Lean and the working environment: a review of the literature

Peter Hasle
National Research Centre for the Working Environment, Copenhagen, Denmark
Anders Bojesen
HK/Stat, Copenhagen, Denmark
Per Langaa Jensen
Department of Management Engineering, Technical University of Denmark, DTU, Lyngby, Denmark, and
Pia Bramming
Department of Education and Pedagogics, University of Aarhus, Copenhagen, Denmark

Abstract

Purpose – The effects of lean on employees have been debated ever since the concept was introduced. The purpose of this paper is to review the scientific literature on the effects of lean on the working environment and employee health and well-being.

Design/methodology/approach – Relevant databases were searched for studies of lean and the working environment. In total, 11 studies with quantitative effects of lean are included in this review. The methodology and results are analysed to extract information about lean and the effects on working environment.

Findings – There is strong evidence for the negative impact of lean on both the working environment and employee health and well-being in cases of manual work with low complexity. However, since examples of positive effects were also found in the literature, it is important to move from a simple cause-and-effect model to a more comprehensive model that understands lean as an open and ambiguous concept, which can have both positive and negative effects depending on the actual lean practice used on the shop floor.

Research limitations/implications – The evidence remains limited with regard to the effect of lean on the working environment outside of manufacturing industry. The literature reflects, only to a limited extent, on the significance of implementation strategy and production context.

Practical implications – Organizations working with lean should make efforts to avoid an impaired working environment for manual employees. Involvement of employees in lean’s practical application is one possible way of developing a healthy working environment.

Originality/value – This is the first paper to make use of the existing research evidence to examine the complex and ambiguous relations between lean and the working environment.

Keywords Manufacturing industries, Lean production, Employees, Manual workers, Employees involvement, Working environment, Research work, Health, Context, Implementation

Paper type Literature review

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Introduction

This paper seeks to investigate and question the relationship between lean and the working environment. The concept of lean production has a long history going back to the 1940s and 1950s which has been thoroughly discussed elsewhere (Holweg, 2007; Shimokawa and Fujimoto, 2009). Lean in the current understanding has been propagated by a number of publications from the late 1980s and early 1990s and (Krafcik, 1988; Womack and Jones, 1996; Womack et al., 1990) in an attempt to make the American auto industry as competitive as the production system developed at the Toyota factories in Japan. The idea of what has been called “The Toyota Production System” or TPS is to a large extent based on Japanese production principles (Liker, 2004; Ohno, 1988; Spear and Bowen, 1999), and is sometimes used as a synonym for lean. From an early stage it was suggested that lean would benefit employees due to its promotion of a higher degree of participation and the possibility to eliminate strained working conditions. This view was not based on empirical findings, however, and Womack (1996) soon pointed out that the lean focus on the reduction of waste implied that employees could be made redundant, and that it could not be expected that the employees would be motivated to become involved in such a process. Lean’s ambiguous nature with regard to employees was thus evident from the beginning. With lean’s growing popularity in the business sector, several studies were made to examine the propagation of lean and discuss its possible effect on the working environment. Some researchers (Anderson-Connolly et al., 2002; Babson, 1993; Harrison, 1994; Kochan and Lansbury, 1997) focused on the possible negative aspects and suggested that “lean is mean”, and that like other ideas for workplace restructuring, it could lead to severe health problems. At this point, light and various shades of grey seem to have entered the debate (de Treville and Antonakis, 2006; Delbridge, 2005; Hampson, 1999), and the question of how lean and its consequences for employees should be understood is now more open.

The aim of this paper is to better understand the relationships between lean, the working environment, and its effects on employee health, job satisfaction, and commitment. We use the concept working environment in order to embrace what is traditionally understood as occupational health and safety, including the psychosocial factors at work. We analyse the relationship by reviewing the current literature, and, based on the results of this review, we create a broader understanding of the consequences of lean for employees. On the basis of previous research, we suggest that lean always affects the working environment in which it is introduced. We argue that there is no simple, determinable (one-way) relationship between the implementation of lean and the working environment. This is due to the open nature of the lean concept. Lean can be and is used for various purposes, and the specific design of the lean system can take many different forms. Lean is also applied and implemented in a great variety of contexts. Since lean always affects the working environment in which it is introduced, it also affects employee motivation. It is therefore important to understand the consequences of lean in order to prevent impaired health and perhaps improve one of the cornerstones of lean: employee involvement.

The paper is structured as follows:

- We begin by addressing the definition of lean in order to delimit the concept we are studying.
- Second, we review the existing literature on the effects of lean on the working environment, and categorize previous studies into four sectors: auto industry, other manufacturing, service industry, and cross sector.
We then turn to a discussion of the findings from the review, addressing the ongoing debate on whether lean is mean, or a healthy and productive work concept. Finally, we summarize our findings in the conclusion, arguing that lean is likely to have a negative effect on the working environment in relative simple manual work, but that this is not necessarily so; it is therefore important to study the relationship between lean and the working environment through the lens of lean practice.

**Definition of lean**

Over the last decade, researchers studying lean have sought a common understanding of the term (de Treville and Antonakis, 2006; Hines *et al.*, 2004; Hopp and Spearman, 2004; Paez *et al.*, 2004; Shah and Ward, 2003; Shah and Ward, 2007). It is often suggested that lean should be understood on two levels:

1. the strategic level of how to understand value; and
2. the operational level (tools) of how to eliminate waste (Hines *et al.*, 2004).

