

# Where does the Theory Informing the International Group for Lean Construction Come From?

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## ABSTRACT

Within the community of Lean construction, as represented by the International Group for Lean Construction (IGLC), some recent discussions about Lean construction theory have questioned the base upon which the theory has been developed. The question asks whether the sources upon which the theory has been based were generated from within the community or from outside. Some fears were expressed that the theory was being developed largely internally, without drawing in enough new ideas or recent thinking from the wider academic and industrial community. This paper attempts to clarify the basis for the debate by enumerating the references used to generate Lean construction theory within the IGLC conference papers and to offer some conclusions that will assist in informing the debate. The analysis identifies the leaders in the development of Lean construction theory and confirms that their work is referred to outside the IGLC community. The research confirmed that the level of referencing from sources published outside the IGLC conferences was in fact high; however, the paper raises concerns about the quality of the sources used and the lack of new thinking being generated. There was no intention to look outside the IGLC forum or to attempt to define any aspect of Lean construction theory the research was merely a counting exercise to ascertain the flow of references and theory sources.

## KEYWORDS

IGLC, development, theory, papers, conferences, references, citations.

## INTRODUCTION

Over the last 20 years, the idea of Lean Construction has been developed across the world by a small number of academics working both together and separately. The aim is to formulate a firm base for Lean Construction theory and to translate this theory into usable and manageable systems for practical application in the construction and building industry. Considerable progress has been made over the years and world-wide co-operation is well established in the form of the International Group for Lean Construction (IGLC) and a number of industry-facing Lean Construction bodies such as the Lean Construction Institute (LCI) and its affiliates.

In spite of the progress made, the development of Lean Construction theory has been largely unstructured – that is to say, it has not been directed by any underlying strategy or pre-prepared road map. This paper presents a review of past conference papers presented on the IGLC website (IGLC 2010) and suggests that it has

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developed in gradual and sometimes variable steps, drawing from a wide range of manufacturing process improvement studies, project planning ideas, specialised workplace studies and management improvement theory.

In the last few years, the Lean Construction community has been criticised for a lack of theoretical foundation or clear idea of what was driving it. Indeed, there were some fears expressed that the theory was being developed largely internally, without drawing in enough new ideas or recent thinking from the wider academic and industrial community. Thus the principal purpose of this work was to test the hypothesis that the majority of IGLC conference papers supporting Lean Construction theory today are largely based on internally developed IGLC literature and reference sources. This paper attempts to test this hypothesis by providing a review of the references cited by IGLC papers and to show, as far as possible, which theories and ideas have driven the development. The work also shows those references originating from journals and conferences and those authors who have the highest number of citations.

## **METHODOLOGY**

The population of references cited by the conference papers was sampled to create a manageable number. The sample included all papers to up to and including 1998 but from subsequent years only the theory theme papers were included. It is recognised that Lean construction theory is developing in all IGLC research themes but the Theory theme is the most likely to concern fundamental theoretical development. The exception to this was the year 2000 where papers were not themed. All papers from this year were originally included but this skewed the statistics by a factor of four. As a result a subjective selection of papers was made to represent the theory theme. In any case, the sample papers cited 2,970 references by 1,873 authors.

Following the sample selection, the second stage of data collection comprised entering the data into a Microsoft Excel spread sheet in such a way that identified the IGLC paper and conference year in which each reference was included, plus the year and place each reference was published, its title and its author/s. The reference titles were entered in such a way that made it possible to search the titles and count the occurrence of significant words.

