

A STUDY OF DELAYS IN PROCUREMENT OF ENGINEERED EQUIPMENT FOR ENGINEERING, PROCUREMENT AND CONSTRUCTION (EPC) PROJECTS IN INDIA: A MIXED METHOD RESEARCH APPROACH

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ABSTRACT

The supply chain of the EPC industry operates predominantly in an engineered to order manner. Most of the equipment procured are specially made for the project as per the technical specifications laid in the contract. Due to this the lead time of these equipment are generally higher than products that are 'out of the shelf'. Any delay in procurement of these equipment can have a cascading effect on the overall construction schedule. There is limited literature available on the procurement in the EPC industry. This paper thus presents a comprehensive review of the existing systems and practices for procurement of engineered equipment in EPC projects in India. The practices are analysed separating them into two segments, i.e. pre-order and post order procurement cycles. An exploratory sequential mixed method of research has been adopted for the purpose by taking inputs from Subject Matter Experts from different industries in the EPC sector. These inputs were in the form of semi structured interviews, which were analysed using the qualitative data analysis package NVIVO 10. A triangulation methodology has been attempted to validate the qualitative data collected. Finally a framework for improving the most significant of the delays in these projects has been presented.

Keywords: Procurement; EPC; Engineered Equipment; Mixed Method; Delays.

1. INTRODUCTION

EPC is an acronym for Engineering, Procurement and Construction. It is a form of contract agreement in the construction industry. The engineering and construction contractor is usually responsible for the detailed engineering design of the project, procurement of materials and equipment and construction of the facility for the end customer (EPC Engineer, 2016). The scope of work in an EPC project varies under different project settings. In some complex engineering projects, the scope of design is distributed between the client and the EPC contractor. Construction of certain critical components may also be in the scope of the client.

EPC projects are one of the most challenging construction models. This paper deals with the problems associated with the procurement of engineered equipment for large EPC projects in India. The main procurement and logistics activities in any construction industry include sourcing, purchasing, contracting and on site materials management. The supply chain of the EPC industry operates predominantly in an engineered to order manner (Cagno and Micheli, 2011). That is to say most of the equipment to be procured by the EPC contractor are not readily available with suppliers. They are specially made for the project abiding to technical requirements as laid in the contract. Due to this the lead time of these equipment are generally higher than products that are 'out of the shelf'. Procurement of these equipment is significantly different from bulk material procurement (Yeo and Ning, 2006). During the procurement cycle there is enormous flow of information between stakeholders. Also, most of the large engineering and construction firms have very elaborate processes laid for placing orders to suppliers. All this makes the process of procurement more complex than the traditional material procurement existing in the construction industry. Thus the objective of this study is to understand the existing systems and practices for procurement of engineered equipment in EPC projects in India and to analyse the various attributes causing delay in the process.

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2. BACKGROUND

Procurement is defined as the acquisition of goods, services, or construction, from a third party at the best possible price, in an appropriate quantity, at the right time and place. There is less clarity of procurement as a process in the construction industry (Ruparathna and Hewage, 2013). The scope of procurement is not only limited to the purchase of equipment/material but also to source any resource (like manpower) utilized in the project. An EPC project is a type of contract agreement made up of a large number of interconnected subsystems consuming considerable human effort (Yeo and Ning, 2002). There is limited literature available on the procurement in the EPC industry (Azambuja, 2014). Most of the available literature focuses on bulk material procurement, i.e. mandatory construction materials like cement, sand, concrete, etc., common to all construction projects (Yeo and Ning, 2006). EPC procurement is an extreme case of engineered to order environment operating under a high degree of complexity and value (Micheli *et al.*, 2009). Engineered to order materials have more complex requirements which influence their design and construction (Neuman, 2015). The same authors echo the concern that a majority of owners and their representatives accept the cheapest price as the most economical long term solution. Project material cost represents a high proportion of the total cost of EPC projects (Cagno and Micheli, 2011). This highlights the need for timely completion of procurement within cost.

