THE AMBIGUITY OF VALUE

Jarkko J. Erikshammar[1], Anders Björnfot[2], and Viktor Gardelli[3]

ABSTRACT

'Value' is a central concept in all of the principles and methods applied in Lean Construction, but it is rather difficult to provide a precise definition of the term. The problem lies in the word value itself: its ambiguity and vagueness make theorization difficult. This paper investigates the philosophical concept of value from a Lean Construction perspective. Several elements that contribute to value are considered, including objective elements such as waste reduction, quality, price and functionality, and more subjective elements such as design.

The hypothesis of this paper is that the reduction or removal of elements that detract from value, such as waste and costs, is not the only means by which value may be increased. The Sorites paradox is used to form a cohesive perspective on some different meanings of the word 'value'. One of the known 'solutions' of the paradox, utilization theory, is then explored through a case study in off-site construction that illustrates how different actors in the construction process view value, and how utility theory can be used to provide a consensus on value that is acceptable.

In practice, 'value' is ambiguous because actors generally value different things and these views seldom converge during projects. Our results indicate that the actors involved strive for value individually. Analysis using utility theory allows the actors to establish a shared conceptualization of value, expressed in monetary terms. The work described in this paper aims to improve our understanding of value and of how to design products in construction to improve value for clients of industrialized housing.

KEY WORDS

Lean Construction, Value, Product, Philosophy Sorites paradox.

INTRODUCTION

Several efforts have been made to define the concept of value in Lean Construction (Salvatierro-Garrido et al, 2009; Bertelsen and Koskela, 2004, Kelly et al., 2004). Two main issues have been identified. The first has to do with the logical grammar of the term 'value', i.e. there seems to be an inadequate conceptualization of production which has led to imprecise concepts such as value (Koskela, 2004). Secondly, the metrics commonly used to define value do not seem to capture all of the attributes that are valued by the customer (Salvatierro-Garrido et al., 2009).

Waste reduction is a measurable value metric pursued by the Lean Construction community (e.g., Taylor and Björnsson, 2002, Josephson and Saukkoriipi, 2003, Höök, 2006). One reason for this is of course that waste is measurable. This approach

[1] M.Sc., Ph.D. Student, Department of Civil, Mining and Environmental Engineering, and member Timber Structures Research Group, Luleå University of Technology, SE-971 87 Luleå, Sweden, Phone +46 920 491 860, Fax +46 920 491 935, jarkko.erikshammar@ltu.se

[2] Ph.D., Department of Civil, Mining and Environmental Engineering, and manager of the TräIN project, Timber Structures Research Group, Luleå University of Technology, SE-971 87 Luleå, Sweden, Phone +46 920 492067, Fax +46 920 491 935, anders.bjornfot@ltu.se

[3] Ph.D. Student, Department of Education, Luleå University of Technology, SE-971 87 Luleå, Sweden, Phone +46 (0)920 491550, viktor.gardelli@ltu.se

has been criticized since it implies that reducing waste will always result in more value. Other ways of increasing or improving value are rarely discussed at all since they are difficult to measure and, consequently, difficult to understand.

However, even if waste reduction is the dominant way of improving value in Lean, there are certainly other ways that value can be managed. One approach is to focus on quality issues, or defect reduction, as in TQM. The impact of poor quality on value has been described by e.g. Saukkoriipi (2004). The impact of project control and supply chain control on value has also been investigated, with an emphasis on costs and earned-value (Kim and Ballard, 2000). Finally, some academics have made an effort to describe value generation in terms of capturing and describing functionality or clients' requirements (Leinonen and Huovila, 2000).

In construction design, the architect is the carrier of the clients' value. During the design process, the architect manages intangible attributes on which different actors will place different values. Emmit et al (2004, 2005) have suggested that these can be captured by *value design*, in which collaborative creative workshops are used

In light of the various perspectives on value discussed above, it is clear that the term value is subjective and therefore ambiguous. In this paper we present the utility theory, originating from the Sorites paradox, as a means of removing the ambiguity of the term value in construction.

The hypothesis of this paper is that the reduction or removal of elements that detract from value, such as waste and costs, is not the only means by which value may be increased. Instead we argue that the term value, as a whole, can be conceptualized and applied in practice using a philosophical method. First the context of the term value is defined within Lean Construction and then the Sorites paradox and utility theory are discussed. In addition, empirical results consisting of interviews with construction practitioners are used to verify the philosophical solution. To conclude, the significance of using a philosophical approach to a known problem and future research is discussed.

THE VALUE CONCEPT – A CONTEXTUAL OVERVIEW

Some concepts are straightforward: either you have a Ph.D. degree or you do not. Other concepts, such as 'being funny' or 'being tall,' are less straightforward: one can be funny in the sense of being amusing (cf. "John Cleese is a funny guy"), and one can also be funny in the sense of being strange (cf. "Forrest Gump is a funny guy"). Forrest Gump might be hilarious, but he is not comical, while John Cleese is. This shows that the predicate 'funny' is ambiguous. On the other hand, while the qualitative meaning of 'tall' is obvious, it is not clear exactly when 'tall' begins to apply: is someone who stands 1.80 m 'tall'? If not, how about 1.90 m? This indicates that 'tall' is a vague concept, involving boundary issues; there seem to be gray-zones where it is unclear whether the concept applies or not.

Value, as a theoretical concept, seems to be both ambiguous and vague, as the term itself can be viewed from many different perspectives.

VALUE IN CONSTRUCTION

The discussion on value within the Lean community mainly originates from Womack and Jones (2003) who state that value is the overall objective of any production system and describe the paradigm with what they call the Lean principles; Specify Value, Identify the value Stream, Flow, Pull, and Perfection.

Bertelsen and Koskela (2002) use the Transform-Flow-Value to define value in construction. The TFV model suggests that construction should be understood as the generation of value for the client. Value is generated by a process that forms a workflow of transformation performed by the contractor under a contractual arrangement. Koskela (2004) analyzed the five Lean principles and their theoretical deficiencies, and concluded that the common conceptualization of 'production' is inadequate, and that this has resulted in an imprecise definition and concept of the term 'value' that focuses on product delivery from a production point of view.

Value in construction has also been discussed by Christoffersen (2003) who states that the perception of value is individual and personal, i.e. it is subjective and will change over time. This was supported by Salvatierro-Garrido et al. (2009) who suggest that in the past, value in construction was defined primarily monetary, but that recently it has also come to be defined in terms such as function, cost and quality.

Product Offer Theory (Björnfot and Stehn, 2007) represents another perspective on the intangible nature of value. In this case, the product's technical platform requires the client to lock their options; "*value is specified by specific product for specific customers, which enables stability.*"

Classification of value being either internal or external (Emmit et al, 2005, Björnfot and Stehn, 2007) even when considered in relation to the value creation process as a whole rather than the project is valuable in many situations but does not necessarily describe the elements of value.

Lean Construction members have advocated an expanded definition of the term 'stakeholders' that extends beyond project group members to encompass the whole construction process, and potentially even society as a whole (Ballard 2006, Kelly et al, 2004). The question raised is "value for whom?", and the conclusion is that each actor has their own definition of value, which is subject to change over time.

Value as Waste Reduction

The Lean Construction has focused heavily on waste reduction and consequently, the concept of value has been transformed to something it is not (Arbulu and Tommelein, 2002, Alwi et al 2002). However, value cannot be achieved solely through waste reduction (Salvatierro-Garrido et al 2009). The key is to understand the customer's perception of value and strive for that. Once the value flow has been decided, waste reduction can start. An unduly heavy emphasis on waste reduction could even become counterproductive, with low inventory or a lack of productive capacity leading to supply chain disruptions. Consequently, value cannot be achieved through waste reduction alone:

Value ≠ Waste Reduction

Value as Quality

Quality management has traditionally sought to achieve customer satisfaction through process control and defect reduction. In recent years, its definition has expanded somewhat to encompass capturing customer satisfaction in relation to customer needs (Bergman and Klefsjö, 2010). In this way, customer satisfaction can be related to the quality or value delivered to the customer. The ideas behind lean production are in harmony with total quality management (Bergman and Klefsjö, 2010); defect reduction needs a defined process, that can be measured, and that aims to reduce or eliminate variation by treating each deviation as an opportunity for improvement. As is the case with waste reduction, a system that places excessive emphasis on reducing process variation may be counterproductive in terms of increasing value. Hence, the reduction of process variation or defects is not the only way to increase value:

Value ≠ Variation Reduction

Value as Price

According to Salvatierro-Garrido et al. (2009), value cannot be described in monetary units alone. It has, however, been suggested that value can be added by increasing stakeholder value, either by reducing the price charged to the customer or by reducing the producer’s costs (Vaidyanathan, 2003; Lindfors, 2000). Risk reduction is a key objective in supply chain management because disruptions of the supply chain are costly. By reducing activities, or risks, costs can be minimized in order to increase value. Costs can be lowered further by reducing buffers and operational costs or by increasing throughput. Hence, decreasing costs is not the only way to add value:

Value ≠ Cost Reduction

Value as Function

Clearly stated functional requirements reduce client uncertainty by providing unambiguous definitions of both the functionality of the object and the customer's requirements (Lennartsson et al, 2008, Nam Suh, 1998). However, the reduction of uncertainty does not confer value in and of itself: the object may be better defined according to the product offer theory, but that does not explain how or why different stakeholders assign different values to the same functional requirements:

Value ≠ Uncertainty Reduction

Value as Design

Emmitt et al (2005) discuss the importance of focusing on value early in the design process, and argue that it can be enhanced by efficient communication and cooperation between the client and the other stakeholders. Classically, the architect's job is to translate the client's needs and visions into a realisable set of plans and concepts; design thus plays a central role in value creation. The intangible elements of value in construction relate to the Vitruvian values - Beauty, Functionality, Durability, Suitability, Sustainability, and Buildability (Emmitt et al., 2005). Architects qualitatively capture intangible values through e.g. material samples and prototypes. Good design must pay equal attention to all of these intangible elements: beauty without function is not good design, and so we can state that

Value ≠ Design

On the basis of the reasoning above, we can conclude that value cannot be understood simply by considering one individual element such as waste reduction. Instead, value should be seen as the sum of its various elements since each actor values each element differently (Figure 1). Thus, value is created through the combination of all of the elements discussed above. This can be illustrated using a mathematical function:

Value = f(Waste | Variation | Cost | Uncertainty | Design)

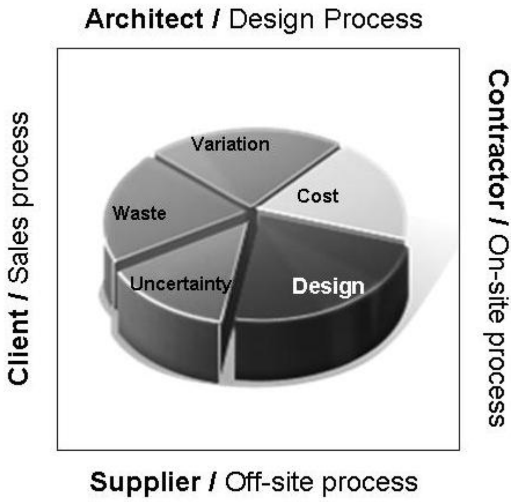

Figure 1: Value illustrated as a sum of the individual elements.

SORITES PARADOX

The Sorites Paradox is a paradox of vagueness. The paradox, first stated in 700 B.C, takes the form of an argument with two seemingly uncontroversial premises that yield a paradoxical solution:

(1) A collection of 10 billion grains is a heap

(2) Removing 1 grain does not cause a heap to cease to be a heap.

(3) Hence: A collection of two grains is a heap.

By iteration, the 10 billion grain heap can be reduced to a 'heap' of two grains, which most would not consider to be a heap. Several solutions to the Sorites paradox have been suggested (Hyde, 2008); we focus on a pragmatic solution called weak conventionalism (c.f. Giedymin, 1982), which sets aside the deeper problem of determining the 'real' truth in favour of establishing a group consensus on the matter (c.f. Quine, 1981). This approach can be used to deal with the problem of the ambiguity of value. Hence, we suggest that the various actors in the construction process should collaborate and strive to understand one another's priorities in order to establish a collective working definition of value.

Utility Theory

If this proposed definition of value is to be applied in practice, it would be beneficial to be able to measure the different elements of value on a single scale, so as to conveniently determine how much emphasis the different actors place on any given element. For instance, one might wish to determine the relative importance of costs and design to each actor. This can be done using von Neumann-Morgenstern utility theory (Resnik, 1987; von Neumann & Morgenstern, 1947). Suppose that you present a client with a plan for a building, on which it would be possible to make one of three different improvements: superior waste reduction, fewer defects in construction, or enhanced functionality. Suppose he prefers functionality to waste reduction, and waste reduction to defect reduction. We want to know how much more, in order to know what monetary value to assign to the different options. Utility theory suggests that we can use hypothetical lotteries to answer this question.

Suppose that the client would be indifferent between reducing *Waste* on the one hand and on the other hand a lottery with a 75 % chance of reducing *Uncertainty* and a 25 % chance of reducing *Variation*. Then we assign the utility-numbers to the options as follows: 1 to Uncertainty, 0.75 to *Variation* and 0 to *Waste*. Hence, we can assign numerical values to the different options and by iteration we can assign monetary values to each possible alternative. This can be used both within *Design* to find out e.g. how much a certain client would value one façade over another, but also to find the balance in weight assigned to *Design* in comparison to some other attribute.

METHOD

A qualitative case study focusing on the product development process was conducted, whose design and analysis was based on the approaches discussed in the preceding section of this paper; the sources of the data analysed are shown in Table 1. The process was led by a Swedish off-site timber construction company. The company produces detached dwellings for leisure and for single- or family-occupancy; the dwellings are constructed using pre-fabricated elements that are assembled on-site. The construction company invited eight suppliers to collaborate in the design and production of single family housing for the B2B market. Rather than using a traditional approach to development, the idea was to collaborate, i.e., the suppliers were to become part of the product development process and design input was provided by architects and potential clients. It was anticipated that collaboration would lead to a better housing design and a more efficient supply chain.

Table 1: Sources of data obtained during the product development process.

Data collection	Number
Interviews	12
Group Interviews	7
e-mail	1358

RESULTS AND ANALYSIS

The product development process was conducted during a series of joint meetings, supported by the authors. However; the project ran into a number of early problems. The first product developed by the group seemed to have no value for the client, and it rapidly became apparent that the group did not have a well-defined target customer for their product. The project team then decided to use a product development method used by small companies, but quickly became troubled by the price of the new design. The technique of target costing was tried, but as it was unfamiliar to many of the participants, it did not prove useful. These problems led the group to consider questions of value, such as “Who is our client and what do they value?” and “How can we incorporate these values into our design?” The project group began to lose focus, and the contractor decided to slow down the development.

Interviews with clients made it clear that the market valued different things in the tender phase than did the producer. It also became apparent that production personnel tended to ignore input from the design process, presuming that features intended to add value would only serve to increase the cost of construction. The production personnel also tended to consider design input to be vague and difficult to understand. The suppliers did not seek to play an active role in the design process, and were content to sit back and wait for an order to produce, which is the way they are used to working in traditional construction.

Using the theory outlined in the preceding sections together with the empirical data collected, an analysis was performed using utility theory and the composite model of value illustrated in Figure 1. Utility theory was used to determine the monetary 'value' of Design to each actor, as this is the only element whose 'value' is not easily specified in monetary terms. On the basis of the empirical data, it is possible to define three archetypical actors in the value creation process; the self-righteous client, the mean contractor, and the structured supplier, all of whom prioritise different elements of value. For example, the client may wish to secure his long term investments, while the contractor would tend to focus more on his short term economical gains from each project.

THE SELF-RIGHTEOUS CLIENT

The stated primary desire of the self-righteous client is to obtain a defect-free product. The client's project manager is an old school site manager who knows that while costs do not vary much, contractors tend to take short-cuts when it comes to quality. He considers himself to have an extensive knowledge and is keen to bargain and haggle.

Using utility theory, we sought to evaluate the client's true desires by means of a lottery, weighing various elements of value against quality improvements. After iteration, and having assigned utility numbers we could state that the actual priorities of the self-righteous client value are as follows (illustrated in Figure 2):

Cost > Variation > Design > Uncertainty > Waste

Similarly, the lottery can be used to determine the monetary value of design to the client; no such procedure is required to determine the monetary value of the other elements, as their costs are readily evaluated. Therefore we can relate design to cost by stating that (where 1 and 2 symbolizes any numerical value):

(1) Design > Uncertainty > 1 AND Design < Cost < 2

(2) Hence: 1 < Design < 2

THE MEAN CONTRACTOR

The mean contractor is primarily interested in costs and time. He needs to deliver the project on time even if the architect is late in delivering the plans. He knows that one thing design is good for is that it can always be used as a bargaining chip when negotiating the contractually-acceptable level of the job. After some iteration and the assignment of utility numbers, the elements of value prioritised by the contractor were ranked as follows (Figure 2):

Cost > Waste > Variation > Uncertainty > Design

As was done with the client, a hypothetical lottery was used to assign a monetary value to design. The structured supplier (Figure 2) and other actors in the construction process emphasise other elements of value. Using similar reasoning and procedures to those described above, it was determined that the supplier is most keen on waste reduction. Of course, because value is subjective in nature, other clients, contractors, and suppliers will prioritize different elements of value.

