VALUE PARADIGM: REVEALING SYNERGY BETWEEN LEAN AND SUSTAINABILITY

Vera M. Novak[1]

ABSTRACT

The current construction environment is characterized by risk aversion, and the delivery of value is constrained by the tension between time, cost and quality. Similarly, the approach to sustainability in the built environment remains largely focused on waste reduction and minimization of the carbon footprint. Yet the challenges of global environmental issues call for a paradigm shift from this reductionist, 'scarcity' approach to one of sustainable prosperity through resource renewal and value generation.

The industry has recognized the need for a more integrated approach, not just to fix the process, but to transform it to deliver value beyond the tangible building product. Lean construction stands out as the approach which can facilitate a net enhancement of sustainability value through fully integrated design and delivery processes.

The author explores the synergy between lean construction and sustainability, as expressed through the construct of value. Data from exemplary lean projects are gathered through survey and interviews of both prime contractor and owners, offering a two point perspective for enhanced data quality and reliability. The findings suggest a strong correlation between the cohesiveness of lean thinking and the level of collaboration on the delivery of sustainability values.

KEYWORDS

Value, lean thinking, construction process, green building, sustainability, integration.

INTRODUCTION

Twenty-five years have passed since the Brundtland report introduced the concept of sustainability (WCED 1987), and the severity of global environmental, economic and social issues is rapidly closing the window of opportunity on this 'do no further harm' approach. A more pro-active response of resource renewal is needed to transition to an ecosystem equilibrium of sustainable prosperity. Construction projects can no longer be viewed in isolation, but must be considered as a network of interdependencies, with a potential contribution to planetary balance, or sustainable prosperity (Figure 1) (Augenbroe and Pearce 1998; Huovila and Koskela 1998; Salvatierra-Garrido et al. 2010). This is a call for sustainability 'beyond buildings.'

[1] PhD Candidate, School of Design and Architecture, Department of Building Construction, Virginia Polytechnic Institute and State University, 410 Bishop-Favrao Hall, Blacksburg, VA, 24061-0156, USA, phone +1(801) 201-1388, vnovak@vt.edu

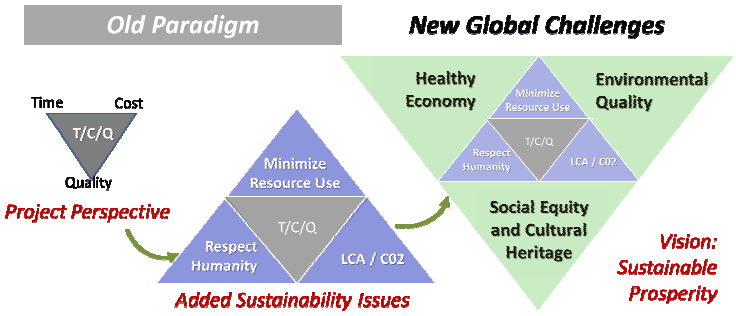

Figure 1: Paradigm shift of value, after Augenbroe, Pearce 1998; Huovila and Koskela 1998.

This systems thinking approach poses a challenge for the construction industry, which is very much rooted in the Tayloristic perspective of disaggregating the whole into a sum of its parts (Miller 2009). This compartmentalization of activities has resulted in increasing cost and delays, coupled with declining quality (Kelly et al. 2004), and a reactive management of risk aversion and low bid contracting. The overall operating mode is restrictive and limiting (Figure 2). As a result, project scope is constrained by the tension between time, cost and quality, and capped by the negotiated specifications. There is no incentive, financial or other, to add value to the project.

