

# **Are Lean and Green Programs Synergistic?**

**Gary G. Bergmiller, PhD**  
**Zero Waste Operations Research and Consulting**  
**Boulder, CO 80503, USA**

**Paul R. McCright, PhD**  
**University of South Florida, Tampa, FL 33620, USA, and**  
**Zero Waste Operations Research and Consulting**  
**Albuquerque, NM 87112, USA**

## **Abstract**

Since Lean and Green Programs each require management commitment and employee involvement, identification and reduction of organizational wastes, and continuously improving organizations, intuition suggests implementing one program may actually make implementing the second program less arduous. A study of known Lean companies shows that many Green elements are included in their Lean Programs. Evidence supports the conclusion that a significant synergy exists between Lean and Green Programs, suggesting that firms pursuing Leanness will be more successful if they also pursue Green objectives.

## **Keywords**

Lean Production, Green Operations, Environment, Efficiency

## **1. Introduction**

Models for increasing effectiveness and efficiency of a firm's production system through implementation of Lean Production have several points in common. All agree that top management commitment to a Lean Production System is necessary to build an organizational culture of continuous improvement and to empower workers to take action to improve the system. All agree that wastes must be identified and appropriate techniques applied to reduce or eliminate these wastes from the production system. All agree that serious, long-term adherence to such a Lean Program will lead to improved business metrics [1, 2].

Models for reducing the negative impacts of organizational activities on the Earth's environment through the implementation of Green initiatives are similarly consistent in structure. All Green models agree that top management commitment to the environment is essential to build a culture of environmental consideration and to empower employees to take actions to prevent negative environmental impacts from company operations. All agree that environmental wastes caused by operations must be identified and appropriate techniques applied to reduce or eliminate the generation of such wastes. All agree that serious, long-term adherence to such a program will lead to improved environmental and business results [1, 3].

The similarities in the structures of successful models for implementation of Lean Production Systems and Green Operations Systems are obvious and amazing. Indeed, the similarities also exist on the elemental level of such programs in the three areas of management, waste identification and elimination, and business results expected from the programs. Since many companies seek Leanness to improve profitability and responsiveness to consumers and many seek Greenness to obtain long-term sustainability and improved market reputation, the similarities in the basic models suggest that companies embracing both initiatives might find a useful synergistic effect. This study looks at the possibility of synergy between Lean and Green programs to determine how companies can appropriate the benefits of this synergy, if it exists.

## **2. Model and Hypothesis Development**

A broad look at the models of Lean programs and those of Green programs was undertaken [1, 4] to determine an aggregate of the principles and theories relating to these programs. A brief summary of the findings is given here.

### 2.1 Lean Production Systems

Researchers [2, 5] adhere to the three foundations of Lean Production (management systems, waste reduction techniques, and business results). While slight differences exist, these researchers suggest similar elements to the steps in Lean programs. Table 1 shows the elements of a Lean Production System.

Table 1: Elements of a Lean Production System

Management Systems	Waste Reduction Techniques	Business Results
Leadership	Vision/Strategy	Quality
Empowerment	Innovation	Costs
Satisfaction	Partnerships	Delivery
Profitability	Operations	Customer
	Support Functions	&

### 2.2 Green Operations Systems

Researchers [3, 6, 7] adhere to the three foundations of Green Operations (management systems, waste reduction techniques, and business results). With some differences, they suggest similar elements to the fundamental steps in Green programs. Table 2 summarizes the elements of a Green Operations System.

Table 2: Elements of a Green Operations System

Management Systems	Waste Reduction Techniques	Business Results
Environmental Management System	Product Redesign	Costs
Years ISO 14001 Certified	Process Redesign	Lead Times
	Disassembly	Quality
	Substitution	Market Position
	Reduce	Reputation
	Recycling	Product Design
	Remanufacturing	Process Waste
	Consume Internally	Equipment
	Prolong Use	Benefits
	Returnable Packaging	International Sales
	Spreading Risks	
	Creating Markets	
	Waste Segregation	
	Alliances	

### 2.3 Synergy Model

To test for synergy, the involvement with one program (either Lean or Green) must be shown to provide an enhanced positive impact on the results of the other program (Green or Lean). This would imply that firms pursuing Lean objectives will be more successful if they also pursue Green objectives, and vice versa. Figure 1 shows this model. This study explores the impact of Green programs on Lean results.

