LEAN MANAGEMENT: AWARENESS, IMPLEMENTATION STATUS, AND NEED FOR IMPLEMENTATION SUPPORT IN VIRGINIA'S WOOD INDUSTRY

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Abstract

During the last decades, the U.S. wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries have been greatly affected by economic cycles, rising production and transportation costs, changing buyer habits, and, arguably, most powerfully, increasing global competition. As a result, tens of thousands of jobs were lost and a large number of companies in the industry experienced bankruptcy, closed operations, or relocated to other countries. However, theories exist stating that the use of management systems, such as, for example, Lean management, allows companies to become more competitive and enhance the likelihood of survival.

A mail survey was conducted to investigate companies in Virginia's wood products and furniture manufacturing industries as to their awareness of Lean management, the implementation of Lean practices, as well as the companies' need for support in Lean implementation efforts.

Findings indicate that a majority of Virginia's wood products and furniture manufacturing industries have heard about terms like, for example, Lean management, Lean manufacturing, or Lean thinking, but are rarely aware of individual Lean elements of which Lean consists. Few businesses thus have implemented Lean. However, findings show that Lean awareness and

Lean implementation status differs between individual industry sub-segments. The group of industry segments with the highest Lean awareness and Lean implementation status were "*engineered wood products*", "*manufactured homes*", and "*household furniture manufacturing*," as opposed to industry sub-segments such as "*sawmill*" and "*wood container and pallets*," which had lower Lean awareness and Lean implementation status. The study also revealed that smaller companies (less than 50 employees) have a lower level of Lean awareness and implementation status than do larger companies (50-499 employees). Despite the low level of Lean implementation across the wood products and furniture manufacturing industry in Virginia, less than one-fourth of all respondents indicated a need for Lean implementation support.

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Table of Contents

List of Tables

List of Figures

1. Introduction

1.1. Industry Background

During the last decade, Virginia's wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries have been greatly affected by a dynamic economy (Bull 2008, International Forest Industries 2009), rising transportation costs (BBCWorldNewsAmerica 2008, Smith et al. 2009), changing buyer habits (Huber 2008), and increasing global competition (Buehlmann and Schuler 2002, Fishman 2005). Particularly the value of imported wood furniture and wood products from countries in Asia and other Pacific regions increased greatly (Pirraglia et al. 2009, Czabke et al. 2008). As a result, tens of thousands jobs were lost (Milauskas 2005) and a large number of companies in the U.S. furniture and wood product industries experienced bankruptcy, closed operations, or undertook relocations to other countries (Quesada and Gazo 2006).

In recent decades, businesses, in their attempt to adapt to a global economy and to become more competitive includes, among other things, the use of management systems, such as, for example, Lean management (Buehlmann and Schuler 2009). Lean management, originating in the automotive industry (Womack et al. 1990), has proven effective in helping companies from different industries to improve their organizational performance (Mintz Testa 2003). In the U.S. furniture manufacturing industry (NAICS 337), for example, several companies successfully transformed their operations through the application of Lean management and got awarded the Shingo Price for Excellence in Manufacturing (Steelcase 2006, Hon 2010, Merillat-Masco Builder Cabinet Group 2009). Some other companies in the wood industry (NAICS 321 and

NAICS 337) have applied Lean management (Czabke 2007) or are considering the implementation of Lean management (Ray et al. 2006). However, not much documentation about Lean implementations in the wood products and furniture manufacturing industries exist. This lack of documentation makes it difficult to assess the Lean awareness and the status of Lean implementation efforts in wood products and furniture manufacturing industries. For the state of Virginian, documentation of Lean implementation efforts is almost nonexistent. Empirical evidence exist that the U.S. wood products and furniture manufacturing industries have been slow in adapting the Lean management approach (Pirraglia et al. 2009). Some authors (Pirraglia et al. 2009, Schuler and Buehlmann 2003) claim with some reason, that the U.S. wood products and furniture manufacturing industries might have been more successful in defending their U.S. market shares and halt the loss of jobs to locations overseas, if management systems such as Lean management would have been pursued more aggressively.

Existing publications and reports relating to Lean management in the wood products and furniture manufacturing industries cover research about large organizations implementing Lean management. However, due to the decline of larger manufacturers, especially in the furniture industry, an increasing percentage of smaller businesses exist (Grushecky et al. 2006). Research conducted in non-wood and non-furniture industries have shown that smaller companies typically are more reluctant to implement structured forms of training and improvement programs (Kotey and Folker 2007, White et al. 1999). Reasons can be found, among other things, in the lack of resources available in small organizations (Curran et al. 1997) and a short-term planning horizon versus the more long-term realization of benefits from training programs (Westhead and Storey 1996).

These and other limitations have created the need for support organizations to cover the need for support of small and medium sized businesses (SME, SME institute 2009, SBDC Idaho 2010). Such support organization focus on providing SMEs with the necessary resources and know-how to manage their daily business. Some of these support organizations offer Lean support, through training, consulting, and coaching to different kinds of organizations across industries (UT 2007, LGN 2009). Such support from third-party organizations has been shown to increase the chance of successful Lean implementations (Greenwood et al. 2002).

This study tries to generate an overview of Lean awareness and Lean implementation in the wood products (NAICS 321) and furniture manufacturing (NAICS 337) in Virginia. Additionally, it evaluates the need among those organizations for support regarding Lean implementation. This first chapter (1.0 Introduction) summarizes the background and motivation for this research, including with the presentation of the research questions. Chapter two (2.0 Literature Review) provides a review of the existing literature on Lean management, the wood industry and its current conditions, and an overview of existing support organizations and their practices. Chapter three (3.0 Methodology) describes the methodology used in this research. Chapters four (4.0 Lean Penetration in Virginia's Wood Industry) and five (5.0 Lean in SMEs) contain two manuscripts for submission to Forest Products Journal and Journal of Small Business Management presenting the results of the research. Chapter six (6.0 General Results and Discussions) provides a holistic view of the results of this study including a discussion. Chapter six pinpoints areas for further research. Finally, chapter seven (7.0 Summary and Conclusions) summarizes the work presented and provides main conclusions.

1.2. Problem statement and Research Questions

Evidence exist (Merillat-Masco Builder Cabinet Group 2009, Pirraglia et al. 2009, Schuler and Buehlmann 2003) that the implementation of Lean management systems provides a potential solution to improve the competitiveness of Virginia's wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries. However, little knowledge exists about the current state of Lean implementation within Virginia's wood product and furniture manufacturing industries. Also, the demand for external support is unknown among these industries. To address these shortcomings, a set of research questions were proposed focused in the areas of (1) Lean Awareness, (2) Lean Implementation, and (3) Need for Support.

1.2.1. Lean Awareness

The following questions were used to investigate Lean awareness within the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industry in Virginia:

- Are wood-related manufacturing companies in Virginia aware of Lean?
- To what extent is Lean management practiced within the wood industry in Virginia?
- Is the degree of Lean awareness different for company size or industry classification (NAICS code, U.S. Census Bureau 2009) within the wood industry in Virginia?

1.2.2. Lean Implementation

The following questions were developed regarding the extent of Lean implementation and practice within the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industry in Virginia:

- Have wood related manufacturing companies in Virginia implemented Lean?
- Which Lean elements have been implemented?
- Which performance measures are used?
- Does the company size or the industry segment have an effect on differences in Lean implementation?
- Does the existence of a Lean change agent working at a company increase the likelihood that Lean elements are implemented?

1.2.3. Need for Support

The following questions were developed regarding the need for support with Lean implementation by participants of the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industry in Virginia:

- Is there a need for support with Lean implementation?
- Which approaches of support are asked for (training, coaching, or implementation support)?
- Which topics require support?

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2. Literature Review

2.1. Lean Management

2.1.1. What is Lean?

Substantial numbers of organizations involved in manufacturing, service, and the public sector have made a commitment to be Lean, among them some of the world's leading organizations. Given this dedicated, global fellowship, it can be assumed that becoming Lean is a worthy effort for organizations. The word Lean was originally coined and first used in the international bestseller "*The Machine that Changed the World*" by Womack, Jones, and Roos (Womack et al. 1990). The book presents and discusses results stemming from the International Motor Vehicle Program (IMVP) study conducted by the Massachusetts Institute of Technology (MIT) and funded by the U.S. Federal Government. The project was started in 1984 to *"…Undertake a detailed study of the new Japanese techniques* (Womack et al. 1990, p.4)." Comparing these Japanese production techniques, which are based on mass-production systems similar to the ones used by the North American and European auto industry, but use a common sense approach in their execution, the IMVP researcher John Krafcik came up with the name *"…Lean production…* (Womack et al. 1990, p.13)." These unique Japanese techniques originated at the Toyota Motor Company, and were coined as the "*Toyota Production System (TPS)*." Toyota's Production System, while the result of input from countless individuals, was primarily designed and implemented by Taiichi Ohno, who is considered to have *"…Pioneered the concept of Lean production* (Womack et al. 1990, p.11)." Ohno (1988) described the goal of the TPS as: *"All that we are doing is looking at the time line from the moment the customer gives us an order to the*

point when we collect the cash. And we are reducing that time line by removing the non-value-added waste (Ohno 1988)."

Womack et al.'s (1990) studies showed that factories applying Lean principles are Lean because they need less human effort and time to assemble a vehicle, less assembly space per vehicle, and less average inventories of parts to produce a *"…Greater and ever growing variety of products…* (Womack et al. 1990, p.13)," with fewer defects than typical mass-production factories. Thus, being Lean means doing more with less.

The following paragraphs provide more insights and details about the Lean concept, the Toyota Production System (TPS), and its origins.

2.1.2. The Toyota Production System (TPS)

The key of Toyota's success is attributed to the Toyota Production System (TPS, Kotelnikov n.d., Takeuchi et al. 2008, Liker 2003). It was developed by Taiichi Ohno (in Japanese: Ōno Taiichi) in the 1960's and 1970's and consists of several elements, each of which is crucial to the structure of the entire system and crucial to the overall goal – Lean production. The TPS tends to be visualized as a house where each element plays an important role to the entire structure. This analogy was created to stress that TPS (Lean) can succeed only if applied as a system (Lander and Liker 2007, Liker 2003). **Error! Reference source not found.** visualizes the TPS concept, ften referred to as the TPS house.

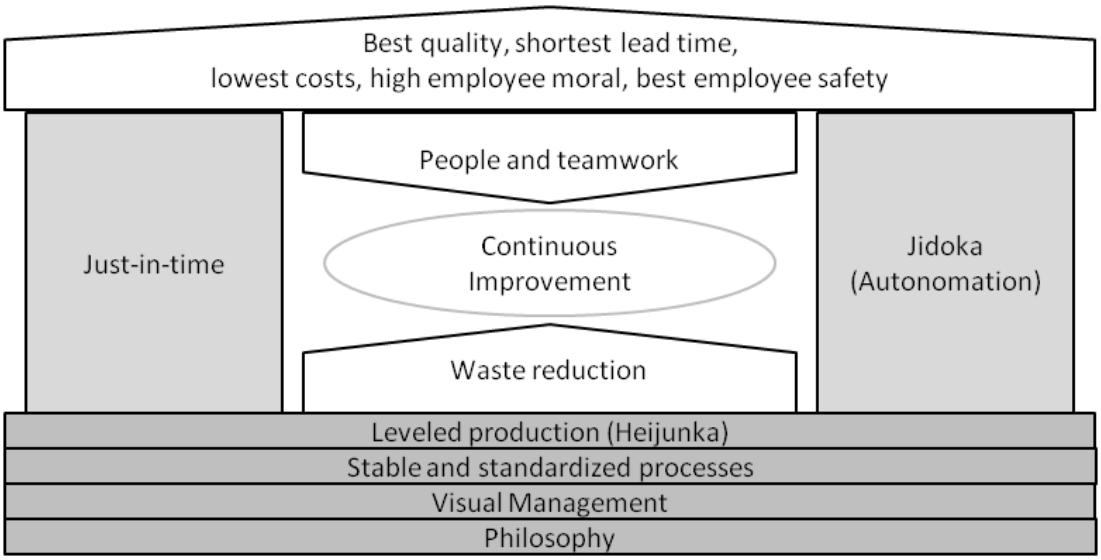

Figure 1: The TPS house (adapted from Liker 2003)

The overall goal of TPS, as visualized by the roof in Figure 1, is to produce quality products at the lowest costs and with short lead time. Toyota puts a high emphasize on their employees' safety, which trumps any other goal (Liker 2003). High employee morale is important to create a positive working environment, which helps achieve the company's goals (Liker 2003). The roof of the TPS house is held by two main pillars: "*just-in-time*" on one side and "*autonomation*", or *"…Automation with a human touch…* (Ohno 1988, p.6)" on the other side. Autonomation is also referred to as "*jidoka*" (Liker 2003).

"*Just-in-time*" production means that only the parts in the quantity needed at a given time are processed, thereby reducing inventory to the minimum. Zero inventories is the theoretical goal, thus completely eliminate inventory costs. However, zero inventory is difficult or impossible to achieve. Ohno, in his review of traditional mass production strategies, states that *"…It is extremely difficult to apply just-in-time to the production plan of every process in an orderly way* (1988, p.4)." By rigorously planning every piece in every process step and

constantly updating them so that the production plan represents the actual requirements are time consuming and costly, letting one *"…fall behind in … production control* (Shimokawa et al. 2009, p.16)." Computerized systems may help, but still require effort and the changes still have to be executed in the physical workplace. Ohno (1988), after careful consideration, concluded that computers do not work well in conjunction with just-in-time production systems (Ohno 1988). Determined to find a better solution to realize just-in-time production, Ohno wondered about the production sequences in manufacturing. He realized that the preceding process only needed to produce the amount of parts that the following process withdraws. These ideas led to the invention of the kanban system. As a result, unlike other manufacturers in the 1950's, Toyota did not introduce computers for planning but used the strikingly simple kanban system to control production (Shimokawa et al. 2009).

The second pillar of the TPS is autonomation, a term which is not to be mistaken with automation. An automated machine operates without human input once the initiation button is pressed, creating automated high part output. Since these parts are not necessarily immediately checked for defects, large quantities of defective parts are possibly produced before being noticed (Ohno 1988). Toyota uses machines that are autonomous instead of automated. Autonomous machines detect defects as they occur through ongoing inspection and stop automatically when non-conformance is detected. Autonomation thus prevents the production of defective parts. Ohno refers to autonomation as *"…Automation with a human touch* (Ohno 1988, p.6)." Sakishi Toyoda actually used autonomation long before the Toyota Production System was established when he created a loom that instantly stopped as soon as abnormal conditions were detected (Ohno 1988).

The foundation of the TPS house, as shown in Figure 1, consists of four elements, which are all necessary to provide a solid foundation. The organization's "*philosophy*" is regarded as the most important element of the foundation as it provides guidance for everyone in the organization regarding the direction the organization is taking and the way the organization wants to reach the goals. Hence, "*philosophy*" is placed on the very bottom of the foundation of the TPS house. The second foundational element is described as "*visual management*". It indicates that everything that is being done within the organization should be visualized so that the current state of any process becomes instantly clear and transparent. Elements three and four state that processes need to be standardized, stable, and reliable as well as leveled in both volume and variety, so that inventories are limited (Liker 2003). Elements three and four are referred to as heijunka in the TPS system.

The center of TPS consists of people, teamwork, and the reduction of waste within the system. Taiichi Ohno (1988) uses the example of sport teams to explain the importance of teamwork in a company: A soccer team may have excellent individual players, but without teamwork this team does not necessarily win (Ohno 1988). Furthermore, the reduction of waste, such as, for example, the reduction of inventory or the elimination of defective parts produced is essential to identify and solve problems in the system immediately (Liker 2003). This approach requires a high level of process stability so that processes do not stop constantly. Stability is established through continuous improvement, an activity that is performed by everybody working for the company or supplying to the company.

2.1.3. Principles of Lean

2.1.3.1. Womack and Jones' 5 Lean Principles

Based on the TPS, Womack and Jones' (2003) research described in *"Lean Thinking"* identified five major principles for a roadmap to become Lean. Figure 2 provides an overview over all five principles. The first principle is to identify and specify the value that is being created within the company, requiring the identification of the customers and the customer's needs. Womack and Jones (2003) stress that customers are the ones who define value by what they are willing to pay for a given product or service.

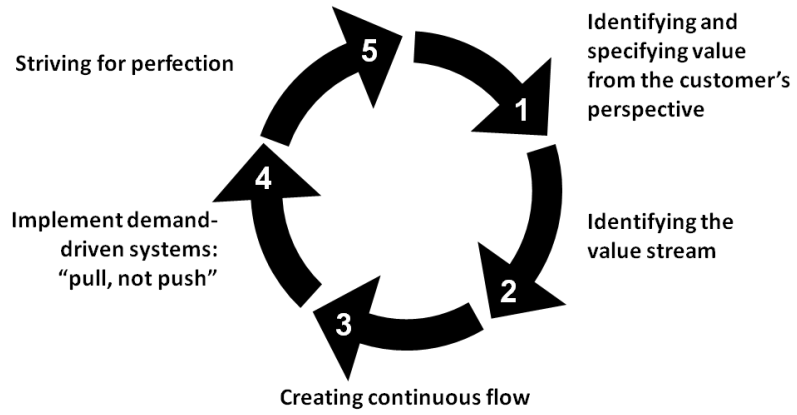

Figure 2: Five Lean principles (adapted from Womack and Jones 2003)

With value identified, all activities required to create a product or to provide a service need to be identified along the value stream through a technique called Value Stream Mapping (VSM). A value stream describes all processes and steps currently needed to produce a product or service (Rother and Shook 2003). Process activities can be classified into three categories: 1) Activities that add value to the product or service, 2) activities that do not add value to a product or service but are still necessary, and 3) activities that do not add value and are not necessary (Emiliani 1998, Liker 2003). For example, joining two tubes through welding (value

added), inspecting welded seams (not value added but necessary), or rework due to a defective welding seam (non-value added and not necessary, Womack and Jones 2003). Figure 3 shows an example of a value stream map. On the top of Figure 3, the flow of information is shown, for example, as the order is placed by the customer or the production plan from the production control department is directing individual process steps. The middle section represents the actual production processes, referred to as material flow including individual process steps with detailed process data and work-in-process (WIP) inventories. Examples of such process data include, for example, cycle time, machine uptime, and number of operators for a given process. The bottom section visualizes value added (VA) and non-value added (NVA) times of processes, such as, for example, process time and inventory or waiting time.

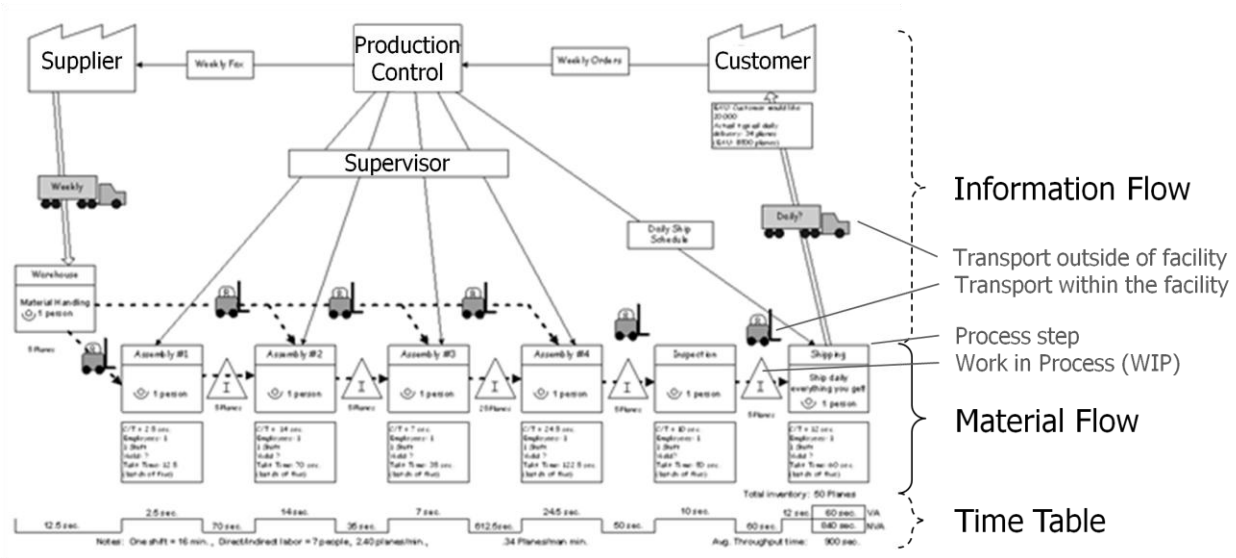

Figure 3: An Example of a value stream map (adapted from Technical Change Associates 2009).

Once the value stream is mapped and waste is identified and eliminated (a never-ending process that needs to be repeated continuously), the remaining value-added and currently necessary non-value added process steps need to be set-up that they flow – allowing the least

amount of work in process (WIP) and thus the shortest lead time possible. According to Womack and Jones (2003) this principle requires a different way of thinking as one has to take the view point of the product or service that is being processed to realize the VA and NVA times that occur during the entire process. This different way of thinking is important as, traditionally, common sense may have suggested to group processes according to function so that they can be performed more efficiently (Womack and Jones 2003). However, such grouping leads to the loss of process overview and consequently to batch-processing. Batch-processing in turn leads to waiting time for individual products and the flow of the product is constantly interrupted (Womack and Jones 2003). Through flow, according to Womack and Jones (2003), most services or goods can be processed more efficiently and accurately with less WIP.

Once flow has been created along the value stream, the lead time of the process from customer order to delivery is dramatically reduced. However, if products or services are produced without existing demand, waste still occurs. Without demand, products or services are pushed through the system and finished goods inventory is created. Finished goods inventory does not add value and creates considerable costs, thus waste occurs. Therefore, the fourth principle of Lean is to create a pull system, which produces only products or services when demanded by a customer. In the ideal state, production time is so short that the actual production of a product or service will start only when a customer order is received. In this case, no finished goods inventory will exist (Womack and Jones 2003).

Lastly, the fifth principle is a merciless drive for perfection which triggers the process of continuously improving the current state – one of the core elements of the Lean philosophy (Womack and Jones 2003). Today, these five Lean principles, summarized in Table 1, are widely recognized (Cardiff University n.d., Mikkel Smith 2006, Emiliani 1998) and applied (Ben-Tovim et al. 2007, Godsell 2009, Ng et al. 2010).

2.1.3.2. Liker's 14 Principles

Liker, another author who uses principles to convey the ideas behind the TPS, published his work in a publication entitled *"The 14 Principles of the Toyota Way…* (Liker 2003, p.35)." He acknowledges the five principles coined by Womack and Jones, however, in his view, the 14 principles *"…Constitute the Toyota Way* (Liker, 2003, p. 6)*"* that also describe the culture behind the Toyota Production System. He structures the 14 principles into four categories, visualized in Table 1 and discussed in the following paragraphs.

Table 1: Liker's 14 principles of the Toyota Way (adapted from Liker 2003)

Category 1: Long-Term Philosophy

Principle 1: Base your management decision on a long-term philosophy, even at the expense of short-term financial goals.

Category 2: The Right Process Will Produce the Right Results

Principle 2: Create continuous process flow to bring problems to the surface.

Principle 3: Use "pull" systems to avoid overproduction.

Principle 4: Level out the workload (heijunka). (Work like the tortoise, not the hare).

Principle 5: Build a culture of stopping to fix problems, to get quality right the first time.

Principle 6: Standardized tasks are the foundation for continuous improvement and employee empowerment.

Principle 7: Use visual control so no problems are hidden.

Principle 8: Use only reliable, thoroughly tested technology that serves your people and processes.

Category 3: Add Value to the Organization by Developing Your People and Partners

Principle 9: Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others.

Principle 10: Develop exceptional people and teams who follow your company's philosophy.

Principle 11: Respect your extended network of partners and suppliers by challenging them and helping them improve.

Category 4: Continuously Solving Root Problems Drives Organizational Learning

Principle 12: Go and see for yourself to thoroughly understand the situation (genchi genbutsu).

Principle 13: Make decisions slowly by consensus, thoroughly considering all options; implement decisions rapidly.

Principle 14: Become a learning organization through relentless reflection (hansei) and continuous improvement

Liker's (2003) four categories are 1) "*Long-term philosophy*," 2) "*The right process will produce the right results*," 3) "*Adding value to the organization by developing people and partners*," and 4) "*Continuous problem solving will create a continuous learning organization*." These four categories are also referred to as the 4 P's (Liker 2003). Most Lean companies focus on the second principle, the process category (Liker 2003, Ohno 1988, Womack and Jones 1994). Also, most of the five Lean principles coined by Womack and Jones (2003) can be found in Liker's second category ("*The right process will produce the right result*"). Companies having successfully implemented principles of the right processes (Category 2) have achieved flow throughout their processes has been established and pull systems have been installed to avoid overproduction. Additionally, the workload has been leveled, standardized work tasks have been set-up as a requirement for continuous improvement, visualization is used to control standards and to hinder problems from being hidden, reliable technology is in use and, finally,

the production line has been set up to be stopped anytime by anyone as soon as a problem occurs, which cannot be solved without interrupting production (Monden 1998, Ohno 1988, Liker 2003).

The idea of Liker's first category, the long-term philosophy, is to have all managerial decisions based on a long-term philosophy, even if this means that short-term financial goals have to be sacrificed. Liker (2003) suggests that finding a bigger purpose for the company than just making money is important. Once a long-term philosophy has been established, every function can be aligned towards this common goal, and all future principles are being based on this philosophy (Yoshida 1989, Liker 2003). Then value can be generated for the *"…Customers, society and the economy…* (Liker 2003, p.37)."

Liker's third category, people and partners, emphasizes the importance of employees and partners of an organization. At the Toyota Motor Company, employees are seen as the greatest assets of the company. Hence, investing in employees' development means investing in the future of the company. Therefore, Liker (2003) describes the development of people and teams that follow the company's long-term philosophy in principle ten "*Develop exceptional people and teams who follow your company's philosophy.*" He emphasizes the importance of a common goal, towards which all human development should be aligned. Also, a company needs to grow leaders who understand and live the company philosophy and are able to teach the philosophy to others. This is captured by Liker's (2003) principle nine ("*Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others."*). Principle eleven ("*Respect your extended network of partners and suppliers by challenging them and helping*

them improve.”) puts additional importance on the extended network of partners and suppliers, essentially stressing that both, internal and external individuals are to be treated with respect. Principle eleven establishes that partners and suppliers are an extension of one's business (Liker 2003, Ohno and Mito 1988).

Liker’s (2003) fourth category, "*Continuous problem solving will create a continuous learning organization*," deals with the creation of a learning organization through continuous solving of the root cause of problems. An important principles is, among others, to go to the source of the problem and see the problem personally “*…Rather than theorizing on the basis of what other people or the computer screen tells…* (Liker 2003, p.40).” This principle is oftentimes referred to as "*genchi genbutsu*." Once the root cause is identified, a decision has to be made about how to solve the problem. In principle 13 Liker (2003) recommends to always try to achieve consensus with all participants. This approach, referred to as "*nemawashi*", might be time consuming but helps to implement the solution quickly after consensus has been established since all participants agreed upon it before the actual implementation begins (Liker 2003, Liker and Meier 2007, Ohno 1988). And finally, principle fourteen ("*Become a learning organization through relentless reflection (hansei) and continuous improvement*“) the last of Liker’s (2003) principles aims at creating a learning organization. This requires stable and standardized processes to be able to apply continuous improvement tools and a continuous improvement process (kaizen). Using frequent reflection meetings to identify lessons learned supports the goal to become a continuous learning organization (Liker 2003).

Both, Womack and Jones' (2003) and Liker's (2003) discussion of the TPS and of Lean stress the importance of continuous improvement as the underlying philosophy driving everything the organization does. The identification of the seven types of waste are widely used today to support this strive for continuous improvement.

2.1.4. Seven Types of Waste

As previously discussed, waste elimination, defined as the elimination of non-value added and not necessary processes and inventories, is a main focus of Lean (Liker 2003, Ohno 1988, Womack and Jones 2003). These non-value adding activities or processes, according to Ohno (1988), can be structured into seven types of waste, as described below:

- **Overproduction** is the action of producing items without an order or producing items not in a timely manner (e.g. too early or too late). Ohno considered overproduction to be the *"…Fundamental waste […] since it causes most of the other wastes* (Liker 2003, p.29)."
- **Excess inventory** can be found in raw material, work-in-process (WIP), or finished goods. It causes longer lead-times since every item has to wait in inventory until every preceding item has been processed. Furthermore, inventory has to be stored and transported, which is costly and may damage the products. Inventory also hides issues such as an unleveled production line (Liker 2003).
- **Unnecessary transport or conveyance** happens when raw material, work in process (WIP), or finished goods are being moved, sometimes over long distances, between process steps or into and out of storage (Liker 2003).

- **Unnecessary movement** performed by employees is considered waste when their activity involves long walking, searching for tools and reaching for parts to perform a task (Liker 2003).
- **Overprocessing or incorrect processing** describes inefficiencies in a process, which can occur *"…Due to poor tools and product design* (Liker 2003, p.29)." Waste also occurs when the product or service is of higher quality than necessary.
- **Waiting (time on hand)** by the employees who only watch automated machines or who have to wait to perform their task due to machine breakdown, stock outs, processing delays, or capacity bottlenecks (Liker 2003).
- **Defects** that need to be reworked or repaired and require additional handling, delays, and effort (Liker 2003).

Besides these original definitions of the seven types of waste different other authors and practitioners added other types of waste to emphasize certain observations made during Lean research and application. Liker (2003), for example, added unused employee creativity as not engaging or listening to employees leads to a loss of "*…Time, ideas, skills, improvements and learning opportunities…* (Liker 2003, p.29)." Emiliani (1998), another author, added the waste that occurs through repeated mistakes as an organization that is unable to learn from its mistakes and continuously improve will have issues to maintain its competitiveness (Czabke et al. 2008).

The identification and elimination of these different types of waste and the application in different industries have been proven successful for the strive to continuously improve the business performance, as plenty of examples show.

2.1.5. Examples of Lean Implementation

Lean has its origin in the production area of an automobile manufacturer (Toyota) and has been applied by countless manufacturing companies. Today, all major car manufacturers have developed their own productions systems that share similarities with the TPS and the Lean approach. For example, Volkswagen, Europe's largest car manufacturer, writes in its 2008 annual report that a group-wide production system is supposed to be developed to increase the company's efficiency by focusing on processes, standardization, and workflow to ultimately become a *"…Self-learning organization* (Volkswagen AG 2009)" through the implementation of a continuous improvement process and the elimination of waste. Another example is the global corporation of Nissan and Renault. Renault developed the Renault Production System (RPS), which borrows elements *"…Extensively from the Nissan Production Way* (Renault 2009)." Its fundamental goal is to eliminate waste throughout their operations and to use best practices from within the organization to improve their operations and to increase their competitiveness in the global market (Hidetoshi 2008).

