



# Current condition and future directions for lean construction in highways projects: A small and medium-sized enterprises (SMEs) perspective

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Received 24 July 2017; received in revised form 25 October 2017; accepted 26 October 2017  
Available online xxxx

## Abstract

The aim of this study is to identify the parameters defining how Lean Construction (LC) is being implemented (current condition) and how LC can be further promoted (future direction) from a Small-Medium Sized Enterprises (SMEs) perspective. Although SMEs constitute the largest group in construction supply chains, LC, as an emerging phenomenon in civil construction project management, has been rarely investigated from an SMEs perspective. Also, overlooking the more macro factors like project governance and supply chain management, LC deployments have been mainly discussed from a production process perspective to date. After a review of the extant literature and 20 interviews with managers from the highways sector, a list of 31 current condition and 40 future direction statements were produced, classified under the delivery, process, training, project governance and supply chain related headings and used in a questionnaire survey with 110 responses. The current condition highlights problems like a short-term relations structure, competitive tendering mechanisms, fragmentation, problems in engaging with SMEs for LC, unstandardised LC techniques, and issues with convincing SMEs to deploy LC by demonstrating the business case on mutual benefits. Action items relating to the current project delivery structure were given the highest importance by the supply chain, alongside the LC training and project governance issues for the future of LC at highways SMEs. Additionally, a statistically significant correlation was identified among many future action items.

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**Keywords:** Lean construction; SMEs; Construction management; Project management; Highways; Deployment; Civil; Implementation; Innovation; Supply chain management; Project governance

## 1. Introduction

The construction industry has long been criticised for being inefficient, wasteful, a high-risk/low-profit industry and “backward” in general when compared to some other major industries (London and Kenley, 2001; Teo and Loosemore, 2001; Woudhuysen and Abley, 2004; Assaf and Al-Hejji, 2006; Smyth, 2010). Many of those criticisms can be traced to the industry characteristics such as supply chain fragmentation (Vrijhoef and Koskela, 2000; Dubois and Gadde, 2002; Baiden et al., 2006),

construction companies’ high sensitiveness to market conditions (Lo et al., 2007; Regan et al., 2010), lack of an industry-level strategic vision (Green et al., 2005; Love et al., 2005), low-entry barriers to the industry coupled with competitive tendering mechanisms and small profit margins (Rooke et al., 2004; Dikmen et al., 2010), and short-term and temporary organisational configurations (Pauget and Wald, 2013; Behera et al., 2015). Also, project management literature has displayed many examples of time overruns (Hwang et al., 2014; Arashpour et al., 2016), cost overruns (Nasirzadeh et al., 2014; Olawale and Sun, 2015), low productivity (Fulford and Standing, 2014), safety issues (Nieto-Morote and Ruz-Vila, 2011; Wang and Yuan, 2011; Demirkesen and Arditi, 2015), and quality problems (Zeng et al., 2007; Arashpour et al., 2017) in construction projects.

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In the early 1990s, to improve the performance of the industry, some researchers advocated developing a production management perspective in construction project management practices through learning from the Japanese manufacturing industry (Koskela, 1992; Ballard and Howell, 1998; Tommelein, 1998; Gao and Low, 2014; Tommelein, 2015), which had attained a global competitive edge after Second World War by adopting certain production management techniques and principles explained under the term Lean Production System (LPS) (Womack et al., 1990; Fujimoto, 1999; Shah and Ward, 2007; Jasti and Kodali, 2015). In time, efforts associated with adapting the LPS techniques and principles into the construction industry and construction project delivery mechanisms were accumulated and called Lean Construction (LC) (Howell, 1999; Ballard and Howell, 2003; Tommelein, 2015).

In the UK, LC came under the spotlight with the Egan report, ‘Rethinking Construction’, which was produced in 1998 to address concerns raised by clients engaging services of construction companies (Egan, 1998). The aim of the report was to stimulate a change in the culture, style and management of the industry (Forbes and Ahmed, 2011). However, after the report, the dissemination of LC across the UK could not be realised as intended (Mossman, 2009; Sarhan and Fox, 2013). Around late 2000s, following grave criticisms for their project management performances, large public construction clients in the country experienced serious budget cuts and performance improvement targets by the government, which induced them to initiate efforts associated with instilling LC capabilities into their supply chains (Ansell et al., 2007; Chloe and Sue, 2012; Drysdale, 2013; Fullalove, 2013).

