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The emergence of lean construction in the Norwegian AEC industry

Jardar Lohne^a , Olav Torp^a, Bjørn Andersen^b , Sigmund Aslesen^c, Lena Bygballe^d, Trond Bølviken^{c,e}, Frode Drevland^a, Atle Engebø^a , Roar Fosse^f, Hans Thomas Holm^f, Lars Kristian Hunn^g, Bo Terje Kalsaas^e , Ole Jonny Klakegg^a , Vegard Knotten^c, Kai Haakon Kristensen^h, Nils Olof Emanuel Olsson^b, Asbjørn Rolstadås^b, John Skaar^e, Fredrik Svalestuen^c, Hajnalka Vaagenⁱ, Paulos Wondimu^{aj} and Ola Laedre^a

^aDepartment of civil and environmental engineering, Norwegian university of science and technology (NTNU), Trondheim, Norway;

^bDepartment of mechanical and industrial engineering, NTNU, Trondheim, Norway; ^cVeidekke Entreprenør AS, Oslo, Norway;

^dDepartment of strategy and entrepreneurship, BI Norwegian Business School, Oslo, Norway; ^eDepartment of engineering sciences, University of Agder (UiA), Grimstad, Norway; ^fDepartment of construction and project management, Statsbygg, Oslo, Norway;

^gMarstrand, Oslo, Norway; ^hBodø Municipality, Bodø, Norway; ⁱDepartment of ocean operations and civil engineering, NTNU, Ålesund, Norway; ^jNorwegian Public Roads Administration, Trondheim, Norway

ABSTRACT

Lean construction has inspired the AEC industry globally over the last decades, and this manifests within a wide array of contexts. The purpose of this paper is to provide a narrative-based qualitative analysis of the emergence and impact of Lean construction on a national level, notably in the Norwegian AEC industry. The analysis is based on the concept of paradigm shift and on empirical knowledge in the form of narratives. The narratives of practitioners and researchers provide deep insights into how Lean Construction has inspired the Norwegian AEC industry and academia, respectively. The reflections indicate that the introduction of the Lean construction principles and tools in the Norwegian AEC industry has depended on promoters who have been convinced about its advantages. The role of active promoters – in particular Dr. Glenn Ballard – is underlined as key to successful introduction of Lean Construction. Key cultural features of the Norwegian AEC industry are emphasized as important success factors. Lean Construction in Norway needs to be understood as a phenomenon occurring within a setting that is generally advantageous but also following an effort carried out on several levels. Key elements that can be used within other contexts are (1) the existence of promoters, (2) cooperation between industry and academic circles, (3) a high degree of trust and (4) a predominance of bottom-up organizations within the industry with few levels of hierarchy.

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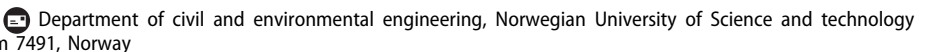
Paradigm shift; systemic change; narrative analysis; lean construction; lean production


Introduction

Lean Construction (LC), both as industry practice and as philosophy, has significantly developed in the decades since its first conception. As witnessed e.g. in the author lists of the publications presented within the cadre of the IGLC conference (International Group for Lean Construction), LC now has global impacts.

This is not to say that LC has attained dominance within the AEC industry in a paradigmatic understanding of the word. As Korb and Ballard (2018) maintain, the vast majority of construction projects are still using traditional styles of management. To understand why this is so, the authors lean heavily on Kuhn's (1970) theory of paradigm shifts. They identify the

current state of the construction industry as one of crisis (phase three of five in the shift from one scientific paradigm to another according to Kuhn), where "*[p]ersistent problems exist that cannot be solved with the existing tools*". In a hopeful tone, the authors envision that the fourth phase – where the new paradigm arises and eventually trumps the old, in this case, the shift from traditional management styles to LC – is about to begin. In this paper, we examine the rise of LC in Norway according to such an optic. Particular interest is given to the role of promoters of LC – in particular Dr. Glenn Ballard – in inciting the interest at several levels within the Norwegian construction industry.

CONTACT Laedre Ola  ola.laedre@ntnu.no 

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Documenting and understanding paradigm shifts when they take place is notoriously difficult. This is partly due to the nature of such shifts since the conceptual foundations constituting the established paradigm prove incommensurable with the conceptual foundations of the new (Sankey 1993). In other words, proponents of the different paradigms can differ fundamentally in how they apprehend the world. In addition, the expressions through which these different paradigms can be understood are typically heterogeneous in nature, running from industry practice and schoolbook texts to the conceptualization taking place at the forefront of scientific endeavours.

Understanding the worldwide emergence – “the process of coming into existence or prominence¹” – of LC in light of a potential shift of paradigm necessarily becomes a challenging task. LC has been practised, developed and studied internationally amongst industry practitioners and researchers. Following the insights from Gadamer (1960), all of these will have their separate perspectives on the world. To apprehend the emergence of LC, this paper studies *how LC has impacted the Norwegian AEC industry* from the perspectives of industry professionals and academics. The analysis presented endeavours to do this by identifying factors affecting successful implementation within the context studied. We base the analysis on the following research question:

1. How has Lean Construction emerged in the Norwegian AEC industry since it was first introduced?

Theoretical framework

Mapping the evolution of scientific fields has attracted attention in recent years. Researchers have proposed various methods to describe, express and predict the spread of scientific ideas, such as network analyses (Sun *et al.* 2016). A phenomenon such as LC is so complex that its emergence cannot, it seems, be explained solely by technical approaches.

According to Rogers (2002), four key factors influence the diffusion of new ideas, of which LC can be an example. These are (1) innovation, (2) communication channels, (3) time, and (4) the social system. Such categorizations must always be considered as abstractions since such factors are far from being discrete entities. An innovation will typically evolve over time, and the communication channels will influence what social system that is reached. Haas (1989), for instance, describes how a group of experts (defined as an

“epistemic community”) from different countries and academic disciplines succeeded in producing an array of shared knowledge, common beliefs, causal links and convergent values that affect the way problems are perceived, as well as the variety of solutions proposed.

