Advancing Lean Implementation within a Construction Supply Chain

M Saini, m.saini@wlv.ac.uk
University of Wolverhampton, UK

M Arif, mohammed.arif@wlv.ac.uk
University of Wolverhampton, UK

Abstract

This investigation leads to critical recommendations for advancing the Small and Medium Enterprises (SMEs) for lean implementation within a Construction Supply Chain (CSC). The findings suggest that implementing Lean within a CSC requires a similar effort at different levels (Organisational and Process) of Supply Chain. This study presents essential recommendations that would ensure smooth flow of Lean implementation at all levels of a CSC.

This paper draws upon relevant literature, sixty-three surveys and interviews with four professionals working on the frontlines and emphasises on the issues that hinder the SMEs engagement and contribution to Lean within Construction Supply Chain. Moreover, this involved respondents from Tier 1, Tier 2, and Tier 3 of a CSC that includes clients, executives, consultants, and other managers, who are directly involved in the Lean implementation in construction projects.

This paper adds value to the existing knowledge of Lean implementation in a CSC and SMEs. This study is original in terms of establishing the recommendation to lean implementation in a CSC.

Keywords – Lean Implementation, Construction Supply Chain, Knowledge Management, Lean in Construction, Lean Construction, Knowledge Sharing

1 Introduction

According to the Department of Business Innovation and Skills, small firms account for 99.3% of all private sector businesses in the United Kingdom (UK), 47.8% of private sector employment and 33.2% of private sector turnover. In addition, more than 18% of all SMEs in the UK industry operate in the construction industry. A key focus of EU and UK policies has been on facilitating SME involvement within the procurement process and capturing the following benefits.

As part of its Lean Strategy, Framework Agreement (2011) promotes a structured approach to enhance Lean Maturity, with a focus on five supporting themes of 1) Collaborative Planning, 2) Visual Management, 3) Problem-Solving, 4) Benefit Realisation and 5) Knowledge Transfer. However, interviews done as part of this project indicate that Lean approaches are not entirely embedded and widely adopted by SMEs. Before committing to Lean adoption, SMEs are seeking surety about the benefits of Lean adoption against the implementation cost. This study reveals that current Lean implementation focus of the UK construction industry is primarily on Tier 1 (main contractors) of the Supply Chain. A long-term strategic direction for Lean Construction needs further development at SME level (i.e. at the level of Tier 2 (sub-contractors) and Tier 3 (sub-sub-contractors) Suppliers).

The current Lean Construction training mechanisms, just cover basic Lean concepts and are not continuous. It is essential to convey the idea that Lean is necessarily a “Learning by Doing” journey where teams have to get their hands dirty and identify bottom-up Kaizen (a Japanese business philosophy of continuous improvement) initiatives. The ultimate objective

is to get to a point where Supply Chain members are practising Kaizen on a daily basis and taking corrective actions to address problems, as and when they become visible.

Such an approach to continuous improvement through experimentation will require addressing existing attitudes towards risk. Currently, risk aversion within SMEs is too high to promote "Learning by Doing" Lean initiatives within a CSC. Some Lean principles (i.e. Collaborative planning, Visual Management, etc.) has been applied in a fragmented manner, as opposed to a holistic Lean production system approach. This leads to the creation of individual pockets of best practice, with organisation slipping back to prior processes because of a lack of adoption of new improved approaches as standard operating procedures. For example, many construction & maintenance performance issues stem from the initial design. However, generally, the SMEs have little say on the design stage of construction. Therefore, the cooperation between the organisations in the Supply Chain to drive Lean Construction is limited and fragmented. Moreover, the external training mechanisms run by consultants and Tier 1s are the principal formal training mean for Lean Construction. Although the SMEs constitute the most significant portion of the Supply Chain, however, the focus of Lean initiative appears to be targeted primarily towards Tier 1 of the CSC.

