LEAN MANUFACTURING IMPLEMENTATION AND PROGRESS MEASUREMENT

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Abstract

Applying Lean manufacturing philosophy is one of the most important concepts that help enterprises to gain competitive advantage in the world market. Lean manufacturing or lean production is a production practice, which regards the use of resources for any work other than the creation of value for the end customer, as waste. Although a lot of companies started implementing Lean concept, and the number of Lean tools, techniques and technologies available to improve operational performance are growing rapidly, only ten percent or less of the companies achieved significant results. The purpose of the paper is creating a model illustrating successful Lean implementation based on prior analysis of Lean implementation progress measurement and the main barriers identification. Implementation of Lean philosophy and principles can be described as a set of actions and processes starting with planning the change and, defining the success factors, and finishing with the implementation and measurement of the progress. For each of the improvement dimensions, several groups of indicators with a set of metrics can show and measure the company's progress: elimination of waste; continuous improvement; continuous flow and pull-driven systems; multifunctional teams; and information systems. Authors of this paper present the original model of the Lean implementation process, which includes success factors, barriers and progress measurement metrics.

The type of the article: *Theoretical article.*

Keywords: *Lean manufacturing, Lean implementation, progress measurement, barriers.*

JEL Classification: *M11, L23, M54.*

1. Introduction

Lean is a philosophy of manufacturing that incorporates a collection of principles, tools and techniques into the business processes to optimize time, human resources, assets, and productivity, while improving the quality level of products and services to their customers (Ronald, 2001). Applying Lean manufacturing philosophy is one of the most important concepts that help enterprises to gain competitive advantage in the world market. The waste-elimination concept of Lean manufacturing has a significant impact on various industries. Numerous tools and techniques have been developed to tackle specific problems in order to eliminate non-value-added activities and become lean.

The problem. Although Lean manufacturing has been widely recognised for its effectiveness in continuously improving productivity, product quality, and on-time delivery to customers and despite the fact that a lot of companies started implementing Lean concept, only 10 percent or less of the companies succeed in implementing Lean manufacturing. Even though the number of available Lean tools, techniques and technologies for the improvement of operational performance is growing rapidly, the companies that attempted to use them failed to produce significant results. Despite significant studies and works on Lean manufacturing, this field has struggled with the lack of clarity on how to make Lean implementation more successful and what measures could be taken to facilitate it.

The background of Lean concept. The concept of producing products in a ”Lean” manner was first introduced by a research group after studying the Japanese style of manufacturing, mainly

Toyota Production Systems (TPS), in the 1980s (Womack, Jones & Roos, 1990). With the unique culture of continuous improvement, Toyota put together numerous tools and methodologies to eliminate wastes and enhance leanness of manufacturing systems (Monden, 1998). In an attempt to generalize the work of Toyota for other manufacturing settings, Krafcik (1988) coined the term "Lean" to highlight the principles of limiting inventory and excess workers, or "waste", as opposed to other auto manufacturers' "buffered" approaches (Hopp & Spearman, 2004; Staats, Brunner & Upton, 2011). Later "Lean" was defined by Howell (2001) as "Give customers what they want, deliver it instantly with no waste".

Lean production can be described at different levels of abstraction: it can be defined as a philosophy, as a set of principles and as bundles of practices. Womack and Jones (1996) define Lean production as a business and production philosophy that shortens the time between order placement and product delivery by eliminating waste from the product's value-stream. They present the Lean Thinking in a systematic way and summarize five critical elements of Lean implementation, i.e. value for the end customer, value stream mapping (VSM), continuous flow, pull driven systems, and the pursuit of perfection. These five principles resulted from a five-year benchmarking study conducted at Massachusetts Institute of Technology (MIT), regarding car production all over the world.

However, the dominant view in describing and measuring Lean production rests on a set of practices and tools used in eliminating waste (Shah & Ward, 2003; Narasimhan, Swink & Kim, 2006). While researchers disagree on the exact practices and their number, there is general consensus that there are four main aspects of Lean production, and they frequently group related practices together into bundles. These are practices associated with the quality management, pull production, preventive maintenance, and human resource management (Cua, McKone & Schroeder, 2001; Shah, Chandrasekaran, & Linderman, 2008). Beside the Lean tools, several performance metrics were developed to evaluate the improvements in Lean implementation.