### 2.4 Hypothesis

We hypothesize that firms pursuing Lean objectives will exhibit greater Lean Business Results if they have stronger Green systems in place. In other words, firms seeking Leanness will naturally be more successful to the degree they include the elements of Green Operations Systems in their programs. Involvement in Green Management Systems and Green Waste Reducing Techniques is expected to enhance both Green Results and Lean Results. Therefore, this study seeks to explore the following hypothesis:

*Lean firms including elements of Green Operations Systems will have stronger Lean Results than those that do not include Green elements.*

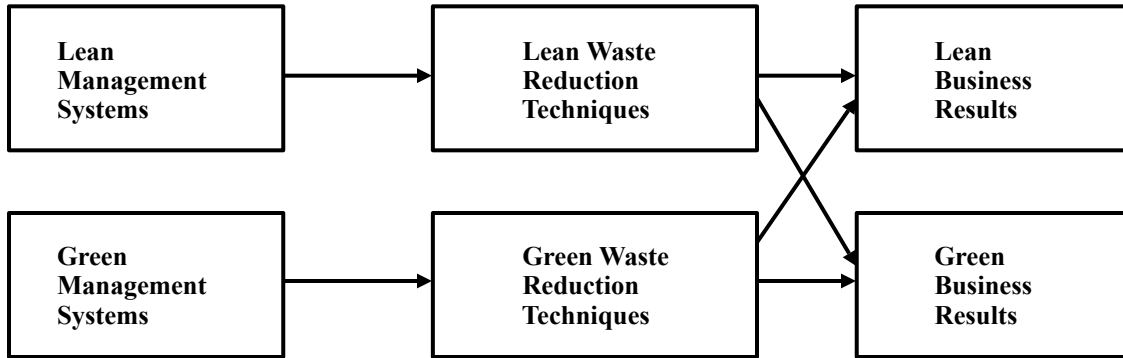


Figure 1: Model of a Synergistic Relationship Between Lean and Green Operations

### 3. Methodology

The hypothesis was tested by comparing scores on measures of elements of Green Management Systems (GMS) and Green Waste Reduction Techniques (GWRT) with scores on measures of Lean Results (LR). Using the Green measures as independent variables and the LR measures as dependent variables in statistical analysis allows the testing of the hypothesis.

#### 3.1 Sample

Winners and finalists of the Shingo Prize for Manufacturing Excellence (America's pre-eminent Lean designation) for 2000 through 2005 comprise the sample for this study [4]. This particular sample was chosen because comparative scores on Leanness compiled by the Shingo Prize Evaluation Committee were made available to the researchers. This measure is comprehensive, including consideration of leadership, organizational culture, employee empowerment, manufacturing strategies, system integration, quality, cost, delivery, and customer satisfaction and is validated by the third-party determination of scores [4].

#### 3.2 Variables

The independent variables were measures of the elements in the composite model of Green Operations Programs shown in Table 2. These variables were elements of GMS and GWRT as well as a composite Greenness score. Detailed descriptions of each of these variables can be found in [4]. Measures of these variables were taken from a study by Melnyk, Sroufe, and Calantone [7]. Their questionnaire was modified to fit this study and posted in an on-line site [8]. All Shingo winners and finalists in the sample were requested to visit the site and complete the questionnaire. Of the 120 companies in the database, 47 submitted usable surveys, resulting in a 39% response rate [4].

The dependent variables were the Lean Results elements (quality, cost, delivery, and customer satisfaction and profitability) obtained from the Shingo prize scoring system database. These measures pertain to an individual manufacturing plant that received a site visit from a team of five Shingo prize examiners. The team collaborated to create a single set of scores for the eleven sub-elements of the Shingo prize criteria including these LR elements. Detailed descriptions of each of these variables can be found in [4].

#### 3.3 Statistical Analysis

The hypothesis was tested by comparing the Green survey statistics of the Shingo plant survey respondents to the Lean element scores taken directly from the Shingo database. Correlations for the elements of the Green Operations System with the Lean Results elements were determined. Table 3 shows the significance of these correlations [4]. These results provide strong statistical evidence that the known Lean Shingo companies integrating more Green System elements achieve greater Lean Results than those with less Green System integration.