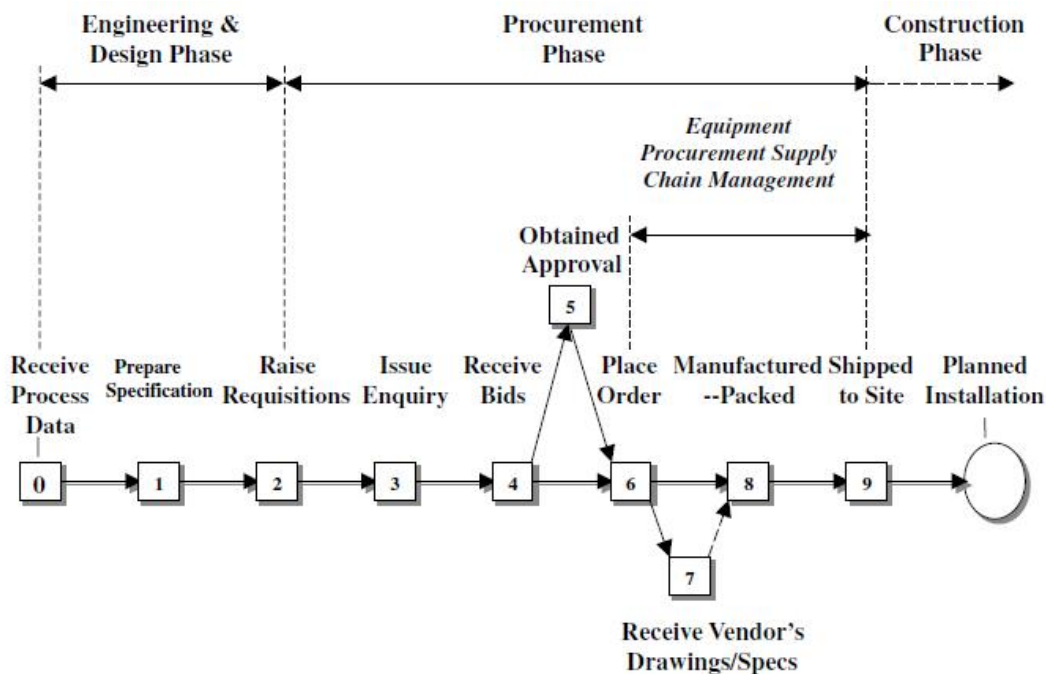


Figure 1: Procurement Process in an EPC Project
Source: Yeo and Ning (2006)

3. METHODOLOGY

Due to lack of available literature specific to EPC procurement in India, an exploratory sequential mixed methods approach has been adopted (Creswell, 2014). The purpose of qualitative study is to get a better understanding of the procurement process and to identify the bottlenecks in the execution. Quantitative analysis has been used to quantify findings from the qualitative study and to identify the most significant of the issues causing delay to the process.

To understand the procurement of engineered equipment for EPC projects in India a case study approach was adopted. Two large EPC projects from an engineering and construction major in India had been taken for the study. Procurement manuals and opinions of subject matter experts were sources of input for understanding the process.

To get a detailed understanding of the process and issues, subject matter experts were interviewed. These experts had vast experience in the field of EPC and procurement. A total of seventeen respondents

comprising of directors, general managers, buyers, original equipment manufacturers were interviewed. The interviews lasted about half an hour to one hour depending on the extent to which the participants shared their experiences about the various questions put forward to them. The interviewees shared their opinion to a semi structured set of questions asked to them. The attributes causing delay were obtained after transcribing and analysing the interviews using the NVIVO 10 software. These attributes were attempted to be validated using a triangulation method. A purchase order¹ (PO) instrument was utilized for this purpose. A purchase order instrument is a questionnaire that is specific to a purchase order (of a company) and aims to track and validate the factors from the interviews with the purchase order data. These are filled by the respective buyers (procurement personnel) associated with the order. Finally a framework for improvements has been suggested.

4. CASE STUDY

Two large power projects (EPC) were studied to comprehend the process of procurement of engineered equipment. This helped understand the pre-order and the post-order procurement cycles involved in this process. The inputs for the case study were the procurement manuals and interviews with subject matter experts conducted in that organization.

