The Toyota Way model: an alternative framework for lean construction

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As the success of lean production is widespread, both inside and outside the manufacturing industry, there have emerged a number of models of lean construction, which look into the possible implementation of the lean principles in the construction industry. While it is commonly accepted that lean production has its basis in the Toyota production system (TPS), the ‘Toyota Way’ has developed as something more than simply the TPS. This study examines the current implementation frameworks of lean construction and proposes an alternative framework for the construction industry based on the Toyota Way model. It is hoped that this ‘back to the basics’ approach can be used to bring greater clarity to lean construction by means of the Toyota Way model. The comprehensiveness of the Toyota Way model means that it can bring about multiple angles from which to look at the lean construction model for the construction industry.

Keywords: Toyota Way model; lean construction; construction industry

Introduction

Today, lean production – a management philosophy which originated from the Toyota production system (TPS) – is widely applied outside of the manufacturing industry. For example, Dahlgaard, Pettersen, and Dahlgaard-Park (2011), among others, have discussed the development of lean and quality systems for healthcare organisations. The research undertaken by Alsmadi, Almani, and Jerisat (2012) found that the service sector has also embraced the concept of lean, and outperformed in soft lean practices compared with the manufacturing sector in the UK. In the construction industry, the term ‘lean construction’ has become an established theme, and is promoted as a means to achieve operational improvement (i.e. quality and productivity) through elimination of waste and maximising value (Egan, 1998; Diekmann, Krewedl, Balonick, Stewart, & Won, 2004). However, a closer examination of the related literature shows that little agreement still exists on the definition of – as well as implementation framework of – lean construction (Green & May, 2005; Morris & Lancaster, 2006; Jørgensen & Emmitt, 2008; Mossman, 2009). As Green and May (2005) noted:

Lean construction is variously understood as a set of techniques, a discourse, a “socio-technical paradigm” or even a “cultural commodity” (p. 503).

The objectives of this article are to provide an alternative framework to give to the lean construction research community better explanations based on the Toyota Way model. First, current frameworks or models of lean construction will be reviewed and synthesised. Topics derived from these models will be discussed, and missing elements that need to be addressed will be highlighted. Second, the Toyota Way model and its associated principles
will be reviewed, with the hope of learning lessons or ‘best practices’ to bridge the missing links lacking from the current lean construction models. The discussion of the alternative framework appears in Section 5, where its applicability and implications for the construction quality are discussed.

**Literature review**

**Development of lean production**

It is commonly acknowledged that lean production was pioneered by Toyota in what is known as the TPS. Holweg (2007) provides a rich account of the genealogy of lean production, in which a timeline of research on and dissemination of lean production was mapped. Lean has had an evolutionary journey similar to the path followed by total quality management (TQM) (Dahlgaard-Park, Chen, Jang, & Dahlgaard, 2013): both have travelled from the USA to Japan and from Japan to the West. In the view of Holweg (2007), before Krafck (1988) coined the term ‘lean’, the TPS as developed by Taiichi Ohno, had long existed as a ‘secret weapon’ for improving operational efficiency. This came to be the first source available in English, until the paper written by Sugimori, Kusunoki, Cho, and Uchikawa (1977) was published. Prior to that, Ohno (1988) acknowledged that the just-in-time (JIT) concept was influenced by the American supermarket system. Lean later became a huge success and drew great attention when the International Motor Vehicle Programme (IMVP) published its findings (Womack, Jones, & Roos, 1990), which clearly showed that there was something special in terms of Japanese quality and efficiency (Dahlgaard & Dahlgaard-Park, 2006). Meanwhile, TPS has ‘evolved’ gradually into the Toyota Way. Efforts have been made by Liker (2004), who conceptualised the Toyota Way as a pyramid model, in which a set of principles are built in, at both shop floor level and firm level (see Figure 1).

The literature has seen a sizable volume of lean production (and lean manufacturing) models emerged in more recent years. According to Dahlgaard-Park et al. (2013), in the

![Figure 1. The Toyota Way model (Source: Liker, 2004).](image-url)
period 1987–2011, articles published in the area of JIT/TPS/lean outnumber those on TQM. Basically, these frameworks of lean can be categorised into two broader themes, namely ‘design/conceptual’ frameworks and ‘implementation’ frameworks. Yusof and Aspinwall (2000) compared the differences between conceptual framework and implementation framework in the context of TQM. In a similar vein, the former (conceptual framework) discusses the contents of lean production, i.e. what the elements of lean production are (Koskela, 1992, 2000; Karlsson & Åhlström, 1996; Shah & Ward, 2007), whereas the latter deals with frameworks that can provide a discussion on how to implement lean production, including what the sequence of activities should be and so on (Åhlström & Karlsson, 2000).