The term 'leanness' was interpreted diversely in the scientific literature. Comm and Mathaisel (2000) describe leanness as a relative measure for whether a company is lean or not. McIvor (2001) uses the term "total leanness" to imply a perfectly lean state with several key dimensions of lean supply. Soriano-Meier and Forrester (2002) evaluate the degree of leanness of manufacturing firms using nine variables suggested by Karlsson and Ahlstrom (1996). Radnor and Boaden (2008) summarize several interpretations of leanness, including an ideal state of lean, a context-dependent process, an ideal to be pursued, a condition of being lean, a particular state of the relationships between the facets of a system, and a journey to the ideal.

Various Lean assessment surveys, such as Feld (2000), Conner (2001) and Jordan, Jordan Jr. & Michel (2001), have been proposed to guide users through the Lean implementation. For typical Lean assessment tools, questionnaires are developed to survey the degree of adoption of Lean principles.

Although the Lean indicators of assessment tools are designed to cover critical Lean principles, a fixed set of indicators cannot fit every system. The resulting scores may not represent the leanness level appropriately. A dynamic assessment approach proposed by Wan and Chen (2006) applies different templates of Lean indicators adaptively. Besides the assessment approaches, the quantitative Lean metrics also concern the leanness level. Allen, Robinson, and Stewart (2001) categorize the metrics into productivity, quality, cost, and safety. Detty and Yingling (2000) utilize simulation models with several performance metrics to quantify potential benefits of Lean implementation. However, the need to evaluate the overall leanness has not been fully addressed. An integrated leanness measure has not been established (Wan & Chen, 2008). As each metric contributes only partially, a group of metrics are needed to measure the progress achieved and to outline the overall leanness level.

The purpose of the paper is creating a model illustrating successful Lean implementation based on prior analysis of Lean implementation progress measurement and the main barriers identification.

2. Method

To fulfil the aim of the study these research methods were applied: the analysis and synthesis of scientific literature, logical analysis, analysis of statistical data, and graphic representation. The conducted analysis of scientific literature disclosed the essence and importance of Lean concept. Synthesis of scientific literature allowed finding out the core principles of Lean manufacturing. On the base of empirical studies and scientific literature review three groups of barriers for Lean implementation — people related barriers, technical and organizational barriers — were identified. As a result of extensive literature review the model illustrating successful Lean implementation process was presented.

Lean Manufacturing Implementation Process and Progress Measurement

Implementation of Lean philosophy and principles can be described as a set of actions and processes including planning the change, Lean tools and techniques, defining the success factors and barriers, and finishing by implementation and measuring the progress. Summarizing Martinez and Perez (2001), Anchanga (2006), Pettersen (2009), Sim and Rogers (2009), Radnor and Boaden (2008), Duque and Cadavid (2007), Upadhye, Deshmukh, and Garg (2010), Bollbach (2012), and Čiarnienė and Vienažindienė (2012), authors of this paper present the model for successful Lean implementation (see Figure 1).

