

LEAN AND VIRGINIA'S WOOD INDUSTRY – PART I: AWARENESS AND IMPLEMENTATION

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During the most recent decades the U.S. wood products and furniture manufacturing industries have been greatly affected by economic cycles, rising production and transportation costs, changing buyer habits, and, arguably most powerfully, increasing global competition. However, theories exist stating that the use of management systems, such as Lean, allows companies to be more successful despite operating in a more challenging environment. To assess Virginia's wood products and furniture manufacturing industry's Lean awareness and Lean implementation efforts, a census survey was conducted. Findings indicate that a majority of Virginia's wood products and furniture manufacturing industry have heard about Lean (72 percent), but a relatively low number of respondents are aware of the details of Lean. Forty-seven percent of respondents indicated to have implemented Lean. However, the extent of Lean implementation varied widely, with a majority having implemented less than half of all 29 Lean elements inquired about in this survey. Business results from implementing Lean and the need for external Lean implementation support are presented in the second manuscript of this two-manuscript series.

Keywords: Wood products industry; Furniture manufacturing industry; Lean awareness; Lean implementation; Need for external Lean implementation support; Commonwealth of Virginia

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INTRODUCTION

During the last decade, Virginia's wood products (North American Industry Classification System (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, 2002; Schuler and Buehlmann 2003; Fishman 2005). Indeed, global competition has greatly changed the origins of manufactured products purchased by U.S. consumers. The Manufacturing Institute (2009, p. 50) calculated that "By 2008, almost 37 percent of all manufactured products bought in the United States were imported, compared to a third as recently as 2003 and less than a tenth in 1967." The non-upholstered wooden household furniture manufacturing sector (NAICS 337122) is an illustrative example when studying the impact of globalization on U.S. manufacturing. In fact, few other industry sectors have faced such intense global competition over the past decade as did the non-upholstered wooden household furniture manufacturing sector, 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, among other things, were able to displace one of the most historic U.S. industries through a combination of manufacturing prowess and collaboration with U.S. businesses and consumers who started buying offshore products (Pirraglia *et al.* 2009; Czabke *et al.* 2008). With the exodus of the furniture manufacturing business, suppliers to the furniture manufacturing industry suffered, too. Thus, challenges in one part of the industry sector were extended to other parts of the wood products and furniture manufacturing value chain (Buehlmann and Schuler 2009; Luppold and Bumgardner 2008; Grushecky *et al.* 2006). As a result, employment in the U.S. wood products and furniture manufacturing industries (NAICS 321 and 337) decreased by almost 100,000 between 2002 and 2007 (a 9 percent decrease, U.S. Census Bureau 2010a; U.S. Census Bureau 2010b), and a large number of companies experienced bankruptcy, closed operations, or relocated to offshore countries.

Given the challenging situation in which the U.S. wood products and furniture manufacturing industry finds itself, discussions center on ideas of how to make the domestic industry more competitive. One idea that has been discussed intensely is the use of management systems, such as Lean management (Buehlmann and Schuler 2009; Pirraglia *et al.* 2009; Czabke 2007; Ray *et al.* 2006; Schuler and Buehlmann 2003; Buehlmann and Schuler 2002). Lean, originating in the automotive industry (Womack *et al.* 1990), 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, Emiliani 2007).

Lean is a management philosophy focused on creating customer value without waste (Womack and Jones 2003). Lean is also referred to as Lean manufacturing, Lean management, Lean production, Lean thinking, or Toyota Production System (TPS). As a comprehensive management philosophy, Lean makes use of decades-old, existing management elements such as, for example, vision and mission statements, employee training, or root cause analysis. However, Lean also introduces unique elements, such as value stream mapping, single minute exchange of die (SMED), or A3-reporting. Besides benefits such as improved efficiency, quality, and functionality (Verlarde *et al.* 2011), cost savings are one of the benefits from Lean implementations. However, companies that focus solely on cost reductions tend to miss the opportunity to improve their performance by fundamentally changing their way of making business decisions that create true competitive advantages (Pirraglia *et al.* 2009, LEI 2007).

Numerous companies in a wide variety of industries successfully transformed their operations through the application of Lean, including companies with activities in the wood products and the furniture manufacturing industry. Some companies in the wood products or furniture manufacturing industry reaped the Shingo Prize for Operational Excellence in Manufacturing (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 but with operational improvements (Czabke 2007), while others are considering the implementation of Lean or elements thereof (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 a few examples. Pirraglia *et al.* (2009) indicated that the U.S. wood products and furniture

manufacturing industry have been slow in adapting Lean 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).

HYPOTHESES

The objective of this research was to assess current Lean management practices in the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in the Commonwealth of Virginia. Understanding the current state of Lean practices by the industry supports public policy setting and educational efforts. Also, industry participants can assess their practices and goals using such information. Particularly, the four areas of interest for this study were Lean awareness, Lean implementation status, business results from Lean implementation, and the need for external support with Lean implementation. This first manuscript reports results pertaining to Lean awareness and Lean implementation status, while the second manuscript (Fricke and Buehlmann 2012) covers the business results and the need for external Lean implementation support. Thus, this first manuscript contains results and discussions on testing the following five hypotheses:

Lean Awareness:

To judge the Lean awareness of Virginia's wood products and furniture manufacturing industry, hypotheses one and two investigated the awareness of industry participants of Lean terminology. In particular, hypotheses one and two tested:

H1₀: "The majority of wood products (NAICS 321) and furniture manufacturing (NAICS 337) companies in the Commonwealth of Virginia are not aware of Lean."

