Critical Factors Effecting Supply Chain Management in Construction Projects

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Abstract- *The construction supply chain plays a major role in the construction market competition. Construction supply chain management assists enterprises by helping to improve competitiveness, increase profits and have more control over the different factors and variables within the project. The purpose of this survey was to obtain a diagnosis about the current situation of the supply chain in the Kerala construction industry. This thesis is to study the critical factors affecting the supply chain management in construction projects using software. The needed data were collected through a structured questionnaires among engineers, contractors, suppliers and clients. The collected data were analysed using SPSS software and MATLAB software. After finding the results, the critical factors affecting the SCM were studied and a set of solutions is recommended for the identified problems.*

Keywords: Statistical Package for the Social Sciences (SPSS), Supply Chain Management (SCM).

1. INTRODUCTION

The prime objective in construction industry is to complete the planned activities of project in time. Supply Chain Management is an important step to complete the project in time. Supply Chain Management is a concept that is gaining in popularity and importance.

Supply Chain Management (SCM) originated in armoury practices of the late 19th century, and was later used in the production methods of Henry Ford in the 1920s. It describes the management of a supply flow over multiple chains. Supply chain management (SCM) has been widely regarded as an effective and efficient management measure and strategy to improve the performance of the construction industry, which has suffered from high fragmentation, large waste, poor productivity, cost and time overruns, and conflicts and disputes for many years. Supplies can range from materials to labour or information. Chains describe the link between different parties, companies or people involved in the delivery or distribution. In other words, Supply Chain Management tries to understand and improve the complete process of all resources needed to deliver a product. The construction sector players including engineers, contractors, suppliers and clients.

'Supply chain' is the term used to describe the interconnected hierarchy of supply contracts necessary to procure a built asset. Managing the supply chain involves understanding the breakdown and traceability of products and services, organisations, logistics, people, activities, information and resources that transform raw materials into a finished product that is fit for its purpose.

1.1 Objective

The main objective of this study is to make Supply Chain Management as an innovative management mode. This study provides a new solution for resolving high fragmentation, low productivity, cost and time overruns, conflicts through system perspective. A well designed supply chain is expected to support the strategic objectives of solving supplier's problems, customer service performance improvement, reduction of pre & post production inventory, to improve the overall organizational performance and customer satisfaction by improving product and service delivery to customer. SCM is important because it is the backbone on which the demand and supply of a company is based on.

2. SUPPLY CHAIN MANAGEMENT

The origins of supply chain management lie in the manufacturing industries. The armoury practices of the late-19th century, and later the production methods of Henry Ford in the 1920s, created the SCM system that remains largely unchanged today. The central focus is on the production process of goods through the control of material flows.

'Supply' is the flow of resources used to satisfy a demand, such as materials, labour, information, skills, and so on. It can also refer to competencies, and represent combinations of resources. Commodity suppliers tend to be more price focused,

whilst strategic suppliers are more quality/delivery focused. 'Chains' represents the notion of links within and between both resources and competencies. They are based upon relationships between people and organisations, and processes within and between organisations. 'Management' is the exercise of formal authority within a structured organisational setting that is directed towards aims and objectives through the efforts of other people using systems and procedures. Supply chain management requires a holistic perspective and a view of organisations as parts of a process. It requires the ability to look beyond organisational boundaries, and a recognition of the interdependence of organisations.

Supply chain is the term used to describe the linkage of companies that turns a series of basic materials, products or services into a finished product for the client. All construction companies, be they client, main contractor, designer, surveyor, sub-contractor, or supplier are therefore part of a supply chain. Because of the project based nature of construction and the way that procurement normally operates, they are usually members of different supply chains on different projects. Each company in the chain has a client – the organisation to which the services are provided – but an integrated supply chain will have the objective of understanding and working wholly in the interests of the 'project client'.

3. RESEARCH METHODOLOGY

Research methodology is an approach to systematically answer the research problem. The methodology includes gathering of primary and secondary data.There are a tremendous number of qualitative and quantitative factors that affect the construction project performance. Finding out critical factors affecting the SCM in construction industry is the prime objective of this research. A relevant literature review and meetings with the industry personnel helped to identify the significant factors which affect the performance of SCM in construction projects. After the identification of factors, structured questionnaires were distributed among the industry experts such as engineers, contractors, suppliers & clients. The questionnaire provides the details regarding the critical factors affecting the supply chain system. From the questionnaire survey information's can be gathered and factors can be identified. Analysis is done using SPSS& MATLAB software. A questionnaire is simply a tool for collecting and recording information about a particular issue of interest. It addresses a large number of issues and questions of concern in a relatively efficient way with the possibility of a high response rate. The success of a questionnaire is based upon the skills and insights with which the lists of questions are formulated along with the type of questions used. Primary data