This is in accordance with the discussion of lean as a philosophy and a set of operational tools (Shah and Ward, 2007). Shah and Ward (2007) reviewed the literature on lean definitions and concluded their review with a simple definition that summarizes some of the most important characteristics of work systems that can be described as lean. They define lean as: “an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability” (Shah and Ward, 2007, p. 791). The two authors follow-up the theoretical definition with a survey of lean practices applied in manufacturing industry, and they end up identifying ten key practices: supplier feedback, JIT delivery, developing suppliers, involved customers, pull, flow, set-up time, controlled processes, TPM, and involved employees. However, as pointed out in the lean literature, treating lean primarily as the reduction or elimination of waste is but one side of the coin. The other side is that lean is also a framework for enhancing efficiency and thus maximizing improvements (Hopp and Spearman, 2004). This side of lean leads Hopp and Spearman (2004, p. 147) to argue that lean in positive terms is better defined as “best buffer production” rather than “low waste” or even “low buffer production”. This is important because there may be many sources to buffering and variability, not necessarily characterized as “waste”.

We agree with Hopp and Spearman that lean should be understood as more than waste reduction and with Shah and Ward that lean is a socio-technical system that can be analysed through its practice. But we support a stronger focus on the human side, as suggested by Spear and Bowen (1999), who point out that the clue to lean (TPS) has to be found in the way employees and managers in Toyota collaborate. This makes it clear that it is important to understand lean as more than tools. The tools should be seen in their practice as an integrated part of a broader socio-technical system, although Spear and Bowen point out that most organizations have difficulties applying the full system.

The definition of lean becomes more complicated when we consider the fact that lean is more and more frequently applied outside the manufacturing sector: in services (Bowen and Yongdahl, 1998), hospitals (Young and McClean, 2008), public administration (Radnor and Walley, 2008), and other places. Private and public organizations in these sectors may pursue some of the key practices suggested by Shah and Ward, and it seems to be relevant to accept that lean production systems can be applied in most sectors.
The most common approach to research on the effect of lean on the working environment is to study job characteristics, such as autonomy, demands, and skills, and the connection with various employee outcomes, such as job satisfaction, commitment and health. This approach is based on the accumulated knowledge about various job characteristics and effects (de Treville and Antonakis, 2006; Hackman and Oldham, 1980; Karasek and Theorell, 1990; Parker, 2003). But lean is also a programme for change, and it is known that change itself may create uncertainty and stress (Bordia et al., 2004; Kiefer, 2005; Womack, 1996). The introduction of lean has consequences for all personnel involved; it is therefore a substantial change, which in itself has consequences for the quality of the working environment. This is even more so, when we consider that lean is also described as a philosophy that creates continuous change (Paez et al., 2004). The effect of lean on the working environment is therefore not only a result of the lean practices listed above, but also of the implementation strategy. The working environment is furthermore influenced by the production context in which lean is implemented. It is only to be expected that in a context of down-sizing and harsh industrial relations (see for instance examples from the auto industry: Lewchuk et al., 2001), lean will have quite different effects than when it is integrated into a broader socio-technical strategy based on employee involvement (Seppälä and Klemola, 2004). It is therefore important to understand the effects of lean on the working environment as a consequence not only of lean practices, but also of the implementation strategy and the industrial context. Finally, the effects on employee health and well-being can be considered a result of the changes in the working environment caused by lean. The relationship can be illustrated by the simple model in Figure 1.

Earlier findings
This paper reviews the literature published after the first extensive review of the effects of lean carried out by Landsbergis et al. (1999). This review was based on literature identified by using keywords that included “lean production”, and a number of possible effects related to working environment characteristics such as “workload”, “work pace”, “job control” and “skill use”, and health outcomes such as “stress”, “job satisfaction”, and “musculoskeletal disorders”. Altogether, 38 studies were identified,
20 of which had been published in peer-reviewed journals. Most of the studies (31) were from USA and Canada, while six were from UK and one from Finland. With regard to sectors, 13 studies were in the auto industry, 13 in various other manufacturing industries, 11 in the health sector, and one in telecommunications. The review included both qualitative and quantitative studies.

In this first review by Landsbergis et al. (1999), the definition of lean constituted a problem, because the scope and context of lean remained largely unarticulated. According to Landsbergis et al. (1999), all the studies in the auto industry, with one exception, made explicit use of the term lean production, whereas none of the other studies use the term lean. In what Landsbergis et al. term “other manufacturing plants”, the new work systems listed are TQM, quality circles, teams, and multi-skilling. Four of the 11 studies refer to JIT, which is often considered a lean tool, but in combination with other not necessarily lean components. Taken together, these studies from other manufacturing plants do not seem to be relevant for an assessment of the specific relationship between lean and the working environment. The terminology issue is even more prevalent in the two other sectors studied. In the telecommunications industry, the work system is described as self-managed teams, and in the health care industry, the work systems are described as magnet hospitals, patient-focused care, and similar terms. Again, these are concepts which do not have clear relation to lean. The Landsbergis review therefore tells us something about lean in the North American auto industry in the 1990s, but not about lean in other sectors.

For the auto industry, Landsbergis et al. draw a clear and negative picture of the outcome of lean on the working environment. The lean jobs have intensified work pace and increased demands, while job control remains low. The health effects are also negative: the authors point to increased work-related musculoskeletal disorders, fatigue, stress, and tension. The change process involved in implementing lean and the context of its introduction are not mentioned, but it should be noted that these conclusions are drawn from a North American setting in which employee participation is traditionally limited. Landsbergis et al. mention one interesting exception: in a British auto parts company (Parker et al., 1995), negative effects were identified in cases where lean (here characterized by the TPS) was introduced without employee participation, while positive effects were identified when employees were involved. Even though the overall effects, also in this study, seem to have been negative, employee participation did seem to play a positive role.