H2₀: "There is no difference in Lean awareness between different sub-segments of the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in the Commonwealth of Virginia."

Lean Implementation:

In a second step, we investigated the extent to which the Commonwealth's industry has implemented Lean practices. We also inquired about the presence of a Lean change agent in responding companies, as the presence of such an agent can be a measure of determination for a successful Lean transformation. Thus, hypotheses three to five tested:

H3₀: "The majority of wood products (NAICS 321) and furniture manufacturing (NAICS 337) companies in the Commonwealth of Virginia have not implemented Lean."

H4₀: "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."

H5₀: "Wood products (NAICS 321) and furniture manufacturing (NAICS 337) companies in the Commonwealth of Virginia employing a Lean change agent are no different in respect to Lean implementation status as compared to companies without a Lean change agent."

Hypotheses tested in the second manuscript (Fricke and Buehlmann 2012) include hypotheses pertaining to the business results obtained due to Lean implementation (H6₀,

H7₀) and Hypotheses related to the need of external support that companies of Virginia's wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries may need (H8₀, H9₀).

METHODOLOGY

A mail questionnaire was used for this study to obtain data to make inferences about a population's characteristics. For this purpose, measurements needed to be taken from the population (Ott and Longnecker 2010; Dillman *et al.* 2009; Rea and Parker 2005).

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 (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 active in these industries in 2009 was 1033 (with 513 establishments in wood products manufacturing and 520 establishments in furniture manufacturing).

Due to a lack of a state-wide address list, 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 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 or furniture manufacturing, the final sample size for this survey was 1,193. The entire sample was used for a census survey (Dillman 2006; Alreck and Settle 1995).

Questionnaire design

A mail questionnaire directed at wood products and furniture manufacturing companies in the Commonwealth of Virginia was developed. The first part consisted of nine questions to gather basic company demographic information regarding NAICS classification and company size. The second part asked questions regarding companies' Lean practices. This included questions about Lean awareness, Lean implementation, and results from Lean implementation. The third part asked questions assessing the respondents' need for external 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 and implementation status, a set of Lean elements (Kirby and Greene 2003; Czabke *et al.* 2008; Liker 2003) were used as proxies. Twenty-nine Lean elements (*e.g.*, practices that are part of Lean) categorized in four categories (Philosophy, Process, People, and Problem Solving; referred to as the 4P's (Liker 2003)) were used as proxies to establish Lean awareness and Lean implementation status in the companies surveyed (Table 1).

Table 1. Twenty-Nine Lean Elements Used as Proxies to Establish Lean Awareness and Lean Implementation Status in the 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)

Respondents were asked which, if any, of these twenty-nine Lean elements were implemented in their company, if the company planned to implement the element in the future, or if the company had no intentions to implement the element at all. Kirby and Greene (2003) found a direct positive relationship between the number of Lean elements (Table 1) implemented and the level of an organization's Lean maturity.

A draft questionnaire was reviewed by the faculty of Virginia Tech, and feedback was obtained from 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 and furniture manufacturing 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 (Rea and Parker 2005).

Data Collection and Analysis

Data collection

In July 2010, the mail questionnaire was mailed to the entire address list. The survey was addressed to corporate-level decision makers in the wood products and furniture manufacturing industries. 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 mirroring the first mailing, 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, 30 randomly selected non-respondents were contacted by telephone and fax and asked three questions. One question asked which industry segment the respondent's company belongs to while one question asked how many employees work in the respondent's company. The third 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 30 non-respondents were used in the determination of non-response bias (Dillman *et al.* 2009; Rea and Parker 2005). All useable data received was entered into a coded MS Excel data analysis spreadsheet (Microsoft 2007).

Data analysis

The data obtained were 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.

Response rate

The final sample size of this survey was 1,193 after accounting for undeliverable surveys (478 questionnaires), businesses that no longer existed (20 questionnaires) or were not involved in wood products manufacturing (160 questionnaires), and updated or changed addresses (80 questionnaires). A total of 188 surveys were received resulting in a response rate of 15.76 percent.

Non-response bias

Non-response bias was tested comparing the responses from 30 of the 1005 non-respondents who were randomly selected and contacted via telephone and fax with

responses obtained from survey respondents (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 ($\alpha = 0.05$) differences between the respondents and non-respondents were found ($p = 0.90, 0.19, \text{ and } 0.67$, respectively, Fisher's exact test).

Definitions

The following definitions for measuring Lean awareness, Lean implementation, and the need for external Lean implementation support were used in this study. Survey participants were considered "aware of Lean" if at least one of the five terms Lean Manufacturing, Lean Management, Lean Production, Lean Thinking, or Toyota Production System (TPS) listed in the survey questionnaire was known by the respondent. To gain a more detailed understanding of individual respondents' Lean awareness, survey respondents were also asked to identify all known elements from the list of 29 Lean elements (Table 1).

