

# APPLICATION OF LEAN CONSTRUCTION: A MULTILEVEL AND MULTIDIMENSIONAL PERSPECTIVE

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## ABSTRACT

This paper addresses the gap between Lean Construction's (LC) widely promoted potential and its frequently observed *Lean light application* in practice. Building on insights from a recent study on the status quo of LC in Germany, we developed a multilevel and multidimensional model that captures where LC is applied, how it is applied, and how corresponding effects emerge. The model distinguishes five hierarchical system levels, ranging from the industry level (L5) to the level of individual operational practitioners (L1) and three application dimensions: length (D1; duration), breadth (D2; quantity), and depth (D3; quality). The effect of LC application is thereby linked to the application volume (V), a combined configuration of the three application dimensions, highlighting that a substantial effect is unlikely unless the approach is applied with sufficient duration, quantity, and quality. For each level and dimension, we propose evaluation scales to support an initial qualitative self-assessment. The model was refined iteratively and subjected to expert-based theoretical and practical validation through 10 interviews and illustrative cases for each level. By providing a common understanding and an evaluative structure across industry levels and application dimensions, the model aims to support both research and practice in moving beyond *Lean light applications*.

## KEYWORDS

Application, maturity, effect, evaluation, transformation.

## INTRODUCTION

Lean Construction (LC) has been promoted as a management approach with the potential to improve project performance and enable transformative change in the construction industry. Realising this potential, however, presupposes that organisations and individuals understand its underlying logic and apply it in a coherent manner (Howell & Ballard, 1998; Ballé et al., 2026). The approach operates through the interaction of its principles, methods, and cultural elements. Thereby, its effectiveness arises from its integrated deployment rather than from components implemented in isolation (Ballard et al., 2007; Wandahl, 2014; Arbulu & Zabelle, 2006).

When it comes to such integrated deployment in practice, multiple studies have demonstrated that LC is still at an early stage of maturity (e.g., Malvik et al., 2024; Ikuabe et al., 2024; John et al., 2025a). Our prior work in Germany has shown, for example, that the approach is frequently adopted as a toolkit, most notably through the application of the Last

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Planner System or Takt Planning/Takt Control during construction execution, without broader alignment of processes, structures, or behavioural norms (John et al., 2025b).

The existence and persistence of this phenomenon, which we refer to as *Lean light application*, can be attributed to multiple factors. One of these is an acceptance challenge, as reflected in our empirical observations. This not only constrains diffusion, leading many organisations and individuals to engage only selectively with LC, but may also prevent the approach from demonstrating its full potential when it is applied in a method-focused manner. While this may generate incremental improvements, it falls short when LC is not implemented coherently and sustained under enabling conditions. In practice, LC is therefore frequently met with scepticism. Consequently, where LC is initiated, its implementation often remains confined to selected projects, departments, or methods. In other cases, LC is discussed or even launched, but not followed through in day-to-day delivery (Wandahl, 2014; Mossman, 2009; Bygballe & Swärd, 2014; John et al., 2025b).

Prior research points to barriers that may contribute to or reinforce this acceptance challenge, including unsuccessful application in earlier projects, affective resistance to change, limited financial and organisational capacity, insufficient understanding, and the absence of enabling structures (Demirkesen et al., 2019; Cano et al., 2015; Wandahl, 2014).

Against this, our paper advances the proposition that shortcomings in LC practice are often less attributable to deficiencies in the approach itself than to inadequate application and misaligned expectations about LC's effect when it is not applied holistically. However, literature and practice still lack a systemic understanding of how the effect of LC emerges (across different levels) and how *Lean light application* shapes this dynamic.

Accordingly, this paper addresses the following research question: *How can LC application and its effect be conceptualised to better explain why LC's effect often remains limited in practice?* To answer this, we propose a conceptual model that contributes in three ways: First, it differentiates LC application across five hierarchical levels in the construction industry, thereby capturing where LC takes place and how influence and responsibility are distributed. Second, it characterises application through three dimensions (duration, quantity, quality), extending prevailing maturity-oriented perspectives. Third, it links these dimensions through a heuristic concept of application volume as an indicator of likely effect. By making the interdependencies explicit, the model enhances conceptual understanding, clarifies how different configurations of LC application contribute to outcomes, and thereby supports systematic planning of transformation efforts. It aims to enable organisations to identify entry points, allocate responsibilities, and monitor progress over time. Through this integrative perspective, the model seeks to advance both research and practical application of LC.

