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Agile manufacturing: Relation to JIT, operational performance and firm performance

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ABSTRACT

A structural model incorporating agile manufacturing as the focal construct is theorized and tested. The model includes the primary components of JIT (JIT-purchasing and JIT-production) as antecedents and operational performance and firm performance as consequences to agile manufacturing. Using data collected from production and operations managers working for large U.S. manufacturers, the model is assessed following a structural equation modeling methodology. The results indicate that JIT-purchasing has a direct positive relationship with agile manufacturing while the positive relationship between JIT-production and agile manufacturing is mediated by JIT-purchasing. The results also indicate that agile manufacturing has a direct positive relationship with the operational performance of the firm, that the operational performance of the firm has a direct positive relationship with the marketing performance of the firm, and that the positive relationship between the operational performance of the firm and the financial performance of the firm is mediated by the marketing performance of the firm.

1. Introduction

Competitive pressures force manufacturers to continuously improve the provision of products and associated services desired by customers. Manufacturers have adopted lean practices such as JIT and TQM to reduce costs and improve quality. As many competitors adopted these practices, some competitive advantage was lost. Many manufacturers now have begun adopting practices that increase their ability to rapidly respond to changes in customer demand. For these, superior responsiveness has become a key to competitive advantage. In short, many manufacturing firms are becoming relatively more agile.

We propose that an element of lean manufacturing, Just-in-Time (JIT), is related to agile manufacturing. Specifically, we propose that the primary elements of JIT, i.e., JIT-production and JIT-purchasing, are related to agility. Further we investigate the relationship between manufacturing agility and operational and firm performance.

We conducted a national survey of production and operations managers working for large U.S. manufacturing concerns to collect data necessary to assess the model using a structural equation methodology. A review of the literature and discussion of the study hypotheses follow in the next section. A discussion of the specific methodology employed is followed by a description of the results of the scale assessment and the structural equation modeling results. Finally, a conclusions section, which incorporates discussions of the contributions of the study, limitations of the study, suggestions for future related research, and implications for practicing managers, is provided.

2. Literature review and hypotheses

Shah and Ward (2003) identify JIT as one of four "bundles" that make up lean manufacturing. Given that JIT is an element of lean manufacturing, discussion of the literature relating lean manufacturing to agile manufacturing is relevant even though the current study focuses on the relationship between JIT and agile manufacturing. Hence, the following section provides a review of the literature for both the JIT/agile relationship and the lean/agile relationship.

2.1. JIT and agile manufacturing

Specific to our research is the relationship between agile manufacturing and the Just-in-Time (JIT) manufacturing strategy.

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Countless research regarding JIT and its individual elements has been generated in the last three decades. Claycomb et al. (1999b) state that "in its ideal form, JIT integrates the entire supply chain's marketing, distribution, customer service, purchasing, and production functions into one controlled process." In an early work regarding JIT implementation, Mehra and Inman (1992) identified four elements of JIT: JIT-production strategy, JIT vendor strategy (purchasing), JIT education strategy and management commitment. Only JIT-production and JIT vendor strategies were found to have a significant impact on JIT implementation success. Since that time a number of published articles have at least partially supported these findings. In more recent work Shah and Ward (2003) identify four "bundles" of lean production: Just-In-time (JIT), Total Quality Management (TQM), Total Preventive Maintenance (TPM) and Human Resource Management (HRM). In a 2007 paper Shah and Ward propose and test 10 dimensions that can be used to measure these four "bundles" of lean production. Six of the 10 dimensions are elements of JIT with three pertaining to supplier aspects of JIT (purchasing) and three related to aspects of JIT-production. Therefore, while a number of JIT elements have been identified, two, JIT-production and JIT-purchasing, seem to garner the most support for their criticality to organization success. As a result, we limit our work here to these two primary elements of JIT.

We define JIT as a comprehensive strategy that combines the primary tactical elements of JIT-production and JIT-purchasing, to eliminate waste and optimally utilize resources throughout the supply chain (Claycomb et al., 1999b). JIT-production focuses on the identification and elimination of all forms of waste, including excess inventories, material movements, production steps, scrap losses, rejects and rework, within the production function (Wisner et al., 2005; Brox and Fader, 2002). JIT-purchasing is operationalized by Freeland (1991) as a "set of techniques and concepts for eliminating waste and inefficiency in the purchasing process." Techniques and concepts associated with JIT-purchasing include daily delivery of small lot sizes from nearby vendors, shared information, supplier education, reduced inspection and early supplier involvement in product/process design. The techniques utilized by JIT-production and JIT-purchasing allow firms to translate the resulting capabilities into a JIT strategy that provides organizational capabilities to deliver near zero defect quality, near zero variance quantity and precise on-time delivery (Green and Inman, 2005).

