A MECHANISM FOR LEAN AND SUSTAINABILITY: THE CASE OF INFRASTRUCTURE PROJECTS IN SOUTH AFRICA

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Abstract

Stakeholders in the construction sector are placing a much stronger emphasis on the importance of attaining sustainability within the industry. While much efforts has been deployed towards attaining sustainable development through infrastructural projects, the methods used by most stakeholders for projects procurement hinders the attainment of criteria for sustainability. The proposed research will thus explore how to evolve a mechanism for promoting lean sustainable construction with infrastructure projects in South Africa. The study is primarily to assess the components of the framework required for the integrative implementation of lean and sustainability concepts in an infrastructure project. The study is qualitative in nature, based on interpretative theoretical framework that is grounded in literatures in the field of built-environment. Emergent findings indicate that a case study approach and specifically, qualitative comparative analysis (QCA) research approach provide answers to the research questions, which are domiciled in a complex socio-technical environment. The evolution of the mechanism shall focus on lean construction and sustainability methods / tools that support the elimination of wastes in work processes, work methods, work culture and materials issues, thereby promoting energy and resource efficiency. It is expected that the framework that will leads to continuous improvement in the areas of energy and resource efficiency, minimization of emission (Co2) from the built environment, improvement in stakeholders working relationships and social benefits to the community, among others.

Keywords: Infrastructure Project, Lean, Sustainability, South Africa

1. INTRODUCTION

According to Yao (2013: 20) "…. as we head into an uncertain future with resource depletions and energy security issues, striving to achieve sustainable urban environments becomes a prerequisite if mankind is to thrive on Earth". The ever increasing concentration of greenhouse gases (GHGs) caused by continuous depletion of natural habitats has been in the forefront of national discuss in many countries (McMichael et al., 2006 as cited in Ghosh et al., 2014: 133). It also has a major dimension for developing countries that are grappling with urbanisation and basic infrastructure needs in the face of rapid population growth, in the middle of finite planetary resources. In this perspective, achieving sustainable development in developing countries requires organisations to be proactive with a new approach to business.

This approach can be new processes, new materials, products, technologies, and new business models so as to ensure that things must be done differently if new trends in the long term would be adapted (Campos et al., 2012: 61; Emuze & Smallwood, 2013: 854).

The construction sector has been probing for answers to the question of how to attain sustainability (Vieira & Cachadinha, 2011: 611). Traditionally, the sector is a massive consumer of raw material and by nature, a large-scale waste producer that is certainly not sustainable (Miller & Ip, 2013: 342). Lean concept has generally been discussed in the context of waste reduction and waste elimination so as to create value (Novak, 2012: 51). Terry and Smith (2011: 47) see lean as "a way of thinking and delivering value, innovation and growth by: doing more with less – less human effort, less equipment, less materials, less time and less space to align efforts closer to meet customers value expectations."

Lean and sustainability philosophy have been pursued as separate and parallel initiatives within the construction sector (Ahuja, Sawhney & Arif, 2014: 123). Researchers have examined the paradigm of 'lean sustainable construction' that could leads to sustainable development (Novak, 2012; 51; Campos et al., 2012: 61; Emuze & Smallwood, 2013: 853 and Corfe, 2013: 1) within the field of construction management. The conclusion from these studies shows a significant overlap between the two approaches and seems to have a common goal of 'doing no further harm' to the environment. It is the synergy between these two philosophies that will be beneficial to the state of continuous improvement and attainment of ecosystem equilibrium for sustainable development. Therefore, this research work is set out to evaluate methodologies of integrating lean with sustainability in developing economies with a focus on South African public sector construction.

2.1 Lean: Overview And Main Features

Under the leadership of Engineer Taichi Ohno of Toyota car manufacturing company in the 1950s, the concept of "lean" was developed as an industry process of eliminating waste (Howell, 1999: 2; Forbes & Ahmed, 2004: 2). In 1992, the work of Koskela (1992) mention the possibility of adopting the production process in construction and recommends that the construction industry should consider implementing it to enhance the industry performance. The proposal by Koskela in 1992 is a new approach not based on technology, but rather on the principles of a production philosophy. This new approach is now known as 'lean construction'. Rybkowski, Abdelhamid and Forbes (2013: 84) look at lean construction as:

> *"the holistic pursuit of continuous improvement with a goal to deliver customer value, while minimizing waste and maximizing value to the customer throughout a project's delivery process and life cycle, and while respecting all stakeholders in the value chain".*

The five principles of lean that serve as a pathway for continuous improvement include (Dulaimi & Tanamas, 2001: 12; Pasquire & Connolly, 2002: 8 and Terry & Smith, 2011: 36):

- Value identification;
- Value stream mapping (VSM);
- Value stream flow;
- Pull' by the client, and
- Perfection.