Rogers (2002) model of diffusion of new ideas has been challenged by scholars such as Czarniawska and Sevón (2005), stating that ideas also might be translated and transformed in the process of diffusion. This represents a complementary view of Rogers’ model. Regardless of the theoretical lens implemented, Koskela and Rooke (2009) suggest that in addition to coming up with creative ideas and addressing translation of ideas, scholars within management should (1) develop new theories and methods based on critical scrutiny of present ones; (2) make concepts in use which are implicit and (3) co-develop new methods based on proven or promising concepts. For example, collaborative project delivery has been transformed into different practical models: IPD in the USA, Alliancing in Australia, and Partnering in Europe. The models are built on the same concept, but they utilize different elements due to – for example – local legislation and culture (Engebø *et al.* 2020).

Koskela *et al.* (2003) call out for systemic change in the construction industry. Arguing that such a change will prove too complex for a top-down implementation strategy, they first argue for a change to be started in the operational processes that create the end product, i.e. in downstream stages. Secondly, following this logic, a strong interrelation between basic research on construction management and industry practices needs to be developed. Thirdly, major clients – especially governmental agencies – ought to strategically use their market power for promoting new methods in the industry.

Systemic changes are in fact taking place at several levels, following coherent strategies. Alarcón *et al.* (2008) propose for instance a strategy that involves systematic training and research actions, proactive interaction with upper management in contractor and project organizations, collaboration among companies and a constant search for new ways to improve the implementation process. This is reflected in mission statements such as “[t]he Lean Construction Institute’s (LCI) goal is to develop and deploy a new way of thinking about and practicing project management” (Ballard and Howell 2004, p. 38).

On a personal level, the literature emphasizes the need for dedicated individuals or organizations – *promoters* – that can drive innovation. Naney *et al.* (2012),

for instance, emphasize how benefits and potentials for innovation are not enough to push innovation to adaptation. Instead, they argue that key influencers must champion new ideas. As Hauschildt and Schewe (2000) comment on innovation in general, “[t]he history of innovation management provides many examples of successful innovations being closely linked with the names of certain individuals. With their active support for the innovation and their specific contribution to its success, these people can be distinguished from others who also take an active role in an innovation process”. Which roles these promoters fill, be they technical, power-related or organizational, is a question under debate (Hauschildt and Kirchmann 2002). For this context, the necessity of active participation from individuals for ideas to have a significant impact is interesting. Previous research has correspondingly emphasized that the implementation of LC must be accompanied by a strategy and championed by senior-level managers (Mossman 2009).

LC Reception studies

Given the paradigmatic nature of shifts involved in LC (see for example Tzortzopoulos *et al.* 2020, p. xxviii), it is not surprising that studies of its implementation have proliferated. In terms of geography, these include studies from a wide range of countries, such as Saudi Arabia (Sarhan *et al.* 2017), Chile (Alarcón *et al.* 2008), the United States (Hamzeh 2011), Australia (Poshdar *et al.* 2019), Ghana (Ayarkwa *et al.*, 2005), South Africa (Monyane *et al.* 2020), Norway (Kalsaas 2017), etc. The studies differ in methodological approach, ranging from analyses based on structured surveys (e.g. Poshdar *et al.* 2019), case studies (e.g. Bygballe and Swärd 2014), database analysis (e.g. Alarcón *et al.* 2008), literature reviews (e.g. Bashir *et al.* 2010, Babalolo *et al.* 2019) and mixed methods approaches (e.g. Tezel *et al.* 2018). Whilst several present frameworks for successful implementation of LC tools (e.g. Hamzeh 2011), even more analyse the barriers against implementing LC within their specific context of analysis, be this project or country-specific. A long list of specific barriers could be made. Wandahl (2014) carried out a meta-study of major barriers behind implementing LC by surveying several papers published in the IGLC conference, identifying them as being lack of communication, lack of top management commitment, lack of knowledge, lack of leadership, lack of training, and most importantly cultural resistance to change. Kenny and Florida (1993) – who describe Japanese production systems in general and not

specifically Lean construction – confirm that successful implementation is heavily reliant on culture.

While acknowledging that cultural resistance constitutes a barrier against the successful implementation of LC, most studies are not outspoken on precisely what is constituting this barrier. An outspoken identifier of specific cultural barriers seems to be Gehbauer *et al.* (2017), maintaining that “[t]he number one waste in construction is corruption”. Further, they maintain that “[l]ittle has been published or done to fight this in Lean research or practical Lean papers”. Interestingly, the corollary of widespread corruption is lack of trust in general. Ballard *et al.* (2011) point at lack of trust as an obstacle for implementation of LC when referring to the paradigm: “trust is for suckers”. Norway is among the least corrupt countries in the world² and – as remarked by Kjesbu *et al.* (2017) – the Norwegian society is characterized by high levels of trust. These characteristics consequently render Norway fertile soil for the implementation of LC.

LC in Norway – specificities of the Norwegian context

The emergence of LC in Norway can be analysed on basis of country-specific characteristics. Here we will mention three: the interest from academics in LC, work-life organization and the cooperation between academic institutions and the industry.

The introduction of LC in Norway, publication rates and academic curriculum

The beginning of the millennium marked the introduction of LC in Norway. Norway’s largest contractor Veidekke began working with the principles of LC and Last Planner since 2002, pioneering the field among contractors. From the educational perspective, LC was firstly described in Frode Drevland’s master thesis in 2003. Following this, a large number of MSc-theses have been dedicated to LC-related topics. At least 15 Norwegian PhD-theses from several universities have been concerned with LC-related questions over the last decade. This trend can be easily observed in publication rates, and a closer look reveals that the authors come from both industry, universities and research institutions. The authors publish across organizational boundaries and operate more as a network rather than followers of a single institution. As can be observed in Figure 1, the number of papers published within the context of the annual IGLC conference has increased markedly. A marked increase can be observed in the year 2014, when the

