

# AN ANALYSIS OF DECISION-MAKING THEORIES APPLIED TO LEAN CONSTRUCTION

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## ABSTRACT

A critical review of decision making theory aspects of relevance to Lean Construction is presented in this study. It hypothesizes that decision making processes have substantial implications to the development and implementation of Lean Construction. Specifically, this study has the objective of identifying the natural human tendencies concerning decision making that can distort rational outcomes of relevance to Lean construction and the Lean Construction features that could be impacted by these biases.

It is concluded that Lean Construction can be described as an enriched option, with more salient features relative to traditional management approaches. Enriched options lead to stronger reactions of adoption and rejection depending on the framing used for their discussion. Lean Construction techniques such as phasing scheduling in the Last Planner System™ can be impacted by the brainstormed number and order of ideas. The human tendency to defer decisions when many similar options are available could lead to a delay in the perceived last responsible moment to make a decision under such conditions. An alternative can be rejected when it contains features perceived as not adding value to current needs, even if the features do not carry any cost. This could point to the need for a gradual introduction of the possibilities offered by Lean Construction at the initial stages of an individual implementation. The role of psychology in the creation, management and even manipulation of value in a Lean Construction context needs further consideration.

The findings of this study are interpretations and extrapolations from areas other than construction management and Lean Construction. They need to be validated by further research.

## KEYWORDS

Theory, Lean Construction, Decision Making, Language / linguistic action

## INTRODUCTION

All humans, individually and in groups, constantly need to make decisions. As Tannenbaum (1964) points out, the need for making decisions arises "out of the fact that knowledge of relevant existing facts is inadequate and that the future is uncertain." Every decision relies to some extent on assumptions that lead to selecting one choice over its alternatives. These assumptions fill in the inevitable holes arising from imperfect information and outcome uncertainty.

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Lean Thinking (Womack 1996) provides comparatively “more autonomy in production decisions and enriched jobs as a consequence of the lean principles regarding distributed decision making, multi-skilling, and pursuit of perfection” (Howell and Ballard 1999). Lean Construction has adapted Lean principles to the construction industry (Koskela 1992). It considers that many project planning and execution decisions should be made field managers, since these individuals are in the best position for understanding the decision at hand (Howell and Ballard 1998). A construction project has many possible alternatives for action at any given point. Lean Construction and its techniques such as the Last Planner System™ (Ballard 2000a) provide guidelines for these required decisions, but in final analysis, each one is the outcome of human thinking only informed by these recommendations. The central role of decision making in Lean Construction management makes imperative the understanding of the decision making mechanisms underlying the actions required to complete a construction project.

### **HYPOTHESIS, OBJECTIVES AND METHODOLOGY**

This paper investigates decision making theory aspects of relevance to Lean Construction.

The hypothesis probed by this study is that decision making processes have substantial implications to the development and implementation of Lean Construction.

The methodology followed to test this hypothesis consists of a critical review of selected decision making theory and experiments, examined from the perspective of generally accepted Lean Construction principles. The questions emphasized by this study are:

- Are there natural human tendencies concerning decision making that distort rational outcomes of relevance to Lean construction?
- What are the potential consequences of the natural human tendencies towards decision making for the theory and practice of Lean Construction?

This study also has the secondary objective of suggesting a new perspective on the definition of value, using the insight of decision making theories as a reference for expanding this concept, central to Lean Construction. This paper concentrates on the effect of individual cognitive limitations. Other studies (e.g., Gehbauer et al. 2006; Weick and Roberts 1993) have examined group behavior patterns.

### **DECISION MAKING PARADIGMS**

Many theories, models and paradigms have been forwarded for explaining human behavior when choosing among alternatives. This study groups these explanations into two distinct frames. The *Value Maximization paradigm* begins with the assumption that decisions are based on the human desire to maximize the value offered by the chosen alternative. Theories in this category assume that human beings act rationally, and offer a quasi-mathematical explanation and optimization of the decision making process. The *Intuitive Reasoning paradigm* groups theories based on evidence strongly suggesting that humans are influenced by factors more complex than the rational behavior assumed by the value maximization paradigm. These factors can be seemingly irrelevant to the decision at hand and lead to irrational

choices that are nevertheless consistent and predictable. The central assumption of the intuitive reasoning paradigm is, paraphrasing Ariely (2008), that human behavior in decision making can be predictably irrational.