Besides manufacturers, other industries have discovered the Lean approach and applied it to their operations. The Virginia Mason Medical Center in Seattle, WA, for example, developed the Virginia Mason Production System (VMPS), which is a management method that aims for zero defects in health care related work by continuously improving its processes. The VMPS is

based on the Toyota Production System (TPS) and was fully integrated by Virginia Mason by 2002 (Virginia Mason Medical Center 2008).

Another example is Flinders Medical Centre, a general hospital in Adelaide, Australia, which offers a *"…Complete range of secondary and tertiary services for a population of around 300,000* (Ben-Tovim et al. 2007, p.11)." The emergency department sees about 50,000 patients per year, 40 percent (20,000 patients) of whom require hospital admission. Over the years, the Flinders Medical Centre has had growing difficulties to provide sufficient service for the population served which ultimately lead to a point where the safety of care in the emergency department could not be fully ensured anymore. After a period of orientation, the hospital board decided to transform their hospital organization using the principles and methods of Lean. Applying the first principle of Lean a *"…Large interdisciplinary group of emergency department staff* (Ben-Tovim et al. 2007, p.12)" value stream mapped the patients' process through the emergency department, starting with arrival of the patients and ending with their exit. This step created a collective awareness about issues within the hospital's emergency treatment process among all participants and, based on that shared understanding, a future state map was developed. By November 2003 a new, improved patient emergency room treatment process was implemented, consisting of the following main aspects: Two main process streams were set up according to two main patient families: "*Likely to go home*" and "*Likely to be admitted to hospital* (Ben-Tovim et al. 2007)" The activities of these two process streams were aligned with a separate team of nurses and doctors in specific areas of the hospital. Also, patients are being seen according to their order of arrival if a threat of life is absent. These changes created the patient stream to "flow," reducing the average time a

patient spends in the emergency department by 48 minutes (13 percent reduction, Ben-Tovim et al. 2007). In addition, the amount of patients that did not wait until they were seen by a doctor and thus did not complete their care shrank by 50 percent. After this instant success of implementing Lean in the hospital's emergency department, Lean efforts were extended to the entire hospital (Ben-Tovim et al. 2007).

Lockheed Martin Aeronautics Sector (LMAS), headquartered in Fort Worth, Texas, is another example who used Lean for drastic business performance improvements. LMAS started its Lean initiative in the late 1990's and first focused on the shop floor. At that time, the company was facing the necessity to seriously lower their costs of operation to increase the company's competitiveness, customer satisfaction, and the quality of their products (Kandebo 1999). Around the same time, British Aerospace, a strong competitor to LMAS, headquartered in Great Britain, also focused on re-engineering their entire businesses and applying Lean principles (Cook and Nick 1999), which made it even more important for LMAS to improve their operational performance. Before the first improvements were implemented, the majority of the company's employees and the management team went through an intensive training period with regards to basic Lean principles, methods, and applications. Support of Lean by all levels of managers is important for the overall success of the Lean transformation (Kandebo 1999). Thus, about 75 percent of the senior staff positions *"…Have changed here since February 1997* (Kandebo 1999)" as executive vice president and chief operating officer Terry A. Graham at that time said. After the training and with the support of experienced consultants, manufacturing cell layouts were adjusted to produce items in a single-piece-flow setup, the work environment for workers was improved to reduce effort needed to perform a task, and

numerous other waste reduction ideas were implemented. The results from the shop floor transformation efforts at LMAS were impressive: space requirements in cells was reduced by 73 percent, distance of parts transported shrank by 94 percent, work-in-process was reduced by 99 percent, direct labor needed was cut by 45 percent, and defects that occurred during the manufacturing process were cut by 50 percent (Kandebo 1999). As a result, several million Dollars were saved as a result of the Lean initiative on the shop floor.

Additionally, after witnessing the success of implementing Lean principles on the shop floor at LMAS, Lean efforts were extended throughout all business areas. The outcomes from these efforts resulted in large reductions in overall lead-time, mainly through simplifying processes. For example, a drawing for a particular product to be released took, on average, 64 days prior to the Lean efforts. After evaluating the process and implementation, the lead time was reduced to 17 days, mainly through a reduction of sign-off parties and the reduction of rework loops. According to participants a *"…Shift in the company's culture…"* (Kandebo 1999) happened, something that is critically important for a sustainable, long-term implementation of Lean.

The Starbucks Corp., based in Seattle, WA, is known for its coffee stores around the world serving different kind of Italian style espresso beverages, pastries and coffee-related accessories (Starbucks 2010). Due to the current recession and growing competition from McDonalds Corp. and Dunkin' Brands Inc., Starbucks Corp. perceived the need to improve the overall efficiencies of their serving processes to *"…free up time for the baristas…* (Jargon 2009)" to increase the number of customers being served, to decrease the chance of customers leaving

the store due to long waiting times (resulting in missed sales), or to serve the same amount of customers with less employees. Starbucks Corp. assembled a 10-person '*Lean team*' to support single branches to improve their processes by applying Lean principles and methods. Analyses of in-store processes showed that thirty percent of a barista's time is spent with motion, such as walking, reaching, and bending while preparing the drink for the customer. A complete redesign of the process reduced the wasted motion to a minimum. For example, the different ingredients, such as syrup, flavors, and whipped cream were relocated for better accessibility. Additionally, the beverage preparation process was reorganized in a flow and bottlenecks were eliminated, which reduced the lead-time of the process. Among other things, results from these efforts took Starbucks' performance from a net loss of $6.7 million in the year before implementing the improvements to net earnings of $151.5 million the following year, while overall operating costs were reduced by $ 175 million (Jargon 2009).

The public sector has discovered Lean to improve *"…Efficiency of government operations* (Scorsone 2008, p.61)," as well. Due to announced efficiency and improvement targets in recent years for a wide range of public institutions and agencies (Eustice 2009), an increasing number of public-sector leaders are interested in the Lean approach (Bhatia and Drew, 2006). Additionally, the current economic recession caused tax revenues to stagnate or shrink, so that cost reductions of government's operations become increasingly important (Scorsone 2008). The city of Grand Rapids, MI, for example, started a Lean initiative in 2005 to be able to handle the same or even growing amounts of work with *"…A much smaller workforce* (Scorsone 2008, p.61)." A Lean team, led by the deputy city manager and consisting of employees working in different functional areas, was set up. Top-level approval and commitment was achieved and

an external coach was hired to help the city of Grand Rapids to get started (Drickhamer 2008). After initial trainings regarding Lean topics, the teams started to map value streams. Employees were trained by the external coach to perform trainings and workshops independently over time (Drickhamer 2008). Three initial value streams were identified and included the material return process at the public library, the purchasing process, and the engineering design process. The improvements resulted in significantly reduced lead-times, decreased rework and other types of waste, and an increased level of quality provided (Drickhamer 2008).

The best-known effort to implement Lean principles in the wood industry in the US has been undertaken by Merillat Industries, a manufacturer of kitchen cabinets, in 1998: In 2003 their manufacturing plant in Atkins, Virginia, was awarded the Shingo Price for Excellence in Manufacturing (Virginia's aCorridor n.d.). The Shingo Prize is awarded to companies that achieve *"…World-class operational excellence status…* (The Shingo Prize 2008)". During Merillat's Lean journey, the company reduced overall lead time from five days to 17 hours, reduced work-in-process by 80 percent, increased product quality by 66 percent, and achieved on-time delivery of 99.7 percent (Virginia's aCorridor n.d.).

Implementing and sustaining Lean principles isn't easy. Companies have struggled with the concept, and numerous companies have failed. Difficulties and obstacles come from a wide range of sources and only the determination of the organizations' leaders allows them to be overcome and reap the rewards of successful Lean implementations.

2.1.6. **Difficulties and Obstacles**

Even though numerous companies and institutions have implemented Lean principles, James P. Womack, the founder of the Lean Enterprise Institute and co-author of the widely read books "*The Machine that Changed the World* (Womack et al. 1990)" and "Lean Thinking (Womack and Jones 2003)", recently expressed his concerns regarding the current Lean movement being a '*Tool Age*' rather than focusing on Lean management (Womack 2007). Most of the organizations practicing Lean emphasize tools, such as kanban, kaizen, five why's, 5S, or others. This is understandable *"Given the magnitude of the tasks and its many dimensions…* (Womack 2007, p.4)." Tools are convenient since they can be applied to any part of the organization in an isolated way without challenging the organization itself. However, according to Womack (Womack 2007), a change in organizational culture is required to obtain the full potential of Lean management (Womack 2007). Liker (2003) in fact addressed a similar concern in his book 'The Toyota Way'. He states that a successful Lean transformation is *"…More than a few concepts, tools, and initiatives…* (Liker 2003)." Success in creating a Lean culture depends on employees getting actively involved and being allowed to practice the application of Lean in frequent trainings and their every-day tasks. Also, employee training should not be limited to shop floor employees only. Rather, leaders and managers from all aspects of the organization need to be coaches and teachers to all members of their teams to continuously improve the skills of their employees (Hogan 2009).

For example, involving all team members in its Lean transformation efforts was an initial issue at Lockheed Martin Aeronautical Systems (LMAS) during the early stages. Its senior staff level was reluctant to teach their lower level employees. Therefore, the initial Lean effort

floundered. As a consequence, about 75 percent of the senior level positions were substituted with managers willing and able to teach their team members in the proper use of Lean. After this reorganization, training became *"…A big part of the company's push towards Lean…"* (Kandebo 1999). Selected senior managers now serve as a training group to teach Lean to other managers. These activities had a large impact on the company's culture (Kandebo 1999).

2.1.7. Summary

Lean principles and ideas can produce remarkable successes when applied and implemented properly. Lean principles and ideas are not limited to any specific industry. Basically all kinds of industries can benefit from Lean by reducing waste and improving their processes to improve their competitiveness. However, compared to other industries and economic sectors, the U.S. wood industry does not seem to adopt the Lean as quickly and easily, even though *"…Many of the wood industry issues could be improved…* (Pirraglia et al. 2009)" by implementing Lean.

2.2. The U.S. Wood Products Industry

Sub-Chapter 2.2 defines the U.S. wood products industry and provides an overview of the industry's economic importance to the U.S. and Virginia's economy.

2.2.1. General Definition

Traditionally, the wood industry is being grouped into two categories: the primary and the secondary wood industry (Buehlmann 2009, Quesada and Gazo 2006). According to this view, companies in the primary industry sector are involved in extracting and collecting wood fibers in the form of logs, cants, or chips, and turning them into primary products. This includes, but is not restricted to, lumber, plywood, and veneer (Smith et al. 2009). Companies in the

secondary wood industry, according to the traditional view discussed here, generally use the output of companies in the primary industry and manufacture finished products. Examples include, but are not restricted to, furniture, windows, doors, and kitchen cabinets (Mark Smith et al. 2009).

The North American Industry Classification System (NAICS) provides another, independent classification of the North American wood industry (U.S. Census Bureau 2009a, U.S. Census Bureau 2009b). The North American Industry Classification System (NAICS) is "…*The standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy* (U.S. Census Bureau 2010)." NAICS is a hierarchical classification system with five levels of detail, two-digits (for example, 31-33 defines "*manufacturing*") being the broadest category describing the economic sector and six-digits (for example, 321214 defines "*truss manufacturing*") being the most detailed category (U.S. Census Bureau 2009c). The wood products manufacturing industry is described in two NAICS categories: NAICS 321 and NAICS 337. NAICS 321 "*Wood Product Manufacturing*" includes the subcategories "*Sawmills and Wood Preservation* (NAICS 3211)", "*Veneer, Plywood, and Engineered Wood Product Manufacturing* (NAICS 3212)" and "*Other Wood Product Manufacturing* (NAICS 3219)" which includes windows, flooring and pallets (U.S. Census Bureau 2009a). The second NAICS category dealing with the wood products industry is NAICS code 337, named "*Furniture Manufacturing*" and consisting of the subcategories "*household and institutional furniture and kitchen cabinet manufacturing* (NAICS 3371)", "*office furniture (including fixtures) manufacturing* (NAICS 3372)", and "*other furniture*

related product manufacturing (NAICS 3379)", such as mattress and blinds manufacturing (U.S. Census Bureau 2009b). Figure 4 provides an overview of the two NAICS classifications.

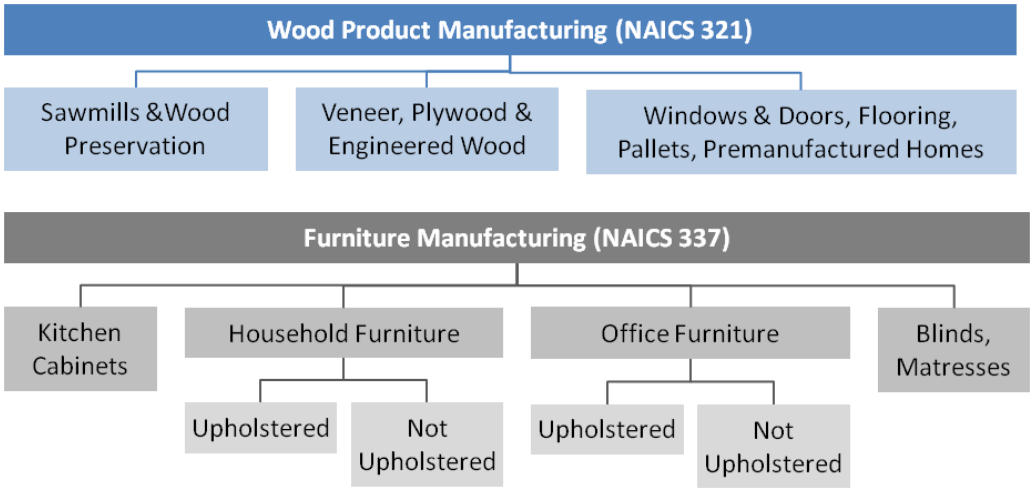

Figure 4: Overview of the wood industry according to the North American Industry Classification System (NAICS, Adapted from U.S. Census Bureau 2009a, U.S. Census Bureau 2009b)

2.2.2. Overview of the wood industry in North America

In 2007, there were 14,862 wood product manufacturing establishments (NAICS 321) in the U.S. employing 519,651 people. The overall sales[1] volume was roughly $100 billion (U.S. Census Bureau 2009a). These numbers account for about five percent of all establishments, four percent of all employees and roughly two percent of all sales of all U.S. manufacturing industries (NAICS 31-33, U.S. Census Bureau 2010). Large numbers of wood product manufacturing establishments (NAICS 321) are located in California, Pennsylvania, North Carolina, and Texas (U.S. Census Bureau 2009a). Figure 5 provides an overview of the number of establishments per state (Adapted from U.S. Census Bureau 2009a).

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[1] In this paper "sales" describes what the U.S. Census Bureau calls "sales, shipments, receipts, revenue, or business done"

[2] The original term 'revenue' used by IBIS World Inc. was changed into 'sales' to be consistent with the

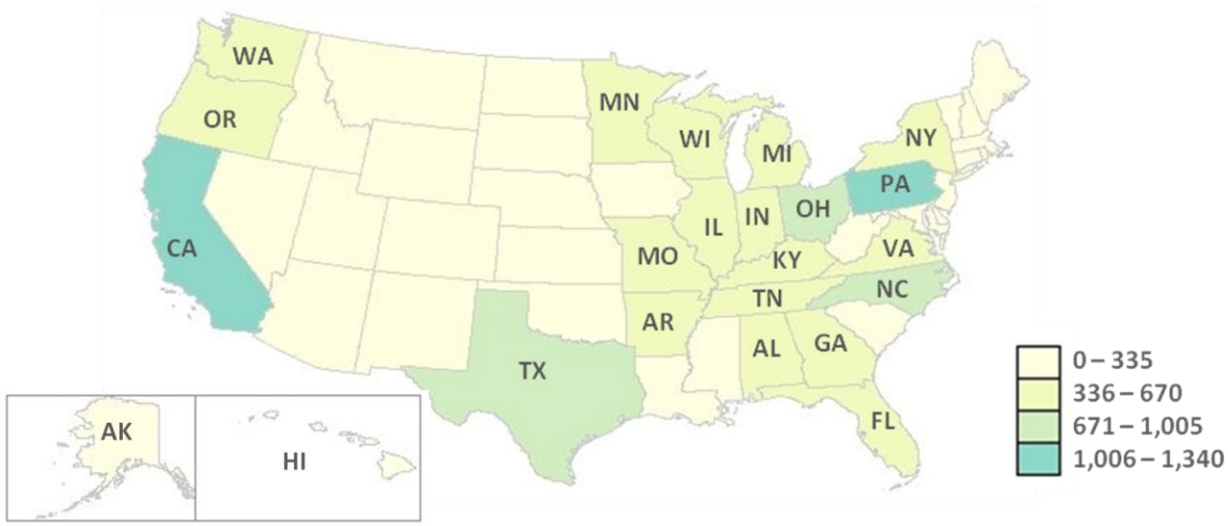

Figure 5: Number of establishments in the wood product manufacturing industry (NAICS 321) by state (adapted from U.S. Census Bureau 2009a).

In 2007, the U.S. furniture manufacturing industry, classified under NAICS 337, consisted of 18,174 establishments that employed 500,230 people. The overall sales volume was approximately $83 billion (U.S. Census Bureau 2009b). The furniture manufacturing industry segment (NAICS 337) accounts for about six percent of all U.S. manufacturing establishments, four percent of all employees and less than two percent of sales of all U.S. manufacturing industries (U.S. Census Bureau 2010).

Large numbers of establishments classified under NAICS 337 are located in California, Texas, Florida, North Carolina, Pennsylvania, Ohio, Illinois, and New York. Figure 6 provides an overview of the number of establishments classified in NAICS 337 per state (Adapted from U.S. Census Bureau 2009a).

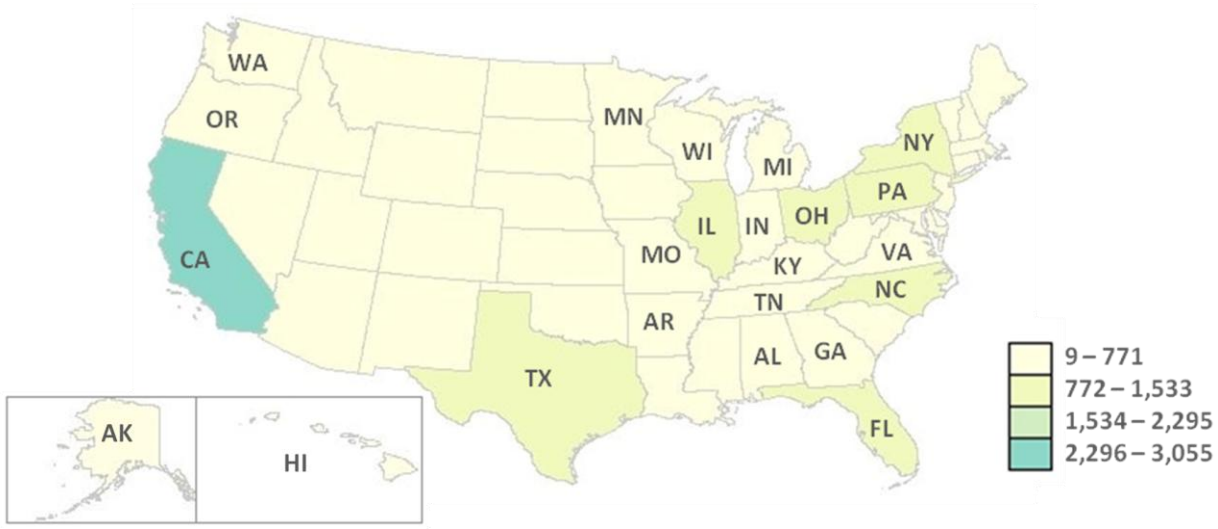

Figure 6: Number of establishments in the furniture manufacturing industry (NAICS 337) per state (Adapted from U.S. Census Bureau 2009b)

Among both, wood product (NAICS 321) and furniture manufacturing (NAICS 337) industries, "*sawmills and wood preservation* (NAICS 32111)" accounted for the largest amount of sales, followed by "*millwork* (NAICS 32191)," "*wood paneling manufacturing* (NAICS 32121)," and "*household furniture manufacturing* (NAICS 33712)." Table 2 gives an overview of selected industry segments of the wood product and furniture manufacturing industry in 2009 regarding sales[2], employment and number of establishments.

[2] The original term 'revenue' used by IBIS World Inc. was changed into 'sales' to be consistent with the terminology used in this text.

Table 2: Data estimates of 2009 for selected sectors of the wood products (NAICS 321) and furniture (NAICS 337) manufacturing industry in the U.S., sorted by sales (Adapted from (IBIS 2009b, IBIS 2010c, IBIS 2010a, IBIS 2009, IBIS 2010b, IBIS 2010b, IBIS 2010a, IBIS 2009a)

Industry	Industry Sector	Sales [mil. $]	Employment	Number of Establishments
Wood Products Manufacturing (NAICS 321)	32111 Sawmills & Wood Production	29,199	95,372	3,859
	32191 Millwork	26,100	143,539	4,294
	32121 Wood Paneling Manufacturing	22,329	100,423	1,632
	32199a Prefabricated Home Manufacturing	8,129	50,190	965
	32192 Wood Pallets & Skids Production	7,487	54,306	2,800
Furniture Manufacturing (NAICS 337)	33712 Household Furniture Manufacturing	22,200	121,478	4,218
	33721 Office Furniture Manufacturing	20,662	117,213	3,203
	33711 Kitchen Cabinet Manufacturing	15,000	113,220	7,650

2.2.3. Overview of the Wood Industry in Virginia

In 2009, roughly 20 percent of all manufacturing entities in Virginia, a total of 1033 establishments, produce wood products (NAICS 321 and 337, Sheffler 2008). The wood industry is thus the largest manufacturing segment by number of establishments in the state (Sheffler 2008). Three industry segments comprise 85 percent of Virginia's wood industry establishments. These segments are (1) "*household and institutional furniture and kitchen cabinets manufacturing* (NAICS 3371)," (2) "*other wood products manufacturing* (NAICS 3219)" including "*millwork* (NAICS 32191)," "*wood container and pallet manufacturing* (NAICS 32192)," and "*all other wood product manufacturing* (NAICS 32199)," including "*manufactured home (mobile home) manufacturing* (NAICS 321991)" and "*prefabricated wood building manufacturing*(NAICS 321992)," and (3) "*sawmills and wood preservation* (NAICS 3211, Virginia Workforce Connection 2010)." Figure 7 displays the number of establishments by primary activity of wood products establishments in Virginia for 2009.

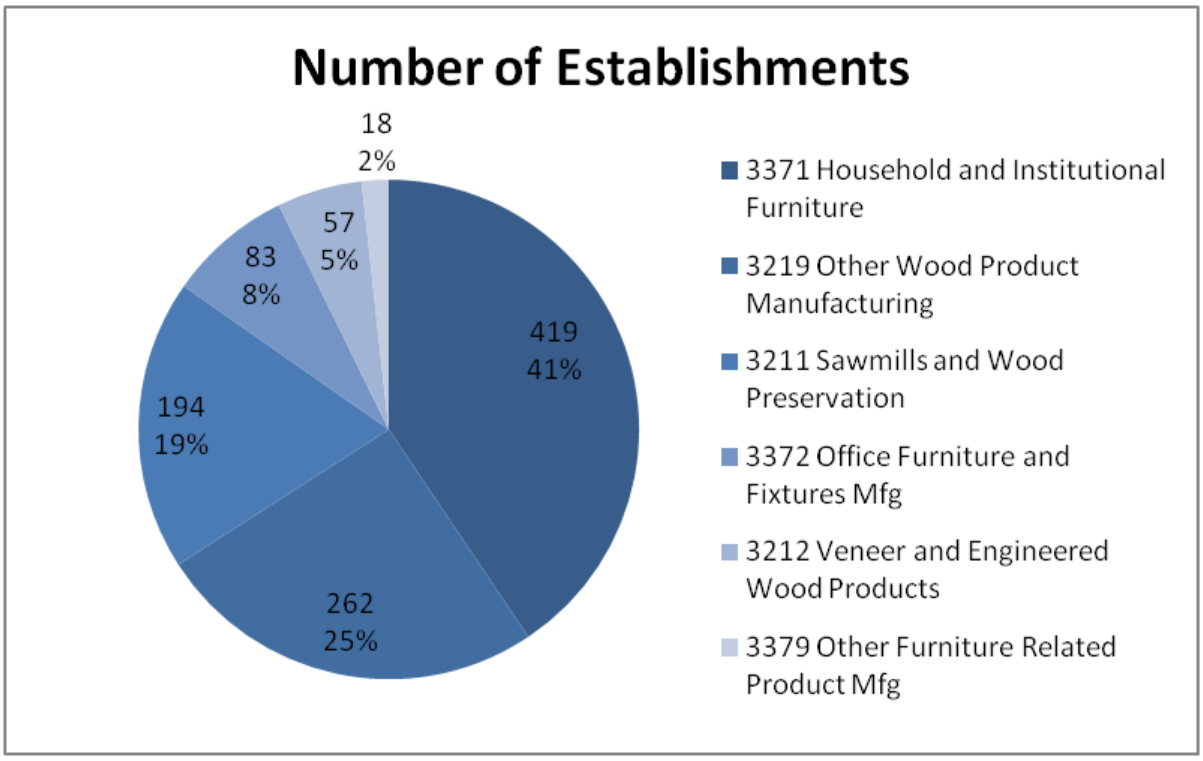

Figure 7: Number of establishments of wood industry segments in Virginia in the third quarter of 2009 (Adapted from Virginia Workforce Connection 2010)

In 2009, a total of 24,147 people were employed in the wood industry in the state of Virginia (Virginia Workforce Connection 2010). The same three industry segments, namely (1) "*household and institutional furniture and kitchen cabinets manufacturing* (NAICS 3371)", (2) "*other wood products manufacturing* (NAICS 3219), and (3) "*sawmills and wood preservation* (NAICS 3211)", that account for the majority of the establishments also employ the majority of the people (79 percent, Virginia Workforce Connection 2010). Figure 8 provides an overview of the employment in each of the wood industry segments discussed in Virginia.

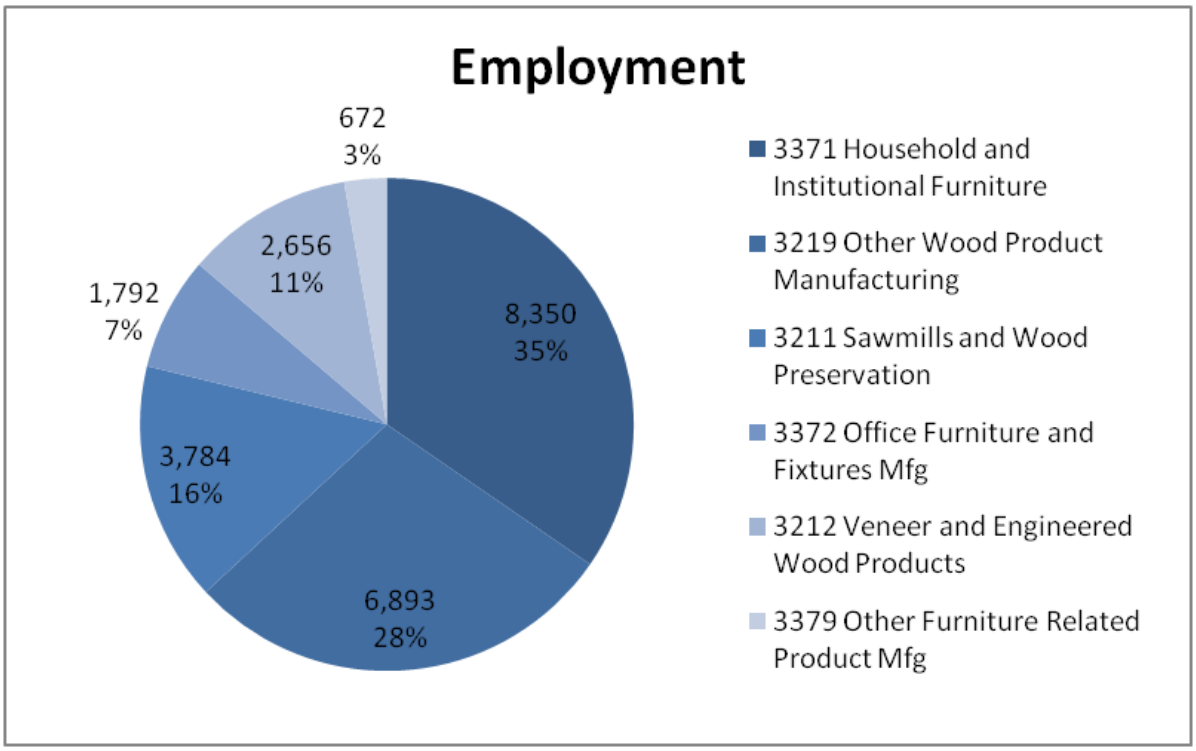

Figure 8: Employment in wood industry segments in Virginia in the third quarter of 2009 (Adapted from Virginia Workforce Connection 2010)

The establishments of the wood products manufacturing industry in Virginia tend to be spread over the entire state, whereas the establishments of the furniture manufacturing industry tend to be more located near metropolitan areas, such as Washington D.C., Richmond, Norfolk, and

Charlottesville. Figure 9 gives an overview of the location of wood industry entities by NAICS code (321 and 337, adapted from Sheffler 2008).

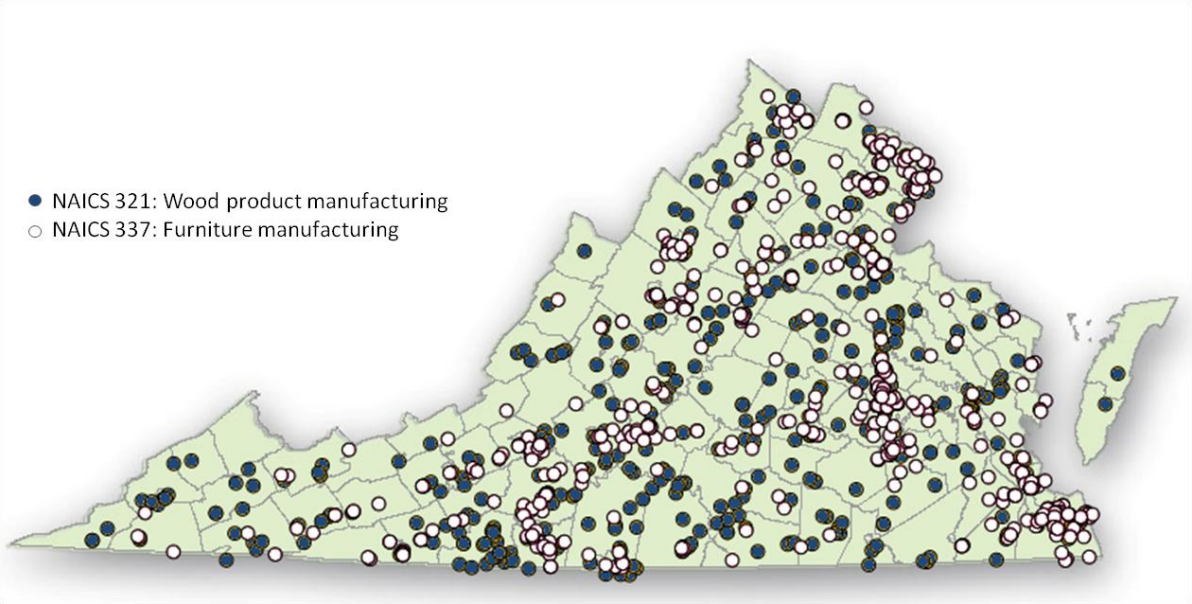

Figure 9: Map of Virginia showing establishments of wood product (NAICS 321, blue) and furniture manufacturing (NAICS 337, white) industry (adapted from Sheffler 2008)

2.3. Economic observations

Economies around the world have faced difficult conditions over the last few years due to the financial crisis (Wessel 2010, International Monetary Fund 2009, Dicks 2008). However, change in the U.S. economy is not only driven by the current economic upveal, but also by the ongoing globalization of economic activities (Buehlmann and Schuler 2002, Fishman 2005). Both events have a profound impact on the U.S. economy and the livelihood of the U.S. population.