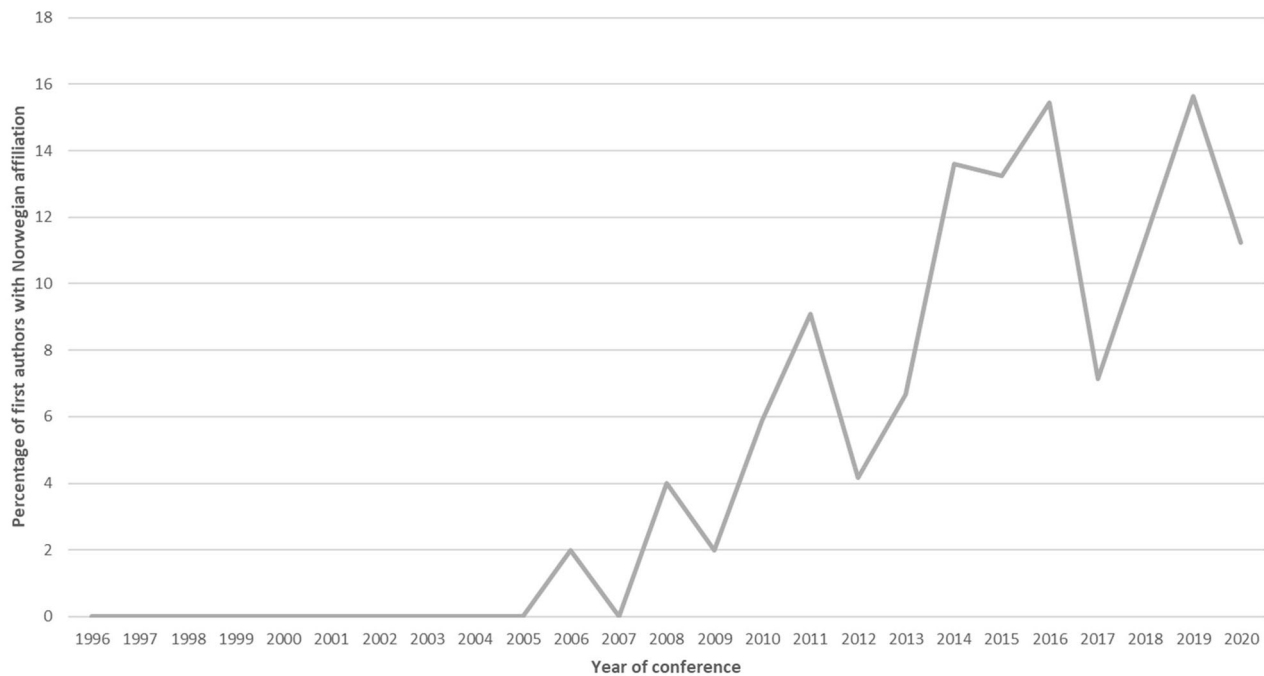


Figure 1. Contributions at the IGLC's annual conferences – the percentage of first authors with Norwegian affiliation.

conference was staged in Oslo, Norway. After this, the trend has continued.

Engebø *et al.* (2017) mapped the geographical distribution of LC by examining web traffic and the number of publications globally. Figure 2 shows the distribution of the 48 most active countries with the number of publications per 10 million inhabitants on the x-axis and sessions per 10 million inhabitants on the y-axis. The publications include 1310 papers from IGLC proceedings from 1996 to 2016 and 72 articles from the Lean Construction Journal³. The sessions refer to 101793 unique internet sessions on the IGLC webpage⁴ and the Lean Construction Blog⁵. Engebø *et al.* (2017) used a log-10 scale for both the y-axis and the x-axis because of the large range of values. As can be observed in Figure 2, Norway is at the forefront of academic endeavour within the LC community (Engebø *et al.* 2017).

This interest in LC is equally reflected in university curriculums in Norway – principles of LC are being taught to a certain extent at all universities in Norway, such as University in Agder (UiA) and Handelshøyskolen BI (BI) – but most significantly, this interest is reflected in the curriculum of Norwegian University of Science and Technology (NTNU). NTNU is a significant actor in educating MSc-students in Civil Engineering in Norway, as approximately 80–90% of all MSc-students within this field are from this university (Lohne *et al.* 2017), thus dominating the managerial levels of the Norwegian construction industry entirely. Students within the Civil and Environmental

Engineering Programme meet LC in courses like “Project-based production”, “Building design management”, “Production management in building and construction projects”, “Project management”, “Construction management”, “Topics in Project Management and Construction Engineering”, “Foundation for use of VDC”, “VDC-certificate Programme Norway”, “Lean construction process” etc. A continuously increasing number of master students select topics within LC when writing their master theses. This emphasis on LC within the NTNU was emphasized during the years (2014–19) of the appointment of Dr. Ballard as an adjunct professor at the institution.

Work-life characteristics

In the Norwegian social model, labour relations are characterized by strong employers' and workers' organizations. There is close cooperation between the government, employers' associations and trade unions, and – highly interesting in the context of implementing principles from LC – strong co-determination and participation from employees at all company levels (Løken and Stokke 2013, Åsgård and Danielsen 2018).

This level of co-operation is in Norway also reflected at the macro level. In addition to the two traditional parties in the working life (employers and employees), the state has often acted as a third party. Though this occurs mainly in collective tariff negotiations about working conditions – where the state typically participates with tax schemes favourable to the