Furthermore, several authors have examined the frameworks of lean production. For example, approximately 30 frameworks for lean production were examined by Anand and Kodali (2010) in terms of their comprehensiveness, abstractness, and degree of fit to an organisation. The results showed that a majority of the examined frameworks lacked a high degree of comprehensiveness, whereas many showed high and medium degrees of abstractness. In short, all these features are attributed to an improper understanding of lean production. Earlier, another comparative study was performed by Paez et al. (2004) with less selected lean production frameworks. In their study, each framework was assessed with respect to its human and technological aspects. The finding implied that most frameworks did not equally take into account of both lean tools on the shop floor and the development of the workforce.

Lean construction

Over the last few decades, in order to introduce aspects of lean production into construction projects, various research efforts have been undertaken. Although lean construction is still in its infancy, a set of practices have been proposed, tested, and implemented (Paez, Salem, Solomon, & Genaidy, 2005; Jørgensen & Emmitt, 2008). In particular, Jørgensen and Emmitt (2008) noted that, ‘implementation and application’ have emerged as a dominant theme in lean construction, in which numerous projects and process performances connected to lean initiatives were reported. However, compared with lean production or TQM (Dahlgaard & Dahlgaard-Park, 2006), which has achieved a certain maturity, lean construction has been slow in opening to critical debate (Jørgensen & Emmitt, 2008). Jørgensen and Emmitt (2008) also pointed out that, in the transition of the lean principles from production to construction, the process losses appear to be related mainly to the challenges surrounding the application of the practices in a different context. This motivates the present research to evaluate existing frameworks of lean construction with a critical eye, and discover what is really missing.

Implementation frameworks for lean construction

In this section, various frameworks for lean construction are reviewed (see Table 1). Given that a full coverage of all frameworks would be impractical, only the most widely published and most relevant ones are presented. The parameters used for analysis are provided below:

1. Objective: this parameter helps to identify what is the drive that has led to the framework being utilised by researchers or practitioners.
2. Topics covered: this represents the main issues addressed in each framework.
3. Research methods (if any): this identifies how the data collected – i.e. questionnaires, interviews, or case study.
<table>
<thead>
<tr>
<th>No.</th>
<th>Author(s)</th>
<th>Model name</th>
<th>Objectives</th>
<th>Topics covered</th>
<th>Research methodology</th>
<th>Where applied</th>
</tr>
</thead>
</table>
| 1   | Ballard (2000)       | Last planner system™ (LPS)   | To produce more reliable schedule                                           | • Four levels of scheduling: master plan, phase plan, look-ahead plan, and weekly plan  
• Reliable matrix: percent plan complete  
• Daily huddle meeting: remove potential barriers | Case studies                | USA                            |
| 2   | Diekmann et al. (2004) | Lean construction wheel     | To assess the extent to which an organisation conforms to lean ideals        | • Elimination of waste  
• Standardisation  
• Culture/people  
• Customer focus  
• Continuous improvement  
• Model 1: waste elimination  
• Model 2: partnering  
• Model 3: structuring the context | Questionnaire and USA case studies |                          |
| 3   | Green and May (2005) | Not mentioned               | To evaluate the existing model of lean construction from policy makers’ point of view | • Model 1: waste elimination  
• Model 2: partnering  
• Model 3: structuring the context | Industry-wide Interviews | UK                            |
| 4   | Johansen and Walter (2007) | Not mentioned               | To investigate the application of, and to understand lean concepts and techniques | The conceptual model investigates eight areas in an organisation, including design, procurement, planning/control, supply, installation, collaboration, management, and behaviour | Questionnaire | Germany                        |
| 5   | Koskela (1992, 2000) | Three views of construction production | To build theoretical foundation for lean construction | • Transformation model  
• Flow model  
• Value generation model | Model development Case studies | Nordic countries |
<table>
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</thead>
<tbody>
<tr>
<td>6/668</td>
<td>Paez et al. (2005)</td>
<td>Lean construction as socio-technical design</td>
<td>To reveal that both lean manufacturing and lean construction are rooted in common human and technical elements</td>
<td>• Human system and technical subsystem</td>
<td>Model development</td>
<td>Not mentioned</td>
</tr>
</tbody>
</table>
| 7/668 | Salem, Solomon, Genaidy, and Minkarah (2006) | Lean assessment framework | To evaluate the implementation of each lean tool within the proposed framework | Six lean tools are identified in four scopes, namely:  
• Flow variability (i.e. last planner)  
• Process variability (i.e. fail safe for quality)  
• Transparency (i.e. 5S)  
• Continuous improvement (i.e. huddle meeting) | Case study (one) | USA |
| 8/668 | Santos (1999) | Application of Flow model in construction industry | To develop the heuristic implementation approaches of the flow model | Influenced by Koskela’s (1992) work, the model developed by Santos (1999) contains four principles:  
• Reduction of process cycle time  
• Reduction of variability  
• Increase of transparency  
• Continuous improvement | Case studies | The UK and Brazil |
As shown in Table 1, there is no doubt that a majority of the above-mentioned frameworks provide answers to questions such as ‘what constitutes lean construction’ (Diekmann et al., 2004; Salem et al., 2006). Some offer good practical references, which can be used to assess the awareness of lean construction among the construction practitioners (Santos, 1999; Johansen & Walter, 2007), or the status quo of their lean construction implementation (Diekmann et al., 2004; Salem et al., 2006). However, the comparisons also highlight the fact that the development of lean construction is uneven, because it is evident that ‘process-focus’ thinking is still the dominant theme among all the lean construction frameworks examined. This is because with the shop floor-focused mindset, implementing lean tools can result in immediate improvements, but it would never come close to the benefits arising from implementation of the whole system (Liker, 2004). In addition, only three of the frameworks selected (Diekmann et al., 2004; Paez et al., 2004; Green & May, 2005) consider the soft side of the lean approach, while the remaining do not consider human resource management (HRM) implications at all. The knowledge gap could be fulfilled if the lean construction paradigm were to move forward to shift its present focus onto the issues of human part (the human resources), which is the soft aspect of lean.

