THE PARADOX OF HYPER-BUREAUCRACY AND LEAN

IN HIGH-TECH MANUFACTURING

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ABSTRACT

Lean is supposed to be waste-less, simple and non-bureaucratic. Practice shows that it is not. This paper draws on insight from two manufacturing companies in the aerospace industry, to argue that the pursuit to be lean in modern high-tech industry conflicts with core lean design principles. The attempt to simultaneously be high-tech and try to become lean results in an unintended hyper-bureaucracy, hindering both effective use of technology in place and efficient implementation of lean.

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INTRODUCTION

High-tech manufacturing companies competing in today's global markets, operate under tremendous pressure for never-ending change. They are encouraged and even forced from multiple sources to continuously improve performance in all the classic Operations Management performance categories: Quality, cost, dependability and speed. Increasingly also work attractiveness and corporate social responsibility (CSR) issues add voices to the choir of change. However, among these voices, it is cost reduction that sets the tone with its repeating verse on "becoming lean". This paper argues that high-tech manufacturing companies and lean improvement programs do not sing well together because they amplify into an unintended hyper-bureaucracy that conflict with key lean design principles.

The paper has the following outline: First, the methodology of which the paper is based is briefly explained. Second, the paper introduces three theoretical fields; (1) implementation of advanced manufacturing technologies in high-tech industries, (2) lean manufacturing, and (3) organisational theory on bureaucracy and hyper-bureaucracy. Third, two industrial examples illustrate the pursuit to be lean while being high-tech. Fourth, the main argument of the paper is presented by discussing the practical insight against the theoretical background. Finally, conclusions are drawn and implications for practitioners and further research are presented.

METHODOLOGY

This conceptual paper presents ideas developed through an action research methodology in the 8 million € Norwegian research project Ideal Factory (2008-2011). In action research projects, the researchers are both participants as well as observers

in the development project, which give detailed insight into processes, procedures and data in the companies under study (Greenwood & Levin, 2007). Four researchers have been engaged with two industrial partners on a regular basis since spring 2008, with on average two researchers being physical present in the manufacturing facilities two days every fortnight. The alteration between presence in industry and theoretical discussions at NTNU/SINTEF has over time given spark to promising new ideas.

THEORETCIAL BACKGROUND

In the following, two key issues in manufacturing strategy are briefly presented; the use of advanced manufacturing technologies (AMT) and lean manufacturing (LM). In addition, an outsider perspective from organisational theory provides a new analytical lens to LM in high-tech industries; theories of bureaucracy and hyper-bureaucracy.

Advanced Manufacturing Technologies in high-tech industries

Competitiveness in high-tech industries are inextricable tied to the use of the latest state-of-the-art technologies. In today's high-tech industry, automation and IT is given and desired. The demand for precision, repetition and speed, has made technology outperform human workers in production and administration tasks. Therefore, the use of advanced manufacturing technologies (AMT) (Boyer, Ward, & Leong, 1996) must be expected to increase as competitive weapons for Western manufacturers in the future.

AMT can be sorted into four categories:
- *Design technologies* including CAD (computer-aided design), CAE (computer-aided engineering) etc.

- *Manufacturing technologies* including automation, robotics, CNC (computer-numerical control), CAM (computer-aided manufacturing), FMS (Flexible manufacturing systems), cellular manufacturing etc.

- *Internal administrative technologies* such as ERP (Enterprise Resource Planning), MES (Manufacturing Execution System), APS (Advanced Planning and Scheduling systems), SCADA (Supervisory Control and Data Acquisition), RFID (Radio Frequency Identification) etc.

- *External administrative technologies* such as EDI (Electronic Data Interchange), Web-portals, BI (business intelligence), CRM/SRM (customer/supplier relationship management) etc.

A key trend is that all systems are sought integrated, moving towards the holistic fully-integrated and automated factory. The products and components are integrated with the manufacturing system through the increasing implementation of automated material handling systems and data-capture technologies (vision technology, RFID etc). The manufacturing system is linked with the internal administrative system through the Manufacturing Execution Systems (MES). The internal administrative system is integrated with the external administrative system through enhanced Enterprise Resource Planning software (ERP), Advanced Planning and Forecasting systems (APS), web portals, Customer/Supplier Relationship Management systems, Business Intelligence solutions, and so on. Supporting and boosting this trend is the development and documentation of standards, which enable a centralized infrastructure, data sharing and plug-and-play functionality. All these advancements make high-tech industries even more high-tech.

