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An Exploration of Lean and BIM synergies with a focus on SMEs in Construction

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Small and Medium Enterprises (SME) account for 99.7% of the Irish Construction Industry and contribute to 68% of all employment in the sector. These organisations now find themselves facing the challenge of returning to productive business post the Covid 19 shutdown. More than ever, SMEs must modernise and adapt their business models to embrace new ways of working, such as Lean Construction and Building Information Modelling (BIM), in the absence of clear business incentives. It has proved difficult to persuade SMEs to change their ways of working due to limited finances, internal resources and above all, the cultural shift required to embrace new ways of working. The vast bulk of Irish construction SMEs are accustomed to working in a sector that produces low product quality, budget overruns, and substantial construction waste. When partnered with lean construction, BIM can address many of these issues, as the two processes can work together to target and eliminate waste while streamlining the value stream. The primary goals of lean construction are to maximise value and minimise waste. Therefore, BIM can be seen as a lean tool that helps eliminate waste and, at the same time, increases business opportunities and promotes sustainability. This paper will explore the synergies between Lean and BIM in the context of construction SMEs through a literature review. The findings will address a number of barriers to entry for SMEs, focusing on how digital technologies, such as BIM can complement lean construction in targeting major types of wastes. Some of the barriers identified include financial and legal concerns, lack of implementation strategies/guides, knowledge retainment, training impendiments, software and hardware restrictions, as well as employee resistance.

Keywords –LEAN, BIM, SYNERGIES, SMEs

I INTRODUCTION

Small and Medium Enterprises (SME) account for 99.7% of the Irish Construction Industry and contribute to 68% of all employment. These organisations now find themselves facing the challenge of returning to productivity post the Covid 19 shutdown. The economic crisis has put many SMEs in "survival" mode, forcing them to prioritise short-term work over long-term investments [1].

Following the COVID-19 outbreak, it is becoming ever more apparent that digital technologies, such as Building Information Modelling (BIM), will play an increasing role in the recovery and the new normal of the sector. For these digital technologies to be embraced, construction SMEs must overcome several challenges, such as the difficulty of envisioning the potential digitised futures of their business, low digital maturity-level of the employees and the employers, and most importantly, the inherently limited human resources. [2]. As a result, SMEs suffer from many problems, such as low product quality and working

efficiency, budget overruns, and substantial construction waste [3].

This paper will explore Lean and BIM synergies with a focus on SMEs. The overarching aim of this research is to establish a lean digital construction innovation framework that SMEs can use to address the critical actions to transition from traditional to digital practices. This paper represents the initial stage of this framework and will provide an exploration on the barriers that SME's encounter and how BIM and Lean synergies can potentially address some of these concerns. Further papers will apply these findings in establishing a lean digital construction innovation framework.

II BIM AND LEAN

BIM is a collaborative process in which all parties involved in a project use three-dimensional design applications. BIM enhances the current communication process, provides a collaborative platform, and supports interoperability between the different business domains [4]. BIM can be applied through the complete lifecycle of a project to evaluate the constructability of designs, visualise construction schedules, provide accurate cost estimates and multiple analyses enabling energy and structural performance predictions that can be applied to compare design alternatives [5-6]. BIM can enable the industry to leverage more value from new software tools and technologies [7]. This can be achieved through the BIM model which can provide accurate information about material resources and subcontractor scheduling. This information can be used to minimise waste by reducing the need for on-site material inventories. The BIM model can also help evaluate the building's function, maintain information and design model integrity, and automate reports [8].

The effective implementation of BIM requires that changes need to be made to almost every aspect of an organisation. For example, for an enterprise to implement BIM, it will require developing BIM guidelines and strategies; otherwise, it may lead to further waste [9].

Furthermore, for an innovation such as BIM to be successful within SMEs, they will need to address several barriers to entry. Barries such as access to finance, cultural change, inadequate communication and information exchange levels, adopting technology, resources, construction project coordination, and bureaucracy [10]. These are all areas that lean construction aims to reduce or eliminate.

The main objectives of lean are to maximise value and at the same time minimise waste [11]. Therefore, the application of lean construction philosophies in SMEs can increase productivity, guarantee better compliance with deadlines, reduce costs associated with waste, and improve quality [12-13].

Lean Construction concentrates on flow and value generation. The flow dimension investigates the tasks' interdependency through the whole project process and reduces waste as a managerial objective. The value generation focuses on customer satisfaction, including internal customers, aiming to improve project participants' integration and information flow [14]. Lean can be attained by combining the following practices, including just-in-time, total quality management, total productive maintenance, continuous improvement, design for manufacturing and assembly, supplier management, and effective human resource management [15].

Lean Construction techniques include daily huddle meetings, last planner system, 5S, first-run studies, just-in-time, pull approach (Kanban), error proofing or fail-saving for quality and safety, value stream mapping, increased visualisation, target value design, partnering, six sigma, total productive maintenance, total quality management and concurrent engineering [16].

BIM and lean construction have been researched independently over the last number of years. However, limited research investigates the positive outcome of combining these two principles and the synergies between them [17]. Although lean construction and BIM have emerged as separate domains in construction IT research, substantial synergies have led to both methods' combined use and implementation [18].

III BIM AND LEAN SYNERGIES

BIM facilitates lean measures through design to construction to occupancy and at the same time contributes directly to lean goals of waste reduction, improved flow, reduction in overall time, improved quality by utilising clash detection, visualisation, and collaborative planning [19-21]. Some of the synergies recorded between both processes include

- Eliminate waste – using the BIM Model to perform suitable design and performance simulation for energy-efficient solutions.
- Amplify learning – positive iteration and client involvement, resulting from BIM using visualisation solutions enabling design and collaborative analysis.
- Decide as late as possible – options-based approach, which is possible with the visualisations permitted through BIM to check for process conflicts.
- Deliver as fast as possible – rapid value flow and iteration of needs, which is again possible with BIM via automated generation of changes and materials schedules.
- Empower the team – facilitate team commitment and rapid feedback through BIM via accurate and complete information sharing.
- Build integrity – conceptual and perceived usefulness over time via BIM through detailed schedules of tasks and materials delivery times.
- See the whole – avoid sub-optimisation via collaboration and concurrent projects by different stakeholders or teams [22].

Lean construction techniques require careful coordination between the general contractor and subcontractors to ensure that work can be performed when the appropriate resources are available on-site. BIM can assist with this as the model provides an accurate model of the design and the material resources required for each segment of the work. In addition, it gives the basis for improved planning and scheduling of subcontractors and helps to ensure the just-in-time arrival of people, equipment, and materials [23].

BIM, in partnership with Augmented and Virtual Reality, can empower Lean Construction Management. A recent pilot project found that Microsoft HoloLens and a webcam can simulate construction progress measurement in real-time. The results showed an improvement in key performance indicators, such as construction time, less time on-site, improved quality, and sustainability by minimising wasted materials [24].

According to Sacks et al., there are 56 synergies between BIM and lean construction. The developed matrix can be seen as an exemplar of the interactions between new information technologies and the production systems they serve [25]. A survey of experimental and practical literature found that 48 of the 56 interactions were beneficial, improving the flow of information and materials. Sacks et al. also developed a prototype BIM-based management information system to support a lean workflow called KanBIM. This system enabled visualisation of the process and the product, and in experiments, a reduction of wasted time spent looking for work was observed.

Other matrices developed include Leite (2012), who presented the benefits of implementing the Last Planner System and BIM, and Clemente and Cachadinha (2013), who applied a BIM-lean matrix approach and found the method improved mechanical, electrical, and plumbing MEP installation works and subcontractor work sequencing. Despite these matrices, there is still a need to clearly evaluate lean principles realised with BIM implementation during the construction phase in a real-world project [26].

For BIM and Lean to be successful, a number of barriers must be addressed, including legal, attitude and market, education, knowledge and learning, technical and software financing issues [27]. There is limited research that has measured the quantitative impact of BIM in improving flow in construction [25]. There is a disconnect between current studies and current practices where BIM-Lean approaches are urgently needed to be integrated with other digital technologies [28]. Increasing BIM and Lean Construction adoption among SMEs is key for achieving the construction industry's transformation [29].

IV BIM AND LEAN FOR SMES

Although Construction SMEs have limited access to investment capital and operate under resource constraints, they are better positioned to innovate than larger firms. SMEs ' flexibility, simple organisational structure, and speed in decision-making are the essential factors that allow them to innovate [30]. SMEs can generate, develop and deliver significant technical innovations due to the level of control that a manager has over decision making. BIM for SMEs has a positive impact over time on project and labour cost [10]. BIM can assist with the lean design process, improved information management, design quality, efficiency, enhanced sub-trades integration, and rework reduction [31].

V BARRIERS

However, there is a lack of focus on BIM implementation and adoption in SMEs despite their contribution to economic growth. This lack occurs due partially to a shortage of experienced staff members and limited technical capacity [32]. The most common

barriers are process/people-related and are often the severest for the SMEs. Obstacles such as lack of implementation strategies/guides, lack of clients' demand for BIM, shortage of experts, lack of awareness of the stakeholders, and resistance to change are the most severe for SMEs [31].

Leadership and management strategies, financial capability, employee expertise and skills, and organisational culture are the critical factors that enable SMEs to achieve a successful Lean implementation [32]. In addition, the application of Lean Construction tools for SMEs can increase productivity, guarantee better compliance with deadlines, reduce costs, and increase Quality [12].

One of the key inhibitors related to SMEs and lean is involving suppliers in Lean practices. Other barriers include deficient processes and quality control systems, the transition of current operations or production systems to a Lean system [33]. Further barriers involve control of materials stored at the site, the waste of raw materials, and the lack of management on the productivity of employees and contractors [12].

Given that SMEs struggle to incorporate either Lean or BIM individually, there are significant barriers to adapting both in unison despite the apparent benefits. Research in the domain of BIM and Lean for SMEs is scarce, with the wholesale uptake problematic. Examples of the combined implementation of Lean Construction and BIM at SMEs are virtually non-existent [29]. The research to be conducted over the life of this project will address some of these gaps.

VI CONCLUSIONS

The Economic analysis of productivity in the Irish construction sector Report has called for public contracts to support, value, and reward innovation through BIM, ISO 19650, Lean processes, and Modern Methods of Construction [34]. This recommendation has formed part of the Construction Sector Group's Building Innovation Report, which provided an overview of the Irish construction sector trends [35]. The Build Digital Project is one of the leading actions of this strategy to raise construction productivity levels. This strategy will, in part, focus on both BIM and Lean in the context of raising its profile within SMEs. As evident from the findings of this paper, the synergies gained from partnering both of these processes together can lead to increased productivity and opportunities for SMEs, which is one of the key targets of the Build Digital Project. As part of this study, the research will establish an essential supporting structure to introduce digital construction and lean processes into SMEs. The proposed innovation framework will address the key pillars of innovation required for SMEs by partnering with BIM and lean methodologies concerning the Irish Construction Sector.

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