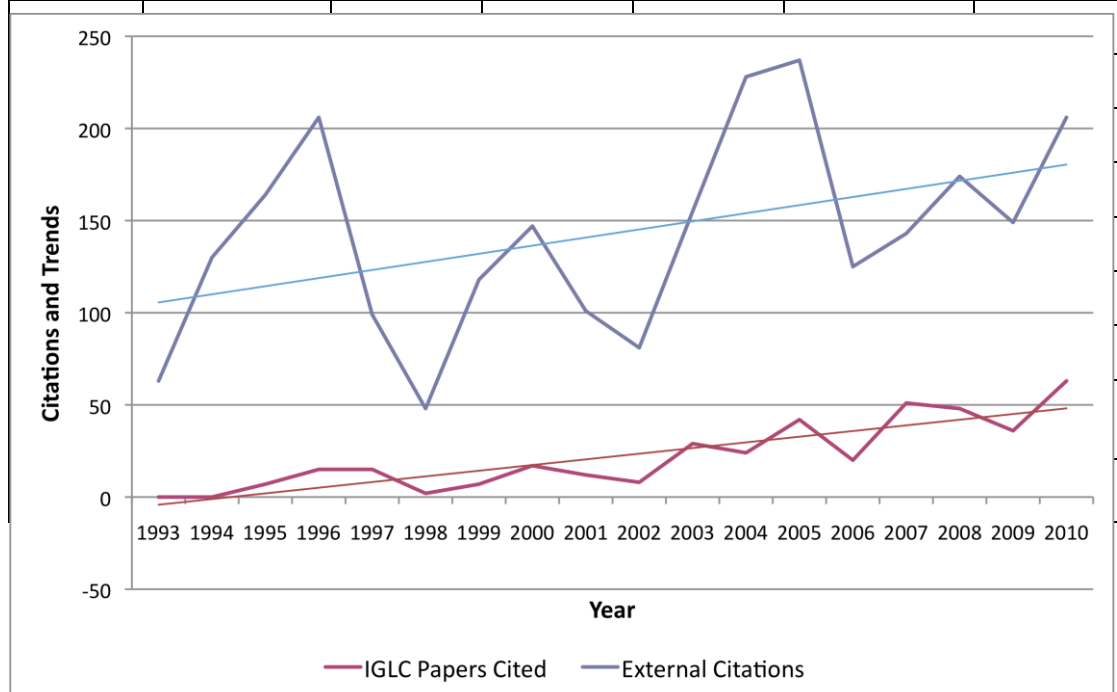
Care was taken to ensure the date entry and subsequent search instructions were precise enough to prevent miscounting as a result; for example, where the word sought also formed part of a longer word e.g. “allen” and “challenge”. A checksum of the data input showed an error rate of 0.01 in the range of 2,970 references. This was considered acceptable given the number of data entries.

## **THE RESULTS**

The statistical results of the work are set out in Table 1. In terms of scale, the number conference papers included in the sample was 162 and the total number of references cited by them was 2970. The annualised average of references cited was 19.7 per paper, of which 11.59% were IGLC papers. The data includes references cited more than once.

Table 1: References Cited in Selected IGLC Conference Papers 1993-2010

Year	No. of IGLC Papers Assessed	Total Citations	IGLC Papers Cited	External Citations	Average citations per Paper	Av. IGLC citations
1993	5	63	0	63	12.6	0.0%
1994	14	130	0	130	9.3	0.0%
1995	16	171	7	164	10.7	4.1%
1996	16	221	15	206	13.8	6.8%
1997	15	114	15	99	7.6	13.2%
1998	4	50	2	48	12.5	4.0%
1999	8	125	7	118	15.6	5.6%
2000	8	164	17	147	20.5	10.4%
2001	6	113	12	101	18.8	10.6%
2002	4	89	8	81	22.3	9.0%
2003	7	184	29	155	26.3	15.8%
2004	9	252	24	228	28.0	9.5%



The number of IGLC conference papers cited in subsequent IGLC papers was plotted against the external references cited and shown in Fig. 2

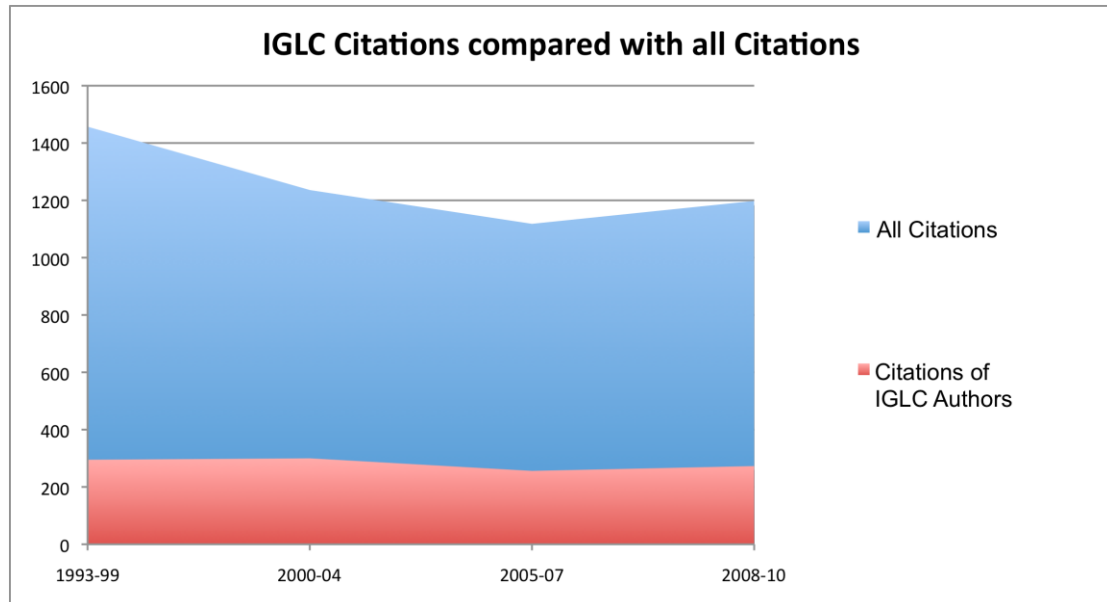
Figure 2: Number of external and internal references per year

The trend lines included in Fig. 2 show a general rise in the number of references per paper. They also show that the percentage difference between external references

and IGLC references has remained reasonably constant. This demonstrates that the original hypothesis is false in assuming that the greater proportion of theory is supported by internal referencing. The proportion of external references amounts to 88.41% annualised over the 18 years reviewed.

### CITED AUTHORS

The total number of named authors cited in the sample papers was 1873. The total



number of authors of IGLC papers cited was 145 or 7.7% of the total. However, these authors are named in an average of 23.53% of cited references (Fig. 3 below).

Figure 3: IGLC authors cited against the total of all authors

The data was also sorted to show the names of authors most cited in the sample papers (Figure 4).

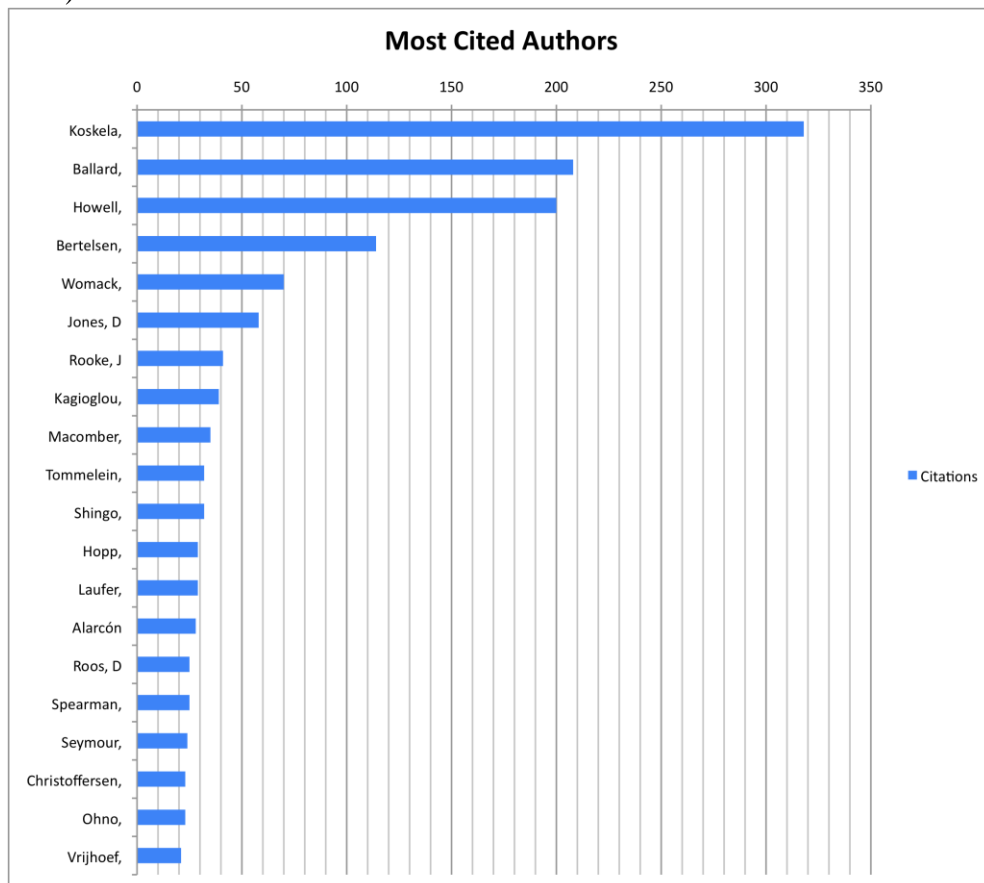


Figure 4: Bar chart showing the top twenty names of authors most cited in all references listed in the surveyed papers.

Then, the authors of IGLC papers sampled were sorted and listed showing the top conference contributors. These are shown in Figure 5 below.



Figure 5: Bar chart showing the authors of the sample conference papers.

It is not surprising to note that the names of the most cited authors are similar in both lists. It is also worthy of note that the top five authors listed in Figure 4 represent 49% of the citations in the total of 1,873 individual authors. Thus 2.5% of the authors are referenced in almost half the total of 2,970 papers cited.

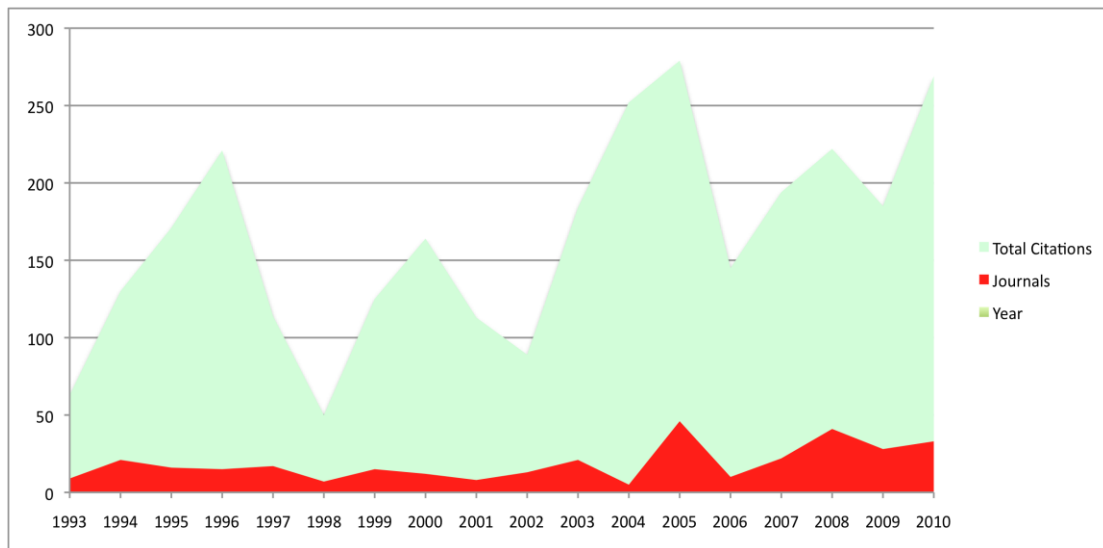
It should be noted that authors like Tommelein who, for example, has published only three of the sampled papers is actually quite highly cited in the sampled papers. Whilst some like Seymour for example, move the other way

## CONFERENCES AND JOURNALS

Peer reviewed journals are considered the most authoritative source of good quality research information. Therefore in order to provide an assessment of the quality of the theory informing the IGLC, the data was further explored to identify the number of references that were published in journals. There is evidence that not all references listed had supplied details of the exact source but the data was checked for known journal publications so that a reasonable level of accuracy was obtained. Nevertheless, there is clear evidence that journal sources are, in general, very low. Of a total of 2,970 sources, only 339 or 13.17% were recognised peer-reviewed journals. Most the remainder was conference papers, trade magazines, books, company reports and

industry papers.

Figure 6: Chart showing the total number of citations to those citing journals.



It is the authors' view that the apparently low number of journal papers informing the IGLC is a concern and needs to be addressed.

### MOST CITED SOURCES

In order to obtain a view of the major sources of theory for the IGLC, the titles of documents cited in the sampled papers were sorted by the number of citations recorded for each. Of these, a total of 57% were cited once, 7% were cited twice and 36% cited more than twice.