4.1. PRE-ORDER PROCUREMENT CYCLE

Pre-order procurement cycle begins in a project with a 'Shopping list'. These are the items that need to be procured under the scope of work of the project. Once the list is available, a procurement plan is prepared in synchronization with the project execution plan and the milestone completion dates. These procurement plans are prepared keeping in mind the criticality of the equipment and the lead time for manufacturing. Once this is done the 'Request for Quote's' are prepared by the design team and floated by the buyers to the respective approved suppliers. The client or the contractor himself has a list of approved suppliers from whom these items are to be procured. These suppliers are shortlisted on the basis of their manufacturing capabilities and their past performance. The list of these suppliers may be provided by the client as a part of the contract or the EPC contractor has his own list of suppliers.

Once the RFQ's are floated a two stage sealed bidding process (technical followed by commercial) is followed. All the approved suppliers are first evaluated on the basis of the technical offers submitted by them. Any queries or comments are clarified to all the bidders and a technical compliance sheet is prepared. This sheet will have the compliance status of all the bidders. Once this is completed the commercial offers of the qualified suppliers are only evaluated. Contractual terms, payment terms and delivery schedules are discussed with the qualified bidders. Commercial negotiations are done with the suppliers if need be. After this process the lowest price bidder (L-1) is finalized and approvals are taken. Finally a 'Letter of Intent' is issued to the L-1 bidder followed by a computerized purchase order. The flow of activities may vary slightly across firms, but the overall framework for operation more/less remains the same. The flow of activities is very similar to that shown in Figure 1 (steps 1-6). A schematic diagram of the pre-order procurement cycle as understood in this study is represented in Figure 2.

^BA purchase order is a document that is issued to the supplier for the scope of work to be completed by him under the order.

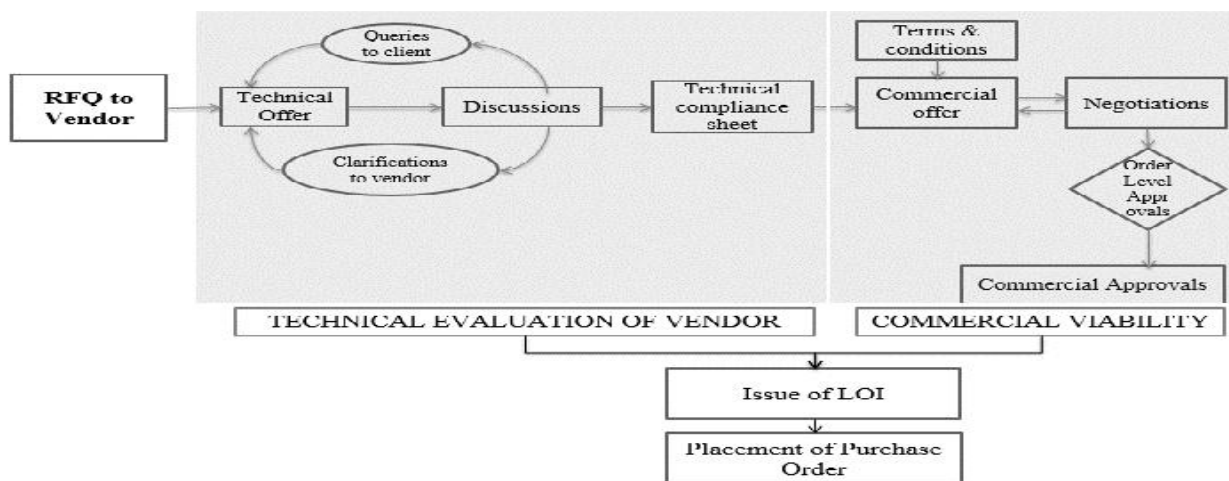


Figure 2: Pre Order Procurement Cycle

4.2. POST ORDER CYCLE

Once the order is issued to the supplier a kick off meeting is held in the presence of the contractor and the client (refer to Figure 3). The major deliverables, schedule of work are discussed and documented in this meeting. A project specific expediting team consisting of engineers, procurement personnel and quality assurance engineers from the contractor/PMC side are made responsible for these item(s). This team is usually specific to a project. Detailed engineering and post order documentation as per the scope of work of the supplier is carried stage by stage. After the entire process is completed the manufacturer is given the clearance for manufacturing. Depending upon the quality assurance plan, stage inspections are carried out. Finally the supplier completes the manufacturing and the material is inspected before it is dispatched to project site. Logistics may or may not be in the scope of the supplier.