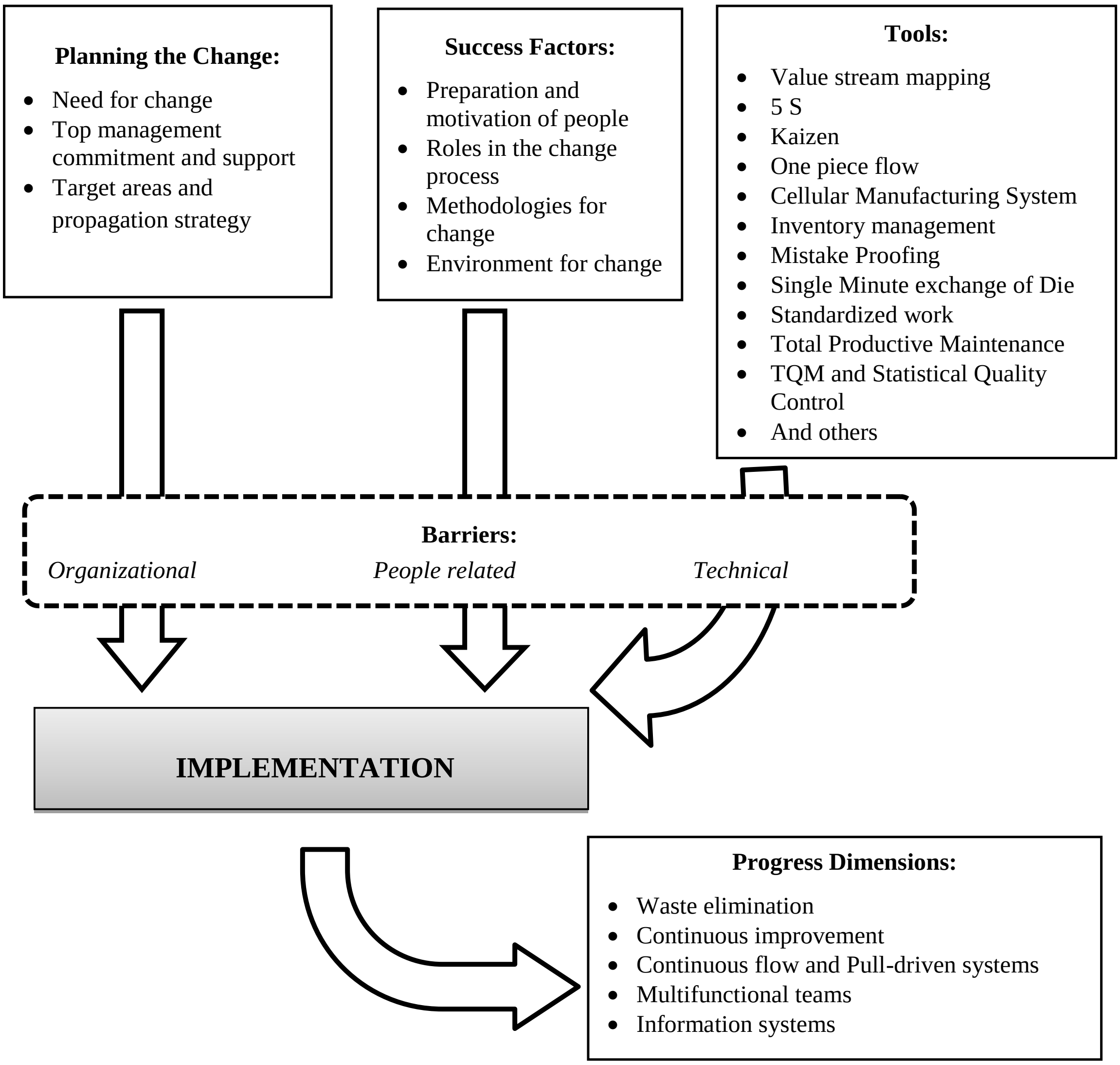

Figure 1. The model for successful Lean implementation

In the presented model these implementation activities should lead to improvement in five dimensions: elimination of waste; continuous improvement; continuous flow and pull-driven systems; multifunctional teams and information systems.

1. Waste is everything that does not add value to the product, like inventories, machine setups, machine downtime, movement of parts and scrap.
2. Continuous improvement: It represents the conviction that improvement efforts are never finished, and it is the consistency to keep the discipline for improvement in place.
3. Continuous flow and Pull-driven systems: It is the ability to abandon the batch mentality and adjust the processes to accept smoother movement of products through the line, which are going to be triggered by the pull of the customer of each process.
4. Multifunctional teams: In Lean implementations, teams have more responsibility and autonomy, so improvement and problem-solving can happen closer to the source. Also, to make flexibility in the line feasible, it is necessary to have a multi-skilled workforce.
5. Information systems: The reduction of vertical levels in the structure, and the autonomous operation that teams have to reach, makes necessary that employees have timely access to better information to enable problem solving and decision making. It does not necessarily mean, but it certainly does not exclude, computerized information systems.