## EVALUATING LEAN CONSTRUCTION APPLICATION AND EFFECT

Within the Lean Construction (LC) literature, several studies have proposed instruments to assess LC application and to indicate the effect that may be expected from LC initiatives. The dominant focus of these approaches is the assessment of maturity or the degree of leanness, whereas systematic evaluation of performance effects remains comparatively limited. Prominent examples include the Lean Conformance Test by Diekmann et al. (2003), the Rapid Lean Construction Quality Rating (Hofacker et al., 2008), the Lean Construction Maturity Model (Nesensohn et al., 2015), the Lean Construction Maturity Evolution Model (Cano et al., 2020), the Lean Maturity Model (ILMM) (Vaidyanathan et al., 2024), the Degree of Lean Construction (DOLC) tool (Carvalho & Scheer, 2017), a Lean audit (Valente et al., 2012; Comelli et al., 2019), the Lean Metric System (Carneiro et al., 2017), the Takt Maturity Model by Lehtovaara et al. (2020) and the Leanness Assessment System by Ead et al. (2024).

Despite their practical value, these contributions exhibit two limitations that constrain their explanatory power for the problem addressed. First, they are typically designed for a single perspective (mostly a project or an organisation) and therefore provide limited guidance on how LC unfolds across a system or how effects may propagate between these levels. An exception is Perez-Apaza et al. (2021), who differentiate three intra-organisational levels (organisation, assignment, operational), yet without extending this logic to an inter-organisational context. In this sense, LC is often treated as a single-level phenomenon. This limitation becomes visible in attempts to infer higher-level impact from lower-level changes (e.g., Martinez et al., 2025).

Second, existing assessment approaches mostly operationalise LC application only through one application dimension, often the quality of application and/or the coverage (limited quantity perspective) of selected LC practices. In contrast, application dimensions that are critical for interpreting outcomes, such as the temporal duration of LC engagement and the breadth of deployment across organisational portfolios, project phases, or stakeholder constellations, are typically mentioned implicitly rather than assessed systematically, if addressed at all.

Closely related, the literature that discusses LC's effect tends to report outcomes without specifying how it was applied (how long, broadly, mature) (e.g., Castillo et al., 2014; Concha et al., 2015; van Dijkhuizen et al., 2021; Mohan & Iyer, 2005; Li et al., 2015; Barth et al., 2019). As a result, commonly cited claims, such as “up to x% savings”, risk being misleading when they are not contextualised by the configuration of the respective LC application.

Therefore, the literature offers only limited understanding of why LC initiatives frequently generate only local or short-term improvements and fail to produce sustained effects across all system levels. This gap indicates the need for a different perspective.

## METHODOLOGY

The development of our conceptual model followed a four-stage research process: (1) conceptual derivation of the model from findings of an interview study, (2) iterative refinement through workshops, (3) validation through 10 expert interviews, and (4) case-based applicability assessment across the five system levels. Each stage is described below:

First, the initial development of the model was grounded in the findings of a recent interview study on the status quo of Lean Construction (LC) in Germany (John et al., 2025b). Analysis of the dataset, based on 15 practitioner interviews, indicated that the findings originated from different layers within the industry, which pointed to the need for a multilevel perspective. The analysis further suggested that LC's effect at each level could be understood in relation to the degree of LC application along three dimensions: duration, quantity, and quality.

Second, once an initial version of the model had been developed, its explanatory potential was examined by analysing how relationships among levels and dimensions could be derived from it. This step revealed that the model enabled a more differentiated understanding of how LC application and its effect unfold across the industry, and how responsibilities and influence are distributed among industry actors. Recognising this, we iteratively refined the model through a series of internal workshops involving repeated rounds of discussion, reflection, and restructuring in order to improve coherence and strengthen its conceptual foundation.

Third, the next step involved subjecting the model to expert-based theoretical validation. For this purpose, we conducted 10 expert interviews with individuals who had several years of LC experience. The interviewees represented roles associated with different system levels and perspectives (project owners, project managers, operational construction managers, industry association representatives, and researchers). The interviews were analysed qualitatively to confirm and refine the proposed model with regard to its conceptual plausibility, perceived completeness, and practical relevance. Feedback from these interviews was incorporated iteratively, allowing several aspects to be further sharpened. Overall, the interviewees supported the model's underlying logic and indicated its practical usefulness as an analytical

and evaluative structure. In line with validation approaches commonly used for conceptual frameworks (Vaidyanathan et al., 2024; Demirdöğen et al., 2021; Nesensohn et al., 2015), this step does not aim to establish generalisability, but rather to examine whether the model is considered consistent with established knowledge and the realities of practice.