is collected through self-administrated questionnaire and analysed and substantial information collected from primary and secondary data. The secondary data is interpreted from the primary data and analysis is further done using SPSS& MATLAB software to achieve best result.Data required for the project work were collected from various construction companies in Kerala.
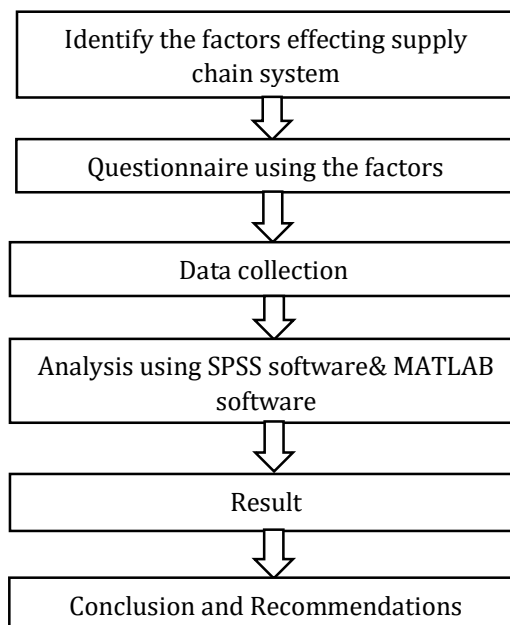

Fig-1: Methodology

4. DATA COLLECTION

Data is collected in two stages, primary and secondary.

4.1 Primary data

Using the available details from the literatures, a questionnaire is prepared using likert scale method for engineers, contractors, suppliers and clients. For conducting the survey, printed copies of questionnaires were distributed to various companies, engineers, contractors, suppliers and clients. These responses are used to identify the most critical factors of Supply Chain Management. The response were measured using a likert scale system ranging from 1 - strongly disagree to 5 - strongly agree (5-strongly agree, 4- agree, 3- undecided, 2- disagree, 1 - strongly disagree).

4.2 Secondary data

After the analysis of primary data, data analysis was further done with the help of SPSS software and MATLAB software to achieve the best result.

5. SPSS SOFTWARE

The software was released in its first version in 1968 as the Statistical Package for the Social Sciences (SPSS) after being developed by Norman H. Nie, Dale H. Bent, and C. Hadlai Hull.

SPSS is a comprehensive and flexible statistical analysis and data management solution. SPSS can take data from almost any type of file and use them to generate tabulated reports, charts, and plots of distributions and trends, descriptive statistics, and conduct complex statistical analyses. In addition to statistical analysis, data management (case selection, file reshaping, creating derived data) and data documentation (a metadata dictionary was stored in the data file) are features of the base software. SPSS is a Windows based program that can be used to carry out data entry and analysis and to create tables and graphs. SPSS is able to handle huge amounts of data and can carry out all of the analyses covered in the text and much more. SPSS is updated often. SPSS Statistics places constraints on internal file structure, data types, data processing, and matching files, which together considerably simplify programming. SPSS datasets have a two-dimensional table structure, where the rows typically represent cases (such as individuals or households) and the columns represent measurements (such as age, sex, or household income). Only two data types are defined: numeric and text (or "string"). All data processing occurs sequentially case-by-case through the file (dataset). Files can be matched one-to-one and one-to-many, but not many-to-many. In addition to that cases-by-variables structure and processing, there is a separate Matrix session where one can process data as matrices using matrix and linear algebra operations.

The graphical user interface has two views which can be toggled by clicking on one of the two tabs in the bottom left of the SPSS Statistics window. The 'Data View' shows a spreadsheet view of the cases (rows) and variables (columns). Unlike spreadsheets, the data cells can only contain numbers or text, and formulas cannot be stored in these cells. The 'Variable View' displays the metadata dictionary where each row represents a variable and shows the variable name, variable label, value label(s), print width, measurement type, and a variety of other characteristics. Cells in both views can be manually edited, defining the file structure and allowing data entry without using command syntax. This may be sufficient for small datasets. Larger datasets such as statistical surveys are more often created in data entry software, or entered during computer-assisted personal interviewing, by scanning and using optical character recognition and optical mark recognition software, or by direct capture from online questionnaires. These datasets are then read into SPSS.

Several variants of SPSS Statistics exist. SPSS Statistics Gradpacks are highly discounted versions sold only to students. SPSS Statistics Server is a version of SPSS Statistics with a client/server architecture. Add-on packages can enhance the base software with additional features (examples include complex samples which can adjust for clustered and stratified samples, and custom tables which can create publication-ready tables). SPSS Statistics is available under either an annual or a monthly subscription license.

SPSS Statistics can read and write data from ASCII text files (including hierarchical files), other statistics packages, spreadsheets and databases. SPSS Statistics can read and write to external relational database tables via ODBC and SQL.