The respondents' companies Lean implementation status was then investigated using the 29 Lean elements listed in Table 1. If a respondent indicated that his company uses at least one of the 29 Lean elements, the respondent's company was considered as having implemented or implementing Lean. A small number of participants ($N = 6$) indicated plans to implement certain Lean elements within one, three, or in more than three years. These six answers were counted as elements currently not in use.

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

Limitations

A major limitation of mail survey research is that results are based on responses from 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 external Lean implementation support as such 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 (Table 1) 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 occur only in few cases and should not bias the overall results of this study. Conversely, a respondent needed to only indicate one of the 29 elements as "used," to be classified as "has implemented Lean," even though the element implemented may be a mission statement, which may not be related to a Lean implementation effort. Misclassification thus could occur. However, more in-depth analysis of the data was conducted (by analyzing usage of purely Lean specific elements) to be able to quantify this error.

Also, survey results could be biased by over or underrepresentation of respondents in particular industry sub-segments. Therefore, a Fisher's exact test was conducted to test the representation of industry sub-segments among respondents as compared to industry sub-segment representation of companies in the mailing list. The test showed a significant difference ($p = 0.01016$, Fisher's exact test). In particular, companies from "other 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 external Lean implementation support. Thus, if bias is present, it should be low.

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 knowledge of at least one of the five Lean terms listed in the questionnaire. However, relatively few companies who are aware of Lean have implemented Lean, a finding consistent with Pirraglia *et al.* (2009). Furthermore, the level of awareness and implementation of Lean among Virginia's wood product and furniture manufacturing industries differs between companies, industry sub-segments, and industry segments.

Lean Awareness

Hypothesis one, stating that "The majority of wood products and furniture manufacturing companies in the Commonwealth of Virginia are not aware of Lean management" was rejected as the majority (72 percent) of the respondents indicated to be aware of Lean as measured by knowing at least one term associated with Lean (Lean Manufacturing, Lean Management, Lean Production, Lean Thinking, or Toyota Production System (TPS)). This conclusion is also supported when measuring Lean awareness by using the 29 Lean elements (Table 1) as 76 percent of the respondents have heard of at least one Lean element. However, as shown in Figure 1, about 28 percent of survey respondents are not aware of Lean and have not heard about any of the five terms typically used in Lean vocabulary.

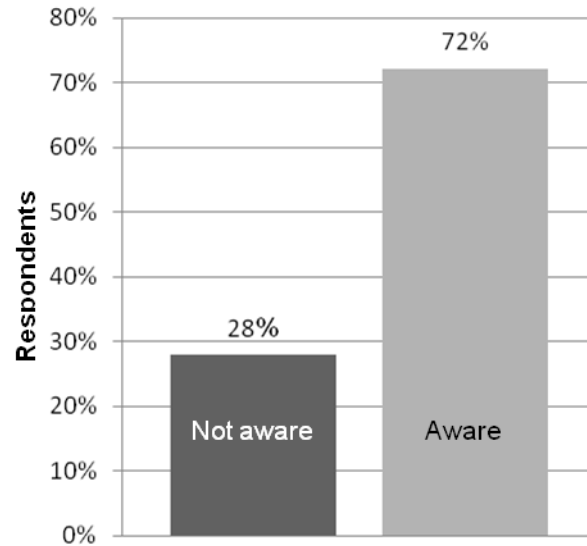


Fig. 1. Lean awareness of survey respondents as measured by knowing at least one of five Lean terms

Among the 72 percent of respondents who are aware of Lean (Fig. 1), Lean Manufacturing was the most widely recognized term (56 percent, Fig. 2), followed by Lean Management (51 percent), Lean Production (44 percent), Lean Thinking (30 percent), and Toyota Production System (TPS; 25 percent).

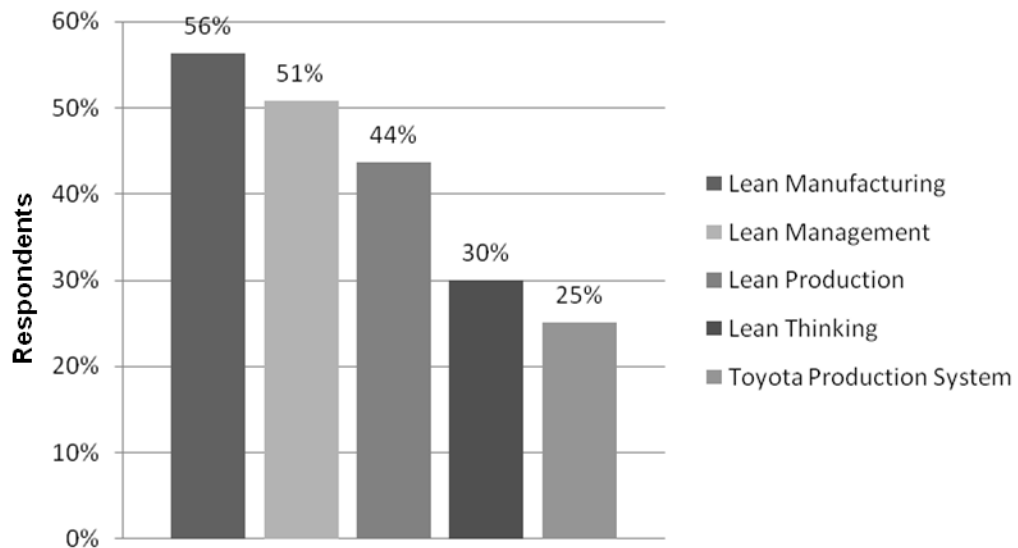


Fig. 2. Lean terms of which respondents were aware

Respondents also exhibited differences in Lean awareness when measured by using the 29 Lean elements listed in Table 1 as proxies for Lean awareness. Figure 3 displays respondent frequency of awareness of individual Lean elements grouped into Liker's (2003) four categories (Philosophy, Process, People, and Problem Solving, *i.e.*, the 4 Ps).