Fourth, we further assessed the model’s practical applicability by analysing illustrative cases provided by the interviewees. These cases demonstrate how the model can be used to categorise real-world observations and interpret system dynamics.

## DESCRIPTION OF THE CONCEPTUAL MODEL

### RATIONALE AND OVERVIEW

As outlined above, Lean Construction (LC) unfolds its effect across different contexts and hierarchical levels of the construction industry. Its application is not confined to isolated practices or single organisational units but emerges through the interaction of multiple actors and different levels. Accordingly, a differentiated analytical perspective is required to capture where and how LC is applied, and how its effect materialises across the system layers.

To address this need, we propose a multilevel and multidimensional conceptual model that structures LC application across five hierarchical system levels and three application dimensions. The levels represent distinct perspectives within the construction industry, ranging from the overall industry level (L5) down to the level of an individual operational practitioner (L1). The application dimensions characterise the duration (D1), quantity (D2), and quality (D3) of LC at each level. In addition, the model includes a derived measure, the application volume (V), conceptualised as the product of D1–D3 and intended to indicate the likely magnitude of the overall effect. Beyond structuring LC application, the model provides an analytical lens for evaluating configurations across levels and dimensions. Together, these elements offer a coherent perspective for analysing how LC manifests within the industry and how different application configurations are likely to shape the effect that can be expected.

In the following, this section first specifies the hierarchical levels. It then discusses level-specific responsibilities and highlights the relationships and interactions across levels. Finally, it elaborates on the application dimensions, explains the relationship to the effect, and outlines the corresponding evaluation scales used to assess cases at each level along each dimension.

### HIERARCHICAL LEVELS OF THE MODEL

The model distinguishes five levels that reflect the hierarchical structure of the construction industry. These levels are ordered from macro to micro, forming a funnel-like structure in which each level constitutes a contextual subset of the preceding one (see Figure 1).

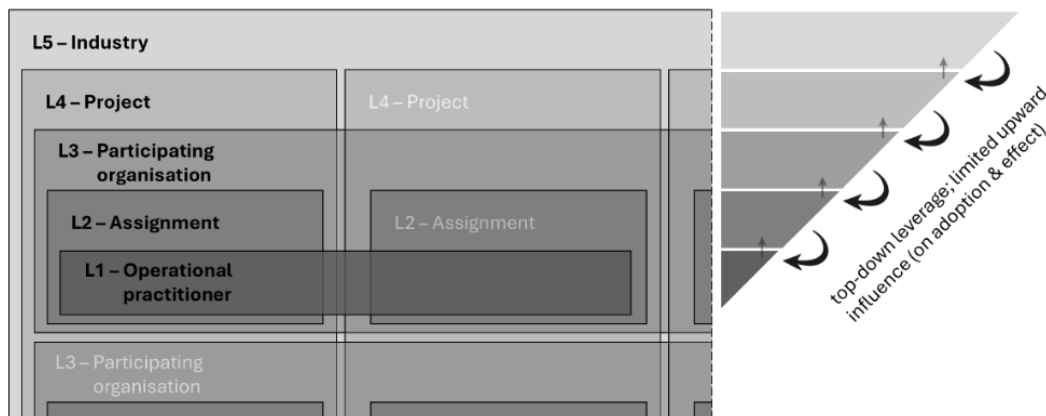


Figure 1: Hierarchical multilevel representation of the construction system with nested instances and cross-level interactions

Figure 1 indicates that each level contains multiple instances of the level below: the industry comprises projects, projects involve organisations, organisations hold assignments in different projects, which involve practitioners, who may in turn work across more than one assignment.

At the highest level, the **industry perspective (L5)** represents the construction industry as a whole. This level captures the state of LC within a national construction industry. Construction projects constitute the central subsystem of the industry level, as they represent the primary context in which value is created. Accordingly, the **project level (L4)** describes how LC practices are applied within projects. The project owner/client brings together multiple project participants that contribute their respective expertise and resources to realise the project. These participating organisations (owner/client included) are represented at the **organisational level (L3)**. At this level, the focus is on how LC is applied within an organisation. The **assignment level (L2)** accordingly reflects the operational execution of specific scopes of work within projects from the perspective of an individual participating organisation. Here, even in projects that are not explicitly managed according to LC, individual organisations may apply the approach in the execution of their assigned work. Finally, the **operational practitioner level (L1)** captures the role of individuals who enact LC within these assignments (L2) carried out by a participating organisation (L3) performed within a project (L4) situated within the construction industry (L5). At this level, individual competence, experience, and mindset influence how LC is interpreted and applied in daily operational work in this context.