Table 3: Significance of Correlations, from [4]

Independent Variables	Dependent Variables				
	Quality	Cost	Delivery	Cust. Satis./ Profitability	Total Lean Results
<b>Env. Mgmt. System</b>	<b>p&lt;0.05</b>	<b>p&lt;0.001</b>	NS	NS	<b>p&lt;0.05</b>
<i>Years Certified</i>	NS	NS	NS	NS	NS
<b>Total GMS</b>	NS	<b>p&lt;0.05</b>	NS	NS	NS
<i>Product Redesign</i>	NS	NS	NS	NS	NS
<i>Process Redesign</i>	NS	NS	NS	NS	NS
<i>Disassembly</i>	NS	NS	NS	NS	NS
<b>Substitution</b>	NS	<b>p&lt;0.01</b>	NS	<b>p&lt;0.05</b>	<b>p&lt;0.05</b>
<i>Reduce</i>	NS	NS	NS	NS	NS
<i>Recycling</i>	NS	NS	NS	NS	NS
<i>Remanufacturing</i>	NS	NS	NS	NS	NS
<i>Consume Internally</i>	NS	NS	NS	NS	NS
<i>Prolong Use</i>	NS	NS	NS	<i>p&lt;0.05</i>	NS
<b>Returnable Packaging</b>	NS	<b>p&lt;0.01</b>	NS	NS	NS
<i>Spreading Risks</i>	NS	NS	NS	NS	NS
<b>Creating Markets</b>	NS	<b>p&lt;0.05</b>	<b>p&lt;0.05</b>	<b>p&lt;0.05</b>	<b>p&lt;0.01</b>
<i>Waste Segregation</i>	NS	<i>p&lt;0.01</i>	NS	<i>p&lt;0.05</i>	<i>p&lt;0.05</i>
<b>Alliances</b>	NS	NS	NS	NS	NS
<b>Total GWRT</b>	NS	<i>p&lt;0.05</i>	NS	NS	<i>p&lt;0.05</i>

Notes: All correlations are positive in direction. NS = not significant.

#### 4. Results

Several interesting findings can be observed directly from this correlation matrix.

- The level of the firm’s environmental management system (ISO 14001) is significantly related to quality and overall Lean Results. It is very significantly related (p<0.001) to improved costs.
- Also, the total GMS score is significantly related to an improved cost picture.
- Substitution of less toxic, more recyclable, or more easily processed materials is significantly correlated to customer satisfaction and profitability as well as total Lean Results. It is highly related (p<0.01) to improved cost performance.
- Prolonging the use of products correlates to improved customer satisfaction and profitability.
- Returnable packaging is highly related (p<0.01) to improved cost performance.
- Creating new markets for the firm’s products/services is significantly correlated to improved cost performance, improved on-time deliveries, and improved customer satisfaction and profitability. It is highly related (p<0.01) to improved total Lean Results.
- Waste segregation is significantly correlated to customer satisfaction and profitability as well as to total Lean Results and highly related (p<0.01) to an improved cost performance for the company.
- Taken collectively, the application of various GWRTs is significantly correlated to improved cost performance and to the total Lean Results.

While many relationships between the various Green elements and Lean Results in Table 3 were not found to be significant in this study, a number of these may prove significant in a study with a larger sample size. The fact that 18 of these relationships are significant at the p<0.05 level or better suggests that synergy is occurring at the elemental level when firms simultaneously implement both Lean and Green activities.

#### 5. Discussion

Each of five Lean Results is significantly influenced by one or more of the Green elements. Exploring these relationships describes the mechanisms through which efforts to improve a company’s Greenness lead naturally to improvements in the company’s Leanness as well.

### **5.1 Quality**

The criteria used to measure Quality include process yield, rework, scrap, process variation, warranty costs, customer rejects, and total manufacturing costs. From the Lean perspective, the direct connection to the objectives of a Green system is visible. The ideal Green process has perfect yield, with no scrap: All resources end up in the finished product with no waste byproducts. Products have a long and useful life, with minimal customer rejects or warranty costs. Total cost of manufacturing is minimized as higher levels of efficiency are achieved. A requirement of ISO14001 is that the plant must establish environmental goals and objectives that drive the organization to continually reduce environmental waste and have a formal management review process to make sure the goals are realized. It is not surprising that the evidence of a formal EMS correlates strongly to quality improvement [4].

### **5.2 Cost**

Cost is significantly influenced by the Green variables Environmental Management System, Overall GMS, Reduce, Returnable Packaging, Creating Markets, Waste Segregation, and Overall GWRT. There can be little debate that one of the most important measures of a Lean System is total cost reduction. It can hardly be more evident that the Green system positively correlates to total cost reduction [4]. Substitution of hazardous raw materials, use of returnable packaging, waste segregation, and creating a market for waste products all speak to material resource efficiency and avoiding the generation of environmental wastes. This clearly indicates that emphasizing total waste reduction drives total cost reduction. This result is a strong indicator that a focus on total waste reduction (Lean and Green) results in total cost reduction, and the ultimate financial justification for integrating Lean and Green manufacturing systems [4].