It is necessary to show progress and to assess the effectiveness of the different changes, tools and techniques that are implemented. For each of the improvement dimensions, several indicators and metrics can show the progress. Summarizing Karlsson and Ahlstrom (1996), Niepce and Molleman (1996), Forza (1996), Martinez and Perez (2001), McDonald, Rentes and Van Aken (2002), and Duque and Cadavid (2007), indicators for Lean implementation measurement are presented in Table 1.

Table 1. Indicators for Lean implementation measurement

Progress dimensions	Metrics and Indicators
Elimination of waste	• Work in process (WIP): Value of WIP in the line. • Setup time: Time spent in setups/ total productive time (percentage). • Machine downtime: Hours-machine lost due to malfunction/Total machine hours scheduled (percentage). • Transportation: Number of parts (trips) transported and distance. • Space Utilization: How much area does the line need, including its WIP and tools.
Continuous improvement	• Number of suggestions per employee per year. • Percentage of suggestions that get implemented. • Scrap: % of the products that need to be scrapped. • Rework: % of the units that need to be sent to rework.
Continuous flow and Pull-driven systems	• Lot sizes: Average lot size for each product. • Order flow time: Time an order spends being processed in the shop floor. • Order lead time: Average time from the placement of an order (by a customer) to its delivery. • Pulling Processes: Percentage of the line processes that pull their inputs from their predecessors. • Pull Value: % of the total annual value or throughput of the system that is scheduled through pull mechanisms.
Multifunctional teams	• Autonomous control: % of quality inspection carried out by the team. • Work team Task Content: % of the tasks required to make the product performed by the team. • Cross training: Average over team members of Number of skills a team member possesses/Number of skills needed in a team. • Number of employees capable of assignment rotation.
Information systems	• Frequency with which information is given to employees. • Percentage of procedures that are documented in the company. • Frequency with which the line or cell progress boards are updated.

Across the world many authors have studied Lean manufacturing system implementation improvements reports' using empirical studies and case studies. The overview of these issues improvement level based on CITEC (2001), Zimmer (2000), Upadhye, Deshmukh and Garg (2010) is presented in Figure 2.

According to the given statistics, the most significant progress is seen in such improvement areas as return on assets (100 %), on time delivery (99 %), machine availability (95 %), machine setup time reduction (80-90 %), reduction in floor space (80 %), and inventory reduction (75 %).

