVER TIME

Years	Topics		
	IT Applications	E-procurement	E-collaboration
1996			
1997			
1998			
1999			
2000			
2001		1	
2002			
2003			
2004			
2005			
2006		1	1
2007	1		
2008			
2009			
2010		1	
2011			
2012			
2013		1	
2014		3	1
2015	1	1	

V. E-COMMERCE APPLICATIONS IN PARTNERSHIP

In order to improve the supply chain in the construction industry, a network structure should be adopted to establish the organizational relations and this structure is founded on the concept of partnership [48]. The network structure is different from the traditional vertical relationship in the sense that it encourages responsiveness, cohesiveness, flexibility, interoperability and compatibility. It is also viewed as a value-added activity in the formal contracting relationship. The inter-organizational sharing of resources and competencies are very important elements in a network structure. To support these activities, proper communication and co-ordination need to be maintained. There is an important role of information technology (IT) in improving communication and coordination in construction [44]. IT is the main enabler of E-commerce applications between organizations in the construction supply chains. E-commerce applications involve the interchange of goods, services, property, ideas or communications through an electronic medium for purposes of facilitating partnership. Moreover, it is suggested by some authors that the interchange of information between partners through E-commerce applications will reduce communication, negotiation and co-ordination barriers [47]. But it will take more time to adopt E-commerce applications in the construction supply chains due to security issues, financial

costs, and changes to existing business practices, and a lack of management commitment [45].

A. Framework for E-Commerce Applications

E-commerce applications need to reconfigure the normal activities performed within the construction supply chains which will create infrastructure reorganization. Such infrastructure creates suitable environment to achieve the common goals of the project as well as contributes to the business objectives of individual organizations. The factors that should be addressed for the establishment of framework for E-commerce applications are: resource planning, teamwork, process improvement tools and techniques and information management. These factors will be discussed in details in the following subsections.

1. Resource Planning

Traditionally in the construction industry, each party plans its own resource, whereas joint resource planning across the entire organization is not present. As a result, there may be over-estimation or under-estimation of resources across the organization. However, the integration of the partners through E-commerce platform helps to establish an overall resource planning, which will estimate the necessary resources accurately and search for the appropriate resources [48]. Therefore, the resources will be effectively organized and managed across the organization. The pool of resources created by this resource planning supports the project activities and tasks.

2. Teamwork

Another key characteristic of a construction project is the teamwork. It is revealed that a construction project is benefited by an inter-organizational team [48]. The team can discuss together and decide for the future construction projects coherently. With the access of internet, the team can easily visualize the links between different portions of a project and the links between the project and different parties. Team members will be creative thinkers and possess problem solving skills. They will be given opportunity to develop policy and future planning for the team.

3. Process Improvement Tools and Techniques

In the construction industry, few technical tools and techniques are utilized to execute the projects. Therefore, it is essential for the construction partners to exploit the full potential of both available and developing technology in order to sustain their competitive positioning. Internet not only can help to search for new development in construction technology but also help parties to benchmark the technology from their partners or even competitors [48]. Therefore, process improvement tools and techniques contribute to the success of organizations by strengthening the capability of the supply chain.

4. Information Management

To make the construction project successful, there should be smooth flow of information between parties from the

beginning to the end of the project. Therefore, information management is a core function of the supply chain. The computer is compulsory to enhance this function by speeding up the transmission of information and expanding the storage capacity. Moreover, instead of the traditional use of mail, telephone or face-to-face contact, electronic media like e-mail and video conferencing can be used for exchanging and conveying construction knowledge and information [49]. Internet based E-commerce helps in quick transmission of both structured and unstructured information in a supply chain network [50]. A security system incorporated in information management categorizes the users to send or retrieve information so that unauthorised users will not be able to access to confidential information. Moreover, information management can help the organization in defining the future information needs for the supply chain.

