MANAGEMENT CYBERNETICS AS A THEORETICAL BASIS FOR LEAN THINKING

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ABSTRACT

The purpose of this paper is to explore to what extent lean thinking embraces the notions of Stafford Beer's management cybernetics. According to Beer, any successful organization responds to the laws of management cybernetics. As there are numerous successful enterprises that use lean thinking as a philosophy, this quest seems promising and may offer the opportunity to sharpen understanding of lean practices and possibly identify new concepts that can be incorporated into lean thinking. For this purpose, we first describe the differences of origins and language used in both theories. Then, we discuss the ideas of management cybernetics, with focus on the governing rules this approach to management puts forth. Based on this, a selection of lean thinking rules are described from a management cybernetics perspective. We conclude that management cybernetics can serve as a theoretical background for lean thinking and offers an additional perspective for lean applications.

KEYWORDS

Theory; lean management; management cybernetics; systems theory; Viable System Model

INTRODUCTION

Ever since Toyota rose to be a major car manufacturer, their way of managing an organization, the Toyota Production System (TPS), and what later has become known as "lean" thinking, have received great attention in the scientific and manufacturing world alike. Meanwhile, a less well known approach to management was developed by an English professor named Stafford Beer, who drew his ideas on managing organizations from the findings of systems theory and cybernetics. His "management cybernetics" proposes a model for an organizational structure, called the "Viable System Model" (VSML), which integrates the rules he found to apply to organizations and their management. Unlike lean thinking, Beer's work had little impact, although it was received with interest by the scientific community (Beer et al. 1989, p. ix). Several explanations in literature express why this is the case, mostly his

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work is said to be impractical or at least difficult to apply to real situations (Beer et al. 1989; Britton and McCallion 1989 p. 146; Beer 1979, p. 120/204).

The idea that lean thinking embraces the notions of management cybernetics originated from our and other scholars' (Herrmann et al. 2008; Dominici and Palumbo 2010; Gregory 2007) study of Beer's writings. He argues that in order to persist in a complex environment, an organization must be viable, meaning "capable of independent existence" (Beer 1984, p. 7). From a cybernetics perspective, viable systems have "necessary and sufficient conditions of their independent existence" (Beer 1979, p. 118), and there is a "set of rules" that applies to *all* viable systems, be it a human or an organization consisting of humans (Beer 1984, p. 9). Beer (1989, p. 211) continues his argumentation: "If the argument that there are laws governing the structure and dynamics of any viable system is valid, then all successful enterprises will respond to those laws". As a great many firms that have become successful through the application of lean thinking (Liker 2004, p. 4; Hines et al. 2004), researching the question if lean thinking embraces the notions from management cybernetics seems promising. The goal is to provide an additional perspective on lean thinking that may offer the opportunity to sharpen understanding of lean practices and possibly identify new concepts that can be incorporated into lean thinking. Furthermore, understanding lean thinking principles from the perspective of management cybernetics may also help to identify problems where the implementation of lean thinking does not live up to the desired results. We may reverse the above line of reasoning and pose as a hypothesis: "If a corporation is not successful and there is a set of rules governing *all* viable systems, then it does not respond to the laws of management cybernetics."

RULES OF MANAGEMENT APPROACHES

Beer (1979) uses the term "rules" synonymous with "laws" to subsume axioms, principles, aphorisms, and theorems. According to Oxford Dictionaries Online (http://oxforddictionaries.com/), a rule can mean "a principle that operates within a particular sphere of knowledge" as well as "a code of practice". We use "rule" as a generic expression to subsume all terms that describe a system of thought. The most important rules are defined subsequently.

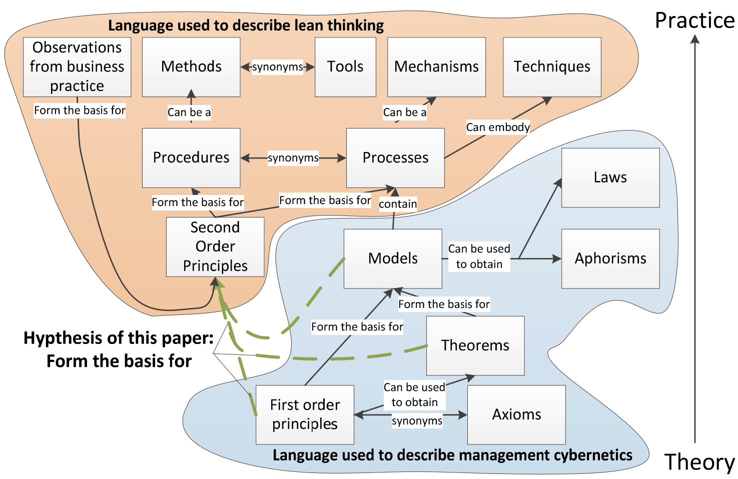

Figure 1: Languages describing lean thinking and management cybernetics

<u>Theorem:</u> a statement not self-evident but proved by a chain of reasoning (http://oxforddictionaries.com/)