Statistical output is to a proprietary file format (*.spv file, supporting pivot tables) for which, in addition to the inpackage viewer, a stand-alone reader can be downloaded. The proprietary output can be exported to text or Microsoft Word, PDF, Excel, and other formats. Alternatively, output can be captured as data (using the OMS command), as text, tab-delimited text, PDF, XLS, HTML, XML, SPSS dataset or a variety of graphic image formats (JPEG, PNG, BMP and EMF).

6. DATA ANALYSIS USING SPSS

From different companies a total of 26 Engineers, 22 Contractors, 20 Suppliers and 19 Clients had answered to the questionnaire. Analysis is done using SPSS software.

6.1 Factors for engineers

From various literature review were studied and made a questionnaire that consists of three types of factors for engineers such as factors affecting the efficiency of supply chain management system for engineers, factors that are barrier to supply chain organization for engineers and factors considering supply chain participation for engineers.

6.1.1 Factors affecting the efficiency of SCMS for engineers

The different factors that affects the efficiency of supply chain management system for engineers is taken were production planning, transportation, inventory, lead time and purchasing.

Table 1- Factors Affecting the Efficiency of SCMS for Engineers

SL NO	FACTORS	MEAN	MEAN
1	PRODUCTION PLANNING	4.5385	3
2	TRANSPORTATION	4.1538	5
3	INVENTORY	4.6538	1
4	LEAD TIME	4.4231	4
5	PURCHASING	4.6154	2

Engineers were asked to scale the functions which were expected to influence their relationship with their suppliers. From the result, inventory is the major factor that affects the efficiency of supply chain management system.

6.1.2 Factors that are barrier to supply chain organization for engineers

The factors that are barrier to supply chain organization for engineers is taken were late and incorrect payments, retention / holding, bidding process, impractical program discussion, traditional contracts do not promote good working relationships, estimators are too demanding on small organizations, companies do not understand other business within supply chain and quality less products purchasing and production.

Table 2- Factors that are barrier to supply chain organization for engineers

SL NO	FACTORS	MEAN	RANK
1	LATE AND INCORRECT PAYMENTS	4.5769	1
2	RETENTION/HOLDING	4.3462	5
3	BIDDING PROCESS	4.4615	3
4	IMPRACTICAL PROGRAM DISCUSSION	4.4231	4
5	TRADITIONAL CONTRACTS DO NOT PROMOTE GOOD WORKING RELATIONSHIPS	3.6538	8
6	ESTIMATORS ARE TOO DEMANDING ON SMALL ORGANIZATIONS	4.2692	6
7	COMPANIES DO NOT UNDERSTAND OTHER BUSINESS WITHIN SUPPLY CHAIN	3.9615	7
8	QUALITY LESS PRODUCTS PURCHASING AND PRODUCTION	4.5000	2

From the result, late and incorrect payments is the main barrier to supply chain organization for engineers.

6.1.3 Factors considering supply chain participation for engineers

The factors that are considering supply chain participation for engineers are improved customer service, overall supply chain reduction, increased profitability, reducing paperwork, increased market competitiveness, cost reductions within your organization, benefits to the client, benefits to your supplier & improved quality assurance.

Table 3- Factors considering supply chain participation for engineers

SL.NO	FACTORS	MEAN	RANK
1	IMPROVED CUSTOMER SERVICE	5.0000	1
2	OVERALL SUPPLY CHAIN REDUCTION	4.6923	3
3	INCREASED PROFITABILITY	4.6154	5
4	REDUCING PAPERWORK	4.3846	7
5	INCREASED MARKET COMPETITIVENESS	4.3462	8
6	COST REDUCTIONS WITHIN YOUR ORGANIZATION	4.5385	6
7	BENEFITS TO THE CLIENT	4.6538	4
8	BENEFITS TO YOUR SUPPLIER	4.2308	9

9	IMPROVED QUALITY ASSURANCE	4.8846	2

The main factor that consider the supply chain participation for engineers is improved customer service. Engineers should analyse their partners' demand logically during the project which is essential for a successful collaboration between an engineer and its partners leading to a well-established and developed SCM organization.

6.2 Factors for contractors

The three types of factors for contractors are similar to engineers such as factors affecting the efficiency of supply chain management system for contractors, factors that are barrier to supply chain organization for contractors and factors considering supply chain participation for contractors.

6.2.1 Factors affecting the efficiency of SCMS for contractors

The factors are production planning, transportation, inventory, purchasing & lead time.

Table 4- Factors affecting the efficiency of SCMS for contractors

SL NO	FACTORS	MEAN	RANK
1	PRODUCTION PLANNING	4.4545	4
2	TRANSPORTATI-ON	3.6818	5
3	INVENTORY	4.7273	1
4	LEAD TIME	4.5000	3
5	PURCHASING	4.6818	2

Similar to engineers, inventory is the main factor that affect the efficiency of SCMS for contractors.