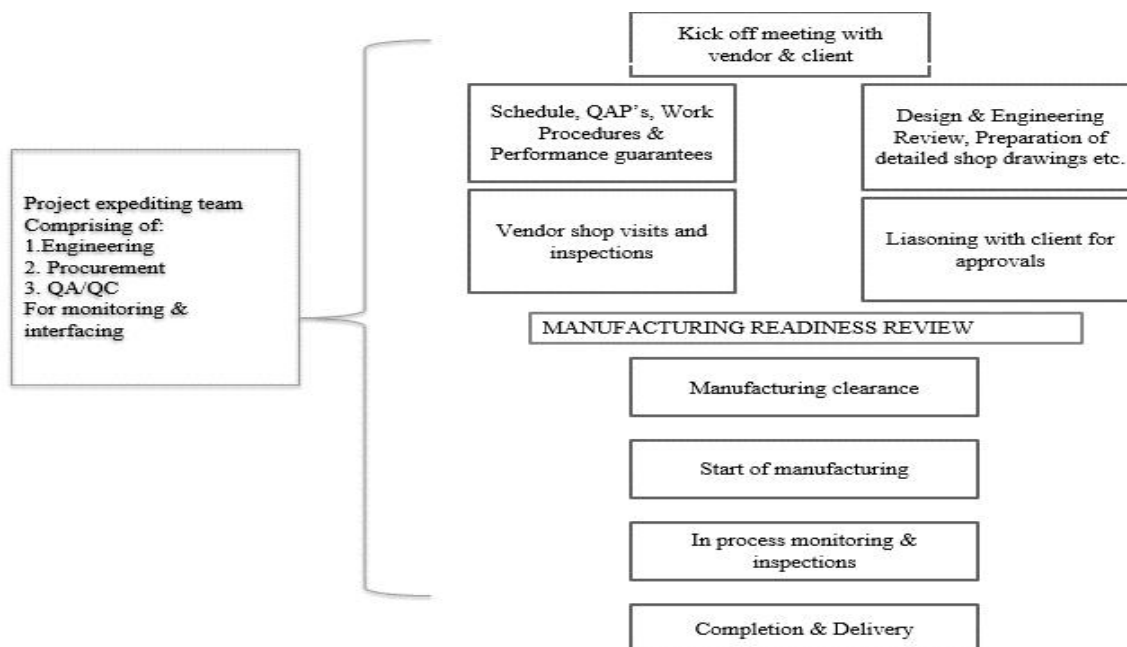


Figure 3: Post Order Procurement Cycle

This case study helped understand the elaborate process of procurement and the various stakeholders involved in the process. It also helped apprehend the issues put forward by the respondents in their interviews.

4.3. DELAY DEFINITION

Currently, there is no standard definition of delay in the pre order procurement cycle. For the post order period this study has considered as any excess time taken from the specified purchase order duration as delay in this stage.

5. QUALITATIVE DATA ANALYSIS

A total of seventeen interviews were conducted to understand the issues relating to the procurement of engineering equipment for EPC projects. The respondents were primarily from petrochemical, oil and gas, nuclear and electrical EPC projects. The interviews were analysed using the qualitative data analysis package NVivo 10 (QSR International, 2016). This software package was used to transcribe the interviews and to find patterns from the transcribed data. Standard reports available on the software were used for reporting the data. The data obtained after coding the transcripts is shown in Table 1. ‘Count’ represents the number of times an issue pertaining to that category has been highlighted. ‘Number of issues’ are the total issues highlighted under that category. A word frequency search in the transcribed interviews is shown in Figure 4. The word ‘vendors’ was used the most number of times by all the respondents. The issues in Table 1 were categorized on the basis of their nature and on the experience of the authors of this paper.