**Review methodology**

We chose to limit the review to quantitative studies in order to evaluate the possible causal effects of lean on the working environment and employee health and well-being. In this systematic review, therefore, we included quantitative studies published in peer-reviewed journals with outcomes measured in the form of effects on the working environment, health and well-being, such as job satisfaction and commitment. Other theoretical and qualitative empirical articles were used, when relevant, for the discussion of how to understand the relationship between lean and its effects on working environment and health.

The literature search was performed in Web of Science and PsycNet. We searched for publications from 1999 onwards with the following search terms: “lean manufacturing”, “lean production” (and the synonyms “Toyota Production System” and “just in time”),
in combination with possible outcomes: stress, job satisfaction, psychosocial, health, safety, working environment, occupational/industrial injuries, diseases, and accidents. Altogether, 239 publications were identified in Web of Science. Most of these hits did not include working environment or health and well-being issues, which identified a total of only three articles. No additional relevant articles were identified in PsycNet. When we then checked literature lists and citations of Landsbergis et al. (1999) and the three articles identified in Web of Science, eight additional relevant articles were identified.

The articles differ in their research questions, design and results; to compare the results, we extracted the information most important for our purpose as shown in Figure 1. This was done with the help of the following items:

(1) Project design:
   - Industrial sector.
   - Worksite/sample.
   - Design of the study.
   - Outcome measures (the dependent variables in the study).

(2) Description of lean:
   - Lean practice (how the authors describe lean in their study).
   - Lean implementation and context (how the authors describe these dimensions in their study, merged to one item due to limited information).

(3) Effects of lean:
   - Effects on working environment (job characteristics which may affect employee health and well-being).
   - Effects on employee health and well-being.

The description of lean in the studies is summarized based on the authors’ own descriptions of the lean practice highlighted in the studies (Table I). There are many differences, since the authors use different definitions of lean and focus on different practices, making direct comparison more difficult. We therefore chose a pragmatic approach: if lean is the term used by the researchers, then we accepted the author’s view that it is indeed a lean system. However, because differences in what is termed lean are important, we also chose to evaluate the descriptions of lean used in the text. In cases where the use of lean core elements is limited, we discuss in the text following Table II the relevance of the study as a contribution to understanding lean effects on the working environment. All the studies focused on the resulting lean practice and not on individual tools, so it was not possible to evaluate the effects of specific tools.

**Review results**

The results of the review is presented in Table II and in the following text we discuss the findings and the validity of the studies, before we discuss a conclusion across the studies.