2.2 Sustainability: Overview And Main Features

The concept of sustainability originates from sustainable society in efforts to preserve and manage renewable and non-renewable resources (Brown, 1981 as cited in Yao, 2013: 4). The International Union for the Conservation of Nature (IUCN) promotes this further by introducing the concept in the World Conservation Strategy in 1980. Brundtland report authored by the World Commission on Environment and Development (WECD) in 1987 is the reference point for sustainable development discuss. The report (1987: 43) defines sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. It involves creating an infrastructure that meet human needs while maintaining a wide array of metrics of environmental quality, human health, social equity, and economic vitality (Crawford-Brown, 2012: 23; Madu & Kuei, 2012: 5; Wagner, 2012: 225 and Yao, 2013: 8). However, the 'concept of needs' has different dimensions and meaning based on the level of development, ideological preference, and dimensions of sustainability. This has led to a dichotomy that place sustainability efforts on a continuum between “weak (false) and strong (true)” or "Brown" and "Green" sustainability (Adebayo, et al., 2002: 9).

2.3 Lean Construction & Sustainability: Drivers & Barriers

Since the emergence of lean and sustainable construction concepts, adaptations have been a challenge. The specific characteristics of construction sector, being fragmented, complex and project based, which make coordination cumbersome are seen as barriers to the implementation of lean and sustainable construction simultaneously in a project (Bygballe & Sward, 2014: 3). Key barriers to the successful implementation of the concept include culture, leadership, education, technology, management, legislation, finance, partial implementation and improper conceptualization of lean and sustainable construction tools within the industry (Wandahl, 2014: 97; Suresh, Bashir & Olomolaiye, 2012: 382). Other factors identified in the literature include uncertainty, lack of trust and misunderstanding, different perceptions, low tolerance for change, and other general reasons such as inertia, timing, surprise and peer pressure (Smit, Cronje, Brevis & Vrba, 2011: 255).

The literature also talked about drivers alongside the aforementioned barriers. Such drivers include awareness, policy shift, training, competitive advantage, legislation, reputation, client demand, financial incentive, and good community relation (Suresh, Bashir, & Olomolaiye, 2012: 383; Othman, 2011:179; Paton & James, 2008: 8 and Alarcon & Seguel, 2002: 3; Elmualim et al., 2010: 58; Madu and Kuei, 2012: 5-7 and Wagner, 2012: 225).

3. RESEARCH PROBLEM FORMULATION AND STATEMENT

The methods used by most stakeholders for the procurement of construction facilities hinders the attainment of criteria for sustainability and efficient project delivery (Lapmski, Horman & Riley, 2006: 1083). While operational savings can result in quick break-even in high performance projects, additional cost that often emerge through wasteful activities hinders the progress of construction work. Lean construction approach is used to reduce waste in complex production environments (Vieira & Cachadinha, 2011: 612). The interwoven nature of lean and sustainability points to synergy that can be created for greater industry, and societal benefits.

Researchers such as Vieira and Cachadinha (2011: 611), Novak (2012: 51), Corfe (2013: 978), Emuze and Smallwood (2013: 853), and Ahuja, Sawhney and Arif, (2014: 123) have work on the need to either integrate lean with sustainability or use lean as catalyst for reaching sustainable development. On one hand, Emuze and Smallwood (2013: 853) demonstrated how health and safety (H&S) can be the focus for integrating lean and sustainability. On the second hand, Ahuja et al. (2014: 123) used the centrality of building information management (BIM) as a means of integrating the two concepts. However, the seemingly general consensus is that there is need for more comprehensive work on methodologies / frameworks to be scientifically developed and empirically verified for this synergy to emerge. Therefore, there is need for scientifically based mechanisms for the integration of the lean and sustainability in construction. The main question is: What mechanism would engender the implementation of lean and sustainability concepts in an infrastructure project for the benefit of end users? This principal question leads to the postulation of the research problem statement, which states that 'the lack of empirical framework for the integration of lean and sustainability as a catalyst for efficiency hinders continuous improvement within public sector construction'. Therefore, this proposed research is aimed to propose a mechanism for operationalising the integration of lean and sustainability in the built environment. The target case is the infrastructure sector in South Africa.

4. METHODOLOGY & RESEARCH DESIGN

Fellows and Liu (2008: 30) indicate that methodology is the general principle that guides the research process.

