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IDENTIFYING CRITICAL FACTORS FOR EFFECTIVENESS OF CONSTRUCTION SUPPLY CHAIN IN INDIA

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The goal of this study is to analyze the various supply chain practices prevailing in Indian Construction Industry and find out the underlying factors, which are impacting the effectiveness of Construction Supply Chain (CSC). The study has adopted a quantitative research method to enquire about the supply chain dimensions impacting effectiveness. Twenty five (25) variables have been identified from the existing literature review and exploratory interviews with 07 construction professionals having more than fifteen year of experience. The Questionnaire survey has been conducted in both online and offline format. One hundred nineteen (119) complete responses were received and 102 responses were used for data analysis purpose, as 17 responses were filtered through data cleaning process. All the respondents are the construction professionals, who are/have been working within construction industry environment. An Exploratory Factor Analysis (EFA) has been performed to find out the factors (constructs), which impacts the effectiveness of the construction supply chain. Five factors (Client Relationship Management, Technology and Information Integration, Flexibility of the Supply Chain, Supplier Partnership and Inventory/Storage Management) attributing effectiveness of the CSC were identified through EFA. The internal consistency of the scale have been achieved with 0.8 Cronbach alpha value. All the individual five factors are also satisfying the minimum required Cronbach Alpha value, i.e., 0.6 (Nunnally, 1978). Construction Industry in India and other part of the world has constantly suffering due to highly unorganized work execution practices, more than 60% of construction projects suffer with delays with various reasons. However the futuristic projections call for a highly organized project management practices. This would certainly demand a more efficient and effective supply chain than ever before. The complex and dynamic nature of construction projects keeps challenge for being efficient and effective. Hence forth the authors have attempted to conceptualize the effectiveness of construction supply for better project performances. A generic approach towards CSC for all types of projects (Residential, commercial and Infrastructure) have been adopted. Within limited time constraints, the study has collected a sample size (119).

Keywords: Supply chain effectiveness, Exploratory factor analysis (EFA), Construction supply chain, Managing construction supplies

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INTRODUCTION

Indian Construction Industry has seen a very decent growth in last one and half decade and it shows a very promising future ahead. Lack of Infrastructure has been a major bottleneck in India's economic double digit growth in last one decade. The development of robust infrastructure base and providing houses to all is on prime importance. However the construction industry has been suffering severely with its poor project management skills and productivity level (Doloi and Sawhney *et al.*, 2011). McKinsey writes in its article "The Construction Imperatives" that the productivity of manufacturing sector increases to two fold in last one decade, however construction industry productivity level has been stagnant. The following three factors (a) Fast growing investment, (b) Very large scale mega projects sharing major portion of Indian construction market and (c) Management skills to deliver projects on time, within budget and on specifications are going to derive the future of Indian construction Industry (McKinsey, June 2015).

It is interesting to observe the changing gears by construction managers to address the upcoming challenges of future. Rising pressure on construction economics and timely deliveries factors is giving emphasis to more lean, efficient and effective practices. The need to increase the productivity is putting up urge to revamp the entire the supply chain practices, which is structured in make-to-order form. Technologies adaptation has to be integrated in a holistic manner throughout a project. The supply chain of the construction industry has to be built up in more effective and efficient manner in order to handle the major challenges ahead of us (Arantes *et al.*, 2015). Lack of commitment, inefficient site management, poor site coordination, improper planning, lack of clarity in project scope, lack of communication, and substandard contract are the major challenges of construction industry (Doloi and Sawhney *et al.*, 2011).

Supply chain effectiveness, which is usual talk in manufacturing is taking more mindfulness in construction industry. In order to deal with current challenges there is strong need to enhance the effectiveness of entire supply chain, application of modern technologies in holistic manner and deploying better project management skills. The SCM principles could be a potential cost saving has been advocated by Proverbs and Holt (2000). Supply Chain Management (SCM) deals with the integration of all information flow and transformation of materials from the souring point to the end-user stage (Handfield and Nichols, 1999). Conventional approach in managing the supplies in construction industry is no more going to be adequate.

The aim of this paper is to analyze the various dimensions of Construction Supply Chain (CSC), which are under practices and how they are impacting the effectiveness of supply chain. In order to achieve more effective supply chain, this study would help in determining the main factors which can improve the CSC to deal with environment changes.

LITERATURE REVIEW

Supply Chain Management

SCM has been defined as a broader concept (Christopher, 1998). SCM is mainly about how an organization utilizes its resource related to suppliers' process, technology and capability. It includes the management of entire supply chain. Tan and Handfield (1998) defines SCM as an

philosophy of bringing trading partners together with a common objective of cost and resource optimization at higher efficiency level.

More over the internal efficiency has been at prime focus while applying SCM concepts, however it is now extended to mechanism of reducing waste and value addition (New and Ramsay, 1997; and Harland *et al.*, 1999). Simchi-Levi *et al.* (2008) given the following definition of SCM:

"Supply Chain Management is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system wide costs while satisfying service level requirements."

Vollman *et al.* (1997) elaborated the SCM as set of practices which manage and coordinate the entire supply chain from raw material to end customer and where by a greater synchronism and collaboration achieved through out the supply chain (New and Ramsay, 1997). Perry (1999) told with his work that information sharing across the entire supply chain would be the most important effects of supply chain strategy. Supplier partnering for achieving quality of delivery among the components of supply chain has given emphasized by Chorafas (2001). Authors argues that stakeholders in the supply chain should integrate their different objectives for development of quality deliverables and costs. Supply chain management concepts should not be constrained up to material flow. SCM is complex and dynamic process, which calls up a thorough understanding of the concept (Akintoye *et al.*, 2000; and Edum-Fotwe *et al.*, 2001).

Construction Supply Chain

SCM is treated as an evolutionary and innovative concepts in construction industry, which is structured in built-to-order form and completes with project delivery. Construction supply chain is built around the single product (Project) and which is a converging supply chain, i.e., driving all materials to the construction site. The product (project) is assembled through all the incoming materials. This form of supply chain very different from manufacturing process of product movement where multiple products delivered to multiple customer.

Sawhney and Maheswari (2013) defines the construction industry structure in these words:

"Construction industry involves a multitude of stakeholders who perform their project-centric work from various dispersed locations. This involvement of numerous stakeholders, which is common in the construction industry compared to the other industries, has led to fragmentation of the design process. The limitations and complexities resulting from this fragmentation can be overcome by proper design coordination".

CSC is very much unsteadyin nature and fragmented due to its nature of reconfiguration at the point of design and during the execution phase changes. The reconfiguration and dynamic upgradation of project deliveries makes it highly complex to create even flow in the supplies. Since every construction project has unique set deliveries so there is a little space of standardization with CSC. However the processes followed up are used to be very similar even with unique type projects.

Dubois and Gadde (2000) explains the relationships among CSC suppliers and says that contractor and subcontractor are at arms-length

and transactional in nature. Most of the disputes among them are resolved with litigation process, which is often time consuming in nature. Suppliers partnering is misconstrued at large scale in the construction industry and it is not resulting as an integratedpart of entire value chain process (Cox and Thompson, 1997). In many innovative procurement approaches various perceptions of partnering has been observed. Partnering seems to be evolving in different manners rather being taking an intentional and systematic approaches. Edum-Fotwe *et al.* (2001) highlighted that most of collaboration among partners have happened only in upstream relationships, i.e., regular and frequent clients, consultants and main contractors. Very occasionally firms at specialist and subcontractor level have shown any systematic partnering approaches (Jones *et al.*, 1998).

Supply Chain Effectiveness

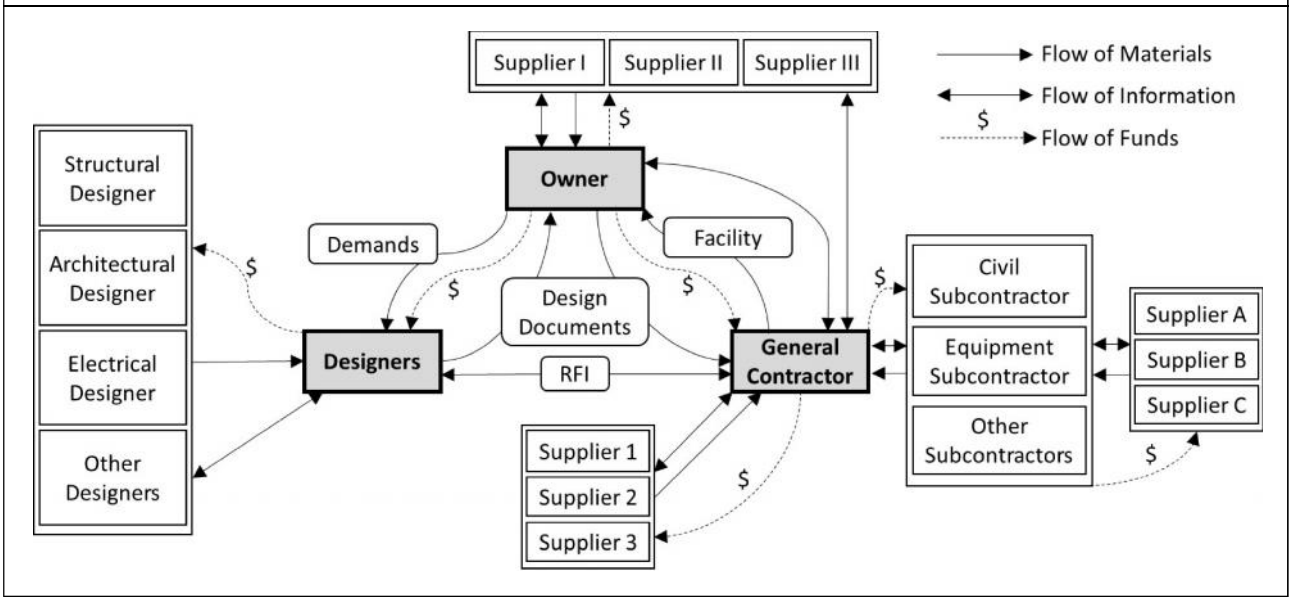
Providing more value to customer (markets), while creating an ability and capability is about being effective (Moller and Torronen, 2003). Effectiveness is externally driven concept and is defined in terms of results achieved by system and organization. Means to become more effective with CSC is topic of interest in this paper. So to measure effectiveness of supply chain we may need to look outside the boundary of organization or projects. While being efficient is concept which is cost driven.

Tan (2002) argues that the application of SCM concept better off the relationship supplier and customer and henceforth results in client satisfaction and better organizational performance.

METHODOLOGY

This research work is a theory building with an exploratory method and the underlying factors contributing to the effectiveness of the Construction Supply Chain (CSC) have been investigated. The effectiveness of an organization is examined on the basis of its results, i.e., deliverables.

Figure 1: General Structure of Construction Supply Chain



The selection of dimensions effecting CSC have been achieved in three main stages. At first stage, the authors have referred the existing literature and examined the construct of effectiveness in supply chain (Borgström, 2005) and (Francis, 1998). At second stage the authors conducted semi structured open ended interviews with highly experienced professional of construction industry. At third stage, the questionnaire with 25 selected variables was formed and a pilot test has been performed with 07 professionals. The questionnaire was refined with the pilot study. This is how the content validity has also been achieved for the questionnaire (instrument).

Finally, an empirical data has been collected through online and offline (on paper face to face) from construction professionals working in Indian context. All the respondents have an experience of working with construction environment. A convenient (biased) sample has been taken up, to ensure the relevant experience and learning of the respondent in the construction industry. Their opinion with respect to all 25 items under practice in construction project environment has been recorded on Likert scale of 1-to-5 (strongly disagree-to strongly agree). Exploratory Factor Analysis (EFA) has used to establish the underlying factors impacting effectiveness of CSC.

Data Collection

The selected sample contains site engineers, project managers, contractors, subcontractors and academician having experience in construction environment. The authors have sent/shared the questionnaire through emails and major social media channels. The web format of questionnaire has also been user friendly with mobile systems. Although a major portion of responses have been collected with face to face interaction. Online respondent also receives the reminder from researchers end. Adequate measures were taken to reduce non response bias.

The questionnaire has been sent to some 180 professionals through online and 75 professionals through offline. A sum total of 119 responses were collected (59 online and 70 offline). Seventeen (17) responses were removed after applying data cleaning process due to incompleteness or very low level of variance (standard deviation) in the responses. A very low value of standard deviation indicates the respondent's disinterest and random/erratic approach in filling up the questionnaire. However, there has been good response rate the authors were closely working with each responded. Further non response bias was also examined.

RESULT AND ANALYSIS

General Descriptive

An overview of the total 102 respondent is represented in Table 1. Major responses (74.5%) have been received from professionals working for Building and Real estate projects. Approximate 50% of the respondents belongs to large scale construction companies (i.e., > 500 employees). Almost half (50%) of the respondent have the experience up to 05 years. There is a good mix of respondents on the basis of their experience and level of operations in construction industry.

Table 2 shows the summary statistics of the response with respect to all 25 items for by all 102 respondents. The average response and standard value deviation are reflecting an appropriate amount of variability in the items, which is good to apply factor analysis with the

Table 1: Demographic Summary of Responses

Demographic Factors	Types	Number of Responses	In Percentage (%)
Organization type	Building & Real Estate	76	74.5
	Infrastructure Projects	22	21.5
	Others	4	4
Size of Organization	Less than 50	8	8
	50-100 employees	14	13.7
	100-250 employees	17	16.5
	250-500 employees	13	13
	>500 employees	50	49
Experience of Respondent	0-5 years	56	55
	5-10 years	17	16.6
	10-15 years	21	20.5
	> 15 years	8	8

listed items/variables. It gives an idea about average opinion of population and the amount of variation (difference of perception) any individual variable showing.

Relative Importance Index

As the listed variables in questionnaire were expressed in positive manner with respect to effectiveness of construction supply chain. So the Relative Importance Index (RII) of each variable/ item gives indication of important variables in achieving effectiveness in the supply chain. Here in Table 3 first fifteen (15) variables are shown. All the top 15 variables are listed in their rank orders. RII reflects the importance of variable in deciding the effectiveness of the Construction Supply Chain (CSC). Timely deliveries and concern for meeting customer expectations/ needs are first parameter to become effective.

Table 2: Mean and Standard Deviation Value for Listed Variables

Item Code	Description of Items	Mean	Standard Deviation
Eff_1	Misplaced order/supplies on site	2.644	0.901
Eff_2	Order fails to be on time	3.238	0.826
Eff_3	Flexible material/equipment availability in inventory management	3.465	0.944
Eff_4	Flexibility in transportation of material/equipment	3.495	0.901
Eff_5	Cost control efforts in supply chain	3.812	0.967
Eff_6	Adaptation of new methods to new integration methods supply chain activities	3.653	0.921
Eff_7	Improving the integration methods and activities across your supply chain	3.812	0.731
Eff_8	The need of establishing more frequent contact with supply chain members	3.931	0.752
Eff_9	Involving supply chain on your product service marketing plan	3.792	0.875
Eff_10	Involvement of Partners in sourcing decision of suppliers	3.733	0.893
Eff_11	Supply chain management Team includes different companies of Supply chain	3.911	0.896
Eff_12	Classified the customers based on service needs	3.881	0.804
Eff_13	Dedicated to create an appropriate information system	3.99	0.781
Eff_14	Informs its trading partner in advance of changing needs	3.911	0.884

Table 2 (Cont.)

Eff_15	The level of interaction with customer to set trustworthiness, responsiveness and other standards	3.931	0.897
Eff_16	Frequent communication with customer for quality and service feed back	3.733	0.989
Eff_17	Frequently measurement of customer satisfaction	3.802	0.883
Eff_18	Frequently measurement of customer future expectations/Needs	3.921	0.913
Eff_19	Participation of the top management while sourcing the supplier	3.822	0.78
Eff_20	Support the supplier to increase their capability to deliver	3.802	0.735
Eff_21	On- time delivery directly to customer	4	0.849
Eff_22	On time delivery directly to your firm by the suppliers	3.941	0.858
Eff_23	Frequent Identification of additional supply chain needs	3.634	0.956
Eff_24	Communicating with customers for development of future strategic need	3.802	0.849
Eff_25	Your organization contributes with suppliers to make them understand the effective	3.802	0.86

Table 3: Relative Importance Index (RII) of First Fifteen Items

Rank	Item Code	Measures	RII
1	Eff_22	On time delivery directly to your firm by the suppliers	0.788
2	Eff_18	Frequently measurement of customer future expectations/Needs	0.784
3	Eff_17	Frequently measurement of customer satisfaction	0.76
4	Eff_25	Your organization contributes with suppliers to create an effective supply chain	0.76
5	Eff_24	Communicating with customers for development of future strategic need	0.76
6	Eff_9	Involving supply chain on your product service marketing plan	0.758
7	Eff_16	Frequent communication with customer for quality and service feed back	0.747
8	Eff_10	Involvement of Partners in sourcing decision of suppliers	0.747
9	Eff_6	Adaptation of new methods to integrate supply chain activities	0.731
10	Eff_4	Flexibility in transportation of material/equipment	0.699
11	Eff_3	Flexible material/equipment availability in inventory management	0.693
12	Eff_2	Order fails to be on time	0.648
13	Eff_5	Cost control efforts in supply chain	0.662
14	Eff_12	Classified the customers based on service needs	0.576
15	Eff_1	Misplaced order/supplies on site	0.529

Factor Analysis

An Exploratory Factor Analysis (EFA) was performed for identifying the underlying major factors out of 25 listed variables. By obtaining hidden characteristics among data through EFA technique, the effectiveness of CSC can

Table 4: Exploratory Factor Analysis Summary

Factor List	Item Code	Measures	Loading	Explained Factors	Variance Explained
F1	Eff_22	On time delivery directly to your firm by the suppliers	0.614	Client/Customer Relationship Management	19.18%
	Eff_17	Frequently measurement of customer satisfaction	0.753		
	Eff_16	Frequent communication with customer for quality and service feed back	0.691		
	Eff_18	Frequently measurement of customer future expectations/needs	0.69		
F2	Eff_6	Adaptation of new methods to integrate supply chain activities	0.792	Integration of Technologies & information	13.72%
	EFF_7	Improving the integration methods and activities across your supply chain	0.758		
F3	Eff_4	Flexibility in transportation of material/equipment	0.865	Flexibility	9.60%
	Eff_3	Flexible material/equipment availability in inventory management	0.739		
F4	Eff_10	Involvement of Partners in sourcing decision of suppliers	0.857	Supplier Partnership Management	9.40%
	Eff_9	Integrating supply chain on your product/project service marketing plan	0.762		
	Eff_19	Participation of the top management while sourcing the supplier	0.768		
F5	EFF2	Order fails to be on time	0.835	Inventory/Storage management	7.20%
	EFF1	Misplaced order/supplies on site	0.794		
F6	Eff_25	Your organization contributes with suppliers to create an effective supply chain	0.618	Collaborative Supply chain	6.70%
	Eff_12	Classified the clients/suppliers/based on service needs	0.652		

be understood and explained in broader terms.

The sample adequacy defined with Kasier-Meyer-Olkin (KMO) is 0.601 (under acceptable criteria) and presence of correlation checked with Barlett's test of sphericity is significant (p-value = 0.000) with chi-square value 292.217 (DF=105). So, both KMO and Barlett's test support the factor analysis appropriateness for the 25 listed items.

With principle component analysis extraction and varimax rotation, the data reductiontechnique has been performed. Variable with low communality (< 0.4) has been

removed at first hand. EFA has been performed for multiple cycles while removing items with no loading, single loading and cross loading in sequence. The six factors achieved here in the case are decided with a loading higher 0.5 and all the items achieving loading less than 0.5 were removed as if no loading cases. It is logical to work with higher loading with smaller size of sample in order achieve most appropriate factors. Finally, the six factor achieved (with 15 items) is explaining 65.85% variance. All six factors are defined and shown in the table 4, while reflecting the individual variance explanative% loading.

The resultant six underlying factors are 1. Client/ Customer, Relationship Management 2. Integration of Technologies and information 3. Flexibility 4. Supplier Partnership Management 5. Inventory/Storage management and 6. Collaborative Supply chain.

Reliability and Validity Analysis

The reliability test for the scale has been performed to ensure that the construct (Supply chain Effectiveness) under formation is free from error. It checks the internal consistency achieved with collected data for the selected scale. Nunnally (1978) told that the minimum acceptable value of Cronbach alpha should be 0.6, however in some cases 0.5 is also considered a fair value. Here, Cronbach alpha for the chosen scale (25 items) is 0.8 and for all six achieved factors it is shown in Table 5.

First five factors have achieved the reliability level of Cronbach alpha, however the sixth factor (collaborative supply chain) is having exceptionally very low value (α = 0.348). A content validity of the scale has been achieved with basic literature review and multiple discussion with construction professionals working at senior level or having very good amount of experience in industry.

Table 5: Reliability Analysis Index Cronbach Alpha

Factors/Scale for Reliability		Cronbach's Alpha	No of Items
For Complete Scale/Instrument (25 Items)		0.8	25
F1	Client/Customer Relationship management	0.665	4
F2	Integration of technologies and Information	0.69	2
F3	Flexibility of Supply chain	0.636	3
F4	Supplier Partnership Management	0.655	2
F5	Inventory/Storage management	0.58	2
F6	Collaborative Supply chain	0.348	2

DISCUSSION

Five main dimension for effectiveness of Construction Supply Chain (CSC) has been identified. The CSC effectiveness construct contains these five dimensions: client relationship management, technology and information Integration, flexible approaches of supply chain, supplier partnership and inventory management.

Client Relationship Management

Dubois and Gadde (2000) told that the new kind of relationships are perceived as new achievements and better utilization of resources through complete supply chain. Bennett and Jayes (1998) says relationship is way to address the fragmented and disintegrated construction industry. Bresnen and Marshall (2000)

emphasized on developing external linkages and inter-organizational relationship as a culture of cooperation in different stakeholders in construction industry. Construction supply chain stakeholderswho operates in transactional manner need to give more emphasis on relationship building (Xue *et al.*, 2005).

Technology and Information Integration

Stank *et al.* (1996a and 1996b) expressed that the amount of operational information shared between stakeholders creates positive perceptions of supply chain performance. Many organization are using internet for supply chain management with growing globalization and rising standard of communication channels (Lancioni *et al.*, 2000). A higher level of technology and information integration would lead to an effective CSC (Cutting-Decelle *et al.*, 2005).

Flexibility in Supply Chain

Three major strategic development in the current century would happen in market with cost, quality and responsiveness to the changes both with in terms in time and flexibility (Aquilano *et al.*, 1995). Ballard (2000) and Chua and Shen (2001) addresses that new project management methods have involved flexibility component in execution of construction projects, so delivery processes are becoming more challenging. With increasing risk from various sources, it has become essential to adapt flexibility in supply chain. This can serve as strong competitive edge all construction industry players.

Supplier Partnership Management

Egan (1998) defines partnership as "two or more organizations working together to improve performance through agreeing mutual objectives, deriving a way of resolving any disputes and committing themselves to continuous improvement, measuring progress and sharing the gains" in his 'Rethinking Construction' reports. The second generation thought of partnering which appears in late 1990's revolves around strategic decision to corporate by the major stakeholders in project (Bennett and Jayes, 1998). The partnering which is quit old concept to manufacturing and retails is seems to very new to construction industry. Various players involved in projects are only collaborated in transactional manner, which would require to change for being effective in supply chain deliveries.

Inventory Management

Halmepuro and Nyste (2003) told the materials on construction site are not usually recorded in any inventory control system, hence forth they are being visually controlled in order ensure the availability of material and equipment. Work progress spreadsheet is used in many situation but due to manual entry system, inventory records tend to be flawed in nature most of the time (Harju-Jeanty and Jantti, 2004). Due to short duration and low cost emphasis by small players it has been become challenging incorporate transparent material flow. This leads most ineffective way of handling the materials at site and results in high level losses. The construction professionals largely emphasize the issue of inventory management and have been trying to adopt lean practices such last planner system.

CONCLUSION

The study identified the underlying attributes associated with effectiveness of Construction Supply Chain (CSC). It accepts five major factors which would play role in determining the effectiveness of supply chain. The study highlighted the need to incorporate technologies in holistic manner in order to create better

integration among various stakeholders involve in the project. Anticipating the future challenges in construction environment the effectiveness of supply chain would desirable at the most. In doing so, these five identified factors client relationship/ customer relationship management, technology and information integration, supplier partnership, flexibility in CSC would help the manager to develop the effective CSC. This study has been performed under a time constraints and being first of its kind in construction domain has considered very limited number of items. Researcher may add more dimensions to this study. It seems the sixth factor (collaborative practices in supply chain) seems to be valid dimension in order to achieve effective CSC, due to small sample size it may not be showing reliability. Further researcher may take more demographic variable in order to explain the CSC.

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