**Auto industry**

The first lean review (Landsbergis et al., 1999) includes a number of studies from the auto industry, and concludes that lean caused deterioration of the working environment and impaired health. The new studies tend to support this conclusion, but they also provide
<table>
<thead>
<tr>
<th>Authors</th>
<th>Industry</th>
<th>Sample/worksite</th>
<th>Design</th>
<th>Lean practice</th>
<th>Lean implementation and context</th>
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<tbody>
<tr>
<td>Lewchuk et al. (2001)</td>
<td>Auto industry</td>
<td>Four Canadian and one British plant with a total of 2,639 employee respondents</td>
<td>Comparison between firms and plants with different lean applications and firm strategies</td>
<td>A distribution of general lean principles such as reduction of buffers, tighter production standards, pull production, and continuous improvements</td>
<td>Five plants with different levels of lean implementation and different management strategies for both lean and collaboration with employees</td>
</tr>
<tr>
<td>Bruno and Jordan (2002)</td>
<td>Auto industry</td>
<td>One Mitsubishi plant, USA 1,090 employee and supervisor respondents</td>
<td>Comparison between surveys from 1989 to 1997</td>
<td>Described as complete lean production systems, specific examples: group work, quality circles, kaizen, stoplights, Team organization Assembly lines (lean content of reorganization of lines not specified) Workflow formalization and standardization (reduction of inventories, pull, standards, redesign for simpler assembly, control of standard compliance)</td>
<td>Entire plant constructed on lean principles. Eight years of operation seem to have worn out many lean elements Lean implemented during three-year follow-up Lean teams spent 18 months on implementation, including a number of lean analyses and improvements</td>
</tr>
<tr>
<td>Parker (2003)</td>
<td>Auto industry (large vehicle manufacture and assembly)</td>
<td>Assembly plant, UK 368 employee respondents</td>
<td>Quasi-experimental follow-up survey of three lean affected groups and one non-lean group over a three year period</td>
<td>Workflow formalization and standardization (reduction of inventories, pull, standards, redesign for simpler assembly, control of standard compliance)</td>
<td>Lean implemented during three-year follow-up Lean teams spent 18 months on implementation, including a number of lean analyses and improvements</td>
</tr>
<tr>
<td>Jackson and Mullankey (2000)</td>
<td>Other manufacturing industries (garment)</td>
<td>Four sites of one garment manufacturer, UK 556 employee respondents</td>
<td>Comparison between workgroups with traditional and lean organization</td>
<td>QRM including teams, u-shaped production cells, reduction of work in progress, &quot;right-first-time&quot;, visible production targets</td>
<td>QRM teams introduced in order to achieve quicker market response Implementation process not described</td>
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<th>Lean practice</th>
<th>Lean implementation and context</th>
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<tr>
<td>Anderson-Connolly <em>et al.</em> (2002)</td>
<td>Other manufacturing industries</td>
<td>Division of a large company, USA Random sample of 1,244 employee respondents</td>
<td>Follow-up surveys 1997 and 1999</td>
<td>Described as restructuring, characterized as outsourcing, reduction of inventory, simplifying process, and cross-functional teams</td>
<td>Fierce market competition resulting in large up- and downsizing. Lean elements included cost cutting programmes</td>
</tr>
<tr>
<td>Schouteten and Benders (2004)</td>
<td>Other manufacturing industries (bicycle assembly)</td>
<td>GEM bicycle plant, The Netherlands 63 employee respondents</td>
<td>Observer work analysis and questionnaire</td>
<td>Not clearly indicated, but it seems the plant is based on lean and that it is a part of normal operations</td>
<td></td>
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<tr>
<td>Seppälä and Klemola (2004)</td>
<td>Other manufacturing industries (metal industry)</td>
<td>Four production units in Finland (transmissions, X-ray imaging devices, axles, elevator cars) 525 employee respondents</td>
<td>Qualitative interviews about production methods and employee cross-sectional questionnaires</td>
<td>Lean principles integrated into large-scale change programmes, including socio-technical systems Lean elements at all sites: pull from customer orders, JIT, teams, quality development Variations: employee responsibility for material requirements, continuous improvements, kanban</td>
<td>Ongoing change programmes. Questions about employee experience with the changes, and qualitative interviews about the implementation of changes</td>
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<tbody>
<tr>
<td>Conti et al. (2006)</td>
<td>Other manufacturing industries (assembly in various metal industries)</td>
<td>21 sites in UK with 1,391 employees working with assembly</td>
<td>Combination of assessments of lean with employee survey</td>
<td>The application of ten lean tools including set-up reduction, waste reduction, kanban, kaizen, mixed model production, TQM, poka-yoke, TPM, SOP</td>
<td>Level of lean implementation measured, but the implementation process as such not studied</td>
</tr>
<tr>
<td>Sprigg and Jackson (2006)</td>
<td>Service industry (call centres)</td>
<td>36 call centres in UK 823 employee respondents</td>
<td>Cross-sectional questionnaire</td>
<td>Workflow integration, process simplification (standardization)</td>
<td>Not studied</td>
</tr>
<tr>
<td>Godard (2001)</td>
<td>Cross sectors</td>
<td>508 telephone interviews with employed Canadians</td>
<td>Comparison of different work practices and employee outcomes</td>
<td>Lean elements such as JIT, quality circles, and teams are part of a larger study of AWP</td>
<td>Not discussed</td>
</tr>
<tr>
<td>Brenner et al. (2004)</td>
<td>Cross sectors</td>
<td>1,848 establishments in USA</td>
<td>Combination of two surveys on injuries and employer training, respectively</td>
<td>Specified as TQM, JIT, teams, quality circles</td>
<td>Not studied</td>
</tr>
<tr>
<td>Authors</td>
<td>Industry</td>
<td>Outcome measures in the study</td>
<td>Effect on working environment</td>
<td>Employee health and well-being</td>
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<tr>
<td>Lewchuk et al. (2001)</td>
<td>Auto industry</td>
<td>Control over work methods, work pace, breaks, work intensity and pressure, physical workload, awkward positions, physical pain, feeling tense, exhaustion</td>
<td>^Control over work methods, work pace, breaks, work intensity and pressure, heavy physical workload and awkward positions</td>
<td>^Physical pain, ^Feeling tense, ^Exhaustion, ^No information</td>
<td></td>
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<tr>
<td>Bruno and Jordan (2002)</td>
<td>Auto industry</td>
<td>Satisfaction with a number of company policies, working environment, and job satisfaction</td>
<td>Working environment impaired from first to second survey, but no clear relation with lean as such</td>
<td>^Commitment, ^Depression levels, ^Self efficacy, ^No information</td>
<td></td>
</tr>
<tr>
<td>Parker (2003)</td>
<td>Auto industry (large vehicle manufacture and assembly)</td>
<td>Work characteristics: job autonomy, skill utilization, participation in decisions, role overload, Outcomes: commitment, job anxiety, job depression, role breadth, self-efficacy</td>
<td>^Job autonomy, ^Skills utilization, ^Participation, ^Lower timing control, ^Demands (pressure and monitoring, responsibility), ^Group cohesiveness, ^Cognitive demands, ^Role breadth, ^Task variety, ^Skill utilization, ^Social contact, ^Co-employee trust, ^Changes in working environment related to lean not reported</td>
<td>^No significant correlations with job-related strain and job satisfaction</td>
<td></td>
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<tr>
<td>Jackson and Mullarkey (2000)</td>
<td>Other manufacturing industries (garment)</td>
<td>Autonomy (six scales), work demands (five scales) social climate (six scales), and psychological well-being measures such as job-related anxiety and depression and job satisfaction</td>
<td></td>
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</tr>
<tr>
<td>Anderson-Connolly et al. (2002)</td>
<td>Other manufacturing industries</td>
<td>Intensity, autonomy, skilling, teamwork, overload, role ambiguity, stress, job satisfaction, harmful behaviours, health, job control</td>
<td>^Impaired health variables related to intensity, skilling, teamwork, ^Improved health variables related to autonomy, ^Managers, ^Impaired health variables related to intensity and autonomy, ^Improved health variables related to teamwork, skilling</td>
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<tr>
<td>Schouteten and Benders (2004)</td>
<td>Other manufacturing industries (bicycle assembly)</td>
<td>Job characteristics: completeness, cycle time, difficulty, autonomy, interaction, information</td>
<td>For assembly employees</td>
<td>Commitment, Need for recovery</td>
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<tr>
<td></td>
<td></td>
<td>Outcomes: commitment, need for recovery, job satisfaction, physical health, emotional strain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seppälä and Klemola (2004)</td>
<td>Other manufacturing industries (metal industry)</td>
<td>Experience with change management, job content, social relations, health and well-being</td>
<td>Job content for FMS operators, More favourable conditions</td>
<td>Job satisfaction, Stress</td>
</tr>
<tr>
<td>Conti et al. (2006)</td>
<td>Other manufacturing industries (assembly in various metal industries)</td>
<td>Physical and mental stress</td>
<td>Not reported independently but included in hypotheses testing. Variables include fitting of parts, interruptions, work for absent employees, ergonomic adaptation, job rotation, removal of resources, teamwork, cycle time, intensity, task support, lack of tools, buffers, change in autonomy, training, output displays, blame for faults, involvement in improvements, and long hours</td>
<td></td>
</tr>
<tr>
<td>Sprigg and Jackson (2006)</td>
<td>Service industry (call centres)</td>
<td>Work characteristics: autonomy, workload, role conflict, skill utilization, task variety, Mental health: anxiety, depression</td>
<td>Timing and method control, Workload, Role conflict and clarity, Task variety, Skill utilization</td>
<td>Job-related anxiety, Job-related depression</td>
</tr>
<tr>
<td>Godard (2001)</td>
<td>Cross sectors</td>
<td>Belongingness, task involvement, empowerment, workload, stressfulness, fatigue, self-esteem, job satisfaction, commitment, motivation, citizenship</td>
<td>Moderate level of AWP, including lean elements’ positive impact on Empowerment, Task involvement</td>
<td>Moderate level of AWP including lean elements’ positive impact on Job satisfaction, self-esteem, motivation, commitment, citizenship, belongingness High levels of AWP Increased stress Cumulative trauma disorders associated with quality circles and JIT</td>
</tr>
<tr>
<td>Brenner et al. (2004)</td>
<td>Cross sectors</td>
<td>Cumulative trauma disorders</td>
<td>No information</td>
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**Notes:**  
"Lean associated with impaired conditions; "lean associated with improved conditions; "unclear association"
evidence that indicates a more complex picture. Lewchuk et al. (2001) indicate that there is a more strenuous working environment and level of psychosocial discomfort (tense feelings and exhaustion) in the plants with the most comprehensive application of lean. However, details about lean are not recorded, and the authors also indicate differences in management strategy as being one possible reason. The three plants with the most extensive lean activities all belong to GM, which is described in the articles as a firm with an aggressive stance towards employees and their unions and great difficulties maintaining productivity. It is thus not clear whether the results are caused by lean practice or by an industrial context and implementation strategy marked by management pressuring employees and by poor industrial relations. Thus, this study does emphasize the importance of both the lean implementation strategy and lean context.

