Hunt, R.J., and Gonzalez, V.A. (2018). "Innovation in the New Zealand Construction Industry - Diffusion of the Last Planner System." In: *Proc. 26th Annual Conference of the International. Group for Lean Construction (IGLC), González, V.A. (ed.)*, Chennai, India, pp. 422–431. DOI: doi.org/10.24928/2018/0486. Available at: www.iglc.net.

INNOVATION IN THE NEW ZEALAND CONSTRUCTION INDUSTRY – DIFFUSION OF THE LAST PLANNER SYSTEM

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ABSTRACT

Globally, the development, diffusion, and adoption of innovation within the construction industry has been shown to occur at significantly slower rates than other industries. This is due to a number of complexities which define the construction industry itself. One particular innovation which appears to be gaining momentum globally as a new standard in construction management is Lean Construction, and in particular, the Last Planner System of production control. The purpose of, and aims of this paper is to determine whether the views of New Zealand construction industry stakeholders regarding innovation align with the literature; to gauge to which degree The Last Planner System has been diffused within the New Zealand industry, and to gain an insight into stakeholder perspectives of The Last Planner System as an innovation. The study covered a range of industry stakeholders consisting of consultants, contractors, and project owners. The results of these interviews suggest that the challenges of construction innovation within New Zealand are consistent with the global outlook; diffusion of The Last Planner System is in its early stages and there is much scepticism within the industry as to the likelihood of its widespread adoption.

KEYWORDS

Innovation, Last Planner System, New Zealand, Lean Construction, Perspective

INTRODUCTION

A strong and well performing construction industry is vital to the economy of every country, contributing between 6-10% of GDP for most OECD countries (Eriksson, 2013). Until recently the New Zealand (NZ) construction industry has been a poor performer in this measure when compared internationally, in 2010 the industry contributed just 4% to national GDP(DBH, 2012).

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Low productivity within the sector was identified as a major contributor to the industry's poor overall contribution to the national economy (DBH, 2012). So in 2011 the NZ government established "The Building and Construction Productivity Partnership" (Ministry of Business Innovation and Employment [MBIE], 2016) which had a clear goal of a 20% productivity increase within the industry by 2020. At the time it was estimated that such an increase could add an additional $3 billion to the economy per year (DBH, 2012).

Since 2010 the NZ construction industry has seen unprecedented growth, this has seen GDP contribution double from 4% to 8% between 2010 to 2015 (DBH, 2012 & PWC, 2016). The key drivers of growth have been the Christchurch rebuild and increasing population demand in Auckland leading to massive investment in public infrastructure, commercial and residential construction. In 2014 the Productivity Partnership was disbanded (MBIE, 2016), with no evidence to suggest the industry was on target to achieve the 20% increase in productivity. The issue of productivity was sidelined whilst the industry rides an unprecedented wave of economic growth driven by macroeconomic effects.

In its inaugural report, the Productivity Partnership identified the key driver to increase construction productivity to be the adoption of new innovation across the industry (DBH, 2012). A qualitative study into onsite construction productivity in NZ by Durdyev & Mbachu (2011) found that the main contributor to poor productivity was ineffective project management. The Last Planner System (LPS) is an innovation in construction project management created under the principles of Lean Construction. LPS is a production planning and control system used to reduce workflow variability and increase planning reliability (Ballard, 2000). LPS has been shown successful in lifting project success and boosting construction productivity.

This research has three aims; Firstly, to highlight the complexities of construction innovation and contextualise it within the NZ setting; secondly, to prove the assumption that knowledge levels of both Lean Construction and LPS in NZ are low; and thirdly to explore whether LPS, as an innovation, could be widely adopted within the NZ industry. There have been numerous articles published relating to the implementation of LPS, mainly undertaken to quantify the benefits of LPS or to resolve the difficulties associated with implementation. Little research has explored how LPS as an innovation has diffused and been adopted throughout an industry, in exploring this the project attempts to address a gap in the literature by relating the adoption of LPS to the body of research on construction innovation.