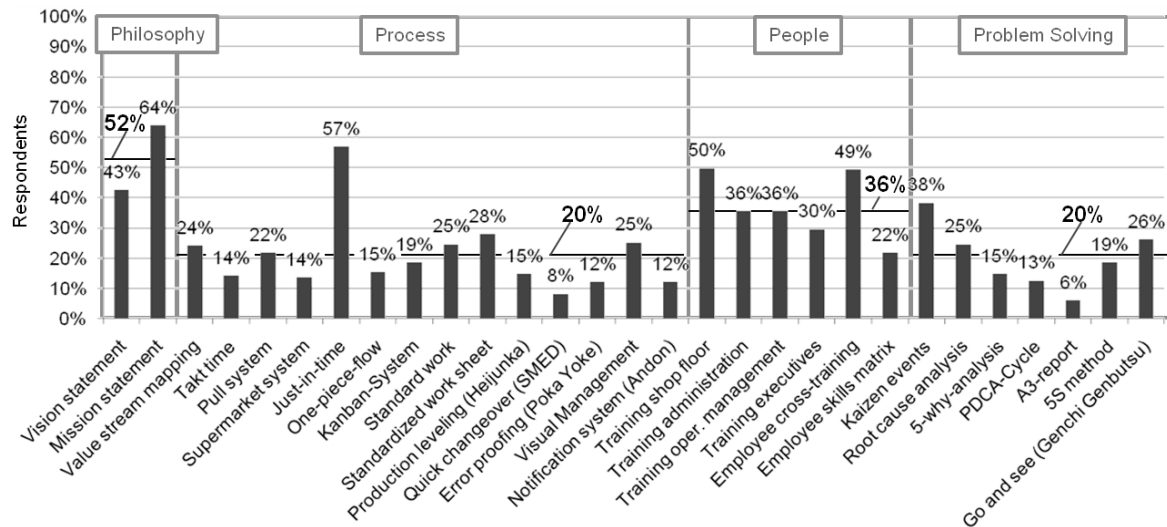


Fig. 3. Awareness of 29 Lean elements by survey respondents grouped into four categories. Solid line in each field signifies the average level of awareness for this particular field

Of 188 respondents, 23 percent ($N = 44$) do not know any of the 29 Lean elements. The remaining 77 percent ($N = 144$) know at least one of these 29 Lean elements. On average for all 29 Lean elements, each of the elements was known by 32 percent of the respondents. However, Fig. 3 shows that certain elements, such as, "mission statement," "just-in-time," "training shop floor," "employee cross-training," or "vision statement (64, 57, 50, 49, and 43 percent awareness, respectively)" are far more widely known than more Lean-specific elements such as, "A3-report," "quick changeover," "error proofing (Poka Yoke)," "visual management," or "PDCA-cycle (6, 8, 12, 12, and 13 percent awareness, respectively)."

Hypothesis two, stating that "There is no difference in Lean awareness between different sub-segments of the wood products and furniture manufacturing industries in the Commonwealth of Virginia," however, was rejected at the 95 percent level of significance ($p = 0.0089$, Kruskal-Wallis test). Thus, Lean awareness differs at least between some of the eight industry sub-segments (e.g., "sawmills and wood preservation (NAICS 32111)," "vener, 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 4 shows the frequency of respondents indicating awareness of individual Lean elements by industry sub-segment.

Figure 4 shows the large variability of Lean awareness that exists between the different industry segments and sub-segments investigated. While the overall average Lean awareness measured by awareness of the number of individual Lean elements by respondent is 7.47, individual industry segments' mean Lean awareness varies from 15.21 for "engineered wood products (column F, Figure 4)" to 3.80 for "sawmills

(column E, Figure 4)." Mean values for "manufactured homes (D)," "office furniture (C)," "household furniture (B)," "millwork (G)," "kitchen cabinets (A)," and "wood container and pallets (H)" are 13.00, 8.17, 8.08, 8.06, 7.06, and 5.50, respectively.