6.2.2 Factors that are barrier to supply chain organization for contractors

Table 5- Factors that are barrier to supply chain organization for contractors

SL NO	FACTORS	MEAN	RANK
1	LATE AND INCORRECT PAYMENTS	4.7727	1
2	RETENTION/HOLDING	4.5909	3
3	BIDDING PROCESS	4.4545	4
4	IMPRACTICAL PROGRAM DISCUSSION	4.2727	6
5	TRADITIONAL CONTRACTS DO NOT PROMOTE GOOD WORKING RELATIONSHIPS	4.0909	8
6	ESTIMATORS ARE TOO DEMANDING ON SMALL ORGANIZATIONS	4.3636	5
7	COMPANIES DO NOT UNDERSTAND OTHER BUSINESS WITHIN SUPPLY CHAIN	4.1364	7
8	QUALITY LESS PRODUCTS PURCHASING AND PRODUCTION	4.6818	2

The main factor that is barrier to supply chain organization for contractors is late and incorrect payments.

6.2.3 Factors considering supply chain participation for contractors

Table 6- Factors considering supply chain participation for contractors

SL.NO	FACTORS	MEAN	RANK
1	IMPROVED CUSTOMER SERVICE	5.0000	1
2	OVERALL SUPPLY CHAIN REDUCTION	4.5455	5
3	INCREASED PROFITABILITY	4.5000	6
4	REDUCING PAPERWORK	4.3182	8
5	INCREASED MARKET COMPETITIVENESS	4.1818	9
6	COST REDUCTIONS WITHIN YOUR ORGANIZATION	4.7727	3
7	BENEFITS TO THE CLIENT	4.6818	4
8	BENEFITS TO YOUR SUPPLIER	4.3636	7
9	IMPROVED QUALITY ASSURANCE	4.9545	2

6.3 Factors for suppliers

The three types of factors for suppliers are factors which develop successful supply chain relationship with clients, factors considered while taking decision with clients and factors considered when sharing information with clients.

6.3.1 Factors which develop successful supply chain relationship with clients

The different factors which develop successful supply chain relationship with clients are valid delivery date, accurate order fulfilment, level of complaints/ returns, delivery at specified time, flexibility/willingness to change or compromise, fast order cycle time, handling of complaints, added value/additional benefits, quality of materials, quality of service, trust, simplifying the whole construction process & cost and financial stability.

Table 7- Factors which develop successful supply chain relationship with clients

SL NO	FACTORS	MEAN	RANK
1	VALID DELIVERY DATE	4.6000	7
2	ACCURATE ORDER FULFILMENT	4.5500	8
3	LEVEL OF COMPLAINTS/ RETURNS	4.2500	11
4	DELIVERY AT SPECIFIED TIME	5.0000	1
5	FLEXIBILITY/WILLINGNESS TO CHANGE OR COMPROMISE	4.4500	9
6	FAST ORDER CYCLE TIME	4.3500	10
7	HANDLING OF COMPLAINTS	4.8500	3
8	ADDED VALUE/ADDITIONAL BENEFITS	4.0000	13
9	QUALITY OF MATERIALS	4.7000	6
10	QUALITY OF SERVICE	4.8000	4
11	TRUST	4.9000	2
12	SIMPLIFYING THE WHOLE CONSTRUCTION PROCESS	4.1000	12
13	COST AND FINANCIAL STABILITY	4.7500	5

It was analysed that suppliers were aware of importance of clients for developing a successful supply chain relationship. The questionnaire were provided to reveal the degree of importance of which factors were more important for them. From the result, delivery at specified time is the main factor which develop successful supply chain relationship with clients.

6.3.2 Factors considered while taking decision with clients

The various factors considered while taking decision with clients are being consulted in deciding the production schedule, being consulted in deciding which new products to develop, being consulted regarding new technological innovations, delivery risk factors, market competitors, production factors (Quality, Quantity, standards), financial status.

Table 8–Factors considered while taking decision with clients

SL NO	FACTORS	MEAN	RANK
1	BEING CONSULTED IN DECIDING THE PRODUCTION SCHEDULE	4.6000	3
2	BEING CONSULTED IN DECIDING WHICH NEW PRODUCTS TO DEVELOP	4.5500	5
3	BEING CONSULTED REGARDING NEW TECHNOLOGICAL INNOVATIONS	4.8500	1
4	DELIVERY RISK FACTORS	4.1500	7
5	MARKET COMPETITORS	4.5000	6
6	PRODUCTION FACTORS (QUALITY, QUANTITY, STANDARDS)	4.6000	4
7	FINANCIAL STATUS	4.7000	2

The highly ranked factor considered while taking decision with clients is being consulted regarding new technological innovations.

6.3.3 Factors considered when sharing information with clients

The selected four factors considered when sharing information with clients are competitive advantage is sought by production planning or inventory decisions, competitive advantage is sought by sharing information with suppliers or customers,

competitive advantage is sought by performing some of your suppliers or customers work for them & proportion of overall production process subcontracted to outside firms.