RESEARCH METHOD & LIMITATIONS

The research was separated into two phases, phase one being a literature review exploring innovation in the construction industry. Phase two employedthe qualitative research methods of a questionnaire and semi-structured interview to assess the research objectives. It was anticipated that there would be a general lack of knowledge relating to Lean Construction and LPS.As such, two sets of interview questions were prepared, one each for those familiar and unfamiliar with Lean Construction and LPS. In order to obtain relevant insight from those unfamiliar with Lean Construction and LPS a 20 minute presentation was prepared on the topic.

Three interviews were undertaken with contractors, three with consultants, and three with construction/land development investment groups. Interviewees were all directors or high level managers within their receptive organisations. The contractor and consultants interviewees came from businesses that would be categorised as tier 2 within the NZ market, having between 100 and 400 staff. This group was chosen as anecdotal evidence suggested that tier 1 contractors in NZ had started adopting Lean Construction, while its diffusion to the wider industry was largely unknown. The investment groups were chosen on the premise that they were large enough to have an influence as to the adoption of innovation within the projects they funded.

Limitations of the research included the use of a presentation to deliver information about Lean Construction and LPS to the participants, every participant stated the explanation was clear. However, the presentations contents,variance in delivery and participant understanding present limitations on views developed towards Lean Construction and LPS. A further limitation is the small sample size of the study and the wide range of industry stakeholders interviewed, however the qualitative research method employed meant that sample size was not as relevant as in quantitative research, where large and representative samples are used to generalise results (Palacios, Gonzalez& Alarcón2013).These qualitative methods were chosen as the research is also exploratory in nature, seeking to gain insight into a concept which has been given little academic attention within the NZ environment.

INNOVATION IN THE CONSTRUCTION INDUSTRY A COMPLEX AND TRADITIONAL INDUSTRY

The construction industry is vastly more complex than most (Aouad et al., 2010). At the institutional level the industry is fragmented, made up of many diverse professions, trades and organisations. Whilst at the operational level firms are almost exclusively project based, undertaking complex tasks (Bresnen, Goussevskaia & Swan 2005). The success of a project is dependent on the competencies of the collective group forming a "temporary multi organisation" (Davidson, 2013). These complexities inhibit the spread of innovative practises both within and between firms, impacting an organisation's ability to learn from experience and develop innovation from within (Gann 2001).

The introduction of innovation within a project adds a significant degree of risk to the implementing organisation. The unknown element of new knowledge within the project environment can have a ripple effect of secondary and tertiary impacts which are difficult to predict (Slaughter 2000). Generally the implementation of a new innovation within a project requires the cooperation and buy-in of all members of the "temporary multi organisation" to be successful (Blayse & Manley, 2004).

The nature of the product being built and the expectation of quality and durability does not always provide incubation for innovation(Pries & Janszen, 1995). Traditional forms of construction contracts and procurement are also inhibitors of innovation (Eriksson, 2013). Design-bid-build contracts do not encourage innovation due to a separation between design and construction, promoting minimal collaboration and adversarial relationships (Kumaraswamy & Dulaimi, 2001). Design-build contracts improve design out-

comes and reduce conflict, however as they are still procured based on the lowest price method there is little incentive for the contractor to outlay additional expense on innovative design (Eriksson, 2013).

DIFFICULTIES IN DEVELOPMENT

Construction firms (especially contractors) are constantly innovating at the local level, developing ingenious solutions to the variety of site specific problems encountered when delivering bespoke designs (Aouad et al., 2010). These local innovations may save time or money within a specific project, however firm development of these innovations into marketable product is rare. Innovation remains hidden due to lack of formal R&D within all but the largest firms (Aouad et al., 2010). The majority of NZ construction firms are incapable of direct investment into R&D expenditure due to their size, with over 95% of construction firms employing less than 19 people (MBIE, 2016. Small Business). This combined with minimal investment or incentive to innovate within government policy (Gann 2001) creates a void in the industry where formal R&D is left almost exclusively to large organisations and the manufacturers of construction products.