These levels enable a differentiated analysis of LC application that avoids treating the approach as homogeneous and instead acknowledges its context-dependent manifestation.

## RESPONSIBILITIES AND CROSS-LEVEL INTERACTIONS

The model further recognises that responsibilities for LC application differ across system levels and that influence is asymmetrical. At the **industry level (L5)**, responsibility is distributed among institutions. It should be noted that this level offers predominantly indirect levers of influence. Industry associations and policy actors, for example, influence the application of LC through diffusion and standardisation, with advocacy and lobbying serving as channels that can shape enabling conditions for projects (L4), organisations (L3), assignments (L2), and operational practitioners (L1). Universities may also exert influence in the long-term by embedding LC in education, thereby shaping mindset and capabilities of future professionals who will operate across L1–L4. In more immediate, albeit limited, terms, large project owners who commission projects frequently and at scale (most notably in the public sector) can influence adoption by requiring LC as a mandatory component. Such requirements can motivate participating organisations (L3) to develop capabilities to remain competitive and may also create reference projects that encourage uptake by other owners in their projects (L4).

Within construction **projects (L4)**, initiating actors (owners/representatives) play a central role in enabling or constraining LC. They can design the overall project setup in line with Lean principles (John & Haghsheno, 2026) or make application a mandatory requirement. In doing so, they influence the other participating organisations (L3), the execution of assignments (L2), and the operational practitioners involved (L1). It is therefore important to recognise that project owners possess significant leverage for introducing LC into (their) construction projects. Beyond this, large projects may, to a limited extent, also influence other projects and industry actors through visible success stories that serve as inspiration or lighthouse examples (Ballard et al., 2007). However, such upward effects to the industry level (L5) remain constrained.

From a **participating organisation's perspective (L3)** (project owners/clients included), responsibility primarily lies with top management or designated departmental leaders. These actors can mandate that LC be integrated into the organisation's philosophy and internal ways of working, and ensure that the organisation's assignments (L2) within construction projects are consistently executed using LC. They are also responsible for providing operational

employees (L1) with appropriate training and development opportunities. Upward influence is also possible, though constrained: due to their hierarchical position, top managers may exert more influence on project owners (L4) during contract negotiations than operational managers. This influence, however, depends on the type, size, and market position of the organisation.

At the **level of assignments (L2)**, responsibility shifts towards those managing the execution (e.g., construction managers). These actors often have a certain degree of autonomy in organising their work and may therefore initiate LC. Through this, they also influence the extent to which the operational practitioners in the assignment (L1) engage with LC. Upward influence is mainly indirect: success experiences and discussions may encourage broader adoption within the organisation (L3). Influence on the project level (L4) is strongly limited and depends on the size of the assignment, relevance within the project, and its position in the project lifecycle. For instance, a manager of a general planning organisation is more likely to influence the introduction of LC at project level than a representative of a small trade contractor.

At the **operational practitioner level (L1)**, responsibility primarily lies with individuals themselves through motivation, reflection, and competence development. Individuals may influence the higher level by proposing LC to those responsible for assignments (L2) or the top management (L3). The influence of these individuals beyond their organisation is marginal.

Notably, every change towards LC application originates with an individual who believes in the approach and advocates for it. Depending on the organisation in which this person operates, the system level at which that organisation is situated, as well as the person's position and (in)formal power, this impulse can have very different reach – as outlined in this section.

## APPLICATION DIMENSIONS OF THE MODEL

Across all five hierarchical levels of the construction industry, the model distinguishes three application dimensions that characterise LC application (D1–D3) and a derived summary measure, the application volume (V), conceptualised as the product of these dimensions. Based on our empirical observations and expert-based validation, the application volume (V) is a proxy measure that provides an indication of the likely magnitude of LC's overall effect (the higher the application volume, the higher the expected effect). The terminology and underlying logic of these dimensions are inspired by geometric principles (see Figure 2). This multiplicative formulation should be understood as a heuristic simplification. Its purpose is to make explicit that the likely magnitude of the effect depends on the configuration of the three dimensions, and that limitations in one dimension constrain the effect that can be expected.