In another auto study, Bruno and Jordan (2002) examine the development of a US Mitsubishi plant from production start in 1989 to 1997. The plant was based on a strong lean practice from the very outset, with management voicing a strong commitment to employee involvement in continuous improvement, therefore also emphasizing the recruitment of a well-qualified workforce. While the employees express strong discontent with lean in 1997, it is not convincing that the problem is lean as such. The description of the situation in 1997 suggests a move away from the original lean ideas and a breach of employee expectations and trust, as employee involvement had dwindled, and for instance follow-up on kaizen improvements had weakened.

Parker (2003) made a diligent study of lean in a UK heavy-vehicle assembly plant. Working environment and employee outcomes were measured before and after the introduction of a number of lean practices, and a group of technical support employees, without any lean modification of their work, served as an internal reference group. Parker found a clear relationship between how lean affected employees and reduced such working environment factors as job autonomy, skills utilization and employee participation, with a subsequent negative impact on employee health and well-being, including commitment, depression levels, and self-efficacy. The negative effects were strongest for employees in the reorganized assembly line, and employees affected by standardization, whereas the lean team was less affected.

Other manufacturing industries
Jackson and Mullarkey (2000) present one of the few examples where it is possible to compare lean and non-lean work organization systems directly. The authors studied traditional and lean-based garment manufacturing in the same firm. The lean approach included team organization using quick-response manufacturing (QRM), which is comparable to a U-cell set-up. The results show both negative and positive effects of lean on the psychosocial working environment. There were lower timing controls, higher demands, and increased conflicts in the lean teams. On the positive side, there were greater breadth in work roles, more variation, higher skills utilization, and higher cognitive demands. Looking at the mental health consequences, it seems that the negative and positive sides cancelled each other out. Although not included in the rigorous study design, the authors report that the QRM teams had less absenteeism and labour turnover. A qualitative study (Locke and Romis, 2007) supports these more positive findings. Two Mexican garment plants were compared: one with a system similar to QRM, and one with a traditional work organization. The authors of the study
found the QRM system to be more favourable in terms of payment, teamwork, task complexity, and employee participation.