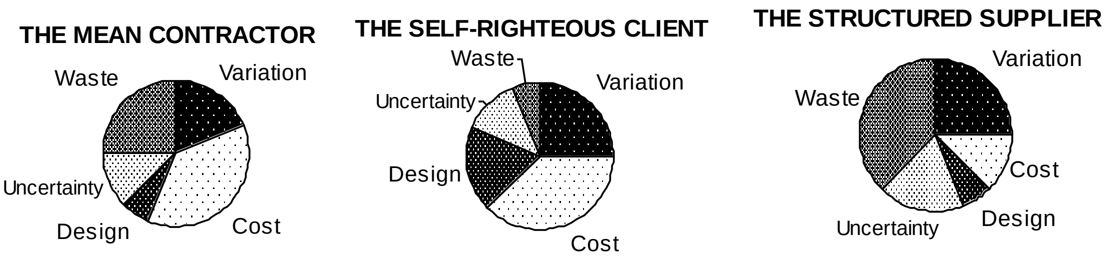

Figure 2: Exemplification of the emphasis placed by the archetypal actors on the different elements of value.

DISCUSSION & CONCLUSIONS

We argue that the reduction or removal of elements that detract from value, such as waste and costs, is not the only means by which value may be increased; this position is supported by both theoretical and practical results. Our theory identifies five different elements that contribute to value, while the empirical results demonstrate that different actors (exemplified by a client, a contractor, and a supplier) do indeed have different opinions on what constitutes 'value'. However, the results do not conclusively prove or disprove the hypothesis. The analysis shows that it is reasonable to think of the overall 'value' of a project as a multivariable function of the different elements of value. Therefore, any analysis that focuses exclusively on one element will only tell part of the story. However, further work is required to obtain a deeper understanding of the elements and the ways in which they are interrelated.

If a project is to be successful, it is important that every actor involved obtain some form of value from it. In construction projects, value is often something that is not gained during the process, but is instead accumulated by other means such as extra work. Actors do also value different things and their views seldom converge during projects. The Lean Construction promotes close collaboration; however, results show that the actors involved strive for value individually. Therefore, the establishment of a consensus definition of 'value' to all of the actors involved is a necessary prerequisite for successful collaboration. Such a consensus can only be established by removing the ambiguity in the meaning of 'value', which necessitates a method for placing monetary units on the more qualitative and subjective elements that contribute to value, such as design.

We have suggested that utility theory may be a useful tool for assigning monetary values to these elements; this allows actors to whom such elements are important to express their priorities on the same terms as are used when discussing more conventional costs. We propose that at the start of the project, a quantitative evaluation of each actor's value preferences in terms of the five elements of value discussed in this paper should be performed, generating data similar to that shown in Figure 2. This is similar to the assessments performed in *value design*.

Further research into the application of utility theory is required. Additionally, research aimed at identifying practical solutions to these problems is warranted: a significant limitation of the method discussed in this paper is its reliance on hypothetical lotteries, which are not readily applied in practice. It is not evident that the use of our definitions and solutions to the problems discussed in the paper will necessarily lead to more efficient management of value, although the results obtained so far are promising. There is also a need, in Lean Construction, to further develop methods for the quantitative assessment of qualitative elements of value in the design process, especially from a perspective other than that of production.

ACKNOWLEDGMENTS

Most of the ideas presented in this article were developed in the course of research conducted at the case study generated by the TräIN program (www.trainorr.se). Special thanks to Dan Engström, Helena Johnsson, and Lars Stehn, for their insights.

REFERENCES

Alwi S, Hampson K., and Mohamed S. (2002). "Non Value-Adding Activities: A Comparative Study of Indonesian and Australian Construction Projects" *Proc of the 10th Annual Conference on Lean Construction*, IGLC, Gramado, Brazil.

Arbulu R. J., and Tommelein I. D. (2002). "Value Stream Analysis of Construction Supply Chains: Case study on Pipe Supports used in Power Plants" *Proc of the 10th Annual Conference on Lean Construction*, IGLC, Gramado, Brazil.