### VALUE MAXIMIZATION PARADIGM

The Value Maximization paradigm is based on the concept of expected utility. It proposes that a decision maker will choose the option that maximizes the weighted sums obtained by adding the utility values of outcomes multiplied by their respective probabilities (Levy 1992). They have been the basis for many practical applications such as advertising strategies and financial forecasting

### Von Neumann Morgenstern Theory

The most mathematically oriented of theories under the Value Maximization paradigm is the *von Neumann Morgenstern Theory* (VNMT). It was introduced in 1944 as a mathematical theorem examining utility value behavior under risk (i.e., under known factors subject to probability in their outcomes (Neumann and Morgenstern 1944). In the VNMT, a person (or “agent”) is rational if and only if his behavior maximizes the expected value of the set of possible outcomes. To achieve this, an agent needs to define measures of risk and value which in practice are extremely difficult to quantify (Dyer and Jia 1998). VNMT is exemplary of a Cartesian view of the world, in which human beings are capable of totally rational decisions such as planning their future (Senior 2007).

VNMT brought decision making to the forefront of decision making applied to economics, and is relevant as a reference point for the evolution of decision making theories.

### Prospect Theory

Decision making theory was significantly advanced by *Prospect Theory*. It follows three principles summarized by Kahneman and Tversky (1979): (1) *Expectation*. The overall utility of a prospect is the expected utility of its outcomes. (2) *Asset Integration*. A prospect is acceptable if the utility resulting from integrating the prospect with one's assets exceeds the utility of those assets alone. (3) *Risk Aversion*. People are generally risk averse. This means that most people will prefer an alternative with expected value X over any riskier alternative with equal expected value X. The curve in Figure 1 shows a *value function* plotting the value assigned by an average person to the various outcomes resulting from a given choice.

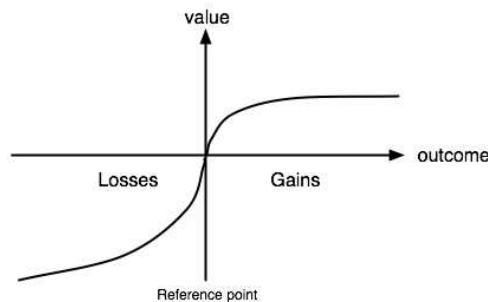


Figure 1: Prospect Theory value function

The figure shows that perceived value does not increase with a gain as quickly as it decreases with a loss. While perceived value tends to flatten after a certain gain is reached, the value of the outcome keeps decreasing as the loss increases. An extra thousand dollars are more valuable to an average income person than to a millionaire. And a millionaire will lament the loss of a thousand dollars more than she will value the gaining of the same amount.

### **INTUITIVE REASONING PARADIGM**

The imperfect information and uncertainty in outcome of all alternatives leading to a decision make inevitable some subjective reasoning in the process of arriving to the decision. As soon as subjective reasoning is involved in the decision, purely rational decision making is difficult to apply (Time for Change 2012). In fact, many studies “leave no doubt about the failure of rational choice as a descriptive model of human behavior.” (Jones 1999). The Intuitive Reasoning paradigm frames substantially more complex processes, in which intuition plays a central role. Intuition has been defined as “a non-sequential information-processing mode, which comprises both cognitive and affective elements and results in direct knowing without any use of conscious reasoning” (Sinclair 2005). The Intuitive Reasoning paradigm requires an understanding of human behavior at levels that are difficult or impossible to rationalize.

### **Bounded Rationality**

A well-known attempt to develop a theory beyond the Value Maximization paradigm is the *Bounded Rationality* theory of Herbert Simon (Simon 1991). Bounded Rationality considers that people act rationally under the limitations of both their knowledge and their cognitive capacity. This theory introduced some concepts increasingly accepted in decision making theory and in economics, such as that people tend to use heuristics (educated rules of thumb) to reach decisions, and that in many instances the objective of decisions is the satisficing of needs (this word combining “satisfying” and “sufficing”) instead of the absolute optimum assumed as the objective of theories in the value maximization paradigm.

Notable contributions of Bounded Rationality theory include recognizing the costs of gathering and processing information. These costs can have a significant effect on the value assigned to an alternative. Bounded Rationality and other closely related derived theories have had an immense influence in current decision making theory. However, some researchers find their approach insufficient to explain the decision making process. For example, Etzioni (2011) complains that Bounded Rationality does not explain satisfactorily the irrationality of many decision making situations, and that instead it lowers the bar “by defining down that which is entailed by being rational.”

### **Behavioral Economics**

A loose continuum of explanations for decision making in which psychological factors play a central role has been developed under the umbrella of *Behavioral Economics*. Etzioni (2011) provides a view of the underpinnings of this theory:

[Research studies] show beyond reasonable doubt that: (a) Indeed, much choice behavior is not based on deliberations of any kind; (b) when reasoning

does occur, it is often subject to the cognitive biases B.E. [Behavioral Economics] systematically observed and reported; and (c) both “intuitive” ... choices and those subject to deliberations are deeply affected by emotions and norms, and these in turn by social and cultural factors.

A cognitive bias is any systematic deviation from a normative criterion that affects thinking, often leading to errors in judgment (Han and Lerner 2009). It can be both unintentional and unconscious (Hamilton Krieger 1995).