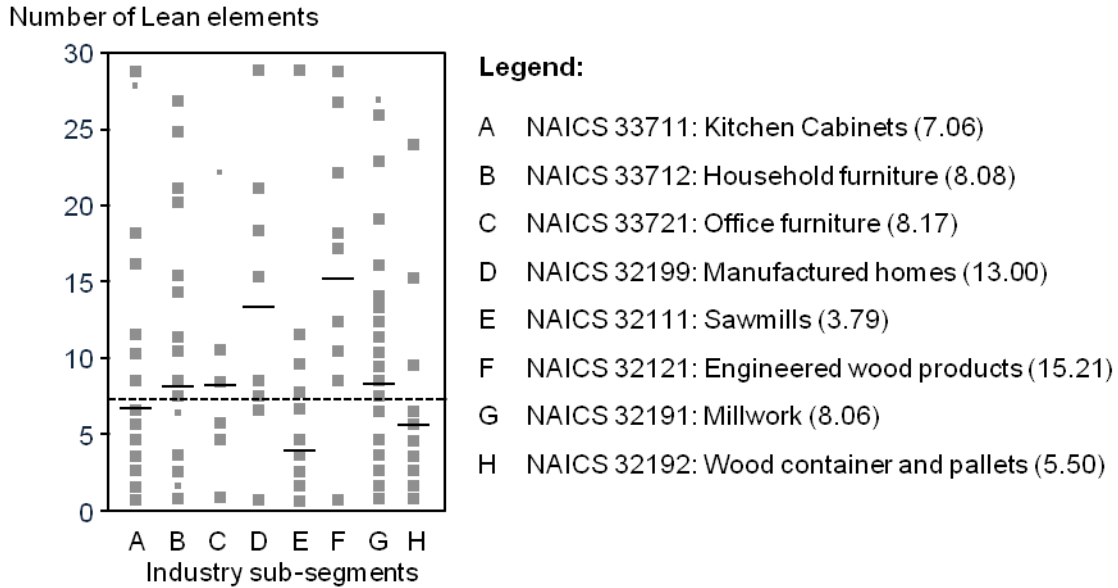


Fig. 4. Frequency of respondents indicating awareness of individual Lean elements, dotted line indicates overall average awareness (7.47), while the continuous line for each category shows the category average (values are listed in parentheses in legend).

Table 2. Significance 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)

Seven pairs of industry sub-segments (e.g., “sawmills and wood preservation” and “veneer, plywood, and engineered wood products;” “sawmills and wood preservation” and “millwork;” “sawmills and wood preservation” and “manufactured home (mobile home) and prefabricated wood building manufacturing;” “veneer, plywood, and engineered wood products” and “millwork;” “veneer, plywood, and engineered wood products” and “wood container and pallet manufacturing;” “veneer, plywood, and

engineered wood products” and “wood kitchen cabinet and countertop manufacturing;” as well as “wood container and pallet manufacturing” and “manufactured home (mobile home) and prefabricated wood building manufacturing;” highlighted with bold rectangles in Table 2) 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 manufacturing industry in the Commonwealth of Virginia, the large within-industry sub-segment variations make the statistical proof a challenge (Fig. 4). Also, variability is not only large between industry segments and sub-segments, but also within segments and sub-segments. Indeed, there is no industry segment or sub-segment where all participants are uniformly aware or not 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 ($p = 0.7130$, Wilcoxon Rank-Sum). Thus, there is no difference in Lean awareness between Virginia’s “wood products” and “furniture manufacturing” industry.

Lean Implementation

While 72 percent of the responding companies are aware of at least one Lean term (Lean Manufacturing, Lean Management, Lean Production, Lean Thinking, or Toyota Production System (TPS), Fig. 2), only 47 percent of the survey participants claim to have implemented one or more of the 29 Lean elements (Table 1). Thus, based on the results of this survey, Lean implementation in companies of the wood products and furniture manufacturing industries in the Commonwealth of Virginia is rather low, a result consistent with Pirraglia *et al.* (2009).

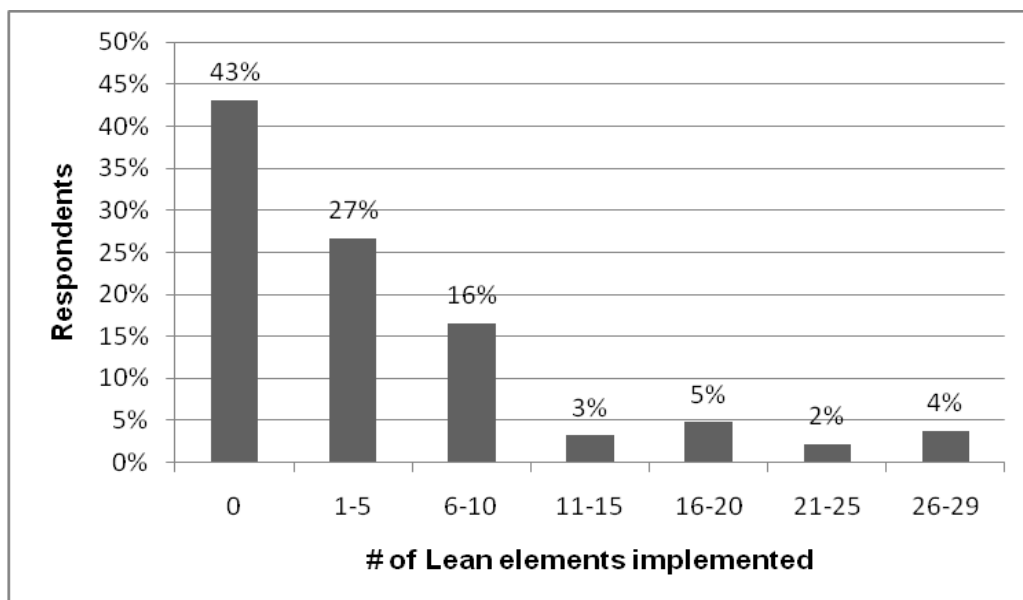


Fig. 5. Number of Lean elements implemented based on survey respondents’ answers

Figure 6 shows the implementation frequency of each of the 29 elements based on the results of the survey. The average frequency for implementing Lean elements by responding companies (21 percent, Fig. 6) is lower than the average frequency for Lean awareness (32 percent, Fig. 3). Not surprisingly, respondents have more likely heard of Lean than have actually implemented it.