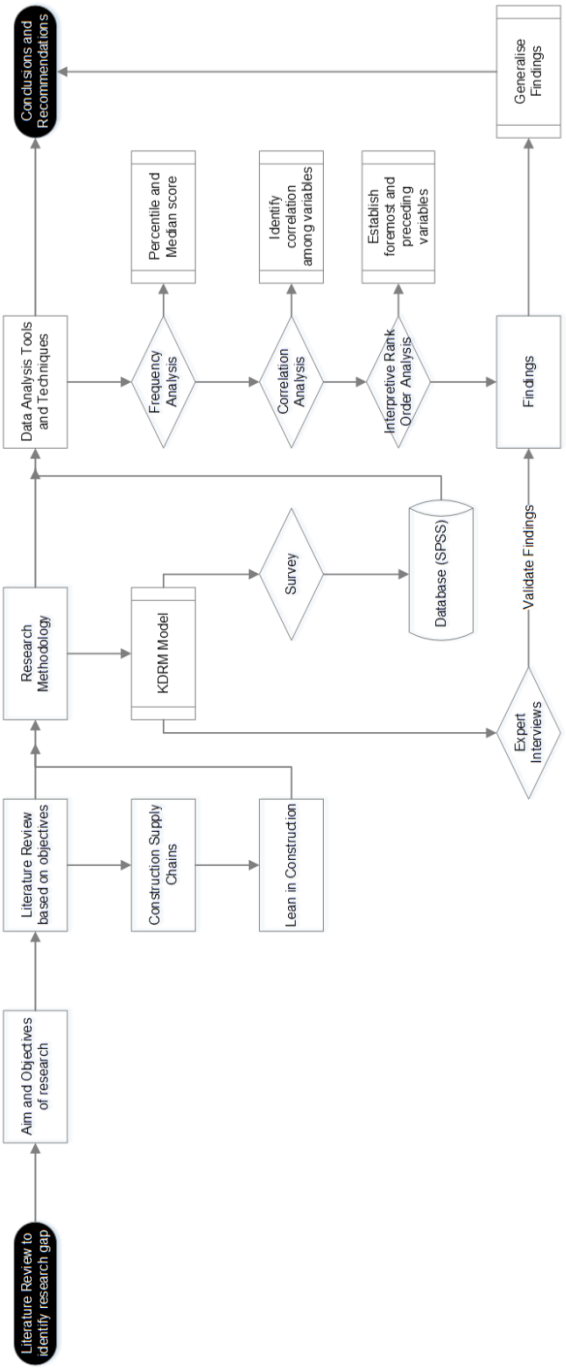
2 Literature Review

The UK construction industry consists of over 280k firms (contracting, services and products) employing over 2.93 million people (10% of total UK employment) in a multitude of roles (BIS 2013). The construction sector is defined as one, which embraces the building materials and products, suppliers and producers, construction services manufacturers, providers and installers; contractors, sub-contractors, professionals, advisors and construction clients and those relevant organisations build, to the design, build, operation and refurbishment of buildings" (Lomax et al 2013). Even so, in 2013 for publication, the construction sector is defined the composition of the construction industry (BIS, 2013d) as, (i) construction contracting, (ii) construction-related professional service and (iii) construction-related products and materials. BIS (2013) also stated that the construction industry is known as one of the knowledge-based value-creating industries. However, the construction sector consists, at least 99.9% of firms are SMEs and, of those, about 70% employ no more than one person (BIS 2013d).

As a critical barrier to change, some of the researchers such as ((Brewer and Johnson 2004, Baldauf C and Hubbard 2011, Lynagh 2011)) suggested that industry needs to be integrated and collaborative Supply Chain approach. Alashwal et al (2011) revealed that the reason could be the number of SMEs increase and substantial firm decreases. In February 2014, in the construction industry, 37% of organisations were more likely than average to have reduced employment (BIS 2013d). The other analysis carried out for BIS (2013) by ES Harris (2013) reveals that the Main Contractors may be directly managing around seventy sub-contracts in which 70% of contracts are below £10k (BIS 2013d) they emphasised this is the clear evidence of the scale of fragmentation in the construction industry. The Egan, Letham & BIS reports suggested that the SMEs held an essential position in the construction sector. However, the individuals SMEs may hold specialised skills and knowledge in one of the aspects of CSC, but not necessarily, they hold the skills that are required for Lean implementation. Therefore, the knowledge of an SME does not contribute as it should be within a CSC for Lean implementation. Herewith, SMEs with the lack of Lean knowledge could not contribute efficiently and more importantly to advance Lean implementation within a CSC. This result, in misleading the real meaning of Lean implementation in CSCs.