B. Barriers for E-Commerce Applications

In the construction industry, it is not straight forward to implement E-commerce applications to enhance partnership among the different actors. There are some barriers, which can hinder E-commerce applications. Some of the identified barriers are as below:

- Cost of investment: E-commerce applications are cost intensive and require huge amount of initial investment. Profit is realized only after running the business for a long time. In the construction industry, partners seek for profit from the beginning and they will not agree entering into partnership and investment if they could not find any benefit in the initial years [46]. Therefore, cost of investment is big challenge for implementing E-commerce applications in partnership in the construction supply chains.
- Absence of Long-term relationship with customers: Contractors will not obtain full benefits from E-commerce applications immediately but they should wait for long time [46]. But they should have constant fund to keep the project alive for a longer time. Therefore, it is necessary to make long-term relationship with customers. But most customers in the construction industries will not always wait for long time and they will require immediate results. Thus, long-term relationship with customers is a barrier to E-commerce applications in partnership.
- Technical issues: Technical issues are the biggest challenges for E-commerce applications in partnering [50]. In most of the construction industries, there is no proper infrastructure for implementing E-commerce applications. So, it is really difficult and time consuming to setup the infrastructure and then establish E-commerce applications. Moreover, during project execution, if IT system does not work properly, then the whole system will be collapsed.

Thus it can be inferred that E-commerce applications are becoming more important in enhancing partnership in the construction supply chains. However, the above mentioned barriers need to be tackled in order to achieve full-fledged benefits from those applications.

VI. CONCLUSION

Literature in construction supply chains is analyzed in order to highlight elements influencing partnership. The papers for the last 20 years (1996-2015) are considered for the analysis. Based on the literature, it is found out that there are three different elements, "Lean approach", "Relationship building" and "E-commerce applications", which influence partnership in construction supply chains. Then, trend analysis of literature for three different streams is performed over the last 20 years to highlight potential areas of research regarding partnership in construction supply chains.

To establish partnership, construction industries should start with internal Lean view. People within the industry should be aware about values derived from implementation of different Lean techniques. They should cooperate with each other in achieving the ultimate goal of the organization. Once there is strong collaboration in the internal environment, then it should interact with the external environment through two fundamental instruments like customer relationship management and supplier relationship management. Customer relationship management and supplier relationship management help in achieving collaboration in the construction supply chains.

Before establishing collaboration, it is important to know about the partners but in construction industry it is difficult to gather information about the partners for which we require elements like trust or coercion/control. Apart from trust, organizational culture helps to increase the strength of the people to resist against the external disorders that may occur during partnership in the construction supply chains. Inter-organizational learning and continuous improvement will bring the partnership to perfection. In collaboration, particularly in case of supplier relationship management, it is important to identify potential suppliers and establish long term relationship with them. It will help to mitigate the variation within the supply chain and mutual benefits can be derived out of this relationship. Traditionally, bidding was done in such a way that the partner having more bargaining power derived more benefit. However, nowadays, a new approach based on cooperation is carried out so that benefits are equally distributed among the partners. In order to have a smooth flow along the entire supply chain, information sharing is very important for which different IT tools are used in the construction industry. Moreover, the E-commerce applications like e-procurement and e-collaboration will enhance the partnership and improve the overall performance of the construction supply chains.

From the literature analysis carried out over last 20 years, it is found out that papers are evenly distributed over years in "Lean approach" and "Relationship building" but there is increasing trend of papers in "E-commerce applications" over the last 5 years. For better understanding, literature for different areas of each element is analyzed within 5 years' time bucket over last 20 years. It is revealed that more focus is given on "External Lean view" rather than "Internal Lean view" which implies that construction industries should concentrate Lean culture for end-to-end supply chain. There is

extensive research on “Trust” and “Organizational structures and culture” in the period (1996-2005) but “Mutual benefits among different actors” is most significant in “Relationship building” in the recent period. There is no significant research in “E-commerce applications” in the period (1996-2005) but papers in the last 5 years signify the importance of this category, particularly e-procurement, in enhancing partnership in construction supply chains.

