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Leanness assessment and optimization by fuzzy cognitive map and multivariate analysis

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ABSTRACT

The strategy of organizational lean production emphasizes on increasing efficiency, quality improvement and cycle time reduction by eliminating non-value added activities (MUDA). This paper presents a comprehensive approach based on data envelopment analysis (DEA), fuzzy DEA (FDEA), fuzzy cognitive map (FCM), Decision Making Trial and Evaluation Laboratory (DEMATEL) and Analytic Hierarchy Process (AHP) for evaluating and optimizing the leanness degree of organizations to survive in competitively growing market. In this regard, a comprehensive list of quantitative and qualitative leanness measures is extracted from the literature. The efficiency of organizations is assessed and optimized by DEA. A heuristic algorithm is proposed to obtain a full ranking of leanness levels of organizations. Accordingly, a sensitivity analysis is carried out to determine impact of each leanness factor on lean strategy. The approach has been found fruitful while applying for a number of packing and printing organizations, in Iran, as a case study. Apart from evaluating overall lean performance metric, the proposed approach can evaluate the impact degree of leanness factors on each other as well as the impact of leanness factors on lean strategy. The result show that production procedure among the leanness measures has the most impact on leanness strategy in the organizations under study. To the best of our knowledge, this is the first study that develops and implements an efficient decision-making procedural hierarchy to support leanness extent evaluation.

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Motivation and significance

To survive in today's competitive market, providing products and services with highest quality and lowest cost are the most important challenges. During the last years of World War II many approaches in different fields have been developed to achieve these aims. But one of the most common approaches in the past two decades that have paid much attention to these concerns, is the lean manufacturing approach (Lewis, 2000). Consequently these approaches can be utilized to evaluate a company's success level in implementing lean culture in comparison with other similar organizations. Nowadays, several techniques have been developed for this aim, but these techniques have shortcomings. In this paper, a novel approach is proposed to cope with these shortcomings. The shortcomings can be expressed in two areas: first, the proposed techniques are usually used for specific parts of organization; second, these methods are not quite systematic.

1. Introduction

Lean production is introduced by Womack (1990). In an integrated system, lean production is a multi-dimensional method that includes a widespread range of management practices like just-in-time (JIT) (Huson & Nanda, 1995), total quality management (TQM) (Andersson, Eriksson, & Torstensson, 2006), team working (Delbridge, Lowe, & Oliver, 2000), cellular manufacturing (Singh, Garg, & Sharma, 2010), supplier involvement (MacDuffie & Helper, 1997). In fact, in all industries, there is a hidden factory that produces defective parts. Modifying processes of this factory reduces costs of system (Miller & Vollmann, 1985).

In this context, fourteen principles of Toyota associated with lean manufacturing are commonly used (Morgan & Liker, 2006). According to these principles wastes is classified into three groups: MUDA, MURI and MORA (Rinehart, 1997). MUDA refers to those activities of processes that do not add value (Waste). MURI refers to any variation leading to unbalanced situations (unevenness). MORA refers to all activities asking material, employees or equipment for irrational stress or effort (overburden). The elimination of MUDA (waste) in lean manufacturing has special effects on the performance of different industries (Rother & Shook, 2003). There

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