3 Research Methodology

Figure 1: Research Process



This investigation adopts a systematic research methodology to define the challenges through literature review. The “Knowledge Driven Research Methodology Model” originated by Saini (2015) has been adopted to drive the research. The **Figure *1*** above illustrates the research process of this study. This study draws the main recommendations of advancing Lean implementation within CSCs and Construction SMEs from the literature review and survey and expert interviews. The interviews were conducted to understand the perspective of senior executives who were directly involved in Lean implementation within Construction SMEs. As presented in **Figure *1*** above, the data is interpreted to generalise the views of respondents about the Lean implementation in a CSC. Finally, recommendations are drawn from significant findings of survey, interviews and literature review. The questionnaire was

designed with five (5) point Likert scale to capture the views of respondents. The questionnaire design through a Likert scale produces data in an ordinal scale (non-parametric). Having, the ordinal scale of data provided the opportunity to analyse in SPSS while running Frequency analysis (to understand the mean, median and mode statistics) Spearman's correlation analysis (to understand relationship between factors) and Rank order analysis (ranking the factors to establish most essential and supporting factors). Eighty-three (83) responses were received. The number of responses gave the research team confidence in the data and indicated that valid inferences could be drawn from this data. A high level of internal consistency for this data is calculated, as Cronbach's alpha (α) is 0.702. The respondent's experience is the basis for their response.

4 Lean Philosophy

Is the term to reduce the non-value added activities such as material waste, operations and equipment's (Muri, Mura, and Muda) from the operations to enhance process flow and add value as well as deliver what customers want? Historically, Lean was initiated based on the flow concept, and the value concept, cultivated by the quality movement and subsequently merged with Lean (Sacks et al 2009). CIRIA (2013) defined, Lean as a term that relates to a proven way of doing business, entirely focused on maximising customer value through the relentless elimination of all forms of process waste and ensuring that value-adding activities are completed in the most efficient and time-effective manner."

Toyota Production System (TPS) defined seven (7) types of waste namely, Defects, Inventory, Processing, Waiting, Motion, Transportation and Overproduction. According to Womack (2006), these kinds of wastes can be removed without the need to coordinate with the larger organisations. Consequently, it defines the in-house waste, and the workers can just remove that. This means that the people involved in the construction process can eliminate the waste.

4.1 Lean Construction

Lean Construction is a new way to manage work over the life of a project. It is not a productivity improvement program (Sacks et al 2010). Lean Construction is a production management-based approach to project delivery; it is a new way to design and build capital facilities (Sacks et al 2009). The application of Lean production management to manufacturing caused a revolution. The objectives of the Lean production systems are to maximise value and minimise waste to specific techniques, and applies those techniques to form a project-based production system (Childerhouse et al 2003). Lean Construction is particularly useful on complex, uncertain, and quick projects. The Lean principles in **Error! Reference source not found.** below are based on increasing the quality of work and products, increase value by eliminating waste and increase flow through the process.

Although there have been many Lean principles suggested explicitly for Lean Construction. In construction, Lean is an operational excellence strategy that enables better change. Kaizen, in Japanese means 'change for good' is the core philosophy of Lean. However, the Lean process is slow and steady, instead of quick and vague (Dombrowski et al 2012). The Japanese views that Lean principles are a persistence pursuit in the elimination of waste. Where waste means any activity that adds no real value to the product or service. Moreover, the Japanese thought of Lean is not only to eliminate the waste to increase the value but also enhance the speed of the processes (to increase flow). Pheng and Fang (2005) given eleven Lean principles while naming them the modern-day Lean Construction principles. However, those Lean principles relate to the main aim of Lean principles to increase the value, increase flow and continuous improvement. Later, Sacks et al (2009) said that, like in the TPS, the focus in Lean Construction is on the reduction of waste, an increase of value for the customer, and continuous improvement in a CSC overall.

Table 1:

Lean principles and its application in construction

Lean Principle	Characteristics	Application Within A CSC
Value	To generate and add value to a construction process while removing waste from it	A precise definition of the project scope (both internal and external) and the definition of what constitutes value is the starting point to attack non-value-adding activities or waste.
Waste	To improve the construction process, while removing unwanted activities (waste) from it	Elimination of all non-value added activities that hinder the flow and efficiency of delivering the customer demand.
Flow/value stream	To enhance the flow of materials and information within construction processes	A flow/value stream is the entire set of activities within the CSC. This consists of the end-to-end process that delivers value to the customers.
Efficiency	To increase the efficiency of construction processes	Main contractors need to understand and increase efficiency to deliver customer demand- what and when it is required.
Continuous improvement	To continuously improve the construction processes until the desired results are achieved	To be bold and challenge some of our current practices, working with suppliers to continuously improve.

Source: Aziz et al (2016)

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4.2 Construction Supply Chains

In a CSC, a process mapping (Value Stream Mapping) is characterised with the five main divisions, Mega-process, Major-process, Sub-process, Activities and Tasks (Saini 2015). The value stream of a CSC can also be characterised by the level of contractual agreements such as Tier 1 (Main Contractors), Tier 2 and 3 (Sub-contractors) and beyond.

A mega-process is the highest level of processes identifies by an organisation. It is a combination of more than one major-process (Capgemini 2004). Mega-process usually forms a core value-chain for an organisation. A major-process is a sub-division of mega-process and is a combination of several subprocesses, and a subprocess is a combination of several activities. An activity is a unit of work performed by one job function at one time with one mode of operation. Each activity can have several tasks. A task is a work step carried out to complete an activity.

A series of processes that work on the Lean principles towards one goal adds value to the self and following processes and across the whole set of manufacturing processes (Jørgensen and Emmitt 2008, Koh et al 2008). In the Lean process, the focus is to improve each in-action task to improve to make it Short, Straighten, Shine, Standardise, and Sustain (5S of Lean) and to reduce wastes (Womack and Jones 2003).

Non-value added type activities need to be removed such as excessive motion involved in a task (Womack & Jones 2003). If tasks within an activity are subsequently improved, it adds value to the activity. In addition, a group of improved activities brings value to the subprocess and afterwards major-process and at the end, mega-process levels (Lin and Tserng 2003).

In reality, Lean in construction is not just to remove waste from the building process, or to make the standardised material to use in construction projects. Lean is mainly to improve the construction process to develop innovative and sustainable construction.

Therefore, this study establishes that if the benefits of Lean thinking is desired in a construction project, the aforementioned Lean principles must be implemented within the entire construction project and within the organisations involved. Organisations handling Lean Construction projects must implement Lean principles on each level of construction (throughout a mega-process, major-process, subprocess, and activity and task levels (Saini 2015).

Failure to employ these principles at all levels will lead to non-achievement of the stated goals/objectives, as all the departments in the organisations are interconnected. Therefore, Lean must be implemented at all stages (i.e. planning, contracts and bid documents, construction, payments and completions) of construction. However, implementing Lean in the lifecycle of a building project is highly challenging.

4.3 Barriers to Lean Implementation Within a CSC

Literature review of this study portrays a list of potential supporting factors (Figure 2 below) those jointly contributes to the problem of implementing lean in a CSC. These below-mentioned factors support the main and sub-clauses of the degradation of a CSCs. However, the lists of supporting factors are not exhausted, there may be other supporting causes in each discipline of the organisational level and further at CSC level.

The further analysis of the challenging factors given us the confidence to categorise those challenges into the causes and the supporting factors through a root-cause analysis. **Figure *2*** below illustrates three main sections of primary challenges to implementing lean in a CSC, fragmented supply chain, Lack of effective knowledge management systems and

insufficiency of transferring and sharing tacit knowledge. It also presents the relationship between the causes that support those three main challenges and supporting factors.

Through this analysis we come to a decision that lack of knowledge management systems and especially the framework of Knowledge Communication is required to advance the Lean implementation in a CSC.

