5-10-2015

# Factors that influence the implementation of the lean 5S tool within U.S. automotive suppliers

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Factors that Influence the Implementation of the Lean 5S Tool within U.S. Automotive Suppliers

by

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Research Dissertation

Submitted to the College of Technology

Eastern Michigan University

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY IN TECHNOLOGY

Concentration in Engineering Management

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May 10, 2015

Ypsilanti, Michigan

## Abstract

This study identified a number of key factors influencing the implementation of each of the phases of the lean 5S tool in suppliers to the U.S. automotive industry and to determine if these factors vary according to selected demographic variables. This study was conceived to develop a better understanding as to why some organizations fail to implement all five of the 5S phases and become stagnant. The research questions that guided the study included:

RQ1: What factors were perceived by the respondents to have influenced the implementation of the lean 5S phases and elements in suppliers of manufacturing products to the U.S. automotive industry?

RQ2: What is the relationship of the selected demographic variables on the perceived factors and the lean 5S phases in suppliers of manufactured products to the U.S. automotive industry?

Active members of the American Society for Quality (ASQ) who have leadership functions within U.S. based automotive industry suppliers constituted the population for this study. An electronic survey questionnaire was developed and administered to active members who have leadership responsibilities within U.S. manufacturing suppliers and belonged to selected ASQ sections from the states of Michigan, Indiana, Ohio and Kentucky.

The findings for research question 1 revealed that there is a strong relationship between all factors, elements and phases, and therefore all nine factors were perceived by the respondents to have an impact on the implementation of the lean 5S phases. The findings for research question 2 revealed that seven of the ten selected demographic variables affected each factor and each lean 5S phase. The results of the study provide a series of steps that

when followed can increase the likelihood of 5S implementation success within suppliers to the U.S. automotive industry.

Suggestions for future research include:

Develop a quasi-experimental study that can address cause and effect relationships for selected factors. A future study could be directed toward a comparison of an organization that has successfully implemented all of the 5S phases to one that has failed to determine what causes resulted in success or failure.

A recommendation for future research is to develop a qualitative study to better understand the conditions that influence significant differences in respondents from different states that operate within the same automotive business.

A recommendation for future research is to study suppliers of manufactured products to non-automotive organizations to determine if any similarities exist.

Additionally, a recommendation for future research is to study the lean 5S implementation by suppliers to the service industries such as academia, medical services and entertainment.

Another recommendation for future research is to study group dynamics such as the behavioral differentiation and the integration process of achieving unity of groups toward a common goal.

## Dedication

*To my wife, Ann; daughter Stacey; and son David, for their love, understanding and support*

## ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to Dr. Dugger, chair of my dissertation committee, for his professional support, guidance, encouragement, and valuable input throughout the dissertation process.

I would also like to thank the other dissertation committee members: Dr. Pilato, Dr. McVey, Dr. Bellamy and Dr. Fields for their valuable advice, support, and feedback throughout this process.

I am grateful to all faculty members at the College of Technology who taught me during the Ph.D. program. I am also grateful to all of the participants who completed my survey and made this study possible.

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# Chapter 1: Introduction and Background

Manufacturing organizations are under tremendous pressure to improve productivity and quality while reducing costs (Chuanan and Singh, 2012). Many of these organizations compete within a challenging global marketplace where there is tremendous pressure to adopt advanced manufacturing practices. The key to achieving sustainable development lies in addressing customer satisfaction through improved quality and productivity, reduced costs, and reduced delivery lead times (Upadhye, et al., 2010).

The lean manufacturing approach offers a solution to the need to improve quality and productivity, reduce costs, and reduce delivery lead times. Shaw and Ward (2003) wrote that the main core thrust of lean is that the lean practices work synergistically to create high-quality systems that produce finished products at the pace of customer demand with little or no waste. "The objective of a lean manufacturing system is to identify and eliminate the processes and resources which do not add value to a product" (Upadhye et al., 2010, p. 126). Karlsson and Ahlstorm (1996) wrote that "Lean manufacturing aims at the elimination of waste in every area of production, including customer relations, product design, supplier networks and factory management" (p. 24-41).

Although early initiatives were developed in Japan in the mid-1940's, lean manufacturing is a methodology that was first described by Taiichi Ohno in his 1988 seminal book entitled the *Toyota Production System*. Ohno (1988) wrote that the elimination of waste through utilization of the lean methodologies reduces costs, thereby increases profits, perhaps by a factor of ten. Dennis (2007) wrote that reducing wasteful activities by doing more with less such as time, human effort and materials is a principle of the lean methodologies that organizations implement when seeking to improve. According to Kumar and Bauer (2010) the cornerstone of the lean approach is the reduction of waste. “The vicious cycle of waste generating waste hides everywhere in production. Careful inspection of any production area reveals waste and room for improvement” (Ohno, 1988, p. 55). “Muda (Japanese term) means waste or any activity for which the customer is not willing to pay” (Dennis, 2007, p. 20).

A key element of the lean approach is the lean 5S tool. The term “5S” refers to five pillars or phases. “The 5S pillars are sorted, set in order, shine, standardize, and sustain” (Moriones, et.al. 2010, p. 217). The 5S tool is the fundamental prerequisite for the implementation of the lean methodologies and is a primary tool for continuous improvement (Imai, 1997). Moriones et al. (2010, p. 218) wrote that “5S is one of the best known and most widely used methodologies when facing improvement processes.” Organizations can utilize a simple 5S as the initial step in gaining a competitive edge through waste elimination projects for immediate gains (Shil, 2009). The lean 5S tool is the first tool that organizations typically implement in their effort toward the overall lean journey (Moriones, 2010). Therefore, the 5S tool is a critical tool to understand and implement if an organization is to benefit from a lean program. The success or failure of the lean initiative will likely hinge on the implementation of the lean 5S tool.

Recent research on lean 5S has been fragmented. Benjamin (2012) explored the implementation of the 5S system within the healthcare industry and reported that five common inhibitors prevented success. The five inhibitors reported were: lack of communication, commitment, personal responsibility, training, and management support.

Naqvi (2013) investigated how effectively the Indian sub-continent workers could cope with the implementation of a 5S lean system within their U.S. employment location. The sample for the study was 33 employees who migrated from the countries of India, Pakistan and Bangladesh. A key element was the impact of religion and culture on the implementation of lean 5S. The religion is much disciplined and the culture is one of obedience. The study revealed that the workers would follow orders as directed by supervisors who would undermine the lean 5S tool implementation and maintenance. Therefore lack of management support and commitment were identified as barriers.

Sofokleous (2003) studied manufacturing improvements through the use of the lean methodologies within a small agricultural business and the results revealed that the 5S tool led to improved efficiency by requiring less time searching for equipment, provided additional space, reduced inventory, and improved worker morale.

Barraza and Pujol (2012), based on the case studies of three Mexican manufacturing facilities that have applied the 5S tool for at least five years, identified three drivers and two inhibitors of successful 5S implementations. The three drivers reported were a strategic link of the 5S effort, implementation of all 5S's, and an implementation plan. The two inhibitors reported were the application of 5S as isolated events and the lack of a philosophical vision.

Moriones et al. (2010) surveyed the managers of 203 Spanish manufacturing firms and reported that the level of implementation of the lean 5S tool was very low at 2.09 on a scale of 1 to 10 with 68% of the respondents not using the 5S methodology at all.

Todorova (2013) studied the relationship of the lean tools, including the lean 5S tool, that play major roles for organizational success within job shop, batch shop, and assembly-line manufacturing settings. In regards to the 5S tool, the study revealed that the positive outcomes of 5S were significant in assembly line settings but not within the job shop or batch job settings.

The 5S tool has been successfully implemented in large and small operations in the U.S. and abroad (Becker, 2001). Hutchins (2006) revealed that workplace cleanliness, workplace organization, and floor space utilization improved with 5S implementations.

Lynch (2005) studied the correlation between the implementation of the lean 5S tool to productivity, quality and cycle time within three electrical departments of a larger electrical product division. The study revealed that the 5S implementation improved results in productivity and quality but not in cycle time in these settings. It was not determined whether all five phases of the 5S tool were not implemented.

Recent studies have focused on several key demographic variables that influence the implementation of lean methods including the 5S tool (Benjamin, 2012; Naqvi, 2013; Barraza and Pujol, 2012; Moriones et. al; Todorova, 2013). The most promising variables that may affect 5S implementations include: manufacturing tier level, number of employees at plant, job title of study respondents, degree of utilization of work teams, amount of 5S training, months of lean usage, level of management commitment, level of communication within the plant, degree of personal responsibility exhibited by employees, degree of utilization of an implementation plan, and availability of implementation resources. These demographic variables appear to need further study to determine their relationship to phases of the lean 5S tool.

The automotive industry is a key component of the Midwestern United States economy. Many original equipment manufacturers of automobiles are moving toward final assembly processes only and pushing manufacturing of automotive parts and accessories to sub-tier suppliers (Thompson and Merchant, 2010). The lean 5S tool has provided desired improvements in a variety of production settings. While factors affecting the 5S implementation have begun to be explored, the relationships between these factors to each phase of the lean 5S tool have not been investigated. Further examination of possible factors affecting each phase will help guide effective and sustained implementation of 5S in manufacturing settings which can result in more competitive manufacturing organizations. In regards to 5S in the United States, many organizations find it challenging, once some improvements have been noted, to go beyond the first three steps (Gapp et al., 2008). It is important to identify factors affecting phases of the 5S journey and determine whether they are mediated by key demographic variables. Such a study can provide insights which may lead to changes in practices that enhance the probability of lean implementation success. The demographic variables for this research were as follows:

1. Location by State (Michigan, Ohio, Indiana, Kentucky)
2. Organizational Function (Quality, Manufacturing, Operations)
3. Management Level (Upper, Middle, Lower)
4. Union or Non-Union
5. Tier Level (I, II, or III)
6. Plant Size (Number of Employees)
7. Time Spent Working with Teams (Percent)
8. Number of Months Using Lean Tools
9. Management Training Hours in the 5S Tool
10. Non-Management Training Hours in the 5S Tool

**Statement of the Problem**

The factors affecting the implementation of each of the phases of the lean 5S tool by manufacturing suppliers to the U.S. automotive industry had not been identified or compared based on key demographic variables. It was believed that such a study could lead to a better understanding as to why some manufacturing organizations fail to implement all five phases and become stagnant.

**Elements of Lean**

Manos and Vincent (2012) wrote that lean is “an approach to improve quality, increase productivity, reduce costs, and increase customer satisfaction by eliminating waste and creating value” (p. 2). Lean begins with a culture. “A lean culture is the sum total of all the lean tools, techniques and knowledge that exist within an organization … (Manos and Vincent, 2012, p. 2). Sohal (1996) wrote that a successful lean implementation requires dramatic changes at all levels and departments involving organization and culture.

There are many authors and publications that identify the lean tools. Some of the work overlaps and others identify different terms. Regardless, the common terms and tools identified as elements of lean include: Just in Time, Continuous Flow, Heijunka, Quick Set Up, Jidoka, Poke-Yoke, Andon, Standardized Work, the Five S’s, Total Productive Maintenance, Visual Management, Kaizen, Multifunctional Teams, Workers Involvement, Value Stream Mapping, and Muda elimination (Dennis, 2007; Detty & Yingling, 2000; Fang & Kleiner, 2003; Fullerton & Watters 2001; Fullerton et al., 2003; Miltenburg, 2007; Liker, 2004; Veech, 2001; Manos & Vincent, 2012; Ohno, 1988; Pettersen, 2009; Torodova, 2013).

Lean was developed and based upon a book written by Taiichi Ohno in 1988 entitled the *Toyota Production System*. After visiting the Ford Motor Company, Ohno realized that much waste existed in the Ford manufacturing facility. Due to that visit, he developed concepts to revamp Japanese automotive manufacturing and developed a system known as the Toyota Production System or TPS. Lean became popularized by a book written by Womack et al. in 1990 entitled *The Machine that Changed the World.* (Bhasin, 2012, p. 403). Liker (2004) identified 14 management principles in his book entitled *The Toyota Way*. The sections and principles are as follows (pp. 37-41):

Table 1:

Toyota's 14 Principles

| | Sections | | Principles |
|---|---|---|---|
| 1 | Long-Term Philosophy | 1 | Base your management decision on a long-term philosophy, even at the expense of short-term financial goals |
| 2 | The right process will produce the right results | 2<br>3<br>4<br>5<br>6<br>7<br>8 | Continuous process flow<br>Use pull systems to avoid overproduction<br>Level out the work load (Heijunka)<br>First time quality right the first time (Jidoka)<br>Standardized tasks<br>Use Visual controls<br>Reliable equipment |
| 3 | Add value to the organization by developing your people and partners | 9<br>10<br>11 | Grow leaders from within<br>Develop exceptional people<br>Respect your partners and help them improve |
| 4 | Continuously solving root problems drive organizational learning | 12<br>13<br>14 | Go and see for yourself (Genchi Gebbutsu)<br>Make decision slowly considering all options<br>Become learning organizations through reflection and Kaizen |

Dennis (2007) identified "The House of Lean Production" in his book titled *Lean Production Simplified.* (p. 19). Dennis showed that Stability and Standardization for the base of the house with the pillars of Just-in-Time, Involvement, and Jidoka holding up the roof, which has the Goal of Customer focus. Dennis also filled in the house with the various lean activities. Several of the lean activities are listed and the lean 5S tool is identified within all of the segments of his House of Lean Production.

"At the heart of the Toyota Production System is a focus on eliminating waste (muda), reducing inconsistency or fluctuation (mura), and minimizing overburden (muri)" (Manos and Vincent, 2012, p. 52). Several authors have documented that waste identification and elimination is an important element of lean. The seven forms of waste include waste in overproduction, waiting, transportation, over-processing, inventory, movement and making defective products. (Manos & Vincent, 2012; Liker, 2004; Dennis, 2007; Ohno, 1988; Womack & Jones, 1996).

**Lean 5S Tool**

Dennis (2007) wrote that visual management is a component of lean and that the lean 5S tool is designed to develop a visual workplace. Dennis (2007) also reported that lean 5S creates a work environment that is "self-explaining, self-ordering, and self-improving" (p. 31). Neese (2007) wrote that the underlying concept of a visual workplace is to provide simplicity in clear communication to employees in doing their jobs. Kattman wrote that the visual workplace manifests itself through many attributes including work instructions, signs, labels, colors, and lighting. Mestre et al. (2000) found that 75 percent of learning and comprehension was done through sight. Manos & Vincent, 2012; Liker, 2004; Dennis, 2007, Ohno, 1988, Womack & Jones, 1996 reported that the components of a 5S system include: Sort, Set in Order, Shine, Standardize, and Sustain.

The lean 5S phases are defined by many authors. (Moriones et al., (2010); Manos & Vincent, 2012; Liker, 2004; Dennis, 2007, Ohno, 1988, Womack & Jones, 1996).

Table 2:

The Lean 5S's

| The "S" | Japanese | English | Meaning |
|---|---|---|---|
| 1S | Seiri | Sort | Focus on eliminating unnecessary items |
| 2S | Seiton | Set-in-Order | Create efficient and effective storage methods |
| 3S | Seiso | Shine | Thorough cleaning |
| 4S | Seiketsu | Standardize | Make best practices the everyday standard |
| 5S | Shitsuke | Sustain | Embed into the culture |

**Rationale for the Study**

In 2012, The U.S. Bureau of Labor Statistics reported that 5.5 million manufacturing jobs were lost in the United States from the year 2000 through 2011. According to the Bureau of Economic Analysis, the 2011 gross output of U.S. manufacturing represented 11.5 percent of the total output for all industries. The Automotive manufacturing industry is an important component of the U.S. economy. A 2010 Center for Automotive Research report revealed that 8 million private sector jobs representing 500 billion dollars in annual compensation and 70 billion dollars in personal tax revenues were generated due to the 1.7 million direct automotive sector jobs. A study by the Motor and Equipment Association (2013) found that the automotive parts segment of the manufacturing industry is the nation's largest employer and accounts for 2.3 percent of the U.S. GDP. A study by the Center for Automotive Research (CAR, 2010) estimated that for every automotive manufacturing job, an additional ten others are created from part manufacturing to restaurant employees. The U.S. Bureau of Labor Statistics reported that in 2008, Midwestern states such as Michigan, Indiana, Ohio and Kentucky had over 4 percent of state GDP dependent on automotive manufacturing. The state of Michigan led the nation at 10.3 percent.

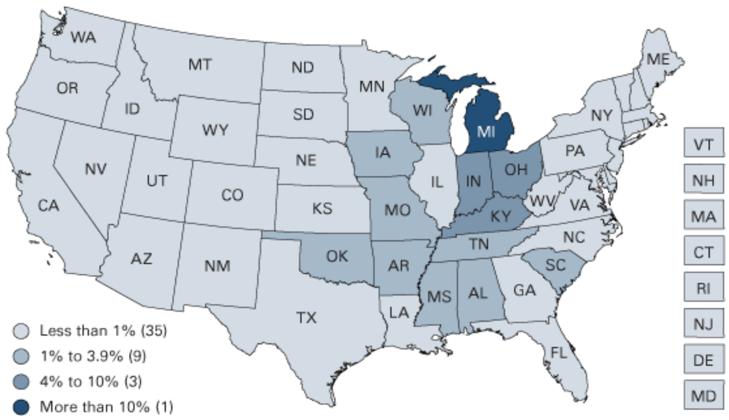


Figure 1: Percentage of State GDP in Automotive Manufacturing, 1998 to 2008

Source: Thompson, M. F., & Merchant, A. A. (2010). Employment and economic growth in the U.S. automotive industry: considering the impact of American and Japanese automakers. *Indiana Business Review*, 10.

The Center for Automotive Research (2010) reported that the automotive industry represented about 1.7 million U.S. employees in 2010 and accounted for 8 million total private sector jobs. Much of the employment in the automotive industry is upstream of the original equipment manufacturers (OEMs) within suppliers since many carmakers focus on final assembly while passing on the bulk of manufacturing their auto parts to independent suppliers.  The 2008 U.S. Bureau of Labor Statistics report identified that OEM suppliers are the largest employers in all but ten of the fifty states. Therefore, the suppliers to the OEM's are vulnerable to economic conditions. In order to remain competitive and reduce the impact recessionary times may dictate, the OEM suppliers within the U.S. automotive industry must implement continual improvement techniques that reduce waste and non-value added activities.

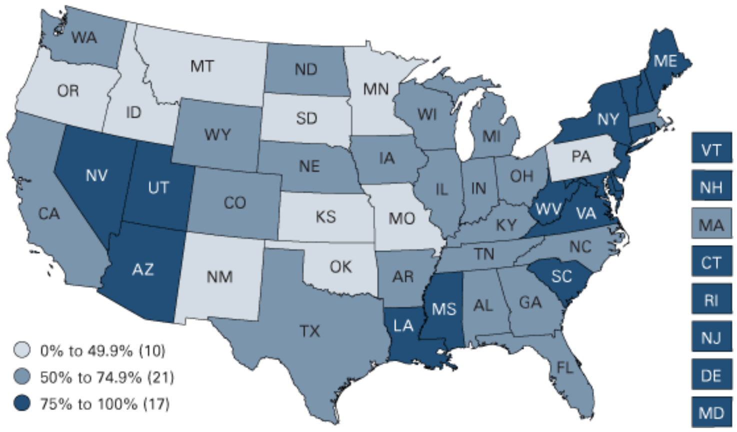


Figure 2: Percentage of Employment Manufacturing in Automotive Parts, 2008

Source: Thompson, M. F., & Merchant, A. A. (2010). Employment and economic growth in the U.S. automotive industry: considering the impact of American and Japanese automakers. *Indiana Business Review*, 10.

DelliFraine, et al. (2010) wrote that structured scientific methods such as Total Quality Management, Zero Defects, Quality Circles, Continuous Quality Improvement, and Continuous Process Improvement used by manufacturing organizations have reduced process variability and standardize outcomes. Womack (2003), Dennis (2007), Pettersen (2009), and Liker (2004) wrote that lean methods provide tools that enable organizations to identify and reduce waste and non-value added activities. In his book entitled *The Toyota Way*, Liker described 14 principles as the “foundation of the Toyota Production System (TPS) practiced by Toyota manufacturing plants around the world” (2004, p. 6). Pettersen (2009) identified thirty-three principles associated with lean production and categorized them into nine common groupings based upon references by authors on the topic.

Turesky and Connell (2010) wrote that companies that have implemented the lean methods have enabled them to produce goods at higher quality and lower costs compared to non-lean companies.

Ho (1999) described the lean 5S tool as a natural starting point for continuous improvement and preparing the organization for a more advanced focus. Moriones et al. (2010) reported that the first lean tool that many organizations implement is the lean 5S tool and that the lean 5S tool has become a favorite approach for manufacturing organizations desiring to improve efficiency, quality, and profitability. The 5S methodology refers to five pillars or phases of the process. “The 5S pillars are sort (seiri), set in order (seiton), shine (seiso), standardize (seiketsu), and sustain (shitsuke)” (Moriones, et al. 2010, p. 217).

Since the Center for Automotive Research (2010) identified OEM suppliers as critical components to the economy in the states of Michigan, Indiana, Ohio and Kentucky, it is important to understand the status of the lean continuous improvement methods and specifically the drivers and inhibitors of the lean 5S tool. Therefore, this study will attempt to identify the degree of implementation of all 5S’s and the relationship to the drivers and inhibitors of the lean 5S tool in OEM suppliers of vehicle parts and accessories within the U.S. automotive industry.

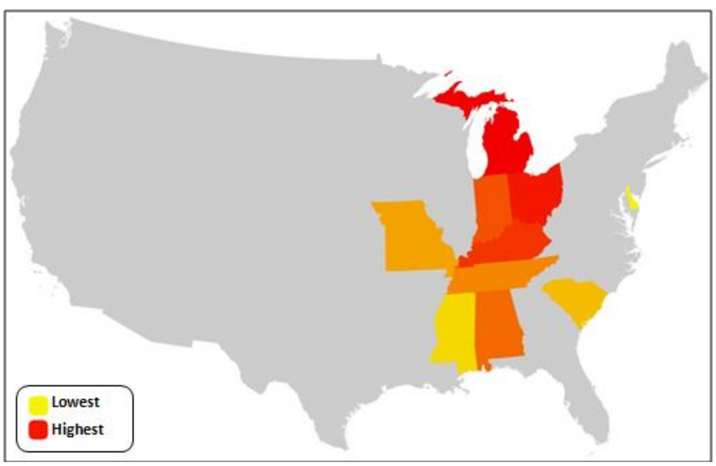


Figure 3: OEM Jobs as Percent of Population (Top 10 States)

Source: Hill, K., Menk, D. M., & Cooper, A. (2010). Contribution of the automotive industry to the economies of all fifty states and the United States. *Center for Automotive Research*, 42.

**Purpose of the Research**

The purpose of this research was to identify the factors influencing each of the phases of the lean 5S tool in manufacturing suppliers to the U.S. automotive industry and to determine if these factors vary according to selected key demographic variables.

**Research Questions**

The following research questions provided a framework for conducting this study.

RQ1: What factors were perceived by the respondents to have influenced the implementation of the lean 5S phases and elements in suppliers of manufacturing products to the U.S. automotive industry?

RQ2: What is the relationship of the selected demographic variables on the perceived factors and the lean 5S phases in suppliers of manufactured products to the U.S. automotive industry?

**Delimitations and Limitations**

A delimitation of the study was that only suppliers of manufactured products to automotive assembly operations were used for the research. An additional delimitation was that the participants of the study were generated from the active members of American Society for Quality Sections within Michigan, Indiana, Ohio and Kentucky.

A limitation of the study was that an electronic survey format captures a fleeting moment in time and self- reported data. In addition, the survey relied on the respondents understanding the questions and did not filter for any personal biases. The use of non-probability convenience sampling is a limitation since the likelihood of representative sampling is reduced with this category of sampling.

**Assumptions**

It was also assumed that the respondents had a minimum of a sixth-grade reading level and that they provided honest responses. It was assumed that the survey instrument reflected accurately the lean 5S tool degrees of implementation and the perceptions of the respondents.

**Definitions of Terms**

Continuous flow: A production system in which products flow continuously rather than being separated into lots or batches (Manos and Vincent, 2012).

OEM: Original Equipment Manufacturer. An original equipment manufacturer (OEM) makes equipment or components that are then marketed by its client, another manufacturer or a reseller, usually under the reseller's own name (*Encyclopedia of Small Business*, 2014).

Five S (5S): 1S-Sort, 2S-Set in Order, 3S-Shine, 4S-Standardize, 5S-Sustain (Dennis, 2007).

OEM Suppliers: The U.S. Department of Commerce (2011) reported that suppliers of OEM parts are broken into three levels. The first level is "Tier 1" suppliers who sell finished components directly to the vehicle manufacturer. The next level is "Tier 2" suppliers who sell parts and materials for the finished components to the Tier 1 suppliers. The third level is "Tier 3" suppliers who supply raw materials to any of the above suppliers or directly to vehicle assemblers. There is often overlap between the tiers.

Heijunka: A method of leveling production for mix and volume (Manos and Vincent, 2012).

ISO 9000: A set of international standards on quality management and quality assurance developed to help companies effectively document the quality system elements to be implemented to maintain an effective quality system (Kubiak and Benbow, 2009).

Jidoka: A device that stops production and/or equipment when an abnormal or defective condition arises (Manos and Vincent, 2012).

Kaizen: A mind set in which all employees are responsible for making continuous incremental improvements to the functions they perform (Kubiak and Benbow, 2009).

Kanban: A system of visual tools that synchronize and provide instruction (Dennis, 2007).

Muda: Waste (Dennis, 2007).

Mura: Unevenness (Dennis, 2007).

Muri: Strain or overburden (Manos and Vincent, 2012).

Poke Yoke: Prevention of inadvertent errors (Manos and Vincent, 2012).

Pull: Producing when asked (Dennis, 2007)

Six Sigma: A fact based, data driven philosophy of improvement that values defect prevention over defect detection (Kubiak and Benbow, 2009).

Standardization: A system of using policies and common procedures to manage processes (Manos and Vincent, 2012).

Total Quality Management: Term used in the 1980's to describe quality management programs that involved all organizational functions (Foster, 2013).

TS 16949: Is an international quality management system specification for the automotive industry based on ISO 9000 (Reid, 2005).

Visual Workplace: The placement in plain view of all of the resources required so that all personnel can understand the status of a system at a glance. Lines, signs and labels, andons, kanbans, production boards, painted floors, and shadow boards are typical visual control tools. (Dennis, 2007)

Zero Defects: Defect free processes (Dennis, 2007).

**Summary**

This chapter introduced the economic challenges faced by the automotive industry during periods of decline and the need for sub-tier suppliers of the automotive industry to eliminate waste and become efficient and effective. This chapter also introduced the background of lean manufacturing, the lean 5S tool, the demographic variables, and the need to identify the factors of the lean 5S tool implementation within the OEM supply base. In the next chapter, a review of literature related to lean manufacturing within the automotive industry and specifically the lean 5S tool will be shared.