Past – Restrictive Mode	Future – Revitalizing Strategy
Construction – • Risk aversion, silo activities • Constrained by time/cost and quality, • Value limited by prescriptive specifications	Value Optimizing Construction • Collaborative, shared risk/reward, integrated • Beyond T/C/Q, value for contingency funds • Value enhanced by performance goals
Sustainability • Waste reduction , based on scarcity • Minimization of carbon footprint • Reductionist benchmarks 'green building"	Sustainable Prosperity • Resource renewal, optimizing use • Economic, Social and Environmental Balance • Systems thinking

Figure 2: Past/ Future of Construction Management (Source: author)

Similarly, the sustainability in construction is typically expressed through green building programs, which have delimited criteria within individual activities. Based on the economics of scarcity, the goals are reduced consumption and minimization of the carbon footprint. Superimposing these criteria on traditional delivery methods results in cost increases from non-traditional materials, raised expectations as to building performance and added costs for project documentation (Klotz et al. 2007; Koskela 1999; Mogge 2004). This activity based incremental thinking may also overlook the potential for leapfrog innovations which can result from whole systems thinking (Hawken et al. 1999). The industry has recognized this limitation and called for a radical change, not just to fix the process, but to transform it to deliver value beyond the tangible building product (Miller 2009). Lean construction stands out as the one approach which can facilitate the net enhancement of sustainability value and fully integrate the design and delivery processes (Lapinski et al. 2006).

THEORY

Lean construction can be understood as a philosophy and production process which redresses the T/C/Q balance by 'increasing value while reducing waste' (Howell 1997). Yet, lean implementation often starts with waste reduction, practiced in the isolation of existing activity silos. This is reductionist at best, and may also result in upsetting the already precarious project flow (Cusumano 1994). Value is also typically presented in a compartmentalized view, in measurable attributes of 'materials, parts, product' as related to cost (Womack and Jones 1996). In lean construction, this concept of value has mainly been addressed in the production process, thus defining the waste. In Koskela's proposed Transformation-Flow-Value model of construction management, a more integrated and balanced approach would also support the elimination of non-value adding activities through flow management, and the generation and management of value (Koskela 1999).

Value is a relative and subjective term, dependent and ever-changing with the context (Salvatierra-Garrido et al. 2010). Customer values represents different interests from owner, users and society, all of which are embedded within a continuous value chain (Bertelsen and Emmitt 2005; Kelly et al. 2004). As society is intrinsically part of a global system, value generation must be considered in relation to the external environment and social problems (Salvatierra-Garrido et al. 2010). Understanding and making this collective value tangible in the briefing and design phases can be pivotal in delivering value and defining waste. The lean community has pioneered a Target Value Design model to facilitate the involvement and consideration of needs from all user groups, including sustainability concerns.

Studies in value management are shaping the understanding of designing for the future (Kelly and Male 1993; Ziegler 1991). The author's research focuses on the corresponding future concept of a 'value-enhancing' construction process, which could support a transition to resource revitalization and sustainable value creation (Laszlo and Cooperrider 2007; Worldwatch 2012).

WORKING PROPOSITION

While previous empirical studies have explored the correlation of lean practices with green building from the perspective of waste reduction (Pulaski and Horman 2005; Sanvido 1990), this exploratory study offers a unique focus on the potential contribution of lean construction towards the creation of enhanced value in the context of sustainability. This opportunity for value beyond the specifications has emerged as projects with highly developed lean practices have reliably broken through the traditional project tensions. This research examines the proposition that there can be a synergistic link between lean construction and sustainability, as expressed through the construct of value.

This proposition is developed through the logical linking of three sequential areas of inquiry (Figure 3). The first explores the correlation between increased cohesiveness of lean with the delivery of project value. The second area of inquiry covers the relationship of the specific project-centric values with the company sustainability values, and the impact on the project processes.

A final line of inquiry brings the logic of the proposition to a full circle, by examining the opportunity for this broader vision of sustainability to serve as a point of reference to distinguish value from waste, at a project level. Establishing value as an appropriate construct of change in the context of the construction process provides a focal point for the implementation of construction process improvements.