Proposing the Toyota Way model for the construction industry

The above comparisons revealed various shortcomings of lean construction frameworks. Hence, a more comprehensive framework for lean construction is called for to bridge such gaps. In this section, as a starting point, the Toyota Way model is proposed to solve some of the inherent limitations of the frameworks that are currently available in the lean construction domain. The Toyota Way model was briefly mentioned earlier: to reiterate, it comprises 14 principles within four layers. Each layer can be viewed as an individual model. The first task with respect to the Toyota Way practices is to operationalise each principle into actionable attributes within the construction industry. Under the Toyota Way model, the underlying principles should have positive implications for the construction industry. In theory, the model equally values the ‘process’ and ‘people’ aspects, among others. This would be an appropriate choice, since most lean construction frameworks have a strong technical focus, and with limited attention to the human dimensions.

Philosophy model

Toyota’s management encourages managers to base their decisions on a well-articulated long-term vision – even if those decisions contradict what might be financially beneficial in the short term (Liker, 2004). Further, efforts are made to evaluate this principle into four sub-elements: ‘constant purpose’, ‘customer focus’, ‘self-reliance and responsibility’, and ‘long-term perspective’ (see Table 2). Of the four identified elements, customer focus has been repeatedly discussed in the construction context (Diekmann et al., 2004; Jørgensen & Emmitt, 2008). It starts with defining value from the viewpoint of the customer (Diekmann et al., 2004) and also includes the person in another department or next in line (Yusuf, Gunasekaran, & Dan, 2007). This can be applied to all parties (contractor, subcontractors, suppliers, etc.) in construction and is expected to facilitate every level in the construction firm to be prepared to add value for the customer. Moreover, it is also important for construction firms to be able to respond rapidly to changing client needs as this is common in the construction industry. Furthermore, Table 2 highlights a checklist of practices derived from this principle that are fit for implementation in the construction industry.


**Process model**

This layer is regarded as a ‘tactical’ or ‘operational’ aspect of the Toyota Way model (Liker, 2004). It contains seven underlying principles, i.e. one-piece flow, level out the workload, use reliable technology, etc. Most attributes or activities identified in this layer will be happening on a day-to-day or week-to-week basis in the shop floor setting. By practicing these, companies are expected to achieve significant improvements in their operations, from improved productivity, enhanced quality, to a more accurate understanding of production waste or ‘muda’ (Liker, 2004). Efforts have been made to operationalise these principles in the construction context (see Table 3) by considering the differences between manufacturing and construction.

**P2: One-piece flow**

To achieve one-piece flow, the following aspects should be considered (Monden, 1998; Liker, 2004): *takt* time, use a flow-oriented layout (U shape), a pull system, standardised work, etc. This implies that this principle (P2) is interrelated with some other process-focused principles, i.e. the pull system (P3) and standardised work (P6). Given the fact that one construction project contains ‘sub-assemblies’ which have different work contents, durations, etc., Ballard and Howell (1998) outlined that how some of the mentioned manufacturing terms (i.e. *takt* time, U-shape, etc.) might not be applicable in construction.

Generally, achieving one-piece flow pertains to eliminating waste from the process. Many positive examples can be found within the literature of waste elimination in construction industry (Diekmann et al., 2004; Sowards, 2007). In Table 3, a number of applicable practices are shown, related to process, material, manpower, and workflow. It contains various waste elimination practices, but also considers that achieving an interrupted work flow by synchronising and aligning the rate and sequence of work done in workflow by each trade, creating adequate working areas, balancing crew members, etc.

**P3: Pull ‘kanban’ system**

Liker (2004) highlighted that in the Toyota Way, the pull system means the ideal state of JIT manufacturing: giving the customers what they want, when they want it, and in the

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**Table 2. Implementation guidelines for sub-principles of the Toyota Way ‘Philosophy’ model in construction.**

<table>
<thead>
<tr>
<th>Sub-principle</th>
<th>Implementation guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1: Management based on the long-term philosophy</td>
<td>&lt;ul&gt;• Constant purpose&lt;br&gt;  Sustain a constant purpose, which aims to generate value towards employees, society, and customers&lt;/ul&gt; &lt;ul&gt;• Long-term perspective&lt;br&gt;  Develop a long-term vision and make a plan to achieve it&lt;/ul&gt; &lt;ul&gt;• Self-reliance and responsibility&lt;br&gt;  Be self-reliant on core technology, and promote research and design for strong backup&lt;br&gt;  Be responsible for what has been promised to employees, society, and clients&lt;/ul&gt;</td>
</tr>
</tbody>
</table>
Table 3. Implementation guidelines for sub-principles of the Toyota Way ‘Process’ model in construction.

<table>
<thead>
<tr>
<th>Sub-principles</th>
<th>Implementation guidelines</th>
</tr>
</thead>
</table>
| **P2. One-piece flow**  
  - Waste elimination |  
  - Process optimisation  
  - Efficient logistics plan  
  - Material JIT delivery  
  - Minimise double handling and workers and equipment movement  
  - Reduce defects  
  - Other forms of waste elimination using the remaining principles in this category  
  - Uninterrupted workflow (i.e. *takt* time, space utilisation, etc.) |  
  - Synchronise the sequence and rate of material, components delivery with the sequence and rate of construction, installation, etc.  
  - Ensure adequate working areas are always available  
  - Balance crew members |
| **P3. Use pull system**  
  - Pull from customer end (including both internal and external customers)  
  - Use *kanban* tool  
  - Pull planning methods |  
  - Schedule material JIT delivery directly to the point of use  
  - Using simple devices or tools to indicate the re-ordering level  
  - Pull tasks through the schedule by determining what each sub-contractor/trade needs completed before the tasks commence  
  - Ensure that tasks only commence when preceding tasks are completely completed and all necessary resources are available |
| **P4. Level out the workload (**Heijunka**)**  
  - Level out the workload |  
  - Use of the LPS: four levels of plans  
  - Seek commitments from foremen or subcontractors to perform a given work task by a specified time  
  - Huddle meeting: to remove constraints that would affect the evenness of workload |
| **P5. Build-in quality**  
  - Stop and fix the problem  
  - Use of error proofing  
  - Employee involvement and empowerment |  
  - An in-process inspection plan is in place to prevent rework  
  - Reveal and solve problems at the source as they occur  
  - Designers are encouraged to use standard design elements and feature  
  - Suppliers are encouraged to make or modify products to facilitate error proofing  
  - Construction firms are encouraged to standardise process  
  - Cultivate the culture of ‘build-in quality’ by active employee involvement and empowerment  
  - Motivate employees to take responsibility for quality |
| **P6. Standardised work**  
  - Standardised operation procedure (SOP)  
  - Continuously improve standardisation |  
  - Use of clear, easily accessed, and up-to-date written SOP on certain processes (i.e. define the content, sequence, terms, and expected results)  
  - Encourage engineers, foremen, and even workers to make contribution to the new standards of current process |

(Continued)
amount they want. It is comforting to see that application of the pull system has already made its first appearance in the construction industry. Among others, Low and Mok (1999), Khalfan et al. (2008), and Arbulu, Ballard, and Harper (2003) have all confirmed the use of the pull concept in the construction sector to manage the replenishment of certain types of made-to-stock products from preferred suppliers to the site. With respect to the kanban tool, Low and Choong (2001) suggested that each empty truck that returned to the plants was like a kanban device. Furthermore, pull planning methods also adopt the pull philosophy, which means that a task will only be triggered when the preceding tasks are 100% complete and all the necessary resources are available.

**P4: Heijunka (level out the workload)**

Heijunka, or levelling out the workload, is perhaps the hardest to implement in the construction industry. Compared to manufacturing, the key difference is that the elements of construction require different amount of time. It is worth mentioning that there are a number of points of commonality between the last planner system and the principle of heijunka. Both aim to achieve a stable and reliable workflow. The last planner system is well documented in the literature (Ballard, 2000) and sometimes it has been used to represent lean construction (Green & May, 2005). Apart from adopting the four levels of plans (Ballard, 2000), including master plan, phase plan, looking-ahead plan, and weekly plan, one of the important issues here is that the foreman needs to be empowered to make his own commitment on what day-to-day or week-to-week tasks he can actually deliver in a given time. By doing this, foremen can have a sense of ownership of the project programme.