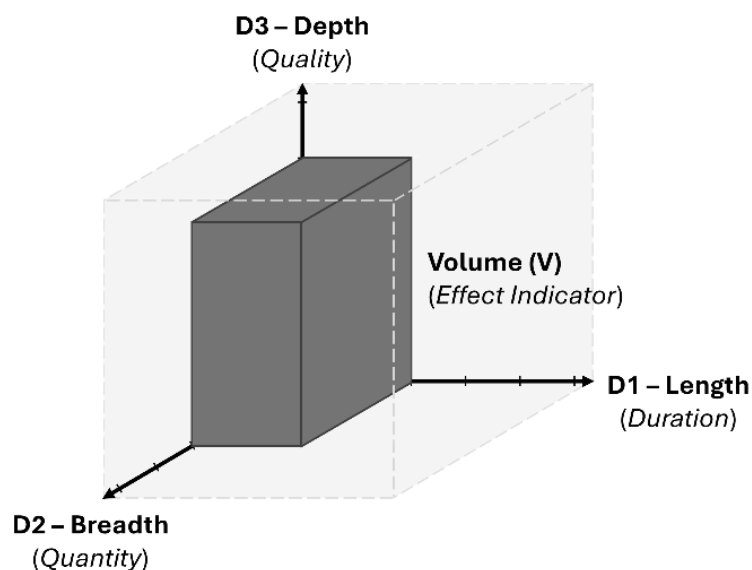


Figure 2: Application dimensions and volume

The **length dimension (D1)** addresses the temporal aspect of LC application and thus answers the question: *How long is Lean Construction applied at the respective level?* It captures the duration over which LC spans different phases of a project lifecycle or an assignment. This dimension reflects the role of continuity and experience, acknowledging that sustained, long-term application influences the effect that emerges from it.

To enable an evaluation of cases, we iteratively developed five evaluation stages for each level, combining theoretical input and discussions with practitioners. The resulting stages capture progressive advancement along the respective dimension and are intended as an initial qualitative classification. Quantitative operationalisation and corresponding measurement procedures will be developed in our future research. Table 1 summarises the five-stage evaluation scales by level. Notably, two temporal horizons need to be distinguished, which is why the stage labels vary across levels: permanent (L1, L3, L5) and temporary (L2, L4).

Table 1: Level-specific five-stage evaluation scales for length (temporal) dimension

| Evaluation stages | L5: industry                                             | L4: project                               | L3: participating organisation                           | L2: assignment                            | L1: operational practitioner                             |
|-------------------|----------------------------------------------------------|-------------------------------------------|----------------------------------------------------------|-------------------------------------------|----------------------------------------------------------|
| 1                 | just started<br><i>initial introduction</i>              | brief<br><i>very limited duration</i>     | just started<br><i>initial introduction</i>              | brief<br><i>very limited duration</i>     | just started<br><i>initial introduction</i>              |
| 2                 | early-stage<br><i>first applications/pioneers</i>        | phase-specific<br><i>isolated periods</i> | early-stage<br><i>first applications/pilots</i>          | phase-specific<br><i>isolated periods</i> | early-stage<br><i>first applications/pioneers</i>        |
| 3                 | ongoing (multi-year)<br><i>growing experience</i>        | temporary<br><i>substantial duration</i>  | ongoing (multi-year)<br><i>growing experience</i>        | temporary<br><i>substantial duration</i>  | ongoing (multi-year)<br><i>growing experience</i>        |
| 4                 | long-standing<br><i>established experience</i>           | extended<br><i>major share</i>            | long-standing<br><i>established experience</i>           | extended<br><i>major share</i>            | long-standing<br><i>established experience</i>           |
| 5                 | sustained (decade-plus)<br><i>long-standing presence</i> | continuous<br><i>entire lifecycle</i>     | sustained (decade-plus)<br><i>long-standing presence</i> | continuous<br><i>entire assignment</i>    | sustained (decade-plus)<br><i>long-standing presence</i> |

In terms of scope, the **breadth dimension (D2)** refers to the quantitative extent of LC application within a given level and addresses the question: *How broadly is Lean Construction applied at the respective level?* It captures the degree of diffusion, involvement, or structural penetration, such as the share of projects, participating organisations, or tasks applying LC, or the breadth of an individual's competence repertoire.

Following the approach used for D1, we developed five evaluation stages for each level to enable an initial qualitative classification (see Table 2).

