Journal of Operations Management 29 (2011) 356–369

Contents lists available at ScienceDirect

Journal of Operations Management

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

Lean, leaner, too lean? The inventory-performance link revisited

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ARTICLE INFO

Article history:
Received 3 November 2009
Received in revised form 18 May 2010
Accepted 18 May 2010
Available online 27 May 2010

Keywords:
Inventory management
Financial/economic analysis
Lean manufacturing
Empirical research methods

ABSTRACT

While firms increasingly adopt lean inventory practices, there is limited evidence that inventory leanness leads to improved firm performance. This study reexamines this relationship in an attempt to overcome some shortcomings of previous research. To that end, a theory-based measure of inventory leanness, which takes into account industry-specific inventory management characteristics, is proposed. The analysis of a large panel data set of U.S. manufacturing companies reveals that the significance and shape of the inventory–performance relationship varies substantially across industries. This relationship is significant in two-thirds of the 54 industries studied. In most of these instances, the relationship is concave, suggesting that there is an optimum level of inventory leanness beyond which firm performance deteriorates. A post-hoc analysis is conducted to identify industry-level characteristics that may determine the nature the inventory–performance relationship. Managerial implications are discussed and several opportunities for future research are outlined.

1. Introduction

The lean production philosophy considers inventory a form of waste that should be minimized (Womack et al., 1990). In recent decades, as lean production has gained widespread adoption (IndustryWeek, 2008), lean inventory management has become synonymous with good inventory management (Hall, 1983; Zipkin, 1991; Chen et al., 2005; Cooper and Maskell, 2008). As a result, inventories have been decreasing in many industries (Chen et al., 2005, 2007). Yet evidence of improved firm performance is mixed (Rumyantsev and Netessine, 2007). The purpose of this research is to investigate the effect of inventory leanness on firm performance by analyzing empirical data from the U.S. manufacturing industry.

Specifically, this study aims to contribute to existing research on three accounts: first, the effect of inventory leanness on firm performance is explored on an industry-by-industry basis. The advantage of this approach is that it controls for industry-specific characteristics that may lead to different types of relationships between inventory leanness and firm performance in various industries. When data from multiple industries are pooled, as is the case in most previous studies, the dissimilar functional forms present in these industries may mask each other and yield insignificant estimation results. Hence, the analysis of data by narrowly defined industries creates a more comprehensive understanding of the relationship between inventory leanness and firm performance.

Second, the functional form of this relationship is explored. While previous empirical studies have assumed a linear relationship only, the use of a more flexible functional form affords a richer perspective on the inventory–performance relationship. For example, there may be industries in which inventory leanness increases firm performance up to a certain point beyond which the incremental effect becomes negative.

Third, an alternative measure of inventory leanness, the Empirical Leanness Indicator (ELI), is proposed. The distinguishing feature of the ELI, as compared to previously used measures, is that it takes into account the nonlinear relationship between firm size and inventory holdings. Prior research has often relied on metrics such as inventory turnover (Schonberger, 2007; Gaur et al., 2005) and average inventory levels (King and Lenox, 2001) to gauge inventory leanness. These measures ignore the effect of firm size on inventory holdings, i.e. economies of scale in inventory management, and can lead to bias in estimation results. Drawing on inventory theory, the ELI estimates a firm's inventory leanness relative to industry-specific norms and takes into account economies of scale. Subsequently, the ELI and conventional inventory leanness measures are compared in terms of their explanatory power in describing the relationship between inventory leanness and firm performance.

The analyses of data from a large set of publicly traded U.S. manufacturing firms presented here provide detailed insights into the linkages between inventory leanness and firm performance, thereby contributing to both inventory theory and the theory of lean production. From a practical perspective, managers can use the methodology presented here as a new technique to benchmark their operational performance.

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doi:10.1016/j.jom.2010.05.002

Table 1
Overview of survey-based studies on lean production and firm performance.

