

Financial Analysis of a Theoretical Lean Manufacturing Implementation Using Hybrid Simulation Modeling

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Abstract

Many researchers have identified the negative impact that accounting methods have on reported profits as inventories are being rapidly reduced. This research explores the magnitude and duration of the negative impact on reported profits experienced during a lean manufacturing implementation.

The effect on reported profit is evaluated under five accounting methods (full absorption costing, activity-based costing, direct costing, throughput costing, and order activity costing) and three levels of inventory reduction rate. The findings reported here indicate that the period-by-period gains in operational efficiency, resulting from process improvements brought by a lean program, will not counteract the negative impact from the accounting system on the income statement while inventories continue to be reduced. This could lead to the early termination of a lean program that is, in fact, bringing operational improvement in the present time, but the improvement is being erased by poor inventory control practices from past periods.

This research uses a multi-period simulation model of a production operation that incorporates a manufacturing planning and inventory tracking system. A hybrid simulation approach is employed using Microsoft® Excel to model the Manufacturing Resource Planning (MRPII) function, while ProModel simulation software is used for the development and operation of the model production environment. Microsoft® Visual Basic® is used to create a bridge between systems for schedule dissemination and inventory updates. The integrated computer simulation modeling approach developed to conduct this research is novel in the sense that multi-period simulation, incorporating MRP, has not been widely used based on available literature.

Keywords: *Multi-Period Manufacturing Simulation, Hybrid Simulation, Lean Manufacturing, Cost Accounting Methods, Integrated Manufacturing Model, Manufacturing Process Model*

Introduction

This research addresses an important and little publicized issue related to lean manufacturing programs—that of the negative impact to reported profit resulting from a depletion in on-hand inventory levels. Currently, quantitative studies describing the impact of this issue are difficult to locate. This research offers some tangible guidelines that could assist lean managers in avoiding resistance from top management and the finance team when reported profits fall.

The rate of reduction of inventory has a significant effect on the reported financial results of the firm. This is primarily due to the movement, on paper, of assets. Using the concept of cost attachment, a business essentially stores the manufacturing costs of finished goods inventory produced in excess of what is needed in the current period. The labor, material, and factory overhead costs are virtually moved to the balance sheet where they are recognized as an asset. Physically, the product is stored in a warehouse facility until disposed of. These costs are not included in the current period's income statement; instead, they are recognized in a future period when they are removed from inventory, either as a result of a sale or as a result of being scrapped as obsolete or otherwise unacceptable inventory.

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Methods employed by the accounting profession, developed over the past 100 years, have resulted in misleading information being used by operations for the purpose of performance appraisal and decision support (Scott 1931; Elnicki 1971; Chandler 1977; Johnson and Kaplan 1987; Kaplan 1994; Cooper and Kaplan 1988; Lere 2001). This research focuses on the quantification of the impact of those methods on net profit resulting from a lean manufacturing implementation, during the period when inventories are being rapidly reduced. Accounting methods, and more specifically the practice of cost attachment, lead to a perceived reduction in operational performance as measured by net profit when inventories are reduced. In addition to reducing labor, shortening delivery lead times, and reducing physical plant space requirements, a successful lean manufacturing implementation will undoubtedly lower all inventories, i.e., raw, WIP, and finished goods (Sugimori et al. 1977; Schonberger 1982; Wantuck 1989; Fullerton and McWatters 2001; Shah and Ward 2003; Womack and Jones 2003). As a result, the lean manufacturing program may be mistakenly viewed as a failure in the early stages of implementation (Womack and Jones 2003; Cunningham and Fiume 2003; Solomon 2003). The more successful the implementation is, the more rapid the reduction rate will be. Rate of reduction, as shown by this research, has a profound impact on the resulting reported net profit.

Various accounting methods are characterized by the inclusion or exclusion of various cost components in the development of a product cost, such as labor, materials, and overhead, and the base upon which overhead costs are distributed. Many researchers are in agreement on the distortions that can be created through the use of an inappropriate allocation base such as direct labor, direct materials, plant square footage, etc. (Hartley 1983; Johnson and Kaplan 1987; Garrison and Noreen 1994; Horngren 1995; Drury and Tayles 1997). In this research, several accounting methods are evaluated. These methods include the traditionally most popular method of full absorption (Cooper and Kaplan 1988) being used by more than 60% of industrial firms. Also studied are direct costing, activity-based costing (ABC), throughput costing (Goldratt and Cox 1992), as well as a new approach of order activity costing (Meade 2004). Order activity costing is similar to ABC in the sense that it uses resource activity level as the measure to determine the amount of overhead cost

to apply to a given product. Order activity costing uses the annual production quantity of a given product and the total number of production orders required to produce that quantity to determine the overhead proportion for each unit of production. The advantage of order activity costing is that the information necessary to determine the overhead allocation is information that is kept electronically in the production order system. This allows the system to be self-maintaining over time. This is in contrast to ABC, which requires continuous, manual updating to remain accurate (Nachtmann and Needy 2003).

The concepts of lean manufacturing are represented in this research through the lean attribute of shrinking inventories. The simulation model used to generate the data for this research represented a post-cellular manufacturing implementation environment, representing one scenario a company might follow when implementing lean strategies. The purpose of the simulation model was to provide a valid representation of a real-world manufacturing environment that would provide the critical information of production output on a month-by-month basis necessary to develop the series of income statements, one for each accounting method. The simulation model reflected the improved responsiveness to customer demand, which is the result of a reduced manufacturing lead time. This operational improvement subsequently allowed the lowering of finished goods inventory levels over a series of simulated months. This paper details the methods and tools employed in the development of a model manufacturing operation that will be used to answer the following research questions.

Research Questions

- Q1: Within a given management accounting method, does the rate of inventory reduction have an influence on reported net profit?
- Q2: Within a given inventory reduction policy, does the management accounting method have an influence on reported net profit?
- Q3: Do various combinations of inventory reduction policy and management accounting method have an influence on reported net profit?
- Q4: Does the inventory reduction policy have an influence on the customer service level, measured by stock-outs, under the production and market environment modeled in this study?

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