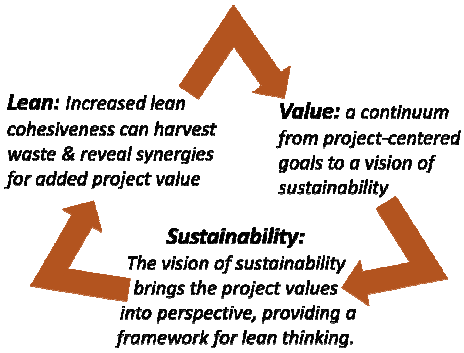

Figure 3: Logical Linking of Proposition (Source: author)

METHODOLOGY

A case study methodology was chosen to best address the exploratory nature of the proposition by investigating exemplary events in the field of lean in construction. The contemporary nature of the phenomena also offers an opportunity for rich data from interviews and surveys.

The selection of cases was based on the criterion of USGBC LEED certification and high level integration of lean thinking, which were verified through survey data. Three cases were chosen that have unique geography, owners and contractors, but are united by the common market sector of secondary education. All three contracts were design-build delivery, as designated by the projects' regulatory environment. However, all three modified the delivery method to include the owner in the core team and establish a shared risk and reward mechanism.

Data are gathered through survey and interviews of both prime contractor and owners, offering a two point perspective for enhanced data quality and reliability. The construct validity of the overall research question was the key driver in the design of this case study. Is there a relationship between the integration of lean and sustainability? Is 'value' an appropriate measure? The internal validity of this case study was addressed through the structuring of the interviews with open ended questions and giving participants the opportunity to offer additional commentary. This case study approach is exploratory, and is generalizable to theory development.

FINDINGS

From the collected data, in-depth case descriptions were developed through an analytic strategy of theme identification and inter-case data points. The phenomena of lean and sustainability are assessed independently, and then compared for areas of similarities, compatibility and synergy.

INTEGRATION OF LEAN IN PRACTICES AND PHASES OF CONSTRUCTION

The first area of inquiry explored the integration of lean within the construction design and delivery processes. As the data is based on perceptions of the participants, the two point perspective of the owner and the general contractor provides some level of reliability and additional insight into the cohesion of understanding of lean.

Lean Thinking in construction phases:	Project #1		Project #2		Project #3	
	Owner	GC	Owner	GC	Owner	GC
Programming		Yes	yes		yes	
Design	yes	Yes	yes	yes	yes	yes
Procurement			yes	yes	yes	
Construction	yes	yes	yes	yes	yes	yes
Ops & Maintenance			yes		yes	
% of lean integration - both parties	2 of 5	40%	3 of 5	60%	2 of 5	40%
either/ or	3 of 5	60%	5 of 5	100%	5 of 5	100%
% inter-rater agreement	2 of 3	67%	3/5	60%	2/5	40%

#1: Pre-selection of primary sub-contractors and vendors

Figure 4: Lean Thinking in Construction Phases

What? Scope of Integration in Phases and Practices

The data from the three cases exhibits very distinct scopes of integration. The perceptions of integration in Projects#1 and #3 showed a disparity between contractor and owner in the perception of lean integration in the phases of construction (Figure 4) and the practices (Figure 5). The low inter-rater agreement on use of tools and practices would indicate a lack of communication, or recognition of the practices and tools by the lean nomenclature. Data gleaned from the interviews confirms the lack of cohesion of lean as a philosophy, rather an emphasis of lean as practices. Project #1 was very much contractor driven, with complementary, but independent lean practices cited by the owner. Project #3 was owner driven in design and construction oversight, but the contractor's understanding of lean was limited to the Last Planner.

By contrast, Project #2 respondents had much higher levels of agreement (60% phases, 67% practices) on the integration of lean. This project also indicated the highest level of implementation of the tools and practices cited in the survey. Lean was described by one interviewee as IPD enhanced by Target Value Design, and supported by the Last Planner.

