Journal of Manufacturing Systems 34 (2015) 1–11

Contents lists available at ScienceDirect

Journal of Manufacturing Systems

journal homepage: www.elsevier.com/locate/jmansys

Technical Paper

Fuzzy logic based method to measure degree of lean activity in manufacturing industry

Anita Susilawati*, John Tan, David Bell, Mohammed Sarwar

Department of Mechanical & Construction Engineering, Faculty of Engineering and Environment, Northumbria University, Newcastle Upon Tyne NE1 8ST, United Kingdom

ARTICLE INFO

Article history:
Received 22 October 2012
Received in revised form 4 March 2014
Accepted 23 September 2014
Available online 25 October 2014

Keywords:
Fuzzy logic
Indonesian manufacturing industry
Lean manufacturing

ABSTRACT

Lean manufacturing is gaining popularity as an approach that can achieve significant performance improvement in the industry. However, the application of lean manufacturing is not an easy process. To reach the level of full implementation of lean manufacturing takes a long time and during that time the continuous improvement must be made. In the process of continuous improvement, lean manufacturing assessment is required. One form of assessment is to measure the degree of lean implementation. However, it is the complexity involved in the measure of degree of leanness. This complexity arises due to (a) the inherent multi-dimensional concept of leanness (b) unavailability manufacturing practice database that can be used as a benchmark in assessing the degree of leanness and (c) the necessity for the application of subjective human judgement on lean practices which involve vagueness and bias due to variation of evaluator's knowledge and experience. In this paper a method to deal with the multi-dimensional concept, unavailability benchmark and uncertainty, which arises from the subjective and vague human judgement for the measurement of degree of leanness, is proposed. The multi-dimensional concept involving a variety of components of lean practices is measured in order to arrive at a measure for the lean activity of a given organization. It is constructed from primary and secondary data involving a comprehensive literature review and validated with interviews with a set of sample organizations representing the entire spectrum of the industry. The vagueness of subjective human judgement on degree of application of lean practices is modelled by fuzzy number in conjunction with an additional consideration related to the length of lean practice implementation and the use of multi-evaluators. Value stream mapping is used in scoring the degree of implementation of lean so the use of benchmark is not necessary. Some results from an initial survey from a sample of respondents from the manufacturing industry in Indonesia are presented to illustrate the applicability and potential strength of the proposed method.

© 2014 The Society of Manufacturing Engineers. Published by Elsevier Ltd. All rights reserved.

1. Introduction

Lean manufacturing with its origin from the Toyota manufacturing system has received attention from practitioners and researchers since its introduction, an example is the well received book "The machine that changed the world" by Womack, Jones and Ross [1]. It should also be noted that the concept of lean manufacturing is not new as it can be traced back to the work of Deming [2], Taylor [3] and Skinner [4]. Recently, lean manufacturing has been widely applied in the manufacturing industry around the world and is considered as one of the most effective methods in improving operational efficiency [5–9]. The success of lean manufacturing can be attributed to its ability to attain and realize improved outputs with less resource in comparison to traditional manufacturing systems. The improvements are achieved by identifying and eliminating waste within a given manufacturing system. The main objective of lean manufacturing is to continuously reduce waste in human effort, inventory, time to market and manufacturing space so as to be responsive to customer demand while maintaining the quality of products [10].

To achieve the full implementation of lean manufacturing can take a long time and during that time a continuous improvement needs to be done. Continuous improvement is an ongoing process that consists of the assessment of current conditions and makes improvements for the future. One type of assessment that needs to be done on the application of lean manufacturing is an assessment of degree of implementation of lean manufacturing. The

* Corresponding author. Tel.: +44 191 227 3624.
E-mail addresses: anita_susilawati@yahoo.co.uk, anita.susilawati@northumbria.ac.uk (A. Susilawati).

http://dx.doi.org/10.1016/j.jmsy.2014.09.007
0278-6125/© 2014 The Society of Manufacturing Engineers. Published by Elsevier Ltd. All rights reserved.

assessment is necessary to determine the data related to the performance status of the current process, best practices and areas of improvement of lean activities.

So far, the measurement of degree of implementation of lean manufacturing does not get much attention from researchers. Among of researcher who published papers on this field are Doolen and Hacker [5], Bayou and Korvin [11], Soriano and Forrester [12], Singh et al. [13]. Soriano and Forrester [12] used data directly collected from questionnaires to measure two dependent and nine independent variables associated with leanness. The degree of adoption of lean practices was decided intuitively using seven tier score. Doolen and Hacker [5] also used data directly from questionnaires to measure six impact areas consisting of thirty lean practices. The degree of leanness was then measured simply by the average score given by respondents. They do not explain how the provision of the score on the application of lean practices. Doolen and Hacker have not considered the bias and vagueness of human perception in awarding score to lean application. In order to reduce vagueness of human perception Bayou and Korvin [11] used fuzzy number in stead of crisp value for the scoring. The degree of leanness is scored by compare the lean application with benchmark company. Singh et al. [13] measured the degree of leanness by using a score awarded by two or more evaluators in order to minimize the tendency to biasness. The score was then awarded incorporating factors such as history and goal of application of lean practice. Singh et al. [13] only involved few numbers of lean practices in their assessment.