Yin (2009: 54) also argues that methodology is about the logic of enquiry, of how new knowledge is generated and the justification for it. Epistemology as describe by Tracy (2013: 61) is the study of the nature of knowledge and it justification. It examines the origin of knowledge, its limits and how it is acquired. Leedy and Ormrod (2009: 53) see research design as the plan, structure and strategy of investigation conceived so as to obtain valid answers to research questions. This particular study however adopts a case study approach to inquiry. Case study research (Proverbs & Gameson, 2008: 99) appears to be highly suited for project based industry with multiple participants. Byrne (2013: 2) affirms that case-based methods are central to proper social scientific understanding and assist us "both to elucidate causation and to specify the ranges of applicability of our account of causual mechanisms". It is by focusing on cases that a proper and explicit dialectical synthesis can be reached between cause and meaning/interpretation in order to achieve rationalization (Byrne 2013: 5). Byrne (2013: 5) further stresses that an attempt of any short of 'generalization' in case-based method requires classification and comparison. In doing this, qualitative comparative analysis (QCA) research approach / technique will be adopted because of the complexity of the work involved and ability to enhance predictability.

4.1 Qualitative Comparative Analysis

Qualitative comparative analysis (QCA) is a rigorous comparative approach that strives to satisfy two apparent contradicting dimensions in balancing the concepts of breadth and depth dichotomy of research approach (Rihoux & Lobe, 2013: 223). QCA helps in gathering in-depth insight in the different cases and capturing the complexity of the cases, while at the same time producing some level of generalization (Ragin, 1987: 121). Verwiej (2014: 3) further stress that QCA being a case-based comparative method that involve classification and comparison processes, avail researchers the freedom of emphasizing the unique aspects of cases and still identify their similarities; by comparing the cases, interpreting the results, and possibly reconstructing the cases – in which (theoretical) ideas and empirical data are in dialogue with (i.e inform) each other. Rihoux and Lobe (2013: 229) affirm that cases are inherently complex and therefore, the trust of QCA techniques is to reduce this complexity and reach some level of parsimony. QCA is an approach and a set of techniques that is centrally concerned with cases, and that 'thick' a case-based knowledge takes a central position in the practical procedure (Rihoux and Lobe, 2013: 237). Figure 1 presents an overview of QCA methodological framework. The framework consists of three main steps and five sub-steps each, making a total of fifteen dialogues along the way. Precisely, to maintain a clear purpose and QCA iterative nature, many returns to the cases' are needed often.

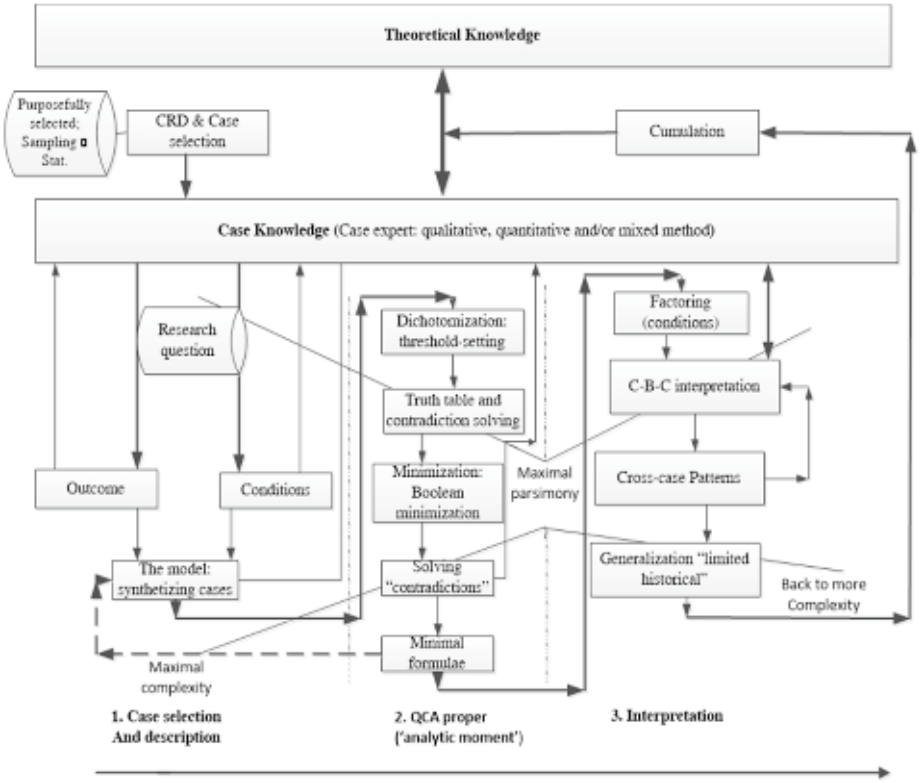

Figure 1: QCA methodology framework (adapted from Rihoux and Lobe, 2013: 229-239)

4.2 The Research procedure and techniques

The first step in QCA case-base methodological framework is variable selection; where the researcher will use a mixed method approach to address the research questions. The initial set of causal conditions and lean sustainability indicators (LSI) will be obtained from the literature through content analysis. This will be followed by assembling a panel of experts - experienced industry role players, academia and policy experts - to participate in 'focus group' for rating the importance of these variables. The final list of LSI and causal conditions will inform the data collection and analysis for the cases selected for this research in South Africa. An overview of this research process is shown in Figure 2.

The second step is the main case studies. The focus here is on comparative research design (CRD), case selection and actual data collection. The case selection will stem from the themes derived from content analysis and expert views in step one.

While in-depth interview and personal observation methods will be adopted for data collection base on the selected LSI and causal conditions.

The third step is the QCA (analytical stage); where data will be calibrated into QCA scores, build "Truth Table" and solving contradictions to arrive at minimal formulae for operationalising integration of lean and sustainability in the sector. This task corresponds to the computer-aided part, achieved with the application of software (TOSMANA and/or FSQCA) for QCA. Here, the type of QCA to be used will be decided based on the data collected.

The fourth step is result interpretation and theory building; where the researcher deal with the quantitative outcomes qualitatively (parsimony back to more complexity) through the use of case-by-case interpretation and cross-case patterns to build theories that is grounded in the cases.

The fifth step is to propose and validate the required mechanism base on the built theory in step four; here the role players determines whether the framework is adequate and sufficiently answers the question proffer within the context of South Africa public construction.

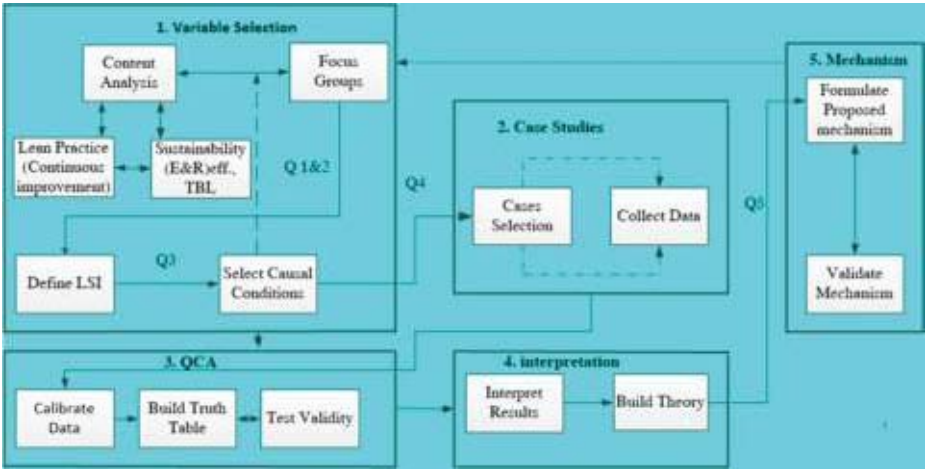

Figure 2: An overview of proposed research process

When the above highlighted statements are justified by role players, then the mechanism will be concluded to be adequate and sufficient for the industry. Finally, the researcher shall deliberate on the overall processes, outcomes and draw conclusions in order to propose for new knowledge and practice.

5. EXPECTED OUTCOMES

The significance of this study is to add to the existing Body of Knowledge in the area of sustainable construction and lean construction. Through critical examination and analysis of relevant case studies, the research will explore how to evolve a mechanism for promoting lean sustainable construction with infrastructure projects in South Africa. The evolution of the mechanism shall focus on lean construction and sustainability methods / tools that support the elimination of wastes in work processes, work methods, work culture and materials issues, thereby promoting energy and resource efficiency. It is expected that the evaluation of these variables would contribute to learning, teaching, research and practice in the construction industry. The results of this research effort would also deepen the debate around lean sustainable construction (LSC). Therefore, creating the level of awareness necessary for industry competitiveness within the region. It is also anticipated that the framework to emerge from the study should create needed buy-in into the integration of lean and sustainability in construction projects. The evaluation could lead to sustainable development, which covers an interdisciplinary field expected to achieve high performance and create value throughout the life cycle of the project, in developing countries such as South Africa. These will be reached by focusing on if; the mechanism leads to industry improved workflow and continuous improvement, the synergy created result in energy and resource efficiency within the industry, there is minimization of emission (Co2) from the built environment, there is reduced noise and dust pollution, there is an improvement in stakeholders working relationships and social benefits to the community, and the quality of project performance and industry competitiveness is enhanced.

6. CONCLUDING REMARKS

The discussion of the need for proper integration of lean and sustainability within construction industry proves to be necessary in other to bring about sustainable development in the infrastructure sector of the economy. The literature review and the preliminary findings brought about some salient outcomes that suggest a probable outcome, which can result into a workable framework necessary for immediate development of the industry. The proposed methodology (QCA) is also expected to contribute to novelty in the field of research in the field of built environment in this sub-region. This proposed framework will be based on the drivers and barriers of lean sustainable construction portrayed by the infrastructure development in the industry and seen by the South African stakeholders in the construction industry. In recognizing the basic tools, features and principles of lean and sustainability, the proposed mechanism may serve as critical tools for sustainable development in the South African construction industry.

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