Bertelsen, S. and Koskela, L. (2002). "Managing the three Aspects of Production in Construction" *Proc of the 10th Annual Conf. on Lean Constr.*, IGLC, Brazil.

Bertelsen, S., and Koskela, L. (2004). "Construction Beyond Lean: A new understanding of construction management." *Proc., 12th Annual Conference on Lean Construction*, IGLC, Elsinore, Denmark, 1-12.

Bergman, B., and Klefsjö, B. (2010). *Quality from customer needs to customer satisfaction*, Studentlitteratur, Lund.

Björnfot, A., and Stehn, L. (2007). "Value Delivery through Product Offers: A Lean Leap in Multi-Story Timber Housing Construction." *Lean Constr. Journal*, 3(1), 23-45.

Emmit, S., Sander, D., Christoffersen, AK. (2004). "Implementing Value Through Lean Design Management" *Proc., 12th Annual Conference on Lean Construction*, IGLC, Elsinore, Denmark, .

Emmit, S., Sander, D., Christoffersen, AK. (2005). "The value Universe: Defining a value Based Approach to Lean Construction" *Proc., 13th Annual Conference on Lean Construction*, IGLC, Sydney, Australia, 57-64 .

Giedymin, J. (1982). *Science and convention. Essay on Henri Poincaré's philosophy of science and the conventionalist tradition.* Oxford: Pergamon Press.

Höök, M. (2006). "Customer value in lean Prefabrication of Housing considering both Construction and Manufacturing" *Proc., 14th Annual Conference on Lean Construction*, IGLC, Santiago, Chile, 583-594.

Hyde, D. (2008). *Sorites Paradox. In E. N. Zalta* (Ed.), The Stanford Encyclopedia of Philosophy (Fall 2008 Edition ed.).

Josephson, P-E., and Saukkoriipi L. (2003). "Non Value-Adding Activities in Building Projects: a Preliminary Categorization" *Proc., 11th Annual Conference on Lean Construction*, IGLC, Virginia, USA, .

Kim, Y-W., and Ballard G (2000). "Is the Earned-value Method an Enemy of Work-Flow" *Proc., 9th Annual Conference on Lean Construction*, IGLC, England.

Koskela, L. (2004). "Moving On- Beyond Lean thinking." *Lean Constr. Journal, 1(1)*, 24-37.

Kelly, J., Male, S., and Graham, D. (2004) "Value Management of Construction Projects.", Blackwell Science, Oxford.

Leinonen J., and Huovila P. (2000). "The House of the Rising Value" *Proc., 9th Annual Conference on Lean Construction*, IGLC, Brighton, England, .

Lennartsson M., Björnfot A., and Stehn L. (2008) ”Lean Modular Design: Value-based progress of industrialised housing” Proc., 16*th Annual Conference on Lean Construction*, IGLC, Brighton, England.

Lindfors C. (2000). “Value Chain Management in Construction: Controlling the House building Process” *Proc., 9th Annual Conference on Lean Construction*, IGLC, Brighton, England.

Quine, W. V. (1981). “What price bivalence?” *Journal of Philosophy, 77, 90-95*.

Resnik, M. D. (1987). *Choices: an introduction to decision theory.* Minneapolis: University of Minnesota Press.

Suh, P., Nam. (1998). “Axiomatic Design Theory for Systems” *Research in Engineering Design, 10(4),* 189-209.

Salvatierra-Garrido, J., Pasquire C., and Thorpe T. (2009). “Value in Construction from a Lean Thinking perspective: Current State and Future Development” *Proc., 17th Annual Conference on Lean Construction*, IGLC, Taipei, Taiwan, 281-294.

Saukkoriipi, L. (2004). “Perspectives on Non-Value Added Activities: The Case of Piece-Rate in the Swedish Construction Industry” *Proc., 12th Annual Conference on Lean Construction*, IGLC, Elsinore, Denmark, .

Taylor J., and Björnsson H. (2002). “Identification and Classification of value Drivers for a New Production Homebuilding Supply Chain” *Proc., 10th Annual Conference on Lean Construction*, Gramado, Brazil, 1-12.

Vaidyanathan K. (2003). “Value of visibility and Planning in an Engineering-to-order Environment” *Proc., 11th Annual Conference on Lean Construction*, IGLC, USA.

von Neumann, J., & Morgenstern, O. (1947). *Theory of games and economic behavior (2nd ed.)*. Princeton, N.J.: Princeton University Press.