**P5: Build-in quality (jidoka)**

Jidoka is a Japanese concept, referring to the idea of never letting a defect pass into the next station, and of freeing people from machines (Liker, 2004). The idea is to ‘build
quality in’ the process, in which all operatives are allowed to stop the entire production line, whenever there is a problem or a defective product is detected. Construction firms may be aware of a similar idea, because it is in line with the overarching goal of TQM, which has been extensively discussed in construction (Love, Li, Irani, & Faniran, 2000; Low & Teo, 2004; Delgado-Hernandez & Aspinwall, 2008). However, the prevalent culture is still characterised as ‘inspect quality in’. To implement the jidoka concept in construction, not only would construction firms be encouraged to use error-proof alike devices, but it would also be more important to establish ‘build-in quality’ as part of the quality culture. Diekmann et al. (2004) showed that the use of error-proof devices can be facilitated through endeavours from all relevant parties, including:

- designers use standard design elements and features;
- suppliers can be alert for marked or modified products;
- construction firms can standardise processes to facilitate error proofing.

Furthermore, with respect to establishing the ‘build-in’ quality culture, this may involve training, empowerment, etc., to change the mindset and to ensure that the employees are willing to take responsibility for quality.

**P6: Standardised work**

Standardisation is the essence of lean methods and forms the basis of continuous improvement. Standardised process does not only involve variation minimisation, but also kaizen activity to be conducted and continuous improvement to be made (Imai, 1986; Liker, 2004). From a construction process perspective, the applications of manufacturing practices like preassembly and prefabrication is a common theme in the recommendation (Egan, 1998). Yet this largely depends on the client’s choice. Within the firm, workers need to follow each detailed standardised procedure that touches every aspect of the firm. At the project level, construction firms need to standardise certain repetitive processes and establish best practice for quality, time, cost, safety practice, etc., so that workers can strictly follow the practice. One final good point of Toyota’s standardisation is that it enables the workers to be part of the process of designing and improving the current standards. In terms of construction, this means that the construction firms should provide the freedom to let the project team, including frontline workers, be creative and improve standards (e.g. construction methods of certain processes).

**P7: Visual management**

Visual management (VM) on the manufacturing shop floor aims to make the process transparent, visualised, and thus easily allow detection of abnormality or defects. It involves various visual control tools, as well as the practices of 5S. The 5S were developed in Japan, and came to be known as part of the lean thinking movement in the 1990s (Kobayashi, Fisher, & Gapp, 2008). The name 5S comes from the first letters of five Japanese terms: Seiri, Seiton, Seiso, Siketsu, and Shitsuke. When translated to English, they mean sorting, simplifying, sweeping, standardising, and self-discipline, respectively. The application of VM in construction has been discussed by Tezel, Koskela, and Tzortzopoulos (2010), in which various cases and practices are presented. In the construction industry, apart from health and safety banners and listings that are enforced by the authorities, alternative visual control tools are also worth applying. For example, this can start with
basic housekeeping, to make the site clean and tidy, as a part of 5S efforts. Incrementally, it can move to standardising (the fourth S), as well as to introduce self-discipline (the fifth S), in order to maintain the efforts put into the first three S’s.

**P8: Use of reliable technology**

Most likely, every organisation wants to be on the cutting edge of technology. This is also true in the construction industry, which is still very labour intensive. Building professionals have attempted various new technologies, in the hope of improving performance, in an industry which is known for its slow rate of adopting new technology. Yet most of the time, it ends up creating unrealistic or unsustainable expectations. Liker (2004) suggests a view of adoption of new technology in the Toyota Way thinking that includes principles such as:

1. new technology must be thoroughly tested and proven to be reliable;
2. new technology must support continuous flow in the operation (process);
3. new technology must help employees perform better (people).

The important implication of the above for the construction industry is obvious. It also provides valid justification for new technology adoption when cost is considered.

**People and partner model**

Liker (2004) mentioned that most companies dabble at the process level of the Toyota Way model. One level up, the People and Partner layer of the Toyota Way model, concerns how Toyota’s strategy relates to its people (i.e. leaders, employees) and partners. From a construction perspective, the framework (see Table 4) clearly states what practices need to be developed and encouraged among different stakeholders. It is worth noting that without good leadership, commitment, exceptional employee ability, long-term relationships with partners, and other human aspects from this category, the application of lean tools or activities will remain incomplete.

**P9: Leaders and leadership**

Driven by Toyota’s philosophy, that the culture must support the people doing the work, leaders must demonstrate a commitment to leading people, coaching them, inspiring them, and so on. Similar commitments are included in areas of quality, going and seeing the real facts in the actual workplace (*genchi genbutsu*), and so on. This translates to the construction context, such that leaders in construction firms (and at the project level) should have the long-term vision of knowing what to do, the knowledge of how to do it, and the ability to develop people so that they can understand and perform their job excellently. Take for example the most commonly seen leadership position in construction, the project manager, whose challenge is to understand the firm’s culture, vision, and ways of doing business. Additionally, project managers also need to be knowledgeable on the site, willing to practise *genchi genbutsu*, involving workers in improving process, and be able to develop their employees’ working ability.

**P10: People management**

The 10th principle pertains to a number of HRM elements that characterise the Japanese or Toyota Way. This includes hiring and selection, various training activities,
teamwork, and motivational strategies. In the literature of lean production, several researchers have highlighted work places with lean thinking, where the above-mentioned human resource practices are stressed (Olivella, Cuatrecasas, & Gavilan, 2008; Martínez-Jurado, Moyano-Fuentes, & Jerez-Gómez, 2013). Critiques of Green (2002) on lean construction concentrate on the absence of implications of HRM. This echoes belief of Liker (2004) that without adopting people and partner-related practice, the implementation of lean approaches cannot go further. It is also a timely warning for construction practitioners, that the majority of them are plagued with short-sighted behaviours in human resource investments. Hence, almost all the activities identified within this principle are worthwhile to be recommended for construction firms. For example, employee training is one of the key elements of lean practices, and takes various forms. Construction firms can evaluate the training needs for a start, and then carry out what is missing from among all the training forms recommended by this framework.

Table 4. Implementation guidelines for sub-principles of the Toyota Way People and partner model in construction.

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<thead>
<tr>
<th>Sub-principles</th>
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</table>
| P9. Leader and leadership | Management must commit to live and understand the company’s values  
* Leadership commitment |  
Leadership commitment  
Management must commit to live and understand the company’s values  
In-depth knowledge  
Leaders must have in-depth understanding of work (at the project level) and have problem-solving skills  
Support the people doing the work  
Leaders must be able to constantly provide solutions to their subordinates  
Coaching ability  
Project personnel are encouraged to provide training sessions to help employees, suppliers, and customers |
| P10. Develop exceptional people and teams | Meticulous screening system (i.e. vocational or technical training required) for recruiting excellent candidates  
People selection |  
People selection  
Meticulous screening system (i.e. vocational or technical training required) for recruiting excellent candidates  
Training |  
Training  
Provide training at all levels and keep skills up to date, including:  
(1) pre-job training  
(2) on-the-job training (OJT)  
(3) off-job training  
(4) multi-skills training  
Work teams |  
Work teams  
Employees coordinate their work with others to complete the whole task.  
Motivation |  
Motivation  
Rewards for constructive ideas, feedback, and opinions that result in improvement |
| P11. Partner relations | Establish long-term and stable relationship  
Length and stability relationship |  
Length and stability relationship  
Achieve small base of suppliers  
Challenge |  
Challenge  
Respect working partners by setting challenging goals, objectives, etc.  
Collaboration |  
Collaboration  
Work with suppliers, subcontractors, and owners to improve project effectiveness  
Encourage suppliers'/subcontractors’ early involvement in the design stage  
Communication and information exchange |  
Communication and information exchange  
Timely and transparent information exchange and problem solving through suggestions |
P11: Partner relationships

Toyota has carefully adopted a holistic approach to its suppliers, among other working partners, realising that they are an extension of the Toyota enterprise that should be encouraged, nurtured, and supported (Liker, 2004). To support this partner relationship, a number of elements are indentified, including establishment of stable and long-term relationship, mutual respect, collaborations, and information exchange (see Table 4). In a similar vein, efforts have been made to discuss some similar constructs to foster long-term, cooperative relationship based on mutual trust between two parties in the construction context. These include optimised supplier base (Bemelmans, Voordijk, Vos, & Buter, 2011), cooperative goals (Wong, 1999), and relationships (Green & May, 2005) that is able to facilitate the integration of joint efforts in operational process, problem solving, and continuous improvement (Evans & Jukes, 2000; Bemelmans et al., 2011).

Problem-solving model

The final layer of the Toyota Way model, the problem-solving model has been seen to be critical in solving problems and sustaining improvements in performance. It starts with leaders’ commitment to genchi genbutsu when a problem is discovered. It is emphasised that decision-making is not an easy process, and can be more demanding than simply accepting authoritative decisions from the top down. The final element (P14) to be addressed in the quest to improve the company (project) performance relates to continuous improvement (kaizen). Table 5 outlines a number of best practices within this category that construction firms can implement.

Table 5. Implementation guidelines for sub-principles of the Toyota Way problem-solving model in construction.