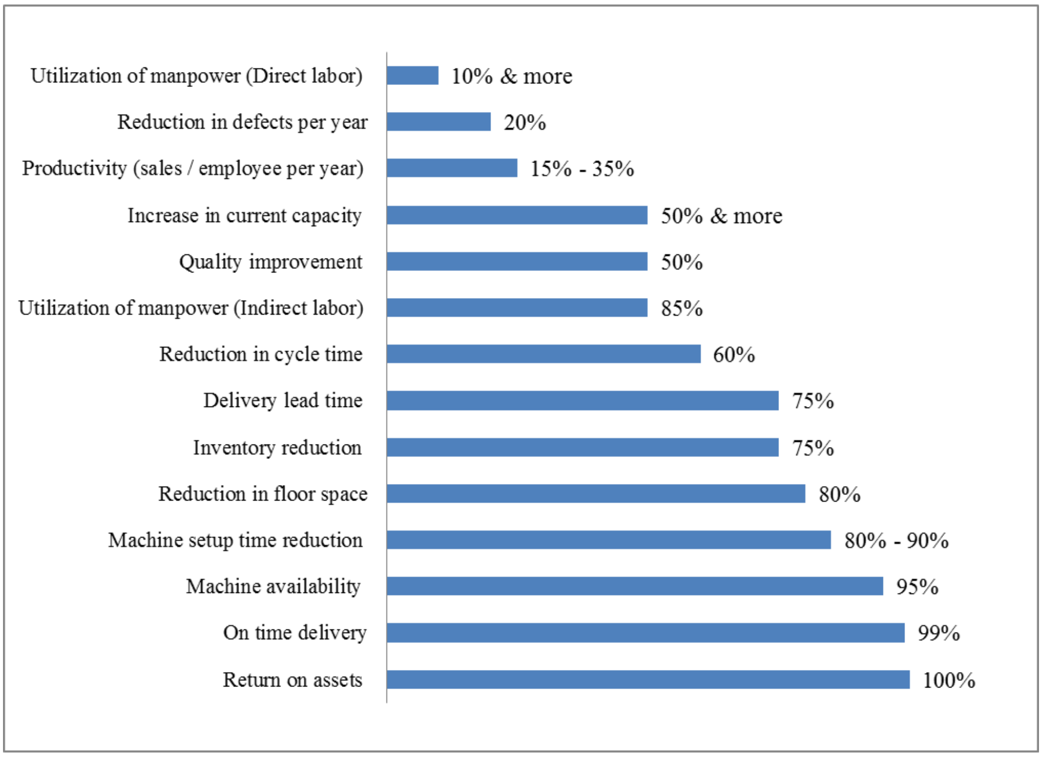

Figure 2. Improvement level after Lean concept implementation

Despite the quite significant results some barriers emerge that make Lean implementation process challenging. The analysis of scientific literature revealed that various authors emphasize slightly different barriers and challenges to Lean manufacturing implementation. Bollbach (2012) depictes the social and technical barriers, while Radnor et al. (2006) highlight barriers related with people issue, process issue, and sustainability issue. Summarizing Radnor and Walley (2008), Brandão de Souza (2009), Alinaitwe (2009), Brandão de Souza and Pidd (2011), Čiarnienė and Vienažindienė (2012), and Bollbach (2012), authors of the presented model (see figure 1) highlight three types of barriers to Lean manufacturing implementation: people related barriers, organizational and technical barriers. One of the major mistakes and reasons of unsuccessful implementing of Lean concept is focusing on tools and techniques instead of sufficient consideration to personally related issues. Lean as a philosophy must be clearly understood and rated at the top managerial level and involved into the company‘s strategy. Technical barriers mostly depend on the specific organization. Presented classification of barriers to Lean implementation is very overall. Barriers can differ depending on the sector of economy and specific company.

According to the empirical research conducted by Pirraglia, Saloni and Van Dyk (2009), Figure 3 depicts the main barriers, which prevent or delay Lean Manufacturing implementation.

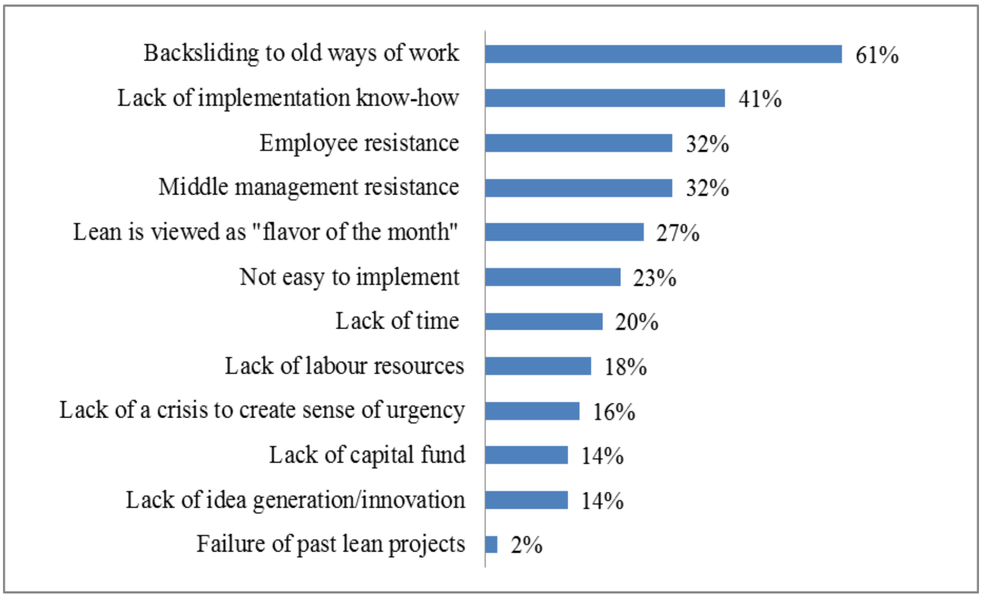

Figure 3. Barriers to Lean manufacturing implementation

The main barriers that were seen as preventing the adoption of Lean Manufacturing principles and techniques were the backsliding to old ways of working, lack of implementation know-how, and employee and middle management resistance.