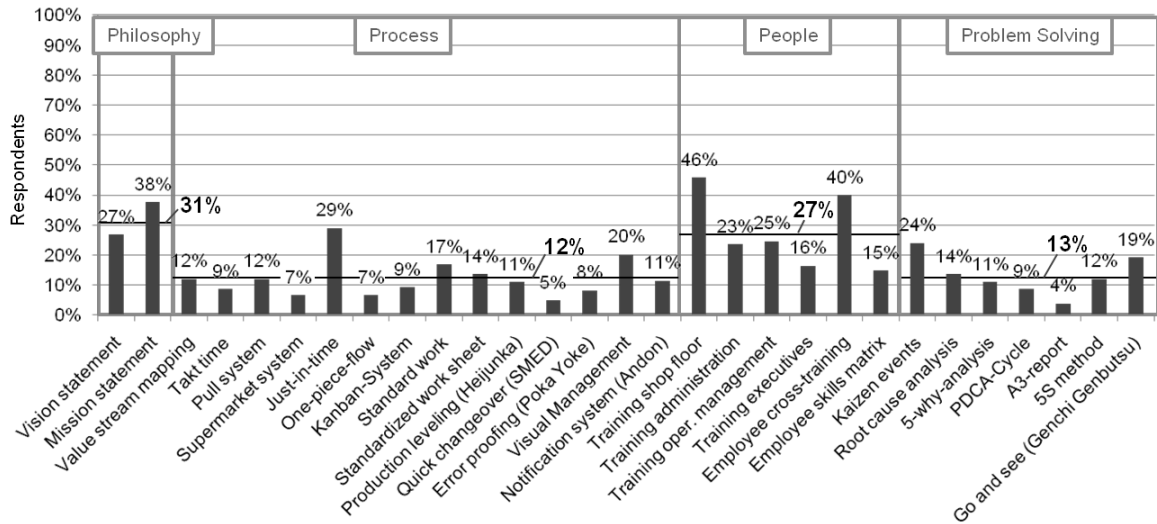


Fig. 6. Overview of implementation of Lean elements by survey respondents grouped into four categories (4 Ps). Solid line in each field signifies the average level of awareness for this particular field.

The “Philosophy” category with its two elements “vision statement” and “mission statement” is, with an average positive response frequency of 31 percent, the category whose elements are, on average, the most actively used. The same observation was made when testing Lean awareness of respondents (52 percent, Fig. 3). In descending order of frequency of average elements implemented, “Philosophy” is followed by “People,” “Problem Solving,” and “Process” (27, 13, and 12 percent average implementation frequency, respectively). A noteworthy observation when looking at the frequency distribution of Lean elements implemented (Fig. 6) might be that more philosophical elements like vision and mission statement (e.g., the “Philosophy” category) or training related elements (e.g., the “People” category) like employee training have higher implementation rates than the more “nuts and bolts” elements like A3 reporting or production leveling (Heijunka).

However, as discussed under “Limitations,” an argument can be made that the penetration of Lean in businesses of the wood products and furniture manufacturing industries in the Commonwealth of Virginia is less pronounced than the frequency averages shown in Fig. 6 would tend to make one believe. Several of the 29 Lean elements (Table 1) are in fact concepts practiced by many businesses that have no awareness of Lean or do not implement or want to implement Lean. In fact, if the assessment of Lean penetration in businesses of the wood products and furniture manufacturing industries in the Commonwealth of Virginia is based on response frequencies for elements that are uniquely associated with Lean, such as, “A3-report,” “quick changeover (SMED),” “one-piece-flow,” “supermarket system,” “error proofing

(Poka Yoke)," "takt time," or "Kanban system," a less favorable picture about the Lean implementation status evolves. When using this more restrictive assessment method, less than ten percent of all respondents (4, 5, 7, 7, 8, 9, 9, and 9 percent, respectively, for "A3-report," "quick changeover (SMED)," "one-piece-flow," "supermarket system," "error proofing (Poka Yoke)," "takt time," "Kanban system," or "PDCA-cycle") indicated that they have implemented those uniquely Lean-specific elements. Even the more widely known and more widely 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 average response frequency, respectively), indicate that Lean has attracted some followers who have implemented selected Lean elements.

Given that only 47 percent of respondents indicated that Lean elements are implemented in their company, hypothesis three stating that "The majority of wood products and furniture manufacturing companies in the Commonwealth of Virginia have not implemented Lean," 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.