Table 9 – Factors considered when sharing information with clients

SL NO	FACTORS	MEAN	RANK
1	COMPETITIVE ADVANTAGE IS SOUGHT BY PRODUCTION PLANNING OR INVENTORY DECISIONS	4.4000	2
2	COMPETITIVE ADVANTAGE IS SOUGHT BY SHARING INFORMATION WITH SUPPLIERS OR CUSTOMERS	4.3000	3
3	COMPETITIVE ADVANTAGE IS SOUGHT BY SHARING INFORMATION WITH SUPPLIERS OR CUSTOMERS	4.6000	1
4	PROPORTION OF OVERALL PRODUCTION PROCESS SUBCONTRACTED TO OUTSIDE FIRMS	4.2500	4

The highly ranked factor considered when sharing information with clients is competitive advantage is sought by performing some of your suppliers or customers work for them.

6.4 Factors for clients

The three main types of factors for clients are factors in relationship between clients & organization, factors considered while taking decision with suppliers and factors considered when sharing information with suppliers.

6.4.1 Factors in relationship between clients & organization

There are thirteen factors selected and they are reliability of supply, top management support, trust, mutual interest, manpower development, closer links between demand / supply, free flow of information, integrated information systems, more frequent meetings, joint business planning, simplifying the whole construction process, creating

standardization of processes & simplifying the bidding process.

Table 10 – Factors in relationship between clients & organization

SL NO	FACTORS	MEAN	RANK
1	RELIABILITY OF SUPPLY	4.6316	5
2	TOP MANAGEMENT SUPPORT	4.4737	8
3	TRUST	4.8947	1
4	MUTUAL INTEREST	4.7895	2
5	MANPOWER DEVELOPMENT	4.2105	11
6	CLOSER LINKS BETWEEN DEMAND/SUPPLY	4.4211	9
7	FREE FLOW OF INFORMATION	4.6842	3
8	INTEGRATED INFORMATION SYSTEMS	4.1579	12
9	MORE FREQUENT MEETINGS	4.2632	10
10	SIMPLIFYING THE WHOLE CONSTRUCTION PROCESS	4.6842	4
11	CREATING STANDARDIZATION OF PROCESSES	4.5789	6
12	SIMPLIFYING THE BIDDING PROCESS	4.5263	7
13	JOINT BUSINESS PLANNING	4.0000	13

Trust, mutual interest, free flow of information are the highly ranked factors in relationship between clients & organization.

6.4.2 Factors considered while taking decision with suppliers

The various factors considered while taking decision with suppliers were being consulted in deciding the production schedule, being consulted in deciding which new products to develop, being consulted regarding new technological innovations, financial status, market competitors, quality standards and inbound transportation.

Table 11 – Factors considered while taking decision with suppliers

SL NO	FACTORS	MEAN	RANK
1	BEING CONSULTED IN DECIDING THE PRODUCTION SCHEDULE	4.6842	3
2	BEING CONSULTED IN DECIDING WHICH NEW PRODUCTS TO DEVELOP	4.6316	4
3	BEING CONSULTED REGARDING NEWTECHNOLOGICAL INNOVATIONS	4.5789	5
4	FINANCIAL STATUS	4.7368	2
5	MARKET COMPETITORS	4.5263	6
6	QUALITY STANDARDS	4.8421	1
7	INBOUND TRANSPORTATION	4.2105	7

The highly ranked factors considered while taking decision with suppliers were quality standards, financial status and being consulted in deciding the production schedule.

6.4.3 Factors considered when sharing information with suppliers

The different factors considered when sharing information with suppliers are competitive advantage is sought by production planning or inventory decisions, competitive advantage is sought by sharing information with suppliers or customers, competitive advantage is sought by performing some of your suppliers or customers work for them and proportion of overall production process subcontracted to outside firms.

Table 12 – Factors considered when sharing information with suppliers

SL NO	FACTORS	MEAN	RANK
1	COMPETITIVE ADVANTAGE IS SOUGHT BY SHARING INFORMATION WITH SUPPLIERS	4.7368	1
2	COMPETITIVE ADVANTAGES IS SOUGHT BY PRODUCTION PLANNING	4.3684	2
3	COMPETITIVE ADVANTAGE IS SOUGHT BY TAKING INVENTORY DECISIONS	3.8947	3
4	PROPORTION OF OVERALL PRODUCTION PROCESS SUBCONTRACTED TO OUTSIDE FIRMS	3.6842	4

All factors were considered and ranked accordingly. Among them competitive advantage is sought by sharing information with suppliers is the highly ranked factor.