One of those large, civil projects clients is Highways England (HE), the organisation responsible for delivering, operating, maintaining and improving England’s motorways and major roads. In 2016, HE announced a strategic plan to attain 250 million GB £ in savings in highways projects through LC between 2015 and 2020 (HE, 2016). This supply-chain level and strategic LC implementation initiative led by a powerful public client (HE) created a rare case for LC, which had not been implemented in the country’s construction industry as intended. A major target in HE’s LC strategy is to disseminate LC across Small-Medium Sized Enterprises (SMEs), companies operating with annual turnover not >50 million GB £ and with employees not >250 (DfBIS, 2012; EC, 2015). Despite constituting the largest group in construction supply chains (Morton and Ross, 2008), the exploration of LC in SMEs has been limited (Dainty et al., 2001; Barros Neto and Alves, 2007; Alves et al., 2009, 2012). The issue has been mainly discussed from the innovation and supply chain integration perspectives. Also, the literature on LC is mostly concerned with the production process, and to a lesser extent, the commercial side of LC implementations at specific projects or specific construction organisations. Beyond generic remarks, the lack of in-depth, sector-specific investigations (i.e. highways, rail, building, energy etc.) of LC in SMEs, covering supply chain characteristics in project governance, project procurement, training and process management is salient in the literature.

The research presented in this paper aims to explore two research questions;

- (1) what are the current supply chain conditions defining how LC, a relatively new phenomenon for civil project management, is being implemented (current condition) and,
- (2) how LC can be further promoted (future direction) in the highways supply chain from an SMEs perspective.

The research was sponsored by and conducted in cooperation with HE to inform future LC strategies in civil projects. Also, the findings are deemed contributing to the current understanding of LC in construction SMEs. In the rest of the paper, following a literature review on LC and construction SMEs, and an explanation of the highways project delivery context in the supply chain, the analysis and discussion of an explorative mixed-method study, involving 20 face-to-face interviews with highways managers and a comprehensive questionnaire survey with 110 responses on LC in highways SMEs, are presented.

## 2. Research background

### 2.1. Lean construction and SMEs

LC presents a practice oriented research and development in construction management and construction projects, which are seen as temporary production systems, with an adaption of the LPS to the end-to-end design and construction process (Garnett et al., 1998; Howell, 1999; Koskela et al., 2002). LC advocates that some of the inherent construction industry problems like fragmented supply chains, strong focus on individual projects narrowing perspectives on general supply development, relationships between actors influenced by a culture of conflict, superficial supply chain integration practices, low-profit margins, frequent time and space conflicts in on-site production, low output productivity and quality, noncompliance between product design and on-site production, insufficient process and operations management perspective in on-site production, poor safety records, working in silos, and a slow-take up of innovation and change (Koskela, 1992; Shirazi et al., 1996; Vrijhoef and Koskela, 2000; Dainty et al., 2002; Dubois and Gadde, 2002; Green and May, 2005; Assaf and Al-Hejji, 2006; Segerstedt and Olofsson, 2010; Eadie et al., 2013; Behera et al., 2015; Tommelein, 2015; Howell et al., 2017) can be mitigated through learnings from the LPS.

The origins of the LPS are traced back to the innovations on the shop-floors of Japanese manufacturers, particularly at Toyota Motor Corporation, between the 1930s and the 1970s, which were first conceived as improvement opportunities inspired by the mass automotive manufacturing in the US (Monden, 1983; Shingo, 1986; Ohno, 1988; Fujimoto, 1999). Following Japan’s successful post-war recovery and emergence as a global economic power, Japanese manufacturing techniques have been benchmarked by Western manufacturers since the 1970s (Drucker, 1971; Sugimori et al., 1977). Although the diffusion of the LPS had started in discrete manufacturing industries in the West in the 1980s, the publication of a business book, ‘The machine that changed the

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