The key word applicable to the definition of both primary elements of JIT is "waste." This is consistent with Shah and Ward's (2007) definition of lean production as an integrated socio-technical system with the main objective of reducing or eliminating internal, customer, and supplier waste. Since JIT is a subset (bundle) of lean, we narrow our definition to the following: JIT is that subset of lean associated primarily with the elimination of waste through planning, scheduling and sequencing of operations. This definition of JIT subsumes both primary elements of JIT, JIT-purchasing and JIT-production, as elements of itself that are distinguishable from each other by where they occur in the system or supply chain.

2.2. Lean manufacturing and agile manufacturing

There has been a tendency to view the development of lean manufacturing and agile manufacturing either in a progression or in isolation (Gunasekaran, 1999a). From an isolation standpoint, Harrison (1997) notes that companies with a lean mindset would find the agile manufacturing concept difficult to follow. Krishnamurthy and Yauch (2007) state that there are "three general positions with respect to lean and agile: those who believe that they are mutually exclusive or *distinct concepts that cannot co-exist*, those who believe that they are *mutually supportive* strategies, and those who believe that leanness must be a *precursor* to agility." Table 1 summarizes the literature supporting each of the three views.

2.2.1. Lean and agile as mutually exclusive concepts

Early concerns that the two concepts cannot co-exist were expressed by Richards (1996), who noted that some agile proponents claimed that flexibility would suffer under lean production and from Harrison (1997) who expressed doubts that lean and agile were compatible while emphasizing that agile implied more resources, not fewer. More recently, Goldsby et al. (2006) note that lean and agile are often pitted as opposing paradigms.

Agility has been recognized as a manufacturing strategy consisting of manufacturing tasks and choices (Gunasekaran et al., 2008). The word "choices" implies that tradeoffs are necessary between lean and agile (Harrison, 1997) or that they cannot completely co-exist. While both strategies address the same competitive priorities (cost, quality, service, flexibility), they each emphasize different elements (Narasimhan et al., 2006) such that clear dividing lines can be drawn between the two (Gunasekaran et al., 2008). Some would state that lean manufacturing subordinates responsiveness (service) to efficiency and productivity (cost) (Vazquez-Bustelo et al., 2007) while agile manufacturing focuses on speed and flexibility and not cost (Gunasekaran et al., 2008). One may consider lean's market winner as cost (Christopher and Towill, 2001) and agile's market winners as speed, flexibility and responsiveness to changes (Zhang and Sharifi, 2007), i.e., service level (Mason-Jones et al., 2000). This is consistent with Narasimhan's et al. (2006) empirical study that found agile plants to meet/exceed lean plants and other plants in all measured performance dimensions with the exception of cost efficiency. Hence, tradeoffs that would prevent lean/agile co-existence can be easily envisioned. Larger lot sizes and higher inventory levels could be necessary to maintain the higher service level required by agile firms while smaller lot sizes and lower inventory levels could be required by cost-efficient lean firms.

It should be noted that there is a stream of thought that advocates the simultaneous use of lean manufacturing and agile manufacturing. Termed "leagile," proponents believe that manufacturing systems can consist of both lean and agile, acting together to "exploit market opportunities in a cost-efficient manner" (Krishnamurthy and Yauch, 2007). However, this appears to be appropriate only for supply chains, not individual manufacturing firms unless the firm is a multi-unit enterprise that functions as a supply chain. Leagile models created thus far contain a decoupling point that separates the lean and agile portions of the system (Krishnamurthy and Yauch, 2007) with the lean portion on the upstream side of the point and the agile portion of the system on the downstream side (Mason-Jones et al., 2000). Krishnamurthy and Yauch (2007) state that this decoupling point *ensures* that lean and agile *do not co-exist*, lending credence to the idea that the two are mutually exclusive within a single manufacturing entity, although both may exist within a supply chain.

From the literature, one can glean that both lean and agile have obtained desired results in isolation and that neither is better nor worse than the other (Naylor et al., 1999). This would imply that either could be used successfully depending upon the individual firm's environment. Specifically, lean manufacturing is appropriate when market conditions are basically stable, demand is smooth and standard products are produced and agile manufacturing is appropriate when the environment is more turbulent and more product variety is present (Vazquez-Bustelo et al., 2007; Naylor et al., 1999). The degree of turbulence in the environment determines the degree of agility needed (Vazquez-Bustelo et al., 2007; Sharifi and Zhang, 2001; Zhang and Sharifi, 2000). Though not stated within the literature, the same could hold true for lean. The degree of stability dictates the degree of leanness required to effectively compete. Consistent with the above, Goldsby et al. (2006) found, via simulation, that a lean strategy resulted in the lowest cost/highest service when demand was smooth and predicted with a high degree of accuracy coupled with low-value finished goods