Using Kruskal-Wallis ($\alpha = 0.05$) 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," produced evidence allowing the rejection of hypothesis four and the conclusion that there are differences in Lean implementation status between the wood products and furniture manufacturing industries in the Commonwealth of Virginia ($p = 0.0096$). Figure 7 provides an overview of Lean elements implemented by individual companies for the different wood products and furniture manufacturing industry sub-segments in the Commonwealth of Virginia as well as the mean frequency of elements implemented by company.

Figure 7 shows that Lean implementation efforts in businesses of the wood products and furniture manufacturing industries in the Commonwealth of Virginia vary widely, ranging from none to all 29 Lean elements being implemented. Interestingly, all industry sub-segments that were part of this study have respondents whose company has not implemented any of the 29 Lean elements inquired about. This indicates that companies in all sub-segments are capable of surviving without any Lean elements being implemented. However, industry sub-segments in the wood products and furniture industry in the Commonwealth of Virginia differ in that some sub-segments do not have any companies who have implemented or plan to implement all Lean elements. Particularly, no respondent from the "sawmills" and the "wood container and pallet manufacturing" industry sub-segment indicated that they have implemented or are planning to implement more than 17 and 13 Lean elements, respectively (Fig. 7). The "wood kitchen cabinet and countertop manufacturing" and the "engineered wood products" industry sub-segments, however, have leaders that have implemented or are planning to implement all 29 Lean elements. Lean implementation as measured by the number of Lean elements implemented (Table 1) averaged 5.76 over all of the industry sub-segments of the wood products and furniture manufacturing industries in the Commonwealth of Virginia.

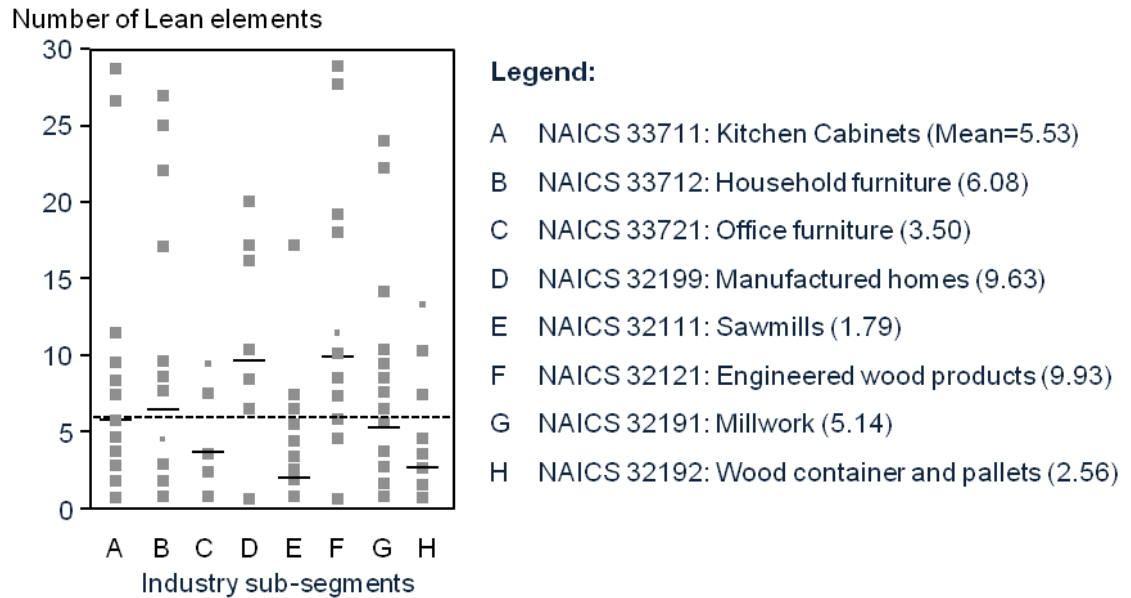


Fig. 7. Frequency of respondents indicating implementation of individual Lean elements, dotted line indicates overall average awareness (5.76), while the continuous line for each category shows the category average (values are listed in parentheses in legend).

On average, companies in the "Engineered wood product (column F in Fig. 7)" sub-segment had 9.93 Lean elements implemented, followed by "manufactured homes (D)" with 9.63 elements implemented. Those leaders were followed by "household furniture (B)," "kitchen cabinets (A)," "millwork (G)," "office furniture (C)," "wood container and pallets (H)" and "sawmills (E)" with mean values of 6.08, 5.53, 5.14, 3.50, 2.56, and 1.79, respectively (Fig. 7). Why these large differences in Lean element implementation between industry sub-segments exist is subject to much controversy. However, no clear, widely accepted answer to this controversy has been found, yet.

A Wilcoxon Rank-Sum test for multiple comparisons at the 95 percent level of significance ($\alpha = 0.05$) with all 28 possible pairs of industry sub-segments revealed six industry sub-segments that are significantly different from the others. These six pairs of industry segments with significant differences are: "Sawmills and wood preservation" and "veneer, plywood, engineered wood products;" "sawmills and wood preservation" and "millwork;" "sawmills and wood preservation" and "manufactured home (mobile home) and prefabricated wood manufacturing;" "sawmills and wood preservation" and "household and institutional furniture manufacturing;" "veneer, plywood, engineered wood products" and "wood container and pallet manufacturing;" as well as the pair "wood container and pallet manufacturing" and "manufactured home (mobile home) and prefabricated wood manufacturing." The probability values from these tests are summarized in Table 3 and significant results are highlighted with bold rectangles.