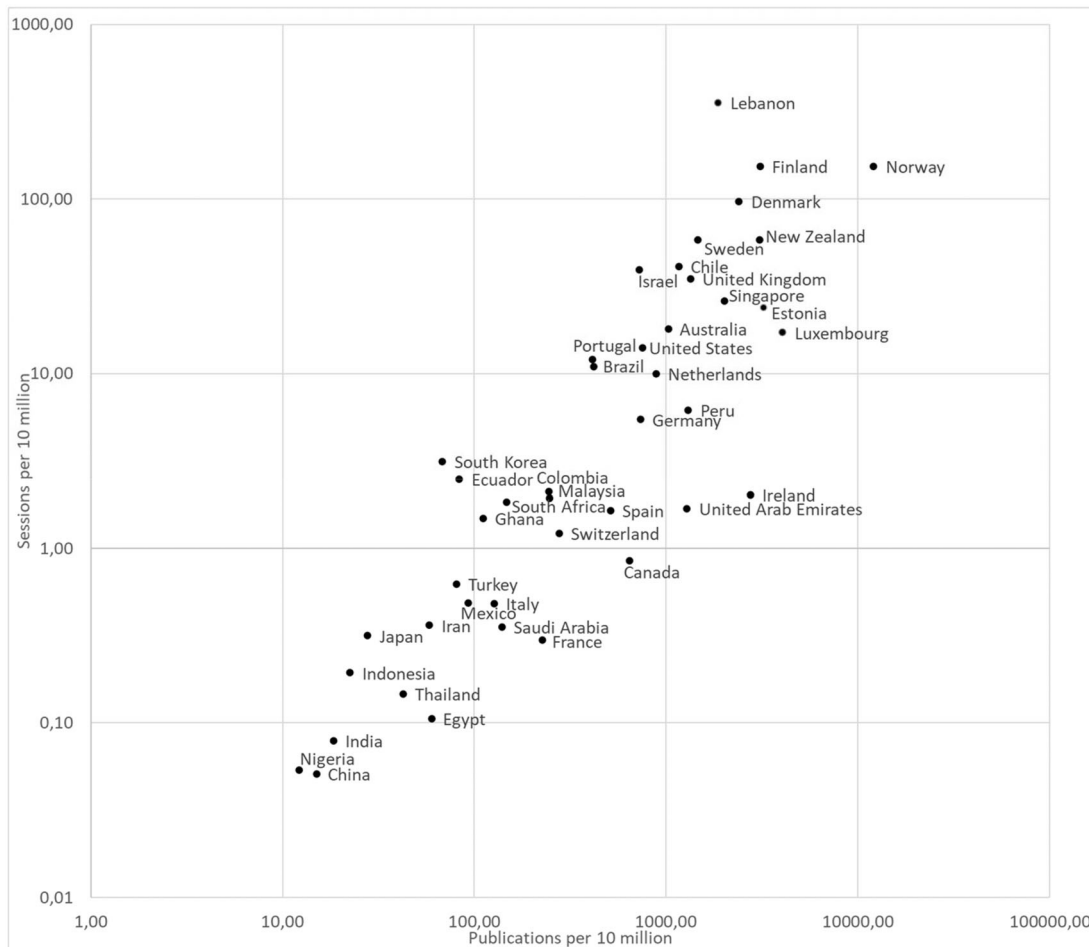


Figure 2. Log-10 representation of distribution of countries, with the number of publications on the x-axis and internet sessions on the y-axis (Engebø *et al.* 2017).

employers or contributions to pension schemes for employees – this manner of organizing the working life has been important for settling working conditions and rules for worker participation in decision-making (Løken and Stokke 2013, Åsgård and Danielsen 2018).

Furthermore, in addition to being a small country with traditions for openness and willingness to sharing data, a common educational background has served to create effective networks amongst professionals (Lohne *et al.* 2017). Strong public clients have clear ambitions for being driving forces for the development of the industry (see for example Statsbygg 2020 or NPRA. 2020). These ambitions are shared by the largest contractors in Norway. Cogently, key persons from several of these organizations have contributed to the present article.

Cooperation between academic institutions and industry

In their report on engineering education in Norway, NOKUT (the Norwegian Agency for Quality Assurance

in Education) underlined close cooperation between academic institutions and the industry as a strength (NOKUT 2008). Much of the curriculum for engineering students has been developed based on the needs of the industry, and the institutions and companies exchange expertise. Students are given opportunities for early vocational contact with their future profession, and master students are encouraged to research industry cases when writing their master's dissertations. The engineering education in Norway has been impacted by the AEC industry's interest in sharing experiences from the implementation of LC methods.

Universities and research institutions have also been impacted by the AEC industry's willingness to initiate research projects related to LC. For example, Holm *et al.* (2019) and Knotten *et al.* (2014) report on research projects where the industry wants to share data and experiences. As a result, the academic institutions have reconciled a stable theoretical basis with practical skills. This is not to say that the relationship between academic institutions and the industry is

flawless, but rather underlines how their relationship is characterized by a flow of ideas permitting quick reciprocal adaptation to novelty.

Bodies of cooperation between academic institutions and industry exist. Project Norway⁶ – with around 33 partner-enterprises, eight academic institutions and seven industry unions – has for some years hosted a Community of Practice (CoP) for LC processes. Bygg21 is another nationwide industry-oriented initiative that has been promoting LC. More prominently, Lean Construction Norway (LC-NO)⁷ – with its around 17 partner enterprises, eight academic institutions and four industry organizations – is an open forum for discussion of LC within the Norwegian AEC industry. Since its inception in 2007, it has held courses and seminars.

Knowledge gap

The literature on the implementation of LC – and associated barriers – is rich. The literature search preceding the research presented in this article did not, however, unearth any narrative-based qualitative analysis of the emergence of LC on national level. This knowledge gap can be partly filled with an analysis of the country-specific characteristics together with the extent of LC in the Norwegian AEC industry.

Research methods

The emergence of LC as a paradigmatic shift must be considered a complex phenomenon. It is taking place at several organizational and analytic levels, with multiple groups of actors and according to both academic and industrial logics. Understanding such a complex phenomenon requires a methodological approach open to plurality.

Inspiration from narrative approaches forms the basis of the analysis presented in this article. As such, there has not been an ambition to assess the individual contributions – the testimonials – in light of traditional narrative concepts (plot, focus/focalization, character, etc.) as described by Holley and Colyar (2009), nor to let them undergo rhetorically-based analysis (identifying governing metaphors, analogies, enthymemes etc.) to uncover underlying patterns of thought (see e.g. Feldman and Horner 2004). Rather, the analysis has been inspired by the ideas of narrative identity, as outlined by Ricoeur (1985). In the present case of understanding the emergence of LC in Norway, the collected self-understanding of actors come together to form a coherent – yet complex – whole. As Brown (2006) underlines, such narrative

approaches typically embrace pluralism, relativism and subjectivity. The approaches are often suited for different forms of disciplinary (here understood as the LC discipline) multi-voiced self-reflection amongst the partakers, a source of data that “*tend to be underutilized*” (Feldman and Horner 2004, p. 168). The overall narrative of the emergence of LC in Norway has in this manner come together after assembling personal narratives from the invited authors.