Lean manufacturing

Few terms have been used (and misused) as extensively as "lean" in business consultancy since the term was coined by John Krafcik (1988) and made conventional wisdom through Womack, Jones and Roos' book "The machine that changed the world" (1990). This paper sees lean manufacturing as a new name for Toyota Production System that at core puts a focus on demand-driven value creation. The five key design principles in lean manufacturing are (Womack & Jones, 2003):

1. Specify value: Customer focus at core

2. Identify the value stream: Minimize waste (non-value adding activities)

3. Create flow: Built-in-quality in products and processes

4. Create pull: Just-in-time production based on customer demand

5. Seek perfection: Implement a continuous improvement efforts (kaizen)

Organisational theory on bureaucracy and hyper-bureaucracy

Max Weber (1947), the most influential writer on bureaucracy, described bureaucracy as the most rational form of any organization, and hence more effective than alternative organization forms. The effectiveness is secured by the existence of a control system based on rational administrative rules. According to Weber, bureaucratic administration means "the exercise of control on the basis of knowledge. This is the feature of it which makes it specifically rational" (Weber, 1947, pg 339). The administrative rules aim to structure and control the organization. In particular, this is achieved by a sophisticated division of labour with detailed descriptions of the work and responsibilities of each position in the organization.

In short, a bureaucratic organisation is generally defined as a system of administration that is distinguished by four characteristics:

i.   A clear hierarchy of authority

ii. A rigid division of labour

iii. Written and inflexible rules, regulations, and procedures

iv. Impersonal relationships

Despite Weber's description of bureaucracy as a superior way to organize, the general contemporary comprehension is to view bureaucracy as something negative and unwanted. Bureaucracy is in everyday talk synonymous with "paperwork", and increasingly the paperwork is done on a computer (Torvatn, Lamvik, & Næsje, 2007). Modern work life in general is increasingly filled with bureaucratic practices that come in addition to the jobs' core value creation. Workers must increasingly adhere to plans, procedures and rules, and thereafter report on the adherence to these work regulations. Both the process and the outcome must be extensively documented.

Hyper-bureaucracy is a term coined by Torvatn et al (2007) to describe the new modern *work form*: Hyper-bureaucracy is an extension of Weberian bureaucracy, with the difference that hyper-bureaucracy describes a work form not an organization form. Hyper-bureaucracy is in particular apparent in companies that are technology driven, because ICT is both an enabler and a driving force behind bureaucracy. "While ICT systems may simplify several work tasks they also create new tasks. These new tasks are bureaucratic in their nature and continue to fuel the growth of hyper-bureaucracy" (Torvatn et al., 2007, pg 11). Hyper includes intensification, and hyper bureaucracy can be seen as the bureaucratization of bureaucracy.

INSIGHT FROM TWO HIGH-TECH AEROSPACE MANUFACTURERS

Practical insight from two high-tech manufacturing companies (A and B) in the aerospace industry illustrates how lean improvement programs are introduced in their high-tech organisations. The companies are world-leading suppliers of vital airplane components to industry champions such as for example Lockheed Martin, Northrop Grumman, Snecma, Rolls Royce, and General Electrics. Companies A and B have traditionally won contracts based on their unique product-offering and superior quality, developed through a world-class systems engineering culture. Both are innovative engineering companies, where cost-leadership and lean manufacturing has not been focused historically.

Evidently, as globalization intensifies competition, the aerospace industry is following the automobile industry in the attempt to be as resource efficient as possible. Even though aerospace manufacturing is striving for lean mass-production, it has some industry characteristics that differ fundamentally from manufacturing of cars: Boeing 737, the most ordered commercial airplane all times, was delivered in a number of 481 in 2009. Lockheed Martin, the producer of the most advanced combat aircraft F-35 lightning (a.k.a. Joint Strike Fighter), has an ambition to produce one F-35 per day by 2016. These figures, however impressive, do not compare with the most selling car Toyota Corolla that sold more than 1.3 million new cars in 2009. Other significant industry differences are size and complexity of the product, much higher product value, much longer order horizons, higher political influence and control, even higher quality requirements, lower number of competitors, and even more high-tech production equipment. Still, the trend towards lean as supreme manufacturing paradigm is also strong in the aerospace industry.