Anderson-Connolly et al. (2002) ask the question: is lean mean? They try to answer the question by measuring job structure, stressors, stress, and mental health in two surveys involving a division of a large manufacturing firm in the US. Lean is described as restructuring, including: outsourcing, reducing inventory, simplifying processes, and teams. However, the effect of lean is not really established. The use of the terms “restructuring” and “outsourcing” brings to mind the management concept of “business process reengineering” which, while popular in the 1990s, is quite different from lean. The analysis is based on a statistical model using job structure (intensity, autonomy, skilling, teamwork and computing) as a predictor for outcomes two years later. The results of the analysis show that intensity, skilling and teamwork impair health, while autonomy improves it; but it is not quite clear how these effects are related to lean. The level of lean and the possible changes in lean during the two year period were not investigated in the surveys.

Schouteten and Benders (2004) studied lean in a bicycle assembly plant in The Netherlands in one of the only two studies not made in an Anglo-Saxon country. The authors used Karasek and Theorell’s (1990) job demand/job control model to evaluate the quality of work in the bicycle plant. The production processes were based on lean from the time the plant was established. Job characteristics were assessed by trained observers, and the employees completed questionnaires on their reactions to their jobs. The authors conclude that assembly jobs offered little autonomy but were also characterized by low complexity, thereby balancing demand and control. A few employees (trouble shooters and team leaders) had higher autonomy and higher job difficulty. The sample was very small (63 respondents), however, and no comparison was made with non-lean assembly. It is therefore difficult to conclude whether the low autonomy and low job difficulty is in fact a lean characteristic or rather representative of assembly jobs with short cycle time.

The other article from a non-Anglo-Saxon country was a Finnish study of four metal manufacturing firms (with one production site each) (Seppälä and Klemola, 2004). This is also one of the few examples of work not dominated by repetitive assembly tasks. A large part of the work at the four sites consisted of machining and related activities carried out by skilled metal workers. The authors emphasize that the lean principles adopted must be considered as integrated parts of larger change programmes, which are based, among other things, on the Scandinavian tradition of socio-technical systems (Emery and Thorsrud, 1976; Gustavsen, 2007). It is one of only a few studies to include questions on the quality of change management. It has methodological limitations because it is a cross-sectional study, without a control group that did not apply lean. The estimate of the consequences of the lean changes was therefore based on the experience of the employees. The authors conclude that the application of a lean practice had primarily positive consequences for the working environment in terms of both job content and quality of work, due to increased opportunities for participation, employee control, and learning. However, they also point out that for the most monotonous work (employees working with the flexible manufacturing system (FMS)), the improvements tended to be minimal or even negative, and also that in two of the firms, dissatisfaction with change management affected the results negatively.
The most comprehensive study of lean was carried out by Conti et al. (2006). They surveyed 21 sites with 1,391 employees engaged in assembly work in manufacturing industry in the UK. They tested 21 hypotheses based on a review of the literature on lean and stress, and 11 of these were supported by the material. They indicate both negative and positive effects: lean practices that increase work intensity and load had a negative effect, whereas practices increasing employee influence and support had a positive effect. The plants were given a score based on their level of lean implementation, and then the correlation between lean level and stress was tested. The authors found a weak significant linear correlation between higher lean level and stress. However, a non-linear convex quadratic curve seemed to fit better. It indicated increasing stress with higher levels of lean implementation, but it levelled out with an improved situation for the highest level of implementation (although still at a higher level than with low levels of lean). It is difficult with a cross-sectional study to judge development over time, but the results seem to indicate that some of the problems with lean may diminish with a more comprehensive lean implementation. The authors answer the oft-raised question, “Is lean mean?”, with the conclusion that it depends on management choices in the design and operation of the lean systems. It is clear, however, that the negative effects were the dominating outcome, but also that employee involvement in the implementation had a positive effect.

Service industry
The only published study conducted outside manufacturing industry was done in call centres (Sprigg and Jackson, 2006). The authors used “workflow integration” and “process simplification” (standardization) as descriptors for the lean practice. They hypothesized that an increased use of workflow integration and process simplification would lead to lower job quality and higher mental strain due to more monotonous jobs and less employee involvement. The hypothesis was tested and confirmed for a large number of call centre employees. However, it should be noted that the call centres did not apply a very wide array of lean practices; for example, they did not use kaizen meetings, which are supposed to increase employee involvement.

Cross sectors
Godard (2001) studied alternative work practices (AWP), which are quite comparable to lean practices but also include non-lean elements such as re-engineering. The study was based on a sample of the Canadian working population and contains certain methodological weaknesses, such as the common method bias. The general trend of the results is that AWP has a positive effect on both the psychosocial working environment and such employee outcomes as job satisfaction and motivation at lower levels of AWP, but that the positive effect weakens or even reverses at higher levels, where stress also increases. The author explains this result as a product of increased job intensity and performance pressure at higher levels of AWP. Brenner et al. (2004) found a relationship between cumulative trauma disorders reported as occupational injuries and the application of quality circles and JIT. However, the information about the lean practices at the establishments included in the study was limited.

Discussion of lean effects
In this section, we discuss what the 11 reviewed studies may be able to tell us about the relationship between lean, the working environment, and employee health
and well-being. Landsbergis et al. (1999) paint a gloomy picture of the consequences of lean in the auto industry, but do not present sufficient material to enable conclusions to be drawn about other industries. What new conclusions may be drawn from the studies made after this previous review? We have summarized the results presented above in Table III. The effects in each of the 11 studies are classified according to whether they are primarily negative, both negative and positive, primarily positive, or indecisive/missing.