	Use of Lean Tools and Practices:	Project #1		Project #2		Project #3	
		Owner	GC	Owner	GC	Owner	GC
Design	IPD (Integrated Project Delivery)	yes		yes	yes		
	IFOA/ IPD Contractual Agreement			yes		yes	
	Value Stream Mapping			yes	yes	yes	
	Set Based Design			yes	yes		
	Target Value Costing		yes	yes	yes	yes	
Construction	Just In Time Supply			yes	yes	yes	
	Partnering	yes		yes	yes	yes	
	Last Planner System		yes	yes	yes	yes	yes
	Prefabrication		yes	yes	yes		
	Modularization			yes	yes		
Lean Tools	6 Sigma						
	Kaizen Events			yes			
	Choosing by Advantages			yes			
	% of lean integration - both parties	0 of 13	0%	9 of 13	69%	1 of 13	8%
	either /or	5 of 13	38%	12 of 13	92%	6 of 13	46%
	% inter-rater agreement	0 / 5	0%	8/ 12	67%	1/6	17%

NOTES: #1: Collaborative Design Process (CDP), Colocation, BIM for collision checking
#2: Kaizen is less formal, more integrated, a way of thinking rather than a series of events.

Figure 5: Use of Lean Tools and Practices

The survey provided an opportunity for additional commentary. Building Information Modeling (BIM) was suggested by one participant as a tool for clash detection, but neither the survey nor following interviews identified BIM as mandatory for lean construction.

How? Structure of Integration

The research also examined the structure of the integration of lean. In all three projects, design-build was the contractual delivery method, as it was proscribed by the funding agency. However, these contracts were then adjusted to accommodate a shared risk and reward structure through the contingency funding. Some of the participants also commented that IFOA contracts are helpful, but not a guarantee of a fully integrated lean process.

The data from the interviews also provided an insight into the difference between a fully integrated design and delivery process vs. a concurrent design and delivery brought about by organizational restructuring. In Project #2, the design process clearly engaged the efforts of owner, GC, professionals and trades in problem solving, target costing, set based design and value stream mapping. This was not just a reporting process, rather a continuous and 'real-time' design and estimating process, which, had been developed out of frustration with 'traditional stop/start design processes.' The phases are recognized, but not formalized. Value stream mapping was used throughout construction to adjust for unexpected complications and costs. By contrast, in the other two projects, the phases of construction seem to have remained relatively unchanged, despite the co-location of the core design team.

Who? Champions

Another perspective is from the level of involvement of the players, in both lean and sustainability initiatives. First, the research compared the source of the champion for lean and for green building (Figure 6). The projects exhibited similar patterns to those identified in the scope. The cohesiveness in understanding of the level of project integration in Project #2 could be traced to a shared championing of both lean and green building initiatives. Surprisingly, this project was the only one which cited resistance on the part of the architect and engineer (due to an unwillingness to share in the creation of ideas), as well as initial push-back from the managing partners of the trades. However, all project interviewees were adamant about the need for complete commitment from the owner group and the contractor. This is in contrast with the more common industry emphasis on the collaboration between designer and contractor, for example through IPD or design-build.

Champion:	Project #1		Project #2		Project #3	
	Owner	GC	Owner	GC	Owner	GC
Champion for Lean?	Contr.	Contr.	Owner + contr.	Contr. + Owner	Owner	Contr.
Champion for Green?	Contr.	Contr.	Owner + contr.	Owner + contr.	Owner	Owner
	Contractor Driven		Jointly Driven		Owner Driven	

Figure 6: Champions of Lean and Green Building

CONTINUUM OF VALUE PARADIGM FROM PROJECT TO SUSTAINABILITY

The second area of inquiry explores the construct of value. If lean thinking is defined as 'increasing value while decreasing waste,' then what is value? Is value defined and created by the absence of waste, does value define waste, or can value exceed that which created by waste reduction? For example, on project #3, in which both participants identified the potential of lean integration, the goal was to reveal more waste, with no specific mention of value. This might indicate a concept of value creation through the absence of waste. Only Project #2 participants identified the potential for revealing value, and offered specific examples. This section of the research explores the relationship of value from the perspective of a project-based concept of quality, to value as understood through sustainability at a global level.

The collected data identified a strong correlation between the existence of a corporate vision statement which included sustainability and the championing of green on the project case study (Figure 6). On Project #1 the contractor company had a sustainability vision to 'empower clients to make informed decisions regarding sustainability.' The client, on the other hand, had no known vision statement regarding sustainability. The reverse as true on Project #3, where the client had a defined commitment of 'environmental stewardship driving the educational mission,' while the contractor cited compliance with LEED goals. The pattern was consistent with previous findings that in Project #2 both owner and contractor had stated commitments to sustainability at the corporate level.

The survey also established percentages of overall participant business which used some level of green building. On Projects #1 and #3, the contractors cited only partial levels (40% and 85% respectively), while Project #2 cited 100%. Follow-up questions during the interviews identified that while LEED certification had increased awareness of green building, it also created barriers to sustainability goals outside of this benchmark. One contractor also noted that they did a lot of civil work, which did not fall under any green certification.

Many of the participant comments also revealed that green building was understood solely within the context of green building criteria, and not within the triple bottom line of sustainability, which would also include social and economic goals. There were notable exceptions, such as the contractor of Project #1, who provided several insightful examples of how sustainability goals such as day lighting can align with client goals such as educational performance improvements.

VISION OF SUSTAINABILITY BRINGS THE PROJECT VALUE INTO PERSPECTIVE

The final area of inquiry brings the logic of the proposition to a full circle, by examining the opportunity for *project* 'value' to be understood relative to a broader perspective of global *sustainability* value. Participants were asked for their perspectives on the proposition that: "the vision of sustainability brings the project values into perspective, providing a framework for lean thinking."

The responses were very consistent with previously identified patterns among the cases. Project #2 participants were in absolute agreement, stating 'that's how you get from gold to platinum,' and 'this is critical to identifying innovations.' They had sustainability goals beyond LEED, and could cite several examples. Both participants also expressed that the greater goals of sustainability help to break through the barriers in the design phase, to capture synergies of resources to support the

additional value. The contractor on Project #1 was also supportive, citing several examples of product improvements driven by sustainability goals which exceeded project specifications, but which decreased waste and thus were self-financed.

Lean was also cited as breaking through the barrier of excessive detailing of prescriptive specifications. As the design process includes more discussion and alignment of project values and goals, it allows the opportunity for field interpretation for the benefit of the project. Workers adhere to best practice installations, but aren't constrained in the details. Materials submittals are a confirmation of previous project decisions and a submittal of technical information for operations & maintenance.

Consistent with previous data patterns, the owner on Project #1 and the contractor on project #3 did not immediately recognize the conceptual relationship between sustainability goals and lean construction. However, both projects cited the benefit of including a non-construction member on the core team, to challenge each aspect of design relative to the perspective of the user group, a community group, or broader issues of sustainability. This is, in essence, the concept expressed in a practical application and a demonstration of how sustainability can drive behavior.

CONCLUSIONS

The significance of this research rests in the opportunity for the construct of value to serve as a catalyst which shifts construction management from negative 'restrictive' overtones to a paradigm of positive sustainable prosperity. The case study findings correlate elements of lean thinking and lean construction with the integration of sustainability in the design and delivery.

The three cases exhibited patterns which were consistent and showed a strong correlation between lean and sustainability. Project #1 and #3 were driven by one stakeholder, contractor or owner. The other party was compliant but not as engaged. The lean activities were compatible, but not synergistic. Only Project #2 had a shared committed leadership. Their level of engagement was very similar through all the phases, practices, scope, structure and leadership. The participants from this project actively leverage the synergy that the integrated process of lean offers to the delivery of sustainability. They also understand a link between value from the project perspective and global sustainability perspective. This data indicates support of the research hypothesis, both by the absence of integration resulting in the absence of sustainability beyond LEED, and in the example of Project #2, which supports the synergistic link.