<u>Principle:</u> A "general or fundamental truth" or a "governing law of conduct: an opinion, an attitude, or belief that exercises a direct influence on the life and behavior" (Babcock 1986). This definition helps to distinguish two kinds of principles:

1. Principle as a "truth" (first-order principle): a statement is formulated in a way that it can be amended by the following opening sentence without changing its meaning: *"it is a fact or a fundament for the system of belief that…"*

2. Principle as a guideline for action (second-order principle): a statement is formulated in a way that it can be amended by the following sentence without changing its meaning: *"You must/should do … in order to achieve …"*

Principles formulated as a truth are more theoretical in nature than principles formulated as a guideline for action that form the basis for methods in lean thinking (such as kanban, total productive maintenance etc.).

MANAGEMENT CYBERNETICS AND THE VIABLE SYSTEM MODEL

The object of management cybernetics is to understand what makes a system viable in a complex environment, in the sense of the definition given in the introduction of this paper. In his writings, Beer uses the human body and the way it is controlled by its nervous system as a model to derive a structural model of any viable system, the Viable System Model. The model "represents the isomorphisms which underlie any viable system, natural or artificial, biological or social" (Beer et al. 1989, p. 3), therefore the human body is just one out of many examples that could have been used as a basis to formulate the VSML (Beer 1972, p. 99). Essentially, the VSML consists of five systems (Figure 2).

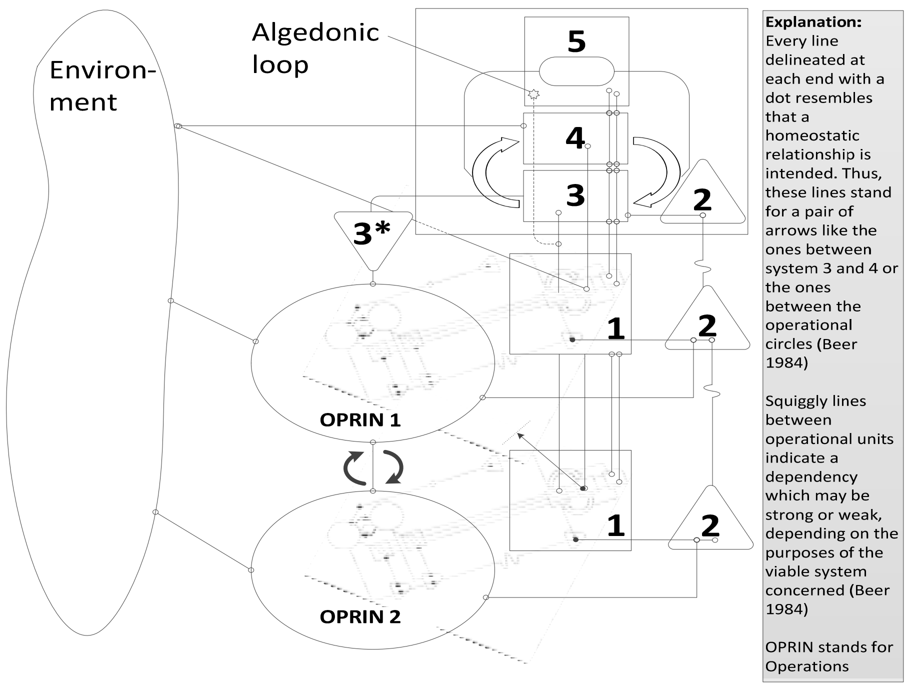

Figure 2: Viable System Model (Beer 1984)

1. System One: Operational control

System One controls an operational unit. As can be seen from Figure 2, the VSML is recursive and every recursion of the VSML can contain any number of System Ones. This means that every System One is viable itself (Beer 1984). System One is the model of the sympathetic nervous system of the human body (Beer 1972, p. 167/170). From a corporate recursion level for example, its task is to control a division, "in response to policy directives and over-riding instructions from above, in reaction to the direct demands of the external world upon it, and in awareness of the needs of other divisions" (Beer 1972, p. 213)

2. System Two: coordinating function

System One inheres a meta-systemic coordination tool, System Two (Beer 1979, p. 174). In biological terms, it belongs to the sympathetic system of the human body's nervous system. It subsumes all Systems One and links them to System Three (Beer 1972, p. 170/220/221). The coordination activity (allocation of resources etc.) should be carried out in a way that ensures maximum autonomy of the parts, "just short from threatening the integrity of the whole". This notion is also known as the law of cohesiveness (Beer 2004).