In general, the various studies show primarily negative effects on both working environment and health and well-being. Nine out of the 11 studies include information about lean and the working environment, and seven found a negative impact. The general trend is that lean can lead to lower job autonomy, especially less timing and method control, although Seppälä and Klemola (2004) found improved job content for most employees. Higher demands, work pace, work load and work intensity are also mentioned in most cases. But two case studies also mention positive effects. Jackson and Mullarkey (2000) found increased breadth of employee role, cognitive demands, skill utilization, and social relations; and Seppälä and Klemola found improved social relations. The cross sector study by Godard (2001) also found positive effects from what he called a moderate level of AWP in terms of empowerment and task involvement. A semi-quantitative study of decision latitude under lean (Delbridge et al., 2000) confirms this ambiguous outcome. The authors conclude on one hand that the discretion handed over to employees is much more limited than suggested by Womack and Jones, but on the other hand, they also notice a break with traditional Taylorism, which removed all discretion about production from the employees.

With regard to health, two articles touch specifically on musculoskeletal disorders. Lewchuk et al. (2001) report physical pain, but the causal link to lean as such is not well established. Brenner et al. (2004) find an association between cumulative trauma disorders and quality circles and JIT. This association is based on correlations found between the reported occurrence of cumulative trauma disorders and the firm’s indication of the use of quality circles and JIT. As there is no further information about the practices behind the application of quality circles and JIT, it is also difficult to understand the possible mechanisms causing cumulative trauma disorders. Most of the studies focus on mental health aspects, and eight of the 11 studies report impaired health. These studies cover a series of effects, such as, feelings of tension, exhaustion, job-related depression symptoms, lower self-efficacy, stress, and anxiety. But there are also examples of positive outcomes. Anderson-Connolly et al. (2002) find that increased autonomy improved health outcomes, Conti et al. (2006) find that certain lean practices such as teamwork, task support, and participation in lean implementation can reduce stress, and Jackson and Mullarkey (2000) conclude that negative and positive changes

<table>
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<tr>
<th>Working environment</th>
<th>Primarily negative effects</th>
<th>Both negative and positive effects</th>
<th>Primarily positive effects</th>
<th>Indecisive or missing information</th>
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<tr>
<td>Health and well-being</td>
<td>5</td>
<td>2</td>
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<td>11</td>
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Table III. A summary of findings from the 11 studies with regard to effects on the working environment and health and well-being.
in the working environment cancel each other out, resulting in no effect on health. Only four studies include information on well-being outcomes, such as job satisfaction, commitment, motivation, and organizational citizenship, and these studies are divided on the two first categories: negative and both negative and positive effects.

All the studies that found negative effects from lean were looking at manual jobs with low complexity. The studies examine the application of certain lean practices such as removal of buffer stock, reduction of idle time, and pull production. Apparently, these changes in manual production work increase work speed and reduce job autonomy, and the additional elements of teamwork and kaizen have such limited weight that they cannot compensate for the work intensification, as pointed out by Delbridge (2005). The studies published from 1999 onwards thus confirm Landsbergis et al.’s review, which concluded that lean has a negative impact on employees in the auto industry. Here, we can add that this negative impact has also been demonstrated for manual work with low complexity outside the auto industry.

Although the negative effects dominate, there also seem to be positive aspects. Seppäla and Klemola (2004) found primarily positive effects such as higher job content, better social relations and higher job satisfaction, but to a lesser degree for jobs with the lowest complexity. Several authors found both positive and negative effects (Anderson-Connolly et al., 2002; Conti et al., 2006; Godard, 2001; Jackson and Mullarkey, 2000), and some studies suggested that a minority of qualified employees with more complex jobs experienced improvements (Parker, 2003; Schouteten and Benders, 2004).

So as yet, no uniformly clear relationship exists between lean and negative effects on employees. It is possible to implement lean, at least to some extent, in such a way that the working environment is improved, as the theoretical analysis by de Treville and Antonakis (2006) suggests.

Lean practice and the effects on the working environment
The results described above are partly contradictory, and it is thus important to point out that there is as yet no uniform or distinct causal relationship between lean, the working environment and employee health and well-being. Both negative and positive effects are present, although the negative effects dominate. When we look at the theoretical analysis, both negative and positive possibilities can be identified in the lean concept and tools (de Treville and Antonakis, 2006), and in the way lean is applied in practice (Bruno and Jordan, 2002; Seppäla and Klemola, 2004).

The definition of lean as a socio-technical system (Shah and Ward, 2007; Spear and Bowen, 1999) also clearly indicates that no such linear causal relationship between lean and the working environment should be expected. Therefore, having ruled out that lean in itself produces either uniformly positive or negative effects, the next question is to find the causes of the effects observed. Several studies indicate that both implementation (how lean is introduced, e.g. top-down or bottom-up) and context (e.g. a harsh environment with many conflicts or a context with high levels of trust) are important for the outcome. With regard to context, the two auto studies tell more about context than about the concrete changes initiated by lean. Lewchuk et al. (2001) describe lean as part of an employer strategy at loggerheads with the unions’ fight for improved working conditions for their members. Bruno and Jordan (2002) tell a story about the establishment of a new Mitsubishi plant in the US in 1989, where a comprehensive version of lean was applied emphasizing recruitment of a highly skilled workforce and
strong encouragement for continuous improvements. Initially, the employees were positive about lean, but eight years later they had lost confidence in the system. The study by Anderson-Connolly et al. (2002) also indicates the importance of context in the form of fierce competition involving both down-sizing and up-sizing in quick succession, which can have a strong impact on employees – perhaps stronger than the effects of lean; and Seppälä and Klemola (2004), who found the most positive effects of lean, indicate that the integration of lean in a larger programme of change, based on the Scandinavian tradition for socio-technique and employee involvement, could play an important and positive role.