The term narrative is not here to be taken in its restricted form as narrations, that is, concerned solely with stories of various kinds. The testimonials annexed to this article vary from pure narrations of personal experience to theoretical reflections set within a specific context.

Narrative approaches are not very common within this field of study; it seemed useful to use this in this case, however, since they typically permit for the mix of cases (personal impressions of cases), experiences on a personal level and the presentation of general insights as perceived by individuals.

What has been sought for has been a methodological approach enabling – as Squire *et al.* (2013) maintain – the identification of different and sometimes contradictory layers of meaning, and to bring these into useful dialogue with each other. As Popay (2006) underline, narrative approaches permit conceptualizing diversity. This poly-perspectivity is thus intended to bring a more complex and richer understanding of the emergence of LC in Norway. Consequently, less emphasis has been laid on providing a homogeneous synthesis of LC in Norway than on exemplification through practical and theoretical examples.

Initiation of the research process – the narratives of the invited individuals

The research process was initiated when three organizing authors sent an invitation to 19 individuals, first by email, then by follow-up phone calls. In the end, all the invited individuals accepted the challenge. In addition, two of the initiators contributed with testimonials. The main target group for contributions was what the organizing authors considered LC-champions within the Norwegian context, both industry professionals and academics. Participation at the annual conferences of the International Group for Lean Construction, membership of the network Lean Construction Norway and being known as an advocate of LC at Norwegian universities were used as guiding selection criteria. The industry professionals represent

Table 1. The 21 contributors and their organizations, positions and years of experience.

Contributor	Organization	Position	Years of exp.
Vegard Knotten	Veidekke AS	Design Discipline Manager	23
Fredrik Svaldstuen	Veidekke AS	Head of production and process	8
Kai Haakon Kristensen	Bodø Municipality	Head of Development and Projects	26
Nils Olsson	NTNU	Professor	27
Paulos Abebe Wondimu	NPRA	Senior Contract Advisor	8
Bjørn Andersen	NTNU	Professor	27
Hans Thomas Holm	Statsbygg	Project director	28
Ole Jonny Klakegg	NTNU	Professor	32
Olav Torp	NTNU	Associate professor	26
Hajnalka Vaagen	NTNU	Associate professor	15
Bo Terje Kalsaas	UiA	Professor	40
Trond Bølviken	UiA	Adjunct professor	40
John Skaar	UiA	University lecturer	21
Asbjørn Rolstadås,	NTNU	Professor	45
Sigmund Aslesen	Veidekke AS	Development manager	25
Lena Bygballe	BI	Associate professor	19
Roar Fosse	Statsbygg	Department director	6
Frode Drevland	NTNU	Associate professor	18
Atle Engebø	NTNU	Phd student	4
Ola Laedre	NTNU	Professor	25
Lars Kristian Hunn	Marstrand	Director	20

contractors (Veidekke AS), public clients (Bodø Municipality, NPRA and Statsbygg) and project management consultants (Marstrand). The academics represent universities (NTNU, UiA and BI). The names of the contributors are given in Table 1.

There is a near equal mix of the industry and academic representatives among the contributors. This has been done to implicate both industrial and academic perspectives on the emergence of LC in Norway. There is, however, a close link between the industry individuals and academic circles; most are holding doctoral degrees and collaborate with academic institutions, in particular with the NTNU. Corresponding to this all included academics have deep interaction with the industry, both as experts, through research and with the integration of students in the industry.

The invited authors were informed that the “planned contribution [i.e. the present article] will not consist of new data, but rather of a descriptive collection of the state-of-the-art in Norway both from an academic and industrial perspective”. Each author was given a maximum of 400 words + 10 references, without thematic binding. In addition to the title of the proposed article, the authors were given a preliminary abstract and research questions. The practitioners were asked to contribute with a description of LC and how it is adopted in the Norwegian AEC industry. The researchers were asked to contribute with a description of research on LC and how it is adopted in education at the university level in Norway. However, some practitioners described research on LC and some researchers described how LC is adopted in the industry. Seen in retrospect, the participating LC champions

were left relatively free to choose a field of interest to describe. Interestingly, very little in terms of thematic overlap could be registered.

Expressions of gratitude to Dr. Glenn Ballard were not actively sought when inviting to this paper. Such expressions did, however, arise from a set of testimonials. Rather than suppressing these, we consider them to illustrate how individuals can influence the workings of the Norwegian AEC industry.

Literature review

The research reported on in this article was underpinned by a literature review based on using Google Scholar and scrutiny of leading journals within the field of project management. To get an understanding of the breadth of literature about emergence, promoters and reception of new ideas within project management Google Scholar was chosen before more reliable databases such as Scopus – which normally returns fewer suggestions with an overweight of journal articles. In addition, the proceedings of the IGLC conferences were scrutinized. These publication channels were searched using key terms such as “Lean construction”, “paradigm shift”, “systemic change” and “Norwegian” alone or combined using Boolean operators. Identified articles were utilized in the search using snowballing techniques (backwards and forwards), according to the prescriptions of Wohlin (2014). The main search was carried out from December 2019 to April 2020 and resulted in 30 journal articles, conference articles, books and reports considered directly relevant for the theoretical framework.

Table 2. Contributors that describe the implementation of LC methods in Norway, and the contributors' connections to the LC community.