Universities, as knowledge creators play a major role in the development of innovation in the construction industry through basic and applied research (Aouad et al., 2010). In spite of this, the industry views universities as one of the least important sources of information ([DTI] 2006). In the UK there is seen to be many "systematic and cultural" differences between universities and the industry, limiting successful collaboration and development of construction innovation (Treasury, H. M. S. 2003). It is believed that improved platforms of engagement between the two sectors would improve the innovation landscape of the industry (Gann 2001).

DRIVERS OF INNOVATION

Clients are seen as being vital participants in driving innovation. They are able to exert pressure on stakeholders to improve project performance and demand higher standards. This acts as a catalyst for consultants and contractors to seek new strategies (Gann & Salter 2000). The more experienced and technically competent the client, the greater influence they can have over the innovation agenda of a project (Nam & Tatum, 1997).

Traditionally, manufacturers and suppliers of construction products have been viewed as the primary source of construction innovation (Pries & Janszen 1995). These firms operate in more stable and standardised environments than project based firms. The end result is sustained investment in internal R&D (Gann, 2001) which stimulates the innovation process (Anderson & Manseau 1999).

Industry relationships are significant to construction innovation as they are one of the key communication channels through which new knowledge is diffused throughout the industry (Dubois & Gadde, 2002). The wider and more diverse an individual's professional network, the greater exposure they have to new ideas. Increased attendance of diverse and high quality networking events linking academia and multiple sectors of the industry is seen to greatly enhance innovation diffusion (Abbott, Jeong & Allen 2006). At the project level, strong relationships between contractors and consultants can see innova-

tion flourish. If firms and individuals are able to engage from project to project, the higher the chance of inter-project and organisational learning (Dubois & Gadde 2002).

RESULTS AND DISCUSSION

DIFFUSION OF INNOVATION

The most important communication channel for the discovery of new innovation was stated by all nine participants as industry relationships, strongly agreeing with the literature. Examples stated by participants included undertaking projects with a variety of contractors and consultants, discussion with manufacturers, looking at competitors, and maintaining a wide professional network of associates. Only one interviewee noted that they looked to their staff as a source of innovation, highlighting the complexities of intra-organisational knowledge sharing within project-based organisations.

Four participants had employees sporadically working on in-house innovation, while none had a dedicated R&D team. With one participant stating "The big organisations have a budget for innovation rather than just an interest." These two points support the view of Gann (2001) that construction firms mainly adopt innovation once it has been first been trailed and exploited within another industry or by industry market leaders.

All participants attended industry seminars and conferences however these were largely confined to their specific areas of expertise, an example of the fragmented and complex nature of the industry. It would appear that diverse industry networking events, linking multiple disciplines and academia as highlighted by Abbott et al (2006) are either not a frequent occurrence within NZ or are not seen to add value by NZ construction firms.

None of the participants read academic publications. Suggesting that the NZ industry places a low level of significance on information produced within academic institutions, as shown to be true in the UK and Europe. The idea that academics have the capability to achieve change through academic research within such a practical industry with heavily ingrained methodologies is questioned by Gann (2001). This idea was also expressed by participants, who believed that in an industry dominated by *"alpha males,"* as one participant put it, the change process, especially by an outsider, is a challenging prospect.

There was an interesting split between the consultant and contractor participants as to the importance of the client as an innovation-driver. Consultants saw the client as vitally important in facilitating new innovation, with most reiterating that the experience and technical knowledge of the client was influential on design outcomes and the incorporation of new innovation. Contractors largely did not see the client as exerting influence over their innovation agenda. The adoption of innovation by contractors was due to site-specific issues, with one contractor stating "*We look for innovation when we are forced to"* and to improve internal efficiencies. Tighter bonds of trust are held between consultants and clients, whilst the contractors are largely left on the outside. The contractor participants confirmed this, stating a hierarchal relationship wherein contractors are thought of as *"low level tradespeople"* by the professional practises. This is an unfortunate cultural aspect that predominates within the industry, creating a further innovation void.

