Implementation Analysis of Lean Manufacturing in the Secondary Wood Industry in North Carolina

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Abstract

The American wood-based industries have experienced a significant reduction of their market share mainly due to overseas competition. As a result, the wood industries need to change their business model to remain competitive and have the ability to compete in a global market. An important philosophy that suits these accomplishments is lean manufacturing, which stems from the fact that far fewer resources are required to produce a given amount of products and services compared with traditional manufacturing operations, while simultaneously reducing the amount of waste in the final product. The objective of this project was to provide insight about the status of lean manufacturing implementation in the wood industry in North Carolina. To facilitate this, 947 surveys were sent to secondary manufacturers (such as furniture, cabinets, moulding and millworks, doors and windows manufacturers, etc.) in North Carolina.

Results show that the majority of the companies are not currently implementing lean manufacturing. Those companies that are aware and implementing it, relate the process improvement activities from lean manufacturing with customer satisfaction and reductions in manufacturing time/cycle times. It was also found that the main triggers for a company to embark on a lean manufacturing project were corporate/group initiatives, customer pressures, or examples and/or case studies, speaking to the importance of education and training of the wood industries on this philosophy. The majority of the surveyed companies stated that lean manufacturing could help to improve in several business areas, with some of them currently implementing the tools that lean manufacturing provides for improvement.

Keywords: lean manufacturing, manufacturing practices, secondary wood products

Introduction

American wood and wood-based industries have been experiencing a significant reduction in their market shares, mainly due to overseas competition (Robb et al. 2003). Brashaw (2008) established that imported products and overseas manufacturing were the key issues for the wood industry. Furthermore, global competition has caused significant market losses in the U.S. and German wood and wood-based industries (Czabke et al. 2008). Thus, the challenge to the industry is to identify their main competitive advantages, transform their weaknesses into strengths, and convert threats into opportunities. The wood industries need to undergo a paradigm shift in the business of designing, manufacturing, marketing, and distributing their products in order to sustain a prosperous U.S. manufacturing base into the future. As a result, the wood industries need to change their business model to remain competitive (Schuler and Buehlmann 2003).

Globalization has permanently changed the face of U.S. manufacturing sectors (LaBissoniere and Bowe 2006). Milauskas (2005) raised concerns about the loss of approximately 61,000 jobs in the U.S. furniture industry over a five-year period, along with the increased values of wood furniture imports (+86% over five years), especially from Asia and other Pacific regions (+149%). Moreover, plentiful low-cost labor, state-of-the-art facilities, and weaker regulations have led to increased imports from China (Bo et al. 2006). Schuler and Buehlmann (2003) explained that the U.S. wood industry manufacturers' ability to compete with Asian producers (and other regions)

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on a pure price basis is limited. In addition, they mentioned that U.S. manufacturers must shift from the mass production environment to more of a mass customization and variety of products strategy. Dossenbach (2002) stated that most manufacturers in the furniture and woodworking industry are plagued with excessive waste and high costs. Many manufacturers are unfocused and scramble to produce a myriad of products in an effort to capture market share. This has resulted in unacceptable cycle times, which continue until specific items are again produced. It also has placed a burden on employees to handle such a wide variety of products. It is common to find factories with little or no continuous flow of materials through the plant. Instead, most are clogged with work in progress, resulting in waste and longer lead times. Dossenbach (2002) has recommended continuous improvement and lean manufacturing initiatives to help elevate wood products manufacturers to a better competitive position.

Lean manufacturing is an important business philosophy (Liker 2004) that can be implemented in wood industries to reduce/eliminate waste. Based on its record in other industries such as the automotive, aerospace, and pharmaceuticals sectors, lean manufacturing is recognized as one of the most successful methodologies and best practices for minimizing or eliminating production waste (Testa 2003). It is called "lean manufacturing" because it requires far fewer resources (labor, capital, machinery, time, and manufacturing space) to make a given amount of products and services, and makes them with fewer defects (related to precise customer specifications) compared to traditional manufacturing operations (Lean Enterprise Institute 2007). Lean manufacturing can be defined as "a way of thinking that focuses on making the product flow through value-adding processes without interruption; a 'pull' system that cascades back from customer demand by replenishing only what the next operation takes away at short intervals, and a culture in which everyone is striving continuously to improve" (Liker 2004).

Lean manufacturing is not only about cutting costs. The Lean Enterprise Institute (2007) referred to lean manufacturing as a fundamentally different system than traditional management for organizing and managing employees, suppliers, customer relationships, product development, production, and the overall enterprise. The benefits of lean manufacturing come from the fact that it frees resources by better utilizing space, human effort, capital, and time (Lean Enterprise Institute 2007). In so doing, it can transform waste into available capacity, which can be used to grow the business. However, many companies fail to notice the benefits in decision making, talent development, and business leadership that lean manufacturing has to offer for significant improvements in their business activities (Lean Enterprise Institute 2007). This might be a reason why few companies are able to transform their competitive levels, and even fewer break through to lead their industry in quality, value, innovation, growth, and profitability.