Contributor	If the contributor holds a PhD	Participation IGLC/ participation Lean in Public Sector (LIPS)/UC Berkeley visits (at least once)	Interaction (especially Dr. Ballard)	LC methods	Continuous improvement
Vegard Knotten/ Fredrik Svalestuen	Yes, financed by Veidekke AS	IGLC Berkeley (2016)	Yes	Collaborative planning/LPS TM	Yes
Kai Haakon Kristensen	Yes, financed by Skanska AS	IGLC	n/a	Due-date-delivery System	Yes
Nils Olsson, NTNU Paulos	Yes Yes, financed by NPRA	IGLC IGLC	Yes Yes	LPS TM Kanban (plan for LPS TM and TVD)	Yes
Abebe Wondimu Bjørn Andersen	Yes	Berkeley (2018) Berkeley (2009)	n/a	Takt, Look-ahead meetings and Daily Huddles	Yes
Hans Thomas Holm	n/a	IGLC (2014) LIPS	Yes	Takt, Lean design, Lean Process, Systematic completion	Yes

The contributors to the annexed testimonials were allowed to provide a maximum of ten literature references. This resulted in a mix of what the contributors considered to be key publications for the described field of interest and their own publications. The annexed testimonials have an additional list of references that do not appear in this paper.

Limitations

The present article is limited to the points of view of selected authors, be they based on personal experiences with LC or theoretical considerations. As the authors are selected among participants at the annual conferences of the International Group for Lean Construction, members of the network Lean Construction Norway and known advocates of LC at Norwegian universities, they probably have reported more positive than negative impacts. The result is probably that certain – including negative – impacts of LC on the Norwegian AEC industry are not included.

Results

This paper has adopted a narrative approach for studying the emergence of LC in Norway, and the influence of Dr. Ballard in that evolution. In the following, the testimonials of 21 contributors are presented in summarized form. The full contributions can be found annexed.

There are three kinds of contributions. Originally, the initiating authors gave the contributors two different messages. The practitioners were asked to contribute with a (qualitative) description of LC and how it is adopted in the Norwegian AEC industry. The

researchers were asked to contribute with a (qualitative) description of research on LC and how it is adopted in education at the university level in Norway. This resulted in three kinds of contributions. The first kind of contributions described the implementation of LC in projects. Secondly, some of the invited authors described how LC has contributed to the body of knowledge. The third kind of contributions – the invitation mentioned that this was supposed to be part of a Festschrift – described personal experiences with the LC champion Ballard. The structure of this section reflects these three kinds of incoming contributions.

Table 2 presents the first kind of contributions, namely descriptions of implementation of LC methods in Norwegian projects. It also presents the contributors' participation in conferences, their visits to UC Berkeley, if they have interacted with LC promoters (especially Dr. Ballard) and if they mention continuous improvement.

In Tables 2 and 3 IGLC means that the contributors have participated in at least one of the annual conferences of the IGLC. Lean in Public Sector (LIPS) means that the contributors have participated in at least one of the annual LIPS conferences. Berkeley means that the authors have visited UC Berkeley in California. Table 2 shows that LC promoters (especially Dr. Ballard) have interacted when LC methods have been implemented in the Norwegian industry and that the contributors have several connections to the LC community.

Table 3 presents the second kind of contributions, and thereby an enriched representation of the impact of LC on the body of knowledge in Norway. The enrichment concerns the nature of the interaction with LC promoters, as well as the question of

Table 3. Contributors that describe the impact of LC on the body of knowledge for their field of interest, and the contributors' connections to the LC community.

Contributor	Described field of interest	Interaction (especially Dr. Ballard)	Participation IGLC/ LIPS/ Berkeley visits (at least once)
Ole Jonny Klakegg and Olav Torp	Integration of Uncertainty Management and LPS™	Yes	IGLC and LIPS Berkeley
Hajnalka Vaagen	Uncertainty management and flexibility within the LPS™	Yes	IGLC
Bo Terje Kalsaas, Trond Bølviken and John Skaar	Call for a Common System for Lean Design Management	Yes	IGLC
Asbjørn Rolstadås	Success factors for mega projects	Yes	Berkeley
Sigmund Aslesen and Lena Bygballe	Establishment and development of the network Lean Construction-NO	Yes	IGLC Berkeley
Roar Fosse	Integrating Lean and BIM	Yes	IGLC

Table 4. Contributors that used examples from their careers to describe the impact of Dr. Ballard in Norway, be it on industry, personal careers, curriculum, supervision of master students and/or supervision of PhD students.

Contributor	Impact on industry	Impact on personal careers	Impact on curriculum	Impact on supervision master students	Impact on supervision PhD students
Frode Drevland	Introduced LPS early	Influenced teaching towards LC	Developed course content	Impacted on my selection of master thesis topic	n/a
Atle Engebø	n/a	Met as active participation in IGLC conferences	Teached me to work in teams	Was supervised by Ballard and observed others being supervised	Was supervised by Ballard
Ola Laedre	Educated a new generation of engineers	Helped me increase quality of publications	Streamlined our master student supervision	Improved our students' performance	Improved our students' performance
Lars Kristian Hunn	Have experienced LC in several companies	Have met LC in several contexts	n/a	n/a	n/a

participation in the LC community through IGLC, LIPS and visits to UC Berkeley.

As can be observed from Table 3, LC has influenced research within the Norwegian context and thereby the body of knowledge over the last two decades. The contributors describe the influence from interacting LC promoters and participation in LC oriented conferences. When it comes to interaction, the name of Ballard was frequently mentioned.

The third kind of contributions described personal experiences with the LC champion Ballard. Table 4 presents contributors that used examples from their career to describe the impact of Dr. Ballard in Norway.

The contributors in Table 4 give examples of how lean promoters have interacted with practitioners and researchers in the Norwegian construction industry. The examples show that LC promoters have been important for industry practice, personal careers, the curriculum in university courses and the supervision of university students. By far, the most important figure amongst these promoters is – according to the testimonials – Dr. Ballard, whilst others include professor Iris Tommelein at UC Berkeley in their texts.

To study the emergence of LC in the Norwegian AEC industry, major events reported in the

testimonials and interaction with the community can be held up against a timeline. When examining the testimonials, it can be observed that the frequency of reported LC-related events increase with time. When counting the number of papers with a Norwegian first author on the annual IGLC conferences, an increase can be observed there as well. Figure 3 graphically presents the starting time of main events reported in the testimonials that have bearing on the emergence of LC in Norway and the number of Norwegian papers on the IGLC conferences.