### **5.3 Delivery**

Delivery is positively influenced by Creating Markets, suggesting that Lean companies with particularly strong delivery and logistics performance use this capability to find creative alternatives to sending waste to landfills and profit from delivering waste to firms that can use it as process inputs. It is reasonable to assume a company seeking markets for its waste products would strive to deliver them efficiently. This could then spill over to the delivery and logistics capabilities of their main products, resulting in improved performance as measured by the Shingo experts [4].

### **5.4 Customer Satisfaction and Profitability**

Customer Satisfaction and Profitability is significantly influenced by Substitution, Prolong Use, Creating Markets, and Waste Segregation. Customers may want to know that their products were produced in a least hazardous way through substituting more benign materials for hazardous materials. Also, prolonging the use of products translates to customer satisfaction, as customers would get more use from the product and thus receive greater value. Regarding profitability, substitution of hazardous materials is suggested in waste minimization/pollution prevention literature to reduce waste management costs, processing costs, and even raw material purchasing costs [3]. Products allowing prolonged use can command a price premium over brands that do not last as long. Creating a market for waste products means that instead of paying for waste removal, the firm is paid for its waste. Finally, waste segregation activities allow the most return on saleable waste products and reduce waste management costs overall. Each of these examples either lowers operating costs or allows a higher price in the market place, which together bring greater profitability [4].

### **5.5 Total Lean Results**

Total Lean Results is influenced by Environmental Management System, Substitution, Creating Markets, Waste Segregation, and Total GWRT. Each of these Green variables positively influences one or more of the individual Lean Results. The relationship between Total Lean Results and Total GWRT is a remarkable finding that implies that the Lean companies in this study who have opted to complement their Lean system implementation with a broad set of GWRT are realizing significantly better results in both Green and Lean categories than the other Lean plants in the study. This finding not only suggests that Lean and Green systems can co-exist, but provides evidence of *synergy*, by virtue of the fact that GWRT improve both Green and Lean results.

## 6. Conclusions

Four major conclusions result from these findings.

### 6.1 Green manufacturing drives Lean results, particularly improved cost performance.

Shingo plants implementing GMS and GWRT show higher Lean results than those less environmentally inclined. This indicates *synergy* because Green practices improve both Green and Lean results when implemented in a Lean environment. Green variables pertaining to GMS and GWRT significantly influenced all categories of Lean results. Most striking is how strongly the Green variables correlated to Cost, perhaps the most important measure of Lean. This very powerful conclusion financially justifies further research into the integration of these systems into a single Zero Waste Operations strategy.

### 6.2 Synergistic Lean and Green practices optimize the human resources applied to waste reduction.

Since no firm has unlimited human resources for improvement projects, priority must be given to projects that maximize Lean and Green synergies and eliminate several forms of Lean and Green wastes simultaneously. Companies interested in improving performance results associated with both Lean and Green systems must focus on these synergistic practices.

### 6.3 It is time to create a Zero Waste Operations system model.

This study indicates that there are substantial research opportunities to create a holistic Lean and Green operations model that maximizes synergistic Lean and Green practices to improve the efficiency and effectiveness of total waste reduction efforts. Lean programming has matured and is now reaching a point of total consensus and standardization. Green programming is younger and has yet to realize consensus on a single system model, except for the management system component (ISO14001). The fact that Green practices serve as a catalyst to Lean results indicates the great potential for integration. Lean systems can provide the structure and broad acceptance Green systems lack. Green techniques will enhance Lean efforts and address ever more pressing environmental issues companies and society face. Uniting Lean and Green into a single Zero Waste Operations system is likely to realize efficiencies and synergies well beyond what was found in this study.

### 6.4 There may already be Zero Waste Manufacturers in our midst.

Strong evidence of transcendence and synergy between Lean and Green systems suggests some of the companies in this study are already practicing what's been dubbed "Zero Waste Operations". Although it was not proven that all manufacturers get Greener as they get Leaner, there is evidence that several of the known Shingo plants are strongly committed to Green manufacturing. What is not known is whether they have attempted to integrate these strategies or if they simply co-exist within the same plant.

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