Table 2: Level-specific five-stage evaluation scales for breadth (quantity) dimension

| Evaluation stages | L5: industry                                | L4: project                                 | L3: participating organisation                    | L2: assignment                              | L1: operational practitioner                        |
|-------------------|---------------------------------------------|---------------------------------------------|---------------------------------------------------|---------------------------------------------|-----------------------------------------------------|
| 1                 | isolated<br><i>fragmentary presence</i>     | isolated<br><i>individual involvement</i>   | isolated<br><i>pilot projects</i>                 | isolated<br><i>individual work packages</i> | isolated<br><i>use of few isolated aspects</i>      |
| 2                 | partial<br><i>niche adoption</i>            | partial<br><i>selective participation</i>   | partial<br><i>limited use</i>                     | partial<br><i>selective work packages</i>   | partial<br><i>use of whole methods</i>              |
| 3                 | segmented<br><i>segmented establishment</i> | segmented<br><i>group-based involvement</i> | segmented<br><i>project- or unit-specific use</i> | segmented<br><i>package-based use</i>       | segmented<br><i>use of methods &amp; principles</i> |
| 4                 | broad<br><i>industry-wide establishment</i> | broad<br><i>project-wide engagement</i>     | broad<br><i>portfolio-wide use</i>                | broad<br><i>assignment-wide use</i>         | broad<br><i>comprehensive Lean Thinking</i>         |
| 5                 | institutionalised<br><i>full coverage</i>   | institutionalised<br><i>full coverage</i>   | institutionalised<br><i>full coverage</i>         | institutionalised<br><i>full coverage</i>   | institutionalised<br><i>full repertoire</i>         |

In terms of application quality, the **depth dimension (D3)** describes how mature the application of LC is at the respective level and addresses the question: *How deep is the application of Lean Construction at the respective level?* This dimension reflects the maturity and competence of LC application, ranging from surface-level method-focused use to high-level and fully mature application.

Table 3 presents, consistent with the preceding dimensions, the five stages for each level.

Table 3: Level-specific five-stage evaluation scales for depth (quality) dimension

| Evaluation stages | L5: industry                                         | L4: project                                          | L3: participating organisation                       | L2: assignment                                       | L1: operational practitioner                         |
|-------------------|------------------------------------------------------|------------------------------------------------------|------------------------------------------------------|------------------------------------------------------|------------------------------------------------------|
| 1                 | informing<br><i>surface-level understanding</i>      | informing<br><i>surface-level understanding</i>      | informing<br><i>surface-level understanding</i>      | informing<br><i>surface-level understanding</i>      | informing<br><i>surface-level understanding</i>      |
| 2                 | emerging<br><i>foundational competence</i>           | emerging<br><i>foundational competence</i>           | emerging<br><i>foundational competence</i>           | emerging<br><i>foundational competence</i>           | emerging<br><i>foundational competence</i>           |
| 3                 | stabilising<br><i>reliable and solid application</i> | stabilising<br><i>reliable and solid application</i> | stabilising<br><i>reliable and solid application</i> | stabilising<br><i>reliable and solid application</i> | stabilising<br><i>reliable and solid application</i> |
| 4                 | advancing<br><i>high-level application</i>           | advancing<br><i>high-level application</i>           | advancing<br><i>high-level application</i>           | advancing<br><i>high-level application</i>           | advancing<br><i>high-level application</i>           |
| 5                 | professional<br><i>fully mature application</i>      | professional<br><i>fully mature application</i>      | professional<br><i>fully mature application</i>      | professional<br><i>fully mature application</i>      | professional<br><i>fully mature application</i>      |

Finally, as a product of the interaction among the three preceding dimensions, the **application volume (V)** captures the overall degree of Lean Construction application at the respective level. Drawing on the underlying geometric analogy of the model, this derived summary measure does not represent an independent aspect of application. Instead, it reflects the combined configuration of length (duration), breadth (quantity), and depth (quality) and serves as an effect proxy, providing an indication of the likely magnitude of LC's overall effect. It therefore addresses the question: *How comprehensive is the Lean Construction application at the respective level, and how large is the expected effect that results from this configuration?*

In doing so, it reflects a relationship that is often observed: a significant effect can only be expected when LC is applied over a sufficient duration, across a sufficiently broad scope, and at a sufficiently high level of maturity. If just one of these dimensions remains limited, the effect is likely to remain marginal, regardless of the strength of the others: LC is often applied only *phase-specifically*, e.g., during execution (D1=2), only by a *segmented* group of participants (D2=3). Even if the quality of application reaches an *advanced state* (D3=4), such a configuration is likely to generate only a *marginal effect* for the project ( $V=1, 2 \times 3 \times 4=24$ ).

Table 4 accordingly presents the classification of the application volume (V), based on our empirical observations, conceptualised as the product of the preceding application dimensions. The corresponding score ranges are intended as an initial qualitative classification of application volume and its likely effect indication. They were defined as an initial communicative simplification for qualitative classification and are not yet empirically derived.

Table 4: Level-specific five-stage evaluation scales for application volume (effect indicator)

| Evaluation stages<br>(by Score) | L5: industry                                | L4: project                                 | L3: participating organisation              | L2: assignment                              | L1: operational practitioner                |
|---------------------------------|---------------------------------------------|---------------------------------------------|---------------------------------------------|---------------------------------------------|---------------------------------------------|
| 1 (1-25)                        | marginal<br><i>barely observable effect</i> | marginal<br><i>barely observable effect</i> | marginal<br><i>barely observable effect</i> | marginal<br><i>barely observable effect</i> | marginal<br><i>barely observable effect</i> |
| 2 (26-50)                       | limited<br><i>localised/isolated effect</i> | limited<br><i>localised/isolated effect</i> | limited<br><i>localised/isolated effect</i> | limited<br><i>localised/isolated effect</i> | limited<br><i>localised/isolated effect</i> |
| 3 (51-75)                       | moderate<br><i>noticeable effect</i>        | moderate<br><i>noticeable effect</i>        | moderate<br><i>noticeable effect</i>        | moderate<br><i>noticeable effect</i>        | moderate<br><i>noticeable effect</i>        |
| 4 (76-100)                      | significant<br><i>far-reaching effect</i>   | significant<br><i>far-reaching effect</i>   | significant<br><i>far-reaching effect</i>   | significant<br><i>far-reaching effect</i>   | significant<br><i>far-reaching effect</i>   |
| 5 (101-125)                     | transformative<br><i>holistic influence</i> | transformative<br><i>holistic influence</i> | transformative<br><i>holistic influence</i> | transformative<br><i>holistic influence</i> | transformative<br><i>holistic influence</i> |

## CASE-BASED ILLUSTRATION OF THE MODEL

To demonstrate the model's practical use, this section provides an illustrative example at the project level (L4). As part of the interviews, we discussed illustrative cases across all system levels to test the model's applicability. For reasons of space, we present one example. This project was selected because it reflects a sustained application of Lean Construction (LC).

*D1 (length/duration) = stage 4 (extended – major share):* LC was applied over an extended duration, spanning major project phases from the feasibility study through Lean Design and pull planning to the construction phase, with defined handovers to downstream phases.

*D2 (breadth/quantity) = stage 5 (institutionalised – full coverage):* The project owner organisation was applying LC comprehensively, fully integrating planners and general contractors – supporting implementation through joint training of project participants.

*D3 (depth/quality) = stage 4 (advancing – high-level application):* The project was characterised by the systematic use of multiple LC methods, integrated and standardised KPIs, schedule-model integration, and regular training. However, the phases varied with regard to quality. While the construction phase was at stage 5, other phases were not as far along.

*V (application volume/effect indicator) = stage 4 (score:  $4 \times 5 \times 4 = 80$ ) (significant – far-reaching effect):* The example achieves a score of 80 points, placing it in the category of a significant application volume and far-reaching effect. This assessment is consistent with the observed reality: despite a high level of temporal and technical complexity, the project was completed on time. The LC application contributed substantially to this performance and was further acknowledged through an external project award recognising the high maturity of LC.

## DISCUSSION

Findings of a recent study on the status quo of Lean Construction (LC) in Germany indicate that LC application cannot be understood as a homogeneous phenomenon (John et al., 2025b). Instead, LC initiatives emerge across different levels within the construction industry. Across all levels, the effect of LC application appears to depend not only on application quality, but also on how broadly and for how long it is applied. Building on this, our multilevel and multidimensional model provides a structured lens for making these relationships explicit and for supporting a more systematic evaluation of application across the construction industry.

By distinguishing length (D1), breadth (D2), and depth (D3) as application dimensions and conceptualising the connection between the (expected) effect and the application volume ( $V = D1 \times D2 \times D3$ ), the model makes an empirical insight explicit: a substantial effect is unlikely unless LC is applied with sufficient duration, across a broad scope, and with high quality. This multiplicative logic helps to explain why many initiatives (*Lean light*) fall short of expectations. Even advanced application quality in isolated contexts, such as a single project phase, department, or assignment, will yield only a limited effect at the respective system level. The model thereby offers a transparent rationale for expectation management: LC is not a universal remedy, and transformative outcomes should not be expected from fragmented applications.