# Chapter 2: Review of the Literature

This chapter provides a summary of the current literature relevant to key concepts pertaining to U.S. Manufacturing, the Automotive Manufacturing Industry, the Automotive Industry Suppliers, Quality Improvement Leaders, Continuous Improvement Systems, Continuous Improvement Tools, Lean Systems, Impacts of Lean Systems on Manufacturing, Lean System Tools, and the Lean 5S Tool.

## U.S. Manufacturing

According to Hiraide and Chakrabirty (2012), automotive manufacturing is vulnerable to economic declines. From its peak during the fourth quarter of 2007 to the second quarter of 2009, the U.S. GDP and auto production decreased from $13.3 trillion and $402 billion to $12.6 trillion and $223 billion, respectively. During this period, the fall in GDP was 5.14 percent while the fall in auto production was 44 percent.

Manufacturing involves a complex system of people, machines, materials, and money organized to produce a product (Schrader and Elshennawy, 2000). Originally the term “manufacturing” meant to “make by hand”. Schrader and Elshennawy (2000) described the transition of the original definition to the “Iron Age” where hand tools were developed to aid in manufacturing and then through the “Industrial Revolution” where power driven tools were developed. Manufacturing is further defined by the type of manufacturing system being utilized and product being produced.

The U.S. Bureau of Labor Statistics (2013) lists twenty-one categories within the manufacturing sector 31 to 33 that are engaged in the mechanical, physical, or chemical transformation of materials, substances, or components into new products. The Small

Business Administration (2013) defined a manufacturer as "a concern which, with its own facilities, performs activities in transforming inorganic or organic substances, including the assembly of parts and components, into the end item being acquired". According to the U.S. Census Bureau (2013) the North American Industry Classification System (NAICS) is the standard used by the Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. Item number 19 with the NAICS code of 336 entitled Transportation Equipment Manufacturing is the category that includes Automotive or Motor Vehicle Manufacturing. The U.S. Census Bureau (2013) defined code 336 as "Establishments primarily engaged in manufacturing complete automobile and light duty motor vehicles or manufacturing chassis only. It also comprises establishments primarily engaged in manufacturing heavy duty truck chassis and assembling complete heavy duty trucks, buses, heavy duty motor homes, and other special purpose heavy duty motor vehicles for highway use or manufacturing heavy duty truck chassis only" (http:// www.census.gov).

Table 3:

U.S. Bureau of Labor Statistics Manufacturing Sectors

| No. | Title | NAICS |
|---|---|---|
| 1 | Food Manufacturing | 311 |
| 2 | Beverage and Tobacco Manufacturing | 312 |
| 3 | Textile Mills | 313 |
| 4 | Textile Product Mills | 314 |
| 5 | Apparel Manufacturing | 315 |
| 6 | Leather and Allied Product Manufacturing | 316 |
| 7 | Wood Product Manufacturing | 321 |
| 8 | Paper Manufacturing | 322 |
| 9 | Printing and Related Support Activities | 323 |
| 10 | Petroleum and Coal Products Manufacturing | 324 |
| 11 | Chemical Manufacturing | 325 |
| 12 | Plastics and Rubber Products Manufacturing | 326 |
| 13 | Nonmetallic Mineral Product Manufacturing | 327 |
| 14 | Primary Metal Manufacturing | 331 |
| 15 | Fabricated Metal Product Manufacturing | 332 |
| 16 | Machinery Manufacturing | 333 |
| 17 | Computer and Electronic Product Manufacturing | 334 |
| 18 | Electrical Equipment, Appliance, and Component | 335 |
| 19 | Transportation Equipment Manufacturing | 336 |
| 20 | Furniture and Related Product Manufacturing | 337 |
| 21 | Miscellaneous Manufacturing | 339 |

**U.S. Manufacturing Trends**

The Bureau of Economic Analysis (2013) defined gross domestic product (GDP) as the value of all goods and services produced by labor and properties in the United States. Dunn (2012) using data from the Bureau of Labor Statistics and the Bureau of Economic Analysis reported that manufacturing as a percent of the GDP and as a percent of the labor force has been declining since the year 1950. The table below identifies the statistical decline of manufacturing in the US from 1950 to 2010.

Table 4:

The Statistical Decline of Manufacturing

| As a % of U.S. Labor Force | | | As a % of U.S. GDP | |
|---|---|---|---|---|
| Year | Manufacturing Jobs in 000's | Total Labor Force in 000's | Percentage of All U.S. Jobs | Percentage of Total Labor Force |
| 1950 | 14782 | 62068 | 23.8 | 27.0 |
| 1960 | 14947 | 70395 | 21.2 | 25.3 |
| 1970 | 17309 | 83670 | 20.7 | 22.7 |
| 1980 | 18640 | 107352 | 17.4 | 20.0 |
| 1990 | 17394 | 126142 | 13.8 | 16.7 |
| 2000 | 17178 | 143248 | 12.0 | 14.2 |
| 2010 | 11565 | 153690 | 7.5 | 11.7 |

In the above table, it can be seen that U.S. manufacturing jobs as a percentage of U.S. Gross Domestic Product (GDP) has declined since 1950. The table shows that in 2010 there were fewer people employed in manufacturing than in 1950. Additionally, the above table shows that the U.S. labor force as a percentage of GDP has also declined in the same time period. In 1960, the U.S. GDP represented 40 percent of the world's total output and by 2008 had declined to 23 percent. Trade of U.S. products also declined from 16 percent of global merchandise exports in 1960 to 8 percent in 2008 (Calleo, 2010). The U.S. increase in manufacturing productivity has led to lower prices, declining employment and as a result, a declining share of GDP (Hemphill and Perry, 2012).

The U.S. Bureau of Labor Statistics (2012) reported that more than 5.5 million manufacturing jobs have been lost from 2000 through 2011. Some perceived causes of employment decline within U.S. manufacturing may be related to increases in automation and productivity (Dunn, 2012). However, if manufacturing had not been in a declining mode, then the improvements in automation and productivity would have resulted in greater output

(Dunn, 2012). However, although China's manufacturing output of 1.922 trillion dollars was slightly ahead of the United States manufacturing output of 1.855 trillion dollars, the output of the American manufacturing worker has increased significantly over recent years and exponentially surpasses that of his or her Chinese counterpart (Hemphill and Perry, 2012). The Bureau of Labor Statistics (2009) wrote that China employed 100 million people in manufacturing compared to 11.5 million in the United States. Therefore, it could be explained that the increases in automation and productivity in the U.S. may contribute to the need for fewer workers. In the thirty-two year period from 1947 to 1979, U.S. manufacturing employment had a clear upward trend of 1 percent gain per year (Hemphill and Perry, 2012). The output per worker doubled in this time from 35,000 to 70,000 dollars. Hemphill and Perry (2012) wrote that productivity of the American manufacturing worker doubled again by 2010 to 140,000 per worker. The ongoing productivity gains by the American worker due to technological advances such as robotics, automated assembly and numerical control innovations in the 1970's, has enabled the U.S. to expand manufacturing output year after year but with fewer and fewer workers since 1980 (Hemphill and Perry, 2012).

The U.S. labor rates are not a root cause to U.S. manufacturing decline. U.S. automotive labor rates make up about 10 percent of a car's cost. If the U.S. lost manufacturing due to high wages, then other countries such as Germany and Japan should have experienced the same trend but have not (Dunn, 2012). One cause for U.S. manufacturing decline is associated to a high rate of corporate taxes which is the highest in the world. Another cause of U.S. manufacturing decline is unfair trade policies (Dunn, 2012). Other countries ignore practices that U.S. organizations are subjected to such as safety practices, equitable wages, patents and trademarks, child labor restrictions, contracts, and regulations for product safety. Dunn (2012) wrote that other trends that relate to U.S. manufacturing decline include healthcare, legacy costs and infrastructure. As an example, Dunn (2012) reported that a comparable Chinese manufacturing firm receives their electric power from the state at no cost. Another cause is excessive litigation costs. In 2003 legal costs in the U.S. were 2.2 percent of the GDP versus about 1 percent in Europe (Dunn, 2012).

The Center for Automotive Research (2010) reported that the composition of the U.S. automotive industry has been transformed over the past twenty years as domestic firms such as Chrysler, Ford and General Motors have slowly lost market share to international firms operating in the United States. The Center for Automotive Research (2010) report reveals how the erosion of OEM market share over only two decades is indicative of how competitive the U.S. automotive landscape has become for manufacturers.

The Center for Automotive Research (2010) reported that the educational requirements of the labor force have changed. The complexity of motor vehicles requires a highly skilled labor force both in the technical functions but also the assembly line itself which typically included mostly non-skilled personnel. Since the late 1970s and early 1980s, the rise in U.S. education levels has not kept up with the rising demand for skilled workers. The earnings of college educated workers relative to high school educated workers have risen steadily over the past three decades (Autor, 2010). In 1963 the hourly wage of a typical college graduate was 1.5 times greater than that of a high school graduate. In 2009, that ratio had grown to 1.95 times (Dunn, 2012).

**Automotive Manufacturing Industry**

The automotive manufacturing industry includes organizations that produce automotive vehicles or (OEM's) original equipment manufacturers and organizations that provide products to the OEM's typically referred to as suppliers. *The Encyclopedia of Small Business* (2014) defined an original equipment manufacturer (OEM) as an original equipment manufacturer that makes equipment or components that are then marketed by its client, another manufacturer or a reseller, usually under the reseller's own name.

Several automotive manufacturing organizations are operating in the United States. Thompson and Merchant (2010) reported that the top three automotive companies based in the U.S. include General Motors, Ford Motor, and Chrysler Corporation. Additionally, the top foreign companies operating in the U.S. are Toyota Motor Corporation, Honda Motor Company, Hyundai, and Nissan USA.

The Center for Automotive Research (2010) using data from the Bureau of Economic Analysis reported that the U.S. vehicle manufacturing industry has been losing market share from the 1986 to 2011 model years.

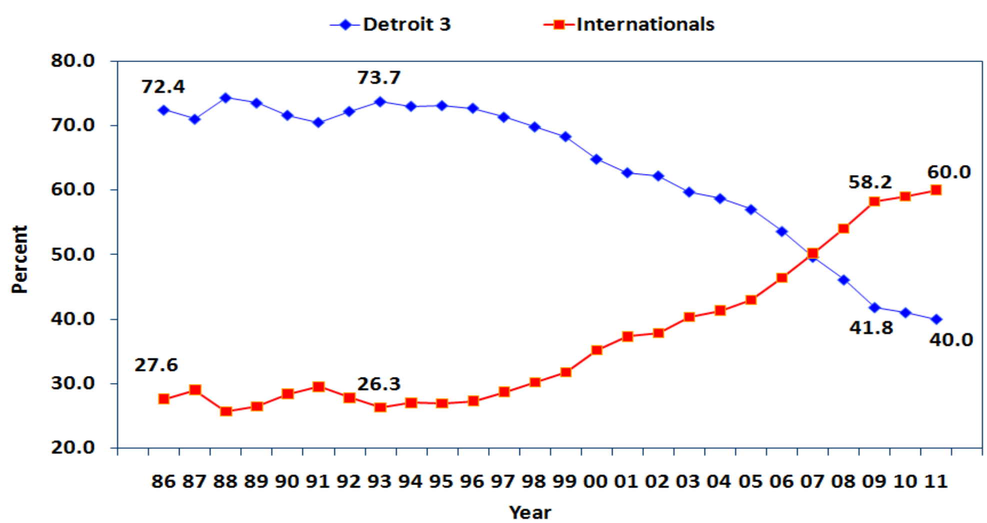


Figure 4: U.S. Motor Vehicle Market Share 1986 – 2011

Source: Hill, K., Menk, D. M., & Cooper, A. (2010). Contribution of the automotive industry to the economies of all fifty states and the United States. *Center for Automotive Research*, 3.

Employment due to the automotive manufacturing industry is a key component to the U.S. economy. The Center for Automotive Research (2010) reported that data developed from the NAICS system revealed that U.S. automotive manufacturing and spin-off employment represented nearly 3,145,000 jobs. The jobs associated with the OEM's account for nearly 2 percent of employment in the entire U.S. economy and nearly 1.5 percent of the total U.S. compensation.

The Center for Automotive Research (2010) reported that the 4.4 percent of the labor force in the United States are employed within the automotive industry. Additionally, the states of Michigan at 21.8 percent, Indiana at 13.9 percent, Ohio at 12.4 percent, and Kentucky at 9.9 percent lead the country in reliance on the industry and are most affected by economic conditions.

The Center for Automotive Research (2010) reported that 8 million private sector jobs are impacted by the U.S. automotive manufacturers, suppliers, and dealers. The Center for Automotive Research (2010) also reported that the industry generated over 500 billion dollars in compensation and that the OEM industry has a job creation multiplier of 10 while the entire industry has a job multiplier of 4.

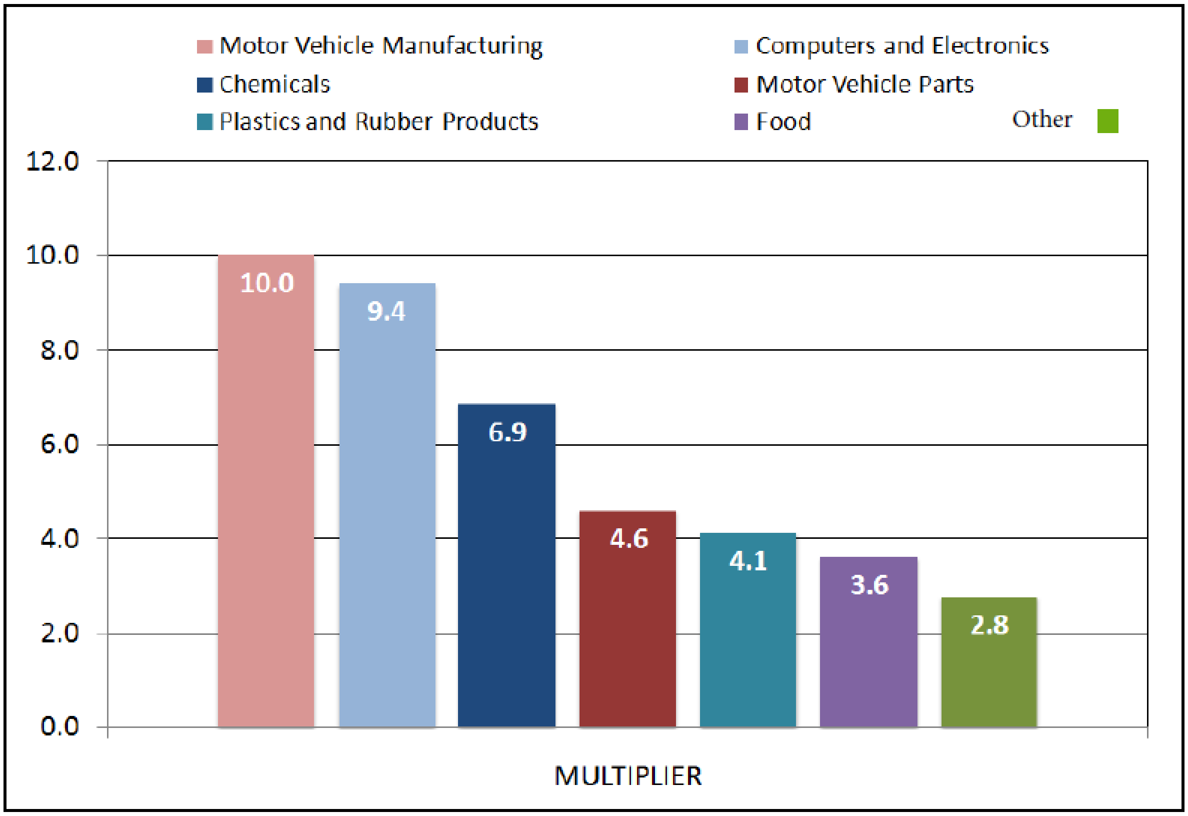


Figure 5: Job Multiplier by Selected Industry

Source: Hill, K., Menk, D. M., & Cooper, A. (2010). Contribution of the automotive industry to the economies of all fifty states and the United States. *Center for Automotive Research*, 9.

The Center for Automotive Research (2010), utilizing data from the U.S. Census Bureau, reported that in 2006, each employee in the motor vehicle assembly industry created 321,000 dollars of value in the final products shipped, which was fourth amongst manufacturing industries.

The Center for Automotive Research (2010) reported that the industry spends 16 to 18 billion dollars every year on research and product development and is a major driver of the 11.5 percent manufacturing contribution to the U.S. GDP along with the 2.2 percent contribution from the automotive industry. Without a healthy automotive sector it is difficult to imagine manufacturing surviving in the United States.

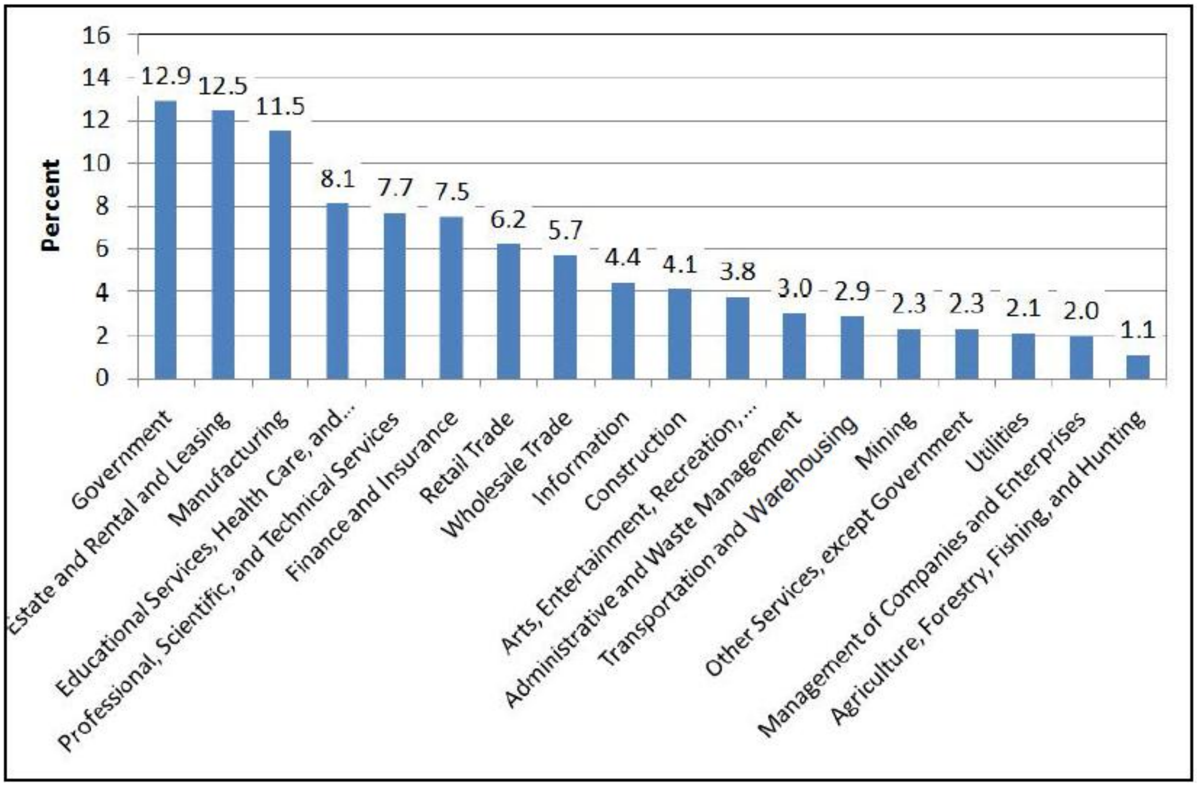


Figure 6: Percent Contribution to GDP by Industry, 2008

Source: Hill, K., Menk, D. M., & Cooper, A. (2010). Contribution of the automotive industry to the economies of all fifty states and the United States. *Center for Automotive Research*, 5.

According to the *Automotive News* (2013), the automotive industry has been growing with three straight years of at least 10 percent growth in year-to- year sales. The Center for Automotive Research (2012) reported that the industry generated 564 billion dollars in automobile sales while parts, repairs and other services added another 173 billion dollars. The U.S. Census Bureau (2012) reported from their annual survey of manufacturers that vehicle and parts manufacturing have the largest number of employees in the U.S. and a payroll over 30.5 billion dollars, which is second only to the aerospace industry. The Bureau of Labor Statistics (2013) estimated that employment in the automotive industry reached 789,000 in March of 2013, which was the highest level in four years. The Bureau of Labor Statistics (2013) reported that motor vehicle and parts manufacturing added more than 95,000 jobs from January 2011 through January 2013.

**Automotive Industry Suppliers**

The U.S. Department of Commerce (2011) reported that suppliers of OEM parts are broken into three levels. The first level is “Tier 1" suppliers who sell finished components directly to the vehicle manufacturer. The next level is “Tier 2" suppliers who sell parts and materials for the finished components to the Tier 1 suppliers. The third level is “Tier 3" suppliers who supply raw materials to any of the above suppliers or directly to vehicle assemblers. There is often overlap between the tiers.

The Center for Automotive Research (2010) reported that employment associated with U.S. parts and supplier operations account for nearly 2 percent of employment in the entire U.S. economy and nearly 1.5 percent of total U.S. compensation. The U.S. Department of Commerce (2011) reported that automotive parts suppliers experienced heavy debt and overcapacity issues due to production cuts by automakers. There was a heavy reliance on the automotive OEM’s by the suppliers as 70 percent of their production is for OEM products while 30 percent is for repairs and aftermarkets. The U.S. Department of Commerce (2011) reported that over 50 suppliers filed for Chapter 11 bankruptcy protection in 2009 while another 200 were liquidated. The U.S. Department of Commerce (2011) reported that the U.S. automotive manufacturers reduced their supply base by 50 percent since 2000 while reducing the suppliers from 1000 per vehicle to a range of 300 to 600 per vehicle. Nagati and

Rebolledo (2013) wrote that many organizations have realized better relationships and cooperation amongst a reduced number of suppliers.

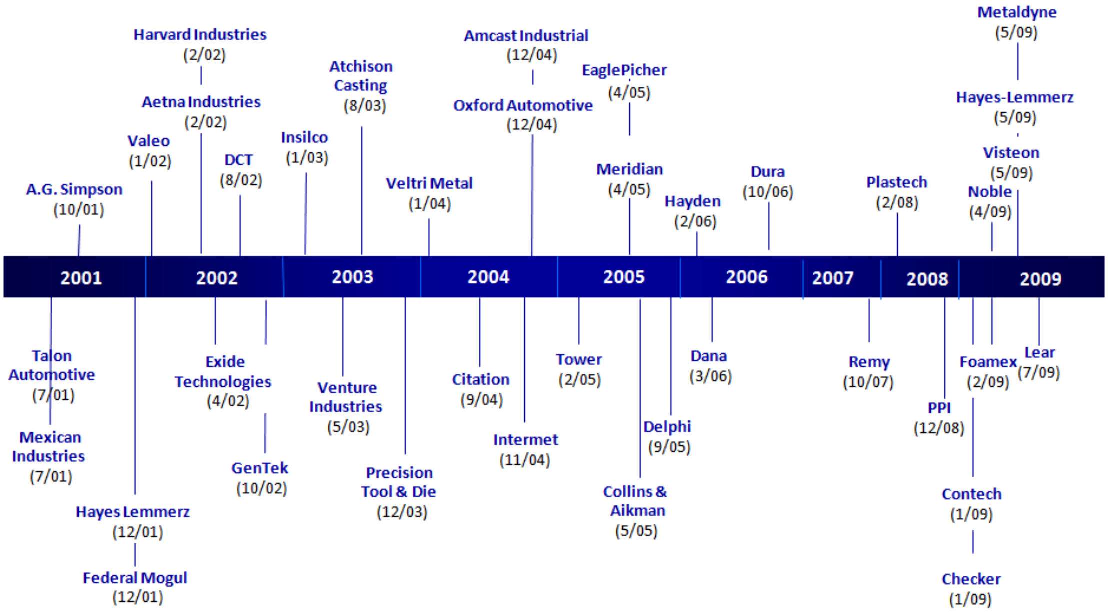


Figure 7: Major Supplier Bankruptcies 2001-2009

Source: Hill, K., Menk, D. M., & Cooper, A. (2010). Contribution of the automotive industry to the economies of all fifty states and the United States. *Center for Automotive Research*, 21.

Kumar and Abuthakeer (2012) wrote that automotive industries are adopting new improvement tools and techniques that enhance their ability to compete and survive in the market. The tools and techniques have been driven by several quality- improvement leaders.

**Quality-Improvement Leaders**

During the 20$^{th}$ century, a significant body of knowledge emerged on achieving superior quality (Gryna et al., 2007). Besterfield  et al. (2003) identified seven quality gurus that contributed to this knowledge. The individuals identified include: Walter Shewhart, W. Edwards Deming, Joseph M. Juran, Armand Feigenbaum, Kaoru Ishikawa, Phillip Crosby, and Genichi Taguchi.

Walter Shewhart identified two types of variation as common cause and assignable cause (Summers, 2009). Shewhart developed the statistical process control chart designed to identify and control variation and these control charts have been used in many industries to improve processes and advance quality initiatives (Summer, 2010). According to Besterfield et al. (2003), Shewhart developed the (PDSA) Plan, Do, Study, Act cycle. Summers (2009) defined the PDSA cycle as a systematic approach to problem solving by planning a solution to a problem, doing or implementing the solution, studying the results, and acting on making the solution permanent.

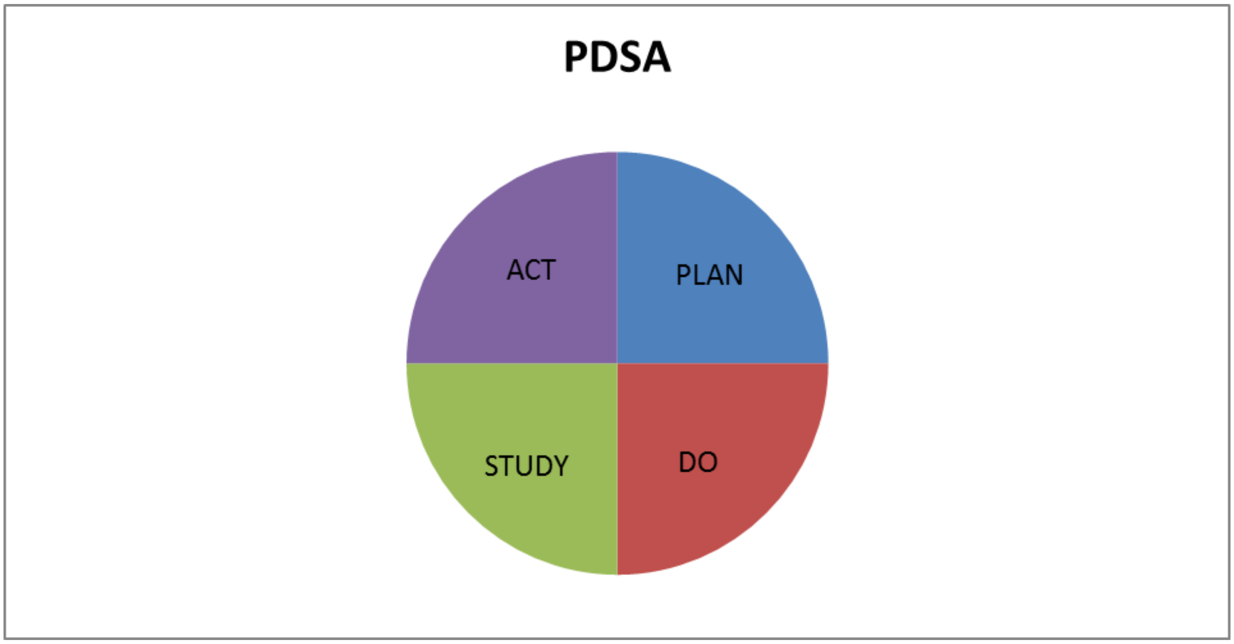


Figure 8: PDSA Cycle (The Deming Cycle)

Source: Deming, E.W., (2000). *Out of crisis*. Cambridge, Massachusetts: MIT Press.