Table 1: Nature of Issues

| Nature of Issue | Count | Number of Issues | Significance |
|----------------------------------|-------|------------------|--------------|
| Procurement Planning | 21 | 13 | 24.1% |
| Information Management | 19 | 9 | 21.8% |
| Procedural Hindrances | 11 | 5 | 12.6% |
| Supplier Related Issues | 8 | 5 | 9.2% |
| Contractor-Organizational Issues | 7 | 3 | 8.0% |
| Technical Issues | 6 | 1 | 6.9% |
| Working Capital / Payment Issues | 5 | 2 | 5.7% |
| Client Related Issues | 4 | 3 | 4.6% |
| Contractual / Order Issues | 3 | 3 | 3.4% |
| Others | 3 | 3 | 3.4% |



Figure 4: ‘Key Word’ Search from Nvivo 10

5.1. FINDINGS FROM STUDY

The key issues causing delay from the qualitative data collected are discussed below:

Procurement planning - This was seen as the most significant type of issue. Issues such as unrealistic project completion dates, lack of a defined procurement lifecycle time, lack of engagement of suppliers in the initial stages of procurement, lack of accurate in-house cost estimates, lack of a project procurement plan and improper supplier pre-qualifications were highlighted here. Ideally planning forms the backbone of any process and it is evident that this supply chain faces problems in it.

Information management - Due to the involvement of a large number of stakeholders, the quantum of information shared and processed in the supply chain is very large. In this scenario the respondents agreed that there were delays in receiving, sharing information and document approvals.

Procedural hindrances - Most of the respondents were from very large EPC firms and had a very well laid work flow for the activities. As highlighted by a few respondents this proved to be a hindrance as well. Some of the government contractors for example felt stringent purchase procedures time consuming leading to delay. Allocation of some minimum orders to MSME (Micro, Small and Medium Enterprises) suppliers was also seen a hindrance. Another significant delay was observed in getting new suppliers qualified.

Supplier related issues - Delay in initiation of the contract post the award of the order, non-compliance at crucial stages and lack of control over the sub-vendors were some of the issues leading to delays in the procurement process.

Contractor/Organisational issues - Indecisiveness and incompetency can lead to delays in the procurement process. Delay in taking decisions, lack of applied oriented qualified engineers and lack of role clarity were the main issues highlighted by the respondents

Technical issues - Unclear and ambiguous specifications was the only issue that was repeatedly highlighted by most respondents. Lack of clarity in the specifications, often leads to delays both during the pre-order as well as the post-order stage of the purchase order

Working Capital/Payment issues - Delay in payments to the suppliers and delay in payments by the clients leads to significant delay in the supply chain. Once the supplier is not paid, he will not have the necessary funds to pay his sub-vendors and the effect cascades throughout.

Client related issues - Lack of cooperation of the client to inspection calls and inadequate staff to provide approvals in time were some of the main issues highlighted.

Others - Lack of proper raw materials, lack of certain testing companies are some of the issues grouped under this category.

6. DATA VALIDATION

A triangulation approach has been attempted to validate the findings from the qualitative data collected. A purchase order instrument has been used for this purpose.

6.1. PURCHASE ORDER INSTRUMENT

This is a questionnaire specific to a purchase order completed by the respective buyers (procurement specialists) associated with the order. This instrument aimed at checking the impact and significance of the issues from the qualitative survey against purchase order. A total of six purchase orders were taken and the respective buyers were asked to complete the purchase order instrument. The purchase orders were of mechanical, electrical and instrumentation equipment taken from a large EPC firm. The buyers were initially asked to indicate whether the issues (from qualitative analysis) led to delays in a particular purchase order and if so the impact of those issues on the order. These impact scores were added to identify the most significant issues.