The model also clarifies why successful applications may generate improvements within their system level while their effect remain siloed. Strong LC performance at a lower level does not automatically translate into an observable effect at higher levels: A single trade contractor; for example, can deliver an exemplary assignment with LC, while the overall project performance may remain poor. Therefore, the model reinforces the need to treat each level as a distinct unit of analysis, rather than assuming spill-over from isolated, bottom-up initiatives.

From a theoretical perspective, the model systematises and extends the maturity discussion in LC research by integrating the application dimensions and by making a link to the expected resulting effect explicit. This multilevel, multidimensional synthesis clarifies LC's impact by showing where and how it is enacted, and which conditions must align for effects to materialise across levels. In addition, by explicating responsibilities and asymmetrical cross-level influence, the model extends previously more fragmented accounts of influence and implementation dynamics, such as notions of contract hierarchy (Ballard et al., 2007) or bottom-up implementation supported by top-down leadership (Arbulu & Zabelle, 2006). In particular, it becomes apparent that only a limited set of actors has substantial leverage to shape adoption across the industry. This clarifies why broad diffusion cannot be expected to emerge solely from operational enthusiasm and why bottom-up initiatives remain bounded without support.

In practical terms, the model can serve as an initial qualitative diagnostic tool. By providing level-specific evaluation stages for each dimension, it enables projects, organisations, and

practitioners to develop a structured self-assessment of where they currently stand and which dimension acts as the primary constraint on achieving a stronger effect. This supports more targeted transformation planning: actors can identify whether they need to extend LC across a longer temporal span, expand coverage, or strengthen application quality. The model also supports strategic discussions about entry points. It encourages practitioners to reframe LC initiatives away from isolated method deployment and towards deliberate configuration design. Finally, by differentiating the likely reach of effects across levels, our model supports more realistic expectation management and can help prevent frustration that often follows when LC is piloted, produces only limited visible effect, and is then prematurely abandoned.

Despite its theoretical grounding and practice-oriented validation, the model has limitations. While this is appropriate for an initial conceptual model, it implies interpretative leeway in case classification, particularly when used as a self-assessment tool. Future studies will therefore operationalise the scales through measurable indicators and develop more objective assessment procedures. Second, the value of the multiplicative logic lies less in numerical precision than in its explanatory power. It provides a compact way of expressing the configurational argument of the model: substantial effects are unlikely to emerge unless LC is applied comprehensively at the respective level. At this stage, the multiplication primarily serves as a heuristic representation of interdependence among the three application dimensions. It does not yet claim a calibrated causal or predictive relationship. Our future research will therefore calibrate this configuration-effect relationship. Such work will also enable more robust benchmarking and comparison, e.g., across organisations, projects, or even national construction industries.

## CONCLUSION

This paper proposed a multilevel and multidimensional model to better understand how Lean Construction (LC) is adopted and applied across the construction industry and why its effect frequently remains limited in practice. Building on empirical insights from a study on the status quo of LC in Germany, the model differentiates five hierarchical system levels and characterises LC application along three foundational dimensions: duration (D1), quantity (D2), and quality (D3), while linking the application volume ( $V=D1 \times D2 \times D3$ ) to the expected effect as an outcome proxy. By making this configuration logic explicit, the model provides a pragmatic explanation for *Lean light* phenomena and supports more realistic expectations: even high-quality LC application in isolated silos is unlikely to generate a substantial effect at the respective level.

Beyond its structure, the model offers further contributions. By modelling responsibilities and asymmetrical cross-level influence, it clarifies where leverage is located, most notably with (large) project owners, their representatives, and the top management of participating organisations, and highlights entry points for LC adoption. In addition, the level-specific evaluation scales provide an initial qualitative basis for a systematic assessment. For research, the model offers a coherent lens for comparing LC application across contexts and for formulating precise explanations of when and why effects emerge. For practice, it can serve as a diagnostic and communication tool that supports the planning of transformation pathways by identifying which dimension constitutes the primary constraint on achieving a stronger effect.

Overall, the proposed model offers a structured and pragmatic contribution to understanding LC application and the effect that results from it. It makes explicit that outcomes depend on configurations across duration, quantity, and quality, that effects do not automatically scale upward across levels, as well as that responsibilities and influence are unevenly distributed across the industry. By providing a common understanding and an evaluative structure across levels and dimensions, our model aims to support both research and practice in moving beyond *Lean light applications* towards more coherent and effective transformation pathways.

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