The construction industry is known to be especially susceptible to macroeconomic effects which bring about the "Boom-Bust" cycles which so heavily affect the industry. These pronounced cycles also appear to be a driver of low investment in innovation in NZ. Four participants stated that implementing new innovation in the midst of the current boom was difficult. One participant stated *"Companies don't have the financial flexibility to take a long term view, they are just peddling to keep up in a boom and peddling to hold on on the way down"* .

DIFFUSION OF LPS

It is believed that Lean Construction and LPS is currently confined to a small number of the larger commercial and civil contractors and has not yet widely diffused throughout the NZ construction industry. All of the consultant and owner participants were *not at all familiar* with the terms. With one contractor being *not at all familiar* with both terms, one being *slightly familiar* with both terms, while the third contractor was *moderately familiar* with both, having had limited practical experience using the system on one project. The wider social systems in which organisations operate have not yet embraced the Lean Construction philosophy. Meaning that through the communication channels open to them, the innovation has not been spread. This deduction is made on the finding that each participant, as a director or high level manager, maintains wide-reaching professional networks, all read industry related publications and attend numerous industry related seminars or conferences per year. A distinct lack of knowledge and understanding about Lean Construction across the wider industry is therefore inferred.

The contractor who did have practical experience in using LPS was engaged as a subcontractor operating alongside one of the largest construction firms in NZ, on a major infrastructure project. This participant also worked for the largest company interviewed. It would seem that the diffusion of LPS throughout the industry is confined to organisations who's social systems overlap the larger companies currently implementing LPS. The participant was full of praise for the system, especially the improved communication channels. The participant made the comment *"We liked it because it gave us some certainty,"* although the firm had not yet been persuaded by the experience to adopt LPS internally.

Based on the researcher's explanation of LPS, all participants stated they believed that LPS could provide improvements on projects currently in progress and to their organisation as a whole. Many believed LPS could provide numerous benefits to current industry standards of operation. Seven participants stated that they would undertake further research on LPS, seeing great value in the adoption of elements of LPS across their organisations, with participants stating:

"I think we could embrace this as an innovation"
"I'll be honest and say that I hadn't considered this concept before but as you have explained it, it makes total sense"
"I think the system would give the investor a more positive influence over the project team, which I think is good for the health of a project"

IMPLEMENTATION OF LPS

THE MASTER PLAN

All participants were skeptical about the practical implementation of certain elements of the system. Implementing the *Master Plan* was thought to present the most challenges. This is based on an ingrained culture of mistrust and scepticism which exists between consultants and contractors across the industry. Participants stated that the traditional methods of procurement inhibit the early contractor involvement required within the Master Plan stage of the system, with two consultants stating;

> "*Contractors thrive on the confusion of a large land development project and are reliant on variations to make money, if they saw there was a way for projects to run more smoothly they may get scared about that"*
> "*The big and experienced contractors are very careful of being open, lest they disclose where they may be able to achieve variations"*

One contractor stated that early involvement form his side was fraught from the outset as engineers and architects believe themselves to be superior to contractors. Being treated on a similar level and having his company's concepts and ideas taken seriously wasn't something he was accustomed to. The views presented above by the consultantswere also inferred by the contractors, with one stating;

> "*A lot of contractors would say, I don't want to pass over my intellectual property to a designer"*

If the implementation of LPS is to be achieved in NZ from project initiation, stakeholders should keep an open mind, especially around the use of advanced forms of contract which encourage cooperation between the project team. Alliance contracting has been shown to be effective within NZ when undertaking public infrastructure projects (Skellern 2016). There appears to be no reason as to why the wider NZ construction industry could not acknowledge the benefit of such forms of progressive contracting. There is a perception that alliancing is reserved solely for large scale infrastructure projects, however its potential positive influence extends across the industry. Mathews & Howell (2005) suggest a relational contracting approach designed specifically around the collaborative principles of Lean Construction called Integrated Project Delivery (IPD). Under IPD the project owner, architect, engineers, main contractor and key subcontractors are united together under a single relational contract called an Integrated Agreement. Profit and risk is shared between the integrated team based on pre-determined agreements and formulas. Projects utilising IPD have been shown to produce amazing results when implemented successfully (Lichtig 2006).