Several studies mention the implementation process, although it has not yet been the subject of a more detailed analysis. Parker (2003) describes in some detail a long process of preparation and implementation of lean, but it is not clear to what extent the implementation strategy had consequences for the outcome. The results from two studies indicate that the degree of employee involvement in the implementation process is particularly important for employee behaviour outcome. Seppälä and Klemola (2004) found that a weak change programme with limited employee involvement accounted for the less positive outcome in two of the studied plants, and Conti et al. (2006) found a positive relationship between the involvement of employees in lean implementation and the reduction of stress.

Although we might not be able to find a clear and distinct causal relationship, the review does suggest that lean influences the working environment and employee health in a number of ways. On the basis of research so far, however, it is not possible to link specific elements in lean with specific effects. Apparently, it all depends on how lean elements are applied; the implementation process and the context also seem to be influential. Thus, we suggest that the effects of lean must be derived, not from the concept as such, but from the way lean is practised and the context into which it is introduced. And in this connection, the involvement of employees, both in lean implementation and in the operation of the lean production system in practice, seems to be the most important means of preventing negative effects on the working environment and employee health and well-being.

**Conclusion**

There is no doubt that lean is a controversial concept that is attracting much debate in both academic and business environments. And feelings run high: you are either for lean or you are against it. With two camps firmly determined to fight for their cause, there seems to be a conceptual deadlock in the lean debate. Those in support of lean argue that it is not merely a production method, but a way of thinking that raises efficiency and rejects waste. In the words of Womack and Jones, “Lean thinking” is embraced to “banish waste and create wealth in corporations”. The opposing camp asserts that ever since its appearance on the scene, lean has been a mean production method, causing attrition along with high demands for efficiency (Anderson-Connolly et al., 2002; Harrison, 1994; Stewart et al., 2009). According to this view, the care-for-less philosophy praised by lean risks becoming carelessness with regard to the people serving under it.

The studies reviewed in this paper searched for causal effects of lean on the working environment, and indeed it was also this relationship we initially wanted to learn about. However, on the basis of the evidence, we must conclude that an unambiguous negative or positive causal effect of lean cannot be established. A standard lean model which can
be tested does not exist. As the review points out, lean takes many different forms (i.e. regarding context, implementation and practice) which will have different effects on workers' working environment, health and well-being. In order to understand the effects of lean on the working environment, we must examine the workings of lean as a socio-technical system where the causal relations with the working environment are a matter of contextual and practical interpretation.

The learning point of this article is therefore not to judge lean, but rather, based on a review of recent lean literature, to ask: how can we think about lean and the working environment productively? By posing the question in this way, we might be able to move the lean debate beyond the opposing views and towards the understanding that:

- lean and the working environment are closely connected;
- the relationship between lean and the working environment is not a simple one; and
- although lean tends to have a negative impact on employees, especially those engaged in manual assembly work, positive effects have also been demonstrated.

It is thus a question of each organization developing its own lean practice based on its technical and organizational context, emphasizing the positive aspects of lean while trying to reduce the negative ones.

In this process, employee involvement in lean has proven to have a positive effect on the working environment, but as pointed out by Shah and Ward (2007), lean production is conceptually multifaceted, and employee involvement is but one of ten dimensions of a lean system. The review shows that it was not possible to distinguish effects of the other nine dimensions. From this finding, we can conclude a need for future studies of lean, designed in such a way that the relations between these ten dimensions and the working environment can be illuminated as well as how the positive aspects of these dimensions can be emphasized. This is particularly necessary regarding the use of lean in other sectors than the auto and other manufacturing industries, such as the service sector where the effects of lean are still little explored.

We therefore propose further exploration of lean as a socio-technical system and its implications for the working environment. In doing that, it is important to go into detailed studies of how lean practice can be developed in such a way that positive job characteristics, such as job autonomy, skill utilization, participation, social support, meaning of work, transparency, fairness, etc. are enhanced, and the possible negative sides of lean are reduced.

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**About the authors**

Peter Hasle is a Professor at the National Research Centre for the Working Environment. He has carried out extensive research in working environment, organisation and management of modern jobs. He has published widely in scientific peer-reviewed journals as well as in books. His current research interests are in lean, organisational social capital, small businesses and management concepts. Peter Hasle is the corresponding author and can be contacted at: pha@nrcwe.dk

Anders Bojesen, PhD, is an External Associate Professor at Copenhagen Business School and a Union Consultant at Government and Public Employees in Denmark. At the time of writing he was a Researcher in Organization and Management at the National Research Centre for the Working Environment in Copenhagen. His research applies a post-constructivist perspective to organization studies, and he has published in several peer-reviewed scientific journals in this field.

Per Langaa Jensen is a Professor at the Department of Management Engineering, Technical University of Denmark. Besides teaching, his current research activities are focused on how to develop productivity and attractive jobs in Danish industries, as a prerequisite for establishing the economic basis for a welfare society.

Pia Bramming is an Associate Professor at the Department of Learning, University of Aarhus. The research reported in the paper was conducted during her employment as a Senior Researcher at the National Researcher Centre for the Working Environment. Her current research interests include self leadership, virtual and affective leadership, human resource management, learning and organizational change, ideology and management. Her work has appeared in a number of journals covering these topics.

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