The benefits of lean manufacturing have also been the subject of academic inquiry. Brown et al. (2006) performed a study on the transformation of manufacturing industries from batch production to lean manufacturing, demonstrating in a case study that, as a result of this transformation process, the organization experienced increased productivity, lower set-up times, and less space required for manufacturing. Testa (2003) affirmed that savings from lean manufacturing generally outweigh its implementation costs. Totev, cited by Testa (2003), discussed the improvements and savings generated by a typical, ongoing lean manufacturing program, such as reductions in downtime for both production and maintenance, reductions in changeover times by as much as 70%, increases in productivity and throughput of as much as 50%, and savings of five to 25 times the cost of a one-time lean manufacturing project. However, Testa (2003) also warned of impatience that companies might have when it comes to implementing lean manufacturing tools. Many companies proclaim themselves to be "lean manufacturers" after the experience of only one project, but before a lean manufacturing company culture, sufficient training, designated lean manufacturing champions, and clear improvement strategies have been put in place. All that said, lean manufacturing clearly has demonstrated benefits. However, several industries in the U.S. have been slow to adopt this philosophy. Lebow (1999) conducted a survey of 26 companies and showed that only one-half of the respondents were currently pursuing a lean manufacturing strategy.

Previous research indicates that there seems to be enormous potential in implementing many lean manufacturing tools and techniques in the wood industry in order to improve operations and profits. In this sense, Brashaw (2008) established that a slow implementation of new technology and best manufacturing practices, such as lean manufacturing, is a key issue that wood companies now face. Abdulmalek et al. (2006) proposed a classification scheme for lean manufacturing implementation in industries with continuous processes, establishing that many lean manufacturing tools traditionally used for discrete processes can be successfully applied in industries such as textiles, food and beverages, pulp and paper, and lumber and wood products. An exploratory analysis performed by Gagnon et al. (2003) demonstrated that an employee strategic alignment became easier to assimilate by workers at a secondary wood products manufacturer when it came as a lean manufacturing implementation program. This enhanced their commitment levels, satisfaction, and trust in the job. Cumbo et al. (2006) found significant improvements for rough mill operations when implementing lean manufacturing. They indicated that some of the tools and techniques used in lean manufacturing have been, to a certain degree, already applied in the wood industry. Part of their findings were related to significant reductions in lead times between companies implementing lean manufacturing and those that were not. Cumbo et al. (2006) also remarked that there is evidence of several barriers for fully implementing lean manufacturing in the secondary wood industry. An overview study of the value-added wood products sector in Canada (Delong et al. 2007) showed that there are opportunities for increased efficiencies through lean manufacturing, but established that this would require education and training, often perceived as an important barrier for lean manufacturing implementation. Hunter et al. (2004) noted how flexible lean manufacturing is by showing its cost effectiveness, quality improvement, and ergonomic progress for the workers in the wood furniture industry. According to Schuler and Buehlmann (2003), wood industries have, by implementing lean manufacturing, become

more cost-competitive, more efficient in worker training, catalyzed higher worker productivity, and developed a more robust and competitive supply chain. In order to identify the challenges of implementation, as well as subsequent successes, Czabke et al. (2008) performed a study in four U.S. and German secondary wood products companies that were considered leaders in lean manufacturing implementation. Findings from Czabke et al. (2008) suggested that lean thinking (which is a holistic management approach incorporating lean practices and principles) may help secondary wood products manufacturers become more profitable. In the organizations studied, the implementation of lean manufacturing practices and principles resulted in more efficient and cost-effective operations. The study also found that the application of lean thinking to marketing processes may improve customer service, new product development processes, and customer satisfaction. A survey conducted by Lihra et al. (2008) found that the implementation of lean manufacturing concepts were necessary to support mass customization of products; a necessary competitive strategy for the furniture industry to offset their production cost disadvantage as compared to imported products from offshore countries. Changes in production systems to become more flexible and lean manufacturing-oriented were perceived as important elements in implementing mass customization in this industry. Finally, Yao and Carlson (2003) noted that lean manufacturing needs to be implemented in the furniture industry due to the large amount of space consumed by the products circulating in the factory and that it also allows for more agility by reducing or maintaining small lot sizes and releasing products more frequently, while increasing its ability to meet customer demands.

Despite these efforts on the part of researchers and wood manufacturers, additional work needs to be conducted in order to help the wood industry to become more competitive in the global markets. The goal of this research was to address this need by providing insight (by means of a survey[1]) on the status of the lean manufacturing implementation in the North Carolina wood industry.

Methods

A methodology followed by Pirraglia et al. (2009) was used to classify the wood industries based on the North America Industry Classification System (NAICS). The wood industry classification was organized by selecting the products with the biggest market shares to understand the distribution of the different industries' wood products types produced in North Carolina. The resulting classification was as follows: engineered wood products, residential furniture, office furniture, cabinets, millwork and mouldings, doors and windows, pallets and containers, panel boards, dimension stock, flooring, remanufactured products, and others industries. This industry segmentation helped to classify the responses received by each industry sector. This was followed by the development of a mail survey instrument.

