Parallel Models for Lean and Green Operations

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Abstract

Many leading companies have implemented Lean Manufacturing Programs which yield increased efficiency, reduced costs, improved customer response time, and more. Others have adopted "Green" Programs resulting in reduced energy consumption, waste generation, and hazardous materials usage. Models for both Lean and Green systems all include management systems, waste identification, and implementation of waste reducing techniques (WRT) to achieve desired business results. Studying known Lean companies, we confirmed that strength of management system correlates with WRT implementation which correlates with business results for both Lean and Green Programs. Our results indicate that Lean and Green Programs lead to improved business results.

Keywords

Lean Production Systems; Green Production Systems; Environment; Efficiency; Cost Reduction; Sustainability

1. Introduction

In recent years programs intended to develop effective Lean Manufacturing Systems have been implemented in many of the world's leading companies. Many have been highly successful at increasing efficiency, reducing costs, improving customer response time, and contributing to improved quality, greater profitability, and enhanced public image. Some companies have committed to reducing negative impacts of their operations on the environment. The resulting "Green" Systems have sometimes created amazing reductions in energy consumption, waste generation, and hazardous materials used while also building the companies' images as socially responsible organizations.

Several research efforts discussed in the literature indicate that Lean companies show significant environmental improvements by being more resource and energy efficient. Some studies also show how Lean and Green Systems share many of the same best practices to reduce their respective wastes. Yet, the consensus view is that these two systems tend to operate independently, administered by distinctly different personnel, even within the same manufacturing plant. The United States Environmental Protection Agency (EPA) eloquently describes the division of environmental personnel focused on Green manufacturing system implementation and operations personnel focused on Lean manufacturing system implementation as "living in parallel universes of waste reduction [1]."

To date, there is little empirical evidence that Lean manufacturers transcend beyond the environmental by-products of their Lean systems and actually commit themselves to comprehensive Green manufacturing systems which lead to continuous environmental improvement. If Lean manufacturing can serve as a catalyst to Green manufacturing system implementation, then this relationship could have a profound effect on the means by which Green manufacturing systems are promoted by agencies such as the EPA, which is currently supporting research on this topic. We compare Lean manufacturing systems models with Green systems models to determine the degree of similarity that exists between the two sets of models. We conclude by suggesting that a model that integrates the two into one comprehensive program focused on reduction of all wastes (those targeted by Lean systems and those targeted by Green systems) can be the most effective and efficient path to long-term organizational sustainability.

2. Methodology

For comparative purposes, this study classifies both Lean and Green manufacturing system components into the same three main categories: Management Systems, Waste Reducing Techniques, and Business Results. The

management system defines the policies and procedures that create the environment/culture that commits the organization toward waste reduction, respective to each manufacturing system. Waste reducing techniques are the specific business and production process practices associated with each manufacturing system that result in waste reduction. Business results are the measurable improvements to the stated objectives of each manufacturing system.

2.1. Lean Manufacturing System Models

We reviewed Lean Manufacturing System Models suggested by leading researchers over the past decade [2]. Here we briefly summarize the most important existing Lean System Models.

Womack and Jones's study compared the practices of Japanese automotive manufacturers that pioneered the Lean manufacturing system against the practices of American and European manufacturers. They conducted another study in the mid-1990's that took a more global look at Lean manufacturers and attempted to capture their common best practices. These studies identified five core principles of Lean manufacturing. They are 1) specifying value, 2) identifying the value stream, 3) flow, 4) pull, and 5) perfection. Value is defined by the customer and is the goods and/or services the customer purchases. Anything not directly contributing to the creation of value is considered waste in the Lean philosophy. The value stream is the set of all the specific actions required to bring products or services to the customer. Mapping the value stream helps companies identify value added steps versus steps that are wasteful. Once value added steps are identified in the value stream and wasteful steps are targeted for reduction, the next step is to make product and information flow freely from value added step to value added step. Pull systems control each stage of production by only allowing preceding operations to produce when the next operation needs parts. This ideal Lean system would then achieve perfection when production creates the products or services required by customers at the very time they are needed without generating wastes along the way [3].

In 1999 the Society of Automotive Engineers (SAE) released a Lean Operations Best Practices Specification titled the J4000. The J4000 includes the Lean best practice categories identified in the Panizzolo study [4] and has a complete section devoted to Management Commitment. In particular, the J4000 indicates that leading Lean manufacturers exhibit management commitment best practices such as consideration of Lean as a strategic tool for competitiveness, establishing Lean policy statements, goals, and objectives, training employees, holding managers accountable for Lean results, and elevating adherence to Lean principles above short-term operating objectives. The J4000 specification is structured as a survey companies can use to benchmark their performance against the best practices of industry's Lean manufacturing leaders. The survey collects data in four areas: Management/Trust, People, Suppliers/Customers, Information, and Process Flow [5].