2.3.1. Global Economy Affects the Wood Industry in the U.S.

Between 2003 and 2007 the U.S. economy was flourishing and adjusted Gross Domestic Product (GDP) grew continually (Anonymous 2010a, U.S. Census Bureau 2009d). However, this positive trend ended in 2007 as growth slowed and reversed eventually to become "…*The worst*

market crisis in 60 years (Soros 2008, p.1)." Between 2007 and 2010 the U.S. economy underwent a profound recession that deeply impacted the world economy (Wessel 2010, International Monetary Fund 2009, Dicks 2008). According to the U.S. Bureau of Economic Analysis (BEA 2010) the U.S. GDP stagnated around zero percent growth in 2008 and decreased by 2.6 percent in 2009. The slowdown was led by manufacturing, retail trade, and finance and insurance (Kim et al. 2009).

Annual investments in the residential construction sector between 2000 and 2005 accounted for roughly five percent of GDP in the United States (US Department of Commerce 2010). Annual net inputs from the residential construction sector contribute approximately 20 percent of the nation's GDP when rent payments, utilities, and furnishings are added to residential investments (Al Schuler and Adair, 2003). Beginning after 2006, the residential construction sector was impacted heavily by the recession of the U.S. economy induced by problems in the financial sector (Pendery 2009). Total new residential house construction peaked in 2005 at nearly 2.1 million units. This number plummeted by about 75 percent to 554,000 in 2009 (NAHB 2010). A similar trend can be witnessed in the prefabricated home manufacturing industry (NAICS 32199): From 2006's sales of $12.2 Billion the industry's sales volume dropped by about 33 percent to $8.1 Billion in 2009 (IBIS 2010b). Decreasing activity in new residential house construction impacted the wood product (NAICS 321) and furniture manufacturing (NAICS 337) industries severely. For example, the softwood lumber sawmilling industry (NAICS 32111), who supplies the raw material for housing construction, experienced drastic declines in consumption: From the peak in 2005 of 28.6 billion board feet of softwood lumber consumed, the consumption dropped to 6.9 billion board feet – a decline of about 75 percent within four

years (International Forest Industries 2009). Manufacturers of kitchen cabinets (NAICS 33711) experienced a decrease by about 28 percent, from $20.8 Billion in 2006 to $15.0 Billion in 2009 (IBIS 2010b, Anonymous 2010c).

Another industry heavily affected by the downturn of the economy is the office furniture industry (NAICS 33721): This industry experienced a drop in sales from $30.2 Billion in 2006 to $20.6 Billion in 2009, a decline of about 31 percent (IBIS 2010a). This development, however, did not happen unexpected since the office furniture industry relies on the well-being of companies and institutions (Miel 2010).

As an exception, the wood pallet and skids production (NAICS 32192) industry overall experienced growth of about seven percent between 2006 and 2009. One possible explanation is that unlike the majority of the previously mentioned industry categories, which heavily rely on the wellbeing of the U.S. housing market, companies in the wood pallets and skids production industry mainly supply non-wood related industries such as automotive manufacturing, aircraft manufacturing, and grocery industry (IBIS 2009a). In 2006, the multiple-use grocery (GMA style) pallets made up more than 70 percent of the sold pallets (Bush and Araman 2008). Ralph Rupert (2010), director of the Center for Unit Load Design at Virginia Polytechnic Institute and State University, confirmed that the grocery industry is the largest category of customers for the wood pallets and skids production industry. He added that it can be assumed that even during times of economic downturns people still have to purchase groceries and groceries still have to be transported and distributed to stores on pallets (Rupert 2010). Hence, the wood pallets and skids production industry is not affected by the economic

crisis. Figure 10 provides an overview over the development of sales in different wood related industries.

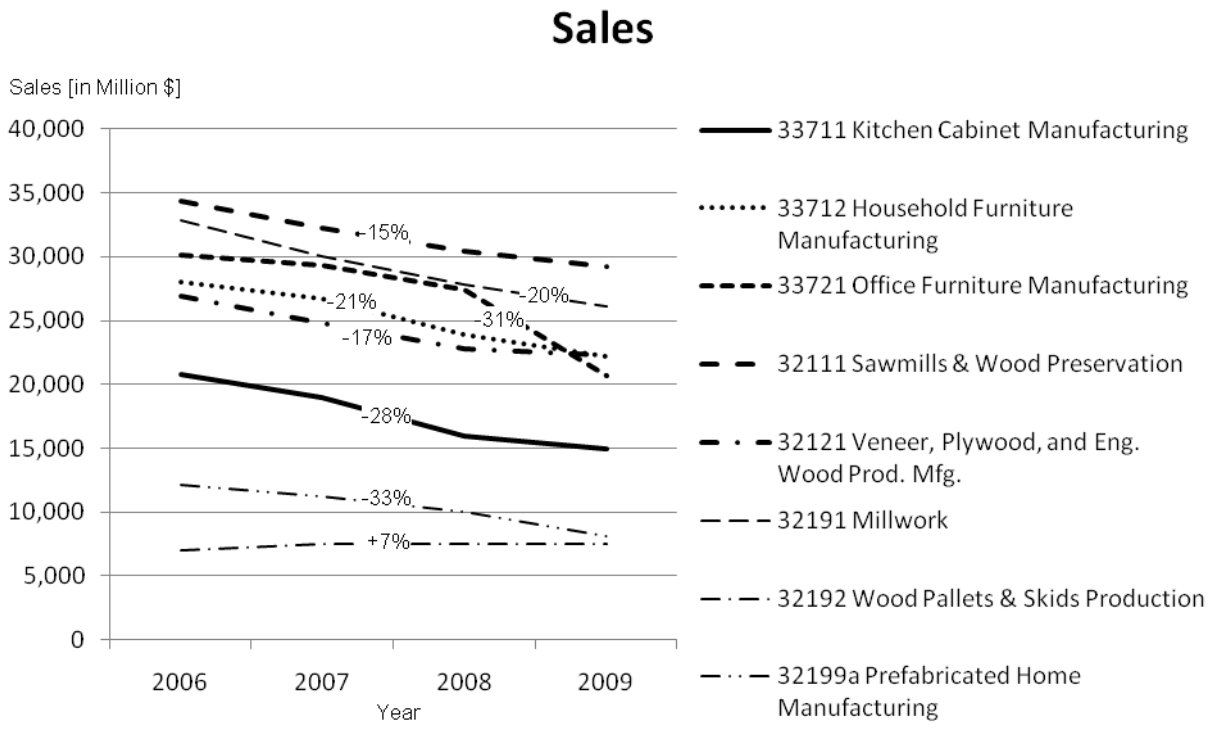

Figure 10: Overview of sales of different industries between 2006 and 2009 including total changes in percent (adapted from IBIS 2010a, IBIS 2010b, IBIS 2010a, IBIS 2010b, IBIS 2010c, IBIS 2009, IBIS 2009b, IBIS 2009a).

Some authors point out, that the well-being of industries is not only shaped by economic fortunes, but also by the ongoing globalization of trades (Buehlmann and Schuler 2002, Fishman 2005). For example, the U.S. household furniture industry (NAICS 337) is more strongly affected by the effect of global competition "*…Than the current economic slowdown* (Buehlmann and Schuler 2009, p.21)." Between 2000 and 2003, a large number of companies in the U.S. furniture industry experienced bankruptcy, closed operations, or relocationed to other countries. As a result, tens of thousands of jobs were cut in the U.S., while China had "…A*ggressively increased its share…* (Quesada and Gazo 2006, p.101)" of the U.S. retail furniture market after it joined the World Trade Organization in 2000 (Buehlmann and Schuler

2009). The peak of job cuts in the U.S. furniture industry was reached in 2001 when about 18,000 furniture employees lost their job. The decline in the value of shipments from the wood products and furniture industry from 2000 on also indicates the impact of globalization on U.S. wood products and furniture manufacturers (Quesada and Gazo 2006).

The decline of the U.S household furniture manufacturing industry (NAICS 337) has affected the wood products manufacturing industry, in particular the U.S. hardwood lumber industry (NAICS 3211). From the late 1990's to the late 2000's, hardwood lumber consumption by the U.S. furniture industry declined from about 2.5 billion board feet (BBF) to 1 BBF (Buehlmann and Schuler 2009). In line with this decrease in demand, the total production of U.S. hardwood lumber has fallen by about 25 percent from 14 to 10 BBF (Parhizkar et al. 2009). However, the decrease in hardwood lumber production is less than the decrease in consumption by the furniture industry, as new markets, particularly the usage of hardwood lumber for construction and remodeling, have taken up some slack. Furthermore, "…*Hardwood lumber exports have increased by 14 percent between 2002 and 2007* (Buehlmann and Schuler 2009, p.21)".

Most wood products related industries (NAICS 321, 337) in the U.S. experienced declining number of employment between 1996 and 2003. Quesada and Gazo (2006) point out that the wood product manufacturing industry (NAICS 321) experienced a decline in employment from 1999 and 2004 ranging between 8.9 percent (Millwork, NAICS 32191) and 35.2 percent (Manufactured and Mobile Homes, NAICS 321991, 321992). An exception was 'Engineered wood members and trusses (NAICS 321213, 321214),' which experienced an increase in employment by 5.4 percent between 1999 and 2004 (Quesada and Gazo 2006). This general

downward trend continued through 2009 ranging from about eight percent (Sawmills and Wood Preservation, NAICS 32111) to about 39 percent (Household Furniture Manufacturing, NAICS 33712) reductions in employment (IBIS 2010a, IBIS 2010b, IBIS 2009, IBIS 2010a, IBIS 2010b, IBIS 2010c, IBIS 2009a, IBIS 2009b). However, the "*wood pallet and skid production*" (NAICS 32192) industry experienced an overall increase in employment between 2006 and 2009 (IBIS 2009a), a similar trend as the increase in sales over the same time period. Thus, the same explanation can be assumed to be valid: Even during times of economic downturns people still have to purchase groceries and groceries still have to be transported and distributed to stores on pallets (Rupert 2010). Since the grocery industry is the largest buyer of pallets for the wood pallets and skids production industry companies in this industry are not affected by the economic crisis. Figure 11 provides an overview over the number of employment in selected wood related industries.

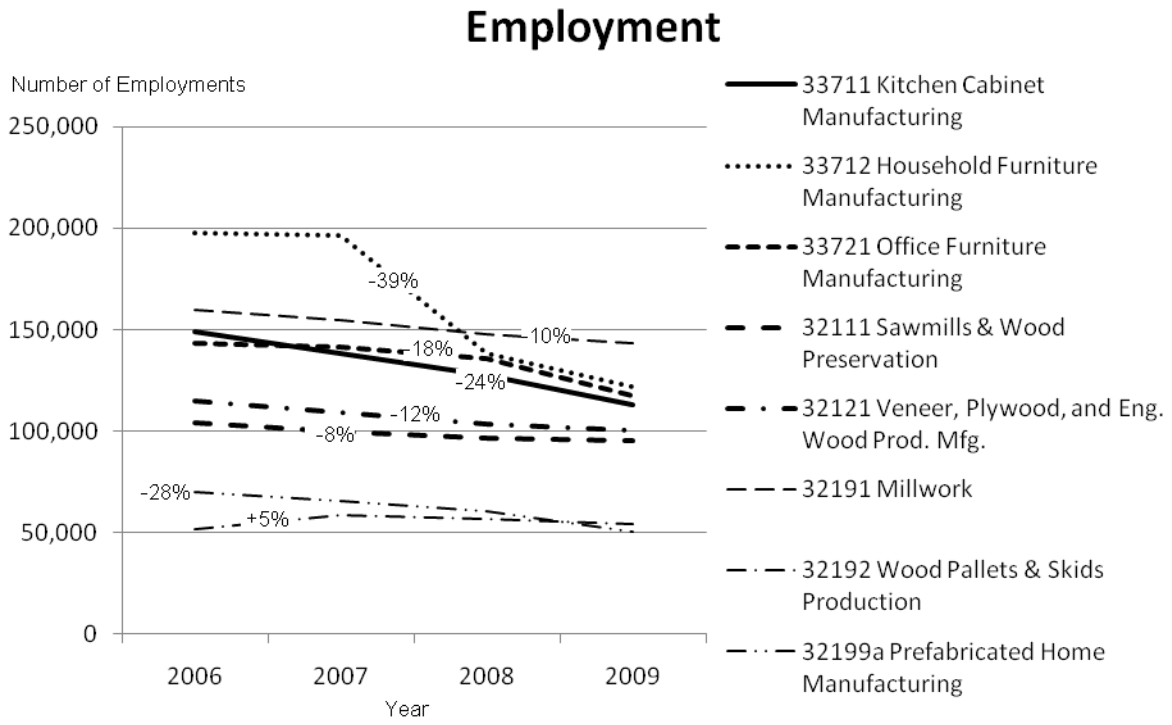

Figure 11: Overview of employment levels in different industries between 2006 and 2009 including total changes in percent (Adapted from (IBIS 2010c, IBIS 2010a, IBIS 2009, IBIS 2010b, IBIS 2010b, IBIS 2010a).

An increased number of plant closures occurred between 2000 and 2003, mainly due to financial difficulties and reorganizations (Quesada and Gazo 2006). A total of 142 plant sites were closed in the wood product industry (NAICS 321). The state with the highest number of plant closures was North Carolina (25) while Virginia experienced 3 plant closures between 1999 and 2004 (Quesada and Gazo, 2006). In this period (1999 to 2004), the U.S. furniture manufacturing sector (NAICS 337) experienced a total of 168 plant sites closures. The state with the largest amount of plant closures was North Carolina (73), followed by Virginia with 15 plant closures (Quesada and Gazo, 2006). This general trend continued through 2009. Particularly the "*household furniture manufacturing*" (NAICS 33712) industry was affected by a 37 percent reduction in number of establishments between 2006 and 2009 (IBIS 2010a). Figure

12 provides an overview over the number of establishments in selected wood related industries.

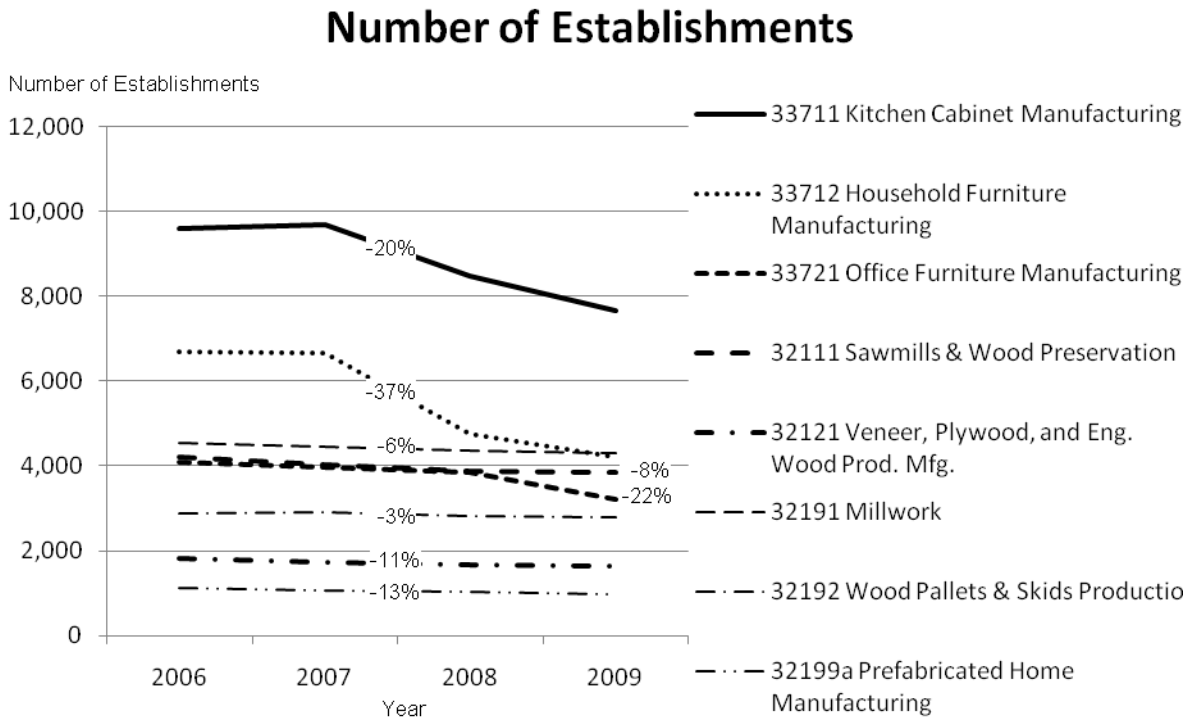

Figure 12: Overview of number of establishments in different industries between 2006 and 2009 including total changes in percent (Adapted from (IBIS 2010c, IBIS 2010a, IBIS 2009, IBIS 2010b, IBIS 2010b, IBIS 2010a).

After several years with a negative trend for these industries, experts expect a modest recovery of the housing market during 2010, which will hopefully impact the wood product (NAICS 321) and furniture (NAICS 337) industries positively (Anonymous 2010c, Anonymous 2010b).

2.3.2. **Virginia's Wood Industry**

Increasing global competition and the current economic situation have impacted Virginia's wood product industry as it impacted the U.S. industry. From 2007 to the beginning of 2010, a total of 3646 jobs were lost in the wood product manufacturing (NAICS 321) and the furniture

(NAICS 337) industry in Virginia. These job losses were the result of closures, reductions, or layoffs (Virginia Economic Development Partnership 2010b).

In the period from 2007 to the beginning of 2010, Virginia's wood product manufacturing industry (NAICS 321) experienced six facility closures with a total of 465 jobs lost, and one layoff with 25 employees losing their jobs. The furniture manufacturing industry (NAICS 337) experienced nine facility closures with a total of 1631 jobs lost and eight reductions with 1525 employees losing their jobs (Virginia Economic Development Partnership 2010b).

On prominent example is Stanley Furniture Co., a furniture company headquartered in Stanleytown, VA. After successful years between 2000 and 2004 with record sales in the fourth quarter of 2004 (Adams 2005), the company appeared in the press quite frequently in the second half of this decade regarding layoffs and closures of manufacturing plants in Virginia and North Carolina. It started in 2007, when Stanley Furniture Co. announced the closure of its Virginia facility in Martinsville and the overall cut of 250 jobs as an adjustment to the declining demand for its furniture (Craver 2007). Following in 2008, despite the assurance in 2007 that its plant in Lexington, NC will not be affected by consolidations (Craver 2007) Stanley Furniture Co. announced the closure of its North Carolina factory, 350 employees were affected (Anonymous 2008). In 2009, another 100 employees were laid off in Stanley's Stanleytown facility to further adjust to the decline in sales (Adams 2009). And, most recently, Stanley announced the closure of its Stanleytown facility by the end of 2010 as a result of the length and the depth of the recession (WSLS 2010). Stanley's CEO, Glenn Prillaman, explained that the

manufacturing of its Stanley furniture is being outsourced to "*…Several strategic offshore vendors…* (WSLS 2010)". As a result, 530 jobs will be lost (WSLS 2010).

Another example of the effect of the current economic turmoil is Chesapeake Hardwood Products Inc., a producer of plywood used for cabinets, interior, and commercial applications. Chesapeake hardwood products, Inc. closed its plywood plant in Chesapeake, VA in August 2008 after losing money for more than two years. A total of 129 employees were laid off. The company explained this decision with the downturn in the home building sectors (Shean 2008).

Lumber production in Virginia was negatively affected by the difficult economic climate, as well. The amount of hardwood and softwood lumber produced in Virginia decreased between 2006 and 2008 from 1,5 million board feet in 2006 to 1,3 million board feet in 2008. Both hardwood and softwood lumber production were affected similarly (U.S. Census Bureau 2009).

However, positive stories exist, as well. According to Virginia Economic Development Partnership announcements, 2,158 new jobs in the wood industry through investments in existing facilities or new facilities were made between January 2007 and the beginning of 2010. The wood product manufacturing industry (NAICS 321) announced 287 new jobs, 162 of those through three new facilities. In the furniture manufacturing industry (NAICS 337), a total of 1875 new jobs were announced (Virginia Economic Development Partnership 2010a).

One prominent example for employment creation is IKEA's $85 million investment in Danville, VA (Kantor 2006), a city that has lost several thousand jobs in the tobacco, textile, and furniture industry between 2003 and 2006. In 2008, Swedwood North America, a subsidiary of IKEA, opened the company's first fully owned manufacturing facility in the U.S. (Hughes 2008).

Among the reasons for IKEA's decision to invest in Danville were the increasing energy and transportation costs since 2000, forcing IKEA to produce furniture near their markets to cut on transportation costs (BBCWorldNewsAmerica 2008). IKEA agreed to employ 270 people by 2011, and to increase its total employment to 740 employees over the following years (Kantor 2006). In 2008, another IKEA-supplier, Com.40, announced the plans to build a new plant near Danville that would bring 813 additional jobs to the area (Hughes 2008).

2.4. Support Organizations

This chapter discusses various organizations providing support to other entities in respect to Lean implementation. Independent from the support organizations' focus and approach, the overall goal of these organizations is to provide a product and/or service that support third parties in improving their operations for increased competitiveness in a global economy.

First, a brief review of known support organizations is given and their support models and results are discussed. Particularly, the focus is on Lean implementation efforts and the involvement of students in the support process. However, for completeness and to capture other successful support models, other support organizations are discussed as well.

2.4.1. How Do Organizations Support Other Business Entities?

Various Lean support organizations exist throughout the U.S. and around the world focusing on different improvement areas using different support models. Their individual approach is equally diverse. Broadly categorizing, there are three different approaches used to provide support: Training, coaching, and consulting. These three approaches are not always clearly delineated and some terms tend to be used interchangeably. For the purpose of a clear

understanding and usage throughout this thesis the following paragraphs provide a brief definition.

2.4.1.1. Training

Wikipedia (2010c) describes training as a way to acquire *"…Knowledge, skills and competencies as a result of the teaching of vocational or practical skills and knowledge that relate to specific useful competencies* (Wikipedia 2010c)." Gottlieb (2010) gives another insightful definition by stating: *"Training programs are based on the acquisition of certain learning objectives as set out by the trainer or instructor* (Gottlieb 2010)".

2.4.1.2. Coaching and Consulting

The terms coaching and consulting seem to be used interchangeably. In fact, there is a fine line between these two terms (Gottlieb 2010) and sometimes an overlapping of activities can be observed (Desertcoach 2010). However, there are definitions that well distinguish the meaning of both terms. For example, consulting is described as the activity involved in diagnosing problems and proposing (and sometimes implementing) solutions (CyninMN 2010). Coaching on the other hand is described as enabling individuals or team to generate "*…Their own solution* (CyninMN 2010)". Gottlieb (2010) states that "*Consulting is about the work, coaching is about the person doing the work* (Gottlieb 2010)." Wikipedia (2010b) defines the consultant as a professional that provides expert advice in a specific field (Wikipedia 2010b), whereas coaching is described as the "*…Activity of a coach in developing the abilities of the person getting coached* (Wikipedia 2010a)" to perform certain tasks on their own. The definition of the International Coach Federation (ICF) is consistent with the previous definition, stating that

coaching is the *"…Partnering with clients in a thought-provoking and creative process that inspires them to maximize their personal and professional potential. Coaching honors the client as the expert in his/her life and work and believes that every client is creative, resourceful, and whole* (International Coach Federation 2010)."

However, at times a coach is "…*Asked to consult about an idea*…(Desertcoach 2010)" and bring in his expertise and solve certain problems. Also, in certain situations the consultant will "…*Ask questions that lead to reflections*… (Desertcoach 2010)" which would fall more under the coaching profession. Krawitz (2010) confirms that the coach or the consultant is likely to perform *"…Both roles* (Krawitz 2010)."

2.4.2. **Examples of Activities Undertaken by Support Organizations**

As pointed out above, this review includes examples of support organizations that do not necessarily focus on Lean but on other matters. Such organizations may have a business model that potentially can be highly useful for companies focusing on supporting the implementation of Lean. The Small and Medium Enterprise Institute LLC is a case in point. Small and medium-sized enterprises (SME) often require more support from third parties than larger organizations since their internal resources are limited (Kotey and Folker 2007, Greenwood et al. 2002). The Small and Medium Enterprise Institute LLC serves as a globally operating association for stakeholders in SME finance, such as fund managers, investors, and entrepreneurs. The organization identifies best practices, provides training and networking opportunities, defines and improves standards, and *"…Promotes supportive legal and regulatory environments"* (SME institute 2009). Customers targeted are growth-oriented entrepreneurs of companies with

annual sales between $0.1 and $5 Mio. The institute offers a forum once a year and organizes one- or two-day workshops and seminars suited to the needs of stakeholders involved in SME finance for different countries and regions (SME institute 2009).

Another example worthwhile of reviewing as a successful support organization is the Idaho Small Business Development Center (Idaho SBDC). The Idaho SBDC is a university-based organization that provides free consulting and low-cost training to small businesses and entrepreneurs starting and growing a business in Idaho (SBDC Idaho 2010b). The Idaho SBDC was founded in 1986 and has six office locations throughout the state of Idaho, which are all affiliated with a local college or university. Idaho SBDC's goal is to support small business owners and entrepreneurs in making the right business decisions (SBDC Idaho 2010a). One noteworthy aspect of the Idaho SBDC is the linkage between higher education, private businesses, and government organizations. For example, the Idaho SBDC office located at Boise State University offers no-cost energy evaluations to small businesses. This service is funded by the U.S. Small Business Administration and is being performed by students of various disciplines, including business, engineering, construction management, and environmental health and science. These students are trained to *"…Analyze utility bills and complete on-site energy evaluations* (IBR 2009)." Idaho SBDC's energy evaluation service is expected to be expanded to other regions of Idaho. In 2009, the Idaho SBDC located at North Idaho College was selected by the U.S. Small Business Administration to be one of the top 10 performing regional offices in the nation with respect to the results due to the coaching and training services (IBR 2010). The center is run with one full-time and three part-time staff members. Additionally, executives from larger businesses and business owners offer voluntary help as

business coaches. Overall, 330 clients were served in 2009, 109 jobs were saved, 144 new jobs were created and the clienteles' revenue was increased by $9.7 million (IBR 2010).

2.4.3. Examples of Lean Related Support Organizations

Probably the largest network of support organizations for Lean implementation is the Lean Global Network (LGN). The LGN is a collaboration of 16 Lean affiliates located in as many countries helping *"…Individuals and organizations undertake Lean journeys and transformations"* (LGN 2009b). The network was chartered in 2007 as a response to the successes of Lean institutes in the U.S., Great Britain, and Brazil with the aim to create an international community of Lean thinkers (LGN 2009a). The LGN enables each affiliate organization, among other things, to learn from one another and to increase the diffusion of Lean knowledge around the globe, to create stronger connections and working relations among the affiliates across the globe, and to share best practices regarding Lean that suit the needs of different countries and industries (LGN 2009c). To make this global community work, each affiliate is required to share gained knowledge and experience within the network. More benefits include, for example, the preferred access to leading Lean experts, such as James P. Womack, Daniel T. Jones, and John Shook, exclusive rights to translate all affiliate-owned publications and learning materials, and technical support on how to run a successful Lean organization (LGN 2009c). Figure 13 shows the locations of all affiliates around the world.

Figure 13: The affiliated institutes of the Lean Global Network (Adapted from LGN, 2009a).

Each individual affiliate organization is expected to develop Lean knowledge through new research and translations, to distribute Lean knowledge with interested parties, and to build a community of *"…Lean practitioners and leaders to undertake Lean transformations within organizations* (LGN 2009a)." Affiliates rely on four core elements to achieve the goals: Summits and conferences are organized to create and increase Lean awareness and provide a networking platform for Lean practitioners, trainings and workshops and on-site coaching sessions are performed to provide organizations with help for a successful Lean transformation, publications and learning materials are provided, and research and development of new knowledge and best practices is performed (LGN 2009a).

Besides the LGN and its affiliates, numerous other organizations exist who promote Lean principles and help companies to improve their businesses through Lean transformations. For example, the University of Tennessee Center for Executive Education and its Tennessee Lean

Enterprise Center (TLEC) offer support for different industries with regards to Lean practices. According to its *"temple of success"*, the center's approach consists of four pillars: Train, do, study, and share (UT 2007). Figure 14 shows the "*temple of success*" by TLEC.

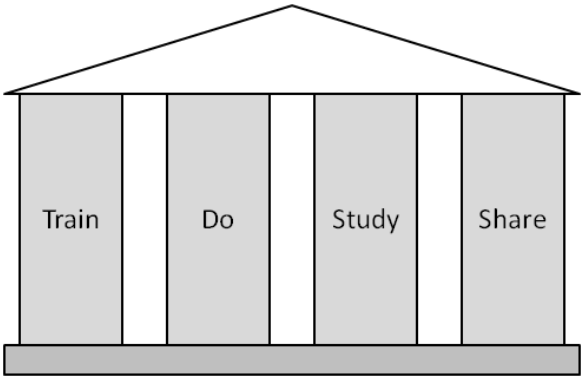

Figure 14: The "*temple of success*" (UT 2007)

The following list describes the four pillars of the Tennessee Lean Enterprise Center (TLEC) in more details:

- Within the Train-pillar the TLEC offers several Lean courses, either standardized and public or tailored to specific customers' needs. The public courses are Lean for Business Processes, Lean Enterprise, Lean Health, Lean MRO (Maintenance, Repair and Overhaul) and Lean Reliability (UT 2007). Each course lasts one week, Monday through Friday, is conducted on-site at the University of Tennessee Campus and is offered for executives, managers, and leaders. The program fee is $4,500 covering all expenses, such as hotel room, meals and workshop literature (UT Center for Executive Education 2009c, UT Center for Executive Education 2009e, UT Center for Executive Education 2009a, UT Center for Executive Education 2009b, UT Center for Executive Education 2009d). Standardized courses are kept relatively general with regards to examples among others to suit a diverse group of attendees. In other

cases, organizations may prefer contents more tailored towards their own needs (UT 2007).