3. Discussion

Lean Manufacturing is much more than a manufacturing technique. It can be described at different levels of abstraction: as a philosophy, as a set of principles and as bundles of practices. It is a different way of thinking, the different attitude the way operations are done and the way value is added.

Lean Manufacturing implementation is a multiplex process, a set of actions that requires planning the change and the establishment of possitive environment, preparation, implementing various tools and techniques, and measuring the achieved progress using specific performance metrics.

The results of this research can be useful for scientists analyzing this topic from theoretical and empirical perspective, and for practicians implementing Lean concept in business.

References

Alinaitwe, H. M. (2009). Prioritising Lean Construction Barriers in Uganda's Construction Industry. *Journal of Construction in Developing Countries*, 14, 15-29.

Allen, J., Robinson, C. & Stewart, D. (2001). Lean manufacturing: a plant floor guide. Society of Manufacturing Engineers: Dearborn, MI.

Anchanga, P. (2006). Critical success factor for lean implementation within SMEs. *Journal of Manufacturing Technology Management*, 17, 11-17.

Bollbach, M.F. (2012). Country - specific barriers to implementing Lean production systems in China. dspace.lboro.ac.uk/2134/10094

Brandão de Souza, L. (2009). Trends and approaches in lean health care. *Leadership in Health Services*, 22, 121-139.

Brandão de Souza, L. & Pidd, M. (2011). Exploring the barriers to lean health care implementation. *Public Money & Management*, 31, 59-66. doi:10.1080/09540962.2011.545548

Čiarnienė, R., Vienažindienė, M. (2012). Lean manufacturing: theory and practice. *Economics and management*, 17, 732-738. doi:10.5755/j01.em.17.2.2205

CITEC Manufacturing and Technology Solutions, 2001, Lean Manufacturing

[http://www.citec.org/Lean_manufacturing.html]

Comm, C.L. & Mathaisel, D.F.X., (2000). A paradigm for benchmarking lean initiatives for quality improvement. Benchmarking: An Int. J., 7, 118–127.

Conner, G. (2001). Lean Manufacturing for the Small Shop. Society of Manufacturing Engineers: Dearborn, MI.

Cua, K.O., McKone, K.E. & Schroeder, R.G. (2001). Relationships between Implementation of TQM, JIT, and TPM and Manufacturing Performance. *Journal of Operation and Management*, 19, 675-695.

Detty, R.B. & Yingling, J.C. (2000). Quantifying benefits of conversion to lean manufacturing with discrete event simulation: a case study. *Int. J. Prod. Res*, 38, 429–445.

Duque, D.F.M. & Cadavid, L.R. (2007). Lean Manufacturing Measurement: the Relationship between Lean Activities and Lean Metrics. *Estudios gerenciales*, 23, 69-83.

Feld, W.M. (2000). Lean Manufacturing: Tools, Techniques, and How to Use Them, St. Lucie Press: Alexandria, VA.

Forza, C. (1996). Work Organization in Lean Production and Traditional Plants: What are the differences? *International Journal of Operations & Production Management*, 16, 42-62.

Hopp, W.J. & Spearman, M.L. (2004). To Pull or not to Pull: What is the Question? *Manufacturing & Service Operations Management*, 6, 133-148.

Howell, G. (2001). Introducing Lean Construction: Reforming Project Management. Report Presented to the Construction User Round Table (CURT), Lean Construction Institute.

Jordan, J.A., Jordan Jr., J.A. & Michel, F.J. (2001). The Lean Company: Making the Right Choices, Society of Manufacturing Engineering: Dearborn, MI.

Karlsson, C & Ahlström, P. (1996). Assessing changes towards Lean production. *International Journal of Operations & Production Management*, 16, 24-41.

Krafcik, J. F. (1988). Triumph of the lean production system. *Sloan Management Review*, 30, 41-51.