After studying the Toyota production system for twenty years with full access to Toyota executives, employees, and factories, both in Japan and the United States, Liker reveals the fourteen principles that comprise the Lean manufacturing system. His description of the Lean system is similar to Womack's, but provides considerably more detail in all aspects of the manufacturing system. Liker's Fourteen Points organized into his "4P model" [6] are:

- **Philosophy:** Long-term Philosophy
- **Process:** Continuous Flow, Pull Systems, Level Workload, Emphasis on Quality, Standardized Tasks and Processes, Visual Controls, Proven Technology
- **People**: Leaders Who Live the Lean Philosophy, Employees Who Follow the Lean Philosophy, Helping Partners and Suppliers Improve
- **Problem Solving:** Managers Who Go See Problems Themselves, Consensus Decision Making and Rapid Implementation, Building a Learning Organization-Continuously Improving

The Shingo Prize for Excellence in Manufacturing is named for Shigeo Shingo, a leading expert in improving manufacturing processes [7]. Established in 1988, the Prize promotes awareness of Lean manufacturing concepts and recognizes companies in the U.S., Canada, and Mexico achieving world-class status. The Shingo philosophy is that world-class business performance may be achieved through focused improvements in core manufacturing and business processes. Criteria used by the Prize Committee are based on leadership, organizational culture, empowerment, manufacturing strategies, system integration, quality, cost, delivery, and customer satisfaction [7].
From these sources, we concluded that the Shingo Prize model is the best representative model for the measure of "Leanness". This model shown in Figure 1 distills the essence of the theories of Womack and Jones, the SAE, and Liker into one coherent model. The Shingo Prize has a unique database of Lean companies' performance to these criteria based on a panel of expert examiners, which is a credible basis for comparing Green system performance.

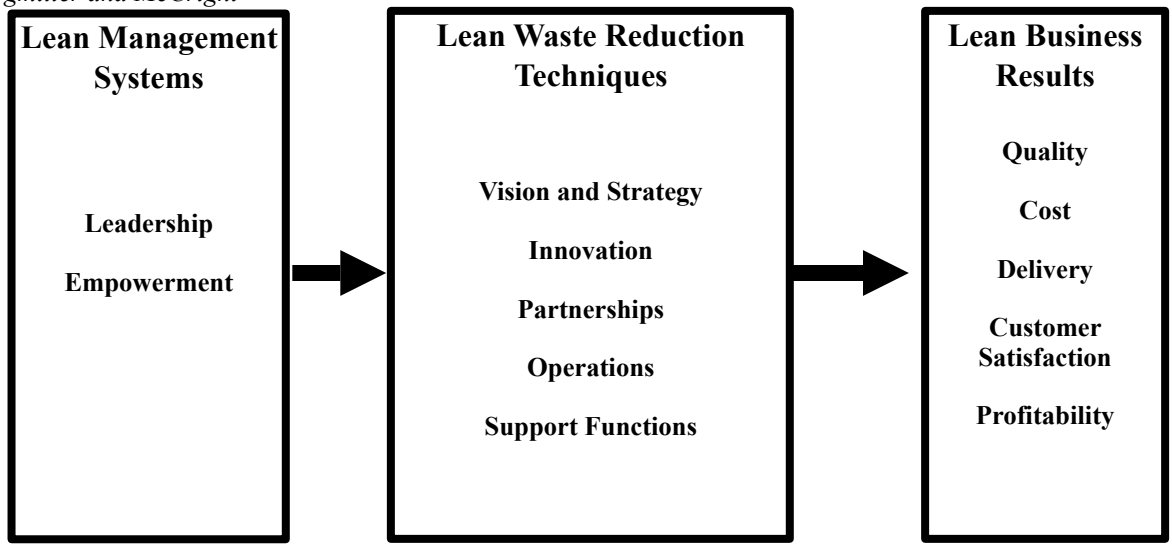

Figure 1: Advanced Lean System Model

2.2 Green Manufacturing System Models

Likewise, we reviewed Green Manufacturing Models suggested by prominent researchers and organizations. Here we briefly summarize the most important of these models.

