REMOVING WASTE WHILE PRESERVING SLACK: THE LEAN AND COMPLEXITY PERSPECTIVES

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1 BACKGROUND

- Lean can contribute to the depletion of necessary slack for coping with variability
- This risk is amplified by the absence of a solid lean theory on slack and on how to manage the trade-off between slack and efficiency

In this paper, the complexity science´s and lean´s views of slack are laid down and compared based on eleven criteria

- Commonalities and conflicts between both approaches are identified, and proposals for future research related to slack management in lean complex systems are presented

2 COMPARING THE LEAN AND COMPLEXITY VIEWS OF SLACK

Criteria	Lean perspective	Complexity perspective
(1) Belief regarding the role of slack	Slack is costly and the need for it arises from waste and variability: the aim is to streamline processes so as slack can be gradually reduced.	Variability is inevitable in complex systems, and slack offers protection against these. Safety is a more important value than efficiency.
(2) Belief regarding the nature of variability	Variability is essentially a hindrance, since it contributes to waste. Some lean practices can reduce variability (e.g. housekeeping), while others require low variability (e.g. pull production)	Variability when making decisions under uncertainty and scarcity of resources can be an asset. Complex systems have a high minimum variability threshold
(3) Origin: how slack arises	It must be designed into the system, and can be created through waste reduction (e.g. by reducing excessive inventories, slack of space and money can be created)	Slack must be designed into the system, and it can also arise from self-organization
(4) How slack evolves over time	The continuous improvement cycle should be used to adjust the size and location of slack resources over time	The behavior of complex systems is based on their past history and the corresponding feedback. Thus, the said systems may learn over time how to manage slack

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(5) Interactions: what triggers the deployment of slack resources and how these interact with other processes	Abnormalities of any sort may trigger the deployment of slack resources. The help chain is a tool that illustrates how lean deals with this criteria	Variability of the outputs of functions triggers the use of slack resources. The FRAM can be used for modelling how functions that deploy slack resources interact with other functions
(6) Typical slack resources stressed by theory	Time and inventories of parts (e.g. finished products, raw materials, semi-processed products).	Literature mentions time, redundant equipment, and cognitive diversity, among others.
(7) Concerns with side-effects of slack	Slack hides waste	Slack interacts with other elements of the system, and this can trigger undesired emergent phenomena.
(8) Concerns with quantification: how much is enough?	A number of industrial engineering methods can be used to calculate process efficiency and the size of inventories, explicitly stipulating an amount of slack	There are no widely accepted and available tools for quantifying slack. Also, what counts as sufficient slack is a social construction.
(9) Concerns with giving visibility to slack	It should be possible to identify at a glance the status of resources. Visibility of slack viewed as waste is stressed	While the need for visibility is emphasized by literature, it does not offer practical tools and principles such as those promoted by lean
(10) Concerns with consumption of slack	Consuming slack, even if unexpectedly, is not necessarily a major issue. If the system halts because of this, it creates pressure for improvement.	There is concern with consumption of slack, especially from efficiency pressures that create ‘‘normalized deviances’’. As such, less and less slack may become the normal state
(11) Typical variability sources that slack should withstand	Demand and supply, inefficiencies in general (e.g. defects, delays, etc.)	Variability that impacts on safety and threaten the system´s existence is stressed by complexity literature

3 CONCLUSIONS

- The two views are in conflict regarding criteria 1 and 2
- The joint use of both views can be useful since it encourages balanced decision-making
- Lean offers practical tools for dealing with criteria 4 (evolution), 5 (interactions), 8 (quantification), and 9 (visibility)
- Complexity science offers a practical tool (i.e. the FRAM) to address criteria 4
- Complexity science takes a broader view of the slack concept, not emphasizing specific types of resources and sources of variability

4 FUTURE RESEARCH

- To develop tools for supporting the design and evaluation of a broad range of slack resources over all phases of construction projects, since the design phase
- To develop operational guidelines for supporting decision-making regarding the trade-off between slack as protection and as waste
- To investigate how existing lean construction practices, such as the Last Planner and BIM address or could address the management of slack.