A STUDY ON INVENTORY MANAGEMENT IN LEAN MANUFACTURING

A THESIS

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Abstract

The relentless pursuit of manufacturing efficiency has led to the widespread adoption of lean practices, particularly emphasizing Just-in-Time (JIT) inventory systems. While these approaches have enhanced performance by reducing waste and streamlining operations, recent global shocks, such as the COVID-19 pandemic, have exposed the limitations of lean practices in responding to a rapidly changing environment. Firms, having prioritized leanness, now grapple with the challenges of robustness, resilience, and flexibility (Helper & Soltas, 2021).

This dissertation addresses the evolving landscape by exploring the influence of operational performance, external environment, and supply chain partners on the outcomes of lean initiatives. The study focuses specifically on lean inventory or JIT practices within manufacturing firms, concentrating on inventory management. Two essays within this dissertation provide distinct perspectives on lean inventory: one scrutinizes its impact at the firm level, while the other examines its influence throughout the supply chain.

The first essay investigates the mediating role of operational performance, precisely production efficiency, and the moderating effect of external environmental conditions on the relationship between lean inventory and firm performance. Empirical analysis, using moderated mediation and fixed-effect models on US manufacturing firms' data from 2005-2021, reveals that the association of lean inventory with financial performance is partially mediated through enhanced production efficiency. Moreover, the mediation effects are weaker in low-munificence environments, cautioning against over-reliance on lean practices during uncertain conditions.

In the second essay, the focus shifts to the challenges of managing the inbound supply chain for JIT manufacturers. Addressing the complexities of JIT inbound logistics, the essay introduces a Production Routing Problem (PRP) model to optimize production quantities,

vehicle selection, and route planning. The study contributes by extending the traditional production routing model to accommodate JIT scenarios, providing insights into efficient inbound logistics systems.

Overall, this dissertation contributes to understanding the nuanced influence of lean practices in real-world manufacturing settings. The unintended consequences of lean practices are explored, emphasizing the need for a thoughtful and context-specific approach to their adoption. The study provides valuable insights for managers across the operational, supply chain, and strategic domains, urging a comprehensive evaluation of internal and external factors before implementing lean practices. By carefully considering these factors, firms can navigate the complexities and intricacies of lean practices to achieve their operational, financial, and environmental objectives.

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List of Abbreviations

ELI – Empirical Leanness Inventory

ELISQ- Empirical Leanness inventory square

DEA- Data envelopment analysis

DEACCR- Efficiency scores using CCR model

DEABCC- Efficiency scores using BCC model

DEABCCBOOT- Efficiency scores using Bootstrapping model

ROA- Return on assets

SG- Sales growth

LV- Leverage

SINT- Selling intensity

ATAN- Asset tangibility

RINT- R&D intensity

R&D- Research and Development

CI- Confidence interval

FE- Fixed effect

EM- Environmental munificence

NAICS- North American Industry Classification System

BLS- Bureau of Labor Statistic

EBIT- earnings before interest and taxes

CEQ- Book value of common equity

AT- Total Assets

CSHO- Common Shares Outstanding

PRCC_F- Closing Price (annual, fiscal)

WARDS- Warton Research Data Services

DMUS- Decision making units.

PPI- Producer Price Index

VIF- Variance Inflation Factors

FP- Financial performance

PE- Production efficiency

JIT- Just in time

PRP- Production routing Problem

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Summary

The primary focus of this thesis is to explore the adoption and impact of lean practices within the manufacturing industry, emphasizing the significance of internal and external firm environments in achieving optimal results. Lean practices are highly beneficial for manufacturing firms regarding efficiency and cost-effectiveness, but operational managers often require a deeper understanding of selecting, implementing, and leveraging these practices. They must comprehend which lean practices are most suitable for implementing them and how they can transform their manufacturing environments positively.

This research underscores the role of both internal and external firm environments. The internal environment, including factors such as firm size and managerial capability, plays a pivotal role in selecting and successfully implementing lean practices. It enhances a firm's ability to utilize resources efficiently. Simultaneously, the external environment provides essential resources and stability to support a lean working environment. This combination of internal and external factors is vital to the success of lean practices in manufacturing firms.

Given the importance of internal and external firm environments in the success of adopting lean practices, the goal of this dissertation is to expand existing scholarly knowledge on the relationship between lean practices and performance. The first study of this dissertation investigates the impact of lean inventory on the financial performance of the United States manufacturing industry. It highlights the potential benefits of improving production efficiency through the adoption of lean inventory practices. However, the study also unveils a critical factor: the significance of external environmental conditions. When the external environment is favorable, there may be better strategies for manufacturing firms than implementing lean practices. This is particularly true in situations where external environmental munificence is low. Environmental munificence refers to abundant resources and favorable conditions

supporting firm growth. A low level of munificence disrupts the supply chain structure, making it challenging for firms to access the resources needed to sustain a lean manufacturing environment. The lack of resources can lead to operational challenges that affect the bottom line. In essence, achieving the goals and objectives of lean practices requires an optimal level of external environmental munificence.

The second study delves into the challenges of managing the inbound supply chain for Just-in-Time (JIT) manufacturers. JIT is a production strategy focusing on delivering materials to the manufacturing plant precisely when needed, minimizing stockpiling. This approach reduces inventory costs and enhances efficiency but necessitates a well-coordinated and efficient inbound supply chain. To address these challenges, the study proposes an "integrated production routing model" designed to optimize delivery routes and production schedules for suppliers. The aim is to minimize the cost and environmental impact of inbound shipments while ensuring the manufacturing plant receives materials on time. The model offers several advantages, including reducing the burden on suppliers through improved production and shipment planning, enhancing the firm-supplier relationship, and reducing overall costs. Additionally, it considers environmental considerations, such as carbon emissions, by optimizing delivery routes and schedules.