Behavioral Economics includes well-known economists, including Nobel Prize winner Kahneman, popular authors (e.g., Ariely 2008, Gladwell 2000), and researchers (e.g., Etzioni 2011, Tversky 1974). Many recent studies have concentrated on the intensely psychological emphasis of this theory. The relevant aspects of decision making discussed in the next section provide from Behavioral Economics experiments.

## RELEVANT ASPECTS OF DECISION MAKING

### DOMINANCE AND CONFLICT

A condition of *dominance* arises when an alternative is perceived as superior to another in all significant features. In contrast, a *conflict* condition arises when one alternative may be superior to another in only some dimensions (Shafir et al. 1993). Lean Construction, for example, would be dominant compared to traditional management techniques if the former is perceived to be superior to the latter in all significant aspects.

Conflict conditions complicate decision making. Experiments have shown that opting to search for additional alternatives does not depend only on the value of the best alternative, but the level of conflict among the alternatives already considered. When options are in conflict, more alternatives may be sought, the decision to choose one may be postponed, or the existing options may be subject to further scrutiny with the possibility of cognitive biases such as the ones described in the following subsections.

### ENRICHED AND IMPOVERISHED OPTIONS

If one decision option has both *more positive* and *more negative* features than another one, then the former is an *enriched* option compared to the latter. The latter would be an *impoverished* option relative to the former.

Individuals and groups choosing between two courses of action tend to *select* the one with most prominent positive features and *reject* the one that has the most prominent negative features (Slovic 1975, Shafir 1993). An enriched option is, paradoxically, more likely to be selected and also more likely to be rejected than an impoverished option, depending on how the decision is framed.

Suppose that a construction company needs to choose between the following productivity improvement techniques.

- A: Significantly improves the construction production rate and eliminates the need for the majority of change orders. It requires major changes to the company’s management practices and continuous commitment by all employees.

- B: Provides some improvement to production rate and eliminates some change orders. It requires small changes to the current management practices and requires employees to attend a single training seminar.

If the situation is framed as “which of the two choices should the company keep?”, then A is more likely to be kept because of its advantages over B. But, if the question is phrased as “which one should the company discard?”, then experimental findings indicate that A is likely to be discarded because of its disadvantages compared to B. The phrasing of whether keep or discard the enriched choice leads to contradictory results.

The above scenario is plausible if Lean Construction is weighted against management procedures already in place in a construction company. A successful Lean implementation requires of a company commitment and challenges to traditional management structures that could be viewed as negative factors by some individuals. The rewards of a successful Lean implementation are many. Lean Construction is an enriched option in this scenario, and a careful structuration of the wording used throughout its implementation (the *framing* of its implementation) can lead to success or failure.

#### INDEPENDENCE OF IRRELEVANT ALTERNATIVES

The *principle of independence of irrelevant alternatives*, also called the *regularity condition of value maximization*, (Shafir et al. 1993) states that if Option 1 is preferred over Option 2, then the addition of an Option 3 of less value than Option 2 should not make a decision maker switch preferences.

This principle frequently does not hold true when applied to practical situations. The author replicated an experiment to this effect described by Ariely (2008). A magazine advertisement similar to the one for Scenario A in Figure 2 was shown to a group of students. The internet-only subscription is listed at \$40, the print-only subscription at \$80, and the internet and print combined subscription at \$80. Students had to choose one option, i.e., there was no “none of the above” option. No student chose the print-only alternative, 57% (20 of 35) chose the internet plus print alternative, and the remaining 43% selected the internet-only option. A second group was shown Scenario B, where the print-only version was removed. This group preferred the internet-only option by 87% (27 of 31) compared to 13% of the internet plus print option. The removal of a seemingly irrelevant third option led to a dramatic change in preferences.

Magazine Subscription Offer	
Scenario A	
Internet-only annual subscription	\$40
Print-only annual subscription	\$85
Internet plus print annual subscription	\$85
Scenario B	
Internet-only annual subscription	\$40
Internet plus print annual subscription	\$85

Figure 2: Example of paradox of independence of irrelevant alternatives

### **DIFFERING THE TIME REQUIRED FOR A DECISION**

The time required for reaching a decision is affected by the number of available choices, and the level of similarity among them. (Shafir et al. 1993). As an example, assume that subcontractors A and B bid for a job and that subcontractor A is deemed to be the best choice. The indecision introduced by the same scenario if subcontractors C and D also bid (i.e., A, B, C, and D bid for the job) would lead to a disproportionately longer time to select a winner, even if C and D are clearly inferior to A. This tendency to defer choice is more pronounced when A and B are of similar perceived value (e.g., Huber, Payne, & Puto 1982). Most individuals are averse to analyzing the tradeoffs required for choosing between similar options, especially when both are valuable. The addition of options, in fact, makes more appealing the choice of doing nothing if this is a possible outcome of the decision making process.