Study	Sample or data source	Dependent variable	Independent variable	Methodology	Results
Inman and Mehra (1992)	U.S. manufacturing firms adopting JIT (N = 114)	ROI, service, total cost	Lean production factors	Regression analysis	Lean production implementation benefits firm performance
White (1993)	Manufacturing and service firms (N = 1035)	Net benefit	Lean production adoption	Percentage breakdown	Most respondents consider lean production a net benefit to organization
Norris et al. (1994)	Plant managers operating under JIT (N = 48)	Plant performance	Lean production adoption	Percentage breakdown	Respondents report positive views on plant performance, e.g. plant efficiency, value added, etc
Callen et al. (2000)	Canadian manufacturing plants (N = 100)	Profitability, total costs	Lean production adoption	Regression analysis	Plants using lean production are more profitable and have lower total costs
Fullerton and McWatters (2001)	U.S. manufacturers adopting JIT (N = 95)	Profitability improvement	Lean production practice scales	ANOVA	Firms scoring higher on lean production-quality factor experience greater profitability improvement
Cua et al. (2001)	Manufacturers adopting JIT (N = 163)	JIT practices	Plant performance	Discriminant analysis	Categorizing plants as high or low performers, differences in lean production practice adoption is tested
Shah and Ward (2003)	Manufacturing plants (N = 1575)	Plant performance	Lean production practice bundles	Regression analysis	Lean production practice bundles have a positive effect on plant performance
Fullerton et al. (2003)	Manufacturing firms (N = 253)	Profitability, ROA, cash flow margin	Lean production practice bundles	Regression analysis	Three lean production practice factors have a positive effect on firm performance
Jayaram et al. (2008)	Auto parts manufacturers (N = 57)	Profitability, ROA	Lean production	SEM	No significant effect of lean production on firm performance

The remainder of this paper is organized as follows: In Section 2, the relevant literature is reviewed. Research hypotheses are presented in Section 3. The definition and measurement of inventory leanness, a central concept in this study, are discussed in Section 4. Other variables of interest and data collection procedures are outlined in Section 5. The results of the empirical analysis are presented in Section 6, and a discussion of various post-hoc analyses is provided in Section 7. The paper concludes with a summary of the study's results, and a discussion of limitations and future research prospects in Section 8.

2. Literature review

Lean production can be described as a strategy or philosophy that relies on a set of practices (e.g. Kanban, total quality management, etc.) to minimize waste (e.g. excess inventories, scrap, rework, etc.) in order to improve firm performance (Womack et al., 1990). In other words, the implementation of lean production practices is expected to result in improved operational outcomes such as inventory leanness, which, in turn, should enhance firm performance. There is, thus, a natural linkage between the broader concept of lean production and inventory leanness. While the latter is the focus of this research, this literature review also includes prior research on the linkage between lean production and firm performance outcomes.

The effects of lean production on firm performance have been studied since the 1980s when U.S. manufacturers first started adopting lean practices (Young and Selto, 1991). However, early evidence was mostly anecdotal in nature with limited generalizability (Inman and Mehra, 1992; Huson and Nanda, 1995). Starting in the 1990s, researchers have explored this relationship in more rigorous ways and three research streams have emerged. The first stream consists of survey-based studies exploring the relationship between lean production practices and firm performance. In the second stream, researchers conceptualize lean production implementation as a dichotomous variable and explore its effects on firm performance. The third stream focuses on the analysis of the relationship between inventory leanness, a presumed outcome of the implementation of lean practices, and firm performance. Each of these streams is discussed in more detail below.

2.1. Stream 1: studies on lean practices and firm performance

The first stream of research uses survey data to explore the effects of lean production practices on firm performance (Table 1). Lean production is typically conceptualized as a multi-dimensional construct composed of multiple lean practices such as total quality control, total productive maintenance, and just-in-time (White, 1993; Fullerton and McWatters, 2001; Cua et al., 2001; Shah and Ward, 2003). Prior studies not only indicate that these practices are widely implemented (White, 1993), but also present evidence that their implementation results in improved operational performance in terms inventory management, process control, information flows, human factors, delivery, flexibility and quality (Norris et al., 1994; Fullerton and McWatters, 2001; Cua et al., 2001). Moreover, multiple studies find that financial performance is positively affected by the implementation of lean production practices (Inman and Mehra, 1992; White, 1993; Callen et al., 2000; Fullerton and McWatters, 2001; Fullerton et al., 2003). Jayaram et al. (2008), however, find no significant effects of lean production on firm performance (profitability and ROA).

While most of the survey-based studies on lean production present at least some evidence of a positive impact of lean production practices on firm performance, there are several common weaknesses among these studies. First, nearly all of them rely on subjective assessments of firm performance in addition to subjective evaluations of lean production. This approach may introduce systematic measurement error resulting in biased estimation results (Podsakoff et al., 2003). Second, none of these studies take into account the endogeneity in their data sets (Huson and