In order to compete with today’s high-end technology; a network structure needs to be adopted in the construction supply chains with the help of E-commerce applications. IT helps in enabling E-commerce applications in construction supply chains. E-commerce applications will enhance partnership by reducing communication, negotiation and co-ordination barriers. But it will take more time to change the perception of the people and build a proper infrastructure for implementing E-commerce applications. The main factors that need to be addressed for the establishment of framework are: resource planning, teamwork, process improvement tools, and techniques and information management. As benefits of E-commerce applications will not be observed immediately, there will be barriers like cost of investment, absence of long-term relationship with customers and technical issues.

REFERENCES

- [1] Z. Shehu, I. R. Endut, A. Akintoye, and G. D. Holt, “Cost overrun in the Malaysian construction industry projects: A deeper insight,” *Int. J. Proj. Manag.*, vol. 32, no. 8, pp. 1471–1480, 2014.
- [2] V. González, L. F. Alarcón, and K. Molenaar, “Multiobjective design of Work-In-Process buffer for scheduling repetitive building projects,” *Autom. Constr.*, vol. 18, no. 2, pp. 95–108, 2009.
- [3] A. Fearn, and N. Fowler, “Efficiency versus effectiveness in construction supply chains: the dangers of “lean” thinking in isolation,” *Supply Chain Manag.: An Int. J.*, vol. 11, no. 4, pp. 283–287, 2006.
- [4] S. Maturana, L. F. Alarcón, P. Gazmuri, and M. Vrsalovic, “On-Site Subcontractor Evaluation Method Based on Lean Principles and Partnering Practices,” *J. Manag. Eng.*, vol. 23, no. 2, pp. 67–74, 2007.
- [5] R. Vrijhoef, and L. Koskela, “The four roles of supply chain management in construction,” *Eur. J. Purch. Supply Manag.*, vol. 6, no. 3–4, pp. 169–178, 2000.
- [6] X. Xue, Y. Wang, Q. Shen, and X. Yu, “Coordination mechanisms for construction supply chain management in the internet environment,” *Int. J. Proj. Manag.*, vol. 25, pp. 150–157, 2007.
- [7] G. H. Briscoe, A. R. J. Dainty, S. J. Millett, and R. H. Neale, “Client led strategies for construction supply chain improvement,” *Constr. Manag. Econ.*, vol. 22, no. 2, pp. 193–201, 2004.
- [8] S. O. Cheung, T. S. T. Ng, S. P. Wong, and H. C. H. Suen, “Behavioral aspects in construction partnering,” *Int. J. Proj. Manag.*, vol. 21, pp. 333–343, 2003.
- [9] M. S. M. Danuri, Z. M. Ishan, N. E. Mustaffa, and M. S. Jaafar, “A revisit on the current practice of dispute resolution and ADR in the Malaysian construction industry,” *J. Des. Built Env.*, vol. 10, no. 1, pp. 1–13, 2012.
- [10] M. Saad, M. Jones, and P. James, “A review of the progress towards the adoption of supply chain management (SCM) relationships in construction,” *Eur. J. Purch. Supply Manag.*, vol. 8, no. 3, pp. 173–183, 2002.
- [11] J. C. P. Cheng, K. H. Law, H. Björnsson, A. Jones, and R. D. Sriram, “Modeling and monitoring of construction supply chains,” *Adv. Eng. Informatics*, vol. 24, no. 4, pp. 435–455, 2010.
- [12] A. Dainty, I. Grugulis, and D. Langford, “Understanding construction employment: the need for a fresh research agenda,” *Persn. Rev.*, vol. 36, no. 4, pp. 501–508, 2007.
- [13] A. Dubois, and L. E. Gadde, “Supply strategy and network effects - purchasing behavior in the construction industry,” *Eur. J. Purch. Supply Manag.*, vol. 6, pp. 207–215, 2000.
- [14] M. Latham, “Constructing the team: final report by Sir Michael Latham; Joint review of procurement and contractual arrangements in the United Kingdom construction industry”, *London: HMSO*, 1994.
- [15] K. Karim, M. Marosszeky, and S. Davis, “Managing subcontractor supply chain for quality in construction”, *Eng. Constr. Architect. Manag.*, vol. 13, no. 1, pp. 27–42, 2006.
- [16] C. M. Harland, R. C. Lammings, and P. D. Cousins, “Developing the concept of supply strategy”, *Int. J. Oper. Prod. Manag.*, vol. 19, no. 7, pp. 650–674, 1999.
- [17] P. J. M. Jurado, and J. M. Fuentes, “Lean Management, Supply Chain Management and Sustainability: A Literature Review”, *J. Cleaner Prod.*, vol. 85, pp. 134–150, 2014.
- [18] D. Aloini, R. Dulmin, V. Mininno, and S. Ponticelli, “Supply chain management: a review of implementation risks in the construction industry”, *Business Proc. Manag. J.*, vol. 18, no. 5, pp. 735 – 761, 2012.
- [19] S. E. Fawcett, and G. M. Magnan, “The rhetoric and reality of supply chain integration”, *Int. J. Physic. Dist. Log. Manag.*, vol. 32, no. 5, pp. 339–361, 2002.
- [20] L. Bankvall, L.E. Bygballe, A. Dubois, and M. Jahre, “Interdependence in supply chains and projects in construction”, *Supply Chain Manag.: An Int. J.*, vol. 15 no. 5, pp. 385–393, 2010.
- [21] M. Barratt, (2004), “Understanding the Meaning of Collaboration in the Supply Chain”, *Supply Chain Manag.: An Int. J.*, vol. 9, no. 1, pp. 30–42, 2004.
- [22] K. Chantarachalee, H. Carvalho, and V. A. C. Machado, “Designing Lean Supply Chains: A Case Study”, *Advan. Intelligent Syst. Comp.*, vol. 280, pp. 797–807, 2014.
- [23] R. Fulford, and C. Standing, “Construction industry productivity and the potential for collaborative practice”, *Int. J. Proj. Manag.*, vol. 32, pp. 315–326, 2014.
- [24] P. E. Eriksson, “Improving construction supply chain collaboration and performance: a lean construction pilot project”, *Supply Chain Manag.: An Int. J.*, vol. 15, no. 5, pp. 394–403, 2010.
- [25] S. Naoum, and C. Egbu, “Critical review of procurement method research in construction journals”, *Proc. Econ. Fin.*, vol. 21, pp. 6–13, 2015.
- [26] P. J. Singh, and D. Power, “The nature and effectiveness of collaboration between firms, their customers and suppliers: a supply chain perspective”, *Supply Chain Manag.: An Int. J.*, vol. 14, no. 3, pp. 189–200, 2009.
- [27] P. E. Eriksson, and A. Laan, “Procurement effects on trust and control in client-contractor relationships”, *Eng. Constr. Architect. Manag.*, vol. 14, no. 4, pp. 387–399, 2007.
- [28] S. Naoum, “An overview into the concept of partnering”, *Int. J. Proj. Manag.*, vol. 21, pp. 71–76, 2003.
- [29] D. M. Rousseau, S. B. Sitkin, R. S. Burt, and C. Camerer, “Not So Different After All: A Cross-Discipline View Of Trust”, *Acad. Manag. Rev.*, vol. 23, no. 3, pp. 393–404, 1998.
- [30] M. Venselaar, V. Gruis, and F. Verhoeven, “Implementing supply chain partnering in the construction industry: Work floor experiences within a Dutch housing association”, *J. Purch. Supply Manag.*, vol. 21, pp. 1–8, 2015.
- [31] A. Ceric, “Communication risk and trust in construction projects: a framework for interdisciplinary research”, *Manag.*, pp. 835–844, 2014.
- [32] P. Davis, and P. Love, “Alliance contracting: adding value through relationship development”, *Eng. Constr. Architect. Manag.*, Vol. 18, No. 5, pp. 444 – 461, 2011.
- [33] F. T. Edum-Fotwe, A. Thorpe, and R. McCaffer, “Information procurement practices of key actors in construction supply chains”, *Eur. J. Purch. Supply Manag.*, vol. 7, no. 3, pp. 155 – 164, 2001.
- [34] K. Y. Mok, G. Q. Shen, and J. Yang, “Stakeholder management studies in mega construction projects: A review and future directions”, *Int. J. Proj. Manag.*, vol. 33, pp. 446–457, 2015.
- [35] A. Kadefors, “Fairness in interorganizational project relations: norms and strategies”, *Constr. Manag. Econ.*, vol. 23, no. 8, pp. 871–878, 2005.
- [36] J. Rooke, D. Seymour, and R. Fellows, “Planning for claims: an ethnography of industry culture”, *Constr. Manag. Econ.*, vol. 22, no. 6, pp. 655–662, 2004.
- [37] G. Graham, and G. Hardaker, “Defence sector procurement and supply chain relationships”, *Supply Chain Manag.: An Int. J.*, vol. 3, no. 3, pp. 142–148, 1998.
- [38] J. Gosling, M. Naim, D. Towill, W. Abouarghoub, and B. Moone, “Supplier development initiatives and their impact on the consistency of