As can be observed, there is a clear increase over time in the frequency of events reported by the contributors. While the representation comports methodological challenges based on it stemming from the narrative approach chosen – in particular the lack of uniform selection criteria for selecting the most important events and the lack of statistical representativity – Figure 3 nonetheless illustrates the perceived emergence of LC within the Norwegian context.

Discussion

This article addresses the question of how LC has emerged in the Norwegian AEC industry since it was

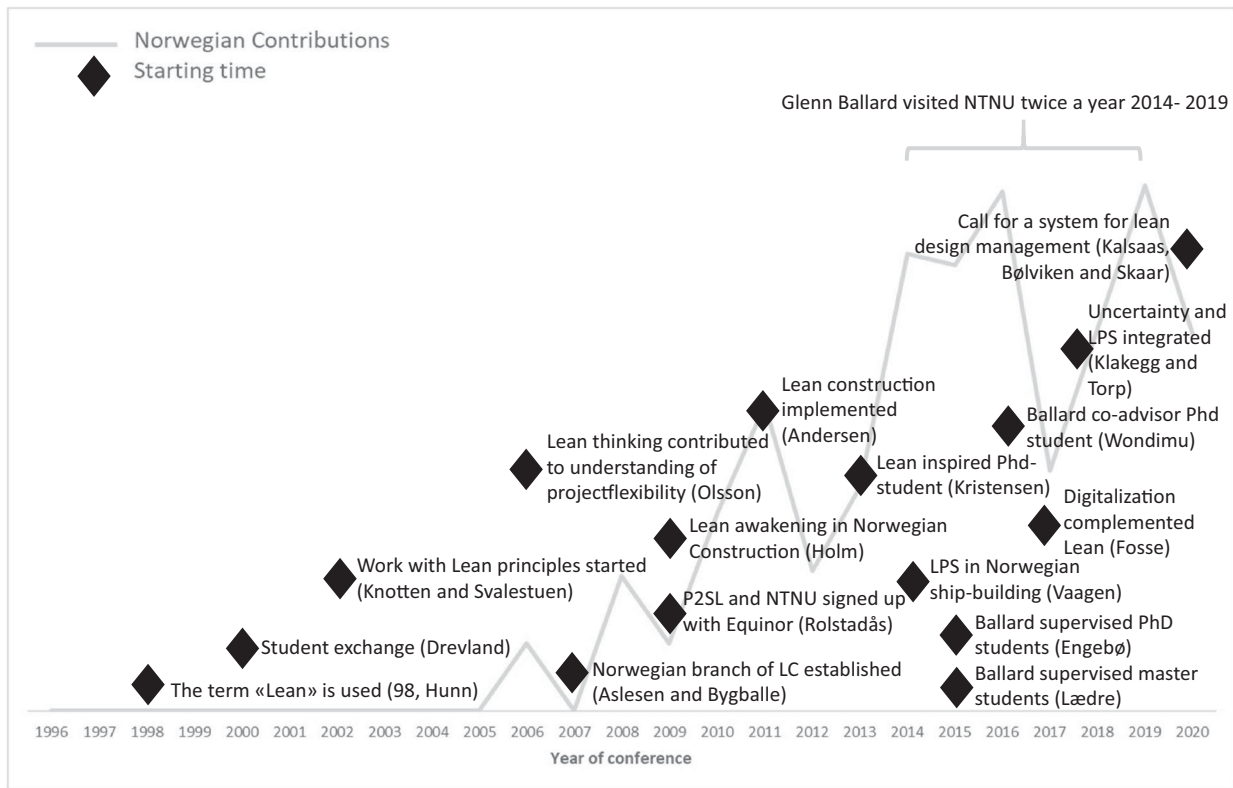


Figure 3. Timeline illustrating the increase in the number of major LC-related events reported in the testimonials (diamonds) and Norwegian contributions to the IGLC conference (line).

first introduced. As noted, questions of this nature do not have an easily accessible answer. The contributions presented in this paper make it evident that LC is a predominant force within the Norwegian AEC industry. The most significant cultural and organizational elements that seem to have facilitated the introduction of LC to the Norwegian context have been (1) the existence of promoters, (2) a high degree of cooperation between industry and academic circles, (3) a high degree of trust and correspondingly low levels of corruption and (4) a predominance of bottom-up organizations within the industry with few levels of hierarchy. These – especially the low levels of corruption and the high degree of trust – do not by themselves explain the emergence of LC in Norway since altering the way the construction industry works is deemed to meet with resistance. Rather, as witnessed in the contributions in this article, LC in Norway needs to be understood as a phenomenon occurring within a setting that is generally advantageous but also following an effort carried out on several levels. Correspondingly, the above-mentioned elements can serve as inspiration for the implementation of LC within other contexts.

In the following, we discuss the emergence of LC in Norway according to at least three axes, notably the implementation of LC in projects, LC's impact on the

body of knowledge and how key individuals have been active promoters of LC.

As can be witnessed in the testimonials annexed to this article, LC principles have been implemented in Norwegian AEC projects. Such projects have also been used as testing grounds for processual innovation based upon LC principles and carried out within LC frameworks. For Knotten and Svalestuen, this has been the case in the essay to adopting Last Planner™ into the design process; for Kristensen, this has been the case in adopting a due-date-delivery system for a unified design ready for use for the contractors. As documented in the contribution of Olsson, key insights from LC have had a significant impact on the understanding of project flexibility. Equally, Wondimu remarks how, even though LC is not widely used within the Norwegian Public Roads Administration, LC principles have helped the organization spend time on the right issues and priorities measures where it is most needed. As Andersen points out, efforts have proved to have chiefly positive effects, providing competitive advantages for the engaged companies. For Holm, the key characteristic of such implementation has been Statsbygg's high reliance on LC principles, in particular, that of openness between involved parties in projects, and in recent years also the connection to systematic completion. Systematic completion is a

procedure that uses a detailed check list of actions with designated responsibility for all phases with the purpose to fulfil all functional requirements for construction projects (Beste 2021).

