THE PREVALENCE OF LEAN PRACTICES IN U.S. MANUFACTURING: A SURVEY OF MIDWEST USER

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ABSTRACT

In spite of much touted benefits, lean implementation continues to be a major challenge for most manufacturing companies. Parenthetically, it is important to note that determinants of lean production are not tantamount to actual lean performance. It becomes imperative to determine the degree to which lean practices have been implemented across manufacturing industries. To date, there have been spotty attempts in U.S. and in Europe to determine, especially across manufacturing industries, the extent to which manufacturing companies are engaging in lean practices and the degree to which various lean practices are implemented.

We posit that there is gap in the research concerning the degree to which various manufacturing companies are using lean practices. The purpose of this paper is to conduct a study that reaches across a wider spectrum of manufacturing industries and over a greater geographic expanse than had previously been accomplished. Specifically, we first develop a comprehensive lean survey instrument to conduct an empirical study across Midwest manufacturing companies in U.S. Secondly, the paper examines and analyzes responses from 140 firms, mostly in the Midwest, and provides a discussion on the implementation status of various lean practices in these firms. It also compares the degree of lean implementation by firm size and job functions within these firms.

1. INTRODUCTION

From the introduction of Taylor's scientific management principles, to the evolution from total inspection, statistical quality control, quality management, reengineering and the famous lean Toyota Production System (TPS), and now agile manufacturing, operations management has increased in significance as an applied academic discipline (Wrege, C.D. & Greenwood, R.G., 1991; Douglas, T.J. and Judge Jr., W.Q. (2001), Liker, 2010). Further, this progressive genre is now being applied in all aspects of organizations including, for example, lean offices and the error and waste elimination in health care systems (Brewton, 2009; Mann, 2009). Consequently, lean principles and management have found their home together in operations research.

With leanness as the centerpiece of both operations management practice and research, it is defined as the total removal of waste to achieve competitive advantages (Womack, Jones, and

Roos, 1990). Proponents argue that, in addition to eliminating waste, the proper implementation of lean practices improves productivity, reduces lead time and cost, and improves quality and overall competitiveness (Lowe, Delbridge, and Oliver, 1997; Sriparavasta and Gupta, 1997, Womack & Jones, 2003). According to Krafcik (1988) and Panizzolo (1998) plants with lean production policies are able to manufacture a wide range of models but maintain high degrees of quality and productivity. Still, others contend that lean practices are too difficult, time consuming, fragile, complex, and costly to implement successfully (Cooney, 2002; Fliedner and Vokurka, 1997; Mason-Jones, Naylor & Towill, 2000; Yuself and Adeleye, 2002). For example, one of the most difficult issues is resolving human resource challenges as workers strain to adjust to change and cost cutting measures (Albino & Garavelli, 1995; Bamber & Dale, 1999). Some researchers advocate a systems approach emphasizing the need for lean practices in all functions of an organization including, for example, product development. In short, lean must be organization-wide to be effective (Karlsson & Ahlstrom, 1996a; Womack & Jones, 1994).

For the purposes of this research, we argue that lean practices have contributed substantially to the field of operations management practice and research. However, in practice, transforming from wasteful to lean practices appears to be a challenge for most organizations. Therefore, our primary concern is the degree to which lean practices have been implemented across manufacturing industries.

2. THE RESEARCH MODEL

With some updates, we chose the production model of Karlsson and Ahlstrom (1996b) to examine the operationalization of lean practices in the manufacturing companies that we surveyed. Their goal was to create a model that could be used by practitioners as a tool to track progress in order to successfully introduce and maintain lean production. Grounded in lean theory as proposed by Womack, Jones, and Roos (1990), their model, and a subsequent model further developed by Sanchez and Perez (2004), first identifies the determinants of lean production, i.e., the actions taken, the principles implemented, and the changes made to the organization to achieve the desired performance. Additionally, five principles of lean include specifying value, identifying the value stream, flow, pull, and perfection (Womack and Jones, 2003). However, planning on the part of management can also improve the chances of success as they 1) develop critical success factors 2) define appropriate business measures 3) define key business processes 4) determine which process contributes to each target area, and 5) decide which processes require more detailed value stream mapping (Hines and Taylor, 2000). Further, Karlsson and Ahlstrom (1996) listed the following groups of lean performance indicators, the focus of this study: 1) elimination of zero-value activities, 2) continuous improvement, 3) multifunctional teams, 4) just-in-time delivery, 5) supplier's involvement and 6) flexible information system.