The first step during the development of the survey was an in-depth investigation of previous surveys addressing lean manufacturing in several other industries (Lean Enterprise Institute 2005, 2007, Ray et al. 2006, Strategem 2003, Yusuf and Adeleye 2002) in order to identify and select the main questions to be included in the survey. In addition, a survey designed by Pirraglia et al. (2009) was consulted. Fifteen single, multiple choice, and open-ended questions were included in the survey and developed based on guidelines proposed and previously used by the Lean Enterprise Institute (2005 and 2007) and considering the most common classifications for the secondary wood industry, process improvement activities, and lean manufacturing tools. The specific types of questions included: demographic questions for classification purposes, general questions about process improvement, specific questions about lean manufacturing and its implementation, and questions regarding lean manufacturing and its findings for the wood industry. In addition, questions regarding awareness levels of lean manufacturing were included in the survey in order to be answered by those companies implementing lean manufacturing. These questions revolved around activities for improvement implemented, tools used in process improvement, and the main benefits obtained from the implementation of those tools in their business. The structures of the questions in the survey were as follows:

- 1st and 2nd questions: Name of the company and job position of respondent.
- 3rd question: Primary product manufactured by the company based on choices from the classification of the secondary wood manufacturing industry.
- 4th and 5th questions: Location of the company and total number of employees.
- 6th question: Process improvement activities performed by the company; multiple choice answer, with three levels (yes, currently involved; not involved; and not involved, but planning).
- 7th question: Awareness of lean manufacturing (including definition); four choices (yes, aware and implementing it; yes, aware but not implementing it; yes, aware and planning to implement it in the future; and no, not aware). If the answer to question 7 was "yes, aware and implementing it" or "yes, aware and planning to implement it in the future," then the surveyed company proceeded to question 8. If the answer to question 7 was "yes, aware but not implementing it," then the surveyed company skipped questions 8 through 12. If the answer to question 7 was "not aware," then surveyed company skipped questions 8 through 14.
- 8th and 9th questions: Triggers that led the company to embark on a lean manufacturing program and level of implementation in the company; multiple choice answers.
- 10th and 11th questions: Resources used to initiate/implement a lean manufacturing program, and where should a lean manufacturing program start; multiple choice answers.
- 12th and 13th questions: Tools and techniques most useful for a lean manufacturing implementation, and benefits of implementing lean manufacturing; multiple choice answers.

[1] As defined by Bennett (1995) and Malhotra and Birks (2003).

- 14th and 15th questions: Barriers to implementing lean manufacturing; multiple choices based on opinion; the degree to which lean manufacturing can help the wood industry become more competitive; open-ended question.

After developing all of the questions, a pretest (Bennett 1995) was conducted in order to obtain feedback about the questions included in the survey, with experts in the field of wood manufacturing. This pretest consisted of mailing the survey to ten people related to the wood industry (such as faculty members, consultants, manufacturers, etc.) in order to verify clearness, ambiguity, time, and effectiveness of the questions. After modifying the survey according to recommendations obtained, they were finalized and sent to a list of companies from a comprehensive database that was provided to the project by the Industry and Extension Service of NC State University, an entity that has dedicated efforts to support the industry (including the wood products sector) within the state of North Carolina. This database consisted of 982 companies' contact information, including company name, address, phone/fax number, contact person, and sector of the industry. From these 982 companies, 947 received the survey (24 were sent to different states, and 11 were rejected). The non-response bias for the population was considered in the early stages of the research, after the closing date for the reception of the surveys. According to the strategies for addressing non-response bias suggested by Israel (1992) and the National Center for Education Statistics (IES, 2002), it can be assumed that there is likely no significant non-response bias in a sample if the population is well known by the researchers. Following this strategy, the authors assumed that there was no significant non-response bias in the sample since the population is well known by the Industry and Extension Service of North Carolina State University and the research team.

The survey instrument was sent via regular mail followed by two reminders to companies that had not yet responded to the survey. From the 947 companies surveyed, 89 responses were returned for a response rate of 9.4%. This percentage is considered to be enough to conduct the respective analyses and conclusions for the behavior of that studied population according to best practices in survey evaluations, as defined by Downing et al. (2003). After the closing date, surveys were processed and the responses were analyzed. In addition, an evaluation of the open-ended questions was conducted.

Results & Discussion

The results from the 89 completed surveys were analyzed in SPSS® V 7.0 and Microsoft Excel® in order to facilitate the analysis of the data. Two variables were created to aggregate the companies by size and regions. The companies' sizes were designated as small (<= 80 employees) and large firms (> 80 employees). The categorization for regions was based on the Census Bureau Regions classification system, which divides North Carolina into three regions. Figure 1 shows that the majority of the responses obtained were from the Coastal region. Approximately 58% of respondents were Owners, CEOs, Presidents, Directors or General Managers, while 19% of respondents were Production Managers. This gives a total of 77% respondents who are upper management, with the remaining 23% respondents being Administrative Personnel and Engineers. A classification of the industries that responded to the survey is shown in Figure 2.