REMAINING ELEMENTS

The participants perceived that reverse phase scheduling would be the most straightforward tool to implement. They believed that the project team could be brought together in the post-tender stage of a traditional contract to create the most relevant and workable project program. Implementation of the in-construction elements of LPS, the look ahead plan and the weekly work plan were viewed by participants with scepticism. There was a

disconnect between consultants and contractors as to whose responsibility it would be to implement and manage the day-to-day running of LPS on site. Both parties were wary of the buy-in required from all stake holders and saw this as a limiting factor to successful implementation. Two interviewees stated implementation should be client-driven, as they are the ultimate benefactor of reduced project cost and running times. However, making clients aware of the system is seen as a huge challenge, especially as Lean Construction and LPS is yet to widely diffuse throughout the industry. One participant suggested a solution of introducing professional consultants to the project to teach and co-ordinate the system, noted in the literature as vitally important to successful implementation.

All participants bar one thought that the widespread adoption and implementation of LPS as a fully integrated system within the NZ construction industry was a difficult proposition. In summary, the research participants shared key sentiments regarding the implementation of LPS in NZ; the system is a fundamental change in thinking to nearly all aspects of the project lifecycle, requiring buy-in from all stakeholders; the NZ construction industry is resistant to change, with ingrained cultures of operation making the adoption of innovation slow. The factors stated by participants relate directly to a vital explanation in the literature of the industry's low level of innovation adoption - that the construction industry is vastly more complex than most.

CONCLUSION

The research found that the adoption of innovation within the NZ construction industry is fraught with the same complexities which see slow rates of innovation the world over. These complexities see the status quo maintained and only gradual advancements achieved over time. The study suggests that knowledge levels of Lean construction and LPS are low across the wider industry, and there was a great deal of apprehension shown by participants about the chances of its widespread adoption throughout the industry.

If the NZ construction industry is to see improvements in construction productivity, deemed vital by The Productivity Partnership in 2011, it is proposed that increased adoption of Lean Construction principles and LPS across the industry is required. The paper presents a number of ways which could advance the diffusion and adoption of Lean Construction & LPS throughout industry:

1. Improved platforms of engagement between academia and industry. This would enhance networking as a means to incubate research collaboration on Lean Construction, also boosting levels of wider innovation within the industry.
2. A greater role played by Universities in facilitating adoption, largely through the undertaking of empirical research on the implementation of the LPS, to demonstrate that benefits are not confined to overseas organisations.
3. The Government as a driver of Lean Construction, through promoting awareness throughout the industry, as a sponsor of academic research and through incentivising its use within the industry. Ultimately change should be industry driven, however, due to the economic benefit proposed by increased construction productivity, a proactive approach should be taken by central government.

4. Little research has been undertaken into the marketing and advertising of Lean Construction and LPS as means of improving its diffusion throughout an industry. Much could be done to increase the flow of Lean Construction knowledge throughout NZ.

The incorporation of Lean Construction principles and LPS as standard practise within the industry could see a hugely positive transformation of the NZ construction industry. As well as boosting productivity it would serve as a driver of industry wide innovation growth.

REFERENCES

Abbott, C., Jeong, K., & Allen, S. (2006). The economic motivation for innovation in small construction companies. Construction Innovation, 6(3), 187-196.

Aouad, G., Ozorhon, B., & Abbott, C. (2010). Facilitating innovation in construction: Di rections and implications for research and policy. Construction Innovation,10(4), 374-394.

Ballard, G. (2000). "The Last Planner System of production control." Ph.D. thesis, Faculty of Engineering, University of Birmingham, Salford, U.K.