This influence of LC principles has also impacted the body of knowledge within the Norwegian context. As documented in the case of Klakegg and Torp, the strong Norwegian tradition for Uncertainty Management has proved to have resonance with key insights of LC, and especially the LPS could help to operationalize Uncertainty Management. Along similar veins, Vaagen has explored a proactive-reactive approach to project uncertainty within the frame of LPS. Such deep involvement in LC has equally triggered calls for deep theoretical aids to experienced challenges. This can be witnessed by the contribution of Kalsaas, Bølviken and Skaar, calling for the development of a system for lean design management based on a thorough understanding of the nature of the design process and the shortcomings of existing concepts, systems and tools. This is not to say that such influence on the body of knowledge within the industry has been detached from practice. As described by Rolstadås, significant theoretical work has been carried out as an extension of efforts to set out LC principles in practice. This corresponds to the ambitious practice of joint industry-research initiatives such as LC-NO, as described by Aslesen and Bygballe, where theoretical puzzles and practical problem-solving go hand-in-hand. This intertwining of theory and practice seems in effect to have influenced the industry profoundly – and made it imperative for advanced project implementation. As Fosse comments on the subject of digitalization efforts; *“A few years ago, it was possible to work within digital construction with no knowledge of lean, but recently it has become increasingly difficult to find any major project or company without a digital strategy underpinned by lean principles and practices”*. This insight is further underlined by Drevland, who describes the systematic introduction of LC tools and methods into the civil engineering study programs, first at master level, thereafter at bachelor levels. The main drivers behind this introduction of LC to the university curriculum were in fact industrialists – aided actively by LC champion Ballard.

In effect, the third axis concerns the influence of Dr. Ballard as an active promoter of LC. As commented by Engebø, Dr. Ballard has served as a spark and driving force that has had profound effect on individuals’ – in this case his own – professional worldview. As witnessed by Laedre, this influence has not at all been random. Under the four-year-long auspices of Dr.

Ballard, the *“number of students that selected topics for their master theses related to lean construction increased. The number of students that managed to get papers accepted at conferences – the IGLC conferences were popular – increased. The number of students invited to submit extended versions of conference papers to journals [...] increased. The number of students winning prizes for best master thesis [...] and best conference papers [...] increased”*. Even without falling into the trap of attributing all of this to one single actor, it must be acknowledged, with Hunn, that Dr. Ballard has served as a “true inspiration”.

Conclusion

The ideas developed within LC met fertile soils within the Norwegian context. A significant element buttressing this was the adaptability of what is commonly called the Norwegian model – with close interaction between employers, employees and the public sector. This model has historically been key to assuring trust between actors, the trust that is key to LC philosophy and implementation. The testimonials tell about cooperation between practitioners and researchers where the industry has implemented LC methods and initiated research projects. The network of universities has included LC in their curriculum, done research on the related principles, methods and tools and published the Norwegian experiences internationally. The close interaction in and between the AEC industry and academic circles paved the way for the first initiatives, implementation and development.

LC has not, however, come to Norway in the form of a package ready for implementation. Pilots based on planning tools inspired by LPS commenced just after the turn of the millennium. These consisted to a certain degree of “cherry-picking” of ideas found particularly apt for improving productivity within the Norwegian context. Measurement initiatives were also undertaken, but not followed up to the same degree. Leading the way in these initiatives were enthusiasts from industry – in ever-closer continuous cooperation with spearheads of LC internationally. This assured that the knowledge implemented was up to date. Subsequently, the formalization of academic cooperation has secured continuation through research and education.

Assuring both reliability and validity when it comes to understanding such complex phenomena as the emergence of LC in Norway will, according to the authors of this paper, prove inherently challenging in most analytic approaches. Its zone of influence spans from university circles to on-the-ground project

execution. The span in intellectual endeavour stretches from philosophical analysis via production theory to the development of concrete implementation tools. The zone of influence and the span in intellectual endeavour makes it challenging to understand how and why central actors have acted according to their perception of the challenges they were facing. Narrative analysis constitutes in general an attempt to overcome such challenges by providing deep insights into complex phenomena. The narrative analysis in this paper does exactly that – it knits the different contributions together.

A key element to understanding the emergence of LC in Norway is the interrelation between industry and academic circles. As noted, there is significant exchange between the two spheres – in terms of research projects, professors visiting universities, PhD candidates at universities financed by the industry etc. – that seems beneficial to the spread of such ideas as LC. This relatively tight-knitted nature of industry and university circles in Norway permits a quick spread of new ideas once these have convinced strategically placed “movers and shakers” within both spheres. An ambition of the present paper has been to illustrate exactly how such a process – going from insight to execution of projects – has been carried out according to narratives of LC champions.

The contribution to knowledge is the documentation of the successful implementation of LC expertise and practice together with an analysis of how this implementation has enabled systemic change within the Norwegian AEC industry and thus led to paradigmatic change.

Korb and Ballard (2018) envisioned in a hopeful tone that the fourth phase of Kuhns five-step theory of paradigm shifts – where the new paradigm arises and eventually trumps the old, in this case, the shift from traditional management styles to LC – is about to begin. In the case of Norway, the presented testimonials indicate that this is now actually the case.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes

1. <https://www.ordnett.no/> (Norwegian dictionary referring to Oxford Sentence Dictionary)
2. <https://www.transparency.org/cpi2019?/news/feature/cpi-2019>
3. www.leanconstruction.org
4. www.iglc.net
5. www.leanconstructionblog.com

6. <https://www.prosjektnorge.no>
7. <https://www.bi.no/forskning/forskningscentre/senter-for-byggenaringen/lc-no/>

ORCID

Jardar Lohne  <http://orcid.org/0000-0002-2135-3468>
 Bjørn Andersen  <http://orcid.org/0000-0003-0533-2816>
 Atle Engebø  <http://orcid.org/0000-0002-5293-0176>
 Bo Terje Kalsaas  <http://orcid.org/0000-0003-4383-1683>
 Ole Jonny Klakegg  <http://orcid.org/0000-0002-1767-0911>

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