Table 3: Most Cited References in the Sampled IGLC Conference Papers 1993-2010

Rank	Source Title	Publication Year	Type of publicat'n	IGLC citations
1	Koskela, L. (1992) 'Application of the New Production Philosophy to Construction', Technical Report No 72, Centre for Integrated Facility Engineering, Stanford University, California.	1992	Report (book)	55
2	Koskela, L. (2000). "An Exploration towards a Production Theory and its Application to Construction." VTT Publication, Technical Research Centre of Finland, Espoo.	2000	PhD	41
3	Womack, J. and Jones, D. (1996) Lean Thinking: Banish waste and create wealth in your corporation. Simon & Schuster, New York.	1996	Book	32
	Womack, J. P., Jones, D. T. & Roos, D. (1990) The Machine That Changed the World, Simon & Schuster, New York.	1990	Book	32
5	Ballard, G. & Howell, G. (1998) 'Shielding Production: Essential Step in Production Control', Journal of Construction Engineering and Management, 124(1):11-17.	1997	Journal	26
6	Shingo, S. (1988). Non-Stock Production: The Shingo System for Continuous Improvement. New York: Productivity Press.	1988	Book	18
7	Ballard, G. (2000): "The Last Planner System of Production	2000	PhD	17

Rank	Source Title	Publication Year	Type of publicat'n	IGLC citations
	Control", School of Civil Engineering, Faculty of Engineering, The University of Birmingham			
	Ohno, T. (1988). Toyota Production System: Beyond Large-scale Production, Productivity Press, Portland, OR.	1987	Book	17
9	Ballard, G. (1999). "Improving Work Flow Reliability." In: IGLC-7, Berkeley, CA, USA, 275-286.	1999	IGLC Conference	16
10	Bertelsen, S. and L. Koskela, 2002 Managing the Three Aspects of Production. 10th Annual International Group for Lean Construction Conference – IGLC. Gramado, Brazil	2002	IGLC Conference	13
11	Ballard, G. & Howell, G. (1994). Implementing Lean Construction: Stabilizing Work Flow. Conference on Lean Construction, IGLC Santiago, Chile.	1994	IGLC Conference	12
	Hopp, W. and Spearman, M. (1996) "Factory Physics: Foundations of Manufacturing Management". Irwin/McGraw-Hill, Boston. 668 p.	1996	Book	12
13	Koskela, L. (1999). "Management of production in construction: a theoretical view." 7th International Group for Lean Construction Conference, Berkeley - USA, p. 241-252.	1999	IGLC Conference	11
	Tavistock Institute (1966). Interdependence and Uncertainty. Tavistock Publications, London, U.K.	1966	Report	11
15	Howell, G.A. (1999). "What is Lean Construction – 1999." IGLC-7, Berkeley, CA.	1999	IGLC Conference	10
16	Howell, G., Laufer A. & Ballard G. (1993). Interaction Between Subcycles: One Key to Improved Methods, ASCE Journal of Construction Engineering and Management, Vol. 119 No. 4.	1993	Journal	8
17	Koskela L. and Howell G. (2002) The underlying theory of project management is obsolete. Proceedings of the PMI Research Conference, pp. 293-302.	2002	Other Conference	8
18	Spear, S & Bowen, H (1999) Decoding the DNA of the Toyota production system, Harvard Business Rweiew, 1 September 1999.	1999	Journal	7
	Howell, G. & Ballard, G. (1994). Lean Production Theory: Moving Beyond 'Can-Do'. Conference on Lean Construction, IGLC Santiago, Chile.	1994	IGLC Conference	7
	Latham, M., (1994): Constructing the Team – Final Report of the Government / Industry Review of Procurement and Contractual Arrangements in the UK Construction Industry HMSO, London, 1994	1994	Report	7
	Koskela (2004), Making-Do - The Eighth Category of Waste, Proceedings of the 12th International Group for Lean Construction Conference, Denmark, 2004.	2004	IGLC Conference	7

In this table, the top five references cited are generally regarded as seminal works informing the industry. Of the remaining 15 sources, 7 are internal IGLC conferences – almost 50% - and this fact alone appears here to be supporting the hypothesis that much of the theory behind the IGLC is internally driven. This is further supported in that, of the 20 sources, 70% are from regular IGLC authors.

It may be noted that this table shows that the most recent paper cited is six years old and most are over 10 years old. It may be considered significant that no new ideas are being introduced regularly into the thinking behind more recent papers.

To see whether the top five sources from Table 3 (above) were informing a wider audience than the IGLC, a Google Scholar search (2011) was done. This represents a quick snapshot of a more global position for citations compared with those for the internal IGLC paper sampled.