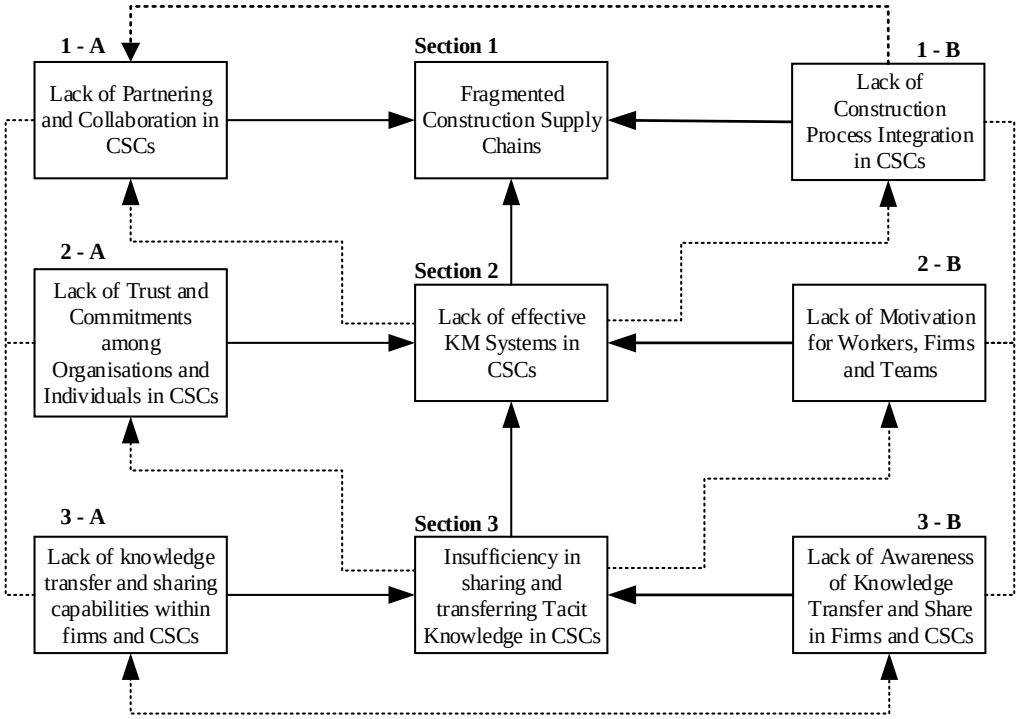

Figure 2: Relationship between main, sub-clauses, and its supporting factors/challenges for lean implementation

5 Discussion

A number of the main findings were identified from the interviews and literature review regarding the current condition of and way forward for Lean Construction at the Construction SMEs. Those key findings for the current condition of Lean Construction at the SMEs are as such:

The qualitative analysis in this study reveals that SMEs contends that main contractor's (Tier 1s') work procedures are too rigid and bureaucratic to enable SMEs to make process improvements through Lean tools and techniques. The SMEs also feels there is a lack of real top management support for Lean Construction and strategic alliances and Supply Chain integration are limited for Lean implementation. The SMEs urged that there is a need for strategic support to implement lean in construction. Moreover, the broad use of term 'business strategies' is equated with the development of a compelling and shared view of a Lean implementation in construction. Business strategies establish pre-implementation success factors of Lean initiatives in inter-personal relationship and leadership. Business strategies must be aligned at the inter-organisational level (Arif, Mohammed and Aman Deep, 2015). This also requires the capacity building of the organisations and individuals to deliver and innovate to implement Lean in construction. Clear and well-planned business strategies are required that drives the success of Lean Construction. Construction Supply Chain still lacks business strategies to manage Lean implementation (Aziz et al 2016). Currently, knowledge retention for Lean Construction is problematic (Saini et al 2017). The factors that hinder knowledge retention is the short-term Supply Chain relationship, unclear

goals, lack of commitment, lack of collaboration and interrupted knowledge communication. Knowledge communication plays the leading role for lean implementation in a construction project and its supply chain levels.

The quantitative analysis of this study reveals that the contribution of tacit knowledge is significant in the application of the aforementioned lean principles within any above-named construction process.

5.1.1 Reduce Waste in Construction Process

The frequency analysis from the level of contribution of Tacit Knowledge in the application of the Lean principle to reduce waste in the construction process establishes that the highest number 43.5% respondents said 'Very High' and the second highest 37.7% respondents said 'High'. Moreover, only 10.1% of respondents said 'Moderate' and 8.7% said Low 5.8% and Very Low 2.9%. However, it computes the median score (4.00). This interprets that the data is statistically significantly distributed among the variables. This also suggests that among the variables (Very Low to Very High) the generalised result is 'High'. This means the contribution of Tacit Knowledge in the application of Lean Principle in the construction process is high to reduce waste.

5.1.2 Generate Value in the Construction Process

Moreover, 44.9% of respondents said that the contribution of Tacit Knowledge is 'High' in the application of the Lean principle to generate value through the construction process.