Lean management in general defines the last responsible moment as “the instant in which the cost of the delay of a decision surpasses the benefit of delay (Lean Tools 2012).” Lean Construction uses this principle to recommend, among other applications, that “design decisions will be deferred until the last responsible moment if doing so offers an opportunity to increase customer value (Ballard 2000b).” However, this principle could have unexpected consequences, since a decision may be deferred as a consequence of the natural reaction to conflict in the presence of many similar options. There is a theoretical possibility of this tendency towards deferment resulting in postponing action for too long. This possibility does not appear to have been addressed by Lean Construction researchers.

### **NON-VALUED FEATURES**

One common device intended for encouraging the choice of an alternative is to expand the offer with extra features or items. Those features may be irrelevant to the choice or even not wanted. These additional features have the purpose of increasing the attractiveness of the main offer, and indeed they may be important for some individuals. However, several studies have shown that non-valued features do not act as incentives. By the contrary, individuals are reluctant to choose alternatives loaded with (subjectively) not valued features. Simonson et al. (1994) found that the tendency to not choosing alternatives with unwanted features holds true even when the feature is offered for free.

Should Lean Construction techniques such as The Last Planner System (Ballard 2000a) be limited, at least during their implementation stages, to their bare minimum? The question is appropriate not only for the logistics of the initial implementation, but also for the possibility of including features that may be initially undesired.

### **REFLECTION ON THE CONCEPT OF VALUE**

Ballard and Howell (2004) summarize the three key goals of Lean Construction as “delivering the product while maximizing value and minimizing waste.” For Lean Construction, “[t]he value concept focuses on matching all customer requirements in the best way possible (design and production), therefore creating value from the point of view of the customer (Henrich et al. 2007).” Value is thus generally recognized as a subjective property aligned with the mental accounting of decision making theory.

Psychological aspects of value are not fully encompassed by the definitions of value found in Lean Construction literature. Decision making research has shown that a customer's perceived value of an option is more than subjective: it has unconscious and malleable dimensions, which can lead to irrational decisions from a value maximization viewpoint.

Value can be fabricated. Advertising, for example, is about creating value for a customer that did not know that he "needed" an advertised product. It can be destroyed, as in the case of negative political campaign advertising. Value hardly has the solid (if subjective) nature that Lean Thinking in general seems to attribute to it.

The role of psychology in the creation, management and even manipulation of value in a Lean Construction context needs to be researched. A deeper understanding of its meaning would lead to a better definition of the role that Lean Construction plays in the management of customer value.

## CONCLUSIONS

There are human tendencies that distort the outcomes of human decision making in ways that could not be considered as rational from a strict value maximization viewpoint. The potential consequences of these biases have been discussed in this paper, based on extrapolation of experimental results in disciplines other than construction management. At the present moment, the identified consequences for Lean Construction are speculative, since there is a significant lack of the research on decision making in Lean Construction necessary to validate these potential consequences.

Decision making is more complicated than a relatively simple quest for maximization of value. Individual decisions are subject to many extraneous considerations, mostly related to the decision maker's psyche. The consideration of reasons for arriving to a decision is complicated by the fact that this process includes subjective factors such as the human tendency to avoid decisions under uncertainty, to prefer options with salient features or to reject options with features of no value to the decision maker even if they are free. These factors are frequently hidden from a person's awareness. A decision that may seem perfectly rational to the person taking it may be unexplainable or even irrational if psychological factors are not considered. Decision making theory frames these explanations, and therefore contributes to a better understanding of Lean Construction's opportunities and challenges.

The findings of this study can be summarized as follows:

- Lean Construction can be described as an enriched option, with more salient features relative to traditional management approaches. Enriched options lead to stronger reactions of adoption and rejection depending on the framing used for discussing their merits.
- The addition or suppression of choice alternatives affects outcomes independently of the apparent relevance of the added or suppressed alternative. Lean Construction techniques such as The Last Planner may be affected by this phenomenon.
- It is not clear to what extent the important Lean Construction recommendation of deferring decisions until their last responsible moment may be affected by the



presence of many similar choices. Multiple similar choices have been shown as leading to excessive deferment and excessively opting for the do-nothing option.

- Non-valued features can have negative effects on the perception of overall value towards a given option. Lean Construction techniques may be affected by this aspect of decision making if too many features are included in its techniques.

Areas for further research on the topics addressed here have been addressed throughout this paper, and closely follow the aspects summarized above. An additional area for further research was also mentioned in the brief discussion about the concept of value. This concept, central to Lean Construction, should be revisited to incorporate the psychological aspects found by studies in decision making.

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