<table>
<thead>
<tr>
<th>Sub-principles</th>
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<tbody>
<tr>
<td>P12. Genchi genbutsu</td>
<td></td>
</tr>
<tr>
<td>• Go and see for yourself</td>
<td></td>
</tr>
<tr>
<td>• Based on personally verified data</td>
<td></td>
</tr>
<tr>
<td>P13. Decision-making and quick implementation</td>
<td></td>
</tr>
<tr>
<td>• 5 ‘Whys’</td>
<td></td>
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<td>• Alternative solutions</td>
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<td>• Practice of consensus</td>
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<td>P14. Reflection (Hansei) and continuous improvement (Kaizen)</td>
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<td>• Attitude towards problems</td>
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<td>• Kaizen activities</td>
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<td>• Reflection</td>
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<td>• Policy deployment</td>
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Leaders must be committed to genchi genbutsu
Leaders must possess the skills to analyse and thoroughly understand the situation
Think and speak based on personally verified data (i.e. through direct report)
Ask questions multiple times until the root causes surface
Encourage workers to propose alternative solutions from the bottom up
Encourage workers to express their ideas, suggestions, and disagreements, and thus to achieve consensus
Management should see problems as opportunities for improvement
Conduct kaizen activities for better improvement
Reflection on strengths and weaknesses of the current process, project, etc.
Project manager sets clear and achievable goals that all the team member are working for
P12: Genchi genbutsu

*Genchi genbutsu* is a critical element of the Toyota culture, interpreted to mean ‘going to the actual place to see the actual situation for thorough understanding’. Not only does it show the leaders’ determination to solve problems, but most importantly, it supports the expectation that leaders should be reliable technical sources and decision-makers. Compared to the repetitiveness of assembly line in a manufacturing setting, construction projects are far more dynamic and unpredictable, i.e. vulnerable to the environment. It is commonly known that both foreseen and unforeseen problems are associated with construction processes. To avoid unnecessary trouble shooting, it is more meaningful for project leaders to go and grasp the actual situation and rely on the valid data provided, not simply their experience.

P13: Decision-making

Decision-making appears to be associated with Japanese characteristics. In countries of East Asia, such as Japan, the culture tends to be collective, which impacts decision-making processes to be more consensus-based. Arguably, construction is sometimes chaotic and sufficient time is often lacking, so this bottom-up time consuming decision-making process might not be a useful tool. Yet one thing construction firms can take away from this approach is that the focus should be on the decision-making process, rather than on jumping to a rushed decision. The above discussion could suggest that in a project, where problems constantly occur, the consensus can be adopted for certain types of decision-making. The success of such an approach will be dependent on the active involvement of front-line workers, foremen, and other relevant parties. To reiterate, they are the ones doing most of the value-added work and hence need to be heard. Moreover, participation can be facilitated through the use of collective decision-making techniques, such as 5 Whys, until the root causes are determined.

P14: Kaizen and continuous improvement

The final principle is perhaps the most important in the Toyota Way problem-solving model. One of the best ways to get started is to objectively and humbly exercise reflection and evaluate the organisation (or a project) in terms of points of potential improvement. This is then followed by carrying out diligent continuous improvement activities. All of this only becomes possible when the company culture allows the active participation of people, fosters a non-blaming culture, a culture that sees/treats problems as opportunities, etc. These provide ample lessons for construction firms. First, the industry needs to shift to a culture that allows problems to be exposed. Instead of blaming employees who expose the problems, the employees should be motivated to collectively come up with counter-measures for improvement. Secondly, reflection is also important on the site, as there are always plenty of problems and concerns, such as delays in the planned schedule, recurring problems, issues of health and safety, etc.

Discussion

Implementation

As outlined by Wong and Aspinwall (2004), the first element to be considered when developing an implementation is to employ a clear structure to depict the tasks that need to be undertaken. As previously stated, the Toyota Way model fits this purpose, as it determines
how processes should be organised, how people should be cultivated, and how in turn the process should be improved and how the company’s culture is established as a supporting factor. Specifically, the pyramidal form of the Toyota Way model suggests that its cornerstone is not a large set of lean tools for process improvement, but rather the firm’s long-term philosophy. It is particularly true that the rest of the layers of the Toyota Way model are associated with, and supported by, the long-term philosophy. For example, build-in quality (P5) in the ‘Process’ model, on one hand, requires the long-term commitment of employees. This is so because only committed frontline operatives can take the responsibility and pull the cord (andon) in a timely manner to reveal quality problems. On the other hand, that workers are capable of doing so due to the fact that the company (Toyota) has generously and continuously provided them with training, not only in the area of quality control, but also to develop them with sophisticated problem solving skills. Moreover, with respect to relationship with partners, Toyota is known as a tough customer, but is credited with its willingness to share the benefits with long-term relationship partners with whom it has mutual trust. Additionally, the problem-solving principles, as well as kaizen activities, explained in themselves the long-term element in the overall approach. All these point to the fact that, for construction firms to embark on the lean journey, commitment to a ‘long-term’ philosophy might not be an easy option – but at least construction firms can set the right values and objectives, hold their purpose constant, and make commitments to employees, society, and project(s) on a long-term perspective. It is worth mentioning that these prerequisites are normally absent from lean production and lean construction principles, as they sound like common sense but would be hard to implement. Hence, it remains obvious, then, that construction practitioners should make an effort in developing and nurturing these sub-elements listed in the long-term philosophy.