This research also identified several 'myth-busters' regarding both lean and sustainability:

- BIM and shared contractual agreements (IFOA) are received to be contributory but not mandatory for lean construction.
- Integration of lean is most effectively driven by a collaboration of the general contractor (GC) and the owner. The collaboration of the designer, engineer and trade in the IPD process are important, but lack of support can be worked around.
- Lean construction does not always include a focus on value delivery. Implementation of some lean tools may only be only concerned with the reduction of waste.

- Operational integration may result only in phase concurrency, not phase integration.
- There is a correlation between corporate vision statement, green champion, and integration of green within all project levels.

This exploratory research was designed to provide the burden of persuasion for further research on the following topics:

- Project value expressed as economic, social and environmental value.
- Empirical data capturing the characteristics of lean integration.
- Implementation of lean as a means of delivering sustainability prosperity values.

REFERENCES

Augenbroe, G., and Pearce, A. (1998). "Sustainable construction in the United States of America." *CIB World Congress*, CIB-W82, ed., CIB.

Bertelsen, S., and Emmitt, S. "The Client as a Complex System." *Proc., 13th Annual Meeting of the International Group for Lean Construction.*

Cusumano, M. A. (1994). "Limits of lean." *MIT Sloan Management Review*, 35(4), 27-32.

Hawken, P., Lovins, A. B., and Lovins, L. H. (1999). *Natural capitalism : creating the next industrial revolution*, Little, Brown and Co., Boston,MA.

Howell, G. A. "What is lean construction." *Proc., 7th Annual Conference of the International Group for Lean Construction*.

Huovila, P., and Koskela, L. "Contribution of the principles of lean construction to meet the challenges of sustainable development." *Proc., 6th Annual Meeing of the International Group Lean Construction*, IGLC.

Kelly, J., and Male, S. (1993). *Value management in design and construction: the economic management of projects*, E&FN Spon, London,U.K.

Kelly, J., Male, S., and Graham, D. (2004). *Value management of construction projects*, Blackwell Science, Oxford,U.K.

Klotz, L., Horman, M. J., and Bodenschatz, M. (2007). "A modeling protocol for evaluating green project delivery." *Journal of Lean Construction*, 3(1), 1-18.

Koskela, L. (1999). "We need a theory of construction." *White Papers for Berkeley-Stanford CE&M workshop*, Berkeley + Stanford, San Francisco,CA, 10.

Lapinski, A. R., Horman, M. J., and Riley, D. R. (2006). "Lean processes for sustainable project delivery." *Journal of Construction Engineering and Management*, 132(10), 1083-1091.

Laszlo, C., and Cooperrider, D. L. (2007). "Design for sustainable value: a whole system approach." *Designing Information and Organizations with a Positive Lens*, M. Avital, R. J. Boland, and D. L. Cooperrider, eds., Emerald Group Publishing Limited, Bingley, U.K., 15-29.

Miller, M. R. (2009). *The commercial real estate revolution : nine transforming keys to lowering costs, cutting waste, and driving change in a broken industry*, Wiley, Hoboken, NJ.

Mogge, J. (2004). "Breaking through the first cost barriers of sustainable planning, design and construction." PhD, Georgia Institute of Technology, Atlanta, GA.

Pulaski, M. H., and Horman, M. J. (2005). "Continuous value enhancement process." *Journal of Construction Engineering and Management*, 131(12), 1274-1282.
Salvatierra-Garrido, J., Pasquire, C., and Thorpe, T. "Critical Review of the Concept of Value in Lean Construction Theory." *Proc., 18th Annual Conference of the International Group for Lean Construction*, IGLC, 33-41.
Sanvido, V. (1990). "An integrated building process model."
WCED (1987). "Our Common Future: The Brundtland Report." World Commission on Environment and Development, ed., Oxford University Press, Oxford, U.K.
Womack, J. P., and Jones, D. T. (1996). *Lean thinking: banish waste and create wealth in your corporation*, Simon & Schuster, New York, NY.
Worldwatch (2012). "Defining sustainable prosperity." <www.worldwatch.org/>. (MAR 10, 2012).
Ziegler, W. (1991). "Envisioning the future." *Futures*, 23(5), 516-527.