Figure 2 shows that the majority of responses came from the furniture (residential) industry with 23.6%, followed by others with 21.3% (the category "others" contains a variety of industries such as flooring, remanufactured products, veneer components, and custom woodwork industries), and cabinets (16.9%). A high percentage of respondents (70%) stated their involvement in the following process-improvement activities: cost reduction (79.8%), improvement in product quality (79.8%), improvement in customer satisfaction (71.9%), and improvement in service quality (70.8%). Similar percentages were reported by Pirraglia et al. (2009) in a study for a particular population, showing consistent results with respondents from this survey. Additionally, more than 50% of respondents were involved in the following activities: improvement in on-time delivery performance (67.4%), reduction in manufacturing lead time/cycle time (62.9%), im-

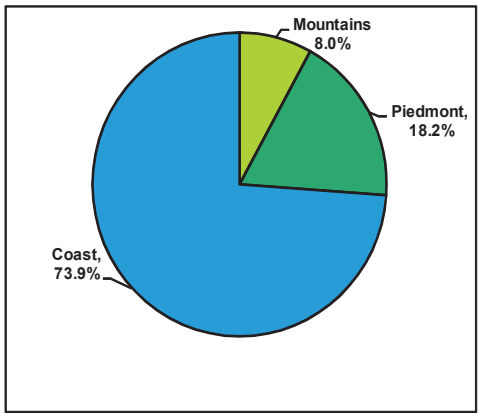

Figure 1. – Responses by region in North Carolina.

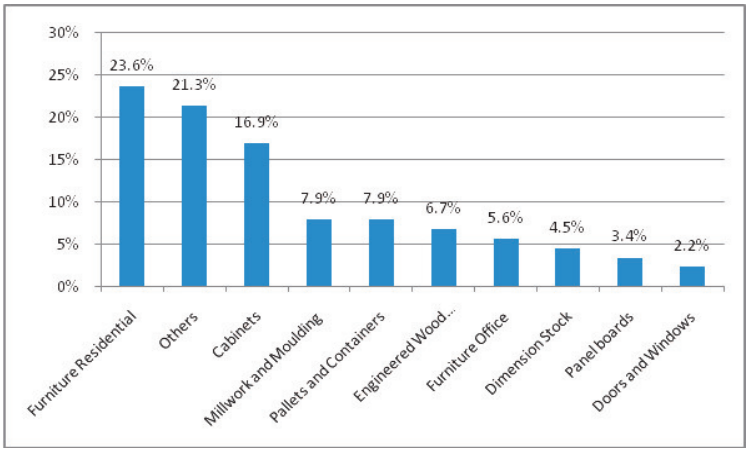

Figure 2. – Classification of respondents according to their industry field (based on NAICS classification system).

provement in manufacturing flexibility/agility (59.6%), and improvement in product development/time to market (58.4%)[2]. It is important to note that until this point in the survey, the term "lean manufacturing" has not yet been introduced.

When asked about process improvement activities implemented in their companies, almost 40% of all respondents were currently involved in all the improvement activities mentioned above. When this group (33 companies) was asked about their awareness of lean manufacturing, four companies pointed out that they are not aware of lean manufacturing (12% of that group). Almost 19% (six companies of that group) stated that they are aware of lean manufacturing, but they are not implementing it at this time, when in fact they were involved in several activities from the lean manufacturing philosophy. In addition, another 19% (six companies) of the 33 companies said that they are aware of lean manufacturing and plan to implement it in the future, even when they are already involved in all the improvement activities listed in the survey. If these last three groups are added together, almost 50% of the companies that are involved in process improvement activities seem to be on the way to implementing lean manufacturing.

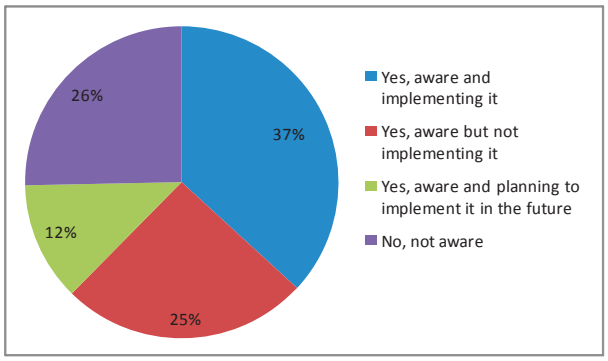

Figure 3. – Awareness of lean manufacturing by respondents.