- The Do-pillar consists of the so-called Lean Graduate Internship Program where "*…Knowledgeable students* (UT 2007)" are hired by companies to support and help during Lean implementation activities.
- The Study-pillar consists of Lean study groups working on specific topics regarding Lean concepts and its application to different industries. These groups are funded by individual companies and do research about specific problems.
- The Share-column provides improvements and exchanges of knowledge regarding Lean implementation for individuals and companies: Resources like books, articles, and case studies are provided on a yearly Lean Success Conference, where companies share their Lean experience and implementation issues. In addition, the "*Lean Enterprise Idea Exchange*" offers a discussion forum "*…That will link practitioners and members of academia* (UT 2007)" to discuss and answer particular questions.

Besides the previously described elements, the TLEC also offers the "*Lean Implementation System* (LIS)." The LIS was developed by Dr. Greenwood, a TLEC executive, based on his extensive experience implementing Lean principles in more than 100 facilities worldwide. The LIS is a structured Lean transformation process consisting of 75 steps that takes a total of ten months to be implemented in any organization (Greenwood et al. 2002). Greenwood et al. (2002) contains a description of successful Lean transformations in two organizations applying the LIS: Cessna Aircraft Company, the world's largest manufacturer of single-engine aircraft

and business-jets, and Adirondack Oral and Maxillofacial Surgery (AOMS), a small oral surgery office. Both organizations realized significant benefits from streamlined processes as well as from lead time and inventory reductions (Cessna 2008, Greenwood et al. 2002). During the transformation process, TLEC guided the companies through their Lean transformation through *"…Workshops and on-site events"* (Greenwood et al. 2002, p.33).

Another university-based Lean support organization is the Fisher College of Business at Ohio State University in corporation with Productivity Inc., an international consulting, training and publishing company. Fisher College offers two training programs regarding Lean concepts and tools. The first one is called the Lean Manager Certification Program (LMAC), which is designed for middle and top-level executives and is conducted during four non-consecutive weeks. The second program is called Lean Tool Awareness Certificate Program and provides participants with the *"…Knowledge-base needed to understand and take part in Lean transformation efforts…* (Fisher College of Business 2009)."

Another example of a Lean support organization is a European-based consortium, consisting of research institutions and manufacturing organizations, which was initiated in the beginning of 2009 as a four-year, €7.6 million research project. Entitled the Lean Product and Process Development (LeanPPD), it is lead by Cranfield University in Great Britain. LeanPPD focuses on the development of a new business model *"…To improve organizational performance and efficiency by turning waste elimination into value creation"* (Cranfield University 2009). European businesses and industries need performance improvements and cost savings to remain competitive in a global economy. However, such improvements require an entire organization to undergo a Lean transformation. The main industrial partners of the LeanPPD

are Rolls-Royce plc, Visteon Engineering Services, Indesit, and Volkswagen A.G. (Cranfield University 2009).

The health care sector becomes increasingly aware of the benefits of Lean. The Virginia Mason Medical Center in Seattle, WA, for example, developed the Virginia Mason Production System (VMPS), which is a management method that aims for zero defects in health care related work by continuously improving its processes. The VMPS is based on the Toyota Production System (TPS) and was fully integrated by Virginia Mason by 2002 (Virginia Mason Medical Center 2008). As a response to increasing industry demands for information about how to apply the VMPS the Virginia Mason Institute was founded in 2008 as a non-profit corporation. It offers education and training with regards to the VMPS management method to *"…Other health-care providers and organizations"* (Virginia Mason Medical Center 2008).

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3. Methodology

3.1. Overview

This research aims to empirically evaluate the level of awareness, the implementation status, and the need for support in implementing Lean management principles and methods within the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industry in the state of Virginia by means of a mail survey. Results from the survey allow the evaluation of the relations between Lean awareness, implementation status, and the need for supporting implementation efforts in respect to company size, industry segment, and the existence and influence of Lean change agents in the company. To acquire the required information a mail questionnaire was developed and addressed to the wood products manufacturing (NAICS 321) and furniture manufacturing (NAICS 337) industry to obtain primary data for this study.

3.2. Data Sources

3.2.1. Population

The population of interest for this study consisted of companies operating in the wood products manufacturing (NAICS 321) and furniture manufacturing (NAICS 337) industry in the state of Virginia. Wood products manufacturing includes companies categorized as "*sawmills and wood preservation* (NAICS 32111)", "*veneer, plywood, and engineered wood product manufacturing* (NAICS 32121)" including trusses, "*millwork* (NAICS 32191)" including windows, doors, and flooring, "*wood container and pallet manufacturing* (NAICS 32192)", and "*all other wood product manufacturing* (NAICS 32199)" including manufactured and prefabricated homes (U.S. Census Bureau 2010a). Furniture manufacturing includes companies categorized in "*wood kitchen cabinet and countertop manufacturing* (NAICS 33711)", "*household and institutional*

furniture manufacturing (NAICS 33712)", "*office furniture (including fixtures) manufacturing* (NAICS 33721)", and "*blind and shade manufacturing* (NAICS 33792, U.S. Census Bureau 2010b)". According to the Quarterly Census of Employment and Wages (2010a) the total number of establishments in the industries listed above in the third quarter of 2009 was 1033, divided in 513 establishments in wood products manufacturing (NAICS 321) and 520 establishments in furniture manufacturing (NAICS 337).

3.2.2. **Mailing List**

The mailing list assembled and used for this study was comprised of data collected from four different sources: Manta's online business listings (Manta 2010), the 2009 Virginia Industrial Directory (D&B 2009), the manufacturer index of the Wood Products Manufacturers Association (WPMA, WPMA 2010), and the members list of the Architectural Woodwork Institute (AWI, AWI 2010).

Manta's online business listings (Manta 2010) were used to create the fundamental address database including company names, addresses, contact information and, if available, the NAICS code. To that end, the descriptions of the desired six-digit NAICS codes of the wood products manufacturing and furniture manufacturing industries, for example, "*wood kitchen cabinet and countertop manufacturing* (NAICS 337110)", were typed into Manta's search field. Depending on the result, the search words were slightly changed or separated to gain more accurate search results. A total of 902 addresses were collected through this approach for both industries from Manta's online business listing (Manta 2010).

The results from Manta's online business listings were then compared with the respective entries in the 2009 Virginia industrial directory (D&B 2009). Insufficiencies in the amount of collected address data in certain categories were identified and companies not listed in the initial list were added from the 2009 Virginia industrial directory. The resulting address list contained a total of 1822 entries.

The data provided from the WPMA (WPMA 2010) and AWI (AWI 2010) were used as additional sources to verify the mailing list entries. Double entries were identified and eliminated. For quality control, randomly selected address entries were chosen and verified through address searches on the internet. Finally, a total of 1771 addresses were available for the first mailing.

3.2.3. **Sample Size**

Beginning with the original list with 1771 addresses for the first mailing, 478 envelopes were returned that could not be delivered. Additionally, questionnaires were also returned because the company was either out of business (20 questionnaires), or not involved in wood product manufacturing (160 questionnaires, most respondents indicated that they are in a trading business). The addresses from questionnaires that could not be delivered in the first mailing were checked online for address changes and 80 addresses then could be updated. These updated addresses were included in the second mailing, which included 1193 companies. The difference between the final number of entities in the mailing list (1193) and the population size of 1033 establishments given by the Virginia Workforce Connection (2010b) exists due to inaccuracies in the categorization of companies and the inherent difficulties in establishing accurate and timely company data.

3.3. Data collection

3.3.1. Mail Questionnaire

A mail questionnaire was developed at Virginia Polytechnic Institute and State University. It was directed at wood products manufacturing (NAICS 321) and furniture manufacturing (NAICS 337) companies in Virginia. The questionnaire was structured as follows:

The first part consisted of nine questions to gather basic demographic company information regarding NAICS classification, company size and its organization. The second part asked questions regarding the company's Lean practices. This included questions about Lean awareness, implementation status of Lean in the company, and Lean improvement successes. The third part asked questions assessing the company's need for support regarding Lean transformation efforts. Lastly, the fourth part consisted of product and market related questions.

To receive the required data two types of questions were used in this questionnaire: 1) categorical scale, and 2) open-ended (Fink 2003, Rea and Parker 2005).

To evaluate the level of Lean awareness and Lean implementation at a given company, a set of commonly applied Lean elements were identified from previous research (Kirby and Greene 2003, Czabke et al. 2008, Liker 2003) and experience. 29 typical Lean elements were selected to measure the level of Lean awareness and the level of Lean implementation status of the respondents' organization. These elements were structured along Liker's four categories (typically referred to as the "*Toyota Way*"): "Philosophy", "process", "people", and "problem

solving". Table 3 shows the selected 29 Lean elements structured according to Liker's (2003) four categories as used in this study's survey.

Table 3: 29 Lean elements, categorized in Liker's (2003) 4Ps

4P's	Lean Elements
Philosophy	Vision statement
	Mission statement
Process	Value stream mapping
	Takt time
	Pull system
	Supermarket replenishment system
	Just-in-time
	One-piece-flow
	Kanban-System
	Standard work
	Standardized work sheet
	Leveling production and schedules (Heijunka)
	Single minute exchange of die (SMED)
	Error proofing (Poka Yoke)
	Visual Management
	Notification system for quality and process problems (Andon)
People	Training shop floor employees
	Training administrative employees
	Training operational management
	Training executives
	Shop floor employee cross-training
	Shop floor employee skills matrix
Problem Solving	Continuous improvement (Kaizen) events
	Root cause analysis (Fish bone diagram)
	5-why-analysis
	Plan-do-check-act (PDCA)-Cycle
	A3-report
	5S method
	Go to where the problem is and see (Genchi genbutsu)

Kirby and Greene's (2003) research found that there is a direct relationship between an organizations Lean maturity and the number of implemented Lean elements within this

organization: The higher the level of maturity, the more Lean elements were implemented by a given organization (Kirby and Greene 2003). This study's focus is to gain an overview over the Lean awareness and Lean implementation in organizations operating in the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in Virginia. A sliding scale along "how many elements are implemented" will be used based on Kirby and Greene's (2003) findings that will permit to conclude that different companies have different levels of Lean maturities.

3.3.2. **Mail Questionnaire Pretest**

The questionnaire was reviewed by experts at Virginia Polytechnic Institute and State University and feedback was also obtained from industry specialists, the USDA Forest Service, and the Lean Management Instituut, The Netherlands. Before the first mailing, a pretest mailing was conducted. A randomly selected sample group of 25 addresses listed on the final mailing list was selected to test the questionnaire for clarity, comprehensiveness, and acceptability (Rea and Parker, 2005). The pretest mail questionnaire was addressed to corporate-level decision makers in the wood products manufacturing (NAICS 321) and furniture manufacturing (NAICS 337) industry. Each of the 25 pretest mailings consisted of a personalized cover letter, a mail questionnaire including a unique tracking number, and a first-class pre-paid return postage. Seven responses were received (28 percent).

The responses received were carefully analyzed and changes were made to the mail questionnaire to address issues and to increase clarity (Rea and Parker 2005).

3.3.3. First Mail Questionnaire and Follow-up Contact

The first mail questionnaire was sent on July 14, 2010 and was addressed to corporate-level decision makers in the wood products manufacturing (NAICS 321) and furniture manufacturing (NAICS 337) industry. A total of 1771 surveys were mailed. Each questionnaire consisted of a personalized cover letter (Appendix A), and a mail questionnaire (Appendix B) including a unique tracking number for accurate response monitoring and follow-up actions on non-respondents (Biemer and Lyberg 2003, Rea and Parker 2005). To increase the response rate, the cover letter and the questionnaire were printed on colored paper (Rea and Parker 2005).

One week after the first mail questionnaire was mailed (July 22, 2010), a reminder postcard was mailed to all non-respondents to remind them of the importance of the study and to encourage them to participate in the survey. The reminder postcard had the same color as the questionnaire from the first mailing. Figure 15 illustrates the timeline of all mailing activities for this survey.

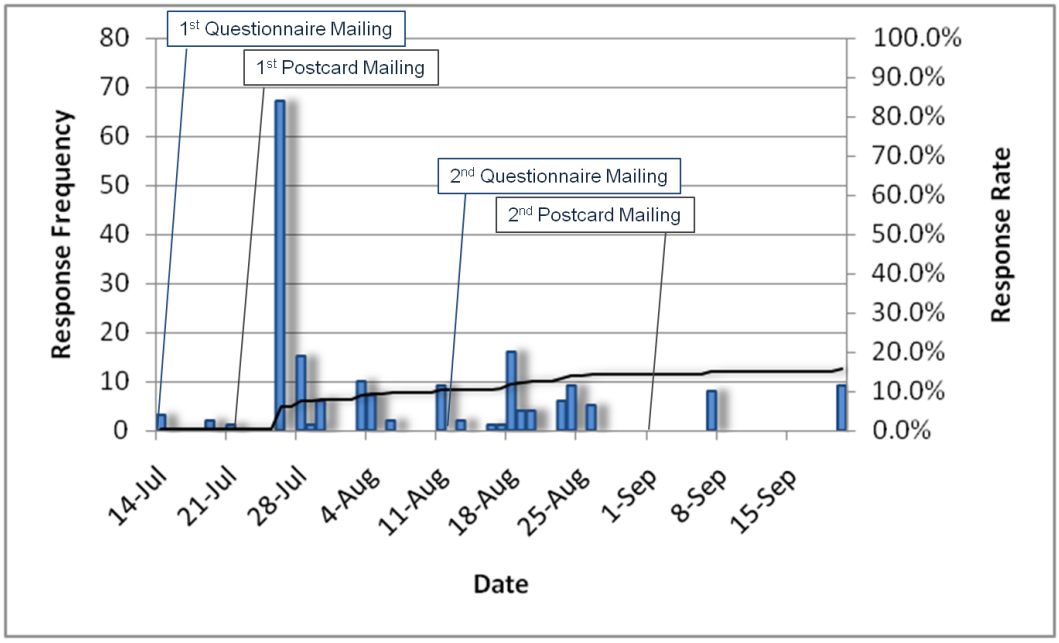

Figure 15: Survey timeline

3.3.4. Second Mailing and Follow-up Contact

Four weeks after the first questionnaire was mailed-out the second questionnaire was sent to all non-respondents (August 11, 2010). The second mail questionnaire was identical to the first one. Three weeks after the second questionnaire mailing (September 1, 2010), another follow-up postcard was send to all non-respondents to remind them of the importance of the study. The second follow-up postcard was identical to the first postcard.

After a three-week period (September 23, 2010), thirty non-respondents were contacted by telephone and fax and asked a series of three questions (Dillman et al., 2009, Rea and Parker, 2005): Two demographic questions were asked including which industry segment the respondent's company belongs to and how many employees are currently working in the respondent's company. Additionally, one question regarding the respondent's awareness of certain Lean terms, such as, for example, Lean Management, Lean Manufacturing, and Lean

Thinking, was asked. Responses to these questions were documented and entered into the data analysis spreadsheet for investigation of non-response bias.

3.4. Data analysis

3.4.1. Mail Questionnaire

Answers from participants were collected, coded, and entered into a Microsoft Excel spreadsheet (Microsoft 2007). The data was coded according to the tracking number, the date received, categorical, and open-ended responses. The coded spread sheet was uploaded to JMP 8.0 statistical software (SAS 2008) for more detailed statistical analysis.

Frequency distributions, contingency tables, and descriptive statistics were used to summarize high-level analysis of responses (Dillman et al., 2009, Rea and Parker, 2005). Dimensional data from industry demographics, market structure, and Lean practices were tested using non-parametric statistics. The Kruskal-Wallis Rank-Sum test was applied to test the difference of population means of more than two response factors. The Wilcoxon Rank-Sum test was used to test on differences between population means of two response factors as well as for multiple comparison tests in case the initial Kruskal-Wallis Rank-Sum test indicated significant differences between the tested means. For multiple comparisons, the alpha value was adjusted using the Bonferroni correction. For the comparison of two nominal response factors the Fisher's exact test was applied (Ott and Longnecker 2010, Miller 1981).

Also, non-response bias was tested using the 30 responses from the non-response bias tests undertaken after closing the survey, as described above (Rea and Parker, 2005). Results were analyzed using fisher's exact test to account for potential small sample sizes (Ott and

Longnecker 2010). No significant differences between the respondents and non-respondents were found. Table 4 provides an overview of the test results.

Table 4: Non-Response Bias

#	Question	P-value	Test Type
2	Please check the categories that best describes the main product produced	0.8952	Fisher's exact test
6	Please indicate how many employees are currently employed in your facility?	0.1913	Fisher's exact test
10	Have you heard of the following terms? (Checked at least one term)	0.6655	Fisher's exact test

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4. Lean Penetration in Virginia's Wood Industry

4.1. Abstract

During the last decades, the U.S. wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries have been greatly affected by economic cycles, rising production and transportation costs, changing buyer habits, and, arguably most powerfully, increasing global competition. As a result, tens of thousands of jobs were lost (Milauskas 2005) and a large number of companies in the industry experienced bankruptcy, closed operations, or relocated to other countries. However, theories exist stating that the use of management systems, such as, for example, Lean management, allows companies to become more competitive and enhance the likelihood of survival.

A survey was conducted to compare companies in Virginia's wood products and furniture manufacturing industries as to their awareness of Lean management, the implementation of Lean management practices, as well as the companies' need for support in Lean implementation efforts.

Findings indicate that a majority of Virginia's wood products and furniture manufacturing industries have heard about general terms like, for example, Lean management, Lean manufacturing, or Lean thinking, but are rarely aware of individual Lean elements of which the Lean philosophy consists. Few businesses thus have implemented any part of the Lean system. However, findings show that Lean awareness and Lean implementation status differs between different industry categories. The group of industry categories with the highest Lean awareness and Lean implementation status were "*engineered wood products*", "*manufactured homes*",

and "*household furniture manufacturing*," versus industry categories such as "*sawmill*" and "*wood container and pallets*," who had lower Lean awareness and Lean implementation status. Despite the low level of Lean implementation across the wood products and furniture manufacturing industry less than one-fourth of all respondents indicated a need for Lean implementation support. No differences in the need for Lean implementation support between different industry sub-segments were found.

4.2. Introduction

During the last decade, Virginia's wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries, have been greatly affected by economic cycles (Bull 2008, International Forest Industries 2009), rising transportation costs (BBCWorldNewsAmerica 2008, Smith et al. 2009), changing buyer habits (Huber 2008), and increasing global competition (Buehlmann and Schuler 2009 and 2002, Schuler and Buehlmann 2003, Fishman 2005). The non-upholstered wood household furniture sector (NAICS 337122) is one of the most illustrative industry sector when studying the impact of globalization on U.S. industries as few other industry sectors have faced such intense global competition over the past decade, with "*...Imports rising from 19 percent in 1992 to 64 percent market share in 2008* (Buehlmann and Schuler 2009, p.22)." Producers in Southeast Asia, thanks to favorable production economics were able to displace one of the most historic U.S. industries with support from many of the long-time U.S. constituents of the industry who started manufacturing or buying their products offshore (Pirraglia et al. 2009, Czabke et al. 2008). With the exodus of the furniture manufacturing business, suppliers suffered, too, extending the problem to other parts of the wood products and furniture manufacturing value chain (Buehlmann and Schuler 2009, William Luppold and

Bumgardner 2008, Grushecky et al. 2006). As a result of globalization, among other things, employment in the U.S. wood products and furniture manufacturing industries decreased by almost 108,000 between 2002 and 2007 (U.S. Census Bureau 2010a, U.S. Census Bureau 2010b) and a large number of companies experienced bankruptcy, closed operations, or relocated to other countries (Quesada and Gazo 2006).

Given the difficult situation in which the U.S. wood products and furniture manufacturing industry finds itself, discussions center on ideas promising a stop or reversal of the situation. Much effort is being directed towards finding ways to make the U.S. industry more competitive. One idea that has been discussed intensely is the use of management systems, such as, for example, Lean management (Buehlmann and Schuler 2009). Lean, originating in the automotive industry (Womack et al. 1990), Lean management has proven effective in helping companies across different industries to improve their organizational performance (Mintz Testa 2003, Stuart and Boyle 2007, Womack and Jones 2003).

Lean, a management system with the goal of creating customer value without waste (Womack and Jones 2003) is also referred to, among others, as Lean management, Lean manufacturing, Lean production, Lean thinking, or Toyota Production System (TPS). The term Lean was originally coined and first used in Womack et al.'s (1990) book "*The Machine that Changed the World*." The book discusses results stemming from the International Motor Vehicle Program (IMVP) study conducted by the Massachusetts Institute of Technology (MIT) and funded by the U.S. Federal Government (Womack et al. 1990). The study revealed that Japanese car manufacturers need less human effort and time, less space, and less average inventory to

manufacture products of higher quality containing higher value for the customer (Womack et al. 1990). Thus, based on Womack et al.'s (1990) premise, Lean companies are more efficient and thus more competitive and profitable.

Lean has gained a group of highly skilled followers in the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industry. In fact, several industry participants successfully transformed their operations through the application of Lean. Some reaped the Shingo Price for Operational Excellence in Manufacturing (the highest such award handed out annually to world class manufacturing companies, The Shingo Prize 2008) for their efforts (Steelcase 2006, Hon 2010, Merillat-Masco Builder Cabinet Group 2009). Other companies in the wood products and furniture manufacturing industry have applied Lean management without reaping awards (Czabke 2007), while others are considering the implementation of Lean management or selected elements (Ray et al. 2006). However, case studies of actual Lean implementation efforts in the wood products and furniture manufacturing industry are rare, making it difficult to assess the level of Lean awareness and the status of Lean implementation efforts in the industry beyond the few published examples. Pirraglia et al. (2009) indicated that the U.S. wood products and furniture manufacturing industries have been slow in adapting the Lean management approach compared with other industries. Interestingly, this is despite a belief that Lean management may help improve company competitiveness and reduce the loss of jobs to locations overseas (Schuler and Buehlmann 2003, Pirraglia et al. 2009).

The objective of this research was to gain an overview over Lean management practices in the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industry in the

Commonwealth of Virginia. Particularly, three areas of interest were: Lean awareness, Lean implementation status, and the need for support in Lean implementation. The following hypotheses were tested:

Lean Awareness

$H1_0$: *"The majority of wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in the Commonwealth of Virginia are not aware of Lean management."*

$H2_0$: *"There is no difference in Lean awareness between different sub-categories of the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in the Commonwealth of Virginia."*

Lean Implementation

$H3_0$: *"The majority of wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in the Commonwealth of Virginia have not implemented Lean management."*

$H4_0$: *"There is no difference in Lean implementation status between the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in the Commonwealth of Virginia."*

$H5_0$: *"Companies of the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries with a Lean change agent are no different in respect to Lean implementation status as compared to companies without a change agent in the Commonwealth of Virginia."*

Need for Support

$H6_0$: *"The majority of the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industry in the Commonwealth of Virginia does not need support for their Lean implementation."*

$H7_0$: *"There is no difference in need for support for Lean implementation between the sub-categories of the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries of the Commonwealth of Virginia*."

4.3. Methodology

A mail questionnaire was chosen as the method of choice for this study. Mail surveys are commonly used to obtain data to make inferences about a population's characteristics. For this purpose, measurements need to be taken from a randomly selected sample of the population (Ott and Longnecker 2010, Rea and Parker 2005). To be able to draw meaningful conclusions from the survey, proper survey design is of high importance (Dillman et al. 2009, Rea and Parker 2005).

4.3.1. Survey Population

The population of interest for this study consisted of all companies operating in the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industry in the Commonwealth of Virginia. According to the U.S. Census (2010a), wood products manufacturing (NAICS 321) includes companies categorized in "*sawmills and wood preservation* (NAICS 32111)", "*veneer, plywood, and engineered wood product manufacturing* (NAICS 32121)" including trusses, "*millwork* (NAICS 32191)" including windows, doors, and flooring, "*wood container and pallet*

manufacturing (NAICS 32192)", and "*all other wood product manufacturing* (NAICS 32199)" including manufactured and prefabricated homes (U.S. Census Bureau 2010a). Furniture manufacturing (NAICS 337) includes companies categorized in "*wood kitchen cabinet and countertop manufacturing* (NAICS 33711)", "*household and institutional furniture manufacturing* (NAICS 33712)", "*office furniture (including fixtures) manufacturing* (NAICS 33721)", and "*blind and shade manufacturing* (NAICS 33792, U.S. Census Bureau 2010b)". According to the Quarterly Census of Employment and Wages (2010) the total number of establishments in the Commonwealth of Virginia in these industries in 2009 was 1033 (513 establishments in wood products manufacturing (NAICS 321) and 520 establishments in furniture manufacturing (NAICS 337).

Due to a lack of a state-wide address list of the companies of interest, addresses were collected from: Manta's online business listings (Manta 2010), the 2009 Virginia industrial directory (DandB 2009), the manufacturer index of the Wood Products Manufacturers Association (WPMA 2010), and the members list of the Architectural Woodwork Institute (AWI 2010). After correcting for surveys that could not be delivered, companies out of business, or companies that were not involved in wood products (NAICS 321) or furniture manufacturing (NAICS 337) the final sample size for this survey was 1,193, which was used for a Census survey (Dillman 2006, Alreck and Settle 1995).

4.3.2. **Questionnaire Design**

A mail questionnaire directed at wood products manufacturing (NAICS 321) and furniture manufacturing (NAICS 337) companies in the Commonwealth of Virginia was developed. The

first part consisted of nine questions to gather basic demographic company information regarding NAICS classification, company size, and the unification of employees. The second part asked questions regarding the company's Lean practices. This included questions about Lean awareness, implementation status of Lean, and Lean improvement success. The third part asked questions assessing the respondents' need for support regarding Lean transformations, while the fourth part consisted of product and market-related questions. Two types of questions were used, namely 1) categorical and 2) open-ended (Fink 2003, Rea and Parker 2005).

In this study, to evaluate the level of Lean awareness/implementation, a set of common Lean elements (Kirby and Greene 2003, Czabke et al. 2008, Liker 2003) were used as proxies. Twenty-nine Lean elements categorized in four categories (4P's - philosophy, process, people, and problem solving) established by Liker (2003) were used (Table 5).

Table 5: Twenty-nine Lean elements (Liker 2003) used as proxies to establish Lean awareness and Lean implementation status in companies surveyed

4P's	Lean Elements
Philosophy	Vision statement
	Mission statement
Process	Value stream mapping
	Takt time
	Pull system
	Supermarket replenishment system
	Just-in-time
	One-piece-flow
	Kanban-System
	Standard work
	Standardized work sheet
	Leveling production and schedules (Heijunka)
	Single minute exchange of die (SMED)
	Error proofing (Poka Yoke)

	Visual Management
	Notification system for quality and process problems (Andon)
People	Training shop floor employees
	Training administrative employees
	Training operational management
	Training executives
	Shop floor employee cross-training
	Shop floor employee skills matrix
Problem Solving	Continuous improvement (Kaizen) events
	Root cause analysis (Fish bone diagram)
	5-why-analysis
	Plan-do-check-act (PDCA)-Cycle
	A3-report
	5S method
	Go to where the problem is and see (Genchi genbutsu)

Kirby and Greene (2003) in their study on "*How value stream type affects the adoption of Lean production tools and techniques*" found a direct positive relationship between the number of Lean elements (Table 5, Liker 2003) implemented and the level of an organization's Lean maturity. They defined five maturity levels from level one with companies starting Lean but not having fully implemented the entire set of Lean tools, to level five having extensively implemented the entire set of tools. It was found that the number of implemented Lean tools increased between maturity levels one to four. By level four, however, the entire set of Lean tools was implemented so that between levels four and five the only distinction in Lean maturity could be made through the evaluation of the intensity the Lean tools were implemented. Based on the available publications (Pirraglia et al. 2009, Czabke et al. 2008) and personal observations, the research team expected the level of Lean implementation to be low among Virginia's wood products and furniture manufacturing companies, and thus the survey

only focused on the patterns of Lean maturity from level one to level four without considering the differences in implementation intensity between levels four and five.

A draft questionnaire was reviewed by faculty of Virginia Tech and feedback was obtained from industry specialists at the USDA Forest Service and the Lean Management Instituut, Netherlands. After incorporating several useful suggestions, a pretest mailing was conducted. A sample group of 25 addresses was randomly selected from the address list to test the questionnaire for clarity, comprehensiveness and acceptability (Rea and Parker 2005). The pretest mail questionnaire was addressed to corporate-level decision makers in the wood products manufacturing (NAICS 321) and furniture manufacturing (NAICS 337) industry in the Commonwealth of Virginia. Each mailing consisted of a personalized cover letter, a mail questionnaire including a unique tracking number, and a first-class postage pre-paid return envelope. Seven responses were received. The responses were analyzed and minor changes were made to the mail questionnaire to address issues and to increase clarity (Rea and Parker 2005).

4.3.3. **Data Collection**

The first mail questionnaire to the entire address list was mailed in July 2010 and was addressed to corporate-level decision makers in the wood products manufacturing (NAICS 321) and furniture manufacturing (NAICS 337) industry. Each questionnaire, contained a personalized cover letter, a questionnaire including a unique tracking number for accurate response monitoring and a first-class, pre-paid return envelope (Biemer and Lyberg 2003, Rea and Parker 2005). To increase the response rate, the cover letter and the questionnaire, were

printed on colored paper (Rea and Parker, 2005). A reminder postcard, a second questionnaire including a unique tracking number for accurate response monitoring and a first-class, pre-paid return envelope, and a second reminder postcard were sent out to all non-respondents one, four, and seven weeks after the first mailing, respectively. Ten weeks after the original mailing of the first questionnaire, thirty non-respondents were contacted by telephone and fax and asked three demographic questions. Two demographic questions asked which industry segment the respondent's company belongs to and how many employees work currently in the respondent's company. Additionally, one question asked if the respondents have "*…Heard of the following terms: Lean Management, Lean Production, Lean Manufacturing, Toyota Production System, and Lean Thinking.*" Responses from these thirty non-respondents were used in the determination of non-response bias (Dillman et al. 2009, Rea and Parker 2005). All data was entered into a coded MS Excel data analysis spreadsheet (Microsoft 2007).

4.3.4. **Data Analysis**

The data obtained was coded according to tracking number, date received, categorical data, and open-ended responses. The coded spreadsheet was then uploaded to JMP 8.0 statistical software (SAS 2008) for statistical analysis, such as frequency distributions, contingency tables, and descriptive statistics (Dillman et al., 2009, Rea and Parker, 2005). Survey data from questions pertaining to industry demographics, market structure, and Lean practices were tested using non-parametric statistics. Non-response bias was tested using the responses from the 30 of the 1005 non-respondents who were randomly selected and contacted via telephone and fax (Rea and Parker, 2005). Results of the non-response data collection were analyzed using Fisher's exact test to account for potential small sample sizes (Ott and Longnecker 2010).

No significant (α = 0.05) differences between the respondents and non-respondents were found (p-values 0.90, 0.19, and 0.67, respectively, for Fisher's exact test).