Having embraced the long-term philosophy into company’s culture, the next thing that should be covered is its processes and activities that take place at the project level. Examples of Toyota Way process principles including waste elimination, pull system, standardisation, visual management, build-in quality and others have been elaborated earlier. The most important lesson is that in the ‘process’ level, the implementation needs to be carried out in a more holistic manner, given that several principles are interconnected. Similar concerns have been voiced by Picchi and Granja (2004), who have pointed out that the current implementation of lean concepts and tools are implemented in isolation, lacking the full perspective.

Moreover, another important consideration for Toyota Way implementation framework in the construction context is to provide a balanced view between a social (human resource aspects of lean) and technical approach (i.e. lean tools). If this issue is not adequately addressed, there may be an inherent tendency for practitioners to take an overly narrow approach towards implementing Toyota Way (Liker, 2004; Paez et al., 2004; Low & Gao, 2011). This is consistent with the early observations made in the examination of various frameworks of lean construction, a majority of which lack consideration of HRM. Therefore, it is strongly advocated that the implementation of Toyota Way in the construction industry should embrace the HRM elements, such as servant leadership, management commitment, training, empowerment, etc. That makes the Toyota Way practices unique among other implementation frameworks of lean construction. In fact, similar concerns have been voiced by Dahlgaard-Park et al. (2013) in terms of implementing TQM, which, as a holistic managerial system, also contains tools and techniques as well as elements of HRM and strategic management.
When it comes to the last model of the Toyota Way – the problem-solving and kaizen activities – the construction practitioners might also find its approach to be frustratingly difficult. Most believe that construction work does not lend itself to kaizen, because unlike assembly line work, it is project based and has fewer repetitive standardised processes. However, the positive side is that construction is plagued with numerous quality, cost, and delay problems, which can in fact benefit from the principle of kaizen. To distinguish this from other frameworks, there is a need to connect to the culture element. Normally, the Toyota Way calls for firms not to be limited to adopting specific lean techniques to solve a targeted problem within one specific unit or department. Rather, it calls the firms to establish a culture or a system oriented towards problem-solving. From a construction process perspective, the Toyota Way problem-solving principles are useful in guiding them from understanding the problem to the point where problems are solved with Plan-Do-Check-Act thinking.

Implications for TQM
Interestingly, the discussion of the application of several principles of the Toyota Way to construction can be found in the individual references. The applications of some principles appear to be closely connected with a broader range of other management techniques. For example, customer focus philosophy (P1), build-in quality (P5), a range of practices pertaining to the soft aspect of the Toyota Way (i.e. P9 and P10), and the kaizen principle (P14) all share common ground with TQM. Not surprisingly, in line with the assertion made by Dahlgaard-Park (2011), much of the literature fails to acknowledge that the roots of lean or Toyota Way actually lie in quality evolution and TQM. With respect to implementation, Dahlgaard and Dahlgaard-Park (2006) advocated that lean and six sigma quality should not be seen as alternatives to TQM, but rather as a collection of concepts and tools for supporting the overall principles and aims of TQM. On one hand, as argued by Gao, Low, Hwang, and Ofori (2012), implementing TQM could be an opportunity to better adopt lean construction in the Chinese construction industry, since TQM has laid a much-needed foundation and received a recognition in terms of implementation prior to lean. On the other hand, given that the Toyota Way principles appear to have some similarities with TQM principles, the interpretation of the Toyota Way model in the construction context can also facilitate the implementation of TQM.

Conclusions
This study complements to contribute in a way to map the complete picture of the implementation framework of Toyota Way in the context of construction. To reiterate, the proposed framework heavily relies on Toyota Way model (Liker, 2004), with views of lean production and lean construction practices. The Toyota Way model has been chosen as the template, because it embraces all the principles and operationalised attributes that enhance its comprehensiveness. The main contribution of this article is to operationalise the constructs of Toyota Way in the construction context. Although construction is genuinely different from manufacturing, it is clear that Toyota Way principles can be applied in some forms, and that similar significant benefits can be expected to improve the current status of the construction industry. In addition, the review of the existing frameworks of lean construction reveals that the proposed framework (the Toyota Way) differs considerably in many areas. It was found that current lean construction frameworks focus specifically, although not exclusively, on the lean practices (tools and techniques) on the
shop floor. This echoes the concerns expressed Green (2002) that a majority of the lean construction frameworks do not take HRM into account. Hence, this article cautions construction practitioners by addressing the importance of complementing the operational factor and human factors of the lean approach in the construction workplace, namely by thinking about implementing a management model or philosophy in a holistic manner. Given that this study has undertaken a challenging task in taking Toyota Way as its implementation framework, it may also suffer from the following drawbacks: first, there are a substantial number of lean practices derived from the 14 Toyota Way principles. Practically, it is not likely for construction firms to adopt such a volume of knowledge related to lean concepts and principles at the same time. Some of the elements might be skipped. Second, some practices or activities are really unique to repetitive processes, and are thus challenging to implement. Therefore, future research is needed to test and validate the framework using empirical data.

References


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