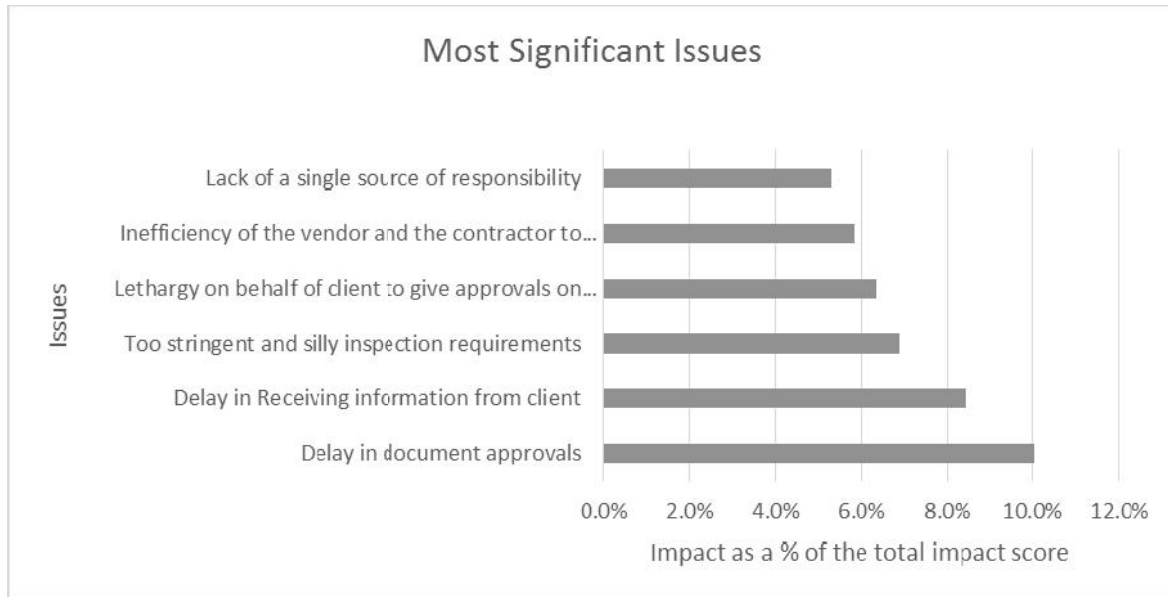


Figure 5: Significant Issues from Purchase Order Instrument

Delay in getting documents approved and delay in receiving information from the client were indicated to be the top two significant issues that buyers faced in purchase orders (refer to Figure 5). Almost all the buyers had given an impact rating of 5 (maximum) to ‘Delay in getting documents approved’ which highlights the importance the process of document approval plays in a purchase order.

6.2. CHALLENGES FACED

The lack of actual documented delay data had proved to be a hindrance in validating the findings from the qualitative data obtained in this study. In most EPC firms, the buyer is responsible for the equipment from start to the end. Due to this the opinion of the buyer was taken into consideration. But because the opinion of the buyer was only taken the element of bias in the output could not be eliminated. Due to this the results from the PO instrument were not sufficient to validate the findings from the qualitative study. But this has opened up the need for new and innovative means of validating qualitative data where the actual documented delay data is not present.

7. MITIGATION MEASURES

Four areas for improvements have been suggested to improve the most significant of the issues:

7.1. PROCUREMENT PLANNING AND MONITORING

Partnerships

Tie-ups and partnerships with equipment and material suppliers can help address the starting hiccups and reduce the procurement the lifecycle time. These suppliers are to enter into an agreement with EPC contractors for the supply of specialized equipment for their projects. This will help save time for detailed engineering as the supplier will be conversant and may not have to tweak the design completely. Due to the nature of this collaboration, the supplier should be in a position to address any fluctuations in demand. Activities like background checks and commercial negotiations can be avoided which significantly reduce the process time. This model will be successful provided the EPC contractor has enough projects in the pipeline.