The general awareness of lean manufacturing and its implementation is depicted in Figure 3. More than one-third of the companies (37%) that responded to the survey said they are implementing lean manufacturing. Of this group of companies, 62.5% responded that they have an extensive or advanced implementation of lean manufacturing (50.0% extensive, 12.5% advanced). However, the majority of companies are not implementing lean manufacturing, whether or not they are aware of it. Furthermore, when comparing the companies that stated their involvement in certain process improvement activities, such as cost reduction, improvement in product, service, etc., 40% of respondents (33 companies) stated that they were involved in every activity listed for process improvement. However, when asked about the ideas, techniques, and tools that have been useful for their business, almost 40% of them (13 companies) did not specify their usage of specific lean manufacturing tools and techniques in their improvement program. This could mean that companies are either not really aware of the concepts, implications, and levels of implementation for lean manufacturing, or that they are not implementing formal lean manufacturing tools to improve their efficiency/effectiveness, quality, and service. In addition, Figure 3 shows that 12% of surveyed companies are planning to implement lean manufacturing. From this group of companies, 40% are planning to begin implementing lean manufacturing within six months, while the other 40% will wait until after six months. The remaining 20% are not planning to implement it at all.

When analyzing the tools that companies tend to use at an early (less than six months into implementation) or ex-

[2] This question was a multiple-selection question. Therefore, the total number of selections was greater than the number of respondents.

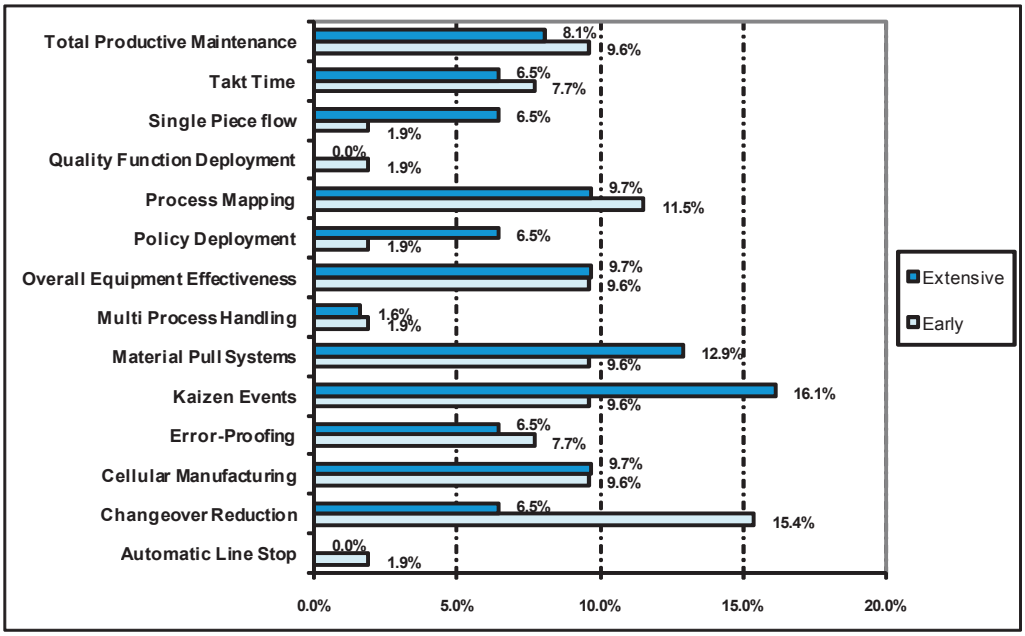

Figure 4. – Utilization of process improvement tools by respondents at an early or extensive lean manufacturing implementation.

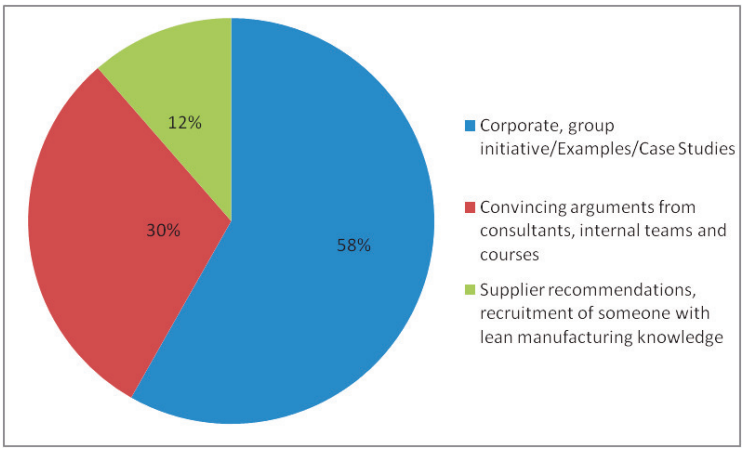

Figure 5. — Convincing triggers for implementing lean manufacturing as reported by respondents.

tensive level of implementation of lean manufacturing (many areas of the business applying lean tools), it was found that companies at an early level of implementation tend to focus more on tools, such as changeover reduction, process mapping, and total productive maintenance, while companies with an extensive level of implementation of lean manufacturing tend to focus on tools, such as Kaizen events, material pull systems, and single piece flow (Figure 4, previous page). Interestingly, some tools seem to be common for both early and extensive implementation, such as overall equipment effectiveness and cellular mkanufacturing.

When asked about trigger(s) that led them to embark on using lean manufacturing, 58% of the companies that were implementing or planning to implement it responded that corporate or group initiatives, customer pressures, or examples and/or case studies were the main triggers that led them to implement a program, followed by convincing arguments from consultants or internal teams, attendance at training courses and/or conferences, and supplier recommendations/ recruitment of someone with lean manufacturing knowledge (Figure 5).

A bi-variate correlation was conducted utilizing the Pearson correlation coefficient (two-tailed) to study possible correlations between process improvement activities and awareness of lean manufacturing. The test was performed comparing the subgroup of respondents aware of lean manufacturing (either implementing it or not), versus the process improvement activities mentioned in one of the questions. Only three process improvement activities were highly correlated to the level of awareness of lean manufacturing: im-

Table 1. – Bi-variate correlation between lean manufacturing awareness and process improvement activities used by respondents.

		Improvement in product quality	Reduction in mgf. lead time/cycle time	Improvement in customer satisfaction
Aware of Lean Manufacturing	Pearson Correlation	.245(*)	.366(**)	.279(*)
	Sig. (2-tailed)	0.024	0.001	0.011
	N	84	81	82

*Correlation is significant at the 0.05 level (2-tailed), **Correlation is significant at the 0.01 level (2-tailed).

Table 2. – Bi-variate correlation between cost reduction versus reduction in manufacturing lead time/ cycle time and improvement in product.

		Reduction in mgf. lead time/cycle time	Improvement in product development/time to market
Cost Reduction	Pearson Correlation	0.1744	0.2996 (*)
	Sig. (2-tailed)	0.1170	0.0073
	N	82	79

*Correlation is significant at the 0.01 level (2-tailed).

Table 3. – Significant results from a Bi-variate correlation between customer satisfaction and process improvement activities implemented by respondents.

		Improvement in service quality	**Improvement in on-time delivery**	**Improvement in product development and time to market**	**Improvement in flexibility/agility**	**Reduction in manufacturing lead time/cycle time**
Customer satisfaction	Pearsonn Correlation	.579(**)	.488(**)	.539(**)	.398(**)	.438(**)
	Sig. (2-tailed)	0	0	0	0	0
	N	82	83	77	81	80

**Correlation is significant at the 0.01 level (2-tailed).

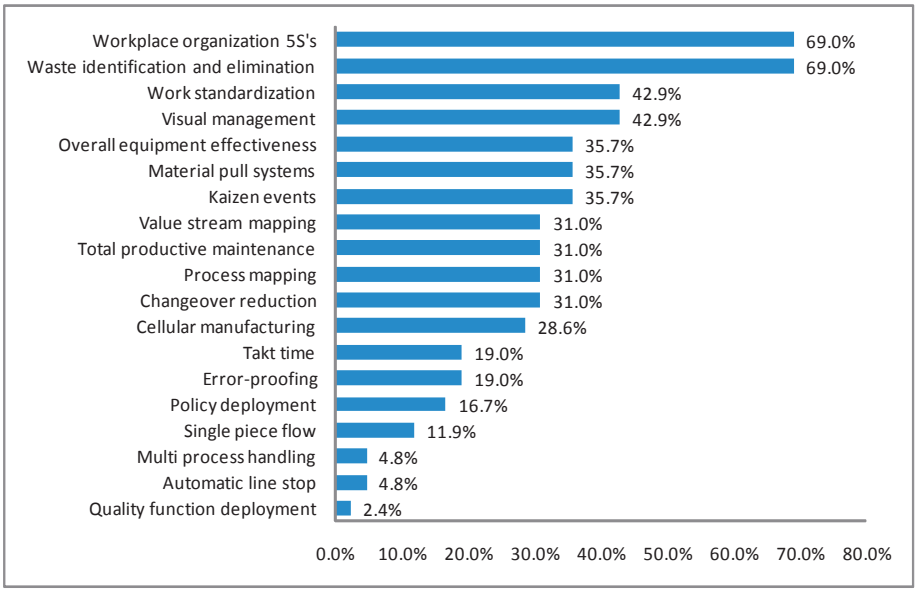

Figure 6. – Tools used by companies implementing or planning to implement lean manufacturing.

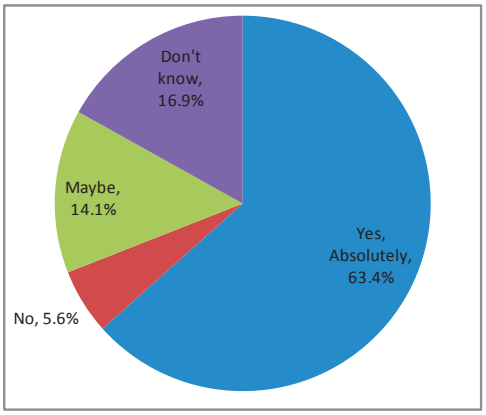

Figure 7. — Opinions of survey respondents regarding whether lean manufacturing could provide a competitive advantage for the wood industry.

provement in product quality, reduction in lead time/cycle time, and improvement in customer satisfaction (Table 1, previous page). Of these three categories, reduction in manufacturing lead time/cycle time has the highest correlation for companies that are implementing lean manufacturing.