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 ($p = 0.7790$, Wilcoxon Rank-Sum), indicating that

there is no statistical significant difference in Lean implementation status between the wood products and furniture manufacturing industries in the Commonwealth of Virginia.

Table 3. Significance of Pair-Wise Comparisons of Industry Sub-Segments Regarding Lean Implementation as Measured by Implementation of the 29 Lean Elements

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)

Using answers from respondents to the question asking “Does your organization employ a lean change agent?,” a Wilcoxon Rank-Sum ($\alpha = 0.05$) test was used to test hypothesis five, “Companies of the wood products and furniture manufacturing industries with a Lean change agent are no different with respect to Lean implementation status as compared to companies without a change agent in the Commonwealth of Virginia.” Fifteen respondents indicated that their company employs a full- or part-time Lean change agent. Businesses employing a Lean change agent worked with 19.80 of the 29 Lean elements, on average, as opposed to an average of 3.59 elements for businesses without a Lean change agent. Thus, Hypothesis five was rejected ($p < 0.0001$, Wilcoxon Rank-Sum test). Hence, according to the this study, the presence of Lean change agents in a company has a positive influence on Lean implementation in the “wood products” and “furniture manufacturing” industries in the Commonwealth of Virginia.

While a majority (72 percent, Fig. 1) of survey respondents in Virginia’s wood products and furniture manufacturing industry is aware of Lean and 47 percent of respondents (Fig. 6) indicated to have implemented at least one Lean element (Table 1), less than ten percent of responding companies employed a Lean change agent. However, this study produced evidence that employing a Lean change agent is beneficial for Lean implementation efforts in a company, as such companies employing a Lean change agent have, on average, a higher number of Lean elements implemented than companies without a Lean change agent (19.80 vs. 3.59 elements implemented, respectively). Part II in this two-part series of manuscripts (Fricke and Buehlmann 2012) will investigate if the implementation of Lean elements is beneficial for a company’s business results and if companies in the Commonwealth of Virginia do have a need for Lean implementation support.

SUMMARY AND CONCLUSIONS

Large parts of the U.S. (and thus, Virginia) wood products and furniture manufacturing industries are struggling to survive due to a set of unfavorable economic facts such as increasing global competition, rising costs, changing buyer habits, and the current economic challenges. Lean, a proven management practice for improved business performance in some industries, has been named as a way to improve the fortunes of the industry. This research was undertaken to gain an understanding of the current awareness and implementation status of Lean by Virginia's wood products and furniture manufacturing industries. Findings were as follows:

1. While roughly three-fourths (72 percent) of the wood products (NAICS 321) and furniture manufacturing (NAICS 337) industries in the Commonwealth of Virginia responding to this survey ($N = 188$) were found to be aware of Lean, less than half (47 percent) of all respondents indicated to have implemented Lean.
2. Lean implementation was measured by the use of one or several of the 29 Lean elements that can potentially be implemented. Of the companies indicating the use of Lean (*e.g.*, 47 percent of all respondents), the average number of Lean elements implemented was found to be 5.76 (averages of 5.81 and 5.70, for the wood products and furniture manufacturing industries, respectively).
3. Large differences in the degree of Lean implementation between industry sub-segments exist. The industry sub-segment "wood container and pallet manufacturing" was found to have no business implementing more than 13 Lean elements (out of 29 possible). Conversely, the industry sub-segments "engineered wood products" and "wood kitchen cabinet and countertop manufacturing" has businesses that have implemented the maximum number of the 29 Lean elements.
4. Lean elements implemented most frequently are elements that are not unique to Lean but are practices used by other management theories. Examples of elements considered as Lean but in widespread use by companies not pursuing Lean strategies are, for example, "training shop floor employees," "employee cross-training," and creating "mission statements." Large numbers of survey respondents were aware of these three elements (50, 49, 64 percent, respectively) and had them implemented (46, 40, 38 percent, respectively). Awareness and implementation of elements uniquely associated with Lean, such as, "A3-report," "quick changeover (SMED)," "one-piece-flow," "supermarket system," "error proofing (Poka Yoke)," "takt time," "Kanban system," or "PDCA-cycle," were much less frequent, with awareness rates of 6, 8, 15, 14, 12, 14, 19, and 13 percent, respectively, and implementation rates of 4, 5, 7, 7, 8, 9, 9, and 9 percent, respectively.
5. Less than ten percent of responding companies employed a Lean change agent. However, companies employing a Lean change agent have, on average, a higher number of Lean elements implemented than companies without a Lean change agent (19.80 vs. 3.59 elements implemented, respectively).

Assuming that the U.S. economy returns to a more normal level of performance after the recent recession, businesses in Virginia's wood products and furniture manufac-

turing industries can expect improvements in their profitability. However, given the global nature of today's economy and price pressures on all factors of production, relentless pursuit of improvements is needed by all economic agents. Business results from Lean implementation and the industry's need for external implementation support are discussed in the second manuscript in this series: "*Lean and Virginia's wood industry – Part II: Results and need for support*," (Fricke and Buehlmann 2012).

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