3. System Three: Managing the "Inside and Now" (Beer 1979, p. 199)

System Three is the model of the autonomic nervous system of the human body. Its job is to monitor the autonomic functions, implement plans within physiological limits and report upwards (Beer 1972, p. 169/171). System Three's job can also be formulated as assuring that the coordinated Systems One achieve a greater effect than the sum of the system's individual activities (Malik 2006). On a corporate recursion level of the VSML, System Three resembles the middle management responsible for the divisions.

System Three*: Auditing/monitoring

System Three* is the model of the parasympathetic loop of the human body's nervous system. Its job is to watch for signs of strain in the operating systems (OPRIN); it does not exert any command function at all (Beer 1979, p. 169/210). System Three* bypasses the operational control of the operational units and thus provides an opportunity for System Three to obtain a genuine impression of the state of affairs in the operational units. According to Beer (1979, p. 211) an example for System Three* in a corporation is an audit channel. Schwaninger (2009, p. 84) describes System Three* as a means to investigate and validate the information flowing between Systems One, Two and Three.

4. System Four: Managing the "Outside and Future"

System Four and System Five resemble the model of the somatic nervous system of the human body (Beer 1972, p.170). Systems One, Two and Three assure a stabilization of the internal milieu, but they do not take account of "progress". Therefore, System Four is "dedicated to the larger environment, and to regulation in its regard" (Beer 1979, p. 226/227).

5. System Five: Policy/"The Three-Four Balancer"

System Five's task is to "monitor the operation of the balancing operation between Three and Four" (Beer 1979, p. 259). The need for a balancing system between the "Inside & Now" and the "Outside & Then" emerges from Beer's observation that in practice, Systems Three and Four will not achieve an equilibrium state without regulation. Viability of the organization can be achieved only if neither one dominates over the other: they must be properly balanced (Beer 1979, p. 258). System Five is also responsible for the policy of the corporation (Schwaninger 2009, p. 106). In the human nervous system, System Five corresponds to the cortex, where conscious decisions are made.

Beer (1972/1979) describe the five subsystems and the VSML in more detail.

RULES OF THE VIABLE SYSTEM MODEL:

The language Beer uses to describe his model is technical and rather unusual to be used in the context of management approaches. We have traced the rules (laws, aphorisms etc.) describing the VSML back to first-order principles and theorems (Figure 1).

<u>First-order principles:</u> "It is a fact or a fundament of the system of belief that":

- Managing a Viable System means managing complexity (Beer 1984). Systemic complexity in cybernetics can be measured by variety, meaning the number of distinguishable states a system can display (Ashby 1956, p. 126).
- To control the variety a system displays, it must be absorbed by the regulator (Beer 1990). In order to do so, the regulator must fulfill Ashby's law of requisite variety. In Beer's (1979, p. 89) formulation, Ashby's law states that the regulator must be capable of generating a variety equivalent to the variety that has to be regulated, or it will fail. In the case of failure, the variety is absorbed by the "situation", not by the regulator (Beer 1990). From the law of requisite variety, Conant and Ashby (1970) derived the Conant-Ashby theorem for regulators: Every good regulator of a system must be a model of that system. Beer formulates the theorem as: "the regulation of a system is only as good as the model of the system that is in the regulator" (Beer 1990).
- Viable Systems produce themselves, they are autopoeitic. This means they are in the business of preserving their own operation. This is different from self-reproduction, because self-reproduction involves changing the level of recursion. After a viable system has been "born", it must autonomously retain its identity, although staff may come and go or departments open up or close down (Beer 1979, p. 404/405).
- Viable systems are recursive: "every viable system contains and is contained in a viable system" (Beer 1984).
- Two variety generating blocks can equate their varieties using one of two basic mechanisms, which are not mutually exclusive (Figure 3):
  - o The bigger variety can attenuated (arc with a triangle)
  - o The lesser variety can be amplified (arc with a squiggly line)

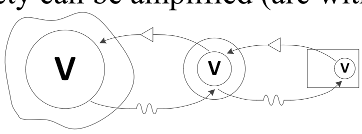

Figure 3: variety generating blocks accommodating Ashby's law (Beer 1979, p. 95/96)

- In a viable system, “just as much variety reduction along vertical channels occurs to keep the identity of the whole intact”. This means, the parts have maximum autonomy, “just short from threatening the whole” (Beer 2004)
- Homeostasis between systems can be achieved through “Adjusted Feedback”, where “adjusted” means that a subsystem does not only blindly use the feedback information from the subsequent subsystem, but also considers other aspects like timely- or demand fluctuations. In a viable system, the adjusting mechanisms enable systems to damp their “explosiveness” in the face of not previously envisaged uncertainties (Beer 1979, p. 62).