Martinez, A. & Perez, M. (2001). Lean Indicators and Manufacturing Strategies. *International Journal of Operations & Production Management*, 21, 1433-1451.

McDonald, T., Van Aken, E.M. & Rentes, A. F. (2002). Utilising Simulation to Enhance Value Stream Mapping: a Manufacturing Case Application. *International Journal of Logistic Research Application*, 5, 213–232.

McIvor, R. (2001). Lean supply: the design and cost reduction dimensions. Euro. J. Purch. Supply Man, 7, 227–242.

Monden, Y. (1998). Toyota Production System: an Integrated Approach to Just-in-Time, 3rd ed., Institute of Industrial Engineers: Norcross, GA.

Narasimhan, R., Swink, M. & Kim, S.W. (2006). Disentangling leanness and agility: An empirical Investigation. *Journal of Operations Management*, 24, 440-457.

Niepce, W. & Molleman, E. (1996). A case study: characteristics of work organization in Lean production and sociotechnical systems. *International Journal of Operations and Production Management*, 16, 77-90.

Pettersen, J. (2009). Defining Lean Production: Some Conceptual and Practical Issues. *The TQM Journal*, 21, 127-142.

Pirraglia, A., Saloni, D. & Van Dyk, H. (2009). Status of lean manufacturing implementation on secondary wood industries including residential, cabinet, millwork, and panel markets. *BioResources*, 4, 1341-1358.

Pirraglia, A., Saloni, D. & Van Dyk, H. (2009). Status of lean manufacturing implementation on secondary wood industries including residential, cabinet, millwork, and panel markets. *BioResources*, 4, 1341-1358.

Radnor, Z. & Boaden, R. (2008). Editorial: Lean in Public Services — Panacea or Paradox? *Public Money & Management*, 28, 3-7. doi:10.1111/j.1467-9302.2008.00610.x

Radnor, Z. & Walley, P. (2008). Learning to Walk Before We Try to Run: Adapting Lean for the Public Sector. *Public Money & Management*, 28, 13-20. doi:10.1111/j.1467-9302.2008.00613.x

Shah, R. & Ward, P. T. (2003). Lean manufacturing: context, practice bundles, and performance. *Journal of Operations Management*, 21, 129-149.

Shah, R., Chandrasekaran, A., Linderman, K. (2008). In Pursuit of Implementation Patterns: the Context of Lean and Six Sigma. *International Journal of production Research*, 46, 6679-6699.

Sim, K.L. & Rogers, J.W. (2009). Implementing Lean Production Systems Barriers to Change. *Management Research News,* 32, 37-49.

Soriano-Meier, H. & Forrester, P.L., (2002). A model for evaluating the degree of leanness of manufacturing firms. *Integ. Manuf. Syst.*, 13, 104–109.

Staats, B.R., Brunner, D.J. & Upton, D.M. (2011). Lean Principles, Learning, and Knowledge Work: Evidence from a Software Services Provider. *Journal of Operations Management*, 29, 376-390.

Upadhye, N., Garg, S. & Deshmukh, S.G. (2010). Lean Manufacturing for Sustainable Development. *Global Business and Management Research: An International Journal*, 2, 125-137.

Wan, H., & Chen, F. (2006). A web-based tool for implementation of lean manufacturing, in 16 th International Conference on Flexible Automation and Intelligent Manufacturing, Limerick, Ireland, 1085–1092.

Wan, H. & Chen, F.F. (2008). A leanness measure of manufacturing systems for quantifying impacts of lean initiatives. *International Journal of Production Research*, 46, 6567–6584. doi: 10.1080/00207540802230058

Womack, J. (2002). Lean Thinking: Where Have We Been and Where Are We Going? *Forming & Fabricating, September 2002, Lean Manufacturing Special Insert*, p. L2.

Womack, J.P. & Jones, D. (1996). Lean Thinking: Banish Waste and Create Wealth in your Corporation. New York: Simon & Schuster.

Womack, J.P., Jones, D.T. & Roos, D. (1990). The Machine that Changed the World, Macmillan: New York.

Zimmer, L. (2000). Get Lean to boost profits. *Forming and Fabricating*, 7, 12-23.