W. Edwards Deming is credited with providing the foundation for the Japanese resurgence as an economic power after World War II (Besterfield et al., (2003). Deming made it his mission to teach optimal management principles for organizations to focus on quality. Deming's philosophy was that improving quality led to decreased costs, fewer mistakes, fewer delays, better use of resources, and improved productivity which enables companies to obtain more market share, stay in business and add jobs (Summers, 2010).

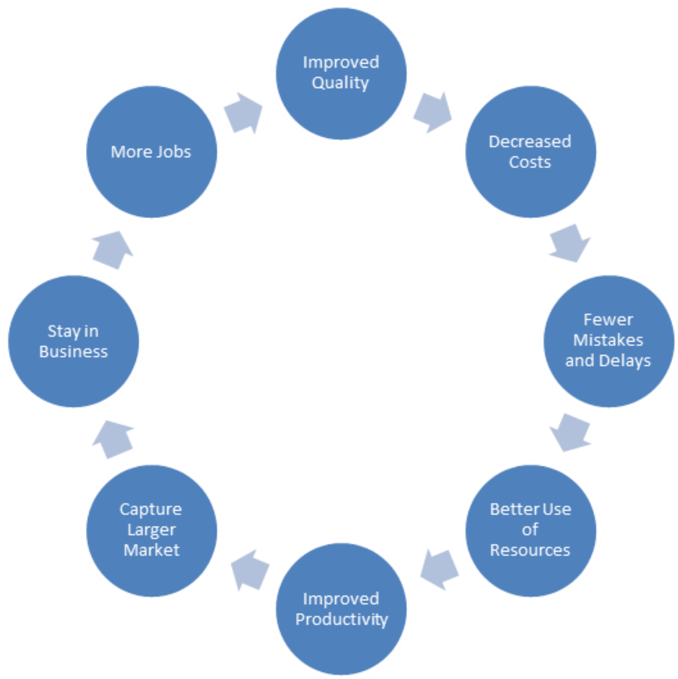


Figure 9: Deming's Economic Chain Reaction

Source: Summers, D.C.S., (2009). *Quality management: creating and sustaining organizational effectiveness.* Upper Saddle River, New Jersey: Prentiss Hall.

Deming's philosophy was detailed within his 14 Points for Management which he presented to the leaders of Japan in the 1950's and then to leaders in the United States throughout later years (Besterfield et al., 2003). Deming (1986) wrote that his 14 Points for Management included the following:

1. Create a constancy of purpose toward improvement of product and service with the aim to become competitive and to stay in business and to provide jobs.
2. Adopt a new philosophy.

3. Cease dependence on inspection to achieve quality.
4. End the practice of awarding business on the basis of price tag alone, and instead minimize total cost.
5. Constantly and forever improve the system of production and service.
6. Institute training on the job.
7. Institute leadership.
8. Drive out fear.
9. Break down barriers between departments.
10. Eliminate slogans, exhortations, and targets for the workforce.
11. Eliminate arbitrary work standards and numerical quotas. Substitute leadership.
12. Remove barriers that rob people of their right to pride and workmanship.
13. Institute a vigorous program of education and self-improvement.
14. Put everybody in the company to work to accomplish the transformation.

Like Deming, Juran played a significant role in the rebuilding of Japan to an economic power after World War II. Juran significantly influenced the quality movement from a narrow statistical field to quality as a management focus (Summers, 2009). Goetsch and Davis (2013) wrote that Joseph Juran developed a trilogy on leadership for quality. Gryna et al. (2007) defined his Juran Trilogy as Quality Planning, Quality Control and Quality Improvement.

Table 5

The Juran Trilogy

| Quality Planning | Quality Control | Quality Improvement |
|---|---|---|
| Establish the project | Choose control subjects | Prove the need |
| Identify customers | Establish measurement | Identify projects |
| Discover customer needs | Establish standards of performance | Organize project teams |
| Develop product | Measure actual performance | Diagnose the causes |
| Develop process | Compare to standards | Provide remedies, prove that the remedies are effective |
| Develop process controls and transfer to operations | Take action on the difference | Deal with the resistance to change |
| | | Control and hold the gains |

Armand Feigenbaum is considered to be the originator of the total quality movement (Summers, 2009). Feigenbaum contributed to the quality movement by claiming that total quality control was necessary to achieve productivity, market penetration, and a competitive advantage (Besterfield et al., 2003). Summers (2009) wrote that Feigenbaum encouraged companies to eliminate waste, which drains profitability by understanding the costs associated with failed quality levels. Feigenbaum emphasized the concepts of total quality control throughout all functions of the organization in order to ensure customer satisfaction and an economical cost of quality (Gryna et al., 2007).

Kaoru Ishikawa taught the Japanese problem solving techniques and the use of high-quality tools. Ishikawa developed the “cause and effect diagram” used to find the root cause of a problem (Gryna et al., 2007), (Summers, 2010). Ishikawa also developed “quality circles” whereby work groups were established to use high-quality tools to solve problems (Besterfield et al., 2003).

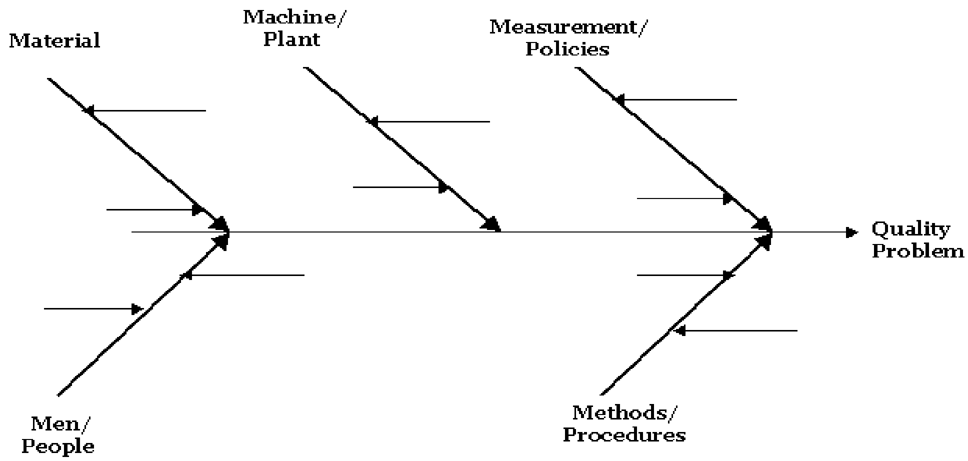


Figure 10: Cause and Effect Diagram

Source: Summers, D. C. S., (2010). *Quality*. Upper Saddle River, New Jersey: Prentice Hall.

Phillip Crosby developed the notion "doing it right the first time" within his 1979 book entitled *Quality is Free* which sold 1.5 million copies. Crosby developed the "four absolutes of quality management" which set expectations for a continuous improvement process to meet (Besterfield et al., 2003), (Summers, 2009). Crosby defined four absolutes of quality management in order to manage quality, prevention of defects, zero defects or making products right the first time, and reducing or eliminating the costs associated with poor quality (Summers, 2009).

Table 6:

Crosby's Absolutes of Quality Management

| | |
|---|---|
| Quality Definition | Conformance to Requirements |
| Quality System | Prevention of Defects |
| Quality Performance Standard | Zero Defects |
| Quality Measurement | Costs of Quality |

Deming (1994) wrote that everyone pays for a mistake or a failure. Genichi Taguchi developed the concept that combines cost, target, and variation into one metric called the "loss function" (Besterfield et al., 2003). Taguchi's concept described that product variation from a target dimension resulted in a total loss to society (Summers, 2010). Taguchi's loss function defined that any deviation from a target, even if within specification, would result in reduced quality levels and a loss to society as a whole (Summers, 2009).

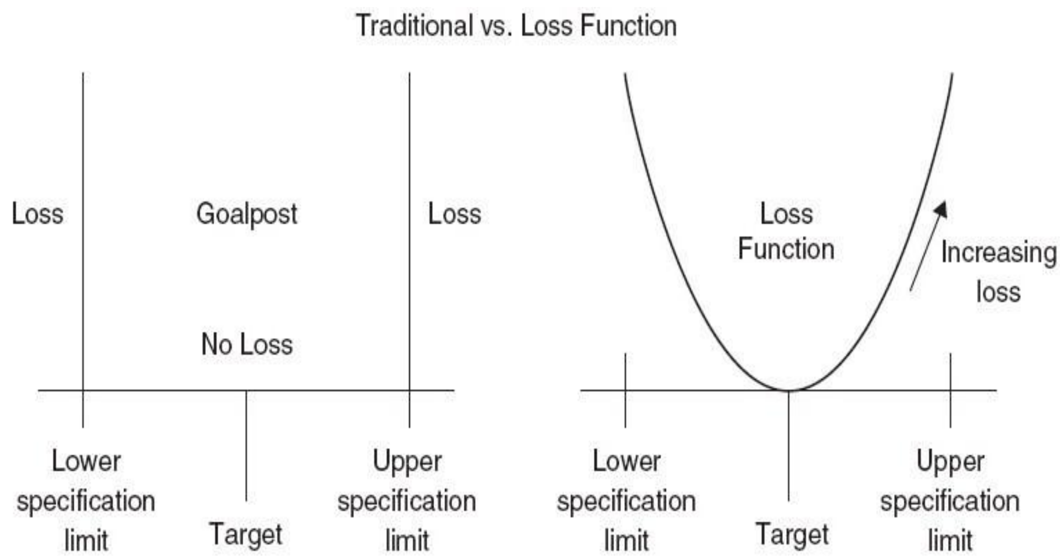


Figure 11**:** The Taguchi Loss Function

Source: Summers, D. C. S., (2010). *Quality*. Upper Saddle River, New Jersey: Prentice Hall.

**Continuous Improvement Systems**

The concept of continuous improvement originated with American companies such as National Cash Register and Lincoln Electric Company dating as far back as 1894 (Wescott, 2006). Japanese companies such as Toshiba, Matsushita Electric, and Toyota Motor Company began development of continuous quality improvement programs in the early 1950's (Westcott, 2006).

Organizations must have a quality system in place in order to ensure that customer requirements are being met (Manos and Vincent, 2012). The ISO 9000 standard requires continual quality improvements (Westcott, 2006). Gryna et al. (2007) wrote that all of the quality gurus have their own definitions of quality and that the (ISO) International Organization for Standardizations definition is the “totality of characteristics of an entity that bear on its ability to satisfy stated or implied needs”. The ISO 9000 family of standards are applicable to any organization that desires to manage and improve their processes that ultimately result in quality products (Goetsch and David, 2013).

ISO 9000 is a quality system standard with eight management principles (Manos and Vincent, 2012). ISO 9000 is a set of individual, but related, international standards and guidelines on quality management and quality assurance designed to assist organizations in developing and maintaining a quality system (Kubiak and Benbow, 2009). The TS 19649 is an international quality management specification specifically for the automotive industry and is based on the requirements of ISO 9001 quality system standard (Reid, 2005). The table below identifies the eight principles of the ISO 9000 standard.

Table 7:

ISO 9000 Principles

| Number | Principle |
|---|---|
| 1 | Customer-Focused Organization |
| 2 | Leadership |
| 3 | Involvement of People |
| 4 | Process Approach |
| 5 | System Approach |
| 6 | Continual Improvement |
| 7 | Factual Approach to Decision Making |
| 8 | Mutually Beneficial Supplier Relationships |

The Malcolm Baldrige National Quality Award (MBNQA) was established in 1987 by the United States Congress. The award is named after a former U.S. Secretary of State, Malcolm Baldrige, due to his personal interest in quality management and improvement

(Summers, 2010). The National Institute of Standards and Technology (2014) defined the MBNQA criterion as follows:

1. Leadership
2. Strategic Planning
3. Customer Focus
4. Measurement, Analysis, and Knowledge Management
5. Workforce Focus
6. Operations Focus
7. Results


Figure 12**:** Baldrige Criteria for Performance Excellence Framework

Source: NIST, (2014). http://www.nist.gov/baldrige/graphics.cfm.

Six Sigma is a methodology that blends many of the previous quality initiatives together while adding the topic of business management (Summers, 2009). The Six Sigma methodology seeks to reduce variability and requires results that enhance profitability through improved quality and efficiency (Summers, 2010). Six Sigma is data driven and profit focused with a goal of 3.4 defects per million opportunities (Summers, 2010). The table below identifies the defects per million opportunities for each sigma value along with the process yield percentage.

Table 8:

Six Sigma

| Sigma | Defects per Million Opportunities | Yield |
|---|---|---|
| 1 | 690,000 | 30.90 % |
| 2 | 308,000 | 69.20 % |
| 3 | 66,800 | 93.30 % |
| 4 | 6,210 | 99.40 % |
| 5 | 320 | 99.98 % |
| 6 | 3.4 | 99.9997 % |

Hambleton (2008) defined DMAIC as a five step method used to solve problems or improve processes or products of defects. The acronym DMAIC stands for the five steps being define, measure, analyze, improve, and control. The nucleus of Six Sigma is the DMAIC process (Goetsch and Davis, 2013). The table below identifies each phase of the DMAIC process and the purpose of each.

Table 9:

DMAIC Process

| Phase | Purpose |
|---|---|
| Define | Initiate the project, define the process, determine customer requirements, and define key process output variables. |
| Measure | Understand the process, evaluate risks on process inputs, develop and evaluate measurement systems, and measure current performance. |
| Analyze | Analyze data and prioritize key input variables, and identify waste. |
| Improve | Verify critical outputs, design improvements, and pilot the new process. |
| Control | Finalize the control system and verify long term capability |

**Continuous Improvement Tools**

Continuous improvement is a philosophy of making frequent and small changes to processes that result in improved quality, cost, and efficiency and include ongoing actions to find ways to improve processes, decrease variation, decrease cycle time, and improve effectiveness of the organization (Manos and Vincent, 2012). There are many other continuous improvement tools. Westcott (2006) defined the seven classic high-quality tools as Flowchart, Check-Sheet, Cause and Effect Diagram, Pareto Chart, Control Charts, Histograms, and Scatter Diagrams. The table below identifies and describes the seven classic high-quality tools.

Table 10:

Seven Classic Quality Tools

| Quality Tool | Description |
|---|---|
| Flowchart | A map of the sequence of steps and decision points in a process |
| Check-Sheet | A tool for gathering information on root causes |
| Cause and Effect Diagram | Also called an Ishikawa Diagram after its developer, Kaoru Ishikawa, or a Fishbone Diagram and is used to show the many causes that may contribute to a particular problem |
| Pareto Chart | Named after Italian economist, Vilfredo Pareto, is a chart used to identify the vital few from the trivial many issues or variation |
| Control Charts | Charts used to gather plotted data in order to identify special and common-cause behavior over time |
| Histograms | A graphical picture of the frequency distribution of data |
| Scatter Diagram | A diagram that shows whether or not there is a correlation between two variables |

Hambleton (2008), Manos & Vincent (2012), and Wescott (2006) defined other problem-solving tools used in manufacturing. Table 11 describes the additional problem-solving tools that are utilized.

Table 11:

Additional Problem-Solving Tools

| Problem Solving Tool | Description |
|---|---|
| 5-Why | 5-Why analysis is a problem-solving and continuous improvement process used to drill down through the layers of cause and effects toward the potential root cause of a problem. |
| Affinity Diagram | An Affinity Diagram is a tool used to categorize a large number of ideas and facts into themes which enables an organized approach toward problem solving. |
| Benchmarking | Benchmarking is a tool used to identify best practices internally and externally from the organization, promotes innovative thinking, and motivates people to focus on continuous improvement activities. |
| Brainstorming | Brainstorming as a tool that is uses creative thinking to generate a large amount of ideas. |
| Design for Six Sigma | Design for Six Sigma (DFSS) is a concept that utilizes statistical techniques to design and develop a product. |
| Design of Experiments | Design of Experiments (DOE) is a process for generating data to analyze interactions of potential variables at one time. |
| Failure Mode and Effects Analysis | FMEA as a preventative risk analysis technique that identifies and ranks potential failure modes of a design or process and then prioritizes improvement actions. The goal of a FMEA is to reduce risk of failures. |
| Quality Functional Deployment | Quality Functional Deployment is a disciplined process for obtaining, translating, and deploying the voice of the customer into the various phases of product or process development. Quality Functional Deployment tool is used to translate customer requirements into technical requirements. |

**Lean Systems**

Manufacturing progressed from craftsman production in the early 1900's to mass production based on the Fred Winslow Taylor system of separating planning from production (Dennis, 2007). Although the Taylor system had the reputation of mindless and dehumanizing work, it did uncover lean-related innovations such as standardized work, reduced cycle time, time and motion study, and measurement and analysis (Dennis, 2007). Dennis (2007) wrote that the next phase or manufacturing development was the Ford Motor

Company system of the assembly line and the interchangeability of production parts. This was followed by managerial and marketing innovations of General Motors and the rise of the mass production labor movement. A gap developed between management and the production worker and that accounting practices encouraged wasteful manufacturing activities such as building inventory rather that building to customer demand. The growing dysfunction resulted in worker alienation, poor quality, excessive machinery, and engineering functionality issues (Dennis, 2007). The birth of lean production originated in 1950 after a Japanese engineer named Eiji Toyoda visited Ford's Rouge plant in Detroit. Upon his return to Japan, Toyoda and production genius Taiichi Ohno concluded that mass production would not work in Japan. Ohno went to work in developing lean principles and while years earlier, Taylor separated planning and production, Ohno brought that back together again (Dennis, 2007).

Taiichi Ohno (1988) defined the topic of lean in his seminal publication entitled *The Toyota Production System*. Liker (2004) described the Toyota Production System (TPS) as the basis for the lean production movement that has dominated manufacturing throughout the world. The publication of the Womack et al. (1990) book entitled *The Machine that Changed the World* generated the concept and interest of lean to the masses. Womack et al. (1990) defined lean manufacturing as a five step process that included defining customer value, value stream, flow, pull system, and striving for excellence. Manos and Vincent (2012) described lean as "an approach to improve quality, increase productivity, reduce costs, and increase customer satisfaction by eliminating wastes and creating value" (p. 2). Shah and Goldstein (2006) wrote that lean manufacturing is a system that is focused on reconfiguration of the manufacturing systems by means of streamlining the processes which facilitate waste reduction, minimizing variation, and thereby facilitating cost reduction. Adopting the lean manufacturing techniques is one promising mode that suppliers and OEM's in the automotive industry can implement to deliver products quickly, at low cost, and of good quality (Kumar and Abuthakeer, 2012).

**Impacts of Lean Systems on Manufacturing**

Lean manufacturing is associated with benefits such as reduced inventory, manufacturing efficiency, increased quality, increased flexibility, and improved customer satisfaction (Wooley and Doolan, 2006). The heart of lean and the Toyota Production System is the elimination of waste (Liker, 2004). Reducing wasteful activities is another principle of the lean methodologies that organizations can implement when seeking to improve. "Muda (Japanese term) means waste or any activity for which the customer is not willing to pay" (Dennis, 2007, p. 20). Womack and Jones (1996) defined waste as "specifically any human activity which absorbs resources but creates no value" (introduction). The objective of a lean manufacturing system was to identify and eliminate the processes, resources which do not add value to a product (Upadhye et al., 2010). The reduction of waste is the cornerstone to the lean approach (Kumar and Buaer, 2010). "The vicious cycle of waste generating waste hides everywhere in production. Careful inspection of any production area reveals wastes and room for improvements" (Ohno, 1988, p. 55). "The core thrust of lean production is that these lean practices can work synergistically to create a streamlined, high quality system that produces finished products at the pace of customer demand with little or no waste" (Shaw and Ward, 2003, p. 129).

A reliable lean system is an essential requirement for organizations that have goals of eliminating costs and improving quality metrics such as on time delivery and quality of products or services (Keysor and Sawhney, 2013). A company named Knoxville Corrugated Box Company and the successes they experienced by transitioning from a non-lean enterprise to a lean manufacturing firm. The successes cited included a 33 percent reduction of inventory levels, an on time delivery performance improvement from 75 to 96 percent and a 50 percent reduction in customer complaints (Keysor and Sawhney, 2013). Kumar and Abuthakeer (2012) wrote that some organizations have been able to reduce their machine set up times from 25 percent to 85 percent through the lean technique known as Single Minute Die Exchange (SMED). This results in more production flexibility and machine utilization. Many organizations have failed to grasp the full benefits of lean while others have accepted and implemented the lean philosophy with success and as a business strategy for long term manufacturing survival (Mortimer, 2006). A study by Zayko et al. (1997) revealed that lean manufacturing resulted in a 50 percent reduction in human effort, manufacturing space, tool investment, product development time and a 200 to 500 percent improvement in quality (Wu, 2003). A study of 200 U.S. manufacturers demonstrated improved inventory, financial, and market performance due to lean methods (Wu, 2003). The use of lean initiatives in a small manufacturing firm resulted in a 33.18 percent reduction in cycle time, an 81.5 percent reduction in change over time, and an 81.4 percent reduction in lead time (Grewel, 2008).

Although some organizations have been successful in adopting lean methods, they were not able to sustain the benefits over time (Sim and Chiang, 2012). Manufacturing organizations embraced the lean methodologies during times of economic decline but many are not successful in their efforts (Wooley and Doolan, 2006). Organizations that fail to implement a culture change prior to lean implementation fail over time (Sim and Chiang, 2012). Many organizations fail to recognize that multiple variables contribute to lean manufacturing success or failure (Wooley and Doolan, 2006). A problem that some organizations that have failed in their lean implementation faced was the tendency to "cherry-pick" lean activities rather than to fully implement all of the lean methods (Liker, 2004). Many organizations spend an inordinate amount of time on training and an insufficient amount of time on implementation with failed lean results (Womack and Jones, 2003). Bhasin (2012) wrote that fewer than 10 percent of UK organizations have accomplished a successful lean implementation and a survey of over 900 executives found that only 4 per cent considered their lean efforts to be at an advanced stage. Many organizations fail to even attempt the implementation of the lean methodologies due to the perceived enormity of the task. Others begin the adoption process but fail to maintain momentum as they realize some initial negative results prior to the absolute implementation (Bhasin, 2012). A Lean Enterprise Institute (2005) survey of over 900 UK executives identified the following obstacles toward the implementation of lean (Bhasin, 2012).

1. Lack of implementation knowledge – 49 percent
2. Backsliding to old ways of thinking – 49 percent
3. Middle management resistance – 40 percent
4. Financial value not recognized – 39 percent
5. Lack of crisis to create a sense of urgency – 36 percent
6. Lean is viewed as a fad – 32 percent
7. Supervisor resistance – 29 percent
8. Not overcoming those opposed to change – 27 percent
9. Employee resistance – 22 percent
10. Other budget constraints – 15 percent

11. Failures of past lean projects – 11 percent

**Lean System Tools**

"Ohno (1988) wrote that the first step toward the application of the Toyota Production System is to identify waste. Dennis (2007) defined waste in the process as shown in the following table.

Table 12:

Seven Forms of Waste

| Waste Type | Description |
|---|---|
| Waste in Production | Waste in overproduction is to produce things that have not or will not be sold. Overproduction can also influence many of the other wastes such as motion, waiting, conveyance, correction, and inventory. Dennis (2007) wrote that "Overproduction is a root cause of the other kinds of muda" (p. 24). |
| Waste of time and hand (waiting) | Waiting is waste that occurs when a "worker has to wait for material to be delivered or for a line stoppage to be cleared, or when employees stand around waiting for a machine to process a part" (p. 22). |
| Waste in Transportation | Waste in transportation is "waste caused by inefficient workplace layout, overly large equipment, or traditional batch production" (p. 23). At times, transportation waste which does not add value to the customer is still needed. |
| Waste of Processing Itself | Waste in over-processing is "doing more than the customer requires" (p. 23). Some organizations lose sight to what exactly is required by the customer and they provide too much or go beyond the need without realizing any benefits. |
| Waste of Stock on Hand (inventory) | Inventory waste is the "keeping of unnecessary raw materials, parts, and WIP" (p. 23). Inventory waste is evident when the organization is producing to build inventory rather than building what may have already have a buyer. |
| Waste of Movement | Waste in motion is ergonomic issues related to humans or machines. "machines placed too far apart result in unnecessary muda in motion" (p. 21). |
| Waste of Making Defective Product | Waste in making defective parts or "the muda of correction is related to making and having to fix defective products" ( p.23). Quality problems create waste in time, materials and additional unplanned costs. |

The seven forms of waste provide ample opportunity for action plans directed toward reduction or elimination of items that fail to add value for the customer. Womack et al. (1990) defined lean as the elimination of waste and that the goal of lean manufacturing was to eliminate activities that do not add value. Dennis (2007) described the House of Lean Production to show common lean activities. The House of Lean Production identifies Stability and Standardization as the foundation that supports the pillars of Just-In-Time and Jidoka. Involvement is the heart of the system and is required within and between all of the lean categories. All of the topics below the roof are required to support the overall goal of Customer focus. Below is a pictorial of the house of lean production.