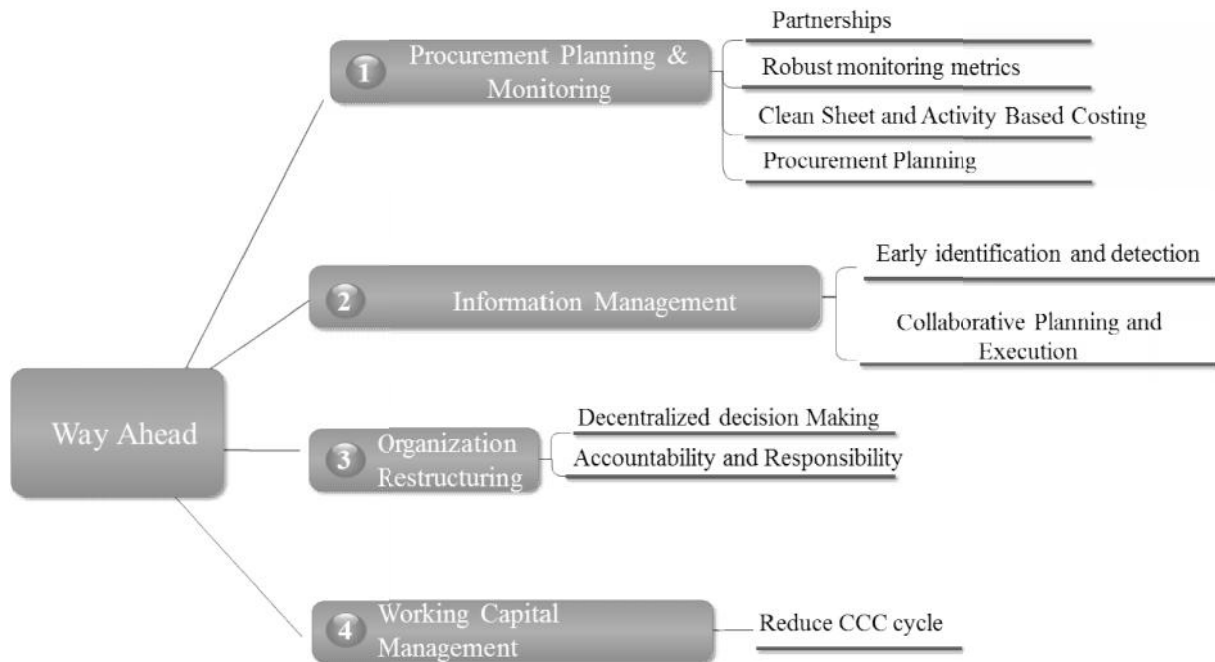


Figure 6: Mitigation Measures

Robust Monitoring Metrics

One of the initial findings of the study were the absence of any robust procurement monitoring metrics in the EPC industry in India. The practice was to follow the purchase order dates as a guideline for measuring delays in the lifecycle. New project specific metrics such as the productivity of the design team (time taken to given technical compliance), productivity of the procurement team (time taken to place an order) etc., depending on the complexity need to be framed.

Activity based Costing

A method of capturing the total cost of a product by including the overhead costs (on the basis of the amount of resource consumed) is used in manufacturing (Accounting Coach, 2016). Such a decision support is required in the procurement process to capture the overhead costs associated with every equipment procured. It will help bifurcate the products which require more time to the ones that can be easily procured, thereby reducing the cycle time significantly.

Procurement Planning

A project specific procurement strategy taking both the upstream suppliers and the downstream clients is required in order to ensure the materials are received at site in time.

7.2. INFORMATION MANAGEMENT

Early Identification and Detection

Most of the delays in document approvals occur due to incomplete or incorrect information submitted by the supplier/contractor. This is partially due to the abundance of documents that are transmitted to and from between the stakeholders. The success here is to ensure that these issues are detected in the early stage of the order and corrected either by having a robust document management tracker or by clearing the documents along with the supplier's team in the first place itself.

Collaborative Planning and Execution

A major cause for delays in the procurement process is the lack of synergy between the stakeholders. It is essential that the client and the prospective suppliers are together involved in the process of procurement planning to ensure that all the information is equally disseminated. The same applies for the interdepartmental information exchange within the EPC contractor's organization.

7.3. ORGANIZATIONAL RESTRUCTURING

Decentralized Decision Making

In order to get a cost advantage most EPC firms have a centralized procurement and overseeing team. Though this process helps achieve that purpose, the orders are inadvertently delayed due to the long chain of approvals. To add to this the buyers, the client and the material suppliers are usually not stationed in the same vicinity. Due to this the amount of communication is extremely large. An ideal situation would be to transfer a few decision making and purchasing operations to the project site. This will help bring the buyers and the client on one platform and ensure a faster approval process.

Accountability and Responsibility

One of the causes of delays in procurement as observed in this study is the lack of a single point of responsibility. Due to the wide-spread nature of the activities having one person responsible (say a buyer) for all the activities may not be feasible as he may be involved simultaneously in multiple projects. It is thus essential to have project specific expeditors who will be earmarked for a particular project and will be responsible for the end to end execution.