Company A: Lean required by main customers

Company A meets increasing pressure to implement lean in all its operations, in particular from its largest customer Lockheed Martin Aeronautics. The world's largest defence contractor Lockheed Martin has set forth a lean supplier program to build long-term relationships with their best suppliers:

> "We have a mutual interest in streamlining our processes and eliminating waste so that we can secure our future together as a world-class supply chain for aerospace products. (...) Our government customers have communicated their need for more affordable, high-quality products, delivered faster, better, and cheaper. A lean initiative called LM 21 is (...) part of a comprehensive effort at Lockheed Martin to achieve affordability and increased speed to market. It is imperative that all LM Aero suppliers become lean enterprises as quickly as possible" (Lockheed Martin, 2010).

When engaging with Airbus as potential new customer, the implementation and continuous assessment of lean practices would be part of the supplier contract as well. The result of the customer focus on lean is a management focus on lean in company A.

Becoming lean for company A involve the following "new" tasks:

- Stating lean as an operational goal in strategic plans

- Learning the lean philosophy, models, tools and vocabulary

- Implementing lean tools as standard part of continuous improvement

- Developing and writing continuous improvement plans for the customers

- Providing weakly reports on lean key performance indicators (KPIs)

- Being assessed several times per year from different customers' lean audit

- Reporting internally about lean efforts and achievements

Company B: Lean required by Mother Company

Company B experiences the highest pressure to become lean from internal sources; the foreign mother company is rolling out a corporate wide lean program. Lean, or more specifically Toyota Production System, is the underlying basis for a company specific production system that was launched in 2008 (here called BPS). BPS take the written form of leaflets, power point slides, books and intranet pages and are developed by a tailored task force and hired consultants, given the assignment from head quarter management. Along with BPS come management and operator training, work shops, maturity assessments, certifications, and rewards.

> The acquisition- driven growth of recent years has made the work with BPS even more important. (...) Instead of everyone developing their own systems and toolboxes, the co-operation within the Group has developed considerably. (...) BPS involves a common approach to reduce production costs and increase quality through identifying what creates customer value, doing it even better and avoiding unnecessary work." (Extract from company B's Annual Report 2009)

Becoming lean for company B involve the following "new" tasks:

- Stating BPS as an operational goal in strategic plans

- Learning the lean philosophy, models, tools and vocabulary described in BPS

- Appointing a BPS coordinator at each factory

- Implementing the lean improvement tools chosen by BPS

- Being assessed once a year from the foreign BPS audit team

- Reporting internally about lean efforts and achievements

THE PARADOX OF HYPER-BUREAUCRACY AND LEAN

Drawing on the theory and case illustrations, we now present our main argument why becoming lean while being high-tech is at odds with key lean design principles. In high-tech industries there is a provable paradox of hyper-bureaucracy and lean.

High-tech manufacturing imply bureaucratic organisation

High-tech manufacturing companies compete through its state-of-the-art technological system. These systems are IT-based and hence designed to handle data and information. To utilize data, we need to collect it, access it, analyze it into information, and have the ability to share it for collaboration purposes. The integrated high-tech company becomes a bureaucracy because all four characteristics of a bureaucratic system are present:

i. "A clear hierarchy of authority" exist because the systems are carefully designed from top-floor software to shop-floor hardware (e.g. BI -> APS -> ERP -> MES -> SCADA -> FMS -> RFID)

ii. "A rigid division of labour" arise because the systems are so complex that only tailored knowledge-workers know how to handle them

iii. "Written and inflexible rules, regulations, and procedures" are implicit in IT

iv. "Impersonal relationships" replace personal relationship

The more high-tech a company becomes, the more bureaucratic it becomes. This is in line with Max Weber's notion of the bureaucracy as more effective than any other organization. Recognizing the obvious benefits and inevitability of increased IT-system integration, the downside is that these modern IT-systems (including IT-controlled manufacturing equipment) requires tremendous amount of data

maintenance. These input-output systems apply directly to the SISO-theorem (shit in – shit out) which imply that the "monsters need to be continuously fed" (Torvatn et al., 2007) to be working. The more interconnected and complex the systems become, the more resource demanding the data management becomes. In brief, the following equation is put forward:

$$\text{High-tech} \uparrow = \text{Bureaucracy} \uparrow$$

Lean efforts in high-tech companies result in hyper-bureaucracy

Becoming lean, as it is practiced by the industrial examples in this paper, clearly force on a new external Weberian bureaucratic system to the organization, because all four characteristics of a bureaucratic system are present:

i.   "A clear hierarchy of authority" exist because the organizational and operational design is demanded from someone else (customer or owner)

ii.   "A rigid division of labour" is designed to implement lean (e.g. lean project managers, lean coordinators , lean audit teams etc)

iii.   "Written and inflexible rules, regulations, and procedures" are introduced both in lean per se and in the process to support the implementation

iv.   "Impersonal relationships" and standard procedures replace personal relationship

Becoming a lean organization is expected to improve the bureaucratic IT-integrated company. In order to manage the requirement to become lean or at least to appear as lean, company A and B must as illustrated previously build up new internal work practices that sum into complete internal bureaucratic systems. Building a

bureaucracy to handle a bureaucracy is exactly what Torvatn et al (2007) refers to as hyper-bureaucracy. Thus the new equation becomes:

High-tech + LM program = Hyper-bureaucracy

Hyper-bureaucracy conflicts with key lean design principles

Being lean in high-tech industries is simply not as simple and un-bureaucratic as the lean philosophy teaches. The paradox arises because the hyper-bureaucracy is at odds with basic lean thinking:

1. The hyper-bureaucracy is paradoxical to the first lean design principle of specifying customer value, because it shifts focus away from value creation through *being* lean to the false value of *appearing* lean.

2. The hyper-bureaucracy is paradoxical to the second lean design principle of minimizing waste, because it introduces new non-value-adding bureaucratic tasks that lean would interpret as waste.

3. The hyper-bureaucracy is paradoxical to the fifth lean design principle of seeking perfection, because it introduces relatively more focus on the bureaucratic tasks than operational, which leads to perfection of the hyper-bureaucracy instead of the operational system.

Hyper-bureaucracy is not at odds with the second design principle of creating flow and the third design principle of creating pull. Nevertheless, we can conclude:

Hyper-bureaucracy $\neq$ LM design principles

CONCLUSION

High-tech manufacturing companies will continue to increase the use advanced manufacturing technologies to secure competitive advantage, and thereby continuously strengthen the bureaucracy in place. At the same time, practice shows that high-tech manufacturing companies are striving to become lean. This effort to become lean in high-tech companies results in unintended hyper bureaucracies because new systems are designed to monitor and manage the existing systems. Hyper-bureaucracy, however, is at odds with key lean design principles. Paradoxically, the more high-tech companies attempt to become lean, the less lean they become. The paper's main argument can thus be summarised in the following equation:

$$\text{High-tech bureaucracy} + \text{LM program} = \text{Hyper-bureaucracy} \neq \text{LM design principles}$$

Implication for practitioners

This paper sheds new light on one of the most popular "truths" of today's business life: the belief that enforcing lean is the single right road to competitiveness. If the argument presented is valid, the implications for industry are straight forward, and imply far-reaching and sensational changes for high-tech companies: Quit chasing lean improvement programs, because high-tech companies will probably be leaner when not engaging in a lean transformation programs. Lean improvement programs turn out counterproductive in high-tech companies.

If your customers or head quarter management demand you to become lean, you will be loosing competitive advantage; not by becoming lean per se (cost effectiveness is still key to competitiveness), but by the resource-intensive and expensive process, that increase non-value-adding bureaucratization of the already bureaucratic high-tech company. Thus, companies should quit enforcing lean improvement programs on suppliers and subsidiaries. *Being* lean however still gives competitive advantage, and therefore new more sophisticated ways to become lean are needed in high-tech industries.

Limitations and implications for further research

The ideas put forward in this conceptual paper must be seen as a first attempt to shed new light on lean improvement programs in high-tech industries through the single theoretical lenses of theory on bureaucracy and hyper-bureaucracy. To the authors' best knowledge no previous paper has analysed the links between high-tech, lean and bureaucracy, and we encourage more research on these interconnected topics.

The paper recognises but does not put much emphasis on the benefits of lean improvement programs. Recognising that *being* lean gives competitive advantage, and suggesting that *pursuing* lean through lean improvement programs will fail, a main weakness of the paper is that it does not give managers any clear normative advices on how to achieve leanness. The proposition that high-tech companies have a stronger probability to be lean when not focusing on lean clearly deserves further research. We would like to end with the important notion that the benefits of lean improvement programs might exceed the cost of the hyper-bureaucracy, but this has not been investigated in this paper.

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