7. MATLAB SOFTWARE

Cleve Moler, the chairman of the computer science department at the University of New Mexico, started developing MATLAB in the late 1970s. MATLAB is the high-level language and interactive environment used by engineers and scientists all over the world. MATLAB (matrix laboratory) is a multi-paradigm numerical computing environment and proprietary programming language developed by MathWorks.MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages. It lets you explore and visualize ideas and collaborate across disciplines including signal and image processing, communications, control systems, and computational finance. MATLAB can be used in projects such as modelling energy consumption to build smart power grids, developing control algorithms for hypersonic vehicles, analysing weather data to visualize the track and intensity of hurricanes, and running millions of simulations to pinpoint optimal dosing for antibiotics. In this study fuzzy logic toolbox is used to find the critical factors that affects the SCM. Fuzzy logic is a solution to complex problems in all fields of life, including medicine, as it resembles human reasoning and decision making. Fuzzy logic is based on the observation that people make decisions based on imprecise and non-numerical information. Fuzzy logic is an approach to computing based on "degrees of truth" rather than the usual "true or false" (1 or 0) Boolean logic on which the modern computer is based.

8. ANALYSIS USING MATLAB

In MATLAB software, the data's are analysed using fuzzy logic toolbox. In this analysis, the critical factors effect supply chain management for engineers, contractors, suppliers and clients are achieved. The fuzzy outputs are of three types of

factors. They are critical, moderate and minimal factors.

8.1 Fuzzy output for engineers

Table 13- Fuzzy output for engineers

SL NO.	FACTORS	RANK	FUZZY OUTPUT
1	**IMPROVED CUSTOMER SERVICE**	**1**	**CRITICAL**
2	**IMPROVED QUALITY ASSURANCE**	**2**	**CRITICAL**
3	**INVENTORY**	**3**	**CRITICAL**
4	**PURCHASING**	**4**	**CRITICAL**
5	**OVERALL SUPPLY CHAIN REDUCTION**	**5**	**CRITICAL**
6	BENEFITS TO THE CLIENT	6	MODERATE
7	INCREASED PROFITABILITY	7	MODERATE
8	PRODUCTION PLANNING	8	MODERATE
9	LATE AND INCORRECT PAYMENTS	9	MODERATE
10	QUALITY LESS PRODUCTS PURCHASING AND PRODUCTION	10	MODERATE
11	COST REDUCTIONS WITHIN YOUR ORGANIZATION	11	MODERATE
12	BIDDING PROCESS	12	MINIMAL
13	LEAD TIME	13	MINIMAL
14	IMPRACTICAL PROGRAM DISCUSSION	14	MINIMAL
15	REDUCING PAPERWORK	15	MINIMAL
16	RETENTION / HOLDING	16	MINIMAL
17	INCREASED MARKET COMPETITIVENESS	17	MINIMAL
18	BENEFITS TO YOUR SUPPLIER	18	MINIMAL
19	ESTIMATORS ARE TOO DEMANDING ON SMALL ORGANIZATIONS	19	MINIMAL
20	TRANSPORTATION	20	MINIMAL
21	COMPANIES DO NOT UNDERSTAND OTHER BUSINESS WITHIN SUPPLY CHAIN	21	MINIMAL
22	TRADITIONAL CONTRACTS DO NOT PROMOTE GOOD WORKING RELATIONSHIPS	22	MINIMAL

8.2 Fuzzy output for contractors

Table 14- Fuzzy output for contractors

SL NO.	FACTORS	RANK	FUZZY OUTPUT
1	**IMPROVED CUSTOMER SERVICE**	**1**	**CRITICAL**
2	**IMPROVED QUALITY ASSURANCE**	**2**	**CRITICAL**
3	**INVENTORY**	**3**	**CRITICAL**

4	LATE AND INCORRECT PAYMENTS	4	CRITICAL
5	COST REDUCTIONS WITHIN YOUR ORGANIZATION	5	CRITICAL
6	BENEFITS TO THE CLIENT	6	MODERATE
7	PURCHASING	7	MODERATE
8	OVERALL SUPPLY CHAIN REDUCTION	8	MODERATE
9	QUALITY LESS PRODUCTS PURCHASING AND PRODUCTION	9	MODERATE
10	LEAD TIME	10	MODERATE
11	RETENTION / HOLDING	11	MODERATE
12	INCREASED PROFITABILITY	12	MINIMAL
13	BIDDING PROCESS	13	MINIMAL
14	REDUCING PAPERWORK	14	MINIMAL
15	PRODUCTION PLANNING	15	MINIMAL
16	BENEFITS TO YOUR SUPPLIER	16	MINIMAL
17	ESTIMATORS ARE TOO DEMANDING ON SMALL ORGANIZATIONS	17	MINIMAL

18	IMPRACTICAL PROGRAM DISCUSSION	18	MINIMAL
19	COMPANIES DO NOT UNDERSTAND OTHER BUSINESS WITHIN SUPPLY CHAIN	19	MINIMAL
20	INCREASED MARKET COMPETITIVENESS	20	MINIMAL
21	TRANSPORTATION	21	MINIMAL
22	TRADITIONAL CONTRACTS DO NOT PROMOTE GOOD WORKING RELATIONSHIPS	22	MINIMAL