**Table 4: Most Cited IGLC Authored Papers compared with Google Scholar citations**

Rank	Source Title	Publication Year	IGLC Citations	Google citations
1	Koskela, L. (1992) 'Application of the New Production Philosophy to Construction', Technical Report No 72, Centre for Integrated Facility Engineering, Stanford University, California.	1992	55	485
2	Koskela, L. (2000). "An Exploration towards a Production Theory and its Application to Construction." VTT Publication, Technical Research Centre of Finland, Espoo.	2000	41	328
3	Ballard, G. (2000): "The Last Planner System of Production Control", School of Civil Engineering, Faculty of Engineering, The University of Birmingham	2000	17	303
4	Ballard, G. & Howell, G. (1998) 'Shielding Production: Essential Step in Production Control', Journal of Construction Engineering and Management, 124(1):11-17.	1997	26	234
5	Ballard, G. (1999). "Improving Work Flow Reliability." In: IGLC-7, Berkeley, CA, USA, 275-286.	1999	16	65

The Google Scholar search indicated that papers 1 – 4 in Table 4 are heavily cited, even when considering they will be commonly cited in the total population of IGLC papers it is clear that these papers are informing wider audience. This is less clear for paper 5, as a further 49 citations included in IGLC not included in the sample would not be an unreasonable figure given the number of papers presented since 1999

## CONCLUSIONS

The results generated by the research carried out for this paper raise a number of issues. It could be said to be reassuring that the original hypothesis for this paper, i.e. that the IGLC knowledgebase is inward looking and that the theory was being developed largely internally, has been disproved, statistically at least, by the analysis. In this respect it is of note that 57% of authors cited are only ever cited once.

This, while comforting to some extent, may be masking a lack of progressive development. A very small number of authors quoted regularly are dominating the citations. As shown earlier, 2.5% of the total of authors occurs in almost half of the total citations. Also the youngest of the top 20 citations is six years old and most are over ten years old. This would confirm the fear that the IGLC is not drawing in enough new ideas or recent thinking from the wider academic and industrial community

So the principal conclusion from this work is that the health of the discipline is open to question and the original hypothesis is neither confirmed nor denied. Although the statistical analysis shows that only 21% of references cited in the sampled papers are by authors who are IGLC members and the actual number of



citations of IGLC-based papers is only 13.3% of the total citations, 14 of the top 20 citations (70%) are internally generated.

The work shows that, only 13.41% of citations are journals. There are more references to books, conference papers, reports and trade magazines, which would suggest less rigorous source data. However, the top eight most cited publications are journals, technical reports and seminal books, not conference papers, indicating the core reference material to be potentially more reliable.

The comparison based on the Google Scholar survey undertaken suggests a wider international use of the top cited IGLC sources. The IGLC references surveyed for this work represent an average of approximately 13% of their international citations generated by Google Scholar (2011). Even allowing for citation within the remaining IGLC body of papers a significant external citation presence can be seen.

The authors appreciate that a view might also be taken that the lack of internal citing might suggest a lack of robust theory being developed within IGLC. But the level of international citing of core of IGLC theory papers suggests there is evidence of a theoretical base developing. An opportunity presents itself for some guided strategy from within IGLC itself to build upon this established base. One method for this might be for IGLC authors to publish more in academic journals and other significant research outputs. Closer links between the IGLC and journal publishers might be helpful here as it seems the majority of IGLC work is not finding its way into the wider academic arena, at least not in any way that can be seen from the IGLC proceedings.

It has not been possible to assess how many citations are self-citations but it is not unreasonable to conclude that the level of self-citing might be similar across all papers so the order of most cited publications will remain the same even if the numbers may be suspect.

The authors consider that whilst the theory development does include a design aspect, as demonstrated by the inclusion of Emmitt and Christofferson in the top 20 authors, the theory associated with production dominates the most cited papers. It is also surprising to note that the Latham report is more widely referred to than the Egan report, even though the latter expressly mentions Lean construction.

The authors observed that some notable contributors seem to be under-represented, e.g. Tommelein, Formoso and Alarcon. This is probably due to the study being concentrated on theory papers, whereas these writers offer contributions in other sectors of the Lean construction arena.

## **ACKNOWLEDGEMENTS**

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## **INTERNET SOURCES**

IGLC (2010), <http://www.iglc.net/conferences/>

HYPERLINK "http://scholar.google.co.uk/"<http://scholar.google.co.uk/> accessed 1st