A second correlation test was conducted in order to understand the relationship between process improvement activities implemented by respondents (Table 2, previous page). This correlation test was performed between cost reduction and reduction in manufacturing lead time/cycle time, and improvement in product development/time to market. Results from this test indicate that many companies that responded to the survey are engaged in cost reduction activities (71 companies out of 89), while improving product development/times to market (only the correlation between cost reduction and improvement in product development/time to market was significant at a significance level of 0.01).

A bi-variate test between the activities for improvement in which companies engage showed a significant correlation between customer satisfaction and improvements in service quality, on-time delivery, manufacturing flexibility/agility, product development, and time to market, as well as reductions in manufacturing lead time/cycle time (Table 3, previous page).

When asked about the tools from lean manufacturing that are useful for their businesses (Figure 6), 69% of the 42 companies that are either currently implementing lean manufacturing or planning to implement it stated that usage of workplace organization (5S's[3]) and waste identification and elimination techniques are utilized. Figure 6 also shows that

[3] 5S's represent 5 words: Sort, Set in Order, Shine, Standardize and Sustain; 5S's is a discipline for maintaining a workplace clean and with no waste (visual controls). This discipline is part of lean manufacturing.

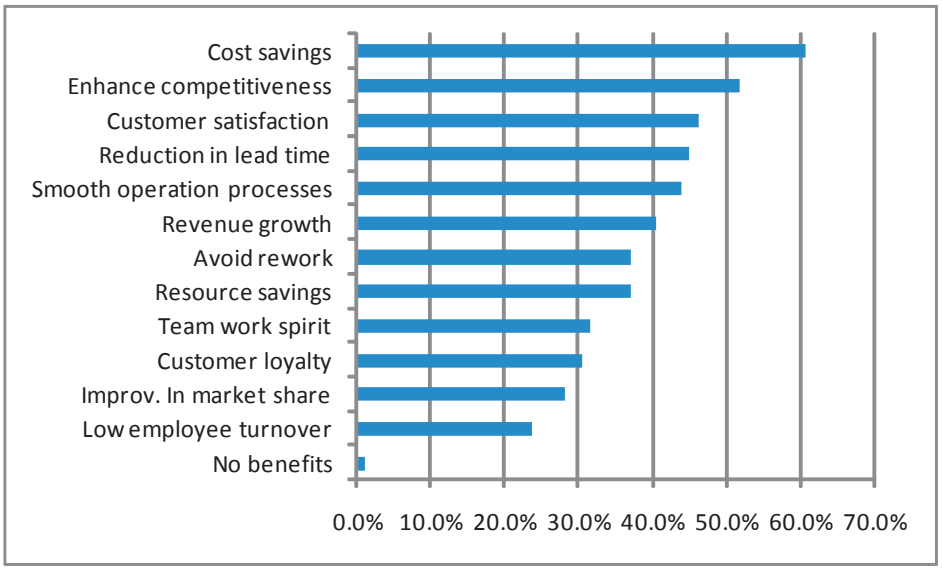

Figure 8. — Improvements that could be achieved with lean manufacturing.

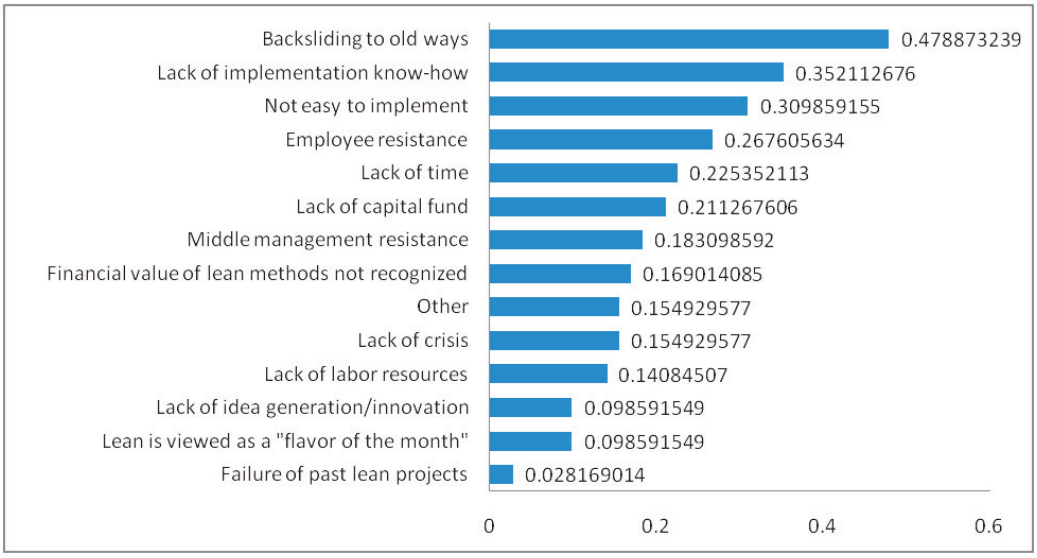

Figure 9. — Perceived barriers to lean manufacturing implementation as perceived by respondents.

the next most commonly used tools were work standardization and visual management (42.9%), overall equipment effectiveness, material pull systems, and Kaizen events (35.7%). Value stream mapping is the seventh most commonly used tool, tied with process mapping, which is a similar but simpler tool[4]. This suggests that there is room for improvement, since value stream mapping is believed among practitioners to be one of the most powerful tools used in lean manufacturing (Lean Enterprise Institute 2005). Companies implementing or planning to implement lean manufacturing may be better served by substituting the use of process mapping with value stream mapping.