8.3 Fuzzy output for suppliers

Table 15 – Fuzzy output for suppliers

SL NO.	FACTORS	RANK	FUZZY OUTPUT
1	DELIVERY AT SPECIFIED TIME	1	CRITICAL
2	TRUST	2	CRITICAL
3	HANDLING OF COMPLAINTS	3	CRITICAL
4	QUALITY OF SERVICE	4	CRITICAL

5	**COST AND FINANCIAL STABILITY**	**5**	**CRITICAL**
6	BEING CONSULTED REGARDING NEW TECHNOLOGICAL INNOVATIONS	6	MODERATE
7	QUALITY OF MATERIALS	7	MODERATE
8	FINANCIAL STATUS	8	MODERATE
9	PRODUCTION FACTORS (QUALITY, QUANTITY, STANDARDS)	9	MODERATE
10	BEING CONSULTED IN DECIDING THE PRODUCTION SCHEDULE	10	MODERATE
11	BEING CONSULTED IN DECIDING WHICH NEW PRODUCTS TO DEVELOP	11	MODERATE
12	MARKET COMPETITORS	12	MINIMAL
13	VALID DELIVERY DATE	13	MINIMAL
14	ACCURATE ORDER FULFILMENT	14	MINIMAL
15	COMPETITIVE ADVANTAGE IS SOUGHT BY PERFORMING SOME OF YOUR SUPPLIERS OR CUSTOMERS WORK FOR THEM	15	MINIMAL
16	FLEXIBILITY/ WILLINGNESS TO CHANGE OR COMPROMISE	16	MINIMAL
17	FAST ORDER CYCLE TIME	17	MINIMAL
18	COMPETITIVE ADVANTAGE IS SOUGHT BY PRODUCTION PLANNING OR INVENTORY DECISIONS	18	MINIMAL
19	SIMPLIFYING THE WHOLE CONSTRUCTION PROCESS	19	MINIMAL
20	COMPETITIVE ADVANTAGE IS SOUGHT BY SHARING INFORMATION WITH SUPPLIERS OR CUSTOMERS	20	MINIMAL

21	PROPORTION OF OVERALL PRODUCTION PROCESS SUBCONTRACTED TO OUTSIDE FIRMS	21	MINIMAL
22	LEVEL OF COMPLAINTS/ RETURNS	22	MINIMAL
23	DELIVERY RISK FACTORS	23	MINIMAL
24	ADDED VALUE/ADDITIONAL BENEFITS	24	MINIMAL

8.4 Fuzzy output for clients

Table 16 – Fuzzy output for clients

SL NO.	FACTORS	RANK	FUZZY OUTPUT
1	**TRUST**	**1**	**CRITICAL**
2	**MUTUAL INTEREST**	**2**	**CRITICAL**
3	**QUALITY STANDARDS**	**3**	**CRITICAL**
4	**FREE FLOW OF INFORMATION**	**4**	**CRITICAL**
5	**SIMPLIFYING THE WHOLE CONSTRUCTION PROCESS**	**5**	**CRITICAL**
6	RELIABILITY OF SUPPLY	6	MODERATE
7	CREATING STANDARDIZATION OF PROCESSES	7	MODERATE

8	SIMPLIFYING THE BIDDING PROCESS	8	MODERATE
9	FINANCIAL STATUS	9	MODERATE
10	COMPETITIVE ADVANTAGE IS SOUGHT BY SHARING INFORMATION WITH SUPPLIERS	10	MODERATE
11	TOP MANAGEMENT SUPPORT	11	MODERATE
12	BEING CONSULTED IN DECIDING THE PRODUCTION SCHEDULE	12	MINIMAL
13	BEING CONSULTED IN DECIDING WHICH NEW PRODUCTS TO DEVELOP	13	MINIMAL
14	BEING CONSULTED REGARDING NEW TECHNOLOGICAL INNOVATIONS	14	MINIMAL
15	CLOSER LINKS BETWEEN DEMAND/ SUPPLY	15	MINIMAL
16	MARKET COMPETITORS	16	MINIMAL
17	INBOUND TRANSPORTATION	17	MINIMAL
18	COMPETITIVE ADVANTAGE IS	18	MINIMAL

	SOUGHT BY TAKING INVENTORY DECISIONS		
19	MORE FREQUENT MEETINGS	19	MINIMAL
20	COMPETITIVE ADVANTAGE IS SOUGHT BY PRODUCTION PLANNING	20	MINIMAL
21	MANPOWER DEVELOPMENT	21	MINIMAL
22	INTEGRATED INFORMATION SYSTEMS	22	MINIMAL
23	JOINT BUSINESS PLANNING	23	MINIMAL
24	PROPORTION OF OVERALL PRODUCTION PROCESS SUBCONTRACTED TO OUTSIDE FIRMS	24	MINIMAL

7. RESULT

From the analysis it is cleared that the critical factors effecting SCMS for engineers are improved customer service, improved quality assurance, inventory, purchasing and overall supply chain reduction. The critical factors effecting SCMS for contractors are improved customer service, improved quality assurance, inventory, late and incorrect payments and cost reductions within your organization. Delivery at specified time, trust, handling of complaints, quality of service and cost and financial stability are the critical factors effecting SCMS for suppliers. Lastly trust, mutual interest, quality standards, free flow of information and simplifying the whole construction process are the critical factors effecting SCMS for clients.