5.1.3 Enhance Flow in Construction Process

In addition, the highest (39.1%) of respondents said, the level of contribution of Tacit Knowledge is 'High' in Lean principle to enhance the flow of materials and information within the construction process. Also, (36.2%) of respondents said the contribution is 'Moderate' and (11.6%) said 'Very High.

5.1.4 Increase Efficiency in the Decision-making Process

The highest number (40.6%) of respondents said that the level of contribution of Tacit Knowledge is 'High' to increase efficiency in the decision-making process. However, others (15.9%) respondents said 'Very High' and 'Moderate'.

5.1.5 Continuous Improvement in Construction Process

The highest number (31.9%) of respondents said that the level of contribution of Tacit Knowledge is 'High' in the application of Lean Principle to improve the construction process. The second highest (23.2%) respondents said 'Moderate' and (21.7%) said 'Low' and (18.8%) said 'Low' and only (4.3%) said Very Low.

The level of contributions of Tacit Knowledge in the application of Lean Principles within the Construction Process is high to reduce waste, generate value, enhance material and information flow and increase efficiency in the decision-making process and continuous improvement within the construction process.

Moreover, a Spearman's correlation analysis and rank order analysis is conducted to understand the ranking of the factors and its relation with other factors. Five broad themes emerged from the analsysis.

1. To reduce waste in the construction process would require enhancing material and information flow in construction process and to continuous improve the process. Which would consequently, generate value in construction process and increase efficiency in the decision-making process.
2. To generate value through the construction process would require enhancing material and information flow through the construction process. However, this would require

enhancing decision-making process to reduce waste and then continuous improve the process.

3. To enhance the flow through the construction process would require increasing efficiency of the decision-making process. Which further require continuous improvement of the process to enhance the flow in order to generate value and reduce waste in the construction process.
4. To enhance efficiency of the decision-making process requires continuous improvement in the construction process. Which, consequently, help to enhance material and information flow and further to generate value while reducing waste in the construction process.
5. To improve the construction process requires enhancing efficiency of the decision-making process. This would consequently, increase flow of material and information and further reduce waste in the construction process, and resultant generates value.

In summary, based on this data analysis, enhancing material and information flow is the first principle followed by an efficient decision-making process. Here withstanding among those findings of the level of contribution of Knowledge Communication in the application of Lean Principles is high. This clear pinpoint that Knowledge Communication plays a vital role in the application and efficiency of Lean Principles.

6 Conclusions

From the evidence collected, the current focus of Lean implementation in CSC is on Tier 1. This finding compliments with the recent study by Aziz et al (2016), that also concluded that Lean implementation in Highways England's supply chain is focused on Tier 1 and Main contractors are forcing the Lean implementation to Tier 2 and Tier 3 of its supply chain without any adequate training and support for them. The current data highlights that due to lack of knowledge and understanding of Lean, there is lack of Lean deployment commitment and motivation of SMEs to implement Lean.

The generalised result from this study also concludes that a practical knowledge management approach can enhance the effectiveness of Lean processes to generate value and reduce waste within a CSC and a Construction Project.

Through learning from Toyota, the Lean should be implemented in the whole CSC. Successful integration of Lean in CSC requires timely information exchange and communication throughout the Supply Chain. The Lean Construction is a fundamental element for temporary organisations that need the ability to integrate individual knowledge. However, lack of importance and awareness of Lean Construction in short-term Supply Chain's, temporary organisations face particular obstacles. We learned that most SMEs are not aware of the tools and techniques of implementing Lean.

We support the view that Lean in construction is not successful if implemented in just one section of Supply Chain (i.e Tier 1) or a process. Moreover, the Lean training initiative requires a transformation from instructive (What to do) approach to directive (How to do) and supportive approach. Better communication and knowledge communication throughout the CSC would be beneficial for SMEs.

However, the recent studies by (Saini et al 2018; Arif et al 2015; Aziz et al 2016; Saini, 2015) show that there is lack of Knowledge Communication frameworks. Especially those studies highlights that communicating Tacit Knowledge is an essential part of Knowledge Communication. Although expensive research has carried out on communicating explicit knowledge in a CSC, the vast majority of researchers has not considered communication Tacit Knowledge in a CSC.

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