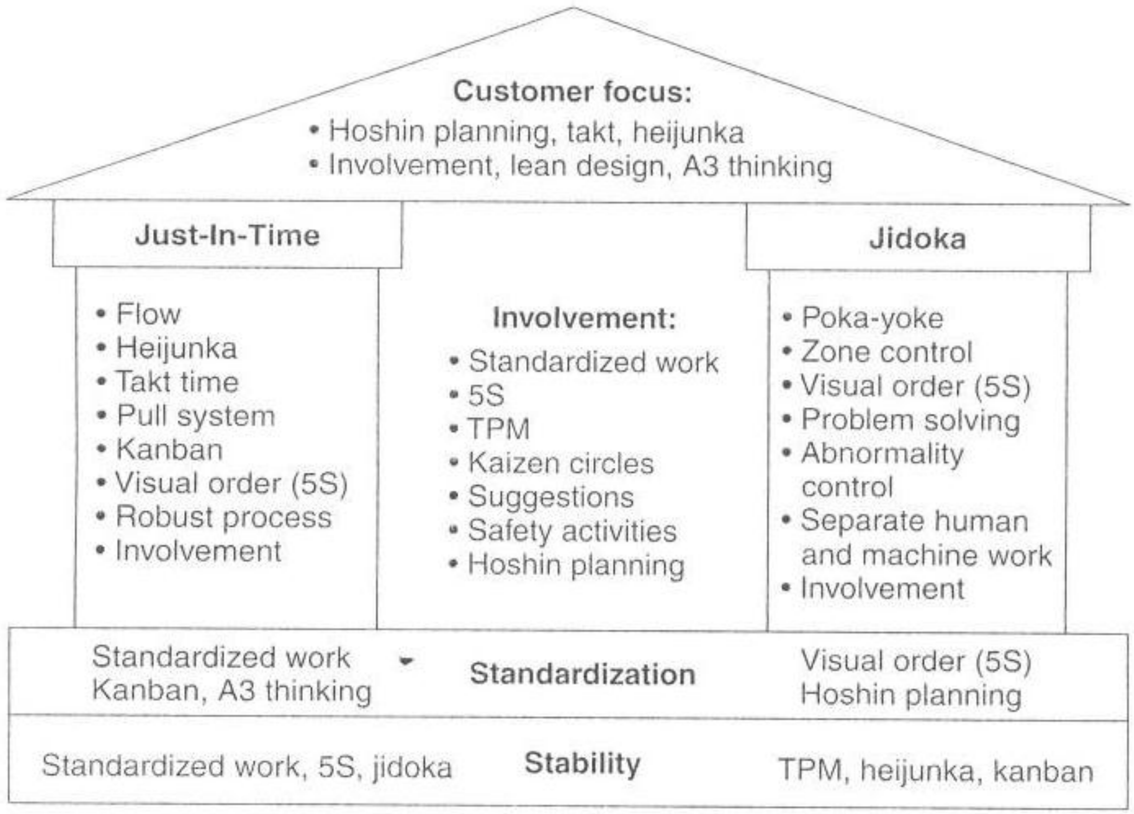


Figure 13: The House of Lean Production

Source: Liker, J. K., (2004). *The toyota way: 14 management principles from the world's greatest manufacturer*. New York: McGraw-Hill.

Below is a table that identifies each of the House of Lean Production headings along with a description of each (Dennis, 2007).

Table 13:

House of Lean Categories

| House of Lean | Description |
|---|---|
| Stability | Improvement is not possible without Stability in the 4M's: Man, Machine, Material, and Method. Stability begins with visual management and the 5S system. 5S supports standardized work, total productive maintenance and just-in-time production which are keys to method and machine stability. |
| Standardization | Standardization is a process with goals to identify and eliminate waste in order to enhance continuous improvement through team member involvement. |
| Just-In-Time | Just-In-Time production means to produce the right item at the right time and in the right quantity. Manos and Vincent (2012) defined Just-in-Time (JIT) as a philosophy that has the elimination of waste by manufacturing only what is needed as its ultimate objective. Westcott (2006) wrote that Just-in-Time is a highly coordinated delivery and production system that matches delivery to usage times. |
| Jidoka | Jidoka is a Japanese term that means process capability improvements by containing or preventing defects and utilizing feedback for quick countermeasures. Manos and Vincent (2012) defined Jidoka as a Japanese word for a device that stops production when an abnormal or defective condition arises. |
| Involvement | Team member involvement is the heart of the lean production process. Involvement develops employees, enhances continuous improvement efforts and promotes long term success. |
| Customer Focus | Lean production means doing more with less but always giving customers what they want. |

Worley & Doolan (2006), Manos & Vincent (2012), Dennis (2007), Womack et al. (1990), Westcott (2006), Rother & Shook (1998), Nicholas (1998), and Liker (2004) identified the additional lean tools and terms as: Five S, Kaizen, Kanban, Pull Production, Quick Changeovers,  Value Stream Mapping, Andon, Gemba, Heijunka, Poke-Yoke, Takt Time, Hoshin Planning, Total Productive Maintenance, Standardized Work, Autonomation, One Piece Flow and Visual Workplace. Each of the lean tools is defined in the table below.

Table 14:

Lean Tools

| Lean Tool | Description |
|---|---|
| Five S | Five S or 5S is a phrase that includes five steps to improve workplace organization and standardization. The five steps come from the Japanese words Seiri, Seiton, Seiso, Seiketsu, and Shitsuke. The English translations are Sort, Set in Order, Shine, Standardize, and Sustain. |
| Kaizen | Kaizen events are continuous improvement in small steps. Kaizen events are typically used by organizations to focus on improving a specific process. |
| Kanban | Kanban is a system that uses a card to signal a need to produce or transport a container of raw materials or partially filled products to the next stage in the manufacturing process. Kanban is a communication tool that controls production quantities depending on the needs of the next process within a sequence. |
| Pull Production | Pull Production is a process characterized by the manufacture of product only when a customer has placed an order. Pull is a system of cascading production and delivery instructions from downstream to upstream activities in which the upstream supplier does not produce until the downstream customer signals a need. |
| Quick Changeovers | Quick Changeovers are characterized as a method for minimizing the amount of time it takes to change a machine's setting or to prepare an area to begin processing a new product. Quick Changeovers are the ability to change tooling and fixtures rapidly to enable smaller batch sizes to be produced efficiently. |
| Value Stream Mapping | Value Stream Mapping is investigating the flow of material through the manufacturing process from the customer's point of view with the end result highlighting areas of waste. Value Stream Mapping is the process of creating a representation of the value stream using icons and metrics that show the information and material flow of a process family. |
| Andon | Andon is a Japanese word meaning "light" or "lantern" utilized within a process as a notification of abnormal conditions or machine breakdowns. Andon is an electronic device used to display status alerts to process personnel. |
| Gemba | Gemba is a Japanese word meaning "real place" as in where the |

| | |
|---|---|
| | value added action is taking place. Management uses Gemba to get out to where the work is being done to better understand a problem while increasing appreciation for the process involved. |
| Heijunka | Heijunka is a Japanese word meaning the leveling of production for product mix and volume. |
| Poke-Yoke | Poke-Yoke is a Japanese term meaning “inadvertent error and prevention”. Poke-Yoke is also known as mistake proofing by implementing simple low cost devices that either detect or prevent abnormal situations from occurring. |
| Takt Time | Takt is a German word that means “pace” or “rhythm” and is the heartbeat of the process. Takt Time is a measure of customer demand. The formula for Takt Time is the available work time divided by customer demand over a given period of time. |
| Hoshin Planning | Hoshin Planning, also known as Hoshin kanri is a strategic planning system and decision making tool for policy deployment targeted at breakthrough goal attainment. |
| Total Productive Maintenance | Total Productive Maintenance (TPM) is a system that ensures overall equipment effectiveness. TPM is a system that ensures that all equipment is capable of performing its intended function without major interruptions. |
| Standardized Work | Standardized work is a precise description of each work activity considering cycle time, takt time, the work sequence of tasks, and the minimum inventory of parts available to conduct the activity. |
| Autonomation | Autonomation is also known by its Japanese term “jidoka”. Autonomation is the combination of human intelligence with automation to enable equipment to detect defects, alert personnel, and immediately halt production. |
| One Piece Flow | One piece flow is a process where a product flows from one process to another in order to minimize waste in a just in time production system. |
| Visual Workplace | The placement in plain view all of the resources required so that all personnel can understand the status of a system at a glance. Lines, signs and labels, andons, kanbans, production boards, painted floors, and shadow boards are typical visual control tools. |

Black (2007) proposed seven preliminary steps for successful lean implementation:

1. Education of everybody in the plant on lean production philosophy and concepts.
2. Top-down commitment.
3. Financial decision based on the lean practices as lean accounting.

4. Selection of measurable parameters that track organizational changes.
5. Full involvement of production workers.
6. The company must share the gains with those who contributed.
7. The middle management reward structure must support the system design.

The 5S tool is the cornerstone for companies pursuing lean in that it lays the groundwork by developing the discipline necessary to support successful implementation of lean concepts (Manos and Vincent, 2012). Ho (1999) described 5S as a natural starting point for continuous improvement and preparing organizations for a more advanced focus. The 5S tool is the starting place for the implementation of lean operations and described the importance of 5S being done properly (Kubiak and Benbow, 2009).

**Lean 5S Tool**

Gapp, et al. (2008) reported that 5S was first used in the manufacturing sector of Japan in the 1950's. The phrase, "lean 5S tool", refers to workplace organization and standardization (Manos and Vincent, 2012). The lean 5S tool is designed to develop a visual workplace and creates an environment that is self-explaining, self- ordering, and self-improving (Dennis, 2007). The 5S tool is the fundamental prerequisite for the implementation of the lean methodologies and is a primary tool for continuous improvement (Imai, 1997).

Manos and Vincent (2012) wrote that 5S stands for five words in Japanese that begin with the letter "S". The components of a 5S system include: (Seiri) Sort, (Seiton) Set in Order, (Seiso) Shine, (Seiketsu) Standardize, and (Shitsuke) Sustain. (Manos & Vincent, 2012; Liker, 2004; Dennis, 2007, Ohno, 1988, and Womack & Jones, 1996). Worley and Doolan (2006) defined Five S events as the five dimensions of workplace organization. The events are designed to organize and clean. Worley (2004) defined the Five S events as sort (identify unnecessary equipment), straighten (arrange and label the area so all tools have a specified home), shine (clean the area and maintain daily), standardize (establish guidelines and standards for the area), and sustain (maintain the established standards). The 5S tool refers to organization of the workplace by organizing areas to be free of clutter, efficient, safe and pleasant (Manos and Vincent, 2012). The 5S tool assists organizations in building awareness in the concepts of continuous improvement, set the stage for waste reduction initiatives, break down barriers to improvement at lower costs, and empower workers to control their work environment (Westcott, 2006). The lean 5S tools are defined by many authors. (Moriones et al., 2010; Manos & Vincent, 2012; Liker, 2004; Dennis, 2007, Ohno, 1988, Womack & Jones, 1996). The table below identifies each of the phases of the lean 5S tool, the Japanese and English word, and the meaning of each.

Table 15:

The Lean 5S Tool

| The "S" | Japanese | English | Meaning |
|---|---|---|---|
| 1S | Seiri<br>(say-ree) | Sort | Organization<br>Focus on eliminating unnecessary items |
| 2S | Seiton<br>(say-ton) | Set-in-Order | Neatness<br>Create efficient and effective storage methods |
| 3S | Seiso<br>(say-so) | Shine | Cleaning<br>Thorough cleaning |
| 4S | Seiketsu<br>(say-ket-soo) | Standardize | Standardization<br>Make best practices the everyday standard |
| 5S | Shitsuke<br>(she-soo-kay) | Sustain | Discipline<br>Embed into the culture |

The 5S tool is one of the best known and most widely used methodologies when facing improvement processes (Moriones et al., 2010). Organizations can utilize a simple 5S waste elimination project for immediate gains (Shil, 2009). The 5S tool is a discipline that creates a foundation for a strong lean organization (Manos and Vincent, 2012). The 5S tool works as a first step on the way to Total Quality Management and that manufacturers could ensure a competitive edge through the use of 5S (Shil, 2009).

Dennis (2007) wrote that 5S is a deceptively simple system. In regards to 5S in the United States, Gapp et al. (2008) wrote that it appears that many researchers and practitioners have difficulty going beyond the simplest 5S concept (or meaning) of housekeeping. Barraza and Pujol (2012) wrote that the original phases of the lean 5S tool included only the initial three phases of sort, set-in-order and shine. This may provide a partial explanation as to why some organizations fail to understand the full benefits of the tool beyond “housekeeping” and have difficulty in implementing all five phases. The 5S tool created a clean, neat, organized, and safe workplace that reduces waste throughout the organization (Manos and Vincent, 2012).


Figure 14: 5S Waste Relationship

Without the organization and discipline provided by successfully implementing the 5S's, other lean manufacturing tools and methods are likely to fail (Hirano, 1996). Some organizations develop a checklist to ensure that their 5S program has been implemented and successful (Ho and Fung, 1995).

Recent research on 5S shows that the tool has been utilized in different types of industry. Benjamin (2012) explored the implementation of the 5S system within the healthcare industry. The qualitative study included a variety of data collection methods that included surveys of hospital staff that play a medical or business role, 5S consultants, and face to face interviews with hospital executives. The study revealed that 57 percent of the participants identified the goal of the lean 5S as a system to prevent problems and to provide excellent patient care. The study also identified barriers and utilized a Likert scale of 1 (most important for implementation) to 5 (least important for implementation) for survey data accumulation. Benjamin (2012) reported that five common inhibitors prevented success. The five inhibitors reported were; lack of communication (2.0), commitment (2.14), personal responsibility (3.29), training (3.71), and management support (3.85). Two additional barriers reported were lack of time and lack of resources.

Naqvi (2013) investigated how effectively the Indian sub-continent workers could cope with the implementation of a 5S lean system within their U.S. employment location. Naqvi (2013) utilized a qualitative research method and an ethnography design. The sample for the study was 33 employees who migrated from the countries of India, Pakistan and Bangladesh. The 33 employees had various religious beliefs of Islam, Christianity, Hinduism, and Sikhism. A key element of the study was the impact of religion and culture on the implementation of lean 5S. The study presented two questions. One question for the study was to determine the significance of religion and culture of a worker on the implementation and maintenance of the lean 5S tool in a manufacturing setting. The results reveal that religion and culture have an effect and align with their religions and culture. The religion is much disciplined and the culture is one of obedience. The study revealed that the workers would follow orders as directed by supervisors which would undermine the lean 5S tool implementation and maintenance. Therefore lack of management support and commitment were identified as barriers. The second question relates to the problems that the Indian sub-continent workers encounter in adapting to a lean environment. The study revealed that the workers support each other in the workplace through teamwork. The workers are submissive to management due to their culture but fail to generate many new ideas toward the lean 5S tool implementation and maintenance efforts.

Sofokleous (2003) studied manufacturing improvements through the use of the lean methodologies within a small agricultural business known as South American Pineapple Company. The study was designed to determine if the lean methods could be utilized in an agricultural setting. One of the research questions was to determine what process could be used to train workers in making a storage room more efficient. The first step was to utilize the lean 5S tool and implement 5S in a storage room. The study revealed that the 5S tool led to improved efficiency by requiring less time searching for equipment, provided additional space, reduced inventory, and improved worker morale which encouraged communication.

Barraza and Pujol (2012), based on the case studies of three Mexican manufacturing facilities that have applied the 5S tool for at least five years, identified three drivers and two inhibitors of successful implementation. The case studies included data collection through four processes such as direct observation, participative observation, documentary analysis, and semi-structured interviews. Three drivers that emerged included a strong commitment from management, the use of work teams, training of lean methodologies including the 5S tool, and clear communication of the effort. The two inhibitors reported were the application of 5S as isolated events and the lack of a philosophical vision. One was that 5S was considered an isolated event synonymous to a "flavor of the month" rather than an organization wide program. The second was a lack of management vision for the 5S program as it was portrayed as a technique to ensure clean and tidy floors.  Barraza and Pujol (2012) studied the benefits of the 5S tool and reported that it is not only useful for improving the working environment but also to raise process and product quality standards, reduce and optimize lead time, reduce operating costs and enhance process performance. Three drivers that emerged included a strong commitment from management, the use of work teams, training of lean methodologies including the 5S tool, and clear communication of the effort.

Moriones et al. (2010) explored the relationship of the lean 5S tool usage to contextual factors and performance. The contextual factors included structural and performance features. The structural features studied were the firm's environment, human resources, technology, and quality management. The performance features studied were productivity, quality, employee satisfaction, lead times, and new designs. The Moriones et al. (2010) study surveyed the managers of 203 Spanish manufacturing firms and reported that the level of implementation of the lean 5S tool was very low at 2.09 on a scale of 1 to 10 with 68% of the respondents not using the 5S methodology at all. The 68% percent low usage rate is due to the survey being administered to a sample of manufacturing organizations of small and large sizes from all manufacturing sectors rather than isolated to the automotive industry. The survey response rate was 47% and the respondents included plant general and operations managers rather than those directly responsible for good quality leadership. Despite the fact that the 5S tool is one of the best known in the manufacturing environment, there is little empirical evidence regarding its adoption in Spanish manufacturers. The Moriones et al. (2010) study indicates that the implementation of 5S in Spanish firms is lower than expected indicating that firms are reluctant to use the tools formally. The results of the study reveal that the use of 5S is positively related to plant size, type of product being manufactured, technology being used, and good quality management programs in place. Moreover, the use of 5S was also reported to positively affect quality and productivity. The Moriones et al. (2010) study also revealed that large manufacturing plants, organizations with multinational functions, and that manufacturing plants with high-quality systems such as ISO 9000 in place were more likely to use 5S.

Todorova (2013) studied the relationship of the lean tools including the lean 5S tool and which play major roles for lean implementation success within job shop, batch shop, and assembly line manufacturing settings. Since 5S has been identified as one of the first steps toward the implementation of lean techniques, there was an expectation that all three types of the manufacturing settings would show a similar usage. However, the study revealed that there was a statistical difference in the level of utilization in the job shop – assembly line group. In regards to the 5S tool and performance, the study revealed that the perceived operational performance was significant in assembly line settings but not within the job shop or batch job settings.

Steinlight (2010) studied lean tools including the lean 5S tool effectiveness and organizational life cycles within young and mature manufacturing organizations within the states of South Dakota, Minnesota, Wisconsin and Iowa. The results indicated that both young and mature organizations utilize the lean 5S tool although the degree of implementation was not studied. Both young and mature organizations list the 5S tool amongst the most utilized and highest rated lean tools.

The 5S tool has been successfully implemented in large and small operations in the U.S. and abroad (Becker, 2001). The Wing Responsibility Center of the Boeing Company incorporated the lean 5S tool within its manufacturing operations resulting in the elimination of wasteful process steps, reduction in labor hours and rework, and reduction of chemical use and hazardous waste by 98 percent (Becker, 2001). A smaller family owned metal hinge manufacturing organization named Cooke Brothers Limited with 98 employees also experienced 5S implementation success (Becker, 2001). The company provided in-house training for all employees regarding the 5S system and experienced benefits such as improved housekeeping, safety and health, and waste reduction particularly of water, oil and energy. The most significant barriers identified were in extensive communication time and reluctant employee input (Becker, 2001). Often the 5S tools are implemented only as a temporary program and as housekeeping with posted slogans, painted floors and machinery. This makes implementation of all phases of the 5S tool difficult to sustain (Becker, 2001). Ho (1999) reported that many organizations are unable to standardize or sustain the 5S phases. Therefore, organizations are able to complete the initial three phases which have many attributes related to “housekeeping” but never realize the benefits of the final phases.

Hutchins (2006) studied the effectiveness of implementing the lean 5S tool through a causal comparative study of his manufacturing employment location. The study explored the espoused benefits of 5S as productivity improvements, safety, quality, use of floor space, and employee attitudes. The study also explored the reported benefits of 5S reported as a decrease in product and maintenance costs, workplace cleanliness and organization, employee commitment and empowerment, and the reduction of machine downtime. The study explored the before and after 5S implementation and revealed that workplace cleanliness, workplace organization, and floor space utilization improved. However, the study also revealed that productivity, safety, quality, and costs did not improve. Although not studied, it is possible that all phases of the 5S tool were not fully implemented.

Lynch (2005) studied the correlation between the implementation of the lean 5S tool to productivity, quality and cycle time within three electrical departments of a larger electrical product division over a 10 month time period. The treatment for the study included an initial 5S assessment, 5S training, and implementation of 5S. The study revealed that there were improvement results in productivity but not in quality or cycle time. The reason that quality did not improve was due to the fact that quality levels were already high at the start of the study. The study also revealed that the implementation of the 5S tool may lead to reduced costs associated with productivity, quality, and cycle time which increase profits. Again, it was not studied but possible that all five phases of the lean 5S tool were not implemented.

**Summary**

1. The U.S. GDP as a percent of the world's output has been declining since 1960 from 40 percent to 23 percent. Additionally, U.S. trade has declined from 16 percent of global merchandise exports to 8 percent during the same time period.

2. U.S. manufacturing jobs and employment have been declining since 1960. Over 5 million manufacturing jobs have been lost through 2011. At the same time, U.S. productivity has increased 400 percent from 1947 to 2010. Therefore, U.S. manufacturing output has been able to expand with fewer and fewer workers.

3. U.S. automotive organizations have been losing market share to international firms operating in the United States from 1986 to 2011. Employment due to automotive manufacturing is a key component to the U.S. economy. The automotive industry employs 4.4 percent of the U.S. labor force with states such as Michigan, Indiana , Ohio and Kentucky leading the nation. Eight million private sector jobs are affected by the U.S. automotive manufacturers, suppliers and dealers.

4. U.S. manufacturing has embraced the continuous improvement paradigm in an attempt to be competitive. U.S. manufacturing utilizes many continuous improvement tools designed to identify opportunities and improve quality, cost and efficiency.

5. The lean systems approaches are essential to manufacturing success. The lean systems provide methods that eliminate waste and reduce inventory, improve manufacturing efficiency, increase quality levels, increase flexibility of resources, and improve customer satisfaction.

6. The lean 5S tool is the starting point for full lean system implementation. The research shows that the lean 5S tool is a fundamental prerequisite for the implementation of the lean methodologies and is a primary tool for continuous improvement.

7. The research shows that although the lean 5S tool is critical to overall lean systems success, barriers stand in the way. The barriers identified include a lack of the proper organizational culture resulting in a 5S approach existing as an isolated event, lack of management commitment supporting a 5S vision, lack of an implementation, evaluation and standardization plan, lack of an application plan, and a lack of clarity of purpose.

There are several trends identified within this literature review. However, it is not clear what factors affect the implementation of the lean 5S tool within the original equipment supply base of vehicle parts and accessories within the U.S. automotive industry. Therefore, additional research is needed to close this gap and advance the knowledge in this area.

# Chapter 3: Methods

The purpose of Chapter three is to describe the research methods, population and sample, instrument development, data collection procedures, and data analysis steps.

## Research Methods

The objective of this study was to identify the significant factors affecting the implementation of the lean 5S tool in OEM suppliers within the U.S. automotive industry and to determine if they vary with selected demographic variables. In order to identify the factors, a survey questionnaire was administered to active members of the American Society for Quality that have leadership functions within U.S. based OEM automotive industry suppliers. “Survey research involves acquiring information about one or more groups of people by asking them questions and tabulating their answers” (Leedy and Omrod, 2005, p. 183). Developing a quality instrument is the biggest challenge in survey research. (Passmore and Parchman, 2002). Conducting an online survey has some advantages: anonymity facilitates sharing of the participants’ experience, and respondents directly enter the data in the electronic file (Selm and Jankowski, 2006).

The study included data preparation and analysis, descriptive statistics and inferential statistics. Leedy and Ormrod (2010) wrote that the use of descriptive statistics is appropriate when exploring a potential correlation between two or more phenomena or when identifying characteristics of the observed phenomena. Using inferential statistics helps researchers in the decision making process about the collected data (Leedy and Ormrod, 2010). Therefore, for the purposes of this study, descriptive and inferential statistics are applied.

## Population and Sample

Montgomery (2013) wrote that a sample is a collection of data selected from some larger population. The population for this study consists of active members of the American Society for Quality (ASQ) Sections that have leadership responsibilities within U.S.-based Tier 1, Tier 2 and Tier 3 manufacturing suppliers to the U.S. automotive industry and are from the states of Michigan, Indiana, Ohio and Kentucky.

The sampling technique for this study was non-probability convenience sampling. Convenience sampling utilizes people or other units that are readily available (Leedy and Ormrod, 2010). The sample for this research study were active members of selected sections of the American Society for Quality (ASQ) from the states of Michigan, Indiana, Ohio and Kentucky that have leadership responsibilities within U.S.-based Tier 1, Tier 2 and Tier 3 manufacturing suppliers to the U.S. automotive industry. The sample sections were selected based upon their location to U.S. automotive assembly plants. The potential sample population is 1043 members.

## Instrument Development

In order to obtain data for analysis, a survey tool was developed. A survey tool has economic benefits, a rapid turnaround of data collection and provides information about a large population from a sampling (Creswell, 2014). The survey tool included questions written in a format that provided responses that addressed research questions. There are four steps for instrument development including concept identification, item construction, validity testing, and reliability testing (Davis, 1996).

**Concept Identification.** The initial step of instrument development is to identify what the tool will measure (Davis 1996). Therefore based on the literature review in Chapter 2, the instrument was designed to measure the significance of the perceived drivers and inhibitors that have affected the implementation of the 5S tool and the relationship of the selected demographic variables to phases of the 5S tool.

**Item Construction.** The second step of instrument development is to develop an item that reflects the content area that is to be tested (Davis, 1996). Based on the comprehensive literature review in Chapter 2, a framework of the instrument was developed based upon the Five S's and relative questions pertaining to the generated hypotheses. A Likert-type scale was used for the instrument. The Likert-type scale allows responses to be numerical, and the respondents are asked to make an evaluation based on the level of agreement or importance (Leedy and Ormrod, 2005). The coding selected for the Likert-type scale was designed to determine a level of agreement that each respondent has with a particular item. The anchors include: 1- Strongly Disagree, 2 - Disagree, 3 – No Opinion, 4 - Agree, 5 – Strongly Agree. Fifteen elements were utilized within the survey tool. The elements are statements that pertain to the phases of the 5S tool. The elements are as follows:

1. Obsolete and excess items removed
2. Empty containers and racks properly stored
3. Floors and aisles cleared and clean
4. Necessary items are properly stored
5. Items are placed in designated areas
6. Inventory is organized and identified
7. Floors and aisles are properly marked

8. Equipment and tools are clean
9. Workstations are neat and organized
10. Visual aids are in place and unobstructed
11. Instructions and procedures are utilized
12. Communication boards are in place and being used
13. 5S audit forms and schedules in place with action plans
14. Trained employees to conduct 5S audits
15. Evidence of effectiveness and improvements

Nine factors were utilized within the survey tool. The factors are statements that pertain to the implementation of the lean 5S phases. The factors are as follows:

1. Management commitment to 5S implementation success
2. Management training of the 5S tool
3. Non-management training of the 5S tool
4. Communication within the plant
5. Personal responsibility of employees
6. Written 5S implementation plan being utilized
7. Adequate resources being provided for implementation
8. Adequate time being provided for implementation
9. Employees are working in teams

**Validity Testing**. Validity testing is the third step suggested by Davis (1996). Content validity is the extent to which a measurement instrument is a representative sample of the content area being measured (Leedy and Ormrod, 2010). The tool was provided to a panel of experienced researchers for review. The researchers were deemed qualified based upon their experience with survey research tools and knowledge regarding lean tools. Their input was used to modify the instrument and improve validity.