Management Systems became popular in recent decades with the development of international standards for both Quality Management Systems (ISO9000) and more recently Environmental Management Systems (ISO14001). Manufacturing plants are certified to one of these standards by independent registrars, upon meeting the requirements stated in the ISO Management System standard [8]. Implementing an environmental management system (EMS) is a process by which an organization's management identifies regulated and unregulated environmental aspects and impacts of its operations, assesses current performance, and develops targets and plans to achieve both significant and incremental environmental improvements. Environmental aspects are human or industrial activities, products, or services that can interact with the environment. Environmental aspects are evaluated as to whether they can cause significant environmental impacts or changes. An EMS integrates environmental management into the organization's overall management system by identifying the policies, environmental targets, measurements, authority structures, and resources necessary to produce both regulatory compliance as well as environmental performance "beyond compliance." A continual improvement cycle is established through this process [8]. The key to a successful ISO14001 EMS is having documented procedures that are implemented and maintained so that successful achievement of environmental goals commensurate with the nature and scale of company activities is promoted. In addition, the EMS must include appropriate monitoring and review to ensure effective functioning of the EMS and to identify and implement corrective measures in a timely manner [8]. The EPA is very supportive of ISO14001, stating, "The new global Environmental Management System standard is proving to be an effective tool in improving industrial environmental performance. The intent of the standard is to establish and maintain a systematic management plan designed to continually identify and reduce the environmental impacts resulting from the organization's activities, products, and services [9]."

In a study of over 1,500 varied manufacturers, Russo found that the closer a company is to ISO14001 certification the more favorable respondents' opinions of the related benefits to the company [10]. He also found that the presence of an EMS (ISO14001 or otherwise) was a significant predictor of improved toxic emissions performance. The Russo study provides strong evidence that there is a correlation between a Green Management System and Green results. It indicates when management formally commits itself and the organization to reduce environmental waste, it happens.

Melnyk, Stoufe and Calantone [11] explored the effect Environmental Management Systems (especially the ISO14001 EMS standard) have on the implementation of "environmental options" (i.e. Green Waste Reducing Techniques) and on "operations performance" described as Lead time, Quality, and Cost (i.e. Lean Results). Melnyk, et al. developed a questionnaire to assess the achievement levels of companies responding to the survey. They identified important variables related to management system implementation, use of identified environmental

waste reduction techniques, and business results achieved through environmental activities of the company. They conclude that "corporate performance is strongly affected by the presence of a formal EMS" in that stronger EMS correlated to more use of environmental waste reduction techniques and more significant business results.

Synthesizing these different models, the EPA developed a core list of elements that should be included in any comprehensive Green manufacturing system. Regardless of the company's approach to minimizing environmental waste, "all of these elements should be included in their program to assure success [9]." The common elements are:

- Planning
- Leadership
- Metrics and Goals
- Focus on Results
- Information and Analysis
- Process Management
- Employee Involvement (Participation)
- Focus on Interested Parties

Note that all are management system elements.