- project performance", *Constr. Manag. Econ.*, DOI: 10.1080/01446193.2015.1028956, 2015.
- [39] O. Pesamaa, P. E. Eriksson, and J. F. Hair, "Validating a model of cooperative procurement in the construction industry", *Int. J. Proj. Manag.*, vol. 27, pp. 552–559, 2009.
- [40] M. M. Azambuja, S. Ponticelli, and W. J. O'Brien, "Strategic Procurement Practices for the Industrial Supply Chain", *J. Constr. Eng. Manag.*, vol. 140, no. 7, pp. 1–4, 2014.
- [41] M. Safa, A. Shahi, C. T. Haas, and K. W. Hipel, "Supplier selection process in an integrated construction materials management model", *Auto. Constr.*, vol. 48, pp. 64–73, 2014.
- [42] P. E. Eriksson, "Procurement Effects on Coopetition in Client-Contractor Relationships", *J. Constr. Eng. Manag.*, vol. 134, no. 2, pp. 103–111, 2008.
- [43] P. X. W. Zou, and Y. Seo, "Effective applications of e-commerce technologies in construction supply chain: current practice and future improvement", *J. Infor. Constr.*, vol. 11, pp. 127–147, 2006.
- [44] S. J. Eom, S. C. Kim, and W. S. Jang, "Paradigm Shift in Main Contractor-Subcontractor Partnerships with an e-Procurement Framework", *KSCE J. Civil Eng.*, DOI 10.1007/s12205-015-0179-5, 2015.
- [45] P. E. D. Love, J. Liu, J. Matthews, C. P. Sing, and J. Smith, "Future proofing PPPs: Life-cycle performance measurement and Building Information Modelling", *Auto. Constr.*, vol. 56, pp. 26–35, 2015.
- [46] J. H. Rankin, Y. Chen, and A. J. Christian, "E-procurement in the Atlantic Canadian AEC industry", <http://itcon.org/2006/06/>, 2006.
- [47] E. O. Ibem, and S. Laryea, "Survey of digital technologies in procurement of construction projects", *Auto. Constr.*, vol. 46, pp. 11–21, 2014.
- [48] E. W. L. Cheng, H. Li, P. E. D. Love, and Z. Irani, "An e-business model to support supply chain activities in construction", *Logistics Infor. Manag.*, vol. 14, no. 1/2, pp. 68–78, 2001.
- [49] E. Tribelsky, and R. Sacks, "An Empirical Study of Information Flows in Multidisciplinary Civil Engineering Design Teams using Lean Measures", *Architec. Eng. Design Manag.*, vol. 7, no. 2, pp. 85–101, 2011.
- [50] J. M. A. Rodriguez, J. E. L. Gayo, and P. O. Pablos, "New trends on e-Procurement applying semantic technologies: Current status and future challenges", *Comp. Ind.*, vol. 65, pp. 800–820, 2014.