Pilot testing of the survey is important to establish content validity of scores on an instrument and to improve questions, format, and scales (Creswell, 2014). Therefore, the survey instrument for this research was provided to active members of the American Society for Quality (Section 1004) located in mid-Michigan. The pilot survey was administered through a hard copy version during an American Society for Quality Section 1004 monthly meeting. Nineteen participants completed and returned the survey along with comments, questions and suggestions. Additionally, the researcher provided a telephone number to the participants of this pilot survey for any additional verbal feedback. This step provided the researcher with feedback for continuous improvement of the instrument.

**Reliability Testing.** Reliability is the fourth step suggested by Davis (1996). Reliability of a measurement instrument is the extent to which the instrument yields consistent results when the characteristics being measured have not changed (Leedy and Ormrod, 2010). Interrater reliability, internal consistency, equivalent form, and test-retest are all methods suggested by Leedy and Ormrod (2010) to test reliability of a survey instrument. Tavakol and Dennick (2011) wrote that alpha was developed by Lee Cronbach in 1951 to provide a measure of the internal consistency of a test or scale. Therefore, the pilot study was used to generate the Cronbach alpha coefficient and to evaluate the reliability of the measuring instrument. The Cronbach alpha is expressed with a number between 0 and 1. A score of 0.70 or greater is considered acceptable (Tavakol and Dennick, 2011).

## Survey Tool Pilot Test Results

The survey tool was administered to active members of the American Society for Quality Section 1004 during a monthly section meeting. Nineteen members completed the survey and provided comments and recommendations. The survey tool was divided into three sections. Section 1 pertains to demographics. Section 2 includes 15 questions that pertain to the elements of the Lean 5S tool. Section 3 includes 8 questions that pertain to factors of the Lean 5S tool. The table below shows the Cronbach Alpha results for Sections 2 and 3. Cronbach alpha is the coefficient assessing consistency of the entire scale (Hair et al.,2009). A Cronbach alpha of 1.00 indicates perfect relationship, while a small alpha indicates that the performance of one item is not predictable on the performance of other items (Davis, 1996). The acceptable lower limit for Cronbach alpha is 0.60 (Hair et al., 2009). The reliability of the survey instrument used for data collection in this study was confirmed with overall and section results above 0.7000. Table 16 shows the Cronbach Alpha results for Sections 2 and 3.

Table 16:

Survey Tool Cronbach Alpha

| Section | Cronbach Alpha |
|---|---|
| 2 and 3 | 0.8925 |
| 2 | 0.9065 |
| 3 | 0.8767 |

## Human Subjects Approval

The Eastern Michigan University Dissertation Manual (2008, p. 13), states “If the doctoral students plan to use human subjects as part of their research, the first step is to submit a Request for Approval of Research Involving Human Subjects along with their dissertation proposal to the university human subjects review committee at the graduate school." A request for human subject approval was submitted to the human subjects review committee and approved prior to any survey administration. The participants were advised of the research process, anonymity, and offered an outlet to withdraw participation as desired.

## Data Collection

SurveyMonkey was used as the mode to create and distribute the electronic survey to the sample population. Conducting a survey online has several cost advantages when the sample is large (Kraut et al., 2004). The survey was administered through the electronic message mail system to active members of American Society for Quality listed on LinkedIn sites located near automotive assembly plants in the states of Michigan, Indiana, Ohio and Kentucky. The selection of American Society for Quality members within Michigan, Indiana, Ohio and Kentucky provided the researcher with participants from those states that lead the United States in GDP dependency on automotive manufacturing and are among the top ten states that have automotive manufacturing jobs as a high percentage of the state population. Additionally, since suppliers to the automotive industry are the largest employers in all but ten of the fifty U.S. states, the survey participants from Michigan, Indiana, Ohio and Kentucky represented the automotive manufacturing suppliers of the United States. The survey was anonymous and participant names were not associated with their corresponding responses. The survey included an introduction and a hyper link to the SurveyMonkey tool. Follow up electronic mail messages were sent as a reminder to the potential participants one week after the initial electronic mail message was distributed. A second reminder was sent two and three weeks afterwards followed by a notice of the survey conclusion after four weeks. As an additional measure to encourage responses, all participants were offered a summary of the research results and entered into a drawing for a chance to win a gift certificate for one hundred dollars.

**Response Rate**

The survey was issued to active members of the American Society for Quality Sections located near automotive assembly plants in the states of Michigan, Indiana, Ohio and Kentucky. A total of 430 American Society for Quality members were issued an electronic message requesting their participation in the survey. Of the 430 contacted, 189 responded representing a response rate of 44.0 percent.

Of the 189 responses, 10 of the surveys were disqualified due to the respondents being from outside the target group. Of the remaining 179 responses, 42 survey respondents were from organizations that did not provide a product to the US Automotive industry. Therefore, the qualified responses for analysis included 138 surveys.

**Data Analysis**

The two types of statistical analysis tools utilized for data analysis are descriptive and inferential statistics (Coolidge, 2013). The estimate of instrument reliability was calculated using Cronbach's Alpha statistic. Cronbach's Alpha measures the internal consistency of a test or scale and is expressed as a number between 0 and 1 (Tavakol and Dennick, 2011). The Cronbach's Alpha for the research survey was calculated to be 0.9583. Additionally, two sections of the survey tool were measured. Section 2 resulted in a Cronbach's Alpha of 0.9583 and Section 3 at 0.9324. The construct validity of phases of the 5S were explored using a factor analytic technique that employs an orthogonal rotation approach.

Research question 1 was addressed using the following statistical tools: measures of central tendency, measures of variability, and charting. The measures of central tendency for the factors were ranked to identify the factors that have the greatest influence on the implementation of each element of the 5S phases. Measures of central tendency and variability were calculated for each factor for each phases of the 5S tool as well.

RQ1: What factors were perceived by the respondents to have influenced the implementation of the lean 5S phases and elements in suppliers of manufactured products to the U.S. automotive industry?

Research question 2 was analyzed using the appropriate correlations tools to determine the relationship of the selected demographic variables to each factor and phase of the 5S tool. Additionally, measures of central tendency and variability were calculated where appropriate.

RQ2: What is the relationship of the selected demographic variables on the perceived factors and the lean 5S phases in suppliers of manufactured products to the U.S. automotive industry?

**Demographic Variables**

The demographic variables for this research were as follows:

Manufacturing tier level

Collective Bargaining (Union or Non-Union Line workers)

Plant size (Total number of employees within the U.S. plant location)

The degree of utilization of work teams

Approximate number of months that your plant has used lean tools

Length in hours of lean 5S tool training for management personnel

Length in hours of lean 5S tool training of non-management line workers

Level of management commitment

Level of communication within the plant

Degree of personal responsibility

Degree of utilization of an implementation plan

Availability of implementation resources

**Summary**

This chapter introduced the research methods that were utilized for the research and included the identification of the population and sample. The structure of the instrument development tool was presented and included the concept identification, item construction, validity testing including a pilot survey, and reliability testing. The Human Subjects Approval was completed and the researcher has completed the CITI training for research involving human subjects. Research questions and the null hypotheses were addressed through a data collection and analysis process that included the use of descriptive and inferential statistics.

# Chapter 4: Results

The purpose of this chapter is to share the results of the analyses of the survey responses. The chapter is organized using the following headings: characteristics of the instrument, descriptive statistics for demographics, descriptive statistics for each 5S phase, descriptive statistics for the factors, results for research question 1, results for research question 2, and a summary.

## Characteristics of the Instrument

The instrument provided an introduction to potential respondents by stating the purpose of the study, explaining confidentiality and risks, informing of voluntary participation, acknowledgement of the Eastern Michigan University Human Subjects Review Board review and approval, and the offer of a potential incentive for participation.

The instrument consisted of four separate sections. Section 1 addressed selected demographic characteristics. Section 2 sought perceptions regarding fifteen elements based upon the implementation of the lean 5S tool within each respondent's manufacturing location. The fifteen elements were statements that pertain to each phase of the lean 5S tool. There were three statements referred to as elements associated with each of the five phases which comprise the fifteen total elements. Section 3 included nine factors based on the implementation of the lean 5S tool within the respondent's manufacturing locations. These nine factors were assumed to be independent of each other. Sections 2 and 3 utilized a five point Likert-type scale to solicit respondent perceptions. The scale anchors included: Strongly Disagree, Disagree, No Opinion, Agree, and Strongly Agree. The measuring instrument is located within Appendix A. Section 4 concluded the survey and provided the respondents with an opportunity to add comments, a method of being included for an incentive award, an opportunity to request a summary of survey results, and the contact information of the researcher and chairman.

**Descriptive Statistics for Demographics**

Table 17 shows the demographics by state. There were a total of 138 qualified respondents who completed the instrument. The potential sample consisted of members of the American Society for Quality Sections located within the states of Michigan, Ohio, Indiana, and Kentucky. There were 62 respondents (44.9%) from Michigan, 34 (24.6%) from Ohio, 23 (16.7%) from Indiana, and 19 (13.8%) from Kentucky.

Table 17:

Respondents by State

| *State* | *Number of Respondents* | *Percentage* |
|---|---|---|
| Michigan | 62 | 44.9 |
| Ohio | 34 | 24.6 |
| Indiana | 23 | 16.7 |
| Kentucky | 19 | 13.8 |

Table 18 shows the leadership levels of the respondents. The respondents occupied leadership positions within U.S. manufacturing organizations that provided a product to the U.S. automotive industry. There were a total of 44 different titles that fell into the three leadership level categories of upper management, middle management and lower management. Of the 138 respondents, 11 (8%) were from upper management positions, 88 (63.7%) were from middle management and 39 (28.3%) were from lower management.

Table 18:

Leadership Levels

| *Leadership Level* | *Number of Respondents* | *Percentage* |
|---|---|---|
| Upper Management | 11 | 8 |
| Middle Management | 88 | 63.7 |
| Lower Management | 39 | 28.3 |

Forty-nine respondents or 35.5% identified the workers of their organizations as not being represented by any collective bargaining unit, while 89 (64.5%) indicated that their workers belonged to a bargaining unit.

Table 19 shows the Tier levels of the respondents' organizations. Three automotive supplier tiers or levels were represented by the respondents. Tier I organizations provide a manufactured product directly to the automotive OEM's, Tier II organizations provide product to the Tier I's while Tier III's provide a product to the Tier II's. Of the 138 respondents, 99 (71.7%) were employed by the Tier I providers, 31 (22.5%) were employed by Tier II providers and 8 (5.8%) were members of Tier III organizations.

Table 19:

Tier Level of Manufacturing Sites

| *Tier Level* | *Number of Respondents* | *Percentage* |
|---|---|---|
| I | 99 | 71.7 |
| II | 31 | 22.5 |
| III | 8 | 5.8 |

The researcher decided to compare responses of Tier I and Tier II respondents to see if any significant correlations existed among the data. The Tier III respondents were not included due to the low number of responses within that group. The means of the responses from Tier II suppliers were higher for all factors and phases than those from Tier I suppliers. However, there was not any statistical significance.

The researcher decided to analyze responses from respondents of Tier I suppliers separately from respondents from Tier II suppliers. Respondents from Tier I suppliers have significant relationships to factors and phases. The respondents from Tier II suppliers also have significant relationships at a less degree. Table 20 shows the relationships of the Tier I suppliers. Table 21 shows the relationships of the Tier II suppliers.

Table 20:

Significant Correlations of Tier I Suppliers between Demographic Variables and Factors (n=99)

| | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 | 1S | 2S | 3S | 4S | 5S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location by State | | | | | | * | * | * | | * | | * | ** | * |
| Organizational Function | | | | ** | | | | | | | | * | | |
| Management Level | | | | | | | | | | | | | | |
| Union/Non-Union | | | * | ** | ** | | | | | * | * | | | |
| Tier Level | | | | | | | | | | | | | | |
| Plant Size | | | | | | | | | | | | | | |
| Time Spent with Teams | | | | | | | | | ** | | | | | * |
| Number of Months | | | | | | | | | | | | | | |
| Mgt. Training | | *** | | | | | | | | | | | | |
| Non-Mgt. Training | | * | | * | | | | | | | | | | |

*** Significant at the ≤ .001 p-value level
** Significant at the ≤ .01 p-value level
* Significant at the ≤ .05 p-value level

Table 21:

Significant Correlations of Tier I Suppliers between Demographic Variables and Factors (n=31)

| | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 | 1S | 2S | 3S | 4S | 5S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location by State | | | | ** | * | | | | | | | | | |
| Organizational Function | | | | * | * | | | | | | | | | |
| Management Level | * | | | | | | | | | | | | | |
| Union/Non-Union | | | | | | | | | | | | | | |
| Tier Level | | | | | | | | | | | | | | |
| Plant Size | | | | | | | | | | | | | | |
| Time Spent with Teams | | | | | | | | | | | | | | |
| Number of Months | | | | | | | | | | | | | | |
| Mgt. Training | | | | | | | | | | | | | * | |
| Non-Mgt. Training | | | | | | | | | | | | | | |

*** Significant at the ≤ .001 p-value level
** Significant at the ≤ .01 p-value level
* Significant at the ≤ .05 p-value level

Table 22 shows the descriptive statistics for the size of the 138 organizations measured by the number of employees at the respondents' manufacturing sites. Table 20 also shows the subset of the 113 organizations with 1000 employees or less.

The average size of the 138 responding organizations was 892.5 with a standard deviation of 1522 and a range of 9995. The median size was 400 employees. These data representing this variable were not normally distributed since the skewness value was 3.43 and the kurtosis value was 13.55. Lomax and Hahs-Vaughn (2012) wrote that skewness is a measure of symmetry of a distribution and values of plus or minus 2 are considered as normal. Kurtosis is a measure of flatness of a distribution and a value of zero indicates a shape close to normal (Knapp, 2014). Lomax and Hahs-Vaughn (2013) wrote that distributions with kurtosis values of plus or minus 2 are considered as normal.

Of the 138 respondents, 113 (81.9%) represented organizations with 1000 employees or less. The data for those 113 organizations is normally distributed with a skewness of 0.75

and kurtosis of -0.48. The mean is 353.7 with a standard deviation of 285.5, a median of 300 and a range of 995.

Table 22:

Size of Manufacturing Sites in Number of Employees

| | *Number of Respondents* | *Mean Number of Employees* | *Standard Deviation* | *Median* | *Range* | *Skewness* | *Kurtosis* |
|---|---|---|---|---|---|---|---|
| *All Organizations* | 138 | 892.5 | 1522 | 400 | 9995 | 3.43 | 13.55 |
| *Organizations with 1000 employees or less* | 113 | 353.7 | 285.5 | 300 | 995 | 0.75 | -0.48 |

Table 23 describes the percentage of time that the leaders reported as spent working with teams as 46.21 percent with a standard deviation of 26.61. The range of the responses was 100 with a median of 50 percent. The distribution is normally distributed with a skewness of 0.21 and a kurtosis of -1.05.

Table 23:

Percentage of Time Spent Working with Teams

| *Number of Respondents* | *Mean Percentage* | *Standard Deviation* | *Median Percentage* | *Range* | *Skewness* | *Kurtosis* |
|---|---|---|---|---|---|---|
| 138 | 46.2 | 26.61 | 50 | 100 | 0.21 | -1.05 |

Figure 15 shows the distribution of the percentage of time that leaders spent working with teams. The distribution shows three modes at 30, 50 and 80 percent.

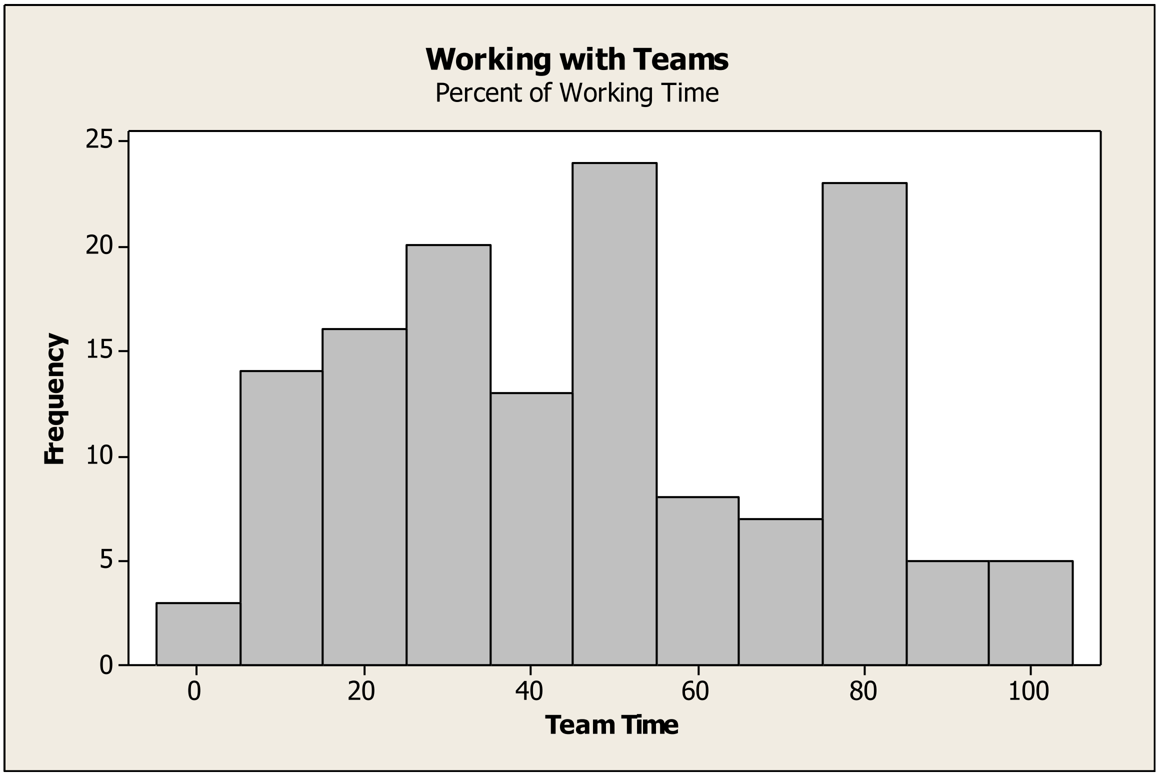


Figure 15: Histogram of Time Spent Working with Teams (n=138)

Table 24 describes the numbers of months that each of the participant's organizations have been using the lean tools. The mean was 128.2 months with a standard deviation of 161.5. The range was 600 months with a median of 72 months. The distribution is not normal and skewed to the high end with a skewness of 1.95 and a kurtosis of 3.05.

Table 24:

Number of Months Using the Lean Tools

| *Number of Respondents* | *Mean* | *Standard Deviation* | *Median* | *Range* | *Skewness* | *Kurtosis* |
|---|---|---|---|---|---|---|
| 138 | 128.2 | 161.5 | 72 | 600 | 1.95 | 3.05 |

Table 25 describes the amount of training in the lean 5S tool for management and non-management personnel. The mean for the management group was 11.2 hours with a standard deviation of 14.8. The mean for the non-management group was less at 9.2 hours with a standard deviation of 18.2. The median for the management group was 5 hours and the median for the non-management group was 4 hours. The range for the management group was 80 and the non-management group was 180.

The non-management data includes one respondent reporting 180 hours and one respondent reporting 60 hours with the next highest reporting 40 hours. Considering central tendency, the mean plus three sigma places the upper confidence level at 54.5. The two outliers are outside of that upper value. Removing those two outliers from the data reduces the skewness and kurtosis values significantly. Table 23 shows the results of the management and non-management statistics plus the modified non-management statistics.

Table 25:

Management and Non-Management Training of the Lean 5S tool

| *Variable* | *Number of Respondents* | *Mean* | *Standard Deviation* | *Median* | *Range* | *Skewness* | *Kurtosis* |
|---|---|---|---|---|---|---|---|
| *Management* | 138 | 11.2 | 14.8 | 5 | 80 | 2 | 4.1 |
| *Non- Management* | 138 | 9.2 | 18.2 | 4 | 180 | 6.5 | 57.2 |
| *Non- Management Without the Outliers* | 136 | 7.6 | 9.9 | 4 | 40 | 1.9 | 3.2 |

**Descriptive Statistics for Each 5S Phase**

Respondents' ratings for each of the fifteen 5S elements are provided in Table 26. Each of the S's of the lean 5S phases included three of the fifteen elements. The researcher was interested in comparing each of the five phases and therefore provided the mean of the means from the three corresponding elements. The data for all phases are normally distributed based on the skewness and kurtosis values. The mean for the fifth S, *sustain* is significantly lower at 3.27 with a standard deviation of 1.07 than the other 4 phases. The initial three phases of the lean 5S tool are misunderstood at times as being housekeeping only (Gapp et al., 2008). When the initial three phases are pooled, the mean is 3.77.

Table 26:

Descriptive Statistics for Each Phase of the Lean 5S Tool (n=138)

| *Phase* | *Mean* | *Standard Deviation* | *Median* | *Range* | *Skewness* | *Kurtosis* |
|---|---|---|---|---|---|---|
| *1S (sort)* | 3.81 | 0.97 | 4 | 4 | -0.73 | -0.15 |
| *2S (set-in-order)* | 3.81 | 0.87 | 4 | 4 | -0.58 | -0.07 |
| *3S (shine)* | 3.68 | 0.94 | 4 | 3.7 | -0.36 | -0.80 |
| *4S (standardize)* | 3.72 | 0.92 | 4 | 4 | -0.68 | 0.00 |
| *5S (sustain)* | 3.27 | 1.07 | 3.3 | 4 | -0.22 | -0.68 |

The fifteen elements of the lean 5S phases are listed in the Appendix A and descriptive statistics for the corresponding element numbers are provided in Table 27. All of the elements are normally distributed as shown by the skewness and kurtosis values. The three highest mean values are element 3, *floors and aisles clear*, element 7, *floors and aisles properly marked* and element 6, *items in designated areas*. That represents at least one element with a higher mean in each of the initial three phases. The three lowest mean values are element 14, *trained employees to conduct 5S audits*, element 13, *5S audit forms and schedules with evidence of actions* and element 15, *evidence of effectiveness and improvements*. All three of these elements represent the fifth S, *sustain*.

Table 27:

Descriptive Statistics for each of the Fifteen Lean 5S Elements (n=138)

| *Element* | *Mean* | *Standard Deviation* | *Median* | *Range* | *Skewness* | *Kurtosis* |
|---|---|---|---|---|---|---|
| *1 (Obsolete and excess items removed)* | 3.73 | 1.18 | 4 | 4 | -0.81 | -0.43 |
| *2 (Empty containers/racks stored)* | 3.70 | 1.17 | 4 | 4 | -0.60 | -0.88 |
| *3 (Floors and Aisles cleared and clean)* | 4.01 | 1.04 | 4 | 4 | -1.03 | 0.40 |
| *4 (Necessary items properly stored)* | 3.85 | 1.05 | 4 | 4 | -0.83 | -0.05 |
| *5 (Items placed in designated areas)* | 3.71 | 1.03 | 4 | 4 | -0.68 | -0.25 |
| *6 (Inventory organized / identified)* | 3.87 | 1.04 | 4 | 4 | -0.85 | 0.06 |
| *7 (Floors and aisles properly marked)* | 3.96 | 1.01 | 4 | 4 | -0.91 | 0.15 |
| *8 (Clean equipment and tools)* | 3.54 | 1.24 | 4 | 4 | -0.44 | -1.05 |
| *9 (Workstations neat and organized)* | 3.53 | 1.10 | 4 | 4 | -0.46 | -0.87 |
| *10 (Visual aids in place and unobstructed)* | 3.68 | 1.07 | 4 | 4 | -0.73 | -0.16 |
| *11 (Instruction and procedures utilized)* | 3.76 | 1.14 | 4 | 4 | -0.82 | -0.20 |
| *12 (Communication boards utilized)* | 3.70 | 1.06 | 4 | 4 | -0.66 | 0.00 |
| *13 (5S audit forms / schedules with actions)* | 3.27 | 1.27 | 3.5 | 4 | -0.28 | -1.03 |
| *14 (Trained employees to conduct 5S audits)* | 3.22 | 1.21 | 3 | 4 | -0.23 | -0.98 |
| *15 (Evidence effectiveness/improvements)* | 3.33 | 1.16 | 4 | 4 | -0.44 | -0.61 |

**Descriptive Statistics for the Factors**

Table 28 shows the respondents ratings of the nine factors. The distributions for each of the nine factors are normal based upon the skewness and kurtosis values. The two highest means are factor 1, *management commitment* at 3.59 with a standard deviation of 1.12 and factor 9, *employee working in teams* at 3.44 with a standard deviation of 1.13. The two lowest means are factor 3, *adequate non-management training of 5S* at 3.04 and a standard deviation of 1.26 and factor 4, *communication within the plant* with a mean of 3.09 and a standard deviation of 1.09. The nine factors are listed in Appendix A.

Table 28:

Descriptive Statistics of the Nine Factors (n=138)

| *Factor* | *Mean* | *Standard Deviation* | *Median* | *Range* | *Skewness* | *Kurtosis* |
|---|---|---|---|---|---|---|
| *1 (Management commitment to 5S success)* | 3.59 | 1.12 | 4 | 4 | -0.64 | -0.35 |
| *2 (Management training of 5S)* | 3.19 | 1.24 | 3 | 4 | 0.01 | -1.18 |
| *3 (Non-management training of 5S)* | 3.04 | 1.26 | 3 | 4 | 0.12 | -1.14 |
| *4 (Communication within the plant)* | 3.09 | 1.09 | 3 | 4 | -0.07 | -0.71 |
| *5 (Personal responsibility of employees)* | 3.31 | 1.07 | 4 | 4 | -0.33 | -0.77 |
| *6 (Written 5S implementation plan utilized)* | 3.15 | 1.16 | 3 | 4 | -0.10 | -0.85 |
| *7 (Adequate resources are provided)* | 3.26 | 1.20 | 3 | 4 | -0.18 | -0.97 |
| *8 (Adequate time is provided)* | 3.13 | 1.18 | 3 | 4 | -0.10 | -0.94 |
| *9 (Employees working in teams)* | 3.44 | 1.13 | 4 | 4 | -0.41 | -0.68 |

**Results for Research Question 1**

RQ1: What factors were perceived by the respondents to have influenced the implementation of the lean 5S phases and elements in suppliers of manufactured products to the U.S. automotive industry?

Table 29 shows the Pearson coefficients between each of the nine factors and each of the 5S phases. Each of the nine factors is correlated at the .001 p-value level with each of the 5S phases, *sort, set-in-order, shine, standardize and sustain*. This is an indication that the nine factors are significant to the 5S phases which partially validates the relevance of each factor to the study. Factor 6 has the highest Pearson coefficient of 0.70 to the fifth S, *sustain*. Factor 6 also has the lowest Pearson coefficient of .43 to the second S, *set-in-order*.