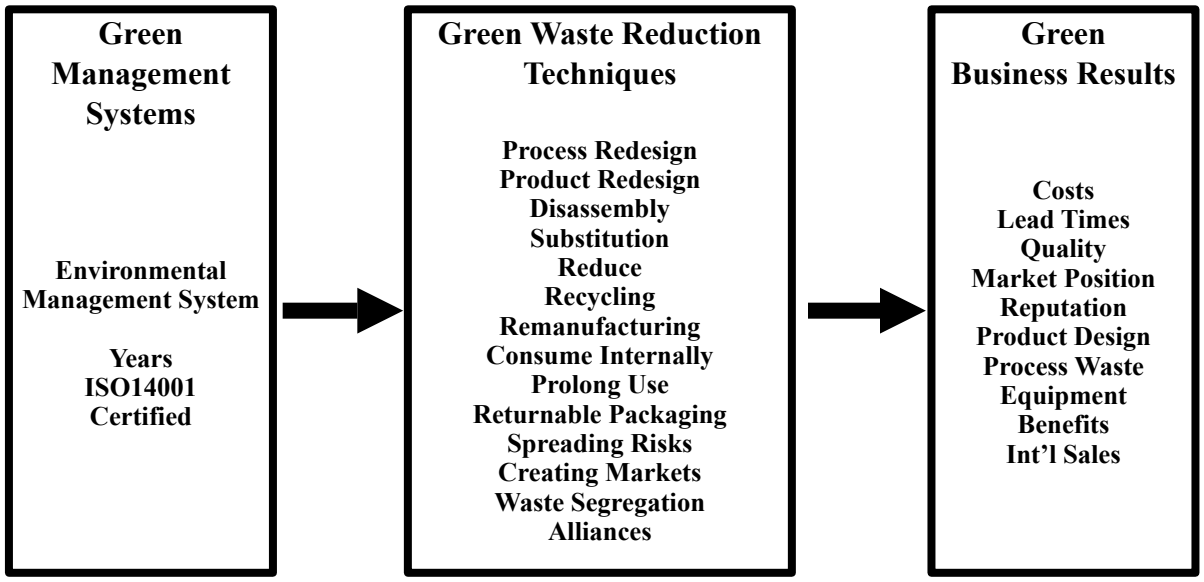

Figure 2: Advanced Green System Model

From these sources, we developed an advanced model of Green Systems, shown in Figure 2. This model draws heavily on the Melnyk, Stroufe, and Calantone model as it is the most comprehensive and best tested of the models. Elements of the theories of Russo, Melnyk, et al, Chiambrone, the ISO, the EPA, and GEMI can also be found in this one coherent model. The separate models of Green Systems have many similarities, chiefly their reliance on management systems to drive waste identification within the organization and the implementation of a comprehensive list of waste reducing techniques to achieve desired business results. The Advanced Green System Model proposed here aggregates the leading models into one integrated comprehensive model.

2.3. Comparative Models of Lean and Green Systems

A small number of scholarly studies have investigated the relationship between Lean and Green manufacturing systems [1, 12, 13]. These studies show a positive relationship between Lean and Green. Each shows correlation between some elements of a Green manufacturing system and some aspects of a Lean manufacturing system.

The Florida study [12] found that progressive companies applied advanced management practices (e.g. management commitment, teams, new process technology, innovative product design, supply chain management) toward minimizing environmental waste. Dr. Florida indicated that these techniques are associated with both Lean and Green manufacturing systems. "Advanced manufacturing facilities, such as those organized under the principles of

lean production, draw on the same underlying principles – a dedication to productivity improvement, quality, cost reduction, and continuous improvement, and technology innovation – that underlie environmental innovation [12]."

Collaborating with Ross & Associates, the EPA studied Boeing Corporation to determine if Boeing's Lean manufacturing program generated environmental improvements. They showed that Boeing's Lean manufacturing program reduced environmental waste as a byproduct of process efficiency and quality improvements associated with "Leaning" the manufacturing process. Secondly, they observed that the "waste reducing culture" associated with Boeing's Lean manufacturing program is exactly the type of culture the EPA has deemed essential for sustained environmental improvement. They also observed that Lean manufacturing programs/systems at Boeing and in general do not specifically address environmental waste reduction as a core objective of the program and considerable research opportunities exist to "build a bridge" between Lean and Green manufacturing systems [1].

Since both Lean System models and Green System models tend to emphasize the importance of the management system, the application of various waste reduction techniques, and the achievement of desired business results, we have recognized that there is great similarity in the structure of such models. Indeed, many of the elements of the models are very similar if not identical. While each study established meaningful correlations between various components of the model, none performed a full correlation analysis of the entire model. Figure 3 provides a comprehensive Lean/Green comparative model.

Figure 3: Comprehensive Lean and Green Systems Model

3. Discussion

Drawing from the major models of Lean Production Systems and the major models of Green Operations Systems, we have illustrated the parallelism between these two sets of theories. Each relies on management systems, waste identification techniques, waste reduction techniques, and measures of various business results. We conclude that Lean and Green Systems are parallel by nature and, indeed, have remarkably similar structures and elements.

Such similar models of operations and production improvement suggest that companies developing the elements of a Lean System can more easily develop the elements of a Green System than companies that have not actively pursued Leanness. We think companies first focused on adoption of Green management systems, coupled with the implementation of Green waste identification and reduction techniques, to achieve Green business results may also find it easier to add focus on Lean management systems, techniques, and business results than companies not pursuing Greenness. Thus, the parallelism in the structures and content of the Lean and Green System Models leads to the intuitive suggestion that a synergistic relationship may exist between Leanness and Greenness.

Studying companies identified by the Shingo Prize as being Lean, we confirmed that strength of management system is correlated to implementation of WRTs and that strength of implementation of WRTs is correlated to business results for both Lean and Green Programs. Thus, implementation of Lean and Green Programs can lead to improved business results.

4. Conclusion

This study of the leading Lean theoretical models and the leading Green theoretical models has yielded undeniable similarities between them. Developing advanced models of Lean Production Systems and Green Operations Systems contributes to a deeper understanding of each. Looking at the similarities and commonalities of the two systems allows us to see the parallel structures of these models and to suggest that an important area for additional research is developing a comprehensive, integrated model for the simultaneous implementation of Lean and Green Systems through one coordinated effort. Having shown the parallel nature of Lean and Green Systems, we leave to other articles the tasks of exploring the relationships between Lean and Green Systems, empirically testing the significance of the inter-correlations between elements of the two system models, and developing a model for an Integrated Lean and Green System.

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