Theorems: *“The first-order principles imply that the following statement is valid:”*

- The logical closure System Five offers and the principle of autopoeises are contradictory to a reductionist view on the firm (Beer 1990).
- Managerial, operational and environmental varieties, diffusing through an institutional system, tend to equate, they should be designed to do so with a minimum damage to people and cost (Beer 1984).
- The four directional channels carrying information between the management unit, the operation, and the environment must each have a higher capacity to transmit a given amount of information relevant to variety selection in a given time than the originating subsystem has to generate it in that time (Beer 1984).
- Wherever the information carried on a channel capable of distinguishing a given variety crosses a boundary, it undergoes transduction; the variety of the transducer must be at least equivalent to the variety of the channel (Beer 1984).
- The operation of the aforementioned theorems 2., 3. and 4. must be cyclically maintained through time without hiatus or lags (Beer 1984).

PRINCIPLES IN LEAN THINKING FROM A MANAGEMENT CYBERNETICS PERSPECTIVE

Lean thinking is widely discussed in contemporary management literature. It is not possible to describe all different notions and aspects of lean thinking from management cybernetics’ perspective (MCP) in a ten-page paper. We next state a selected number of lean principles, taken from Liker (2004), and describe them using the management cybernetics conceptualization. If Beer’s previously-mentioned statement (any successful corporation will respond to the laws of management cybernetics) is true, then the management cybernetics approach will also be able to describe lean principles that are not discussed in this paper. If such principles cannot be described it may be because Beer’s language is possibly lacking in some ways. Our expectation in any case is that lean principles would not contradict the laws of management cybernetics.

Second-order principles: “*You must/should do… in order to achieve…”*

- “Base your management decisions on a long term philosophy, even at the expense of short term financial goals.” (Liker 2004, p.71)
- MCP: The viability of a system depends on the homeostasis between System Three (Inside & Now”) and System Four (“Outside & Then”). Only if the

"Outside & Then" is properly represented can a system be viable. To assure that their homeostasis does not result in uncontrolled oscillations, System Five's task is to monitor the operation of the balancing operation between Systems Three and Four (Beer 1979, p. 259)

- "Create continuous flow to bring problems to the surface." (Liker 2004, p. 87)
- MCP: Continuous flow reduces input oscillations systems may face and thus the variety that systems have to cope with. Therefore, it supports the achievement of homeostatic relationships between pairs of variety-generating blocks.
- "Use pull systems to avoid overproduction." (Liker 2004, p. 104)
- MCP: For a pair of subsystems, homeostatic relationships would be easiest to achieve by using a push system, because a push system exhibits less variety than a pull system based on fluctuating customer demand. However, a viable system must also maintain homeostatic relationships between operational units and their local environments (figure 2), which is impossible under a push-based production schedule. Thus, use of pull systems, also known as real-time feedback (Tommelein 1998), is the only way to maintain viability. In order for pull production to work, the variety the system can display has to be kept at a minimum.
- "Level out the workload (heijunka)." (Liker 2004, p. 113)
- MCP: A leveled workload is a prerequisite for the establishment of pull systems (Liker 2004, p. 113/Womack et al. 1991, p. 150), therefore it is in alignment with the first-order principle of homeostasis in management cybernetics. A leveled workload ensures that the variety the production schedule can display is kept at a minimum.
- "Build a culture of stopping to fix problems, to get quality right the first time (Jidoka)." (Liker 2004, p. 128)
- MCP: Empowering employees to stop and fix problems is equivalent to an algedonic loop in management cybernetics. In lean, the notion of "building a culture of stopping to fix problems" applies to the whole corporation, not only to the production line. This property is resembled through the recursiveness of any viable system. On every level of recursion, there is an algedonic loop.
- "Standardized tasks are the foundation for continuous improvement and employee empowerment" (Liker 2004, p. 140)
- MCP: Standardized tasks lower the requisite variety an employee must bring along to successfully work on a task, because it decreases the variety a task can display. In the context of the Conant-Ashby theorem, this means that the employee (regulator) is more likely to be in better control of the task (system) if what he expects of the system (his model of the system) can assume as little different states as possible.
- "Use visual control so no problems are hidden." (Liker 2004, p.149)