This dissertation's Study One and Two are interconnected yet distinct in their scopes and methodologies. Study one primarily focuses on examining lean practices at the firm level, specifically investigating the impact of lean inventory management on financial performance. It takes an empirical approach, leveraging real-world data to draw insights into how internal firm environments and external factors influence the impact of lean practices. On the other hand, study two operates at the supply chain level, delving into the complexities of Just-in-Time (JIT) inbound logistics and proposing an integrated production routing model. Unlike the

empirical nature of the first study, the second study adopts a mathematical modeling approach, offering a theoretical framework to optimize delivery routes and production schedules. These studies share the common thread of enhancing efficiency in manufacturing but tackle different facets, with the first focusing on internal operations and the second addressing supply chain dynamics. They complement each other in providing a comprehensive perspective on how lean practices and JIT logistics can be harnessed for improved competitiveness and sustainability in the manufacturing industry.

We drive several managerial implications for operational, supply chain, and strategic management.

1. Lean Inventory and External Factors: Firms considering the adoption of lean practices in inventory management should recognize that the benefits primarily manifest through enhanced production efficiency. However, managers must account for the external factors that influence the feasibility and impact of these practices. Understanding the intricacies of the external environment, such as the level of munificence, is essential. This knowledge will enable firms to decide when and how to implement lean inventory practices. Additionally, managers should assess their internal capabilities, including firm size and managerial proficiency, to optimize their resources efficiently.

2. Integrated Models for JIT Inbound Logistics: Managers in JIT manufacturing are encouraged to explore and consider adopting integrated models for inbound supply chain management. These models offer a multifaceted advantage that extends beyond mere cost reduction. They provide a unique opportunity to enhance relationships with suppliers. By optimizing production schedules and delivery routes, the burden on suppliers can be substantially reduced. This, in turn, fosters collaborative, mutually beneficial partnerships between manufacturers and suppliers. Furthermore, these

models significantly reduce costs in the inbound supply chain, aligning with sustainability and environmental goals. The resulting reduction in carbon emissions and overall environmental impact is increasingly relevant in today's business landscape.

3. Supporting Lean Practices Effectively: Our research underscores the importance of a thoughtful approach to adopting lean practices. Rather than blindly implementing them, firms should concentrate on developing their capabilities to reap the full benefits of lean principles. This underscores the need for close collaboration between strategic and operations managers and suppliers for long-term success. Strategic managers should prioritize the adoption of new technologies to enhance transparency, thereby improving inventory efficiency and resource utilization. Operational managers should focus on enhancing production efficiency, all while considering the external environment and product characteristics. Our study demonstrates that lean inventory alone may only partially impact production efficiency, emphasizing the importance of identifying additional factors that can provide greater advantages.

In conclusion, adopting lean practices in inventory management and JIT inbound logistics is not merely an operational strategy. It is a strategic decision influenced by both internal and external factors. By carefully considering these factors, firms can navigate the complexities and intricacies of lean practices to achieve their operational, financial, and environmental objectives. Furthermore, embracing integrated supply chain models can enhance the symbiotic relationship between manufacturers and suppliers, paving the way for mutual growth, cost reduction, and a sustainable, eco-conscious future.

While our study offers valuable insights, it is important to acknowledge certain limitations. One limitation of this study is that it primarily focuses on financial performance, and future research may need to delve deeper into non-financial performance metrics such as customer

satisfaction, quality, and employee well-being to provide a more comprehensive picture of the impact of lean practices. The other limitation is the study's focus on the manufacturing sector. Its applicability to other industries needs further exploration. Moreover, the real-world integration of such models into existing supply chain management systems may pose challenges.

The future research directions for this dissertation are classified into the following categories.

1. **Lean Practices and Specific Industries:** Investigate how lean practices can be adapted and tailored to different industries beyond manufacturing, such as healthcare, services, and technology sectors.

2. **Advanced Environmental Considerations**: Explore more sophisticated models incorporating environmental concerns and regulations for manufacturing supply chains, considering sustainability and carbon footprint reduction as essential factors.

3. **Resilience in Lean Supply Chains**: Examine the resilience of lean supply chains, especially in unforeseen disruptions like the COVID-19 pandemic, and develop strategies to enhance supply chain robustness.

4. **AI and Digital Transformation in Supply Chains**: Investigate how the integration of artificial intelligence, machine learning, and digital technologies can enhance lean practices, especially in terms of demand forecasting, inventory management, and real-time decision-making in supply chains.

5. **Lean Principles in Buyer-Supplier Relationships**: Analyze how lean principles can be extended to foster collaborative and efficient relationships between buyers and suppliers, transcending traditional transactional interactions and enabling just-in-time material flow.

6. **Lean Concepts in Emerging Fields**: In emerging fields like ride-sharing and the hotel industry, future research should focus on exploring the applicability of lean thinking. In these dynamic sectors, where efficient resource allocation and demand fulfillment are paramount, investigating how Lean concepts can be adapted and leveraged to optimize operations and enhance customer experiences is essential. Moreover, examining the integration of Lean principles with Industry 4.0 technologies, including IoT and big data, offers an opportunity to identify innovative business models and gain a competitive edge.

7. **Cross-Cultural Lean Implementation**: Investigate the cultural factors influencing the adoption and effectiveness of lean practices in various regions and the role of cultural adaptation in lean implementation.

These future research directions can contribute to a deeper understanding of lean practices, their adaptability, and their broader implications in various contexts, ultimately leading to more efficient and sustainable business operations.