In this work, a procedure for measuring degree of lean application which combine the advantage of the various procedures and improve the weakness of various procedures is proposed. The procedure measuring degree of lean application proposed in this work used fuzzy number for scoring degree of application of lean practices, use wide range of lean activity and scoring awarded to lean practices is based on value stream mapping instead of based on comparison to a benchmark. So that the difficulties to find a company data which can be used as a benchmark is avoided. This is also consideration of the years of application for lean practice in scoring of leanness degree. A survey sample from manufacturing industry in Indonesia is presented to address a real situation and to gauge the potential strengths and weaknesses of the proposed method. Currently, the application of modern engineering tools such as lean manufacturing in Indonesia is sporadic and these implementations are poorly documented. Hence this study also serves as a means to reveal the state of lean manufacturing in the Indonesian manufacturing sector, while reflecting local conditions and current business practices.

2. Literature review

2.1. Lean manufacturing activity

Lean manufacturing is a system with a systematic approach to eliminate waste (non-value added) in its form and enabling continuous improvement to satisfy the customers. According to Womack and Jones [14], waste can be associated with activities such as excess motion, waiting or time delay, defects, inappropriate processing, over production, excess inventory, transportation and lack of knowledge. Similarly, Lee [15] described waste/non-value added activities as those which involve excess motion, waiting, and defects, inappropriate processing, over production, excess inventory, transportation, under-utilisation of employees and waste of energy. The characteristics of lean manufacturing were identified by Carlson and Ahlstrom [16], Pham [17], Soriano and Forrester [12], as the variables of leanness, namely: elimination of waste, continuous improvement, zero defect, just-in-time delivery, pull of material, multi-functional teams, decentralization, integration of functions, vertical information systems and time to market and value adding operations.

A number of researchers have created assessment tools which allow the organization to measure their lean progress. Puvanasvaran et al. [18] mentioned the implementation of lean include the degree of leanness, management commitment, workers empowerment, quality leadership and group problem solving. Others, Wong et al. [19] assessed lean manufacturing implementation that based on 14 key areas of lean manufacturing namely: scheduling, inventory, material handling, equipment, work processes, quality, employees, layout, suppliers, customers, safety and ergonomics, product design, management and culture, tools and techniques. Detty and Yingling [20] categorized lean implementation by process stability, standardized work, level production, just in-time technique, quality at the source, visual control, production stop policy and continuous improvement. Some organization improvement activities were mentioned by Sohal and Egglestone [21], who divided lean manufacturing assessment into competitiveness, customer, quality, flexibility, production, performance, supplier, organization, inventory control, wastes and cycle times.

A number of survey studies have been conducted on lean manufacturing activities in both developed and developing countries. Table 1 outlines examples of survey research from developing countries in the last decade. In general, all survey indicated the lean manufacturing implementation have a positive impact areas for companies/organizations performance.

2.2. Fuzzy methods and its applications

The fuzzy method is a mathematical theory that allows ambiguity and vagueness to be modelled [34–36] through the use of fuzzy numbers. The fuzzy number is illustrated graphically in Fig. 1. The fuzzy methods have been implemented in many research and application areas such as economics, industries, manufacturing operations, production management, engineering, health sciences, natural sciences, mathematics, services, information and communication technologies [37–52]. Azadegana et al. [37] reviewed implementation of the fuzzy logic in manufacturing perspectives. They found that a little paper discussed the fuzzy methods in more detail and special implementation, especially in term of decision making for lean manufacturing.

In the lean manufacturing operations, the fuzzy methods are generally used in order to improve the performance of the manufacturing operations. Ko [38] applied the fuzzy membership function to eliminate production risk and imprecise product quantity. Gien et al. [39] used the fuzzy set approach to evaluate level of expectation of design quality in manufacturing systems. Yavuz [40] employed fuzzy logic for scheduling models of just in time and lean production. Chan et al. [41] developed a fuzzy membership function to select an alternative operation scheduling in flexible

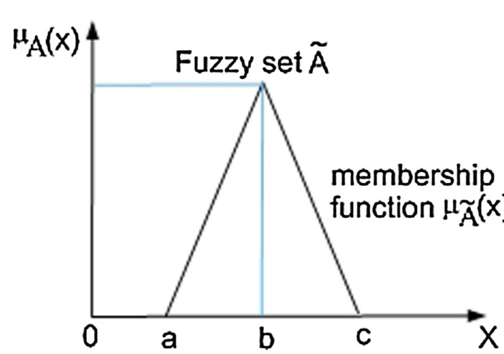

Fig. 1. Triangular membership function (Klir and Yuan [36]).

متن کامل مقاله ← دریافت فوری

ISIArticles
مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات