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Lean manufacturing: context, practice bundles, and performance

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Abstract

Management literature has suggested that contextual factors may present strong inertial forces within organizations that inhibit implementations that appear technically rational [R.R. Nelson, S.G. Winter, An Evolutionary Theory of Economic Change, Harvard University Press, Cambridge, MA, 1982]. This paper examines the effects of three contextual factors, plant size, plant age and unionization status, on the likelihood of implementing 22 manufacturing practices that are key facets of lean production systems. Further, we postulate four "bundles" of inter-related and internally consistent practices; these are just-in-time (JIT), total quality management (TQM), total preventive maintenance (TPM), and human resource management (HRM). We empirically validate our bundles and investigate their effects on operational performance. The study sample uses data from *IndustryWeek*'s Census of Manufacturers. The evidence provides strong support for the influence of plant size on lean implementation, whereas the influence of unionization and plant age is less pervasive than conventional wisdom suggests. The results also indicate that lean bundles contribute substantially to the operating performance of plants, and explain about 23% of the variation in operational performance after accounting for the effects of industry and contextual factors.

Keywords: Contextual factors; Lean manufacturing practices; Lean bundles; Operational performance

1. Introduction

Heightened challenges from global competitors during the past 2 decades have prompted many US manufacturing firms to adopt new manufacturing approaches (Hall, 1987; Meredith and McTavish, 1992). Particularly salient among these is the concept of lean production (Womack and Jones, 1996; Womack et al., 1990). Lean production is a multi-dimensional approach that encompasses a wide variety of management practices, including just-in-time, quality systems, work teams, cellular manufacturing, supplier management, etc. in an integrated system. The core thrust of lean production is that these practices can work synergistically to create a streamlined, high quality system that produces finished products at the pace of customer demand with little or no waste. Anecdotal evidence suggests that several organizational factors may enable or inhibit the implementation of lean practices among manufacturing plants. With the notable exception of White et al. (1999), there is relatively little published empirical evidence about the implementation of lean practices and the factors that may influence implementation.

A majority of articles on the topic of lean production system focus on the relationship between implementation of lean and performance. While most of these studies have focused on a single aspect of

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lean and its performance implications (e.g. Hackman and Wageman, 1995; Samson and Terziovski, 1999; McKone et al., 2001), a few studies have explored the implementation and performance relationship with two aspects of lean (e.g. Flynn et al., 1995; McKone et al., 2001). Even fewer studies have investigated the simultaneous synergistic effects of multiple aspects of lean implementation and performance implication. A noteworthy exception is Cua et al.'s (2001) investigation of implementation of practices related to just-in-time (JIT), total quality management (TQM), and total preventive maintenance (TPM) programs and their impact on operational performance. However, conceptual research continues to stress the importance of empirically examining the effect of multiple dimensions of lean production programs simultaneously.

We examine the relationship between contextual factors and extent of implementation of a number of manufacturing practices that are key facets of lean systems. These contextual factors have been suggested as possible impediments to implementing lean production systems. Specifically, we focus on three contextual factors, plant size, plant age, and extent of unionization. Further, we extend Osterman (1994) and MacDuffie's (1995) notion of "bundles" from human resource practices to a larger set of manufacturing practices. Specifically, we postulate four "bundles" of inter-related and internally consistent practices; these are just-in-time (JIT), total quality management (TQM), total preventive maintenance (TPM), and human resource management (HRM). We empirically validate our bundles and further investigate their simultaneous and synergistic effects on operational performance.

2. Literature and propositions

2.1. Lean practices and lean bundles

In the last several years, scholarly journals have published a number of articles that focus on the content of lean production or comprise of case studies that concentrate on individual firm experiences. A review of this literature reveals a number of manufacturing practices that are commonly associated with lean production. Table 1 summarizes our review by cross-listing key practices identified with references.

Table 1 links substantive literature on high performance, lean manufacturing with each of the lean practices addressed in our research. As can be seen, there is varying degree of frequency that each of the items selected is considered in the studies reviewed. JIT/continuous flow production and quick changeover methods are included most frequently, while safety improvement methods are referenced least frequently in the literature. The practices shown in Table 1 emerge from a fairly extensive literature review and provide a representative view of the components comprising lean production. Our discussion and measurement of lean production is necessarily related to the manufacturing practices that are commonly observed in the literature describing high performance, lean manufacturers. This literature is also rich with descriptions of values and philosophy associated with lean production that are less readily measured than practices. For example, lean production philosophy focuses on avoiding seven cardinal wastes and on respecting customers, employees and suppliers (Schonberger, 1986). Although we do not directly address such philosophical positions, we recognize that they are important and believe that they are reflected in the implementation of the lean practices that we do address.

There are multiple ways to combine the individual practices to represent the multi-dimensional nature of lean manufacturing. In combining these practices, the researcher has to contend with the method used to combine and the actual content of the combinations. The dominant method in operations management literature has been to use exploratory or confirmatory factor analysis to combine individual practices in a multiplicative function to form orthogonal and unidimensional factors (Flynn et al., 1995; Cua et al., 2001). A review of research from organization theory, and labor and human resource management shows less reliance on factor analysis and offers multiple ways for combining individual practices and creating an index. One such method is the additive index used by Osterman (1994) and MacDuffie (1995) in developing "bundles" of inter-related human resource management practices. We used the additive index method for developing our lean bundles.

There is general agreement within operations management literature that just-in-time (JIT), total preventive maintenance (TPM), total quality management