Consistent with these studies, Panizzolo (1997) also identified six areas of concentration for manufacturing improvement: 1) manufacturing equipment and processes, 2) shop floor management, 3) new product development, 4) supplier management, 5) customer relations, and 6) workforce management. This model is generally sufficient to take into account most major dimensions of lean practices for the purposes of this research. To this model, however, we add new technology driven systems such as autonomation (a process used by the Japanese for error proofing which eliminates human error through machine vision sensors) and agile pull systems (customer orders transmitted directly to automated plant floor via inter or intranet system. These systems fundamentally enhance the model such that global competitiveness depends on it.

3. PREVIOUS EMPIRICAL STUDIES

To date, there have been spotty attempts to determine, especially across manufacturing industries, the portion of companies that are engaging in lean practices. For example, Doolen and Hacker's (2005) study was limited to twelve firms in the electronics industry in the northwest region of the U.S. Doolen and Hacker (2005) reviewed seven industry instruments and five academic research surveys to design a comprehensive tool to assess lean production practices. While the most comprehensive survey found to date, we modified the survey to include newer fundamental competitive technology-drive systems which were not included in the original survey. Doolen and Hacker found that all twelve of the manufacturers had implemented lean practices to some extent. For example, electronic manufacturers ranked highest in shop floor management, new product development and supplier management. However the industry was limited (as are most industries) because they are "subject to a variety of challenging conditions that limit the applicability of lean practices". Overall, organizational size and the type of manufacturing may be significant factors. Larger organizations tend to have more resources available to implement lean. Further, the demand of customers, for example, may determine in which areas a company excels at lean practices. Equipment manufacturers may be forced, by a customer need, to adjust to rapidly changing requirements and to design equipment that meets new product and process requirements.

Sanchez and Perez (2004) surveyed 350 service companies but only received 108 useful responses from a single geographic region near Aragon in Spain. Their goal was to discover the use and usefulness of lean operations indicators. While restricted by limited sample size, they also concluded that company size was the most important factor in determining the extent to which service companies expressed the use of lean indicators. Panizzolo's (1998) earlier efforts included only twenty seven international firms. They concluded that to fully implement lean practices, the most important factors are the integration and management of external relationships, i.e., suppliers. They advocated a move away from operations to relationships management.

Wemmerlov and Hyer (1989) studied 53 U.S. mostly metal working firms including machine tools, agricultural and construction equipment, medical equipment, defense products, engines, and pieces and components. They measured the benefits and extent of celluarization, i.e., the number and size of cells. Of the 53 surveyed, 32 used cellular manufacturing to varying degrees and were able to achieve gains through it. The only major support dimension for lean manufacturing considered in this study was human resources. Some of these HR issues included selection of personnel, education and training, compensation systems, and resistance to change. Not surprisingly, human resource issues, especially resistance to change, were more salient than any technical issues. Wemmerlov and Johnson (1997) conducted a similar follow-up study nearly ten years later. They found that of 46 plants studied, most found cellular manufacturing to be a benefit with regard to lead time, customer response time, and quality. However, organizational and human resource issues continued to the most problematic. These earlier studies did not rely on a comprehensive model nor did they measure most of the elements studied in the Doolen and Hacker research.

Prior to Wemmerlov et al (1989, 1997), there were some limited studies of companies using cellular manufacturing. These included Ham and Reed (1977), Levulis (1978), Burbridge (1979), and Hyer (1984). Again, these very early studies were limited in the number of participating plants or companies and focused primarily on group technology applications. Most of these empirical studies predated the development of useful research model for lean practices.

While all of these studies have made important contributions to the body of lean literature, the question still remains, "What percentage of firms are actually using lean practices and to what degree across manufacturing industries? To what degree various lean practices are prevalent among manufacturing industries?" Therefore, the primary goal of this research is to cover a broader geographic area and a greater variety of manufacturing organizations.

4. METHODOLOGY

A comprehensive set of 29 representative lean practices was developed after reviewing relevant research literature, and reviewing surveys and assessment tools (Wemmerlov, Roos, & Jones, 1990; James-Moore and Gibbons, 1997; Panizzolo, 1998; Benteley, Nightingale, and Taneja, 2000; Karlson and Ahlstrom, 1996). Each lean practice was further divided into 3-5 follow on sub-practices as shown in the sample survey (Appendix 1). Respondents were asked to use a 3 point Likert scale to answer questions related to each of the lean sub-practice. The survey was made available online using www.monkeysurvey.com web site which hosted the survey. The link for the survey was made available to 200 manufacturing companies in the Midwest region. The names of these companies were procured using a variety of sources such as published directory of manufacturers and the listings available with the local Chamber of Commerce. Of all the completed surveys received, only 140 were found to be complete and usable.

5. RESULTS

Table 1 provides the summary scores on 15 lean practices across a variety of manufacturing industries. It shows that the work standardization lean practice was implemented by 97% of the respondents' companies while use of integrated flow operations lean practice was implemented by only 33% of the companies. It is interesting to note that the mean score for integrated flow operations is higher than that for work standardization implying higher degree of its implementation. Table 2 provides a summary of lean practice implementations by job function. Lean practices have the highest level of implementation in R&D with the overall score of 2.02. Lean practices are therefore implemented in R&D most of the time as compared to other two job functions. R&D got higher scores on 15 out of 29 practices and only 3 out of 29 practices - utilizing Pokayoke, DFM, and delegating decisions to the lowest level possible - had the lowest numbers. Use of integrated flow operations (Nagara System) had the highest score out of the 15 practices highlighted in R&D, which means it was is implemented with higher level of commitment. However, it is noteworthy that the support for product customization has the highest score at 2.7.

TABLE 1: PRELIMINARY SUMMARIZED RESULTS ON 15 LEAN PRACTICES

Function	Percentage	Standard Deviation	Score
1. Reduce Set Up Time	**85%**	**0.60**	**1.94**
2. Work Standardization	**97%**	**0.61**	**1.71**
3. Implementation of Cellular Manufacturing Principles	**65%**	**0.59**	**2.09**
4. Performing Value Add Analysis to identify non-value activities	**83%**	**0.59**	**1.98**
5. Utilizing Poka Yoke	**78%**	**0.56**	**1.85**
6. Using TPM	**79%**	**0.67**	**2.00**
7. Cycle Time Reduction	**81%**	**0.60**	**1.82**
8. TQM	**88%**	**0.72**	**1.91**
9. Application of 5S Criteria	**73%**	**0.63**	**1.71**
10. Automation Usage	**48%**	**0.53**	**1.88**
11. Improving Production Scheduling	**80%**	**0.63**	**1.94**
12. Using visual controls to detect problems	**80%**	**0.63**	**1.72**
13. Using small Lot sizes	**63%**	**0.61**	**1.86**
14. Use of the integrated flow operations (also called Nagara System)	**33%**	**0.59**	**2.09**
15. Parts standardization	**74%**	**0.57**	**2.03**

TABLE 2: SUMMARIZED RESULTS ON LEAN PRACTICES BY JOB FUNCTION

Function	Quality	Manufacturing	R&D
1. Reduce Set Up Time	**1.40**	**1.92**	**2.14**
2. Work Standardization	**1.65**	**1.64**	**1.93**
3. Implementation of Cellular Manufacturing Principles	**2.22**	**2.07**	**2.28**
4. Performing Value Add Analysis to identify non-value activities	**1.92**	**1.93**	**2.07**
5. Utilizing Poka Yoke	**2.02**	**1.88**	**1.80**
6. Using TPM	**1.94**	**1.89**	**2.26**
7. Cycle Time Reduction	**1.69**	**1.80**	**2.13**
8. TQM	**1.87**	**1.90**	**1.83**
9. Application of 5S Criteria	**1.88**	**1.60**	**2.00**
10. Automation Usage	**1.96**	**1.83**	**1.92**
11. Improving Production Scheduling	**1.92**	**1.79**	**2.07**
12. Using visual controls to detect problems	**1.68**	**1.46**	**2.16**
13. Using small Lot sizes	**1.71**	**1.70**	**2.03**
14. Use of the integrated flow operations (also called Nagara System)	**2.08**	**1.77**	**2.42**
15. Parts standardization	**2.27**	**1.85**	**2.14**
16. Pull Flow System	**1.38**	**1.66**	**1.42**
17. Use of concurrent Engineering	**2.03**	**1.99**	**1.99**
18. Use of design for manufacturability (DFM) principles	**2.29**	**2.25**	**2.09**
19. Evaluating Suppliers	**1.64**	**1.67**	**1.92**
20. Evaluate total cost of using a supplier	**2.38**	**2.17**	**2.20**
21. Exchanging Information with supplier	**1.81**	**1.77**	**2.04**
22. create long-term relationships with suppliers,	**1.99**	**2.20**	**2.21**

23. Improve delivery performance	**1.64**	**1.60**	**1.92**
24. Stabilize demand	**1.78**	**1.96**	**1.95**
25. Provide services to enhance product value	**1.92**	**1.64**	**1.84**
26. Collects customer requirements information	**2.32**	**1.51**	**2.06**
27. Supports product customization	**2.70**	**1.78**	**1.97**
28. Develops multi-functional workers	**2.43**	**1.84**	**2.09**
29. Delegates decisions to the lowest level possible	**2.13**	**1.90**	**1.85**
30. Total Mean of Functions	**1.95**	**1.83**	**2.02**

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