8.CONCLUSION&RECOMMENDATION

Supply Chain Management is being practiced in many organizations as a tool to leverage their overall performance. It is also helpful to increase the profit by minimizing the cost and to satisfy the end-customer. Supply chains virtually exist in every organization but are especially apparent in manufacturing industries that have an obvious flow of goods from suppliers to manufacturing facility to the end customers. Today's supply chain management department, division or group is tailored and formulated to the level that meets the company needs. Supply chain overall main functions such as procurement, manufacturing, distribution, retailing etc. can be done differently and categorized as fits each firm. A good formulation of supply chain entity results in supply chain success that leads to organizational success.

The study was aimed to study the factors effecting supply chain management in Kerala construction projects. The different factors effecting supply chain management in construction industries were identified from different journals. The data's required for the study is achieved through questionnaire survey for engineers, contractors, suppliers and clients. As shown in the survey's analysis, some of the adverse conditions for engineers are customer service, quality assurance, inventory, purchasing and overall supply chain reduction. The critical factors effecting SCMS for contractors are improved customer service, improved quality assurance, inventory, late and incorrect payments and cost reductions within your organization. Delivery at specified time, trust, handling of complaints, quality of service and cost and financial stability are the critical factors effecting SCMS for suppliers. Trust, mutual interest, quality standards, free flow of information and simplifying the whole construction process are the critical factors effecting SCMS for clients. Therefore, it is proposed that to achieve the benefits of SCM it is necessary to apply a very systematic but flexible approach and with a long-term planning horizon so that many of these conditions can be changed effectively.

Some of the major benefits that construction organizations can achieve by means of applying SCM principles are: (i) the development of internal capacities to carry out their processes in a more effective and efficient way than that of their competitors; (ii) the development of strategies that will allow them to deliver better products and services to their targeted market segments and (iii) the effective organization and handling of the information and resources flows needed to improve the performance of their suppliers.

Recommendations:

1. Awareness and accountability should be created within the organization

2. Improvisation in customer service for better customer satisfaction.

3. Better purchasing management

4. Proper control, tracking and monitoring of the system is required

5. Firms employing proper supply chain management system should increasetheir overall efficiency.

6. Track your inventory

7. Timely payments

8. Cost control techniques

9. Improve distribution network

10. Establish information conduits

11. Trust between co-members

REFERENCES

1. Ana Beatriz Lopes de Sousa Jabbour, Alceu Gomes Alves Filho, Adriana Backx Noronha Viana, Charbel Jos Chiappetta Jabbour, (2011), '*Factors affecting the adoption of supply chain management practices: Evidence from the Brazilian electro-electronic sector*', IIMB Management Review 23, pp.208 -222.

2. Anders Segerstedt, Thomas Olofsson, (2010), '*Supply chains in the construction industry*', Supply Chain Management: An International Journal, Vol. 15, Issue 5, pp. 347 – 353.

3. Elbaz.M, (2011), '*Fuzzy performance measurement of supply chain in manufacturing companies, Expert Systems with Applications'*, Expert Systems with Applications, Vol 38, Issue 6, (June 2011), PP.6681-6688.

4. M.Agung Wibowo, Moh Nur Sholeh, (2015), '*The analysis of supply chain performance measurement at construction project*' Procedia Engineering 125, PP. 25 – 31.

5. Manoj Hudnurkar, Suresh Jakhar, Urvashi Rathod, (2014), '*Factors affecting collaboration in supply chain: A literature Review'*, Procedia - Social and Behavioral Sciences 133, pp 189 – 202.

6. Rajen B. Mistry, Vishal R Gajera, Hiren A. Rathod, *'Evaluation of factor affecting for supply chain in construction project'*,International Journals of Advanced Research in Engineering Science &Management. ISSN : 2394-1766.

7. Rajesh K. Singh, (2011), '*Developing the framework for coordination in supply chain of SMEs*', Business Process Management Journal Vol. 17 issue. 4.

8. S.Mukesh Balwani, S.A. Hussain, Aquib Ansari, Naseeruddin Haris, (2010), '*Supply Chain Management in Construction*', International Journal on Recent and Innovation Trends in Computing and Communication pp Volume: 3, Issue: 2.

9. Se-Hak Chun, Ho Joong Hwang and Yong-Hwan Byun, (2015), '*Green Supply Chain Management in the Construction Industry: Case of Korean Construction Companies'* Procedia - Social and Behavioral Sciences 186, pp. 507 – 512.