- MCP: In the TPS, this principle is realized through the 5s method, which stands for Sort, Straighten (orderliness), Shine (cleanliness), Standardize (create rules), Sustain (self-discipline). The idea behind this method is not to make a mass-production system “neat and shiny”, but to support “smooth flow” and to “ensure fast and proper execution of tasks” (Liker 2004, p.152). This notion matches theorem 5 in management cybernetics (see above).
- “Use only reliable, thoroughly tested technology that serves your people and processes.” This second-order lean principle states that new technology is “introduced only after it is proven out through direct experimentation”, meaning after its support for people, process and values has been determined (Liker 2004, p. 160).
- MCP: People, processes and values are what the organization consists of. Therefore, they are the very essence of viability. Thus, in management cybernetics, this principle translates to evaluating new technology towards its support of viability in the corporation.
- “Develop exceptional people and teams who follow your company’s philosophy”. (Liker 2004, p.184)
- MCP: The philosophy in a viable system is to stay viable. Obviously, the system can only be viable if all stakeholders understand what it takes to do so.
- “Respect your extended network partners and suppliers by challenging them and helping them to improve.” This lean principle aims at maintaining a close relationship to suppliers, which increases the information which is available for both partners. (Liker 2004, p. 199)
- MCP: Controlling great amounts of variety can be daunting, but only if all states a system can display are equally likely. The more information is available about a part of the environment (in this case, suppliers), the less requisite variety a system must have (Beer 1984).
- “Go see for yourself to thoroughly understand the situation (genchi genbutsu)”. Here, the idea is that it is unacceptable to take anything for granted or to rely on the reports of others (Liker 2004, p. 223).
- MCP: In the VSML, the idea of genchi genbutsu is resembled by System Three*, providing a genuine impression of the state of affairs in the operational units.
- “Become a learning organization through relentless reflection (hansei) and continuous improvement (kaizen)” (Liker 2004, p. 250).
- MCP: Hansei and kaizen are manifestations of the autopoeises principle in management cybernetics. These lean thinking principles aim to get every employee, no matter on which hierarchy level, to suggest improvements wherever he sees problems or potential for improvement. Through autopoeitic operation, every viable recursion retains its identity autonomously on its level of recursion, which entails that that it is the job of the people on this level of recursion to solve problems or improve processes.

CONCLUSION

Our paper provides an approach for theoretically understanding lean thinking from the theoretical basis of management cybernetics. It is yet another contribution to the understanding of several other scholars (e.g. Seddon and Caulkin 2008; Elfving et al. 2002; Howell and Ballard 1998) that lean thinking is a systemic approach to management, not merely a collection of tools. When implementing lean thinking tools in a company, one may want to first understand where the viability may be in danger and which first-order management cybernetics principles are violated, before one looks at the second-order principles of lean thinking and starts implementing tools. One way to do this is by using the VSML as a diagnostic tool. Once pathological structures have been identified, one can see which second-order lean thinking principles are not working. If the theoretical work has been thoroughly conducted, appropriate lean tools will lead to success. Take for instance the Five Why method, a lean thinking tool that asks the question “Why?” at least five times for any given problem to identify its root-cause. It is an “integral part of the kaizen principle” (Liker 2004, p. 252). However, if one has failed to see that the *modus operandi* of the whole system does not respond to the first-order principle of autopoeises, the system does not offer the proper milieu for the second-order principle kaizen to work: The worker cannot “produce” the system autonomously in that he cannot implement a countermeasure to the root cause of the problem.

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GLOSSARY OF TERMS IN MANAGEMENT CYBERNETICS (BEER 1972, P. 305/306)

<u>Algedonic:</u> pertaining to regulation in a non-analytic mode. For example, we may train others to perform a task by explaining analytically the "why" and the "how", or algedonically by a system of rewards and punishments without explanation.

<u>Algedonic Loop:</u> a circuit for algedonic regulation, which may be used to override an analytic control circuit. For example, a whole plant may be switched off by a fail-safe device if a critical variable is exceeded, without the workers knowing what happened.

<u>Homeostasis:</u> The capability of a system to hold its critical variables within physiological limits in the face of unexpected disturbance or perturbation.

<u>Feedback:</u> The return of part of a system's output to its input, which is thereby changed. Positive feedback takes an increase in output back to increase the input, negative feedback takes back an output increase to decrease the input. Note: Feedback does not simply mean "a response to a stimulus".