Blayse, A. M., & Manley, K. (2004). Key influences on construction innovation. Construction innovation, 4(3), 143-154.

Bresnen, M., Goussevskaia, A., & Swan, J. (2005). Implementing change in construction projectorganizations: exploring the interplay between structure and agency. Building Research & Information, 33(6), 547-560.

Davidson, C. (2013). Innovation in construction–before the curtain goes up. Construction Innovation, 13(4), 344-351.

Department of Building and Housing [DBH] (2012). *Productivity Road Map.* Retrieved from https://www.parliament.nz/resource/0000182839

Department of Trade and Industry [DTI] (2006), *Innovation in the UK: Indicators and Insights*, Department of Trade and Industry, London.

Dubois, A., & Gadde, L. E. (2002). The construction industry as a loosely coupled system: implications for productivity and innovation. Construction Management & Economics, 20(7), 621-631.

Durdyev, S., & Mbachu, J. (2011). On-site labour productivity of New Zealand construction industry: Key constraints and improvement measures. Australasian Journal of Construction Economics and Building, The, 11(3), 18.

Eriksson, P. E. (2013). Exploration and exploitation in project-based organizations: Development and diffusion of knowledge at different organizational levels in construction companies. International Journal of Project Management, 31(3), 333-341.

Gann, D. M., & Salter, A. J. (2000). Innovation in project-based, service-enhanced firms: the construction of complex products and systems. Research policy, 29(7), 955-972.

Gann, D. (2001). Putting academic ideas into practice: technological progress and the absorptive capacity of construction organizations. Construction Management & Economics, 19(3), 321-330.

Kumaraswamy, M., & Dulaimi, M. (2001). Empowering innovative improvements through creative construction procurement. Engineering Construction and Architectural Management, 8(5-6), 325-334.

Lichtig, W. A. (2006). The integrated agreement for lean project delivery. *Constr. Law.*, *26*, 25.

Mathews, O., & Howell, G. A. (2005). Integrated project delivery an example of relational contracting. *Lean construction journal*, *2*(1), 46-61.

Ministry of Business Innovation and Employment (2016). *National Construction Pipeline Report.* Retrieved from http://www.mbie.govt.nz/publications-research/research/ construction-sector-productivity/national- construction-pipeline-report-2016.pdf

Ministry of Business, Innovation and Employment (2016). *Small Businesses in New Zealand. How do they compare with larger firms?.*Retrieved from http:// www.mbie.govt.nz/info-services/business/business-growth- agenda/sectors- reports-series/pdf-image-library/the-small-business-sector-report-and-factsheet/ small-business-factsheet-2016.pdf

Palacios, J. L., Gonzalez, V., & Alarcón, L.F. (2013). Selection of third party relationships in construction . American Society of Civil Engineers , 140(4), 55-65.

Pries, F., & Janszen, F. (1995). Innovation in the construction industry: the dominant role of the environment. Construction management and economics, 13(1), 43-51.

Porter, M.E. and Ketel, C.H.M. (2003) *UK competitiveness: Moving to the next stage*. DTI Economics Paper, The Stationery Office.

PWC (2016). *Valuing the Role of Construction in the New Zealand Economy.* Retrieved from https://www.pwc.co.nz/insights-and-publications/2016-publications/valu ing-the-role-of-construction-in-the-new-zealand-economy.html

Slaughter, E. S. (2000). Implementation of construction innovations. Building Research & Information, 28(1), 2-17.

Skellern, G. (2016, October 20). Project alliances providee greater value for money. *The New Zealand Herald p. D10.*

Statistics New Zealand, (2016). *Gross Domestic Product: June 2016 quarter*. Retrieved fromhttp:// www.stats.govt.nz/browse_for_stats/economic_indicators/GDP/Gross Domestic Product_HOTPJun16qtr.aspx

Treasury, H. M. S. (2003). Lambert review of business-university collaboration: final report. HM Treasury, London.