4.3.5. **Definitions**

The following definitions for measuring Lean awareness, Lean implementation status, and the need for Lean implementation support were used in this study. Survey participants were considered "*aware of Lean*" if at least one of five Lean terms Lean Management, Lean Manufacturing, Lean Production, Lean Thinking, or Toyota Production System (TPS) listed in the survey questionnaire was answered affirmative to the question "*Have you heard of the following terms (check all that apply)?*" For additional elaboration on Lean awareness of the survey participants, survey respondents were also asked to identify all known elements from the list of 29 Lean elements (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003).

The participants' Lean implementation status was also tested using the 29 Lean elements. If a respondent was indicating that his company is using at least one of the 29 Lean elements, the respondent's company was considered as having "*implemented Lean*". Due to the small number of responses (N=6), participants that answered to be implementing certain Lean elements within one, three, or in more than three years from now were forced into the category "*not planned*" indicating that these elements are currently not in use. Additional insights on respondents' Lean implementation status were gained from the analysis of type and number of Lean elements used.

To evaluate the need for Lean implementation support, the survey participants were asked to answer the question "*Do you have a need for external support in order to improve your*

organization's performance." Affirmative answers were used to conclude a need for Lean implementation support.

4.3.6. **Limitations**

A major limitation occurring in mail survey research is that results are based on only one respondent from each company. Thus, the respondent's feedback may not reflect company policy or the view of other management level employees. Such personal bias may particularly affect answers made to questions regarding Lean awareness, Lean implementation and the need for Lean implementation support as answers tend to be subjective.

This study used awareness of at least one of the five Lean terms and use of at least one of the 29 Lean elements (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003) to determine Lean awareness and Lean implementation status. If a respondent simply chose to ignore questions regarding those five Lean terms and 29 Lean elements, bias occurred through a possibly wrongful classification of the respondent as "*is not aware of Lean*" and "*has not implemented Lean*." However, a respondent need only indicate one of the five Lean terms as "*aware of*" and one of the 29 elements as "*used"* to be classified correctly. Thus, the research team decided that misclassification could only occur in few cases and should not bias the overall results of this study.

A Fisher's exact test was conducted to test on reliability between the population and the responses to compare every industry sub-segment's representation. The test showed a significant difference (p-value = 0.01016) in representation from the original data (Fisher's exact test, $\alpha = 0.05$). Companies from "o*ther wood product manufacturing* (NAICS 3219)" including "millwork (NAICS 32191)", "*wood container and pallet manufacturing* (NAICS 32192)", and

"*manufactured home (mobile home) manufacturing* (NAICS 32199)" were overrepresented, while companies from "*office furniture (including fixtures) manufacturing* (NAICS 3372)" were underrepresented.

Lastly, this survey asked questions about a specific topic (Lean). It can be argued that individuals knowledgeable about Lean tend to be more likely to respond to the survey. However, the results obtained seem consistent with previous research (Pirraglia et al. 2009, Stuart and Boyle 2007, Kumar et al. 2006, Achanga et al. 2006, Westhead and Storey 1996) regarding Lean awareness, Lean implementation, and the need for Lean implementation support. Thus, if bias is present, it should be low.

4.4. Results and Discussions

Roughly three-fourths of the responding wood products (NAICS 321) and furniture manufacturing (NAICS 337) companies in the Commonwealth of Virginia are aware of Lean as measured by the knowledge of at least one of the five Lean terms listed in the questionnaire (Lean Management, Lean Manufacturing, Lean Production, Lean Thinking, or Toyota Production System (TPS)). However, relatively few companies who are aware of Lean have implemented Lean, as was suggested by Pirraglia et al.'s (2009). Furthermore, the level of awareness and implementation of Lean among Virginia's wood product and furniture manufacturing industries differs between industry segment and sub-segment.

4.4.1. Lean Awareness

As shown in Figure 16 (left graph), about 28 percent of the survey respondents are not aware of Lean and have not heard about any of the five terms typically used in Lean vocabulary: Lean

Management, Lean Manufacturing, Lean Production, Lean Thinking, or Toyota Production System (TPS). However, 72 percent of survey respondents have heard of at least one of the terms (Figure 16, left graph).

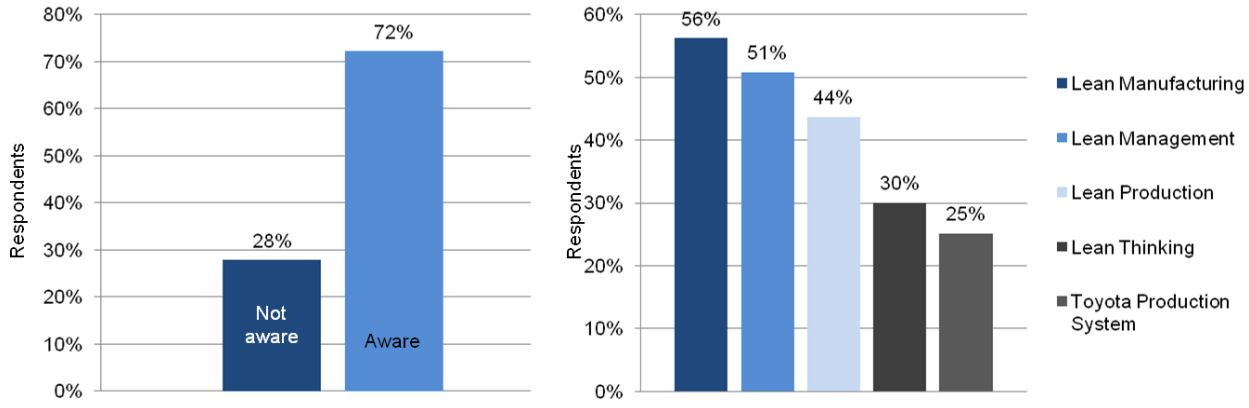

Figure 16: Lean awareness of survey respondents as measured by knowing at least one of five Lean terms (left) and known Lean terms of respondents aware of Lean (right)

Of the five Lean terms listed in the survey, Lean Manufacturing was the most widely recognized name (56 percent, Figure 16, right graph) followed by Lean Management, Lean Production, Toyota Production System (TPS), and Lean Thinking (51, 44, 30, 25 percent frequency, respectively, Figure 16, right graph). Respondents also exhibited a wide range of Lean awareness when measured by using the 29 Lean elements (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003) as a proxy. Figure 17 displays the awareness of Lean elements by survey respondents grouped into Liker's (2003) four categories (4 Ps).

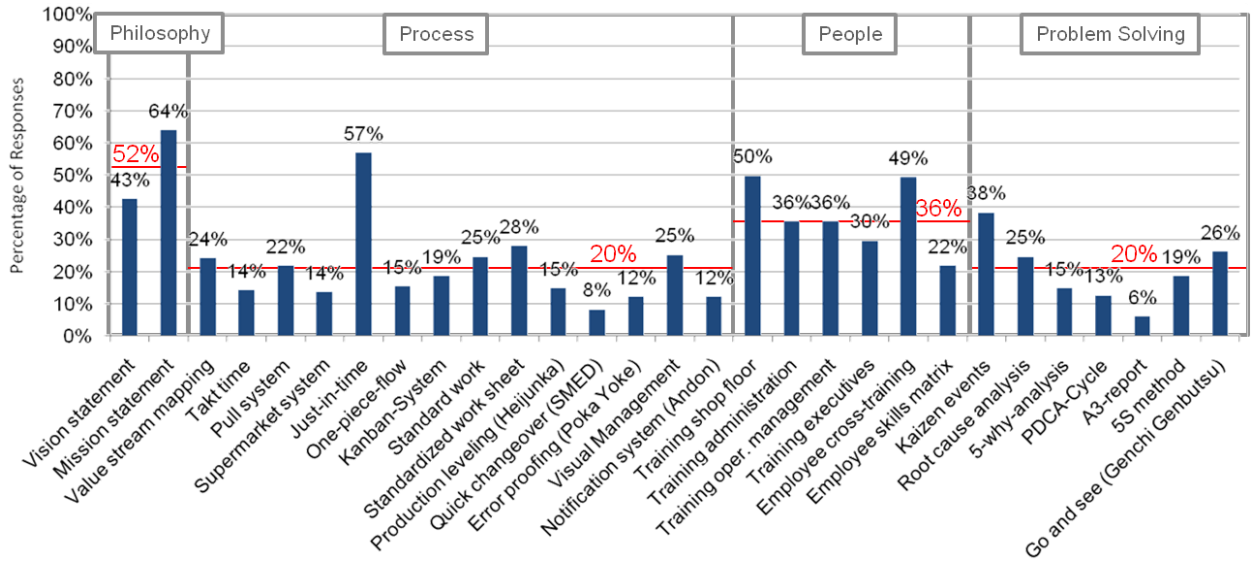

Figure 17: **Overview of awareness of Lean elements by survey respondents grouped into four categories (Liker 2003)**

On average, each of the 29 Lean elements was known by 32 percent of the respondents. Figure **17** shows that elements such as, for example, "*mission statement*, *just-in-time*, *training shop floor*, *employee cross-training*, or *vision statement* (64, 57, 50, 49, and 43 percent awareness, respectively)" were more widely known than more Lean-specific elements such as, for example, "*A3-report*, *quick changeover*, *error proofing* (*Poka Yoke*), *visual management*, or *PDCA-cycle* (6, 8, 12, 12, and 13 percent awareness, respectively)."

Awareness of individual elements varied widely by Liker's (2003) 4P categories (Philosophy, Process, People, Problem Solving), as well. On average, the elements in the "*philosophy*" segment were best known by respondents (52 percent, Figure **17**), followed by elements in the "*people* (36 percent)," "*process*" and "*problem solving* (20 percent, each)" categories. Both elements in the "*philosophy*" segment, e.g., "*vision* and *mission statement*," were better known (by 64 and 43 percent of respondents, respectively) than the average over all 29 elements (32 percent). In the "*people*" segment, respondents were least aware of the "*employee skill matrix*

(22 percent)" and most aware of "*training shop floor employees* (50 percent). However, most elements in the "*philosophy*" and the "*people*" categories are often used by companies without a specific interest in Lean as these elements are also part of more traditional management systems. Therefore, the elements in the "*philosophy*" and the "*people*" categories cannot be considered "pure" indicators for a company's Lean awareness.

The other two categories, "*process*" and "*problem solving*", however, can be considered core elements of Lean since they include specific elements uniquely associated with Lean or the Toyota Production System (TPS, (Liker 2003, Womack and Jones 2003). Elements from these two categories, however, were only known by about 20 percent of the respondents, respectively (Figure **17**). For example, only 8 percent of the respondents knew about "*quick changeover (SMED)*" in the segment "*process*", whereas more than half (57 percent) of the respondents have heard of "*just-in-time*". In the segment "*problem solving*" only 6 percent were aware of the "*A3-report*", but 38 percent of the respondents were aware of "*continuous improvement (kaizen) events*". Using Fisher's exact test, significant differences in Lean awareness between the categories "p*hilosophy"* and *"people*" versus "*process"* and *"problem solving*" were found (p = 0.01773). Thus, it can be concluded that companies in the wood products and furniture manufacturing industries in the Commonwealth of Virginia are better aware of Lean elements related to the categories "p*hilosophy"* and *"people*" versus the categories "*process"* and *"problem solving*".

Hypothesis one, *"The majority of wood products and furniture manufacturing industries in the Commonwealth of Virginia are not aware of Lean management",* has to be rejected as the

majority (72 percent) of the respondents are aware of Lean as measured by knowing at least one Lean term, a conclusion further supported when measuring Lean awareness by awareness of the 29 Lean elements: 76 percent of the survey participants have heard of at least one Lean element.

Hypothesis 2, *"There is no difference in Lean awareness between different sub-categories of the wood products and furniture manufacturing industries in the Commonwealth of Virginia*," however, was rejected at the 95 percent level of significance (Kruskal-Wallis test, $p = 0.0089$). Thus, Lean awareness differs at least between some of the eight segments (e.g., "*sawmills and wood preservation* (NAICS 32111)," "*veneer, plywood, and engineered wood product manufacturing* (NAICS 32121)," "*millwork* (NAICS 32191)," "*wood container and pallet manufacturing* (NAICS 32192)," and "*all other wood product manufacturing* (NAICS 32199)" in the "*wood products* (NAICS 321)" and "*wood kitchen cabinet and countertop manufacturing* (NAICS 33711)," "*household and institutional furniture manufacturing* (NAICS 33712)," "*office furniture (including fixtures) manufacturing* (NAICS 33721)," and "*blind and shade manufacturing*" in the "*furniture manufacturing* (NAICS 337)" industry) operating in the Commonwealth of Virginia. Figure 18 shows the frequency of respondents indicating awareness of individual Lean elements.

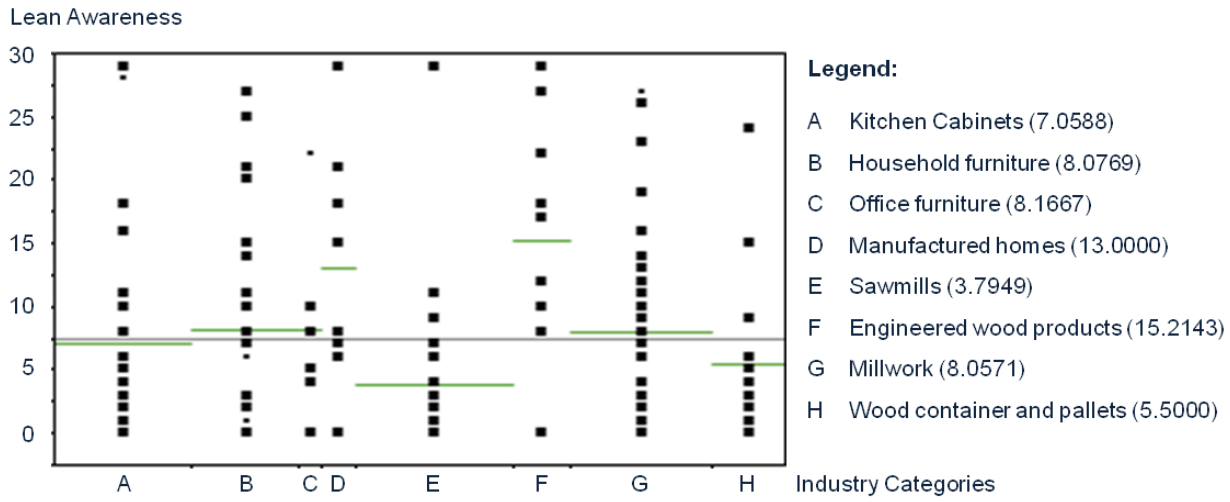

Figure 18: Frequency of respondents indicating awareness of individual Lean elements.

Figure 18 shows the large variability of Lean awareness that exists between companies in every industry segment. While the overall average Lean awareness as measured by awareness of numbers of Lean elements is 7.47, individual industry segment's mean Lean awareness varies from 15.21 for "*engineered wood products* (column F in Figure 18)" to 3.80 for "*sawmills* (column E, Figure 18)." Mean values for "*manufactured homes* (D)," "*office furniture* (C)," "*household furniture* (B)," "*millwork* (G)," "*kitchen cabinets* (A)," and "*wood container and pallets* (H)" are 13, 8.17, 8.08, 8.06, 7.06, and 5.5 respectively.

Table 6 shows results from performing multiple comparisons (Wilcoxon Rank-Sum test, α = 0.05) regarding Lean awareness including all 28 pairs that can be formed with the 29 Lean elements (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003).

Table 6: Significance (Wilcoxon Rank-Sum) of pair-wise comparison of industry sub-segments regarding Lean awareness as measured by knowledge of the 29 Lean elements.

NAICS	Description	32111	32121	32191	32192	32199	33711	33712	33721
32111	Sawmills and wood preservation		**0.0013**	0.0073	0.3305	0.0047	0.3045	0.1269	0.0837
32121	Veneer, plywood, engineered wood prdts			0.0430	0.0220	0.6064	0.0238	0.0518	0.1706
32191	Millwork				0.2498	0.1780	0.2407	0.6334	0.9852
32192	Wood containers and pallet manufacturing					0.0316	1.0000	0.7181	0.2685
32199	Manufactured homes/ prefab. buildings						0.0628	0.1770	0.4003
33711	Kitchen and bath cabinets or countertops							0.7149	0.4321
33712	Household and institutional furniture								0.6668
33721	Office furniture (incl. fixtures)								

Significantly different (before Bonferroni correction)

In terms of lean awareness between industry sub-segments, seven pairs ("*sawmills and wood preservation*" and "*veneer, plywood, and engineered wood products,*" "*sawmills and wood preservation*" and "*wood container and pallets manufacturing,*" "*veneer, plywood, and engineered wood products*" and "*manufactured home (mobile home) and prefabricated wood building manufacturing*," and "*millwork*" and "*wood kitchen cabinet and countertop manufacturing*") were found to be significantly different ($\alpha = 0.05$) before applying the Bonferroni correction (Hsu 1996). When applying the Bonferroni correction (corrected $\alpha = 0.00179$), known to result in conservative conclusions (Hsu 1996), only one pair, "*sawmills and wood preservation*" and "*veneer, plywood, and engineered wood products*," was found to be significantly different. Thus, while there are differences in Lean awareness between industry sub-segments in the wood products and furniture industry in the Commonwealth of Virginia, the large within industry sub-segment variation is even more pronounced (Figure 18). Also, it is interesting to note that all industry sub-segments display large variability, e.g., that there is no industry sub-segment where all participants are uniformly aware of Lean.

A separate comparison of the two industries, "*wood products* (NAICS 321)" and "*furniture manufacturing* (NAICS 337)" did not result in a significant result (Wilcoxon Rank-Sum, p-value=0.7130). Thus, there is no difference in Lean awareness between Virginia's "*wood products*" and "*furniture manufacturing*" industry.

4.4.2. **Lean Implementation**

While 72 percent of responding companies are aware of at least one Lean term (Figure 16), only 47 percent of the survey participants claim to have implemented (as defined in the Methodology section, "... *to have implemented*..." means that the respondent's company is currently using) one or more of the 29 Lean elements (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003). Thus, based on the results of this survey, Lean implementation in companies of the wood products and furniture manufacturing industries of the Commonwealth of Virginia is rather low, a result consistent with Pirraglia et al.'s (2009) findings. In this survey, from 188 responding businesses, 100 reported that none of the 29 elements are used, 35 companies report that one to five elements are implemented, 29 companies report six to ten, six companies 11 to 15, seven companies 16 to 20, four companies 21 to 25, and seven companies report that 26 to 29 elements are implemented, respectively. Figure 19 provides an overview of these findings.

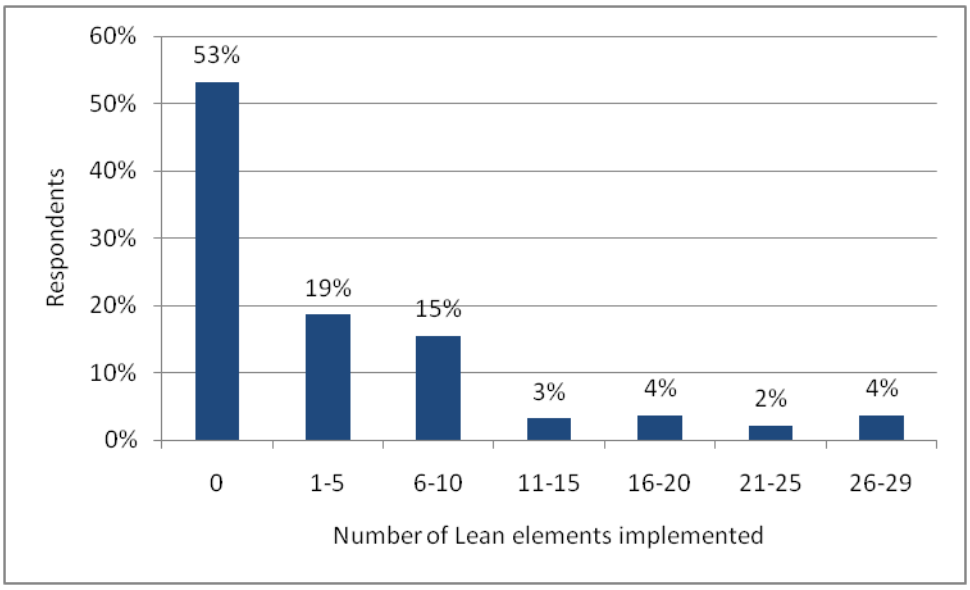

Figure 19: Respondents categorized by number of Lean elements (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003) implemented.

Figure 20 shows the frequency of responses obtained for each of the 29 elements from the survey. The average frequency distribution for implementing Lean elements by responding companies (21 percent, Figure 20) is lower than the average frequency for Lean awareness (32 percent, Figure **17**). Not surprisingly, respondents have more likely heard of Lean than actually implemented it.

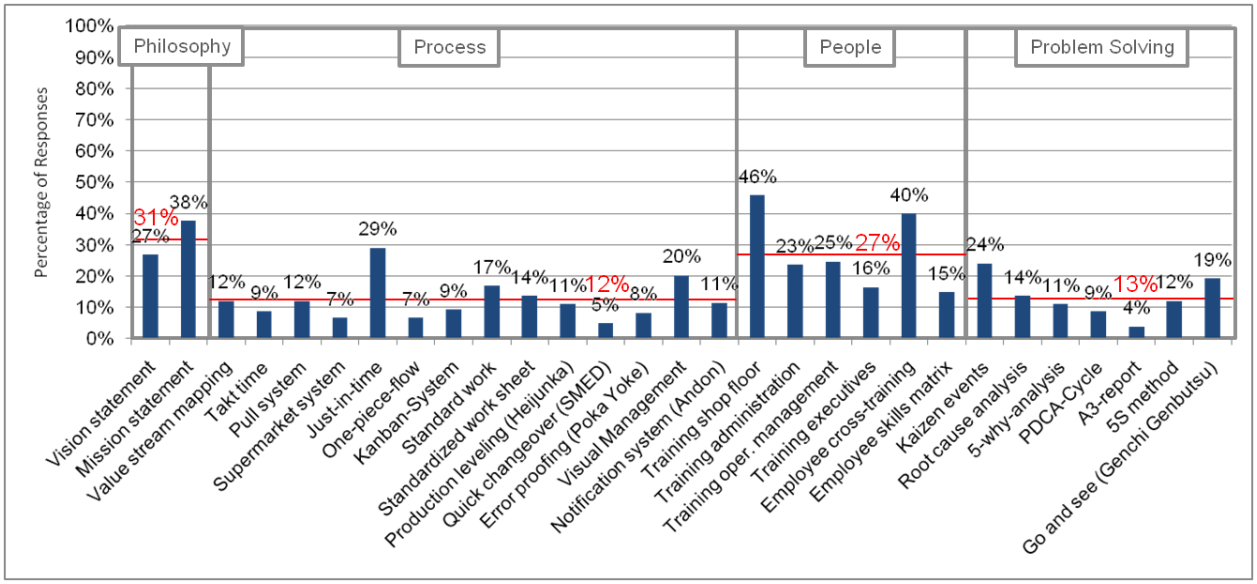

Figure 20: Overview of implementation of Lean elements by survey respondents grouped into four categories according to Liker (2003)

The "*philosophy*" segment with its two elements "*vision statement*" and "*mission statement*" is, with an average positive response frequency of 31 percent, the segment with the most activity, an observation already made when testing Lean awareness of respondents (52 percent, Figure 3). In descending order of frequency of which elements are implemented, "*Philosophy*" is followed by the "*people*," "*problem solving*," and "*process*" categories (27, 13, and 12 percent average frequency).

However, an argument can be made that the penetration of Lean in businesses of the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in the Commonwealth of Virginia is less pronounced than the frequency averages for the four categories ("p*hilosophy*," "*people*," "*problem solving*," and "*process*," Figure 20) would make believe. As discussed before, several of the 29 Lean elements (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003) are in fact concepts practiced by many businesses that have no awareness of Lean or do not want to implement Lean. If the assessment of Lean penetration in

businesses of the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in the Commonwealth of Virginia is based on response frequency for elements that are uniquely associated with Lean (Figure 20), such as, for example, "*A3-report*," "*quick changeover (SMED)* ," "*one-piece-flow*," "*supermarket system*," "*error proofing (Poka Yoke)*," "*takt time*," "*Kanban system*," *or* "*PDCA-cycle*," a less favorable picture evolves. Less than ten percent of all respondents (4, 5, 7, 7, 8, 9, 9, and 9 percent, respectively) indicated that they have implemented those uniquely Lean-specific elements. Even the more widely known and used element "*value stream mapping*" is used by only 12 percent of respondents. However, elements like "*kaizen events*" or "*just-in-time*," which appear to be in more widespread use in the wood products and furniture manufacturing industry in the Commonwealth of Virginia (24 and 29 percent, respectively), indicate that Lean has attracted some followers who have implemented Lean elements.

Given that 47 percent of respondents indicated that Lean elements are implemented, hypothesis three stating that *"The majority of wood products and furniture manufacturing industries in the Commonwealth of Virginia have not implemented Lean management*," could not be rejected. Thus, based on this research, it can be concluded that the majority of the wood products and furniture manufacturing industries in the Commonwealth of Virginia have not implemented Lean or individual elements of Lean (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003).

Using a Kruskal-Wallis test ($\alpha = 0.05$) to test hypothesis four, *"There is no difference in Lean implementation status between the wood products and furniture manufacturing industries in*

the Commonwealth of Virginia," evidence was found to reject this hypothesis and to conclude that there are differences in Lean implementation status between different participants of the wood products and furniture manufacturing industries in the Commonwealth of Virginia (p = 0.0096). Figure 21 provides an overview of Lean elements implemented by individual companies for the different wood products and furniture industry sub-segments in the Commonwealth of Virginia as well as the mean frequency of elements implemented.

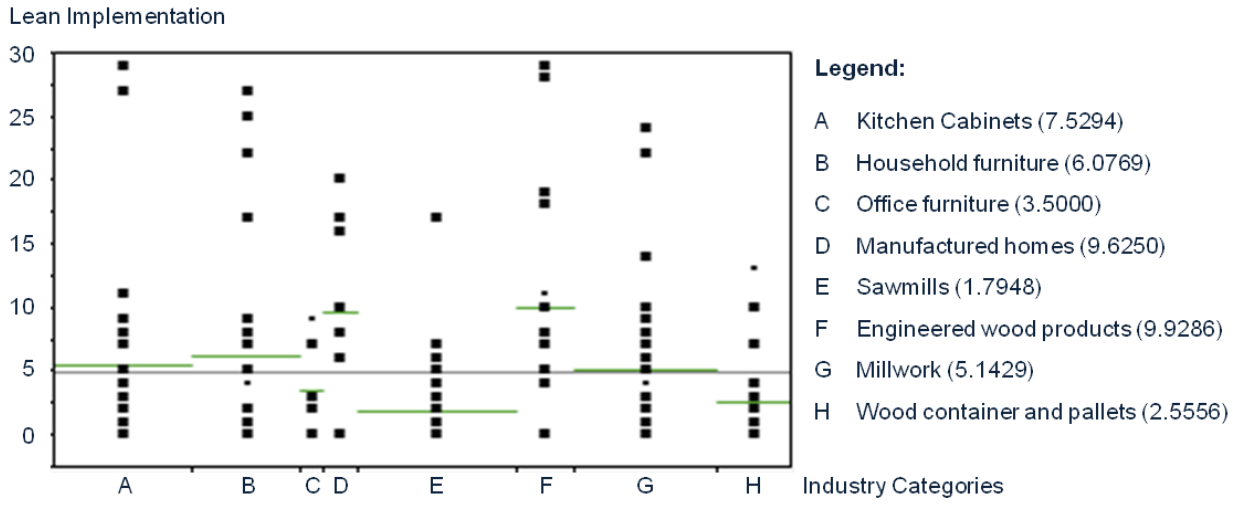

Figure 21: Frequency of respondents indicating awareness of individual Lean elements

Figure 21 shows that Lean implementation efforts in businesses of the wood products and furniture industries in the Commonwealth of Virginia vary widely, ranging from none to maximum (e.g., 29 Lean elements). All industry sub-segments have respondents that have not implemented any Lean elements (N = 0). However, industry sub-segments differ in that some segments do not have any Lean-implementation leaders, e.g., businesses that have implemented or plan to be implementing all Lean elements. Particularly, respondents from the "*sawmills*" and the "*wood container and pallet manufacturing*" have no businesses implementing more than 17 and 13 Lean elements, respectively (Figure 21). On the other hand,

the "*wood kitchen cabinet and countertop manufacturing*" and the "*engineered wood products*" industry sub-segment have leaders that are involved with all 29 Lean elements. Lean implementation as measured by number of elements (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003) implemented averaged 5.76 over all industry sub-segments of the *wood products* and *furniture manufacturing* industries in the Commonwealth of Virginia. "*Engineered wood product* (column F in Figure 11)" companies, on average, had 9.93 Lean elements implemented, followed by "*manufactured homes* (D)" with 9.63 elements implemented. Those leaders were followed by "*kitchen cabinets* (A)," "*household furniture* (B)," "*millwork* (G)," "*office furniture* (C)," "*wood container and pallets* (H)" and "*sawmills* (E)" with mean values of, respectively, 7.53, 6.08, 5.14, 3.50, 2.56, and 1.80.

A Wilcoxon Rank-Sum test for multiple comparisons at the 95 percent of significance level (α = 0.05) with all 28 possible pairs revealed six industry sub-segments that are significantly different before applying the Bonferroni corrections. The p-values from these tests are summarized in Table 7.

Table 7: Significance (Wilcoxon rank-sum) of pair wise comparisons of industry sub-segments regarding Lean implementation as measured by implementation of the 29 Lean elements (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003).

NAICS	Description	32111	32121	32191	32192	32199	33711	33712	33721
32111	Sawmills and wood preservation		0.0018	0.0035	0.5606	0.0044	0.1293	0.0268	0.1975
32121	Veneer/plywood/engineered wood prdts			0.1409	0.0225	0.9176	0.0854	0.2039	0.2097
32191	Millwork				0.0981	0.1204	0.2046	0.8294	0.2348
32192	Wood containers and pallet manufacturing					0.0280	0.5134	0.2251	0.5269
32199	Manufactured homes/prefab. buildings						0.1091	0.2555	0.1705
33711	Kitchen/bath cabinets or countertops							0.9213	0.8580
33712	Household/ institutional furniture								0.5822
33721	Office furniture (incl. fixtures)								

Significantly different (before Bonferroni correction)

The corrected α-value for the Wilcoxon Rank-Sum test for multiple comparisons using the Bonferroni correction was 0.00179. Using this conservative measure (Hsu 1996), no significant differences could be detected.

A comparison of the two industries segments "*wood products* (NAICS 321)" and "*furniture manufacturing* (NAICS 337)" resulted in no significant outcome (Wilcoxon Rank-Sum, $p = 0.7790$). Thus, there is no difference in Lean implementation status between the wood products and furniture manufacturing industries.

A Wilcoxon Rank-Sum ($\alpha = 0.05$) test was used to test hypothesis 5, "*Companies of the wood products and furniture manufacturing industries with a Lean change agent are no different in respect to Lean implementation status as compared to companies without a change agent in the Commonwealth of Virginia*." Hypothesis 5 was rejected ($p < 0.0001$), proofing that Lean change agents have a positive influence on Lean implementation in the "*wood products*" and "*furniture manufacturing*" industries in the Commonwealth of Virginia. Businesses with a Lean change agent (part or full time), on average, worked with 19.80 of the 29 Lean elements, as opposed to only 3.59 elements for businesses without a Lean change agent.

4.4.3. Need for Lean Implementation Support

Only 23 percent of respondents answered the question "*Do you have a need for external support in order to improve your organization's performance?*" affirmative. Thus, hypothesis 6, *"The majority of the wood products and furniture manufacturing industry in the Commonwealth of Virginia does not need support for their Lean implementation*," could not be rejected. Also, this survey produced no evidence to reject hypothesis seven that "*There is no difference in need*

for support for Lean implementation between the sub-segments of the wood products and furniture manufacturing industries of the Commonwealth of Virginia (Fisher's exact test, p = 0.0509).

Interestingly, the "*need for support*" is influenced by the level of Lean awareness of respondents. Eighty-five percent of respondents indicating a "*need for support*" are aware of Lean, while only 15 percent of respondents indicating a "*need for support*" were not aware of Lean. For respondents indicating "*no need for support*," 70 percent were aware and 30 percent were not aware of Lean. Figure 7 displays the comparison.

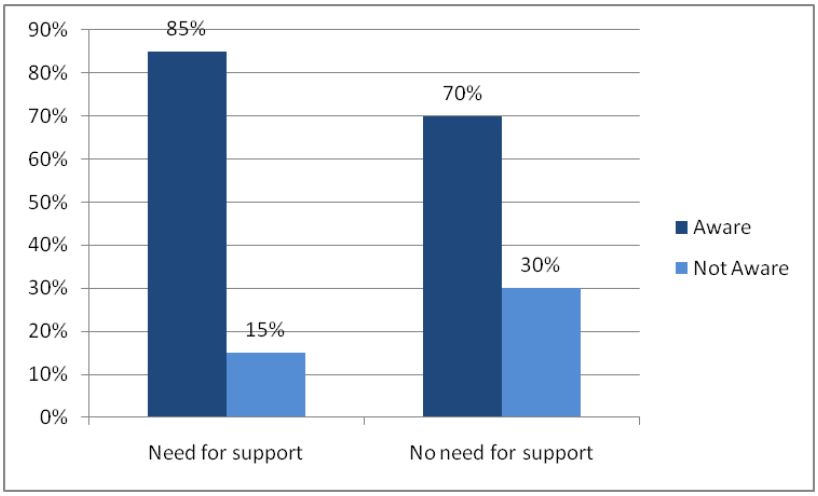

Figure 22: Comparison of Lean awareness and the need for support

After asking respondents about their need for support, the questionnaire asked survey participants "*How should external support look like?*" The questionnaire offered respondents 9 choices ("*Training shop floor employees*," "*Training administrative employees*," "*Training management*," "*Training executives*," "*Implementing certain elements with **no** company employee involvement*," "*Implementing certain elements with **little** company employee involvement*," "*Implementing certain elements with **extensive** company employee involvement*,"

"*Audits*," and "*Lean certification program for employees*." Additionally, respondents could mark "*Other (please specify)*" and "*I don't know, I need more information*." Figure 23 shows the results.

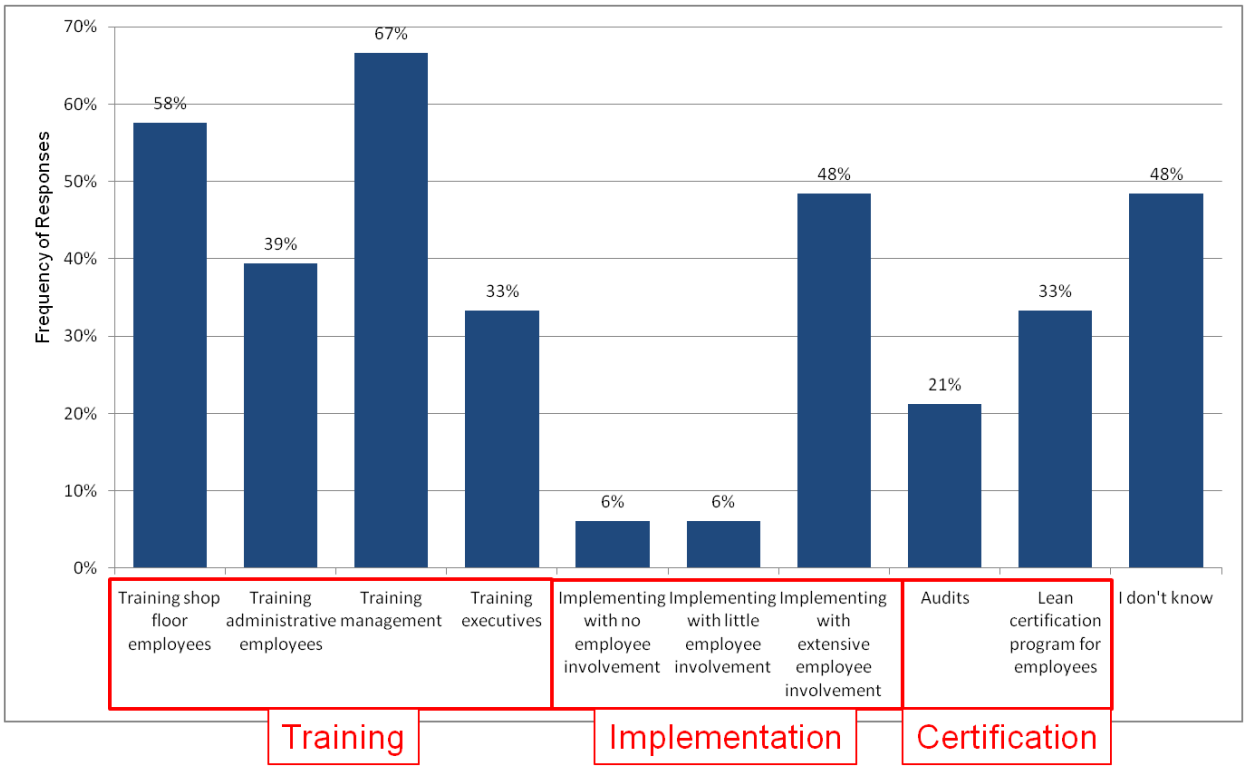

Figure 23: Respondents' need for support regarding training, implementation, and certification.

Only 18 percent (33 survey participants) of all survey participants answered the question *"How should external support look like?"* and all of them indicated to have a need for Lean implementation support.

Forty-eight percent of respondents indicated that they "*... don't know*" what form of support they want or need. "*Training*" was the most important area for support according to the findings of this survey. Two-third of the respondents (67 percent) indicated that "*training management*" is an important field in need for external support, a finding consistent with

Kandebo's (1999) claim that active management involvement is crucial for successful Lean implementation. "*Training shop floor employees*" was listed by 58 percent of all respondents, followed by "*Training administrative employees* (39 percent)," and "*Training executives* (33 percent).

Support for "*Implementation*" ranked highly on the perceived list of needs of respondents. Almost half of all respondents (48 percent) indicated a need for support for "*Implementing* (Lean) *with extensive employee involvement*." Solutions that offered little or no employee involvement received fewer demands, with both, "*Implementing* (Lean) *with no employee involvement*" and "*Implementing* (Lean) *with little employee involvement*" being selected by six percent of all respondents. The preference of respondents for support for Lean implementation "*...with employee involvement*" indicates a basic understanding of at least some respondents that employee involvement is a fundamental requirement of Lean (Liker 2003, Liker and Meier 2005).

"*Certification*" and "*Audits*" were of interest to 33 percent and 21 percent of respondents, respectively. Certifications in general certify that an individual is capable of competently completing tasks, *"…Usually by the passing of an examination* (Wikipedia 2010)," while audits are frequently used to establish a Lean culture and to certify a certain level of "Leanness" of the company (Hamel 2010).

4.5. Summary and Conclusions

While roughly three-fourths (72 percent) of the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in the Commonwealth of Virginia are aware of Lean, less

than half (47 percent) of all respondents of this survey indicated that they have implemented Lean elements in their business. Although Lean is slow to penetrate these two industry segments, large differences between industry sub-segments can be detected. While the average number of Lean elements implemented is 5.8094 and 5.7021 in the wood products and furniture manufacturing industries in the Commonwealth of Virginia, respectively, the industry sub-segment "*wood container and pallet manufacturing*" has no business implementing more than 13 Lean elements. Conversely, the industry sub-segments "*engineered wood products*" and "*wood kitchen cabinet and countertop manufacturing*" have businesses that have implemented the maximum number of 29 Lean elements.

Based on the results obtained from this survey of wood products and furniture manufacturing industries in the Commonwealth of Virginia, Lean elements that were implemented most frequently were concepts practiced by businesses that are not necessarily aware of Lean and are not planning to implement Lean. Examples of elements classified as Lean by Liker (2003) but in widespread use by companies not pursuing Lean strategies are, for example, "*training shop floor employees*", or "*employee cross training*", and "*mission statement*." Large numbers of survey respondents were aware of these three elements (50, 49, 64 percent, respectively) and had them implemented (46 percent, 40 percent, 38 percent, respectively). If responses for elements that are uniquely associated with Lean are considered, such as, for example, "*A3-report, quick changeover (SMED), one-piece-flow, supermarket system, error proofing (Poka Yoke), takt time, Kanban system, or PDCA-cycle*," a much lower rate of Lean awareness and Lean implementation became apparent (4, 5, 7, 7, 8, 9, 9, and 9percent, respectively).

Interestingly, despite the low level of Lean implementation among companies in the wood products and furniture manufacturing industries in the Commonwealth of Virginia, only 23 percent of the respondents claimed to have a need for Lean implementation support. The respondents indicated a need for support with the training of management and shop floor employees, as well as implementation support with extensive employee involvement (67 percent, 58 percent, 48 percent, respectively). However, forty-eight percent of respondents indicated that they "*... don't know*" what form of support they want or need.

The outcome of this study shows that the wood products and furniture manufacturing industry n Virginia is slow adapting and implementing Lean elements, a finding supported by results from a study by Pirraglia et al. (2009). Only a few industry sub-segments, "*kitchen cabinets*" and "*engineered wood products*", have "*Lean leaders*," who have implemented all 29 Lean elements (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003). Also, the low number of respondents indicating the need for Lean implementation support (23 percent) suggests that companies may not be aware of the potential benefits that Lean might generate. Thus, future efforts should focus on the dissemination of potential benefits of Lean for the wood products and furniture manufacturing industries. Future research should also investigate Lean awareness and implementation status of other industries to establish the relative status of the wood products and furniture manufacturing industries in respect to other manufacturing industries. However, the ultimate measure of business success is survival and growth, two characteristics that have been sorely missing in the wood products and furniture manufacturing industries in Virginia for the last decade. Lean might be a way to improve the industry's success rate, should more Lean followers emerge in the future.

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5. Lean in Small and Medium Enterprises (SMEs)

5.1. Abstract

This study examined the awareness, implementation status, and the need for implementation support of Lean practices among small and medium-sized companies in Virginia's wood products (NAICS 321) and furniture industry (NAICS 337). One-hundred eighty responses from a census mail survey (population size 1033) were analyzed using non-parametric statistical tests. The results confirm previous research that smaller companies in these industries are marginally aware of Lean and its potential benefits. These small companies also have implemented Lean practices to a lesser degree than have medium-sized companies. Furthermore, the data obtained reveals that increased company size leads to an increased need for Lean implementation support from third parties.

5.2. Introduction

Economies around the world have faced difficult conditions over the last years due to the financial crisis (Wessel 2010, International Monetary Fund 2009, Dicks 2008). However, change in the U.S. economy is not entirely driven by the current economic upveal, but also by the ongoing globalization of economic activities (Buehlmann and Schuler 2009 and 2002, Fishman 2005). Increased global trade has caused a dramatic upsurge in products from overseas entering the U.S. market, prompting stiff competition in the market place (Umble et al. 2003). Small and medium-sized enterprises (SME) are particularly affected by these global events as they have limited power to influence third-parties, such as, for example, require cost reductions from their suppliers (Achanga et al. 2006). Thus, operational excellence and flexibility to adapt

to market conditions is crucial for SMEs (Achanga et al. 2006). Various authors (Emiliani 2007 and 1998, Liker 2003, Womack and Jones 2003) have maintained that Lean management enables companies to achieve operational excellence and flexibility resulting in improved organizational performance and increased rates of business survival.

Lean, originating in the automotive industry (Womack et al. 1990), focuses on creating value for customers while eliminating waste at every step of a product's gestation sequence(Womack and Jones 2003, Liker 2003). Research funded by the U.S. Federal government in the 1980s into the success of Japan's car industry revealed that Japanese car manufacturers needed less human effort and time, less space, and less inventory to manufacture products of higher quality and higher value for the customer (Womack et al. 1990). Womack et al. (1990) introduced the term "Lean" for the Japanese way of manufacturing, but other terms such as "Toyota Production System (TPS)," or "Lean manufacturing," among others, are used interchangeably.

Subsequent research has found that Lean Management is not only applicable to high volume manufacturers, but can also help small businesses to improve their performance (Achanga et al. 2006, Lee 1997, Brown and Inman 1993). However, research has also shown that smaller companies typically are more reluctant to implement improvement programs, such as Lean (Stuart and Boyle 2007, Kumar et al. 2006, Achanga et al. 2006). Reasons may be, among other things, a lack of resources in small organizations (Curran et al. 1997), a short-term planning horizon, and lower awareness of the benefits of improvement programs and training opportunities offered by third-party support organizations (Westhead and Storey 1996).

The U.S. manufacturing industries have experienced challenging times over the past decades. The rapid globalization of economies has brought the comparative disadvantage in production costs, labor skills, and regulations of the U.S. economy to the forefront. As "…*Imports started surging in the late 1990s, manufacturing employment started plunging* (Anonymous 2010)," with U.S. manufacturing employment today less than 12 million from a peak of almost 20 million in 1979 (BLS 2010).

The U.S. forest products industries (wood products [NAICS 321], pulp and paper [NAICS 322], and furniture [NAICS 337], respectively) have not done better than other U.S. manufacturing segments. The U.S. forest products industries are important contributors to the U.S. economy creating an estimated $362 billion in sales and employing almost 1.5 million in 2007 (U.S. Census Bureau 2009a, U.S. Census Bureau 2009b, U.S. Census Bureau 2009c). However, large parts of the U.S. forest products industries have lost considerable market share over the past decade or two. For example, from 1990 to 2008, the share of domestically produced Oriented Strand Board (OSB) and Plywood, hardwood and softwood mouldings, or wooden, non-upholstered household furniture decreased from 96, 87, and 78 percent to 83, 63 and 36 percent, respectively (Buehlmann and Schuler 2009), trends that can be observed among other sectors of the U.S. manufacturing industry as well. Acknowledging the problem, numerous authors have called for a paradigm shift for U.S. manufacturing industries facing stiff global competition and shrinking domestic markets (Oh et al. 2008, Schuler and Buehlmann 2003, Becker 2003). Among others, the proposed actions include adapting new strategic business models, use of mass customization, creating supply chain alliances, and, embracing Lean as a

holistic system to focus on creating customer value while eliminating waste (Buehlmann and Schuler 2009).

Lean, a powerful management system to increase business performance for companies offers an opportunity for remaining U.S. manufacturers to compete more successfully. In the wood and furniture industries, consisting of mostly small and medium sized businesses (SME, according to U.S. Census (2010a), 66 percent of wood products [NAICS 321] and 80 percent of furniture manufacturing [NAICS 337] companies have less than 20 employees), Lean offers companies the ability to achieve performance improvements while also increasing production flexibility required to adapt to a more customer-centric business model (Brown and Inman 1993, Lee 1997, Achanga et al. 2006). However, little research exists investigating the awareness and implementation of Lean in small companies, nor is there much insight about the need for support by those small businesses. Existing publications mostly cover efforts of large organizations implementing Lean (Hon 2010, Merillat-Masco Builder Cabinet Group 2009, Steelcase 2006).

The objective of this research was to gain an understanding of the awareness and implementation of Lean practices by small and medium-sized companies in the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industry in the Commonwealth of Virginia. The following three areas of interest were investigated: Lean awareness, Lean implementation status, and the need for supporting Lean implementation. Thus, the following three hypotheses were tested:

Lean Awareness

$H1_0$: "*No difference in Lean awareness exists between companies with 1-19, 20-49, and 50-499 employees in the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in the Commonwealth of Virginia*."

Lean Implementation

$H2_0$: *"No difference in Lean implementation status exists between companies with 1-19, 20-49, and 50-499 employees in the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in the Commonwealth of Virginia*."

Need for Support

$H3_0$: *"No difference in need for support of Lean implementation exists between companies with 1-19, 20-49, and 50-499 employees in the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in the Commonwealth of Virginia*."

5.2.1. Definition of SME

Depending on the source, industry, and country, different definitions exist as to what constitutes a small and medium-sized business (SME). For example, the U.S. small business administration (SBA 2010) defines companies in most industries with less than 500 employees as small and with 500 and more employees as large. However, no additional distinction is made between small and medium-sized organizations (SBA 2010). In the European Union, the European Commission standardized the definition for SMEs across all industries and countries in the European Union as follows: Companies with less than 10 employees are called micro, companies with fewer than 50 employees are considered small, medium when employing between 51 and 249 employees, and large when 250 or more employees are involved

(European Commission 2010). Australia's Bureau of Statistics (2002) classifies companies with less than 20 employees as small, companies with between 20 and 199 employees as medium, and large when 200 or more employees are employed (ABS 2002).

For the purpose of this study, to account for the large number of companies with one to 19 employees and to discover differences between smaller companies, the following company size structure has been adapted: (1) 1-19 employees, (2) 20-49 employees, and (3) 50-499 employees.

5.3. Research Methods

A mail survey was chosen as the method of choice for this study. Mail surveys are a commonly used method to make inferences about a population's characteristics by taking measurements on a randomly selected sample from the population of interest without having to contact the entire population (Ott and Longnecker 2010, Rea and Parker 2005). Attention has to be paid to the sample selection process to minimize the risk of unwanted bias. Typically, a random selection is to be preferred. To be able to draw meaningful conclusions from the information gathered, the survey design is of high importance, too (Dillman et al. 2009, Rea and Parker 2005).

5.3.1. Survey Population

The population of interest for this study consisted of all companies operating in the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in the Commonwealth of Virginia. According to the U.S. Census, wood products manufacturing (NAICS 321) includes companies categorized in "*sawmills and wood preservation* (NAICS 32111)",

"*veneer, plywood, and engineered wood product manufacturing*(NAICS 32121)" including trusses, "*millwork* (NAICS 32191)" including windows, doors, and flooring, "*wood container and pallet manufacturing* (NAICS 32192)", and "*all other wood product manufacturing* (NAICS 32199)" including manufactured and prefabricated homes (U.S. Census Bureau 2010b). Furniture manufacturing (NAICS 337) includes companies categorized in "*wood kitchen cabinet and countertop manufacturing* (NAICS 33711)", "*household and institutional furniture manufacturing* (NAICS 33712)", "*office furniture (including Fixtures) manufacturing* (NAICS 33721)", and "*blind and shade manufacturing* (NAICS 33792, U.S. Census Bureau 2010b)". According to the Quarterly Census of Employment and Wages (2010), the total number of establishments in the Commonwealth of Virginia in these industries in 2009 was 1033 (513 establishments in wood products manufacturing (NAICS 321) and 520 establishments in furniture manufacturing (NAICS 337)).

Due to a lack of a state-wide address list containing the companies of interest, address data was collected from: Manta's online business listings (Manta 2010), the 2009 Virginia industrial directory (D&B 2009), the manufacturer index of the Wood Products Manufacturers Association (WPMA 2010), and the membership list of the Architectural Woodwork Institute (AWI 2010). After correcting for surveys that could not be delivered, companies out of business, or companies that were not involved in wood products (NAICS 321) or furniture manufacturing (NAICS 337) the final sample size for this survey was 1,193, which was used for a Census survey (Dillman 2006, Alreck and Settle 1995)

5.3.2. **Questionnaire Design**

A mail questionnaire directed at wood products manufacturing (NAICS 321) and furniture manufacturing (NAICS 337) companies in the Commonwealth of Virginia was developed. The first part of the questionnaire consisted of nine questions to gather basic company information regarding NAICS classification, company size, and the unification of its employees. The second part asked questions regarding the company's Lean practices, including questions about Lean awareness, implementation status of Lean, and Lean improvement success. The third part asked questions assessing the respondents' need for support regarding Lean transformations, while the fourth part consisted of product and market related questions. Two types of questions were used: 1) categorical and 2) open-ended (Fink 2003, Rea and Parker 2005).

This study, to evaluate the level of Lean awareness and Lean implementation status, as well as the need for Lean implementation support of companies in the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in the Commonwealth of Virginia, a set of widely used 29 Lean elements categorized in four categories (4P's - philosophy, process, people, and problem solving) developed by Liker (2003) were employed as proxies (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003).

Table 8: The 29 Lean elements used as proxies to establish Lean awareness and Lean implementation status (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003).

4P's	Lean Elements
Philosophy	Vision statement
	Mission statement
Process	Value stream mapping
	Takt time
	Pull system
	Supermarket replenishment system

	Just-in-time
	One-piece-flow
	Kanban-System
	Standard work
	Standardized work sheet
	Leveling production and schedules (Heijunka)
	Single minute exchange of die (SMED)
	Error proofing (Poka Yoke)
	Visual Management
	Notification system for quality and process problems (Andon)
People	Training shop floor employees
	Training administrative employees
	Training operational management
	Training executives
	Shop floor employee cross-training
	Shop floor employee skills matrix
Problem Solving	Continuous improvement (Kaizen) events
	Root cause analysis (Fish bone diagram)
	5-why-analysis
	Plan-do-check-act (PDCA)-Cycle
	A3-report
	5S method
	Go to where the problem is and see (Genchi genbutsu)

Kirby and Greene (2003) in their study on "*How value stream type affects the adoption of Lean production tools and techniques*" found a direct positive relationship between the number of Lean elements (Table 8, Liker 2003, Czabke et al. 2008, Kirby and Greene 2003) implemented and the level of an organization's Lean maturity. They defined five maturity levels from level one with companies starting Lean but not having fully implemented the entire set of Lean tools, to level five having extensively implemented the entire set of tools. It was found that the number of implemented Lean tools increased between maturity levels one to four. By level four, however, the entire set of Lean tools was implemented so that between levels four and

five the only distinction in Lean maturity could be made through the evaluation of the intensity the Lean tools were implemented. Based on the available publications (Pirraglia et al. 2009, Czabke et al. 2008) and personal observations, the research team expected the level of Lean implementation to be low among Virginia's wood products and furniture manufacturing companies, and thus the survey only focused on the patterns of Lean maturity from level one to level four without considering the differences in implementation intensity between levels four and five.

The questionnaire was reviewed by faculty at Virginia Tech and feedback was obtained from industry specialists at the USDA Forest Service and the Lean Management Instituut, Netherlands. After incorporation of all useful suggestions, a pretest mailing was conducted. A sample group of 25 addresses was randomly selected from the address list to test the questionnaire for clarity, comprehensiveness and acceptability (Rea and Parker, 2005). The pretest mail questionnaire was addressed to corporate-level decision makers in the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in the Commonwealth of Virginia. Each mailing consisted of a personalized cover letter, a mail questionnaire including a unique tracking number, and a first-class postage pre-paid return envelope. Seven responses were received. The responses were analyzed and minor changes were made to the mail questionnaire to address issues and to increase clarity (Rea and Parker 2005).

5.3.3. **Data Collection**

The first mail questionnaire to the entire address list (N = 1771) was mailed in July 2010 and was addressed to corporate-level decision makers in the wood products manufacturing (NAICS 321) and furniture manufacturing (NAICS 337) industry. Each questionnaire contained a personalized cover letter, a questionnaire with a unique tracking number for accurate response monitoring, and a first-class, pre-paid return envelope (Biemer and Lyberg 2003, Rea and Parker 2005). To increase the response rate, the cover letter and the questionnaire, were printed on colored paper (Rea and Parker, 2005). A reminder postcard, a second survey (including cover letter, questionnaire with tracking number, and pre-paid return envelope), and a second reminder postcard were sent out to all non-respondents one, four, and seven weeks after the first mailing, respectively. Ten weeks after the original mailing of the first questionnaire, thirty non-respondents were contacted by telephone and fax and asked three demographic questions for use in the determination of non-response bias (Dillman et al. 2009, Rea and Parker 2005). All data was entered into a coded MS Excel data analysis spreadsheet (Microsoft 2007).

5.3.4. **Data Analysis**

The data obtained was coded according to tracking number, date received, categorical data, and open-ended responses. The coded spreadsheet was then uploaded to JMP 8.0 statistical software (SAS 2008) for statistical analysis, such as frequency distributions, contingency tables, and descriptive statistics (Dillman et al., 2009, Rea and Parker, 2005). Survey data from questions pertaining to industry demographics, market structure, and Lean practices were tested using non-parametric statistics. Non-response bias was tested using the data from the 30 of the 1005 non-respondents who were randomly selected and contacted via telephone and

fax (Rea and Parker, 2005). Two demographic questions were asked (which industry segment the respondent's company belongs to and how many employees are currently working in the respondent's company). Additionally, one question regarding the respondent's awareness of Lean terms was asked. Results of this telephone and fax data collection were analyzed using Fisher's exact test to account for potential small sample sizes (Ott and Longnecker 2010). No significant ($\alpha = 0.05$) differences between the respondents and non-respondents were found (p-values 0.90, 0.19, 0.67, respectively, for Fisher's exact test).

5.3.5. **Definitions**

The following definitions for measuring Lean awareness, Lean implementation status, and the need for Lean implementation support were used in this study.

Survey participants were considered "*aware of Lean*" if at least one of five Lean terms (Lean Management, Lean Manufacturing, Lean Production, Lean Thinking, or Toyota Production System (TPS) was answered affirmative to the question "*Have you heard of the following terms (check all that apply)?*" For additional details on the Lean awareness of the survey participants, respondents were asked to indicate awareness of any of the 29 Lean elements (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003) listed in the questionnaire .

To assess the participants' Lean implementation status, respondents needed to check at least one of the 29 Lean elements (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003) as "*already in use*." If at least one of the 29 elements were checked as "*already in use*" the company was considered as having "*implemented Lean*". Due to the small number of responses (N=6), participants that answered to be implementing certain Lean elements within

one, three, or in more than three years from now were forced into the category "*not planned*" indicating that these elements are currently not in use. An additional in-depth analysis of the type and number of used Lean elements was then used to gain more insight into the Lean implementation status of participating companies.

To evaluate the need for Lean implementation support, the survey participants were asked to answer the question "*Do you have a need for external support in order to improve your organization's performance*". All affirmative answers were used to conclude a need for Lean implementation support.

5.3.6. **Limitations**

A limitation of survey research is that all results are based on only one respondent from each company. Thus, the feedback received may not reflect the views or opinions of the company or of other management level employees. This may particularly affect answers made to questions regarding Lean awareness, Lean implementation and the need for Lean implementation support as answers on this subject contain an element of subjectivity.

This study used knowledge of at least one of the 29 Lean elements to determine companies' Lean implementation status. If a respondent simply chose to ignore questions regarding those 29 Lean elements, bias occurred through a possibly wrongful classification of the respondent as "*has not implemented Lean*." However, the research team decided that such a misclassification could only occur in few cases and should not bias the overall results of this study.

A Fisher's exact test was conducted to test on reliability between the population and the responses to compare every industry sub-segment's representation. The test showed a

significant difference (p-value = 0.01016) in representation from the original data (Fisher's exact test, $\alpha = 0.05$). Companies from "o*ther wood product manufacturing* (NAICS 3219)" including "millwork (NAICS 32191)", "*wood container and pallet manufacturing* (NAICS 32192)", and "*manufactured home (mobile home) manufacturing* (NAICS 32199)" were overrepresented, while companies from "*office furniture (including fixtures) manufacturing* (NAICS 3372)" were underrepresented.

The survey's questionnaire asked respondents if there is "…A *need for external support…*" in their quest to implement Lean. This question may have caused bias by respondents as they may have become concerned about unwanted soliciting for Lean implementation support from third parties. Not all respondents thus may have answered this question affirmative despite an actual need for support.

Lastly, this survey asked questions about a specific topic (Lean). It can be argued that individuals knowledgeable about Lean tend to be more likely to respond to the survey. However, the results obtained seem consistent with previous research (Pirraglia et al. 2009, Stuart and Boyle 2007, Kumar et al. 2006, Achanga et al. 2006, Westhead and Storey 1996) regarding Lean awareness, Lean implementation, and the need for Lean implementation support. Thus, if bias is present, it should be low.

5.4. Results and Discussion

5.4.1. Respondent Profiles

Eighty-seven percent of the survey respondents worked for corporate management, operating management, or were the owners or presidents of the company. Seven percent of the

respondents were part of production management, while the rest either worked for marketing and sales, engineering and other (2, 1, and 3 percent, respectively).

A majority (61 percent, N = 112) of the responding wood products (NAICS 321) and furniture manufacturing (NAICS 337) companies in the Commonwealth of Virginia employed less than 20 employees. Twenty percent of respondents had between 20 and 49 employees, while 19 percent employed between 50 and 499 employees. Figure 24 gives an overview of respondents' company size as measured by number of employees for all respondents (Figure 24 left), for the wood products Industry (NAICS 321, Figure 24 middle), and for the furniture manufacturing Industry (NAICS 337, Figure 24 right).

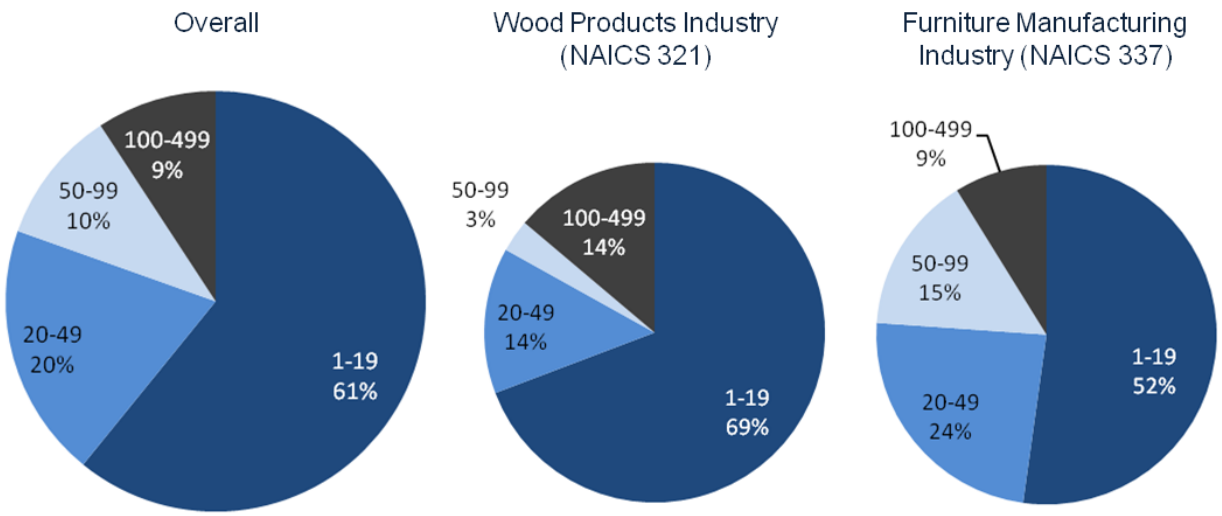

Figure 24: Number of employees by responding company, overall, for the wood products and for the furniture manufacturing industry

Figure 24 shows that the wood products industry has a larger share of companies with less than 20 employees (69 percent, N = 45) than does the furniture manufacturing industry (52 percent, N = 59). The wood products industry segment, however, has fewer companies with

20-49 and with 50 to 499 employees (14 and 17 percent, respectively) than the furniture manufacturing industry (24 and 24 percent, respectively).

Detailed analysis of respondents' company size as measured by number of employees reveals that the furniture manufacturing segment of Virginia's forest products industry has relatively few companies with more than 100 employees. When breaking the cluster of 50-499 employees down to 50-99 and 100-499 employees, 63 percent of the furniture industry belongs to the former and only 38 belong to the later. The same breakdown for the wood products industry results in an 18 and 82 percent distribution, respectively. The relatively low number of larger furniture manufacturers (by number of employees) in the Commonwealth of Virginia may result from the closure of large furniture manufacturing operations over the past two decades when production was outsourced to lower cost offshore locations (Buehlmann and Schuler 2009, Quesada and Gazo 2006, Buehlmann and Schuler 2002).

More than three-fourth (78 percent) of the survey participants operate a single facility operation (Figure 25, left graph). Seventy percent of the single facility operations employ between 1-19 employees, followed by 21 percent employing 20-49 employees, and 9 percent employing 50-499 employees. Sixty-two percent of the multi-facility operations employ between 50-499 employees, 14 percent employ 20-49, and 24 percent employ 1-19 employees (Figure 25, right graph).

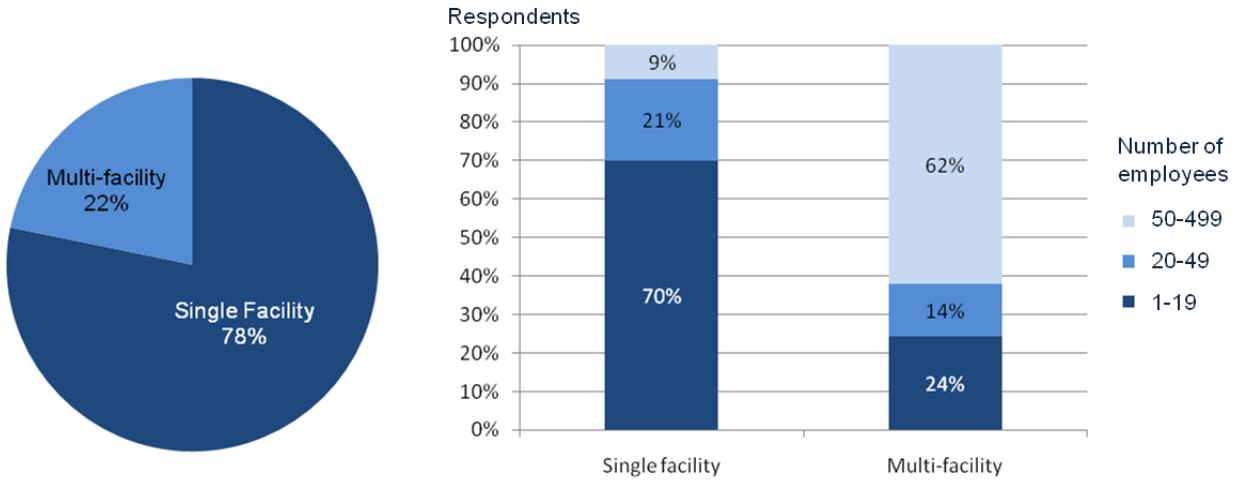

Figure 25: Survey respondents' working in single facility and multi-facility operations (left graph) and company size distribution by single facility and multi-facility operations (right graph)

The survey participants were also asked if their employees were "*…Organized in unions.*" Ninety-nine percent of the respondents negated this question.

5.4.2. **Lean Awareness**

As defined in the Methodology section, Lean awareness of respondents was measured by respondents answering positively to having heard one of the following five terms: Lean Management, Lean Manufacturing, Lean Production, Lean Thinking, and Toyota Production System (TPS). 72 percent of the respondents indicated that they are aware of at least one of the terms (Figure 26). Awareness of Lean, however, differed by size of company for which the respondent worked. Only 65 percent of respondents from the smallest companies (1-19 employees, N=112) were aware of at least one of the Lean terms while 82 percent of the respondents from companies with 20-49 employees (N=33) were familiar with at least one term. Respondents working for companies with 50-499 employees (N=35) were, with 86 percent, the most familiar with at least one of the five Lean terms listed in the questionnaire.

Figure 26 graphically displays the awareness of respondents to at least one of the five Lean terms overall and by company size.

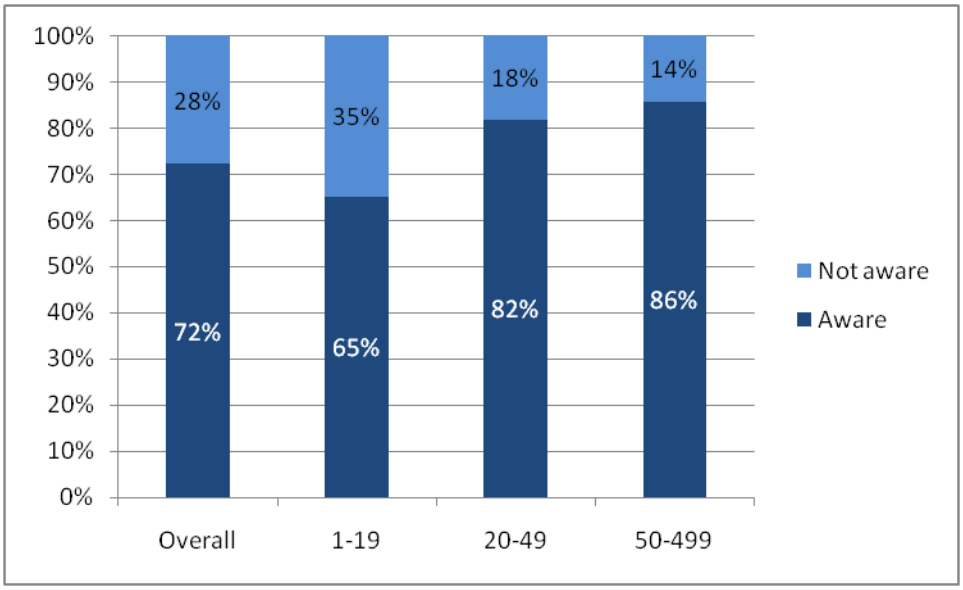

Figure 26: Lean awareness of respondents as measured by knowing at least one of the five Lean terms overall and by company size (1-19, 20-49, and 50-499 employees).

Hypothesis one ("*No difference in Lean awareness exists between companies with 1-19, 20-49, and 50-499 employees in the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in the Commonwealth of Virginia*.") was tested using Fisher's exact test and found highly significant (p-value of 0.02504). Thus, Lean awareness differs between companies with 1-19, 20-49, and 50-499 employees. Conducting pair-wise comparisons (Fisher's exact test, $\alpha = 0.05$), evidence was found that respondents working for companies with 1-19 employees and respondents working for companies with 50-499 employees do not share the same level of Lean awareness. For this comparison, a significant p-value of 0.0210 was found (Table 9). However, when applying the Bonferroni correction (corrected $\alpha = 0.01667$), known to result in conservative conclusions (Hsu 1996), no significant difference was found. Nevertheless, a trend can be observed that larger companies are more aware of Lean. Table 9

shows the p-values of the pair wise analysis between the three different company sizes using Fisher's exact test.

Table 9: Results of pair wise analysis (p-values) regarding awareness of Lean terms.

	1-19	20-49	50-499
1-19 employees		0.0873	**0.0210**
20-49 employees			**0.7487**
50-499 employees			

Significantly different (before Bonferroni correction)

On average, each one of the 29 Lean elements (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003) was known by 25 percent of the respondents. However, Lean elements such as, for example "*mission statement, just-in-time, training shop floor, employee cross-training, or vision statement* (63, 56, 49, 48, 42 percent awareness, respectively)" were more widely known than more Lean-specific elements such as, for example, "*A3-report*, *quick changeover (SMED)*, *error proofing* (*Poka Yoke*), *notification system (Andon)*, or *PDCA-cycle* (6, 8, 12, 12, and 13 percent awareness, respectively)." Figure 27 displays the awareness of Lean elements by survey respondents overall and by company size.

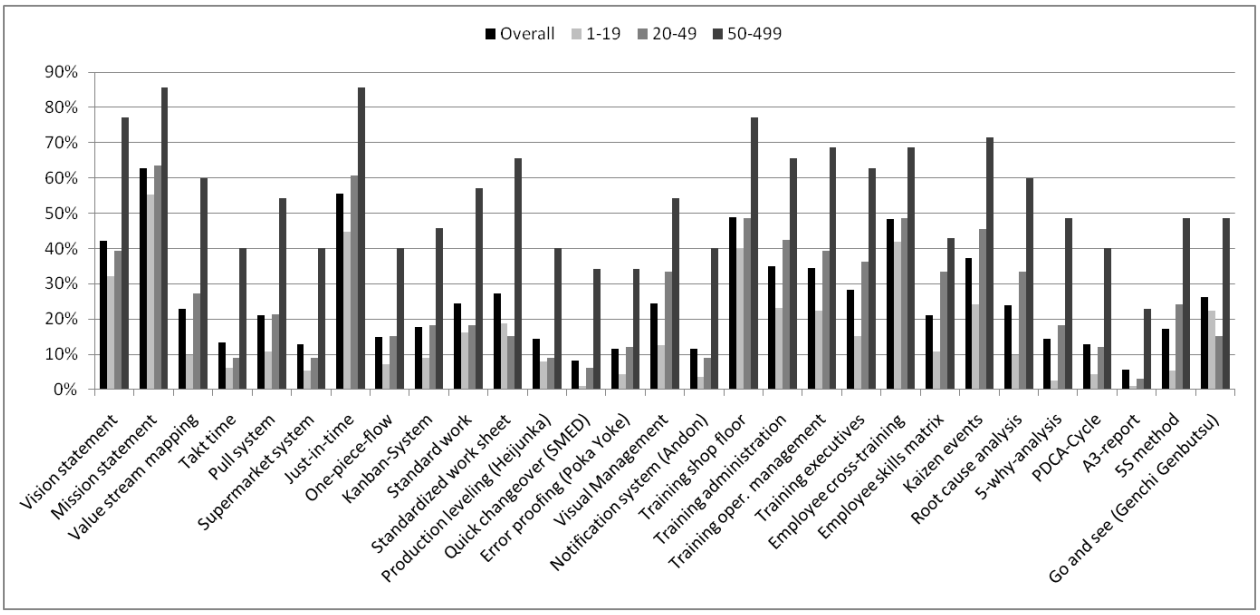

Figure 27: Awareness of Lean elements by survey respondents overall and by company size (1-19, 20-49, and 50-499 employees).

Figure 27 shows that larger companies are more aware of Lean elements than are smaller companies. At smaller companies (1-19 employees), the respondents' awareness of Lean elements is below the average (16 percent). On the other hand, the awareness of Lean elements of respondents from larger companies (50-499 employees) is higher than the average (54 percent).

On average, companies with 1-19, 20-49, and 50-499 employees were aware of 4.68, 7.03, and 15.36 Lean elements, respectively. Testing the data using a Kruskal-Wallis non-parametric test over the three company sizes established (1-19, 20-49, and 50-499 employees), Hypothesis one was rejected as it had been previously ($p < 0.0001$). Thus, it can be concluded that "*a difference in Lean awareness exists between companies with 1-19, 20-49, and 50-499 employees in the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in the*

Commonwealth of Virginia." Figure 28 shows the distribution of awareness of Lean elements (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003) by company size.

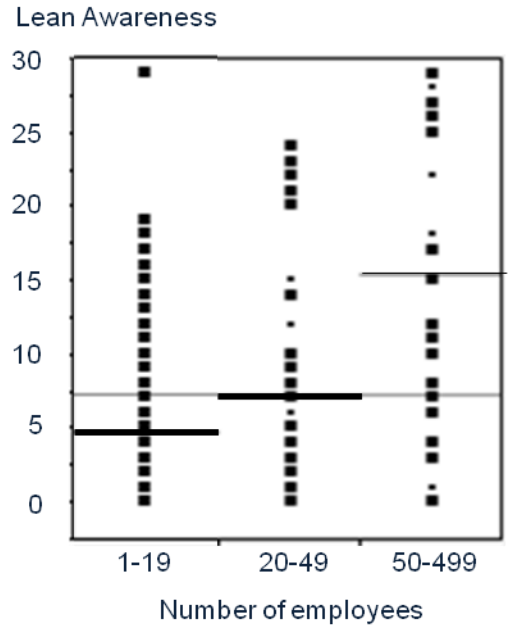

Figure 28: Results of testing Lean awareness by company size using Kruskal-Wallis testing

Using a Wilcoxon Rank-Sum multiple comparison test, significant differences were found between companies with 50-499 employees and both, 20-49 ($p = 0.0007$) and 1-19 employees ($p = 0.0001$). However, no statistically significant difference was detected between 1-19 and 20-49 employees ($p = 0.1012$). The difference between the identified pairs remained significant after applying the Bonferroni correction (corrected $\alpha = 0.01667$).

5.4.3. Lean implementation status

The average frequency distribution for Lean elements in use is lower than the average frequency for Lean awareness. Fewer companies have actually implemented Lean elements than companies that are aware of the 29 Lean elements (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003). Forty-seven percent of responding companies have at least one of the 29

Lean elements implemented. Thus, fewer companies are implementing any of the Lean elements than companies that are aware of at least one (72 percent). Not surprisingly, respondents have more likely heard of Lean elements than actually implemented it. Figure 29 provides an overview of individual Lean elements being implemented by survey participants.

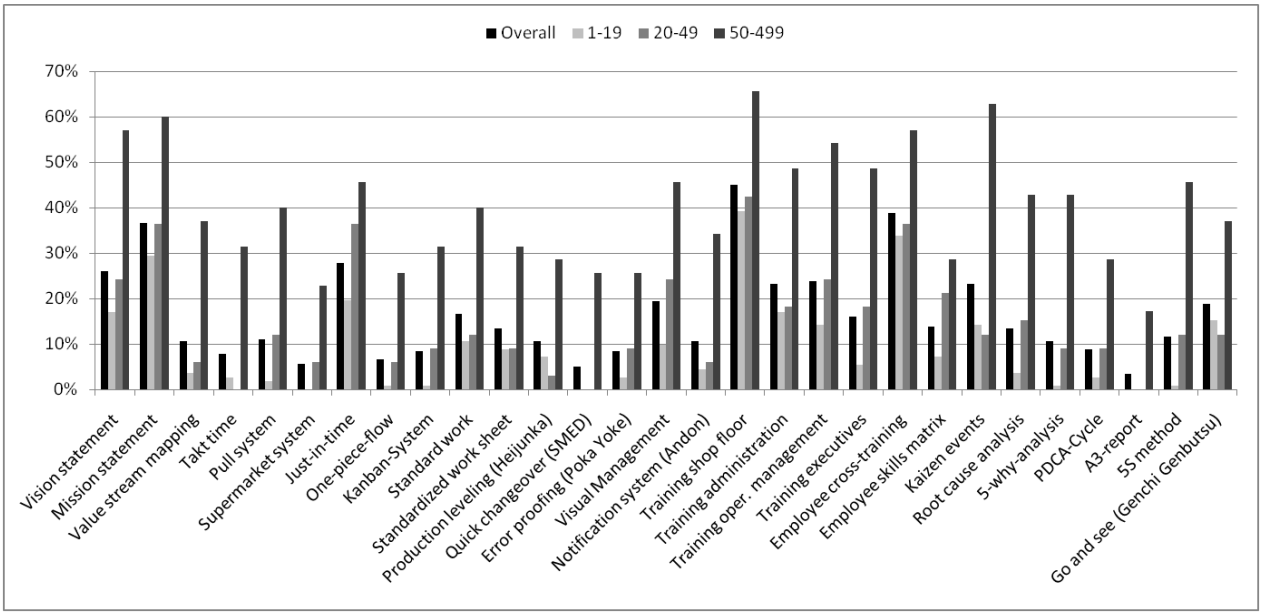

Figure 29: Overview of implementation of Lean elements by survey respondents

On average, each Lean element is implemented by 16 percent of the respondents (Figure 29) versus an average awareness of individual elements by respondents of 25 percent (Figure 27). Smaller companies (1-19 employees) indicated that they had, on average, only implemented each of the 29 elements 9 percent of the time, only about half of the average for all companies (16 percent) and four times lower than the average implementation frequency (40 percent) of the largest companies researched (50-499 employees).

However, these average numbers are misleading as the implementation frequency of Lean elements varies greatly. Lean elements such as, for example, "*training shop floor, employee*

cross-training, mission statement, just-in-time, and vision statement (overall implementation frequency 45, 39, 37, 28, and 26 percent, respectively)" were implemented above average (16 percent). These elements listed are concepts practiced by many businesses that have no awareness of Lean or do not want to implement Lean. The response frequency for elements that are more uniquely associated with Lean such as, for example, "*A3-report, quick changeover (SMED), supermarket system, one-piece-flow, takt time, Kanban system, and error proofing (Poka Yoke)* (overall implementation frequency 3, 5, 6, 7, 8, 8, and 8, respectively)" is rather low and draws a less favorable picture of Lean implementation penetration of the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industry in the Commonwealth of Virginia.

Using a Kruskal-Wallis test ($\alpha = 0.05$), hypothesis two, "*No difference in Lean implementation status exists between companies with 1-19, 20-49, and 50-499 employees in the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in the Commonwealth of Virginia*," was rejected ($p < 0.0001$). Thus, there is at least one company size group that is different from the others. Figure 30 shows the distribution of Lean element implementation by company size (1-19, 20-49, and 50-499 employees).

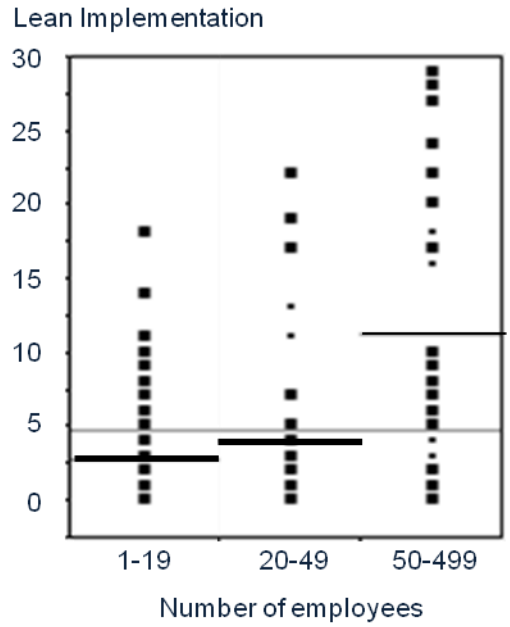

Figure 30: Distribution of Lean implementation by company size (1-19, 20-49, and 50-499 employees).

While all three company sizes (1-19, 20-49, 50-499 employees) have representatives with no Lean elements implemented, only the largest companies (50-499 employees) had representatives with more than 25 elements implemented (N = 7).

On average, companies with 1-19 employees have implemented 2.74 Lean elements, companies with 20-49 employees have implemented 3.94 Lean elements, and companies with between 50-499 employees have implemented 11.31 Lean elements.

Conducting pair wise comparisons for number of elements implemented by company size (as measured by number of employees) using Wilcoxon Rank-Sum tests, highly significant differences between companies with 50-499, 20-49 ($p = 0.0030$), and 1-19 ($p = <0.0001$) employees were found. No significant difference was found between companies with 1-19 and 20-49 employees ($p = 0.3751$). The significant differences of the two pairs remain after applying the Bonferroni correction (corrected $\alpha = 0.01667$).

5.4.4. **Need for Lean Implementation Support**

Eighty percent or more of the respondents working for companies with 1-19 and 20-49 employees indicated that they have no need for Lean implementation support. However, over 40 percent of respondents working in companies with 50-499 employees indicated a need for Lean implementation support. Figure 31 visualizes the need for Lean implementation support overall and across the three different company size categories (1-19, 20-49, 50-499 employees).

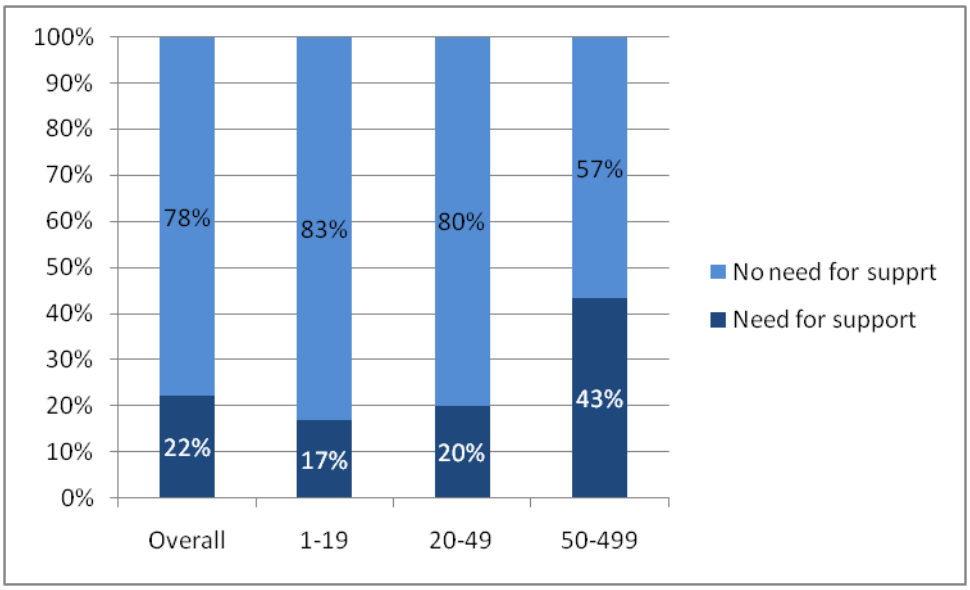

Figure 31: Need for Lean implementation support overall and across the three different company size categories

Differences in the need for Lean implementation support between the three company size categories were tested using Fisher's exact test to account for potentially small sample sizes within categories. Hypothesis three, "*No difference in need for support of Lean implementation exists between companies with 1-19, 20-49, and 50-499 employees in the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in the Commonwealth of Virginia*." was rejected ($p = 0.01231$), concluding that there is a significant difference in the need for Lean

implementation support between at least two of the different company size categories (1-19, 20-49, and 50-499 employees).

Fisher's exact test was also used to perform pair wise analysis of the three company size categories. A significant difference ($p=0.0053$) in need for Lean implementation support could only be established between the smallest company cluster (1-19 employees) and the largest company cluster (50-499 employees). No significant difference were found between companies with 1-19 and 20-49 ($p=0.7984$) and 20-49 and 50-499 employees ($p=0.0598$). The outcome of these statistical tests did not change when the Bonferroni correction was applied (corrected α-value of 0.01667).

5.5. Summary and Conclusions

The results of this study confirm previous research that smaller companies tend to have lower awareness of the benefits of operational improvement programs (Westhead and Storey 1996). Smaller companies are also more reluctant to implement such improvement programs, of which Lean is an example (Stuart and Boyle 2007, Kumar et al. 2006, Achanga et al. 2006). A mail survey targeting the wood products and furniture manufacturing industries (NAICS codes 332 and 337, respectively) in the Commonwealth of Virginia investigated the level of Lean awareness, the status of Lean implementation, and the need for Lean implementation support from companies with 1-19, 20-49, and 50-499 employees.

Sixty-five percent of the smallest companies (e.g., 1-19 employees), are aware of Lean as measured by recognizing one of five key Lean terms (Lean Management, Lean Manufacturing, Lean Production, Lean Thinking, and Toyota Production System). However, on average of all

respondents in this company size category (1-19 employees), only three key Lean elements of a total of 29 (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003) have been implemented, are being implemented, or are planned to be implemented in the near future.

Eighty-two percent of respondents from companies with 20-49 employees were aware of Lean and have implemented an average of four Lean elements from the 29 elements identified (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003). Of the largest company strata investigated, companies with 50 to 499 employees, 86 percent are aware of Lean and have implemented, on average, 11 Lean elements.

No large need for Lean implementation support was voiced by the respondents working for smaller companies (1-19 and 20-49 employees), despite the low level of Lean implementation among such companies. Only 17 and 20 percent, respectively, of respondents from these two company categories indicated a need for Lean implementation support. Larger companies (50-499 employees), however, signaled a larger need for Lean implementation support as 43 percent of respondents indicated a need.

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6. General Results, Discussions, Future Research

This chapter discusses additional observation made in the course of this research that go beyond the results described in chapters 5 and 6. Also, ideas regarding future research are presented.

6.1. Performance Indicators

As discussed in chapter 5, the most frequent Lean elements implemented as indicated by the survey participants were elements from Liker's (2003) "*philosophy and people*" categories, such as, for example, "*training shop floor, employee cross-training, just-in-time, and mission statement* (implemented by 46, 40, 38, and 29 percent of all respondents, respectively). However, these elements are concepts practiced by both, businesses that have and businesses that have no awareness of Lean as the survey outcomes suggest. Thus, the study may have overrated the actual Lean awareness and Lean implementation status of the industry. If measuring Lean awareness and implementation status by less widely used core Lean elements such as, for example, "*A3-report*," "*quick changeover (SMED)* ," "*one-piece-flow*," "*supermarket system*," "*error proofing (Poka Yoke)*," "*takt time*," "*Kanban system*," *or* "*PDCA-cycle* (implemented by 4, 5, 7, 7, 8, 9, 9, and 9% of all respondents, respectively)" the penetration of Lean in the wood products and furniture manufacturing industry in Virginia appears drastically lower.

Another question that survey participants were asked to provide information for centered about the actual results of their Lean implementation by checking *"…The performance indicator(s) that are implemented…"* and by specifying *"…The degree of improvement*." The list

of typical Lean performance measures consisted of "*lead time, on-time delivery, inventory turnover, cost per unit, and sales per employee* (Emiliani 2007)". Twenty-three percent of all survey participants answered these questions (N=44), although the response frequency for the different performance indicators varied. "*On-time delivery*" was implemented by 20 percent of the respondents (N=37), followed by "*lead time* (18 percent, N=33)," "*cost per unit* (17 percent, N=32)," "*inventory turnover* (17 percent, N=31)," and "*sales per unit* (13 percent, N= 25)."

The majority of the respondents indicated that improvements regarding "*on-time delivery* (78 percent)," "*lead time* (70 percent)," "*inventory turnover* (58 percent)," and "*cost per unit* (56 percent)" have been made in their business when implementing Lean. Less than half (44 percent) of the respondents also improved "*sales per employee*," a measure that encourages doing more with less. Figure 32 provides an overview of the answers collected.

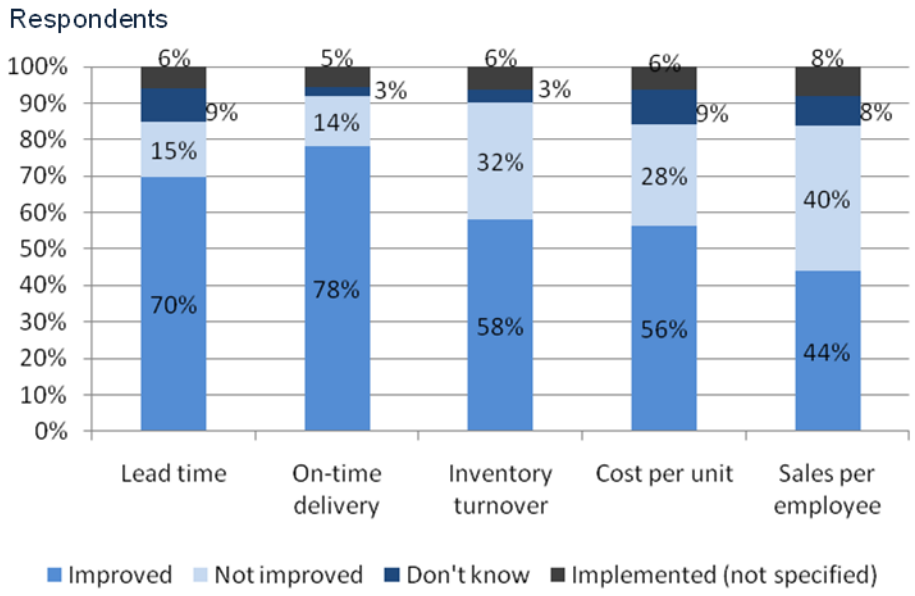

Figure 32: Survey respondents' answers to improvements made through Lean implementation efforts.

Based on these responses, Lean appears to have achieved considerable improvements for companies implementing it. Lean was least successful in improving "*sales per employee*," with no improvement reported by 40 percent of the respondents, followed by "*inventory turnover, cost per unit, lead time, and on-time delivery* (32, 28, 15, and 14 percent, respectively)." Another interesting observation also is that between three ("*on-time delivery*" and "*inventory turnover*") and nine percent ("*lead time*" and "*cost per unit*") of the respondents did not know if certain performance indicators improved (Figure 32).

When respondents indicating improvements in Figure 32 were asked about the size of the average improvement achieved for "*lead time, on-time delivery, inventory turnover, cost per unit, and sales per employee*," they reported gains of 31, 31, 27, 23, and 22 percent, respectively (Figure 33).

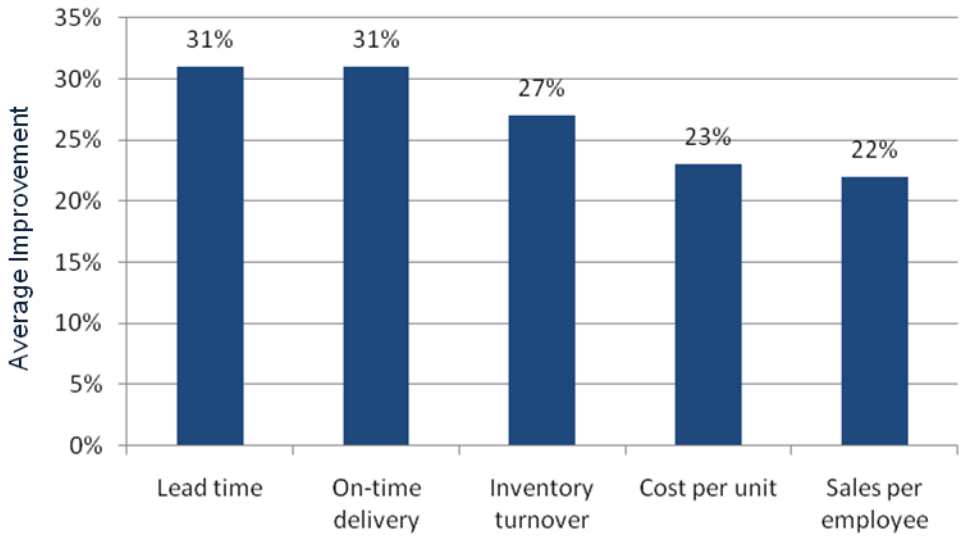

Figure 33: Average improvement rate by performance indicator

As a follow-up question, question survey participants were asked if the improvements gained through their Lean implementation efforts met their expectations (response rate 32 percent,

N=60). The majority of these respondents (58 percent) were satisfied with the improvements achieved through the use of Lean. However, almost one-third (32 percent) replied that their Lean implementation did not yield the expected results, ten percent had mixed experiences.

Another question asked the survey participants "*…Why certain improvements did not meet expectations*." Some of the survey participants (response rate 13 percent, N=24) explained their reasons for their dissatisfaction. The answers given most frequently, in decreasing order of frequency, were "*employees not trained enough, lack of leadership, time frame for transformation not appropriate, lack of communication within the company, and management not trained enough*" and "*other* (25, 21, 17, 17, 17, and 50 percent, respectively, Figure 34)." "O*ther*" reasons included, among others, "*low sales volume due to the current economic downturn, hard to measure results, more control needed at mid-management to sustain, lack of structured approach, changing the culture is challenging and takes time, and implementation did not penetrate entire company*."

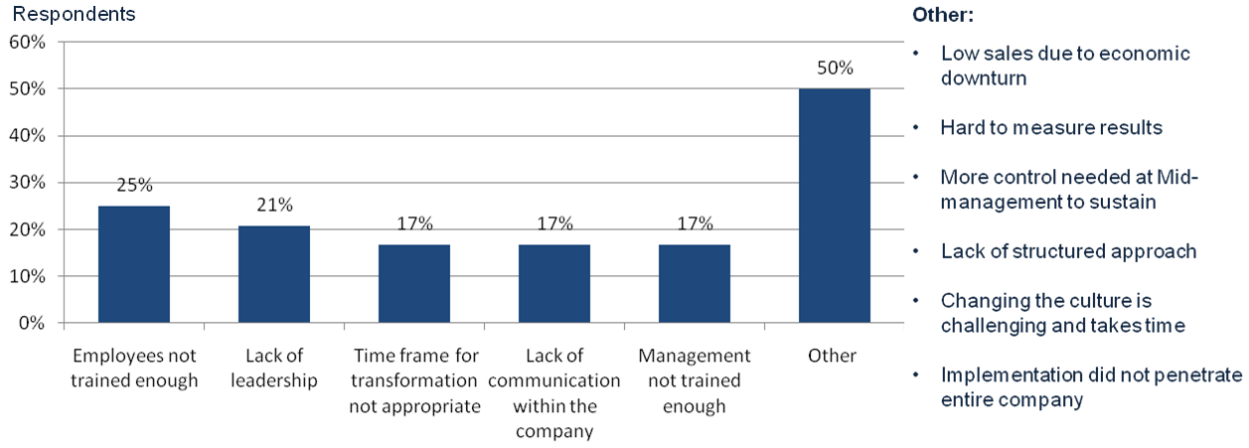

Figure 34: Overview of reasons for dissatisfaction with their results of Lean implementation

6.2. Company Size and Industry Sub-Segments

Chapter 5 identified the industry sub-segments "*engineered wood products* (NAICS 32121)" and "*manufactured homes* (NAICS 32199)" as the sub-segments to have implemented Lean most extensively in the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industry (average number of implemented Lean elements 9.93 and 9.63, Figure 21, respectively). Chapter 6 also revealed that larger companies (50 to 499 employees) tend to be more aggressive in implementing Lean. Figure 35 shows the distribution of company size (1-19, 20-49, and 50-499 employees) of respondents' companies by industry sub-segment.

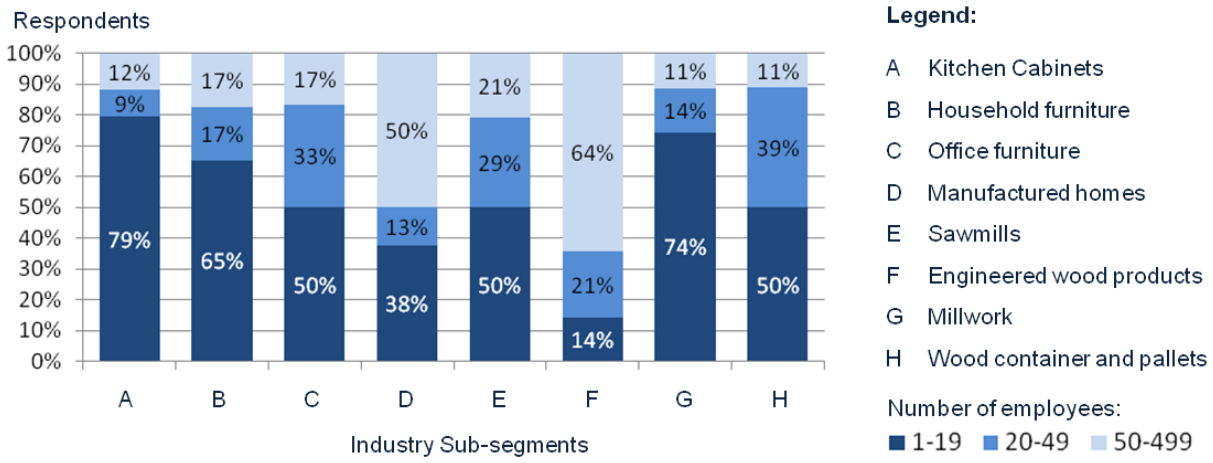

Figure 35: Overview over the company size (1-19, 20-49, and 50-499 employees) distribution in each industry sub-segment

"*Manufactured homes and engineered wood products*," the industry sub-segments most active in implementing Lean, were found to have the largest percentage of companies employing 50-499 employees (50 and 64 percent, respectively, Figure 35). These two industry sub-segments also had the smallest percentage of small companies with 1-19 employees (38 and 14 percent, respectively) of all industry sub-segments investigated (Figure 35). These results are another

indication that the level of Lean implementation in companies is related to company size, among other factors.

6.3. Support Organizations

The majority of the companies in the wood products (66 percent) and furniture manufacturing (80 percent) industries have below 20 employees (U.S. Census Bureau 2010). Various support organizations exist throughout the U.S. to help small and medium-sized (SME) companies by providing financial services, consulting, and trainings. However, Lean does not seem to be predominant part of their services for SMEs as discussed in Chapter two.

The findings of this study show a low awareness and implementation status of core Lean elements across different sub-segments and smaller companies in the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in the Commonwealth of Virginia (Chapters four and five). Surprisingly, only 23 percent of the respondents indicated a need for support regarding their Lean implementation. These results suggest that certain sub-segments ("*wood container and pallet manufacturing*" and "*sawmills*") and smaller companies (1-19 employees) may not be aware of the benefits Lean may have to offer for their business.

The organizational model used by the Small Business Development Center (SBDC, Idaho SBDC) in Idaho appears to be an effective way to support small and medium-sized companies. It is a university-based organization that provides free consulting and low-cost training to small businesses and entrepreneurs starting and growing a business in Idaho (SBDC Idaho 2010). An increased offering of services related to Lean implementation support may be promising in

increasing the awareness and actual implementation of Lean among small and medium-sized companies.

6.4. Future Research

This research compares Lean awareness, Lean implementation status, and the need for Lean implementation support across the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industry. To eliminate the restrictions imposed by this focus on a particular industry segment, future research should investigate the Lean awareness, Lean implementation status, and the need for Lean implementation support across other industries and its sub-segments, such as, for example the automotive and aerospace industry which appear to have implemented Lean quite extensively over the past decades. The survey design developed for this research is transferable and thus results can be directly compared if applied to other industries.

To be able to compare the wood industry in the Commonwealth of Virginia to other states of the United States or other countries, future research should evaluate the Lean awareness, Lean implementation status, and the need for Lean implementation support in those localities.

More research also is needed in defining "*Lean*." This study revealed the challenges of assessing Lean awareness and Lean implementation status because there is no uniform set of measurements describing the "*Leaness*" of a company. The 29 elements (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003) used in this research are of limited use, as they contain elements that are not uniquely associated with Lean. Research should establish a widely

agreed upon set of Lean criteria that can be used to assess an organizations awareness and implementation status of Lean.

6.5. References

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7. Summary and Conclusions

Lean, originating in the automotive industry (Womack et al. 1990), has proven effective in helping companies across different industries to improve their organizational performance (Womack and Jones 2003, Stuart and Boyle 2007, Mintz Testa 2003). Despite the potential benefits of Lean to the U.S. wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries to improve their competitiveness, this research found that these industry segments have been slow in adapting Lean, especially compared with other industries (Pirraglia et al. 2009).

This study investigated Lean awareness, Lean implementation status, and the need for Lean implementation support in the wood products and furniture manufacturing industries in the Commonwealth of Virginia. Furthermore, differences in respect to Lean awareness, Lean implementation status, and the need for Lean implementation support by different industry sub-segments and company sizes, were investigated. Findings included that the extent to which Lean is implemented in industry sub-segments of the wood products and furniture manufacturing industries in the Commonwealth of Virginia differs significantly. Also, smaller companies (1-19 and 20-49 employees) have implemented Lean to a lesser extent than did larger companies (50-499 employees). The following paragraphs discuss these findings in more detail.

7.1. Penetration of Lean in the Wood Products and Furniture Manufacturing Industries

Overall, roughly three-fourths (72 percent) of the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in the Commonwealth of Virginia are aware of Lean as measured by being aware of at least one of five Lean terms ("*Lean management, Lean manufacturing, Lean production, Lean Thinking, and Toyota Production System [TPS]"*), while less than half (47 percent) of all respondents of this survey indicated that they have implemented Lean in their business as measured by having implemented at least one of 29 Lean elements (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003). Although Lean is only slowly adapted by these two industry segments, closer analysis of the data reveals large differences between individual industry sub-segments. While the average number of Lean elements implemented by the wood products and furniture manufacturing industries in the Commonwealth of Virginia is 5.81 and 5.70, averages for individual sub-segments vary from a maximum average of 9.93 by the "*Engineered Wood Products*" to a minimum of 1.79 by the "*sawmills*" industry segment. While most industry sub-segments have one or several "Lean leaders," e.g., companies that have implemented all or most of the 29 lean elements (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003, f.e., "*engineered wood products*" and "*wood kitchen cabinet and countertop manufacturing*"), the industry sub-segment "*wood container and pallet manufacturing*" has no business that has implemented more than 13 Lean elements.

Of the 29 Lean elements (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003) used in this research as proxies for Lean awareness and implementation, not all are uniquely associated with Lean. Examples of elements listed as Lean elements by this research but in widespread

use by companies not pursuing Lean are, for example, "*training shop floor employees*", or "*employee cross training*", and "*mission statement*." Large numbers of survey respondents were aware of these three elements (50, 49, 64 percent, respectively) and had them implemented (46 percent, 40 percent, 38 percent, respectively). Since knowledge (awareness) or use (implementation status) was measured based on having implemented at least one of the Lean 29 elements (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003), the Lean awareness and Lean implementation status of Virginia's wood products and furniture manufacturing industries may have been overstated. In fact, if responses for elements that are uniquely associated with Lean are considered, such as, for example, "*A3-report, quick changeover (SMED), one-piece-flow, supermarket system, error proofing (Poka Yoke), takt time, Kanban system, or PDCA-cycle*," a much lower rate of Lean awareness and Lean implementation became apparent (4, 5, 7, 7, 8, 9, 9, and 9percent, respectively).

Interestingly, despite the low level of Lean implementation (measured as being 47 percent of all respondents when using all 29 Lean elements as proxies) among companies in the wood products and furniture manufacturing industries in the Commonwealth of Virginia, only 23 percent of the all respondents claimed to have a need for Lean implementation support. The respondents indicated a need for support with the training of management and shop floor employees, as well as implementation support with extensive employee involvement (67 percent, 58 percent, 48 percent, respectively). However, forty-eight percent of respondents indicating a need for support, indicated that they "*... don't know*" what form of support they want or need.

7.2. Penetration of Lean in Smaller Companies

Sixty-five percent of the smallest company cluster (e.g., 1-19 employees) considered in this study are aware of Lean as measured by recognizing one of five key Lean terms (Lean Management, Lean Manufacturing, Lean Production, Lean Thinking, and Toyota Production System). However, on average of all respondents in this company size category (1-19 employees), only three key Lean elements of a total of 29 (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003) have been implemented. Eighty-two percent of respondents working in companies with 20-49 employees were aware of Lean and have implemented an average of four Lean elements from the 29. From the largest company cluster investigated (50 to 499 employees), 86 percent are aware of Lean and have implemented, on average, 11 Lean elements.

A limited need for Lean implementation support was voiced by the respondents working for smaller companies (1-19 and 20-49 employees). Only 17 and 20 percent, respectively, of respondents from these two company clusters indicated a need for Lean implementation support. Larger companies (50-499 employees), however, signaled a larger need for Lean implementation support, with 43 percent of respondents indicating a need.

7.3. Conclusions

Results from this study show that the wood products and furniture manufacturing industry in Virginia is slow in adapting and implementing Lean elements, a finding supported by results from a study by Pirraglia et al. in 2009. Only a few industry sub-segments, "*kitchen cabinets*" and "*engineered wood products*" among them, have "Lean leaders," who have implemented all

29 Lean elements (Liker 2003, Czabke et al. 2008, Kirby and Greene 2003). Also, mainly smaller companies tend to have lower awareness of the benefits of operational improvement programs such as Lean (Westhead and Storey 1996) and are also more reluctant to implement such programs (Stuart and Boyle 2007, Kumar et al. 2006, Achanga et al. 2006).

The surprisingly low number of respondents indicating the need for Lean implementation support (23 percent) suggests that industry participants may not be aware of the potential benefits that Lean might generate. Thus, future efforts should focus on the dissemination of potential benefits of Lean for the wood products and furniture manufacturing industries in Virginia.

The survey design developed for this study is transferable and thus should be used for future research to investigate Lean awareness and Lean implementation status of other industries to establish the relative status of the wood products and furniture manufacturing industries. However, the ultimate measure of business success is survival and growth, two characteristics that have been way too infrequent in the wood products and furniture manufacturing industries in Virginia for the last decade. Lean might be a way to improve the industry's success rate, should more "Lean followers" emerge in the future.

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Appendix A – Survey Letter

VirginiaTech
College of Natural Resources and Environment

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Brooks Center (0503), 1650 Ramble Road
Blacksburg, Virginia 24061
Phone: 540-231-9759 Fax: 540-231-8868
Email: chris80@vt.edu
www.woodscience.vt.edu

Date

Name
Company
Street
City, State ZIP Code

Dear Name,

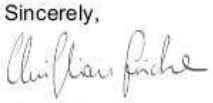
During the last decade, Virginia's wood products industry has been greatly affected by globalization, the economy, rising transportation costs, and changing buyer habits. Companies are working hard to stay cost competitive and to adapt to these changing market conditions. A critical part of companies' strive to adapt and become more competitive includes the use of management systems, such as, for example, lean management. Such systems have proven effective in helping leading companies to better performance and results. Lean management focuses on achieving short lead times, quick inventory turnovers, on-time delivery, built-in quality, high productivity, respect for all employees, and high customer satisfaction.

Virginia Tech is conducting research to determine the awareness and the status of lean management systems implementation and the need for support for its implementations within Virginia's wood products industry. Thus, results from this survey will provide valuable information regarding lean implementation practices and potential for improvement. Results will also help review and adapt services available to Virginia's industry to implement company-wide lean performance improvements. **We are asking for your help on this project by completing and returning the enclosed questionnaire**.

Your company was chosen at random from a list of wood products manufacturers in Virginia. Since the number of participants is small, your response is vital for the success of this project. The postage is prepaid. Please be assured that your response will be treated with **complete confidentiality**. Your name and your company will never be identified in the study results. Only aggregated results will be reported.

Thank you very much for your time and assistance. Should you have any questions, please contact me by phone at 540-231-9759, (fax) 540-231-8868, or (email) chris80@vt.edu.

Sincerely,



Christian Fricke
Graduate Assistant

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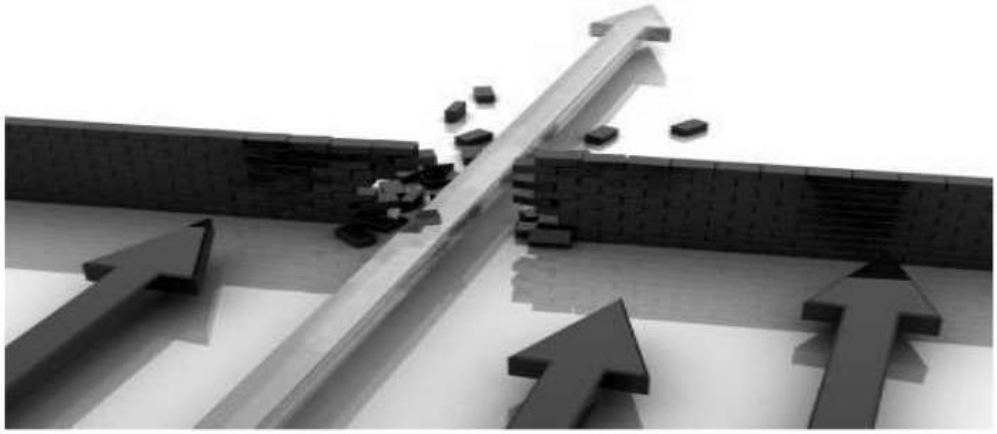
Appendix B – Survey Questionnaire

Lean implementation and need assessment for Virginia's wood products industry



Department of Wood Science and Forest Products
Virginia Tech
Brooks Center 0503
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If you have any questions please contact:
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Objective

The objective of this study is to analyze the awareness of Virginia's wood products industry about lean management and to gather information about the status of lean implementation efforts. Furthermore, questions regarding the industry's need for support of lean implementation efforts are asked. The responses given are **confidential** and no company information will be disclosed at any time. Filling out this questionnaire will take approximately 20 minutes. Your input is critical for providing Virginia's industry with valuable information regarding lean implementation practices and potential for improvement. Participation is voluntary and questions can be left unanswered if preferred. Your help and time is greatly appreciated. Thank you for your willingness to participate. If you have any questions or concerns, please do not hesitate to contact me.

Company Information

1. Is your company involved in manufacturing or trading/brokering/distributing **wood products** (check all that apply)?
   - ❑ Manufacturing
   - ❑ Trading/brokering/distributing
     (if **only** "trading/brokering/distributing" please stop here; fold, tape and return the questionnaire. The postage is prepaid. Thank you for your time!)
   - ❑ **Not involved** in manufacturing or trading/brokering/distributing wood products
     (please stop here; fold, tape and return the questionnaire. The postage is prepaid. Thank you for your time!)

2. Please check the category that best describes the main product produced by your company (check one):
   - ❑ Kitchen/bath cabinets or countertops
   - ❑ Household/ institutional furniture
   - ❑ Office furniture (incl. fixtures)
   - ❑ Blinds and shades
   - ❑ Manufactured homes/prefab. buildings
   - ❑ Sawmills and wood preservation
   - ❑ Veneer/plywood/engineered wood products
   - ❑ Millwork
   - ❑ Containers and pallets
   - ❑ Other (please specify)_____

3. Please indicate your position (check one):
   - ❑ Corporate or Operating Management
   - ❑ Production Management
   - ❑ Engineering
   - ❑ Design
   - ❑ Marketing and Sales
   - ❑ Other (please specify)_____

4. Is your company a single facility or multi-facility operation (check one)?
   - ❑ Single facility
   - ❑ Multi-facility

5. In what state (country) is your home facility located:_____

6. Please indicate how many employees are currently employed in **your facility** and, if your company is a multi-facility operation, **in the US** (incl. your facility) and, if your company has international facilities, **worldwide** (incl. US):

Number of employees	In your facility	In the US (incl. your facility)	Worldwide (incl. US)
1-19	❑	❑	❑
20-49	❑	❑	❑
50-99	❑	❑	❑
100-499	❑	❑	❑
500 or more	❑	❑	❑

7. What category best represents your annual sales in 2009? If applicable, please differentiate between the annual sales in **your facility**, **in the US** (incl. your facility) and **worldwide** (incl. US):

Annual sales in 2009	In your facility	In the US (incl. your facility)	Worldwide (incl. US)
Less than $1 million	❑	❑	❑
$1.1 million - $2 million	❑	❑	❑
$2.1 million - $5 million	❑	❑	❑
$5.1 million - $10 million	❑	❑	❑
$10.1 million - $25 million	❑	❑	❑
$25.1 million - $75 million	❑	❑	❑
$75.1 million - $300 million	❑	❑	❑
More than $300 million	❑	❑	❑

8. Compared to three years ago, your total annual sales of your organization in 2009 is:
   - ❑ Smaller
   - ❑ Same
   - ❑ Larger

9. Are your employees organized in unions?
   - ❑ Yes
   - ❑ No

Lean practices

10. Have you heard of the following terms (check all that apply)?
    - ❑ Lean Management
    - ❑ Lean Production
    - ❑ Lean Manufacturing
    - ❑ Toyota Production System
    - ❑ Lean Thinking

11. According to J.F. Liker[1] lean consists of 4P's: philosophy, process, people, and problem solving. Which of the following elements of lean **have you heard of before** (check all that apply)?

4P's	Lean Elements
Philosophy	❑ Vision statement
	❑ Mission statement
Process	❑ Value stream mapping
	❑ Takt time
	❑ Pull system
	❑ Supermarket replenishment system
	❑ Just-in-time
	❑ One-piece-flow
	❑ Kanban-System
	❑ Standard work
	❑ Standardized work sheet
	❑ Leveling production and schedules (Heijunka)
	❑ Single minute exchange of die (SMED)
	❑ Error proofing (Poka Yoke)
	❑ Visual Management
	❑ Notification system for quality and process problems (Andon)
People	❑ Training shop floor employees
	❑ Training administrative employees
	❑ Training operational management
	❑ Training executives
	❑ Shop floor employee cross-training
	❑ Shop floor employee skills matrix
Problem Solving	❑ Continuous improvement (Kaizen) events
	❑ Root cause analysis (Fish bone diagram)
	❑ 5-why-analysis
	❑ Plan-do-check-act (PDCA)-Cycle
	❑ A3-report
	❑ 5S method
	❑ Go to where the problem is and see (Genchi genbutsu)

[1] "The Toyota Way", 2003

12. Please indicate the **implementation status** (Already in use; not in use and not planned to be implemented; planned to be implemented in 1, 3, or 3+ years) of each respective lean element.

4P's	Lean Elements	Already in use	Not planned	Planned to be implemented within the next ___years		
				1	3	3+
Philosophy	Vision statement	❑	❑	❑	❑	❑
	Mission statement	❑	❑	❑	❑	❑
Process	Value stream mapping	❑	❑	❑	❑	❑
	Takt time	❑	❑	❑	❑	❑
	Pull system	❑	❑	❑	❑	❑
	Supermarket replenishment system	❑	❑	❑	❑	❑
	Just-in-time	❑	❑	❑	❑	❑
	One-piece-flow	❑	❑	❑	❑	❑
	Kanban-System	❑	❑	❑	❑	❑
	Standard work	❑	❑	❑	❑	❑
	Standardized work sheet	❑	❑	❑	❑	❑
	Leveling production and schedules (Heijunka)	❑	❑	❑	❑	❑
	Single minute exchange of die (SMED)	❑	❑	❑	❑	❑
	Error proofing (Poka Yoke)	❑	❑	❑	❑	❑
	Visual Management	❑	❑	❑	❑	❑
	Notification system for quality and process problems (Andon)	❑	❑	❑	❑	❑
People	Training shop floor employees	❑	❑	❑	❑	❑
	Training administrative employees	❑	❑	❑	❑	❑
	Training operational management	❑	❑	❑	❑	❑
	Training executives	❑	❑	❑	❑	❑
	Shop floor employee cross-training	❑	❑	❑	❑	❑
	Shop floor employee skills matrix	❑	❑	❑	❑	❑
Problem Solving	Continuous improvement (Kaizen) events	❑	❑	❑	❑	❑
	Root cause analysis (Fish bone diagram)	❑	❑	❑	❑	❑
	5-why-analysis	❑	❑	❑	❑	❑
	Plan-do-check-act (PDCA)-Cycle	❑	❑	❑	❑	❑
	A3-report	❑	❑	❑	❑	❑
	5S method	❑	❑	❑	❑	❑
	Go to where the problem is and see (Genchi genbutsu)	❑	❑	❑	❑	❑

NOTE: If **none** of the lean elements in question 12 **are planned** to be implemented, please continue with question 16.

13. If lean elements (as indicated in question 12) have been implemented, please check the performance indicator(s) that are implemented and specify the degree of improvement:

Performance Indicator	Not improved	Improved by ___%
❑ Lead time	❑	___%
❑ On-time delivery	❑	___%
❑ Inventory turnover	❑	___%
❑ Cost per unit	❑	___%
❑ Sales per employee	❑	___%
❑ Other:_____	❑	___%
❑ I don't know		

14. If lean elements (as indicated in question 12) have been implemented, did the improvements meet your expectations?
    - ❑ Yes (please continue with question 16)
    - ❑ No

15. Please indicate the reasons why certain improvements did not meet expectations:
    - ❑ Management not trained enough
    - ❑ Employees not trained enough
    - ❑ Lack of leadership
    - ❑ Lack of communication within the company
    - ❑ Time frame for transformation not appropriate
    - ❑ The company's union did not approve upon the changes to be made
    - ❑ Other (please specify) _____

16. Does your organization employ a lean change agent?
    Yes: ❑ No
    - ❑ Full time
    - ❑ Part time

17. Did your organization get support from an external party?
    - ❑ Yes, please specify name of external party (if known) _____
    - ❑ No (please continue with question 23)

18. What activities did the external party perform? (check all that apply)
    - ❑ Training for shop floor employees
    - ❑ Training for administrative employees
    - ❑ Training for operational management
    - ❑ Training for executives
    - ❑ Implementing certain lean elements with **no** company employee involvement
    - ❑ Implementing certain lean elements with **little** company employee involvement
    - ❑ Implementing certain lean elements with **extensive** company employee involvement
    - ❑ Audits
    - ❑ Lean certification program for employees
    - ❑ Other (please specify) _____

19. If "training" was checked in question 18, please indicate the topics covered during the training (check all that apply):
    - ❑ Did not receive training by external party
    - ❑ General overview of lean
    - ❑ Specific lean elements (please specify) _____
    - ❑ Presentation skills
    - ❑ Moderation skills
    - ❑ Communication skills
    - ❑ Other (please specify) _____

20. Where were the activities by the external party facilitated (check one)?
    - ❑ In our company
    - ❑ At location of external party
    - ❑ At "neutral" locality (e.g. hotel or conference center)

21. Were the results that were achieved with the external party meeting expectations?
    - ❑ Yes (please continue with questions 23)
    - ❑ No

22. Please indicate why the results achieved with the help of the external party did not meet expectations (please check all that apply):
    - ❑ Insufficient knowledge of topic by external party
    - ❑ Employees not enough integrated in implementation effort
    - ❑ Training did not result in required knowledge
    - ❑ Other (please specify) _____

Need for support

23. Do you have a need for external support in order to improve your organization's performance?
    - ❑ Yes
    - ❑ No (please continue with question 26)

24. What should the external support look like (check all that apply)?
    - ❑ Training shop floor employees
    - ❑ Training administrative employees
    - ❑ Training management
    - ❑ Training executives
    - ❑ Implementing certain elements with **no** company employee involvement
    - ❑ Implementing certain elements with **little** company employee involvement
    - ❑ Implementing certain elements with **extensive** company employee involvement
    - ❑ Audits
    - ❑ Lean certification program for employees
    - ❑ Other (please specify) _____
    - ❑ I don't know, I need more information

25. If you have indicated "training" being of interest (question 24), please indicate the topics of interest to be covered by training (check all that apply):
    - ❑ General overview of lean
    - ❑ Specific lean elements (please specify) _____
    - ❑ Presentation skills
    - ❑ Moderation skills
    - ❑ Communication skills
    - ❑ Other (please specify) _____
    - ❑ I don't know, I need more information

Product and market related questions

26. What kind of wood material do you use most (by volume) when manufacturing your product?
    - ❑ Mostly solid wood
    - ❑ Mostly wood composite or engineered products
    - ❑ A combination of solid wood and wood composites
    - ❑ We don't use solid wood or wood composites

27. For your company, approximately what percent of sales will result from domestically (US) produced and/or sourced products in 2010?
    - ❑ 0%
    - ❑ 1-20%
    - ❑ 21-40%
    - ❑ 41-60%
    - ❑ 61-80%
    - ❑ 81-100%

28. Indicate all parts of the US where you do regular business (please check all that apply):
    - ❑ Northeast
    - ❑ Mid-Atlantic
    - ❑ Southeast
    - ❑ South
    - ❑ Southwest
    - ❑ California
    - ❑ Midwest
    - ❑ Northwest

29. Please indicate your company's position on price-point within your primary product category:
    ❑ Low ❑ Low-to-Medium ❑ Medium ❑ Medium-to-High ❑ High

30. Approximately what percent of your company's overall product mix can be classified as being *semi-custom products*? (e.g., for a given design, customers have a choice of species, finish, hardware, etc.)?
    ❑ 0%
    ❑ 1-20%
    ❑ 21-40%
    ❑ 41-60%
    ❑ 61-80%
    ❑ 81-100%

31. Compared to three years ago, this *semi-custom* proportion now is:
    ❑ Smaller
    ❑ About the same
    ❑ Larger

32. Approximately what percent of your company's overall product mix can be classified as being completely *made-to-order products*? (e.g., customers specify all aspects of the product including design)?
    ❑ 0%
    ❑ 1-20%
    ❑ 21-40%
    ❑ 41-60%
    ❑ 61-80%
    ❑ 81-100%

33. Compared to three years ago, this *made-to-order* proportion now is:
    ❑ Smaller
    ❑ About the same
    ❑ Larger

34. Over the last five years, have you increased use of wood imports in your product line?
    Yes:
    ❑ Imported finished product
    ❑ Imported components or lumber
    ❑ Both
    ❑ No

35. Have you seen increased interest from customers in sourcing products compliant with any green standards program?
    ❑ Yes
    ❑ No
    ❑ Uncertain

Thank you! Please fold, tape and return the completed questionnaire. The postage is prepaid. Also, please indicate if you would like to receive a summary of results.
❑ Yes, please send results to the following email address: _____
❑ No, thank you, please do not send results

Declaration

I assure that I made this submitted paper on my own and did not make use of outside help. All sources literally or logically quoted from published or unpublished literature are marked accordingly.

12/01/2010 

Date Signature