All the participating companies were asked if they think lean manufacturing could help the wood industry to become more competitive[5]. Figure 7 (previous page) shows that a majority of companies (63.4%) agree that lean manufacturing will definitely help to enhance the competitiveness of the wood industry, 14.1% believed that lean manufacturing (if implemented correctly) could help the wood industry (some of them stated that it must be combined with other philosophies and customized to the companies in order to help the wood industry become more competitive), while 16.9% of the respondents did not know if lean manufacturing could help the wood industry, and 5.6% stated that it would not make a difference. Thus, a concerted effort should be made to demonstrate the benefits of lean manufacturing, which might drive the change that the industry needs. Education is important to strengthen the usage and belief in the lean manufacturing philosophy in the wood industry in order to enhance productivity and competitiveness.

Figure 8 (previous page) shows the perceived benefits that could be achieved in the wood industry by implementing lean manufacturing. A total of 61% of all respondents claimed that lean manufacturing could help them improve in several aspect of their businesses, including cost savings (52%), enhancing competitiveness (46%), and improving customer satisfaction (45%), followed by a number of other improvements like increased market share and customer loyalty. Many of these benefits may relate to each other and future research could attempt to demonstrate if such relationships exist. As explained previously, surveyed companies consider cost savings, enhanced competitiveness, customer satisfaction, and lead time reduction to be the most important improvements of lean manufacturing. These results point to the importance of increasing awareness (education and training) among company CEOs and Plant Managers of the many benefits that lean manufacturing might have in their companies.

The final question related to the barriers to the implementation of lean manufacturing. Figure 9 shows that respondents perceived that there were four main barriers preventing the adoption of lean manufacturing principles: backsliding to old ways, lack of implementation know-how, not being easy to implement, and employee resistance. Many similarities can be observed comparing these barriers with ones found by the LEI's research (2005) for other industries. Specifically, their findings showed that a lack of implementation know-how, backsliding to old ways, and middle management resistance were the main barriers preventing the successful implementation of lean manufacturing programs.

Conclusions

A mail survey regarding the state of lean manufacturing implementation in the wood industry in North Carolina was conducted. Responses indicated that a large number of companies surveyed were involved in at least one lean manufacturing activity for process improvement, such as cost reduction and improvements in service and quality. However, when specifically asked about particular lean manufacturing tools used to perform the process improvement activities, such as cellular manufacturing, values stream mapping, etc., many companies did not specify the use of any of these tools, implying a misconception between the activities and goals of lean manufacturing, and the tools it provides for achieving process improvement. Many of the companies surveyed stated that either they are not aware of lean manufacturing, or that they are aware but not implementing it, when in fact most of the

[4] In value stream mapping, lean manufacturing metrics (changeover time, lead times, work in process, overall equipment effectiveness, etc.) are required, as well as information flow, which is not required for process mapping.

[5] This was an open-ended question.

improvement activities listed belonged to a well-implemented lean manufacturing programs. Many companies seem to be pursuing process improvement and cost reduction activities, but they are not completely aware that a well-designed lean manufacturing program can provide the tools and techniques to effectively perform the desired improvement activities. It was also found that tools used for process improvement are dependent on the stage of implementation, specifically when comparing companies in an early stage and extensive stage of lean manufacturing implementation. This finding helps to identify the set of tools that companies tend to implement first when starting a lean manufacturing program. The most important triggers for implementing a lean manufacturing program were found to be corporate or group initiatives, customer pressure, and/or examples and case studies.

A strong relationship was uncovered between awareness of lean manufacturing and the reduction in manufacturing time/cycle times, indicating that respondents who were aware of lean manufacturing strongly relate this philosophy with a reduction in manufacturing time. Another significant correlation was found when comparing cost reduction activities implemented by respondents with improvement in product development/time to market. This correlation indicates that respondents associate cost reduction highly with a better product development cycle. To improve time to market, non-value added activities can be eliminated and/or reduced, leading to reductions in costs. Companies also related customer satisfaction highly with several process improvement activities that they are currently performing, such as improvements in service quality, on-time delivery, and faster product development/time to market. When analyzing the most common tools employed, it was found that value stream mapping was not among them. This suggests that there is room for improvement by leveraging the use of value stream mapping as a powerful tool, or as a substitute for process mapping.

Finally, many respondents completely agreed that lean manufacturing may help the wood industry, despite the fact that many of them are not implementing this philosophy in their companies. From these results, it can be inferred that companies might need a more convincing argument to start implementing lean manufacturing, such as case studies, plant tours, and lean manufacturing training courses.

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