7.4. WORKING CAPITAL MANAGEMENT

Reducing the Cash Conversion Cycle (CCC)

CCC is the liquidity of the working capital of a firm (Investopedia, 2016). The lesser the CCC, the more liquid cash available to be spent. In the context of this study, CCC cycle can be kept low by ensuring appropriate payment terms by the client and to the supplier at the starting of the contract. Studying the cash conversion cycle helps understand the working capital requirements in advance so that appropriate action can be taken in time.

8. SUMMARY

EPC projects are one of the most challenging construction models. Procurement in EPC operates predominantly in a 'made to order' fashion with material costs representing a major proportion of the total project cost. In such a scenario any delay in the procurement process has a cascading effect on the construction process and in turn on the overall project schedule. There is limited study done on procurement in EPC industry specific to an Indian setting. This study thus aims to understand the procurement process specific to engineered equipment and identify issues that lead to a delay in the process.

An exploratory sequential mixed method approach has been adopted in this study. A case study was done to understand the procurement process. A qualitative analysis was carried out to understand the process of procurement and the issues during execution. Subject matter experts were interviewed to understand the same. Quantitative analysis of the data was carried out to quantify and rank the findings from the qualitative study. An attempt to validate the findings using a triangulation method was carried out.

The case study helped understand the stages of pre-order and the post-order procurement cycles in a typical EPC procurement life-cycle. An analysis of the issues from the qualitative data collected was presented in this study. The data from the interviews were broadly classified into ten categories of which procurement planning and information management were the top two most significant issue areas. A framework for improvement of these issues focussing on procurement planning, information management, organization restructuring and working capital management has been presented.

While this study followed a structured approach from start, the absence of documented delay data proved the biggest challenge in validating the findings from the study. The results from the purchase order instrument were not sufficient to validate the findings and this calls for an extension to the current work and identifying new and innovative means of validating qualitative data where the actual documented delay data is not present.

9. REFERENCES

- Accounting Coach. 2016. *Activity Based Costing* [Online]. Available from: <http://www.accountingcoach.com/activity-based-costing/explanation> [Accessed 2 March 2016].
- Azambuja, M., Ponticelli, S. and O'Brien, W., 2014. Strategic Procurement Practices for the Industrial Supply Chain. *Journal of Construction Engineering and Management*, 140(7), 06014005.
- Cagno, E. and Micheli, G.J., 2011. Enhancing EPC supply chain competitiveness through procurement risk management. *Risk Management*, 13(3), 147-180.
- Creswell, J., 2003. *Research Design*. Thousand Oaks, California: Sage Publications.
- EPC Engineer, 2016. *EPC - Engineering Procurement Construction* [online]. Available from: <http://www.epcengineer.com/definition/132/epc-engineering-procurement-construction> [Accessed 15 February 2016].
- Investopedia, 2016. *Cash Conversion Cycle* [online]. Retrieved from: <http://www.investopedia.com/terms/c/cashconversioncycle.asp> [Accessed 10 March 2016].
- Micheli, G.J., Cagno, E. and Di Giulio, A., 2009. Reducing the total cost of supply through risk-efficiency-based supplier selection in the EPC industry. *Journal of Purchasing and Supply Management*, 15(3), 166-177.
- Neuman, Y., Alves, T., Walsh, K. and Needy, K. 2015. Quantitative Analysis of Supplier Quality Surveillance Practices in EPC Projects. *Journal of Construction Engineering and Management*, 141(11), 04015039.
- QSR International, 2016. *NVivo 10 for Windows Help* [online]. Available from: http://help-nv10.qsrinternational.com/desktop/procedures/run_a_text_search_query.htm [Accessed 10 January 2016].
- Ruparathna, R. and Hewage, K., 2013. Review of contemporary construction procurement practices. *Journal of Management in Engineering*, 31(3), 04014038.
- Yeo, K.T. and Ning, J.H., 2002. Integrating supply chain and critical chain concepts in engineer-procure-construct (EPC) projects. *International Journal of Project Management*, 20(4), pp.253-262.
- Yeo, K.T. and Ning, J.H., 2006. Managing uncertainty in major equipment procurement in engineering projects. *European Journal of Operational Research*, 171(1), 123-134.