Table 29:

Relationships of Factors to the 5S Phases (n=138)

| *Factor* | *1S (sort)* | *2S (set-in-order)* | *3S (shine)* | *4S (standardize)* | *5S (sustain)* |
|---|---|---|---|---|---|
| *1 (Management commitment to 5S success)* | .624 *** | .634 *** | .570 *** | .658 *** | .548 *** |
| *2 (Management training of 5S)* | .522 *** | .472 *** | .507 *** | .450 *** | .589 *** |
| *3 (Non-management training of 5S)* | .509 *** | .506 *** | .562 *** | .515 *** | .651 *** |
| *4 (Communication within the plant)* | .490 *** | .455 *** | .577 *** | .529 *** | .530 *** |
| *5 (Personal responsibility of employees)* | .520 *** | .506 *** | .595 *** | .512 *** | .525 *** |
| *6 (Written 5S implementation plan)* | .468 *** | .426 *** | .505 *** | .511 *** | .697 *** |
| *7 (Adequate resources are provided)* | .472 *** | .458 *** | .474 *** | .450 *** | .649 *** |
| *8 (Adequate time is provided)* | .489 *** | .470 *** | .517 *** | .491 *** | .614 *** |
| *9 (Employees working in teams)* | .502 *** | .438 *** | .475 *** | .449 *** | .513 *** |

*** Significant at the ≤ .001 p-value level

All nine factors were tested for correlations to each other and the results are shown in Table 30. The results show that all factors are correlated to each other at the .001 p-value level. This is an expected result and partially validates that the factors are relevant to the study.

Table 30:

Pearson Correlations of Factors (n=138)

| *Factor* | *1 Mgt. commitment to 5S* | *2 Mgt. training of 5S* | *3 Non-mgt. training of 5S* | *4 Communication within the plant* | *5 Personal responsibility of employees* | *6 Written 5S implementation plan* | *7 Adequate resources are provided* | *8 Adequate time is provided* | *9 Employees working in teams* |
|---|---|---|---|---|---|---|---|---|---|
| *F1* | 1.000 *** | | | | | | | | |
| *F2* | .605 *** | 1.000 *** | | | | | | | |
| *F3* | .601 *** | .842 *** | 1.000 *** | | | | | | |
| *F4* | .568 *** | .529 *** | .616 *** | 1.000 *** | | | | | |
| *F5* | .490 *** | .429 *** | .576 *** | .701 *** | 1.000 *** | | | | |
| *F6* | .533 *** | .607 *** | .633 *** | .567 *** | .549 *** | 1.000 *** | | | |
| *F7* | .608 *** | .721 *** | .726 *** | .519 *** | .510 *** | .708 *** | 1.000 *** | | |
| *F8* | .570 *** | .687 *** | .749 *** | .574 *** | .566 *** | .657 *** | .846 *** | 1.000 *** | |
| *F9* | .560 *** | .521 *** | .575 *** | .610 *** | .598 *** | .485 *** | .498 *** | .608 *** | 1.000 *** |

*** Significant at the ≤ .001 p-value level

Table 31 shows the results of comparing all of the phases of the lean 5S tool to each other. All five phases are correlated to each other at the .001 p-value level. This is an expected result and partially validates that the phases are relevant to the study.

Table 31:

Pearson Correlation of the Phases (n=138)

| *Phase* | *1S (sort)* | *2S (set-in-order)* | *3S (shine)* | *4S (standardize)* | *5S (sustain)* |
|---|---|---|---|---|---|
| *1S (sort)* | 1.000 *** | | | | |
| *2S (set-in-order)* | .706 *** | 1.000 *** | | | |
| *3S (shine)* | .714 *** | .718 *** | 1.000 *** | | |
| *4S (standardize)* | .663 *** | .675 *** | .721 *** | 1.000 *** | |
| *5S (sustain)* | .530 *** | .530 *** | .598 *** | .660 *** | 1.000 *** |

*** Significant at the ≤ .001 p-value level

Each element of the lean 5S phases were tested for correlations and the results are shown in Table 32. All fifteen elements are correlated to each other at the .001 p-value level. This is an expected result and partially validates the relevance of the elements to the study.

Table 32:

Pearson Correlations of the Elements (n=138)

| Element | E1 | E2 | E3 | E4 | E5 | E6 | E7 | E8 | E9 | E10 | E11 | E12 | E13 | E14 | E15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *1 Obsolete and excess items removed* | 1.00 *** | | | | | | | | | | | | | | |
| *2 Empty containers/racks stored* | .724 *** | 1.00 *** | | | | | | | | | | | | | |
| *3 Floors and Aisles cleared and clean* | .597 *** | .505 *** | 1.00 *** | | | | | | | | | | | | |
| *4 Necessary items properly stored* | .510 *** | .450 *** | .566 *** | 1.00 *** | | | | | | | | | | | |
| *5 Items placed in designated areas* | .513 *** | .569 *** | .462 *** | .583 *** | 1.00 *** | | | | | | | | | | |
| *6 Inventory organized / identified* | .558 *** | .456 *** | .500 *** | .543 *** | .529 *** | 1.00 *** | | | | | | | | | |
| *7 Floors and aisles properly marked* | .372 *** | .373 *** | .463 *** | .412 *** | .415 *** | .384 *** | 1.00 *** | | | | | | | | |
| *8 Clean equipment and tools* | .543 *** | .482 *** | .610 *** | .575 *** | .502 *** | .489 *** | .624 *** | 1.00 *** | | | | | | | |
| *9 Workstations neat and organized* | .576 *** | .540 *** | .674 *** | .646 *** | .542 *** | .543 *** | .690 *** | .733 *** | 1.00 *** | | | | | | |
| *10 Visual aids in place and unobstructed* | .522 *** | .489 *** | .595 *** | .538 *** | .462 *** | .421 *** | .566 *** | .615 *** | .709 *** | 1.00 *** | | | | | |
| *11 Instruction and procedures utilized* | .493 *** | .523 *** | .432 *** | .622 *** | .500 *** | .493 *** | .643 *** | .519 *** | .548 *** | .613 *** | 1.00 *** | | | | |
| *12 Communication boards utilized* | .429 *** | .443 *** | .413 *** | .504 *** | .395 *** | .344 *** | .495 *** | .438 *** | .484 *** | .579 *** | .518 *** | 1.00 *** | | | |
| *13 5S audit forms / schedules with actions* | .398 *** | .405 *** | .342 *** | .464 *** | .367 *** | .338 *** | .466 *** | .418 *** | .482 *** | .579 *** | .492 *** | .492 *** | 1.00 *** | | |
| *14 Trained employees to conduct 5S audits* | .417 *** | .397 *** | .283 *** | .348 *** | .343 *** | .448 *** | .454 *** | .398 *** | .398 *** | .499 *** | .336 *** | .383 *** | .717 *** | 1.00 *** | |
| *15 Evidence effectiveness/improvements* | .515 *** | .492 *** | .414 *** | .513 *** | .493 *** | .490 *** | .596 *** | .495 *** | .553 *** | .606 *** | .569 *** | .473 *** | .681 *** | .590 *** | 1.00 *** |

*** Significant at the ≤ .001 p-value level
E = Element

Respondents from suppliers that provide manufactured products to the U.S. automotive industry perceived that the nine factors in the study have a significant impact on the successful implementation of the lean 5S phases and elements. This is an important resultant of the study and provides a response to the research question 1.

## Results for Research Question 2

RQ2: What is the relationship of the selected demographic variables on the perceived factors and the lean 5S phases in suppliers of manufactured products to the U.S. automotive industry?

Table 33 shows the statistics for ten demographic variables compared to each of the nine factors. The first five variables are based upon nominal data and therefore were not used for any correlation testing and analysis. Analyses of means with t-tests were used to determine relationships between the variables to the factors, elements and phases. The remaining five variables were also tested and analyzed using t-tests along with correlation studies. There are several correlations identified within the table. The level of significance is identified with asterisks and shown below the table. The researcher did not stratify any of the data due to the participant selection process and non-equal sample sizes within segmented groups.

The demographic variable, *management training hours* is significantly correlated to four of the factors. The demographic variables, *time spent working with teams* and *non-management training hours* are significantly correlated to three of the factors. The demographic variables identified as the *number of employees* and *numbers of months using lean* are not significantly correlated to any of the nine factors.

The factors *communications within the plant and management commitment to 5S success are* significantly correlated to the demographic variable, *management training hours*. The factor *personal responsibility of employees* is significantly correlated to the demographic variable *non-management training hours*. The factor *adequate resources provided* is significantly correlated to the demographic variables of *percent time working with teams* and *management training hours*. The factor *adequate time provided* is significantly correlated to the demographic variable of percent time working with teams. The factor *management training of 5S* is significantly correlated to the demographic variables of *management training hours* and *non-management training hours*. The factor *employees working in teams* is significantly correlated to the demographic variables of *percent time working in teams* and *non-management training hours*. The factors *non-management training of 5S* and *written 5S implementation plan* are not significantly correlated to any of the demographic variables based upon correlation tests.

Table 33:

Correlations of Demographic Variables to the Nine Factors (n=138)

| | 1 *Mgt. commitment to 5S success* | 2 *Mgt. training of 5S* | 3 *Non-mgt. training of 5S* | 4 *Communication within the plant* | 5 *Personal responsibility of employees* | 6 *Written 5S implementation plan* | 7 *Adequate resources are provided* | 8 *Adequate time is provided* | 9 *Employees working in teams* |
|---|---|---|---|---|---|---|---|---|---|
| *Location by State* | Nom | Nom | Nom | Nom | Nom | Nom | Nom | Nom | Nom |
| *Organization Function* | Nom | Nom | Nom | Nom | Nom | Nom | Nom | Nom | Nom |
| *Management Level* | Nom | Nom | Nom | Nom | Nom | Nom | Nom | Nom | Nom |
| *Union / Non Union* | Nom | Nom | Nom | Nom | Nom | Nom | Nom | Nom | Nom |
| *Tier Level I, II, III* | Nom | Nom | Nom | Nom | Nom | Nom | Nom | Nom | Nom |
| *Number of Employees* | .119 | .124 | .103 | -.089 | -.035 | -.018 | .163 | .142 | .053 |
| *Time Working with Teams* | .034 | .158 | .100 | .007 | .051 | .136 | .193 * | .194 * | .244 ** |
| *Months Using Lean* | .053 | .099 | .004 | -.026 | -.044 | .022 | .010 | -.019 | .057 |
| *Management Training Hours* | .178 * | .286 *** | .123 | .177 * | .157 | .154 | .174 * | .028 | .096 |
| *Non MGT. Training Hours* | .140 | .203 * | .112 | .137 | .192 * | .046 | .099 | .069 | .170 * |

*** Significant at the ≤ .001 p-value level
** Significant at the ≤ .01 p-value level
* Significant at the ≤ .05 p-value level

Table 34 shows the statistics of the demographic variables compared to each of the lean 5S phases. The first five variables are based upon nominal data and therefore were not used for any correlation testing and analysis. Analyses of means with t-tests were used to determine relationships between the variables to the factors, elements and phases. The remaining five variables were also tested and analyzed using t-tests along with correlation studies. There are several correlations identified within the table. The level of significance is identified with asterisks and shown below the table.

The demographic variable, *time spent working with teams* is correlated at the .05 p-value to the *5S sustain.* The demographic variables of *number of employees*, *number of months using lean, management training hours,* and *non-management training hours* are not significantly correlated to any of the 5S phases at a p-value level of .05 or less. However, the management training hour's variable is correlated to the *1S sort* at a p-value of .055.

Table 34:

Correlations of the Demographic Variables to the Five Phases (n=138)

| | *1S (sort)* | *2S (set-in-order)* | *3S (shine)* | *4S (standardize)* | *5S (sustain)* |
|---|---|---|---|---|---|
| *Location by State* | Nom | Nom | Nom | Nom | Nom |
| *Organizational Function* | Nom | Nom | Nom | Nom | Nom |
| *Management Level* | Nom | Nom | Nom | Nom | Nom |
| *Union / Non Union* | Nom | Nom | Nom | Nom | Nom |
| *Tier Level I, II, III* | Nom | Nom | Nom | Nom | Nom |
| *Number of Employees* | -.023 | .069 | .044 | .028 | .084 |
| *Time Working with Teams* | .060 | .040 | .018 | .039 | .221* |
| *Months Using Lean* | .058 | .156 | .002 | .048 | .129 |
| *Management Training Hours* | .164 | .110 | .054 | .060 | .153 |
| *Non MGT. Training Hours* | .086 | .105 | .003 | .015 | .071 |

*** Significant at the ≤ .001 p-value level
** Significant at the ≤ .01 p-value level
* Significant at the ≤ .05 p-value level

Table 35 shows the comparison of the means of responses between the four states of Michigan (62 respondents), Ohio (34 respondents), Indiana (23 respondents) and Kentucky

(19 respondents) to the nine factors. All of the distributions are normal as exhibited by skewness and kurtosis values. T-tests of the means between the states of Michigan and Kentucky show statistically significant differences in the means within four of the nine factors. Factor 7 *written 5S plan in place* and factor 7 *adequate resources provided* are significant at the .01 p-value level. Factor 8 *adequate time provided* and factor 1 *management commitment* are significant at the .05 p-value level. A statistically significant difference in means is also shown between the state of Michigan and Indiana for factor 7 *adequate resources provided*. The U.S. Bureau of Labor Statistics (2008) wrote that the state of Michigan, which is the root of automotive manufacturing, has several automotive assembly plants and localized supplier organizations. These businesses have been involved in the automotive industry for decades and have deeply rooted cultures. This is in contrast to the state of Kentucky, being relatively new to the automotive industry and with its association with the Toyota Motor Manufacturing company since 1988. The relationship with Toyota which invented lean production that includes the lean 5S tool, provides lean methodologies as normal business practices rather than a process to replace existing conditions (Liker, 2004).

The factors of having a strong *management commitment to 5S* along with providing *adequate resources provided* and *adequate time provided* with a *written 5S implementation plan* are perceived as key factors toward 5S implementation success. Factor 9, *employees working in teams* is showing as statistically significant at a .05 p-value level between the states of Ohio and Kentucky. The development of teams may be more feasible in a state like Kentucky versus an automotive industry established state such as Ohio. Liker (2004) wrote that teams are the focal point for problem solving in the Toyota Production System.

The interesting question that is raised with this factor pertains to the state of Michigan and why a similar significance was not detected. Team formation was one of the first strategies attempted by well-established organizations in their pursuit to become more like Japanese companies (Manos and Vincent, 2012). This explains why Michigan is not showing as significantly different to Kentucky in the *employees working in teams* factor.

Table 35:

Comparison of State Location Means and T-Tests Results to the Nine Factors

| | *Michigan n=62* | *Ohio n=34* | *Indiana n=23* | *Kentucky n=19* | *Michigan Ohio n=96* | *Michigan Indiana n=85* | *Michigan Kentucky n=81* | *Ohio Indiana n=57* | *Ohio Kentucky n=53* | *Indiana Kentucky n=42* |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Factors*** | *Means* | *Mean* | *Mean* | *Mean* | *t-test p-value* | *t-test p-value* | *t-test p-value* | *t-test p-value* | *t-test p-value* | *t-test p-value* |
| *1 Mgt. commitment to 5S success* | 3.387 | 3.588 | 3.826 | 4.000 | -.870 .386 | -1.65 .107 | -2.03 .050* | -.830. 411 | -1.29 .207 | -.500 .619 |
| *2 Mgt. training of 5S* | 3.097 | 2.971 | 3.435 | 3.579 | .510 .615 | -1.07 .292 | -1.50 .145 | -1.39 .171 | -1.80 .081 | -.370 .714 |
| *3 Non-mgt. training of 5S* | 2.984 | 2.765 | 3.348 | 3.368 | .910 .365 | -1.09 .282 | -1.11 .277 | -1.70 .097 | -1.69 .101 | -.370 .714 |
| *4 Communication within the plant* | 2.871 | 3.118 | 3.391 | 3.368 | -1.13 .261 | -1.78 .084 | -1.84 .075 | -.890 .378 | -.880 .387 | .070 .948 |
| *5 Personal responsibility of employees* | 3.177 | 3.206 | 3.522 | 3.684 | -.130 .899 | -1.29 .204 | -1.95 .059 | -1.11 .272 | -1.72 .093 | -.520 .607 |
| *6 Written 5S implementation plan* | 2.871 | 3.206 | 3.478 | 3.579 | -1.42 .159 | -1.95 .059 | -2.78 .008** | -.830 .412 | -1.35 .184 | -.290 .770 |
| *7 Adequate resources are provided* | 2.935 | 3.353 | 3.609 | 3.737 | -1.65 .103 | -2.34 .024* | -3.01 .005** | -.820 .416 | -1.32 .194 | -.400 .693 |
| *8 Adequate time is provided* | 2.887 | 3.265 | 3.217 | 3.579 | -1.52 .133 | -1.10 .280 | -2.57 .014* | .150 .885 | -1.07 .292 | -1.06 .294 |
| *9 Employees working in teams* | 3.484 | 3.235 | 3.261 | 3.895 | 1.06 .294 | .770 .445 | -1.42 .165 | -.080 .936 | -2.09 .043* | -1.77 .084 |

** Significant at the ≤ .01 p-value level
* Significant at the ≤ .05 p-value level

Table 36 shows the comparison of means and T-test results between the four states and the 5S phases. All four groups have normal distributions as exhibited by the skewness and kurtosis values. There is a statistically significant difference in means between the state of Michigan and Kentucky in four of the five phases. There is a statistically significant difference at the .01 p-value level for the 4S *standardize*. There is also a statistically significant difference in means between the state of Michigan and Kentucky at the 0.05 p-value level for the *1S sort, 3S shine* and the *5S sustain*. This indicates that respondents from the state of Michigan perceive that their organizations as unable to get the initial start of the 5S implementation started and therefore are also unable to standardize and sustain the process. This may also be due to having system already embedded in the cultures of organizations from the state of Michigan with a long history of association in the automotive industry.

The state of Kentucky, being relatively new to the automotive industry can adopt the lean methods and specifically the 5S phases and include the process within their organizational foundation. Another statistically significant difference in means at the .01 p-value occurs between the states of Ohio and Kentucky for the 4S *standardize.* Additionally, there is a difference in the *1S sort* between these two states as well. This shows that although strongly correlated differences to Michigan are present, the differences show up in Ohio as well. This shows that the difference is related to conditions for implementation that a state like Kentucky enjoys over other states that were unable to begin with a clean slate and avoid legacy barriers while maintaining normal production requirements.

Table 36:

Comparison of State Means and T-Test to the Five Phases

| | *Michigan n=62* | *Ohio n=34* | *Indiana n=23* | *Kentucky n=19* | *Michigan Ohio n=96* | *Michigan Indiana n=85* | *Michigan Kentucky n=81* | *Ohio Indiana n=57* | *Ohio Kentucky n=53* | *Indiana Kentucky n=42* |
|---|---|---|---|---|---|---|---|---|---|---|
| *Phase* | *Mean* | *Mean* | *Mean* | *Mean* | *t-test p-value* | *t-test p-value* | *t-test p-value* | *t-test p-value* | *t-test p-value* | *t-test p-value* |
| *1S (sort)* | 3.656 | 3.725 | 4.000 | 4.263 | -.340<br>.738 | -1.45<br>.154 | -2.65<br>.012* | -1.06<br>.297 | -2.13<br>.040* | -.950<br>.349 |
| *2S (set-in-order)* | 3.704 | 3.745 | 3.957 | 4.088 | -.240<br>.813 | -1.14<br>.262 | -1.55<br>.132 | -.910<br>.367 | -1.33<br>.192 | -.450<br>.656 |
| *3S (shine)* | 3.500 | 3.647 | 3.928 | 4.000 | -.730<br>.471 | -1.96<br>.057 | -2.07<br>.048* | -1.13<br>.262 | -1.31<br>.197 | -.260<br>.798 |
| *4S (standardize)* | 3.575 | 3.598 | 3.812 | 4.263 | -.130<br>.898 | -.940<br>.356 | -3.23<br>.003** | -.820<br>.417 | -2.99<br>.005** | -1.58<br>.122 |
| *5S (sustain)* | 3.091 | 3.176 | 3.507 | 3.737 | -.400<br>.691 | -1.61<br>.116 | -2.15<br>.040* | -1.20<br>.237 | -1.78<br>.085 | -.660<br>.513 |

** Significant at the ≤ .01 p-value level
* Significant at the ≤ .05 p-value level

Table 37 shows the means and T-Test results in comparing the three organizational functions to the nine factors. There is a statistical significance in the difference of means at the .05 p-value between the quality function and the manufacturing and operations functions for the factor *management commitment to 5S success*. There is a very strong significant difference between the quality function and the operations function at the .001 p-value level for the factor *communication within the plant*. As in the 5S phases identified in Table 35, the quality function appears to be more critical in their perception. It is clear that based upon organizational functions, the factors of *management commitment* and *communication within the plant* are critical for a successful implementation of the 5S phases.

The researcher decided to analyze the demographic variable of *location of state* with a One Factor ANOVA. An ANOVA is more flexible in that it can compare two or more sample means at the same time. The ANOVA verified the results of the t-tests on the factors and phases. Additionally, a Tukey test was conducted and verified that a significant difference in means existed in responses between the state of Kentucky and the state of Michigan.

Table 37:

Comparison of the Three Organization Functions to the Nine Factors

| | *Quality n=71* | *Manufacturing n=35* | *Operations n=32* | *Quality to Manuf. n=106* | *Quality to Operations n=103* | *Manuf. to Operations n=67* |
|---|---|---|---|---|---|---|
| ***Factors*** | *Mean* | *Mean* | *Mean* | *t-test p-value* | *t-test p-value* | *t-test p-value* |
| *1 Mgt. commitment to 5S success* | 3.320 | 3.890 | 3.875 | -2.50 .015* | -2.50 .015* | .040 .966 |
| *2 Mgt. training of 5S* | 2.990 | 3.460 | 3.340 | -1.79 .078 | -1.40 .167 | .370 .714 |
| *3 Non-mgt. training of 5S* | 2.900 | 3.140 | 3.250 | -.850 .398 | -1.40 .167 | -.330 .740 |
| *4 Communication within the plant* | 2.820 | 3.140 | 3.625 | -1.38 .173 | -4.009 .000*** | -1.900 .062 |
| *5 Personal responsibility of employees* | 3.170 | 3.460 | 3.469 | -1.260 .212 | -1.390 .170 | -.050 .964 |
| *6 Written 5S implementation plan* | 2.970 | 3.310 | 3.380 | -1.360 .178 | -1.740 .087 | -.210 .832 |
| *7 Adequate resources are provided* | 3.100 | 3.430 | 3.44 | -1.260 .211 | -1.390 .169 | -.030 .976 |
| *8 Adequate time is provided* | 3.040 | 3.110 | 3.340 | -.270 .788 | -1.260 .212 | -.750 .454 |
| *9 Employees workin g in teams* | 3.240 | 3.660 | 3.660 | -1.790 .077 | -1.850 .068 | .000 .997 |

*** Significant at the ≤ .001 p-value level
** Significant at the ≤ .01 p-value level
* Significant at the ≤ .05 p-value level

Table 38 shows the means and T-test results in comparing the organizational functions to each other and to the five phases. There are significant differences in three of the five phases between the quality and manufacturing functions. There is a statistical significance in the difference of means between the quality function and the manufacturing function at the .01 p-value level for the *1S sort*. There is also a statistical significance in the difference of means between the quality function and the manufacturing function at the .05 p-value level for the *3S set-in-order* and the *5S sustain*. There is also a statistical difference in the difference of means at the .05 p-value level between the quality and operations functions. There are not any significant differences in means between the manufacturing and operations functions. This indicates that the quality function perceives the implementation of the 5S phases as being less successful than the manufacturing and operations functions. It is interesting that there is a perceived difference depending on which function respondents are associated with.

Table 38:

Comparison of Means and T-Tests between Organizational Functions to the 5S Phases

| | *Quality n=71* | *Manufacturing n=35* | *Operations n=32* | *Quality to Manufacturing n=106* | *Quality to Operations n=103* | *Manufacturing to Operations n=67* |
|---|---|---|---|---|---|---|
| *Phase* | *Mean* | *Mean* | *Mean* | *t-test p-value* | *t-test p-value* | *t-test p-value* |
| *1S (sort)* | 3.620 | 4.162 | 3.875 | -2.92<br>.005** | -1.30<br>.197 | 1.35<br>.183 |
| *2S (set-in-order)* | 3.746 | 3.971 | 3.771 | -1.20<br>.236 | -.130<br>.898 | .880<br>.384 |
| *3S (shine)* | 3.451 | 3.924 | 3.906 | -2.48<br>.015* | -2.48<br>.016* | .080<br>.934 |
| *4S (standardize)* | 3.563 | 3.890 | 3.865 | -1.55<br>.128 | -1.71<br>.092 | .090<br>.927 |
| *5S (sustain)* | 3.090 | 3.580 | 3.320 | -2.12<br>.038* | -1.05<br>.296 | .970<br>.335 |

** Significant at the ≤ .01 p-value level
* Significant at the ≤ .05 p-value level

Table 39 shows the comparison of means and the T-test results between the three management levels and the nine factors. In regards to the factor *management commitment to 5S success*, there are significant differences in means at the .05 p-value level between the upper and lower management levels and between the middle and lower management levels. The lower level management group that is on the ground floor daily has a reduced perception of upper and middle management's commitment to 5S success. Therefore, the upper levels are not conveying the message and not engaging in activities that would show their commitment. Employees may see the 5S implementation program as a "flavor of the month" rather than something identified as critical to the success of the organization. This can also be seen in the factor *communication within the plant* with a significant difference in means at the .05 p-value level between the upper and lower management levels. There is also a significant difference in means at the .05 p-value level for the factor *adequate time is provided* between the middle and lower management levels.

Table 39:

Mean Responses for Levels of Management to the Nine Factors

| | *Upper n=11* | *Middle n=88* | *Lower n=39* | *Upper Middle n=99* | *Upper Lower n=50* | *Middle Lower n=127* |
|---|---|---|---|---|---|---|
| ***Factors*** | *Mean* | *Mean* | *Mean* | *t-test p-value* | *t-test p-value* | *t-test p-value* |
| *1 Mgt. commitment to 5S success* | 3.909 | 3.727 | 3.205 | .660<br>.517 | 2.16<br>.041* | 2.22<br>.030* |
| *2 Mgt. training of 5S* | 3.364 | 3.261 | 2.974 | .250<br>.807 | .890<br>.386 | 1.20<br>.233 |
| *3 Non-mgt. training of 5S* | 3.364 | 3.102 | 2.821 | .640<br>.534 | 1.22<br>.239 | 1.12<br>.268 |
| *4 Communication within the plant* | 3.636 | 3.125 | 2.846 | 1.70<br>.112 | 2.35<br>.029* | 1.27<br>.209 |
| *5 Personal responsibility of employees* | 3.636 | 3.318 | 3.205 | 1.06<br>.309 | 1.29<br>.212 | .520<br>.602 |
| *6 Written 5S implementation plan* | 3.182 | 3.148 | 3.154 | .090<br>.929 | .070<br>.946 | -.030<br>.979 |
| *7 Adequate resources are provided* | 3.273 | 3.386 | 2.974 | -.350<br>.735 | .810<br>.426 | 1.71<br>.092 |
| *8 Adequate time for 5S implementation* | 3.091 | 3.273 | 2.821 | -.540<br>.601 | .730<br>.474 | 1.96<br>.054 |
| *9 Employees working in teams* | 3.545 | 3.489 | 3.308 | .160<br>.877 | .610<br>.547 | .820<br>.413 |

*** Significant at the ≤ .001 p-value level
** Significant at the ≤ .01 p-value level
* Significant at the ≤ .05 p-value level

Although the mean responses for the lower level management were lower for all phases then the middle and upper management, the differences were minimal. Therefore, all levels of management were similar in regards to the 5S phases and no significant differences were detected through T-tests. All three groups have normal distributions as exhibited by the skewness and kurtosis values.

Table 40 shows the statistics of the demographic variable, *union/non-union* compared to the nine factors. Both groups have normal distributions as exhibited by the skewness and kurtosis values. The means for the union group are consistently lower for all but one factor *adequate management training of 5S* when compared to the non-union group. The largest variation in means occurs in factor 4 *communication within the plant* followed by factor 5 *personal responsibility*, factor 3 *adequate non-management training* and factor 8 *adequate time provided*. The researcher decided to compare means and conduct T-test between the dependent variable, union/non-union to the nine factors. The results show a statistically significant difference in means at the .01 p-value for the *communication within the plant* and *personal responsibility* factors between the union and non-union variables. The results also show significance at the .05 p-value for the *non-management training* and *adequate time provided* variables.

Table 40:

Comparison of Union and Non-Union Responses to the Nine Factors

| | *Union n=89* | *Non-Union n=49* | | |
|---|---|---|---|---|
| ***Factors*** | *Mean* | *Mean* | *t-statistic* | *p-value* |
| *1 Mgt. commitment to 5S success* | 3.388 | 3.708 | -1.62 | .109 |
| *2 Mgt. training of 5S* | 3.061 | 3.258 | -.920 | .362 |
| *3 Non-mgt. training of 5S* | 2.755 | 3.202 | -2.03 | .045* |
| *4 Communication within the plant* | 2.673 | 3.315 | -3.22 | .002** |
| *5 Personal responsibility of employees* | 2.980 | 3.494 | -2.61 | .010** |
| *6 Written 5S implementation plan* | 2.918 | 3.281 | -1.69 | .095 |
| *7 Adequate resources are provided* | 3.082 | 3.360 | -1.25 | .213 |
| *8 Adequate time is provided* | 2.857 | 3.281 | -1.98 | .050* |
| *9 Employees working in teams* | 3.245 | 3.551 | -1.53 | .130 |

** Significant at the ≤ .01 p-value level
* Significant at the ≤ .05 p-value level

Table 41 shows the statistics of the demographic variable, *union/non-union* to the five phases. The means for the union group are consistently lower for every phase compared to the non-union group. The largest variation in means occurs in phases *1S sort* and *2S set-in-order*. The lowest variation in means occurs in phase *5S sustain*.

Table 41:

Comparison of Union and Non-Union Responses to the 5 Phases

| | *Union n=89* | *Non-Union n=49* | | |
|---|---|---|---|---|
| *Phase* | *Mean* | *Mean* | *t-statistic* | *p-value* |
| *1S (sort)* | 3.612 | 3.925 | -1.74 | .086 |
| *2S (set-in-order)* | 3.605 | 3.921 | -2.01 | .047* |
| *3S (shine)* | 3.497 | 3.775 | -1.63 | .107 |
| *4S (standardize)* | 3.571 | 3.794 | -1.29 | .202 |
| *5S (sustain)* | 3.136 | 3.345 | -1.07 | .286 |

** Significant at the ≤ .01 p-value level
* Significant at the ≤ .05 p-value level

Table 42 shows the statistics for the demographic variable, *time spent working with teams*. This demographic variable is correlated at the .01 p-value level to the *employee working in teams* factor and at the 05 p-value to the *adequate resources provided* and *adequate time provided* factors. This factor is also close to being correlated at the .05 p-value level to the *management 5S training, .064* factor. The demographic variable, *time working in teams* is of interest due to its significant correlation at the .010 p-value level to factor 9 *employees working in teams*. This is an expected correlation based upon the description of the two items. However, the demographic variable, time spent working in teams is also correlated at the .05 p-value to factor 7 *adequate resources provided* and factor 8 *adequate time provided*. The histogram in Figure 15 shows two distinct modes. The researcher decided to compare the means of team time percent using two groups from the responses. One group includes team time from 0 to 50 percent. The second group includes team time from 51 to

100 percent.  Table 39 shows the descriptive statistics for the two groups. The mean of the first group is 29.81 with a standard deviation of 15.41. The mean of the second group is 76.96 with a standard deviation of 11.52. Both groups are normally distributed as shown by the skewness and kurtosis values.

Table 42:

Descriptive Statistics for Percent Time Working With Teams

| *Percent Time* | *Mean* | *St. Dev.* | *Median* | *Range* | *Skewness* | *Kurtosis* |
|---|---|---|---|---|---|---|
| *0 to 50 (n=90)* | 29.81 | 15.41 | 30 | 50 | -0.04 | -1.24 |
| *51 to 100 (n=48)* | 76.96 | 11.52 | 77.5 | 45 | 0.21 | -0.25 |

Table 43 shows the statistics of the two groups for the *percent time working with teams* compared to the nine factors. The distributions are normal as shown with the skewness and kurtosis values.  The two groups are similar in their means for factors 1 through 7. There is variation in the means for factor 8 *adequate time provided* and factor 9 *employees working in teams*. The 51 to 100 percent team time group is higher in both of those factors compared to the 0 to 50 percent group. The researcher decided to compare means and conduct T-tests on the data. The results show that there is a statistical significance between the means for two of the nine factors. Factor 8 *adequate time provided* is significant at the .01 p-value level. Factor 9 *employees working in teams* is significant at the .001 p-value level. Significance of employees working in teams is expected for this demographic variable comparison. However, the analysis indicates that for those organizations that spend over 50 percent of their time working in teams, adequate time needs to be provided in order to enable success of the 5S implementation process.

Table 43:

Comparison of the Two Groups to Time Working With Teams to the Nine Factors

| | *0 to 50% n=90* | *51 to 100% n=48* | | |
|---|---|---|---|---|
| ***Factors*** | *Mean* | *Mean* | *t-test* | *p-value* |
| *1 Mgt. commitment to 5S success* | 3.570 | 3.650 | -.390 | .696 |
| *2 Mgt. training of 5S* | 3.060 | 3.444 | -1.81 | .073 |
| *3 Non-mgt. training of 5S* | 2.920 | 3.270 | -1.60 | .112 |
| *4 Communication within the plant* | 3.070 | 3.130 | -.280 | .779 |
| *5 Personal responsibility of employees* | 3.240 | 3.440 | -1.00 | .320 |
| *6 Written 5S implementation plan* | 3.070 | 3.500 | -1.18 | .240 |
| *7 Adequate resources are provided* | 3.130 | 3.500 | -1.73 | .087 |
| *8 Adequate time for 5S implementation* | 2.940 | 3.480 | -2.65 | .009** |
| *9 Employees working in teams* | 3.220 | 3.850 | -3.33 | .001*** |

*** Significant at the ≤ .001 p-value level
** Significant at the ≤ .01 p-value level
* Significant at the ≤ .05 p-value level

Table 44 shows the descriptive statistics of the two groups for the *percent time working with teams* compared to the five phases. The distributions are normal as shown with the skewness and kurtosis values. The variation in means is not significant for the first four phases. The variation in means does increase for the *5S sustain* indicating that more time spent working on teams provides a greater degree in success of maintaining a fully implemented 5S program. The researcher decided to compare the means and conduct T-tests to determine if any differences in means were present. The *5S sustain* phase shows statistical significance in the differences between the two groups. This is a very important determination. The final phase of the 5S phases enables organizations to experience success in the implementation. Therefore, over 50% of time spent working with teams drives 5S implementation success.

Table 44:

Descriptive Statistics for Two Groups of Time Working With Teams to the Five Phases

| | *0 to 50% n=90* | *51 to 100% n=48* | | |
|---|---|---|---|---|
| *Phase* | *Mean* | *Mean* | *t-test* | *p-value* |
| *1S (sort)* | 3.796 | 3.850 | -.290 | .774 |
| *2S (set-in-order)* | 3.793 | 3.840 | -.300 | .528 |
| *3S (shine)* | 3.641 | 3.743 | -.630 | .528 |
| *4S (standardize)* | 3.644 | 3.847 | -1.30 | .197 |
| *5S (sustain)* | 3.110 | 3.570 | -2.41 | .018* |

*** Significant at the ≤ .001 p-value level
** Significant at the ≤ .01 p-value level
* Significant at the ≤ .05 p-value level

The demographic variable, *management training hours* is of interest due to its significant correlation at a p-value of .001 to the factor 2 *management training of 5S*. This correlation was expected to be significant and is validated by the data. This demographic variable also has significant correlations at the .05 p-value level to three other factors *management commitment*, *communication and adequate resources*.

The researcher decided to compare the means and T-test to the nine factors of two groups. Table 45 shows the results. One group included respondents that indicated training hours of zero to five hours. Five hours was used as the break point for the first group due to that being the median point of the data. The second group included respondents that indicated training hours over five hours. However, four data points were identified as outliers beyond the standard deviation from the mean and removed from the group. Both groups were normally distributed as represented by skewness and kurtosis values. The results indicate that an increased amount of management drives an increase in on the floor actions with such factors as *non-management training, personal responsibility of employees* and *employees working in teams.* Therefore, management training in the 5S tool is important in order to promote and obtain involvement at the floor level.

Table 45:

Comparison of means and T-tests to the Nine Factors for Management Training

| | *0 to 5 hours n=74* | *Over 5 hours n=64* | | |
|---|---|---|---|---|
| ***Factors*** | *Mean* | *Mean* | *t-test* | *p-value* |
| *1 Mgt. commitment to 5S success* | 3.420 | 3.783 | -1.92 | .057 |
| *2 Mgt. training of 5S* | 2.850 | 3.500 | -3.21 | .002** |
| *3 Non-mgt. training of 5S* | 2.820 | 3.280 | -2.15 | .034* |
| *4 Communication within the plant* | 2.930 | 3.233 | -1.62 | .108 |
| *5 Personal responsibility of employees* | 3.140 | 3.500 | -2.01 | .046* |
| *6 Written 5S implementation plan* | 3.000 | 3.300 | -1.55 | .124 |
| *7 Adequate resources are provided* | 3.080 | 3.430 | -1.73 | .086 |
| *8 Adequate time for 5S implementation* | 3.080 | 3.200 | -.590 | .555 |
| *9 Employees working in teams* | 3.240 | 3.667 | -2.29 | .023* |

*** Significant at the ≤ .001 p-value level
** Significant at the ≤ .01 p-value level
* Significant at the ≤ .05 p-value level

The researcher decided to conduct T-tests on the demographic variable, *management training hours* to the 5S phases. The same two groups used in comparing the demographic variable, management training hours to the nine factors were utilized. The results were that no significant differences in the means existed between the groups in regards to the impact on the 5S phases.

The demographic variable, *non-management training hours* is of interest due to its correlation to three of the factors at the .05 p-value *management training of 5S*, *personal responsibility of employees* and *employees working in teams*.

The researcher decided to conduct the same analysis of the non-management training variable by comparing means and T-tests to the nine factors. Table 46 shows the results. The data were separated into two groups. One group included respondents that identified training hours between zero and four hours. The second group included respondents that identified training hours as being greater than four hours. Four hours was selected because it is the mean of all respondents. Additionally, two fliers were eliminated from the data due to being beyond three standard deviations from the mean. Both groups were normally distributed as shown by skewness and kurtosis values. The results show statistically significant differences in the means for eight of the nine factors. Non-management training in the 5S tool is perceived as a critical demographic variable and effects the factors that influence successful implementation of the process. It is interesting that unlike the significant correlation between the demographic variable, management training hours and the factor *adequate management training of 5S*, there is not a significant correlation between the demographic variable, non-management training hours and the factor *adequate non-management training of 5S*.

Table 46:

Comparison of means and T-tests to the Nine Factors for Non- Management Training

| | *0 to 4 hours n=80* | *Over 4 hours n=56* | | |
|---|---|---|---|---|
| ***Factors*** | *Mean* | *Mean* | *t-statistic* | *p-value* |
| *1 Mgt. commitment to 5S success* | 3.360 | 3.893 | -2.97 | .004** |
| *2 Mgt. training of 5S* | 2.880 | 3.590 | -3.53 | .001*** |
| *3 Non-mgt. training of 5S* | 2.740 | 3.460 | -3.43 | .001*** |
| *4 Communication within the plant* | 2.830 | 3.446 | -3.53 | .001*** |
| *5 Personal responsibility of employees* | 3.050 | 3.643 | -3.40 | .001*** |
| *6 Written 5S implementation plan* | 2.950 | 3.446 | -2.62 | .010** |
| *7 Adequate resources are provided* | 3.010 | 3.610 | -2.98 | .003** |
| *8 Adequate time for 5S implementation* | 2.980 | 3.320 | -1.74 | .084 |
| *9 Employees working in teams* | 3.260 | 3.660 | -2.07 | .041* |

*** Significant at the ≤ .001 p-value level
** Significant at the ≤ .01 p-value level
* Significant at the ≤ .05 p-value level

Table 47 shows the statistics for the demographic variable, *non-management training hours* compared to the 5 phases. The same two groups were used as described in the comparison between the demographic variable, *non-management training* to the nine factors. The results show that there are statistical differences in the means between the two groups. The *1S sort* is significant at the .001 p-value level. The *2S set-in-order*, *4S standardize*, and *5S sustain* are significant at the .01 p-value level. This data indicates that non-management training in the 5S tools are perceived as being critical for a successful implementation of the phases. This result did not show as being significant for the management training variable, although the management training demographic variable was significant in directing training to the non-management personnel.

Table 47:

Comparison of means and T-tests to the 5S Phases for Non- Management Training

| | *0 to 4 hours n=80* | *Over 4 hours n=56* | | |
|---|---|---|---|---|
| *Phase* | *Mean* | *Mean* | *t-test* | *p-value* |
| *1S (sort)* | 3.580 | 4.143 | -3.61 | .000*** |
| *2S (set-in-order)* | 3.621 | 4.060 | -3.06 | .003** |
| *3S (shine)* | 3.558 | 3.845 | -1.76 | .081 |
| *4S (standardize)* | 3.542 | 3.964 | -2.75 | .007** |
| *5S (sustain)* | 3.050 | 3.571 | -2.89 | .005** |

*** Significant at the ≤ .001 p-value level
** Significant at the ≤ .01 p-value level
* Significant at the ≤ .05 p-value level

The demographic variables, *tier level*, *number of months using lean*, and *number of employees* do not have any significant differences in means or correlations on the factors, fifteen elements or 5S phases. An isolation of Tier I and Tier II separately does reveal some correlations of demographic variables to factors and phases. The correlations are present more with the Tier I suppliers than the Tier II suppliers. This may indicate a higher level of 5S knowledge due to their direct association to the OEM's. This also may indicate that with that knowledge a more accurate perception of their implementation process is developed. Although the differences in means are higher for the Tier II suppliers, there is not any level of significance in the differences.

There are statistically significant correlations and differences in the means of certain selected demographic variables to the perceived factors and lean 5S phases in suppliers to the U.S. automotive industry. Seven of the ten demographic variables have significant relationships to the factors and 5S phases. The demographic variables*, tier level, number of months using lean*, and *number of employees* do not impact any of the factors of phases. The demographic variables*, location by state, organizational function, management level, union/non- union, time spent working with teams, management training,* and *non-management training* have significant relationships to the factors and phases.

Some of the factors and phases are more significant than others. The *communication within the plant* factor is perceived as critical followed by a *management commitment*. Factors such as *personal responsibility of employees, adequate time provided, adequate resources provided, and time spent working with teams* are important. *Non-management training* is identified more than *management training* but to a lesser degree than the other factors to the demographic variables. The factor *written 5S implementation plan* is perceived as having a lesser degree of importance. In regards to the 5S phases, the demographic variables have significant relationships to *1S sort* and *5S sustain* followed by *2S set-in-order* and *4S standardize*. The *5S shine* has the least relationship to any of the demographic variables.

Table 48 shows the statistics for each of the continuous demographic variables compared to the fifteen elements of the 5S phases. The demographic variables of *number of employees, months working with teams,* and *non-management training hours* are not significantly correlated to any of the fifteen elements. The demographic variable of *time working with teams* is significantly correlated to elements 14 and 15 which pertain to the 5S (sustain). The demographic variable of *management training hours* is significantly correlated to element 15 which pertains to the 5S (sustain).

Table 48:

Pearson Correlations of Continuous Demographic Variables to the Fifteen Elements (n=138)

| *Factor* | *Location of State* | *Org. Function* | *Mgt. Level* | *Union/ Non Union* | *Tier Level* | *No. of Employees* | *Time Working with Teams* | *Months Working with Teams* | *Mgt. Training hours* | *Non Mgt. Training hours* |
|---|---|---|---|---|---|---|---|---|---|---|
| E1 | Nom | Nom | Nom | Nom | Nom | .068 | .114 | .086 | .161 | .140 |
| E2 | Nom | Nom | Nom | Nom | Nom | -.100 | .070 | .070 | .128 | -.004 |
| E3 | Nom | Nom | Nom | Nom | Nom | -.028 | -.040 | -.013 | .134 | .087 |
| E4 | Nom | Nom | Nom | Nom | Nom | .087 | .079 | .121 | .110 | .116 |
| E5 | Nom | Nom | Nom | Nom | Nom | -.031 | .024 | .127 | .038 | -.020 |
| E6 | Nom | Nom | Nom | Nom | Nom | .117 | -.003 | .144 | .129 | .166 |
| E7 | Nom | Nom | Nom | Nom | Nom | .009 | .148 | .026 | -.032 | -.070 |
| E8 | Nom | Nom | Nom | Nom | Nom | .056 | -.021 | -.011 | .041 | .006 |
| E9 | Nom | Nom | Nom | Nom | Nom | .041 | -.067 | -.007 | .122 | .065 |
| E10 | Nom | Nom | Nom | Nom | Nom | -.010 | .014 | -.053 | .048 | .011 |
| E11 | Nom | Nom | Nom | Nom | Nom | .026 | .020 | .098 | .131 | .111 |
| E12 | Nom | Nom | Nom | Nom | Nom | .056 | .065 | .075 | -.032 | -.091 |
| E13 | Nom | Nom | Nom | Nom | Nom | .074 | .107 | .111 | .101 | .016 |
| E14 | Nom | Nom | Nom | Nom | Nom | .152 | .254** | .122 | .140 | .096 |
| E15 | Nom | Nom | Nom | Nom | Nom | -.007 | .228** | .108 | .167* | .077 |

*** Significant at the ≤ .001 p-value level
** Significant at the ≤ .01 p-value level
* Significant at the ≤ .05 p-value level

**Summary**

This chapter introduced the characteristics of the instrument. An analysis of the data provided descriptive statistics of demographics, descriptive statistics for each 5S phase, descriptive statistics for the nine factors, results for research question 1, results for research question 2 and additional analysis of demographic variables to the phases and factors.

The results for research question 1 were that all factors were correlated with each other and to the 5S phases and elements. All 5S phases were correlated to each other and to the factors and elements. All elements were correlated to each other and to the factors and 5S phases.

The results for research question 2 were that relationships with statistical significance existed with demographic variables on the factors and 5S phases.

The demographic variable, *location by state* revealed statistically differences in means between states on the factors *communication within the plant, management commitment, adequate resources provided, adequate time provided, personal responsibility of employees and written 5S implementation plan.* This variable also revealed statistically differences in means between states on the phases *sort, shine, standardize, and sustain.*

The demographic variable, *organizational function* revealed statistically differences in means between functions on the factors *communication within the plant, management commitment, and employees working in teams*. This variable also revealed statistically differences in means between functions on the phases *sort, set-in-order, and sustain*.

The demographic variable, *management level* revealed statistically differences in means between management levels on the factors *communication within the plant and* *management commitment*. This variable did not reveal any statistically differences in means between management levels on the phases.

The demographic variable, *union/non-union* revealed statistically differences in means on the factors *communication within the plant, personal responsibility of employees, adequate time provided, and non-management training*. This variable did not reveal any statistically differences in means on the phases.

The demographic variable, *time spent working with teams* is correlated to factors *employees working in teams, adequate time provided, and adequate resources provided*. This variable is also correlated to the phase *5S sustain.* The demographic variable, time spent working with teams revealed statistically differences in means between the amounts of time on the factors *employees working in teams, adequate time provided, and adequate resources provided*. This variable did not reveal any statistically differences in means between the amounts of time on the phase *5S sustain.*

The demographic variable, *management training hours* is correlated to factors *communication within the plant, management commitment, adequate resources provided, and non-management training*. This variable is not correlated to any of the phases.

The demographic variable, *management training hours* revealed statistically differences in means between training hours on the factors *communication within the plant, management commitment, adequate resources provided, and non-management training*. This variable did not reveal any statistically differences in means between training hours on any of the phases.

The demographic variable, *non-management training hours* is correlated to factors *management training hours, personal responsibility of employees, and employees working in teams*. This variable is also correlated to phases *sort, set-in-order, standardize, and sustain*.

The demographic variable, *non-management training hours* revealed statistically differences in means between training hours on the factors *management training hours, personal responsibility of employees, and employees working in teams*. This variable also revealed statistically differences in means between training hours on the phases *sort, set-in-order, standardize, and sustain*.

The demographic variables, *tier level, months using lean tools,* and *number of employees* did not revealed any statistically differences in means between tier levels, number of months, or number of employees on any of the factors or phases. An isolation of Tier I and Tier II separately does reveal some correlations of demographic variables to factors and phases. The correlations are present more with the Tier I suppliers than the Tier II suppliers. This may indicate a higher level of 5S knowledge due to their direct association to the OEM's. This also may indicate that with that knowledge comes a more accurate perception of their implementation process. Although the differences in means are higher for the Tier II suppliers, there is not any level of significance in the differences.

There are certain demographic variables and factors that have an impact on the implementation of the lean 5S tool in U.S organizations that provide a manufactured product to the U.S. automotive industry. There are also others that have no impact at all. Understanding these characteristics can provide a roadmap for organizations interested in implementing the lean 5S tool successfully.

# Chapter 5: Summary, Conclusions, Implications and Recommendations

The purpose of this chapter is to provide a summary of the findings, conclusions based on these findings, implications for automotive suppliers and recommendations for future research.

## Summary of Findings

Manufacturing leaders employed by suppliers that provide manufactured products to the U.S. automotive industry were asked to provide responses to a series of questions within a survey format that included ten demographic variables, nine factors and fifteen elements of the lean 5S phases. Usable responses were received from these respondents representing three tiers or levels of suppliers from four states.

Research question 1 asked what factors were perceived by the respondents to have influenced the implementation of the lean 5S phases and elements in suppliers of manufactured products to the U.S. automotive industry.

An analysis of the responses revealed that each of the nine factors in the study has a statistically significant relationship at a .001 level with each of the other factors and with each of the fifteen 5S elements. As one would expect, the nine factors have statistically significant relationships to each of the element groupings that represent each of the 5S phases at a .001 level as well. An analysis of the responses also revealed that each of the fifteen elements has a statistically significant relationship at a .001 level to each other. Another result of the study revealed that each of the 5S phases have a statistically significant relationship at a .001 level to each other.

In summary regarding research question 1, there is a strong relationship between all factors, elements and phases and therefore all nine factors were perceived by the respondents to have an influence on the implementation of the lean 5S phases.

Research question 2 asked what relationship if any, exists between the selected demographic variables and the perceived factors as well as the selected demographic variables and the lean 5S phases in suppliers of manufactured products to the U.S. automotive industry.

An analysis of the data provided by the respondents revealed that there were statistical significant relationships between some of the selected demographic variables with both the factors and 5S phases. Those demographic variables used for the purposes of this study were:

Location by state (Michigan, Ohio, Indiana, or Kentucky)

Organizational functions (Quality, Manufacturing, or Operations)

Management levels (Upper, Middle, or Lower)

Union or Non-union

The time spent working with teams (0 to 50 percent or 51 to 100 percent)

Management training of 5S in hours (0 to 5 hours or over 5 hours)

Non-management training of 5S in hours (0 to 4 hours or over 4 hours)

Comparisons of means from respondent ratings from the state of Kentucky were higher for all nine factors when compared to the states of Michigan, Ohio and Indiana. T-tests revealed that statistically significant differences existed between respondents from the state of Kentucky to respondents from the state of Michigan at the .01 level on the factors *adequate resources provided* and *written 5S implementation plan* and at the .05 level to factors *adequate time provided* and *management commitment to 5S success*. The means from respondents from the state of Kentucky were higher for each of the 5S phases when compared to the states of Michigan, Ohio and Indiana. T-tests revealed that statistically significant differences existed between the state of Kentucky to respondents from the state of Michigan at the .01 level to the 5S phase *4S standardize* and at the .05 level to the 5S phases *1S sort, 3S shine, and 5S sustain*. The t-tests results also show statistically significant differences existed between respondents from the state of Kentucky to respondents from the state of Ohio to the 5S phase *4S standardize* at the .01 level and the 5S phase *1S sort* at the .05 level.

A comparison of means from respondent ratings for the demographic variable, *organizational function* revealed that the quality function perception of the each of the nine factors was lower than the manufacturing and operations functions. T-tests revealed that a statistically significant difference existed between the respondents from the quality function to respondents from the management and operations functions on the *commitment to 5S success* at a .05 level. The t-tests also showed that a statistically significant difference existed between the quality function to the operations function in *communication within the plant* at a .001 level. A comparison of the means from respondent ratings revealed that the quality function was lower for all 5S phases compared to the manufacturing function and to four of the five phases to the operations function where the only exception was with the *2S set-in-order* phase where the operations function was only lower by a .02 value. T-tests revealed that a statistically significant difference existed between respondent ratings from the quality function and the manufacturing function at the .01 level for *1S sort* and at the .05 level for the *3S shine* and *5S sustain*. T-tests also revealed a statistically significance difference between respondent ratings from the quality function and operations function for the *3S shine* at a .05 level.

A comparison of the means between the upper, middle and lower management levels revealed that respondent ratings from the lower management levels were lower for all nine factors. T-tests showed that there were not any statistically significant differences between the responses from the upper and middle management. T-tests showed that statistically significant differences existed between the response ratings from upper and lower management in regards to *management commitment to 5S success and communication within the plant* at the .05 level. T-tests also revealed that statistically significant differences existed between the respondent ratings from the middle and lower management in regards to *management commitment to 5S success* at the .05 level. This demographic variable was not statistically significant to any of the 5S phases.

A comparison of the means of the respondent ratings for the *union / non-union* demographic variable revealed that the means from the responses from the respondents located in non-union plants were higher for all factors. T-tests revealed that statistically significant differences existed in regards to *communication within the plant* and *personal responsibility of employees* at the .01 level and in *non-management training of 5S* and *adequate time provided* at the .05 level. The demographic variable (union / non-union) is statistically significant with the 5S phase *2S set-in-order* at a .05 level. A comparison of the respondent ratings also revealed that the means from the non-union respondents were higher than the union respondents for each of the 5S phases. T-tests revealed that the only statistically significant difference between the two was in the *2S set-in-order* phase at the .05 level.

The demographic variable, *time spent working with teams* was statistically correlated to three of the factors. When all responses were analyzed, this variable was statistically correlated at the .01 level to respondent ratings regarding *employees working in teams* and at the .05 level to *adequate resources provided* and *adequate time provided*. A comparison of the means between the *time spent working with teams* from 51 to 100 percent to the *time spent working in teams* from 0 to 50 percent shows that the higher percentage of time was greater for all nine factors. T-tests revealed that there were statistically significant differences in *employees working in teams* at the .001 level and *adequate time for 5S implementation* at the .01 level. A comparison of the means between the *time spent working with teams* from 51 to 100 percent to the *time spent working in teams* from 0 to 50 percent revealed that the means for the 51 to 100 percent time was greater for each of the 5S phases. T-tests revealed that the 51 to 100 percent of *time spent working with teams* was also statistically different to the 5S phase *sustain* at the .05 level.

The demographic variable, *management training of 5S* in hours was correlated to four of the factors based on all of the responses. Those four factors are *adequate management training in 5S, management commitment to 5S success, communication within the plant, and* *adequate resources provided for 5S implementation*. There was no significant correlation between the ratings regarding *management training of 5S* in hours provided by the respondents to any of the 5S phases. A comparison between those respondents reporting *management training of 5S* from zero to five hours to those reporting over five hours was analyzed. The means of the responses showed that the over five hours of training group was higher for all nine factors. T-tests revealed that *management training of 5S* over five hours was significantly different than management training of zero to five hours regarding the following factors *adequate management training of 5S, adequate non-management training of 5S, personal responsibility of employees and employees working in teams*. The study also revealed that the means of the respondents of the over five hours of training group was higher than the zero to five hour group for each of the 5S phases. T-test showed that there were not any statistically significant differences in the amount of management training hours to each of the 5S phases.

The demographic variable, *non-management training of 5S* hours was significantly correlated to three of the factors based on all of the responses. Those three factors are *adequate management training of 5S, personal responsibility of employees, and employees working in teams*. There was no significant correlation between the ratings regarding *non-management training of 5S* hours provided by the respondents to any of the 5S phases. A comparison between those respondents reporting *non-management training of 5S* from zero to four hours to those reporting over four hours was analyzed. The means of the responses revealed that *management training of 5S* over four hours was higher than management training of zero to four hours for all factors. T-tests revealed that *non-management training in 5S* over four hours was statistically different regarding the factors of *management* *commitment to 5S success, adequate management training of 5S, adequate non-management training of 5S, communication within the plant, personal responsibility of employees, written 5S plan provided, adequate resources provided and employees working in teams*. The means of the responses also showed that the "over four hours of training" group was higher than the "zero to four hours of training" group for each of the 5S phases. T-tests revealed that there were statistically significant differences in the amount of non-management training hours to the 5S phases *1S sort*, *2S set-in-order, 4S standardize, and 5S sustain*.

The demographic variables, *tier level, number of months using lean tools* and *plant size* measured by the number of employees have no significant relationships with any of the factors or any of the 5S phases. One exception was revealed when the researcher analyzed responses from respondents of Tier I suppliers separately from respondents from Tier II suppliers. Respondents from Tier I suppliers have significant relationships to factors and phases. The respondents from Tier II suppliers also have significant relationships at a less degree.

In summary regarding research question 2, relationships exist between seven of the ten the selected demographic variables and the perceived factors and each of the lean 5S phases in suppliers of manufactured products to the U.S. automotive industry. The seven demographic variables with relationships to the factors or 5S phases are as follows:

Location by state (Michigan, Ohio, Indiana, or Kentucky)

Organizational functions (Quality, Manufacturing, or Operations)

Management levels (Upper, Middle, or Lower)

Union or Non-union

The time spent working with teams (0 to 50 percent or 51 to 100 percent)

Management training of 5S in hours (0 to 5 hours or over 5 hours)

Non-management training of 5S in hours (0 to 4 hours or over 4 hours)

The three demographic variables without any relationships to the factors or 5S phases are as follows:

Tier level (Tier I, II, III)

Number of months using lean tools (0 to 600 months)

Plant size (Number of employees at manufacturing site)

**Conclusions**

Research question 1 asked: What factors were perceived by the respondents to have influenced the implementation of the lean 5S phases and elements in suppliers of manufactured products to the U.S. automotive industry?

When addressing research question 1, one may conclude that there is a strong relationship between all nine factors and each of the lean 5S phases and elements. Since each of the nine factors is strongly correlated to each other and each of the 5S phases and fifteen elements of those phases, the factors are appropriate to consider as guides for implementation of the lean 5S tool. Also, each of the nine factors, 5S phases and fifteen elements are strongly correlated to each other.

Regarding research question 2, the following demographic variables have a strong relationship with the nine factors and each of the 5S phases:

Location by state (Michigan, Ohio, Indiana, or Kentucky)

Organizational functions (Quality, Manufacturing, or Operations)

Management levels (Upper, Middle, or Lower)

Union or Non-union

The time spent working with teams (0 to 50 percent or 51 to 100 percent)

Management training of 5S in hours (0 to 5 hours or over 5 hours)

Non-management training of 5S in hours (0 to 4 hours or over 4 hours)

The state in which the manufacturing plant is located has an impact on the successful implementation of the lean 5S phases. An analysis of all respondents regardless of manufacturing location shows that *providing adequate resources and time* with a *written 5S implementation plan* is important for success. Additionally, *communication within the plant* and showing a *management commitment to 5S success* to employees that have a sense of *personal responsibility* are important as well. The analysis of means from respondents from the state of Kentucky shows ratings of all nine factors higher than the states of Michigan, Ohio and Indiana. The state of Michigan is the heart of the automotive industry with a historic past and the state of Kentucky is relatively new to the industry with ties to the Toyota manufacturing system that includes lean methodologies. It is interesting to compare results from the study between those two states. The analysis of the data allows one to conclude that respondents from the state of Kentucky perceive that the *management commitment to 5S success* is prevalent along with having *adequate resources provided* and *adequate time provided* to implement a *written 5S plan*. The state in which the manufacturing plant is located also has an impact on the successful implementation of the 5S phases *1S sort, 3S shine, 4S standardize and 5S sustain*. Becker (2001) and (Gapp et al., 2008) wrote that many organizations have difficulty in the implementation of the fourth and fifth 5S phases and understand the process to be a matter of housekeeping only or the initial 3S's. Sim and Chiang (2012) wrote that organizations that attempt to implement the lean methodologies without implementing a culture change fail over time. This is shown in the study by comparing the means from the rating responses regarding the each of the 5S phases between the four states. The ratings from the state of Kentucky are higher than any of the other three states. Comparing respondent ratings from the state of Michigan to those from the state of Kentucky in regards to each of the 5S phases revealed that the state of Kentucky is statistically significant and different in four of the five phases including the important *4S standardize* and *5S sustain* of which many organizations fail to attain. One could conclude that respondents from the state of Kentucky perceive that their 5S implementation process is more successful than those respondents from the other states. Recognition of this demographic variable and the relevant factors that have an impact on the 5S implementation are critical to suppliers interested in successfully implementing the lean 5S tool.

The *union/non-union* demographic variable has an impact on the successful implementation of the initial lean 5S phases. The means of respondent ratings from non-union employees were higher for all nine factors and for each of the 5S phases. Statistically significant differences show that there were higher ratings for *communication within the* *plant* by non-union employees as well as being flexible enough to adopt a sense of *personal responsibility*. One may conclude that these factors lead to greater probabilities of success in 5S implementation success within non-union organizations. Manufacturing leaders must recognize that these employees at the *non-management level* must receive *adequate training in the 5S tool* and given *adequate time to implement* the 5S process. There are not any significant differences between union and non-union organizations in the *2S shine, 4S standardize and 5S sustain* phases. One could conclude that the non-union and union organizations are able to begin the 5S implementation process but both have difficulty in attaining the later phases of *4S standardize* and *5S sustain* which enable full exposure and the benefits of the 5S program. These successful factors are effective in beginning the 5S implementation process but need to be associated with other demographic variables in order to implement all five phases. Therefore, leaders in organizations that understand these dynamics and factors will increase their potential for a successful implementation of the lean 5S tools.

The demographic variable, *management training of 5S hours* has a significant relationship between each of the lean 5S phases and is significantly correlated to four of the factors when all respondents are analyzed. One may conclude that *adequate management training in the 5S* must be supported by *management commitment in the 5S implementation* along with *communication in the plant* and *providing adequate resources*. A comparison between those respondents reporting 5S training from zero to five hours with those respondents reporting 5S training over 5 hours was analyzed. Management training of over five hours in the 5S tools has an influence of support for *non-management training of 5S* and promotes *employees working in teams* and empowering them with *personal responsibilities*.

However, management training in the 5S tool did not have any direct impact on the implementation of the 5S phases or any significant differences between the numbers of hours trained. One may conclude that adequate management training in the 5S tool has an effect on engaging the non-management personnel which appears to be important when initiating the process. Therefore, it is important to provide adequate training to management personnel in the lean 5S tools for supportive and commitment measures.

The *time spent working with teams* variable is correlated to three of the nine factors when analyzed using data from all of the respondents. The responses were divided into two groups with one being 0 to 50 percent of the time and the other being 51 to 100 percent of the time. Based upon the comparison of the two groups, one could conclude that the more time spent working in teams results in an increased impact on some factors. When working in teams is above the 50 percent time level, there is a statistically significant impact on having an *adequate amount of time for the 5S implementation*. The study also shows that this demographic variable has a statistically significant impact on the *5S sustain* phase. This is a critical conclusion of the study since the *5S sustain* phase is important in maintaining implementation success. Therefore, manufacturing leaders of suppliers must have teams in place and become actively involved by spending over 50 percent of their time working with them in order to maintain their 5S implementation efforts.

The demographic variable, *non-management training hours* in the 5S tool is correlated to three of the nine factors when all respondent ratings are analyzed. Based on confidence intervals, the responses were divided into two groups with one group that included those respondents that identified the 5S training from zero to four hours and the other group that identified 5S training as over four hours. One could conclude that non-management training in the 5S tool is critical to success. When the non-management personnel at the floor level receive over four hours of training, eight of the nine factors are affected. The training at this level has a relationship to the *management commitment to 5S success* and affects the *adequate management training in 5S* as well. It appears that as the non-management personnel are trained and begin the 5S implementation process, the management personnel attain an increased understanding of the program and its benefits. The factors c*ommunication in the plant* and *personal responsibility* are affected as *adequate resources* of employees that are *working in teams* are provided to implement the *written 5S implementation plan*. Providing over four hours of training to non-management personnel has a significant relationship to the successful implementation of the 5S phases. One could conclude that training influences the start of the initial phases and also affects the important *4S standardize* and *5S sustain* phases. The study shows that non-management training in the 5S tool is critical to 5S implementation success. One may conclude that organizations that are committed and provide adequate 5S training to their non-management personnel are more successful in implementing and maintaining all of the lean 5S phases.

The demographic variable, *organizational function* is represented in the study by the quality, manufacturing and operations disciplines. One could conclude that there are significant differences in the quality groups' perception of the factors and phases as compared to manufacturing and operations. Additionally, one could conclude that respondents from the manufacturing and operations functions perceive that management is committed to 5S success while the quality function is more reserved. The quality function does not perceive communication as being very strong within their organizations while the operations functions feels that it is strong. Another conclusion that could be made is that there are also differences in how the quality function perceives their organizations implementation of the 5S phases as compared to the manufacturing and operations functions. It appears that the manufacturing group perceives that the phases of *1S sort, 2S shine and 5S sustain* are implemented to a higher degree than the quality function. It also appears that a difference exists in the perception between the quality and operations functions in regards to the *2S shine* phase. One may conclude that there are differences in perceptions between organizational functions. The quality group was more negative on their perception of the 5S implementation than the manufacturing or operations functions. This is an interesting finding of the study. One conclusion may be that since the implementation of the lean 5S tool occurs in the plant and within the manufacturing arena, a survey format could be looked upon as a report card by the manufacturing function which may grade their area higher due to human nature. The quality function usually operates as an independent support group. They may provide survey ratings based upon their perceptions. Therefore, one may conclude that perceptions depend on organizational functions. The study also may indicate the importance of independent audits that remove functional bias from perceptions of implementation efforts. Organizations that understand this conclusion may be able to generate synergistic team oriented efforts toward 5S phase implementation rather than individual functional approaches.

The *level of management* variable was divided into groups of upper, middle and lower levels. One could conclude that there are significant differences between the upper management to the middle and lower management levels for *management commitment to5S success*. It appears that the upper management personnel perceive this commitment to be higher than the middle and lower management levels. It can also be concluded that there is a difference between the upper management and lower management levels in how *communication within the plant* is perceived. Additionally, one could conclude that the lower management personnel perceive that *adequate time for 5S implementation* is not being provided as compared to the perception of the upper management personnel. This is an important result of the study and suggests that upper management personnel need to be active and visible at the floor level. The results of the study also seem to indicate that the upper management group perceives the 5S implementation as being successful while the floor level personnel do not. Once all levels are united, the 5S program will have a higher degree of potential success. There are not any significant differences between each of the three levels and each of the 5S phases. Being fragmented in their perceptions, one could conclude that the lack of groups being united affects the perceived success of any phase.

The demographic variables, *tier level, plant size in number of employees* and *number of months using the lean tools* do not show any significant relationships to the factors or phases. This is an important finding from the study. Organizations of any tier level and size can implement the lean 5S phases with success. However, further analysis of the Tier I and Tier II suppliers separately indicates that the Tier 1 suppliers have some correlations between demographic variables to factors and phases. This may be associated to their direct association with the OEM's and possible increased knowledge of the 5S process. Also, the number of months using the lean tools does not relate to 5S implementation success. Once all five of the lean 5S phases are implemented successfully, the process continues and time may not matter.

The conclusions are consistent with many related studies. A study by the Lean Enterprise Institute in 2005 that included a survey of over 900 UK executives found that some obstacles in implementing the lean tools were a lack of implementation knowledge and management's resistance to changes. The Benjamin (2012) study determined that the greatest inhibitor to 5S implementation success was communication and a management commitment. Benjamin also found that personal responsibility, training, management support, adequate time, and adequate resources were important elements contributing to 5S implementation success. A study by Naqvi (2013) reported that a lack of management commitment and support were barriers to a successful 5S implementation process and that floor level teamwork was critical. The Sofokleous (2003) study identified that floor level employee training, adequate resources and communication as important factors. Barraza and Pujol (2012) studied three Mexican manufacturing facilities and identified drivers and inhibitors of successful 5S implementation. The study identified a strong management commitment, the use of work teams, training, and clear communication as critical. Moriones (2010) studied Spanish manufacturing firms and found that plant size as a factor indicating that larger plants were more successful. This is inconsistent with this study which identified plant size as not being related to any factors of 5S phase implementation success. A study by Steinlight (2010) of manufacturing organizations within the U.S. found that implementation success was not related to the maturity levels of organizations. This is consistent with this study which found that the number of months using the lean tools was not related to any of the factors of 5S phase implementation success.  The Becker (2001) study identified communication and employee involvement as key factors toward success.

In summary, one may conclude that several factors and demographic variables either lead to 5S implementation success or become barriers if not applied. The factors of *communication within the plant* and *management commitment to 5S success* are identified most frequently. These were followed by *employees working in teams, personal responsibility of employees, along with adequate time and resources for 5S implementation*. Additional important factors include *adequate non-management training in 5S, adequate management training in 5S* and having a *written 5S implementation plan* as a guide.

### Implications for Manufacturing Organizations

Lean manufacturing is associated with benefits such as reduced inventory, manufacturing efficiency, increased quality, increased flexibility, and improved customer satisfaction (Wooley and Doolan, 2006). Manos and Vincent (2012) described lean as “an approach to improve quality, increase productivity, reduce costs, and increase customer satisfaction by eliminating wastes and creating value” (p. 2). The lean 5S tool is the first tool that organizations typically implement in their effort toward the overall lean journey (Moriones, 2010). Manufacturers that supply products to the U.S. automotive industry that are interested realizing the benefits that the implementation of the lean 5S tools provide should consider the factors identified in this study that relate to implementation of the 5S phases. These factors are important when implementing the 5S phases but as manufacturing context changes, some are more important than others.

Benefiting from the lean 5S tool requires that all five phases are implemented successfully rather than a reduced amount. The factors of *management commitment to 5S implementation* and *communication within the plant* must be taken seriously as they affect implementation of all the 5S phases *1S sort, 2S set-in-order, 3S shine, 4S standardize, 5S sustain*.

Managers must also spend over 50 percent of their *time working with the teams* which shows a demonstrated commitment and enhances the communication factor. When managers are active within the plant, teams sense that *adequate resources* and *adequate time* are being provided to implement the 5S phases. This leads to strong success in the *5S sustain* phase which is critical in preventing a relapse of implementation efforts.

Training in the lean 5S tool is critical for implementation success. Management personnel must be trained in order to understand the support required for success in the program but this training does not have a direct effect on implementation success. It is more important that *non-management personnel receive an adequate amount of training*. Success or failure of the 5S implementation process and realization of the associated benefits depends on the floor level employees. Management must provide the framework with a *written 5S implementation plan* but as the non-management personnel are trained and empowered, they take on a *personal responsibility for implementation* success. This very important component of the 5S implementation process enables success in the initial phases as well as the critical phases of *4S standardize* and *5S sustain*.

Managers must develop a common understanding regarding the status of the lean journey regardless of their organizational function in order for the 5S implementation to be successful. Organizations can implement the initial phases sometimes referred to as "housekeeping", however, in order to move into the final two phases, all organization functions must have a true understanding of the program status. A fragmented organization that allows the perceptions of the 5S status to be dictated based upon their function such as quality, manufacturing and operations is likely a recipe for failure. Organizations must become united as one team with one game plan. An independent analysis of the 5S implementation status is helpful in providing an adequate status and form the foundation of a common understanding of the 5S implementation status.

Based on the analysis of this study, employees within union organizations may be less receptive to accepting change and taking on more personal responsibility and therefore the implementation of the 5S tool may be more effective in non-union affiliated organizations. Management and non-management personnel need to understand this difference in order to be mutually successful and profitable. Communication within the plant and training of non-management personnel in the 5S tools is an effective method in breaking down any barriers. This may lead to an increase in personal responsibility as long as adequate time to implement is provided within union or non-union facilities.

Plant size or tier level, did not have any relationship with any of the factors or 5S phases in this study.

The amount of time that the 5S tools are utilized does not appear to have any relationship with any of the factors or 5S phases.

In summary, managers of suppliers to the automotive industry who understand the 5S process and are committed to providing adequate training to their non-management floor level employees with continued floor level visibility and communication with their teams will enhance their chances of success.

The critical factors that can help ensure success are listed below in order of importance. Organizations that address these factors will enhance their chances of being successful in their 5S implementation efforts.

1. Training of non-management personnel
2. Communication within the plant

3. Management commitment to 5S success
4. Spending time working with teams and being visible

The following factors also support the lean 5S implementation process. These factors require attention by companies desiring a successful 5S implementation but are secondary to the four critical factors listed previously.

1. Training of management personnel
2. Empowering employees with personal responsibility
3. Providing adequate time and resources
4. Providing a written 5S implementation plan

**Recommendations for Future Research**

This study has not addressed cause and effect relationships. One recommendation for future research is to consider a quasi-experimental study that can address cause and effect for selected factors. For example, a future study could be directed toward a comparison of an organization that has successfully implemented all of the 5S phases to one that has failed to determine what causes resulted in success or failure.

The study revealed significant differences between respondents from the state of Kentucky when compared to the states of Michigan, Indiana and Ohio. Future research should include a qualitative study to better understand the reasons as to why the state of Kentucky is significantly different.

This study focused on suppliers located in the United States that provide a manufactured product to the U.S. automotive industry. A recommendation for future research is to study suppliers of manufactured products to non-automotive organizations to determine if any similarities exist. Organizations that provide products such as computers, communications equipment, and household appliances are examples of potential targets for additional research. Additionally, a recommendation for future research is to study the lean 5S implementation by suppliers to the service industries such as academia, medical services and entertainment.

This study utilized several demographic variables but did not identify how specific behavioral attributes of employees within groups may affect implementation efforts. A study related to the Lawrence & Lorsch (1967) research where the behavioral differentiation of groups and integration process of achieving unity of groups toward a common goal is a recommended future study.

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## Appendix A

5S Instrument

## Factors and Elements for Phases of the Lean 5S Tool

### Introduction

The purpose of this study is to identify the factors impacting each of the phases of the lean 5S tool in manufacturing suppliers to the U.S. automotive industry and to determine if these factors vary according to selected key independent and organizational variables. The information gathered will be used to guide the development of strategies to improve the implementation of the lean 5S tool in the United States.

Confidentiality and Risks
Survey respondents will not be identified and will remain anonymous. Any reports of this research will only include information in aggregate form which will ensure confidentiality. There will be no risks for the participants.

Voluntary Participation
Participation in this survey is voluntary and respondents can opt out at any time.

Human Subjects Review Board
The research protocol and informed consent document has been reviewed and approved by the Eastern Michigan University Human Subjects Review Committee (UHSRC).

Incentive
All respondents are eligible to be included in a random drawing for a $100 VISA card. To be included in the drawing, please follow the instructions at the conclusion of the survey. In addition, respondents may request a copy of the final research results by completing the information requested at the end of the survey

If you have any questions or concerns about this survey, please e-mail me at rkazmier@emich.edu or call me at 989-295-4210.

### Section 1 - Demographics

The following questions pertain to demographic characteristics. Please provide the appropriate response as they pertain to your manufacturing plant.

**1. Does your plant supply a manufactured product to the US Automotive Industry?**

- Yes
- No

**2. Your manufacturing plant is located in what city and state?**

**3. What is your job title?**

**4. Are your production employees represented by a collective bargaining group?**

- Yes
- No

## Factors and Elements for Phases of the Lean 5S Tool

**5. Which is the highest Tier level of your plant to the US Automotive Assembly plants?**

- Tier I
- Tier II
- Tier III

**6. What is the total number of employees at your manufacturing plant?**

**7. What percentage of your time is spent working on teams? (Please enter number between 0 and 100)**

**8. What is the approximate number of months that your plant has used lean tools? (Please enter a number between 0 and 600)**

**9. Approximately how many hours of 5S training does a individual management employee in the plant receive?**

**10. Approximately how many hours of 5S training do your non-management personnel in the plant receive?**

## Section 2 - Elements

## Factors and Elements for Phases of the Lean 5S Tool

**11. Please rate the following fifteen elements based on the implementation of the lean 5S tool within your manufacturing organization**

| | Strongly Disagree | Disagree | No Opinion | Agree | Strongly Agree |
|---|---|---|---|---|---|
| Obsolete or unnecessary tools, equipment, tables, cabinets, personal items and materials are cleared from your manufacturing plant | ◯ | ◯ | ◯ | ◯ | ◯ |
| Empty/unused containers and racks that are not being used are cleared from your manufacturing plant | ◯ | ◯ | ◯ | ◯ | ◯ |
| Floors are free of dropped parts, trash, refuse and aisle ways are clear and free of debris | ◯ | ◯ | ◯ | ◯ | ◯ |
| Necessary tools, fixtures, gauges and masters are properly stored in designated locations and clearly labeled | ◯ | ◯ | ◯ | ◯ | ◯ |
| Handling carts, pallets, and empty containers are properly stacked and stored in designated areas | ◯ | ◯ | ◯ | ◯ | ◯ |
| Inventory is organized and identified | ◯ | ◯ | ◯ | ◯ | ◯ |
| The plant floor and aisles are clean and properly marked | ◯ | ◯ | ◯ | ◯ | ◯ |
| Equipment is clean and free of excessive grease, oil, chips, leaks and dirt | ◯ | ◯ | ◯ | ◯ | ◯ |
| Workstations are neat, clean and organized | ◯ | ◯ | ◯ | ◯ | ◯ |
| Visual aids are in place and unobstructed | ◯ | ◯ | ◯ | ◯ | ◯ |
| Area work instructions, standard operating procedures, and drawings are accessible and are being followed by employees | ◯ | ◯ | ◯ | ◯ | ◯ |
| Communication boards are being utilized and are up to date | ◯ | ◯ | ◯ | ◯ | ◯ |
| 5S audit forms and schedules are in place and utilized with action plans and progress displayed | ◯ | ◯ | ◯ | ◯ | ◯ |
| Employees are assigned and trained to conduct 5S audits | ◯ | ◯ | ◯ | ◯ | ◯ |
| 5S effectively has been evaluated or implemented and improvements have been noted | ◯ | ◯ | ◯ | ◯ | ◯ |

## Section 3 - Factors

Based on previous research, factors that likely affect the implementation of the lean 5S tool have been identified.

## Factors and Elements for Phases of the Lean 5S Tool

**12. Please rate the following nine factors based on the implementation of the lean 5S tool within your manufacturing organization**

| | Strongly Disagree | Disagree | No Opinion | Agree | Strongly Agree |
|---|---|---|---|---|---|
| Plant management is committed to the success of 5S | ◯ | ◯ | ◯ | ◯ | ◯ |
| Adequate 5S training of management employees has been provided | ◯ | ◯ | ◯ | ◯ | ◯ |
| Adequate 5S training of non-management employees has been provided | ◯ | ◯ | ◯ | ◯ | ◯ |
| Communication within the plant is excellent | ◯ | ◯ | ◯ | ◯ | ◯ |
| Personal responsibility demonstrated by employees is prevalent in the plant | ◯ | ◯ | ◯ | ◯ | ◯ |
| A written 5S implementation plan is utilized within the plant | ◯ | ◯ | ◯ | ◯ | ◯ |
| Adequate resources are provided for 5S implementation | ◯ | ◯ | ◯ | ◯ | ◯ |
| Adequate time is provided for 5S implementation | ◯ | ◯ | ◯ | ◯ | ◯ |
| Employees working together in teams are used extensively in the plant | ◯ | ◯ | ◯ | ◯ | ◯ |

## Section 4

## Factors and Elements for Phases of the Lean 5S Tool

**13. Please add any comments that you may have.**

**If you would like to be included in a drawing for $100 VISA card, please include your e-mail address in the comment box space below.**

**If you would like to receive a copy of the final research results, please send an e-mail message to rkazmier@emich.edu with "Request Research Results" listed in the subject line.**

**If you would like to contact the researcher, please send an email message to Randy Kazmierski at rkazmier@emich.edu or Dr. John Dugger at jdugger@emich.edu**

**Thank you for completing the survey**

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